THESIS

INFANTICIDE OR DEMOGRAPHIC EXPECTATION? THE CURIOUS ABUNDANCE OF CHILDREN'S REMAINS IN THE IRON AGE NECROPOLIS AT KOPILA HILLFORT, KORČULA, CROATIA.

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ABSTRACT

INFANTICIDE OR DEMOGRAPHIC EXPECTATION?

THE CURIOUS ABUNDANCE OF CHILDREN'S REMAINS IN THE IRON AGE NECROPOLIS AT KOPILA HILLFORT, KORČULA, CROATIA.

Most archaeological sites yield few sub-adult remains and when recovered they are often too poorly preserved for analysis. A lack of children in the archaeological record limits our perspective on variation in human growth and development and the history of children in the past. In this context, the high representation of children in the abundant collection of remains from a Late Iron Age Illyrian necropolis on the island of Korčula, Croatia is somewhat curious and a remarkable resource. Is this curious pattern the result of an unusual preservation pattern, differential burial practices, or infanticide? Notably, large deposits of infants from Classical Antiquity and the Iron Age Mediterranean are controversially interpreted as the byproduct of infanticide. This study estimates age-at-death for 1177 isolated teeth from three tombs via assessment of dental development using Moorrees' and Irurita's systems, as well as Liversidge's tooth length regression formulas. The resulting relative age profiles are employed to test the null hypothesis that the assemblages are unusually preserved multiple-inhumation, family tombs, rather than tombs specifically designated for sub-adults or exclusively for the victims of infanticide. The unique size and quality of this sample allows for a refined reconstruction of age-at-death and examination of growth and development patterns in the Iron Age Adriatic. Despite, a lack of adult dental age estimates, the presence of adult post-crania and the low volume of remains suggests that Tomb 3 is a multiple inhumation family tomb. Alternatively, Tombs 1 and

7 appear to exclusively contain sub-adults, with a wide age range, who received differential burial treatment. Infanticide does not appear to be the impetus for any of the tombs, although the results do not preclude the possibility that some of the individuals included in the deposit were victims of infanticide. Future research will expand on these results with analysis of dental non-metric traits and post-cranial remains.

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Last but not least, I would like to extend my warmest thanks to my loving family and dear friends for their continual support and encouragement throughout this and all seasons of my life. Thank you, all.

DEDICATION

To my grandmother, Dorothy Hollar Martin, Ph.D., for leading the way…

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CHAPTER I: INTRODUCTION

Osteologically, children and neonates tend to be underrepresented in the archaeological record. Because mortality rates are highest for the very young and very old and lowest for adults in their prime, a histogram of a typical mortality profile is shaped like the letter "U".[1] If the archaeological record accurately reflected these patterns, most necropoles would contain a large proportion of infants, children, and the elderly and a smaller proportion of young adults in their prime. Despite this expectation, infant and child remains are reportedly rare in archaeological contexts.[2]

This phenomenon is likely the result of a few factors. First, in many communities, children receive differential mortuary treatment than adults for various reasons which can include a difference in civic value, incomplete development of the soul, lack of emotional attachment or extreme reverence.[3] Often, children are buried in an entirely separate space, frequently unmarked, making it more difficult to recover their remains.[4] Moreover, differential burial practices, even in the same space, may result in differential preservation and recovery.[5]

Second, the remains of children and infants are not fully fused, they are small, and they often contain a large proportion of organic material, all of which lead to challenges in recognition, preservation, and excavation.[6] Overall, the combined absence of children in the record and in historical texts has frustrated those trying to understand coming of age in the past and convinced some that children played only a minor role in history. Feminist archaeologists in

[1] Parkin, 2013
[2] Scheuer and Black, 2004; Liston and Rotroff, 2013; Inglis and Halcrow, 2018
[3] Sillar, 1994; Scheper-Hughes; 2004, Dasen, 2013; Gowland, 2014; Craig-Atkins, 2014; Baker et al., 2014
[4] Scheper-Hughes, 2004; Hillson, 2009; Craig-Atkins, 2014
[5] Gordon and Buikstra, 1981; Saunders, 1992; Cox, 1995; Scheuer and Bowman, 1995; Guy et al., 1997; Mays, 1998; Scheuer, 1998; Scheuer and Black, 2004; Hillson, 2009; Baker et al., 2014
[6] Kerley, 1976; Johnston and Zimmer, 1989; Goode et al., 1993; Guy et al., 1997; Scheuer and Black, 2004; Hillson, 2009; Baker et al., 2014

the 1970s argued that the absence of children in the record is only perceived and instead reflects a bias in archaeological methodology which privileges adult males thus causing a self-perpetuated underrepresentation of women and children in the record (Ariès, 1962; Sundick, 1978; Ubelaker, 1999; Halcrow and Tayles, 2008; Baker et al., 2014; Inglis and Halcrow, 2018). Amidst this archaeological challenge, the collection recovered from the necropolis at Kopila hillfort on the island of Korčula, Croatia is a curious and remarkable resource. Currently, no comparable collection of Iron Age, Illyrian sub-adults exists.

At this Iron Age, Illyrian hillfort, excavations revealed seven tombs, thus far, many of which contain a high volume of sub-adult remains. This is particularly true of the first and last tombs excavated, Tombs 1 and 7. Compared to the sub-adult remains, the adult bones are limited and usually poorly preserved. This is the opposite of the preservation pattern seen at most archaeological sites. Such an unusual pattern of preservation provides a rare opportunity for researchers to delve into the world of children that is often unexplored due to a lack of material, particularly in the Iron Age Adriatic. Such a unique collection inspires a wide range of questions. My own questions, some of which inspired the hypotheses tested in this study, can be loosely organized into two groups: questions inspired by bioarchaeology and questions inspired by dental anthropology.

Bioarchaeologically, this study aims to understand who is buried in the Kopila necropolis and why. Why is there such an unusual proportion of sub-adults and how are they distributed throughout the necropolis? Could widespread infanticide be the impetus for the two sub-adult rich Tombs, 1 and 7, which appear to exclusively contain children? Did the people of Kopila have differential burial practices for sub-adults? In a broader context, how do the people living at Kopila compare to their contemporaries phenotypically and culturally? Using phenotype as a proxy for genetic nearness, who are the Kopila people most closely related to? How do the mortuary practices seen in the Kopila necropolis compare to contemporaneous burial practices, particularly for children? And further, what are the implications of these similarities and differences for our understanding of the connectivity of the Iron Age Adriatic and the place of the Kopila people within that world? This study focuses primarily on the age distribution of the individuals buried in the Kopila necropolis to try to understand the cause of such an unusual preservation pattern however future research into non-metric trait expression will address comparisons to contemporaneous populations.

The second group of questions inspired by this unusual collection is derived from growth and development research in dental anthropology and human evolution studies. Due to their scarcity in the field, large collections of child remains become an invaluable resource for studying variation in human growth and development and the human life history pattern (Liversidge et al., 1993; Scheuer and Black, 2004; Hillson, 2009; Baker et al., 2014). These collections can be used to test, improve, and develop standard methods of age estimation as well as compare rates of development within the individual, the population, and between populations. Although none of the individuals at Kopila have a known age-at-death, the large collection still has the potential to contribute to growth and development research. While beyond the scope of this study, research into variance in enamel production between permanent and deciduous teeth are in the works for this collection. However, the results of this study do provide an opportunity to compare and critique different methods of dental age estimation and their usefulness for assessing a bioarchaeological collection of isolated teeth. Beyond the teeth, dental age estimates can be compared to post-cranial age estimates, providing insights into the bias of various aging methods and the limitations of using only one aging method to assess an assemblage. All of these questions contribute to a greater dialogue about variation in dental development, and the general pattern of growth and development in modern humans.

With all of these questions in mind, this study focuses on dental age estimates in order to understand the age distributions of each tomb and test the following set of hypotheses.

H_0: Both adult and sub-adult remains are present.

Support of the null hypothesis suggests that the unusual distribution of sub-adults may just be the product of random sampling caused by the passage of time and archaeological excavation.

H_1: Only sub-adult remains are present.

Support for this alternative hypothesis would suggest that differential burial practices in the Kopila necropolis resulted in tombs which exclusively contain sub-adults.

H_2: All individuals are estimated to be under 2 at death.

Support for this alternative hypothesis suggests that infanticide may be the impetus for these sub-adult rich tombs. Infants are considered children who are 1 or younger, therefore, their age should be under 2. Ultimately, testing these hypotheses provides insights into the first set of questions regarding who is buried in the Kopila necropolis and why, setting a foundational groundwork for future studies about biodistance and growth and development.

To address these hypotheses, this study continues with Chapter II, a literature review, which discusses the history of the site and provides some historical context. Chapter II will also discuss contemporaneous burial practices for children and some estimated demographic statistics for the Iron Age Adriatic, as well as the criteria for determining episodes of infanticide in the classic archaeological record. Following the literature review, Chapter III will detail the materials and methods required to execute this study, beginning with a review of dental aging methods and their appropriateness for the analysis of this collection, followed by a detailed description of the sample and the procedures used for data collection and analysis. Chapter IV will present the results of analysis including a summary of frequencies, wear, metrics, age estimates, the identification of individuals, and the proportions of different age groups. Chapter V includes a discussion of the results and how they pertain to the initial hypotheses. Chapter VI will conclude the study, summarizing the results and discussing possible future directions for the research of the Kopila collection.

CHAPTER II: LITERATURE REVIEW

2.1 Historical Context of the Site

Figure 1: Map of Croatia. Korčula is highlighted red.[7]

Figure 2: Map of Korčula. Kopila is approximately where Blato is labelled.[8]

Kopila is located on the western portion of the island of Korčula, Croatia (Fig. 2). Korčula is about 5-10 miles west of the Pelješac peninsula which extends off the narrow coast of Croatia about 20 miles north of Dubrovnik (Fig. 1). The island sits in the Adriatic about halfway

[7] Source: http://www.korculatriporte.com/karte.asp
[8] Source: http://www.korcula-info.com/Korcula-map.php

between Split to the north and Dubrovnik to the south. Physically, the island extends 46.8 km, running almost perfectly east to west, with an average width of 7.8 km (276 km^2). Occupation of Korčula by various populations began in the Mesolithic and, currently, the island boasts a population of around 17,000 people (Borzić et al., 2017).

Kopila is located on a hill overlooking the Blatsko polje or valley which is a karstic depression created by the Blato fault line (Borzić et al., 2017). The valley is a well-used agricultural site with fertile soil and a manageable incline for human activity. During the Middle Neolithic, erosive agricultural practices blocked the natural drainage of the valley creating a seasonal lake which occasionally persisted throughout the year. This lake provided fertile soil and water to the people living adjacent to the Blatsko polje during the dry season (Borzić et al., 2017). As with most Iron Age communities, subsistence on the island likely relied heavily on cereal grains. The fertile soil of the valley was likely beneficial in this pursuit. Various middens revealed that the people of Kopila also relied heavily on domesticated sheep and, occasionally, cows, pigs, dogs, and horses for both meat and dairy. These resources were probably further supplemented by the hunting of game and extensive fishing (Borzić et al., 2017). The valley was permanently drained, and the hillside terraced by the Austrian government in the 20th century.

Prior to 2012, when the Kopila Project began excavating, archaeological research at the site was neither systematic nor comprehensive. In 1878, the first mayor of the municipality of Blato, Nikola Ostoić (1803-1869), published a compendium of island history, in which he described his 1835 surveys and excavations of a fort on top of Stražišće hill, the same hill where Kopila is located. He remarked on various finds including jewelry, Roman coins, Greek vases, a ram’s head, and other artifacts (Borzić et al., 2017). He also speculated that the site may be the looted source location for various objects of dubious origin housed in a Dubrovnik museum. A lack of comprehensive and systematic excavations prior to the 20th century and the suspected removal and distribution of some artifacts to individuals and institutions during the 19th century guarantee that the record at Kopila is disturbed and incomplete. Thus, the original location for most artifacts and remains are indeterminable and the exact provenance is unknown for specimens excavated prior to 2012.

After limited excavation and survey in the 19th century, no formal archaeological work was initiated at the hillfort until the 1990s when Byron Bass, a doctoral candidate at the University of Edinburgh, partnered with local archaeologist, Dr. Dinko Radić, to conduct an archaeological survey and excavation of sites on the island of Korčula for Bass's dissertation, producing a large volume of information about the history and ecology of the island (Bass, 1993, 1997, 1998). Unfortunately, the collapse of the Soviet Union and proceeding Yugoslav Wars (1991-2001) served as a huge impediment to this project and made it difficult to continue research during war time. Formal excavations on the island halted until 2012 when the Kopila Project began. The project is funded by the Cultural Ministry of Croatia, coordinated by the Municipality of Blato, and conducted by the Cultural Center of Vela Luka, Department of Archaeology of the University of Zadar, and the Museum of Ancient Glass in Zadar (Borzić et al., 2017).

Based on initial survey and the first few years of excavation, the Kopila research team is confident that Kopila hillfort is the most important Late Iron Age site on the western half of Korčula (Borzić et al., 2017). The hillfort is believed to be Illyrian. Illyrian is a generalized term developed by the Greeks and Romans to describe the large population of local tribes inhabiting the Balkans which eventually became a confederacy that came head to head with the Romans in the Illyrian Wars. In the past, the term often carried otherizing or barbaric connotations in ancient texts. Recently, as an extension of the Croatian national revival period, some Croatians reclaimed the term Illyrian in an effort to reinforce a national narrative of Slavic unity and historical continuity between past and present Croatians. The name Kopila has an unclear etymology but may indicate a hill, heap, or mound. Kopila is a typical proto-historic hillfort in that it consists of three parts: a citadel or fortified civic center, a suburb or residential area, and a necropolis, where the dead are buried.

Figure 3: Kopila. Photograph of the hill where the fort is located overlooking the necropolis below. Austrian terracing can be seen to either side of the necropolis. Image from Borzić et al., 2017.

Based on date from the styles of recovered artifacts, the hillfort and associated necropolis are currently dated to the Late Iron Age, specifically 4th century BC to mid-1st century BC, however some artifacts exist from preceding centuries of the Iron Age. Tombs 1 and 7 are more narrowly defined from 3rd- 1st century BC (Radić & Borzić, 2017). While the citadel sits atop a hill, the necropolis sits on an outcropping 400 meters south of the citadel (Fig. 3). From this position, the necropolis is visible to the entire valley of Blatsko. The Kopila Project research team suggests that these monumental tombs may symbolize the residents' ancestral claim over the land to visitors and neighboring groups. Additionally, the orientation of the necropolis towards the valley may represent a symbolic positioning towards the community's "source of life" (Borzić et al., 2017). Use of the necropolis for burial prior to the 4th century BC is unclear.

In the late 19th and early 20th centuries, the Austrian government terraced large portions of the island for vine crop production (Fig. 4). Despite the wide spread terracing, many tombs in the necropolis persist intact, likely because the rocky tumuli marking the graves served as an inconvenient impediment (Borzić et al., 2017). However, some tombs sustained damage during the terracing as evidenced by the remains and artifacts incorporated into the matrix of the terrace walls (Borzić et al., 2017). The extent of the damage from the terracing process is unknown.

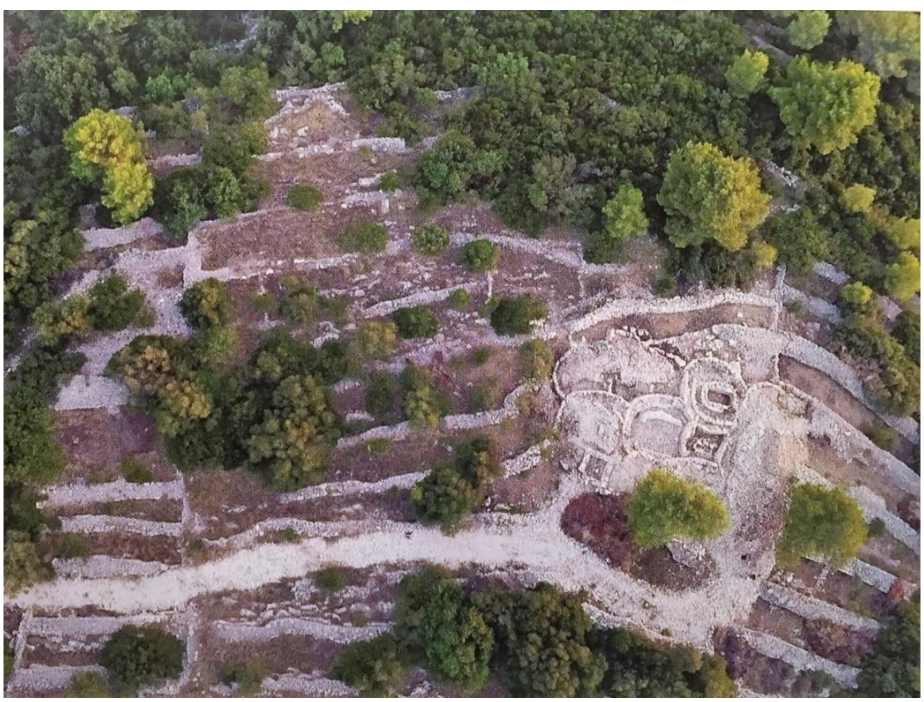

Figure 4: Necropolis. Arial photograph of the currently excavated portions of the westernmost nucleus. Image from Borzić et al., 2017.

Another factor impacting the integrity of the necropolis is looting. As mentioned before, some looting occurred prior to the 1830s. Additionally, Ostoić's lack of method during his excavations produced a similarly untraceable removal of artifacts which makes the original positioning of most specimens indeterminable. Grave looting has a long history in most parts of the world and locals and colonizers alike have practiced grave looting for various economic, educational, and pernicious purposes across time and space. Kopila is likely no exception. This, in combination with the practice of multiple inhumations, makes it difficult and, at times, impossible to pinpoint the original location of any specimen at Kopila, with the exception of some remains and artifacts recovered from Tomb 4 (Borzić et al., 2017).

Figure 5: Tombs. Photograph of the westernmost cluster of graves. At the time of this photograph, Tomb 7 had not yet been excavated. Gr. is an abbreviation of grobnica, which is Croatian for tomb. Image from Borzić et al., 2017.

The necropolis itself consists of 12+ interrelated monumental graves organized around two small nuclei in a grapevine-like pattern, covering an area of about 500 m² (Fig. 5).

Researchers suggest that these nuclei may represent two clans or family groups present in the community during the 4th century BC. Alternatively, the dual nuclei organization may also be a remnant of burial rituals from a dualistic religion. Most remains from the original tomb in the westernmost nucleus, Tomb 0, could not be recovered and at this point, only the westernmost nucleus has been excavated.

Figure 6: Tomb 1. Photograph of Tomb 1, set between Tomb 2 on the left and Tombs 5 and 6 on the right. Tomb 3 forms the superior edge of Tomb 1. Image from Borzić et al., 2017.

In 2013 and 2014, Tomb 1 was excavated from the interspace between Tombs 2, 3, and 5 (Fig. 6). Rather than following the ring like format of most of the other tombs, Tomb 1 is wedged in-between two larger tombs and is constructed with large amorphous blocks (Borzić et al., 2017). This tomb primarily contains neonates and infants. In addition to the human remains, archaeologists recovered Hellenistic vessels and jewelry including silver, bronze, glass, and amber beads. Notably, the ceramic finds included imported Greek drinking cups, mostly *skyphoi*, likely imported from nearby Greek colonies. *Skyphoi* style chronology dates Tomb 1 from 300 to 50 BC (Radovčić et al., *in preparation*). The presence of amber beads may harken to a Greek practice of using amber beads during morning to symbolize the amber tears of the Heliades while mourning their brother (Borzić et al., 2017). The tomb also contained 1000+ juvenile bones and bone fragments including the 556 teeth assessed in this study. The most frequent post-cranial bone was the right humerus (42) and the most frequent cranial bone was the left petrous portion (89) (Borzić et al., 2017). There were also 46 unsided petrous portions suggesting that 89 individuals would be an underestimate of the minimum number of individuals for this tomb. A more accurate estimate would be over 100 individuals (Borzić et al., 2017). Most of the skeletal remains in Tomb 1 are estimated to have an age-at-death between the first trimester and 6 months of age, however the teeth range up to 12.27 years old at death. The tomb contained no animal remains aside from intrusive micromammalia and turtle shell fragments.

In contrast, Tomb 2 was largely destroyed and contained only three cranial fragments, likely from a single adult individual, along with backfill dirt from the other tombs (Borzić et al., 2017). Tomb 3 was also excavated in 2014. The structure of Tomb 3 was more consistent with the other tombs in both shape and size. This tomb displayed poor preservation with a high frequency of rodent gnawing (Borzić et al., 2017). The remains mostly consisted of teeth, carpals, and tarsals, likely because of the unique size, volume, and density of these bones. Based on these remains, researchers estimate an MNI of 22-23 individuals for Tomb 3, including at least two fetuses, 13 children, 1 post-pubertal, young adult male, and 6-7 adults (Borzić et al., 2017).

Tomb 4 was excavated during the 2015 season and is the only tomb with exact locations preserved for some of the remains. Tomb 4 consists entirely of adults except for one individual estimated to be in their late teens (Borzić et al., 2017). The intact remains in this tomb are aligned parallel to each other with individuals alternating directions. The spears associated with these individuals are all pointing in one direction, perhaps indicating a social distinction, maybe associated with gender or roles in the community (Borzić et al., 2017). There are also sherds of local pottery included in this tomb. Despite, the intact remains, this tomb is also poorly preserved with many remains pushed to either end of the tomb to make room for the final intact burial.

Tomb 5 is a single inhumation of a late teen layered over Tomb 6. Based on the condition of the tomb, this inhumation was likely interred much later than the other tombs, perhaps during the Byzantine. The individual is only about 20% preserved. Tomb 6 sits under Tomb 5 and contains a minimum of 6 individuals, 3 adults and 3 children, all of which are highly fragmentary. Enamel hypoplasia lines were observed on some of the adult teeth in this tomb (Borzić et al., 2017).

Tomb 7 was excavated in 2017 and the details of the excavation have yet to be published. Early analysis reveals that it contained a large volume of sub-adult remains, comparable in number to Tomb 1. Like Tomb 1, Tomb 7 included many Hellenistic cups dated from 250 to 30 BC. Notably, other grave goods include a single cremation contained in an urn and a unguentarium dated to approximately 50 to 30 BC (Radovčić et al., *in publication*). This is considered the final burial event of Tomb 7 and the unusual mortuary practices may suggest a dramatic cultural shift associated with Roman colonization at the end of the Illyrian Wars.

Two primary tomb types were identified. One style, seen in Tombs 5 and 6 consists of three concentric rings, each ring slightly higher and more visible than the next, with the grave contained in the innermost ring (Borzić et al., 2017). In the second style, the grave gradually reaches bedrock in a step-like fashion and is framed by two concentric rings. The spaces between the grave and the rings are filled with amorphous rock. Tombs 2 and 3 are examples of this style (Borzić et al., 2017). As with most tumuli in the Balkans, the tombs were covered with a heap of limestone in a domed shape. Each individual inhumation begins with a bed of sea pebbles carried from nearby coves, however the way the pebbles fall makes it nearly impossible to determine complete individuals or the exact order of inhumation. This unusual pattern may play a factor in the unusual preservation bias observed in some of the tombs at Kopila where sub-adults are far better preserved than adults (Borzić et al., 2017). Ultimately, all of the tombs were designed in response to the preexisting environment so that tombs accommodated the limitations of existing phenomena like trees and other tombs. As a result, all tombs follow similar principles of organization, but no two tombs are exactly alike.

Prior to the Late Iron Age, multiple inhumation burials marked by tumuli are seen in other parts of the Balkans. While there is no established Illyrian burial tradition in the Adriatic, there are distinctions between Greek practices and the practices of local Illyrians (Borzić et al., 2017). Typically, the Greeks chose extended, single burials rather than the comingled tumuli seen at Kopila. There are similar tumuli seen throughout southern Dalmatia and their hinterlands but also on the Hellenistic island Issa (Borzić et al., 2017; Stipčević, 1977; Wilkes, 1992). The earlier tumuli at Kopila closely mimic the traditional tumuli style. However, as the proceeding tumuli are added around the earlier ones, the shape of the tombs are forced to adapt to the limitations of the landscape and the presence of pre-existing tombs. Tomb placement prioritizes proximity to the original tomb over the original organization of the tumuli. This style reflects both strong tradition and adaptability to the environment. Typically, the karstic systems and multi-inhumation practices in the Balkans result in poor osteological preservation (Borzić et al., 2017). For this reason, little osteological analysis has been done in the region which makes the Kopila collection so invaluable.

As with the burial style, a similar fusion between Greek and local practices is seen in grave goods. While all of the tombs have some sort of artifact debris or amassed grave good remnants, no consistent pattern is observed in the distribution of these grave goods. Most graves contain some combination of Hellenistic ceramics, local pottery, jewelry of various materials, wardrobe related objects, numismatics, and iron weapons (Borzić et al., 2017). The craftsmanship demonstrated both in the grave goods and the tombs themselves suggest access to a wealth of resources. The styles of ceramics suggest an Illyrian-Hellenistic fusion of ritual, the weapons imply that the community was capable of warfare and experienced in contest, and various jewelry suggests that the people of Kopila had complex cultural identities (Borzić et al., 2017). In general, the artifacts demonstrate the strength and a control of resources by the Illyrians rather than a traditional colonizing narrative associated with ancient Greeks and Romans. It is posited that the Greek items, may have served as payment for safe passage through the nearby channel rather than as relics of oppressive colonization, The current interpretation of these artifacts by the Kopila Project research team is that the objects signify a position of power during the Iron Age, via control of the water ways, amidst the infamous power struggles and colonial quests of the Ancient Greeks and Romans (Borzić et al., 2017).

The positioning of Korčula with its western coast in the open sea and the eastern coast lining the premier naval channel between Central and South Dalmatia suggests that this island served as a "trans-Adriatic connection" between the eastern and western coasts of the Adriatic. This powerful positioning in the eastern Adriatic did not escape the notice of the Greeks. Unlike many coastal islands, Korčula is actually mentioned in many ancient Greek historical texts written by classic historical figures like Pseudo-Scymnus, Strabo, Pliny the Elder, Appian, Livy and others (Borzić et al., 2017; Stipčević, 1977; Wilkes,1992). Reference to Korčula always makes a clear distinction between the Adriatic Corcyra Melaina (Black Corcyra) and the Hellenistic island of Corcyra. The Adriatic Corcyra is distinguished from the original Corcyra with a descriptor meaning black which describes the dense forest cover on the island (Borzić et al., 2017; Stipčević, 1977; Wilkes,1992).

Strong evidence of Greek (Corinthian and Daunian) trade on the island exists as early as 7th century BC, but none of the evidence suggest political control. The ability to observe and control nautical movement through the channel and exploit coastal resources while also maintaining an appropriate defensive distance from the shores makes Kopila an idea location for an island hillfort. Amidst the rich trade of the Adriatic, piracy was notoriously rampant during this era. However, the cove held innumerable resources essential to the survival of an island community. Therefore, being near, but not on the coast would be ideal, particularly if hilltop positioning allowed for observation of the coast. Additionally, proximity and control over the Blatsko valley and aforementioned seasonal lake would have allowed the people of Kopila to meet the agricultural and livestock demands of a substantial, independent community (Borzić et al., 2017).

As the 5th century transitioned into the 4th century, the second wave of Greek colonization led by Dionysius the Elder of Syracuse expanded to the region, establishing colonies on Vis (Issa) and Hvar (Pharos) (Borzić et al., 2017; Stipčević, 1977; Wilkes,1992). During the collapse of this expansion in the following rein (Dionysius II), the Issaeans gained independence and joined forces with the people of Pharos to control central and south Dalmatia.

As a part of this quest, the Issaeans founded a colony on the south eastern end of Korčula. Some of the only evidence for an Issaean colony on the island is a partially excavated necropolis, which contains 5 or 6 Issaean burials (extended position with ceramic grave goods from southern Italy). Unlike most Issaean burials, these are singular rather than multiple family burials (Borzić et al., 2017). Other artifacts may not have been found because this region of the island was simultaneously unexplored and also an area of intensive use. Additionally, the conflict between Issaeans and the Illyrian state may have resulted in the destruction of the Issaean colony.

During this time, the Illyrian state, a confederation of Balkan tribes where each tribe is represented by one leader, emerged as a formidable force in the central and southern Adriatic. During the reign of the Ardiaean tribe under Agron (250-231 BC), the Illyrian state thrived, controlling the area from Ionia to Korčula, with the exception of a few independent Greek cities (Apollonia, Epidamnos, and Issa) (Borzić et al., 2017; Stipčević, 1977; Wilkes,1992). The infamous Teuta, successor queen to Agron and regent to stepson Pinnes (231-227 BC), sought control over this region and besieged Issa in 229 BC. This conquest caught the attention of the Romans forcing them to acknowledge that the Illyrian state may be a nuisance in their quest for "world" domination. Thus, began the first of three Illyrian wars (229-228, 219-218, 169-168 BC) which eventually resulted in Roman control of the region in 35/33 BC (Borzić et al., 2017; Stipčević, 1977; Wilkes,1992).

During this period, Korčula was inhabited by the Illyrian tribe, Plerei, who may have occupied Kopila hillfort. Based on location and time period, the western portion of the island likely played a part in the military stratagem of the multiple attempts to capture Issa by Agron, Tetua, and Gentius (Borzić et al., 2017). The dense population of the island at this time as well as the abundance of offensive weapons recovered from the necropolis suggests that Kopila posed a strong military threat. Since the graves are dated to 3rd and 2nd century BC, it is not unreasonable to suggest that some of the deceased may have been casualties of the conquest of Issa and proceeding Illyrian wars (Borzić et al., 2017). During the end of the 1st century BC, Romans conquered Korčula, reportedly killing or selling all young men and likely razing the island in typical Roman fashion. Shortly thereafter, Romans began to settle the island and invest in its agriculture. This historical narrative is consistent with the archaeological record. Roman settlements persisted until the Early Middle Ages (Borzić et al., 2017).

2.2 Demography and the Death of Children in the Iron Age Adriatic

To contextualize the Kopila remains, what constitutes a normal population distribution in the Iron Age and the role of children during this time must be understood. During antiquity, children made up a large proportion of the population. In a stabilized community, they would consist of roughly 1/3 of the population with only about 7% of the population being over sixty (Parkin, 2013). The proportion of children would increase beyond 1/3, if a population was growing. This ratio contrasts starkly to present proportions in developing countries where about 19% of the population is made up of children and 21% are over the age of sixty (Parkin 2013). As such a large contingent of Iron Age communities, children likely played a large part in daily life, despite a paucity of information on them in classic historical texts. Children were economically important to a household both as a cost liability as another mouth to feed and body to clothe but also as a form of labor production (Parkin, 2013). In the absence of child labor laws, Iron Age children often children served as slaves or worked in their household for their share of its bounty.

Aside from being an economic asset in the day-to-day management of the house, large families improved the likelihood of preserving lineages and forming alliances through marriage, particularly for the elite. Roman law required heirs in order for land to be passed down. However, many children died before they could inherit their portion. In antiquity, most people considered the death of the young and old to be natural and commonplace. As Cicero recognized, children are rather vulnerable to a wide swath of threatening factors. Thus, high mortality rates during the periods of infancy and early childhood is often paired with high fertility rates to either stabilize or grow the community (Parkin, 2013). As always, the infant was most at risk during the first week of life. As a response to this uncertainty, heads of households in ancient Greece and Rome abstained from naming children until about a week to ten days after birth, in concordance with the loss of the umbilical cord (Parkin, 2013).

During the neonatal period, fetuses are susceptible to endogenous factors, particularly the health of the mother. During the post-natal period the threats to the health of the new born are exogenous factors such as food, hygiene, and environment. These exogenous factors are compounded in an urban environment with decreased hygiene and a higher density of people (Parkin, 2013). It is estimated that in the preindustrial world the infant mortality rate (IMR) or the number of deaths before the first birthday per 1000 live births was 200-300+ deaths per 1000 births (Parkin, 2013). Industrialization, particularly the rise of extended breastfeeding and pasteurized milk, decreased the IMR to less than 10 deaths per 1000 births and lowered fertility rates (Parkin, 2013). Although the difference between these numbers seems dramatic, present developing communities vary between 90 and 200 deaths per 1000 births. It is also important to keep in mind that the IMR for a region can disguise variation in infant mortality caused by class, race, or even just variation across space and time (Parkin, 2013).

After that first year, 35-45% of Iron Age children died before the age of 5 (Parkin, 2013). While infancy is the riskiest period, the first five years of life can be challenging because it is the weaning period. Typical weaning during the Iron Age occurred between 6 months and three years (Parkin, 2013). After 9 months, breast milk alone is not enough to fuel the growth and development of the child. Unfortunately, for many children of antiquity, this transition proved difficult or even fatal. Often, supplementary food provided for children during weaning lacked in quantity, nutritional quality, and hygienic preparation (Parkin, 2013). The decreased intake of breast milk can also reduce immunity. After the five-year mark, puberty is the next major threshold for life expectancy. If a child in antiquity lived through puberty, they would likely survive into their 40s (Parkin, 2013). Thus, at Kopila, an Iron Age Adriatic hillfort, expectations dictate that we should recover a larger proportion of sub-adults, particularly infants and children, than adults. However, adult remains should still have a significant presence. In most cases, archaeological sites do not meet demographic expectations and sub-adults are vastly underrepresented. At Kopila, this is not the case. Remarkably, sub-adults appear to be more numerous and better preserved than the adults in the Kopila necropolis. Are these unusual proportions the result of limited preservation bias or an unusually, and perhaps ominously high volume of dead children?

Some answers may lie in different burial treatments. There are five infant and children burial types recorded in the literature for the Mediterranean during the Iron Age: urns, cremation, multiple inhumations, domestic inhumation, and well or sewer deposits (Table 1).

Urn or amphora burials are the most commonly recovered child burial types in the Iron Age Mediterranean. Some of its popularity may be a product of preservation bias as this practice protects the skeleton of the fetus, infant, or child better than other burial methods (Hillson, 2009). However, the urn, amphora, or domestic pot burials, also known as the burial style of *enchytrismos* dominate the era as the typical or canalized style of child burial throughout the ancient Mediterranean world. Urn interment almost always occurred in formalized burials spaces, but whether the urns of children are buried with or without adults varies (Stevens 2013, Hillson 2009, Bourbou and Themelis 2010).

Table 1: Table of burials types observed in the Iron Age Mediterranean with descriptions.

Burial Type	Description	Region	Time Period	Examples
Urns and Amphoras	Individual inserted into urn via an opening cut into the side. Urn is then buried in a formalized space, with or without adults. Preserves body well. Intentional ritual. Also known as *enchytrismos.* Most common.	Adriatic, Mediterranean (Greece, Italy, North Africa)	Iron Age	Hillson, 2009; Stevens, 2013; Bourbou and Themelis, 2010
Cremation	Subset of urn/amphora burials where the remains are cremated before being put in the urn and buried.	North Africa	Iron Age	Smith et al., 2011, 2013
Multiple Inhumations	One tomb used for a series of inhumations. Can include adults or just children. Often reflects familial relationships and/or a belief in the need for companionship in the afterlife.	Greece, Balkans, Mediterranean	Bronze Age, Iron Age	Borzić et al., 2017; Stipčević, 1977; Wilkes, 1992; Hillson, 2009
Domestic	Remains or urn interred near or within the household/domestic space. Informal burial. May signify inclusion within the family but not within the civic community.	Roman Britain, Mediterranean	Classical Antiquity	Moore, 2009; Gowland, 2014
Sewer/Well	Informal deposits with a large volume of neonates and infants. Few grave goods. Domestic pot sherds and the remains of dogs are often included. Location often out of sight in a back alley. Most often interpreted as the byproduct of infanticide.	Mediterranean	Iron Age, Classical Antiquity, Byzantine	Liston and Rotroff, 2013; Bourbou and Themelis, 2010; Smith and Kahila, 1992

Researchers investigating a Roman amphora burial in North Africa suggest that the shape of the amphora symbolizes the womb and that different styles purposefully reflect the stage of life the child died in, particularly the 6-month mark associated with weaning in historical texts (Stevens, 2013). While the womb analogy is compelling, many argue that little historical evidence exists to confirm this interpretation (Hillson, 2009). Either way, variation in urn size and positioning reflect intentional choices to differentiate either by age, size, or another factor not yet considered (Stevens, 2013).

At a 3rd century BC- 1st century BC site in Messene, Greece, researchers recovered 25 domestic pot infant burials along the wall of an elite adult burial site (Bourbou and Themelis, 2010). Their positioning along the wall indicates simultaneous inclusion as a member of this family grouping as well as exclusion with their marginalized placement in the site, signally a sort of half-belonging. Alternatively, Hillson (2009) and his team recovered an astonishing collection of infant burials (all individuals under 2 years) from the Kylindra cemetery on the slope below the citadel at Astypalaia, Greece. The cemetery is dated to 600 BC – 100 AD and contains 2400+ individual infant burials with no associated adult remains. At this site, the ritual and burial space for infants is clearly differentiated from that of adults.

A subset of urn-based burial is seen in a Roman cemetery in Carthage where researchers recovered a large collection of young children, mostly infants, found in cremation urns (Smith et al., 2011, 2013). Burial in an urn is a specific ritual which protects the integrity of an individual's body, preventing mixture between individuals in the same space. Placement of these urns within or outside the boundaries of formal burial places as well as with or without adult remains are purposeful choices that indicate social distinctions and cultural beliefs about childhood. In general, urn burials are licit, ritualized, common, and suggest a level of inclusion in the community. Occasionally, child inhumations and urn burials may be interred in a domestic space like the floor of a kitchen or just outside of housing. This form of informal burial signifies inclusion in the household but not necessarily in the greater civic community (Moore, 2009; Gowland, 2014).

An alternative to urns observed occasionally in ancient Greece and regularly throughout the Balkans are multiple inhumation tombs organized by familial groupings, wherein infants are buried with older children and adults from their family (Borzić et al., 2017; Stipčević, 1977; Wilkes, 1992; Hillson, 2009). In this case, children are included as part of the familial group. Compare this inclusion to the separation of children into a separate cemetery or their burial outside of the boundaries of the formalized burial space. This also suggests an emphasis on family groupings in the extant members of the community and potentially a belief in the need for companionship and caretaking in the afterlife.

Some of the most sensationalized forms of infant and child burials are the sewer and well deposits observed at a few ancient Mediterranean sites. Often these assemblages include large numbers of infants, informally deposited with sherds of pottery and sometimes the remains of dogs. This burial type is frequently interpreted as an atypical or deviant form of burial resulting from macabre circumstances such as morbid illness, infanticide, or exposure. One such example is an assemblage recovered from a well in the Ancient Agora of Athens and dated to 2nd century BC. In this well, archaeologists found a large deposit of infant remains along with sherds of pottery and a large volume of dog remains (Liston and Rotroff, 2013). This community also had a formal cemetery nearby which contained fewer infant burials than would be expected. The presence of a formal cemetery and the exclusion of the infants in the well from that space suggest purposeful differentiation and exclusion of the well infants from the community.

Likewise, in a 3rd-2nd century BC well in Messene, Greece, a team recovered hundreds of sub-adult remains along with pottery sherds and dog remains (Bourbou and Themelis, 2010). Although dated later than the Iron Age, another Israeli site also contains a large, late Roman/early Byzantine infant burial site recovered from a sewer. Again, this large deposit of infant remains juxtaposed to a nearby sanctioned cemetery containing infants buried in urns is notable (Smith and Kahila, 1992). In all of these contexts, the well and sewer deposits of young children exist as a separate and opposing illicit burial place to the formal, licit cemeteries within the same community wherein children are buried in urns. This supports the interpretation that these deposits are exclusionary or atypical while urn burials are inclusive and typical.

At Kopila, the excavation team recovered a large volume of sub-adult remains interred not in urns but in multiple inhumation tumuli. Many of the tombs appear to exclusively contain sub-adults, some containing over 100 sub-adults and no adults. When large deposits of infants and young children are recovered, popular lines of questioning often include whether or not the unusual assemblage is the result of widespread infanticide. An understanding of the history of infanticide in the Iron Age Adriatic as well as how bioarchaeologists diagnosis infanticide in the archaeological record is necessary to assess the Kopila sample for infanticide.

While there are a few descriptions of war-related infanticide in ancient historical texts, the more common practice from 600 BC to 600 AD in the Mediterranean was to expose unwanted children. Exposure is when the head of a household decides against keeping a new baby, prior to its naming day, and renounces his responsibility for that child. The father had the right to determine who lived and who died in his household, as long as the choice was made prior to the loss of the umbilical cord/naming day/first ten days of the child's life (Smith and Kahila, 1992). Often, men had the babies of slaves and concubines exposed to mitigate financial burden or distractions in his household (Smith and Kahila, 1992). After such a decision, he would abandon the baby in a public space leaving its future up to fate. Abandonment could occur in a busy public place or deep in the woods. Often the baby was either devoured by animals, adopted by passersby, or killed by starvation or exposure to the cold (Gowland, 2014, Evans

Grubbs, 2013). While many babies died during this process, the practice was less taboo than infanticide because the death of the baby appeared to be the will of the gods, rather than the malevolent desire of the parents. Babies who survived exposure through adoption often became slaves, bolstering the economic value of their new household. Child circulation through exposure played an important role in the economics and cultural anxieties of ancient Greek and Roman communities and as such also furnished many historic legal disputes and dramatic plots (Evans Grubbs, 2013).

Exposure was unregulated until the 3rd century AD when it was finally codified in Roman law. The purpose of these laws was not to criminalize exposure but rather to regulate the practice and minimize conflict by clarifying whether or not an exposed child has any claim to the estate of their birth parents or, inversely, whether the birth parents have any say as to how their exposed child is raised by another family (Dasen, 2013; Evans Grubbs, 2013). The criminalization of infanticide and exposure coincided with the rise of Judeo-Christian law (Smith and Kahila, 1992; Dasen 2013). Although not criminalized, infanticide was taboo. The scholars of antiquity frequently debated when exactly a child develops a human soul. In general, they considered the disposal of the body without proper burial to be the fate of non-human animals, a categorization deemed appropriate for unnamed infants (Liston and Rotroff, 2013; Dasen, 2013).

Iron Age adults chose exposure or infanticide for many reasons. Children produced via rape or sex out of wedlock were often killed. Along the same line, children suspected to be the product of adultery were also killed. The pervasive fear that another man's child might lay claim to his land led many men to abandon or kill their own, legitimate children out of sheer paranoia (Evans Grubbs, 2013). Children believed to be superfluous such as the children of slaves and concubines, or any child born after a household reached perceived capacity was also disposed of

(Evans Grubbs, 2013). Likewise, poverty lead many to exposure or infanticide. Physical deformities such as cleft palate or hydrocephaly often proved fatal during antiquity so parents would hasten the process and minimize suffering via exposure or infanticide. Some historical texts suggest that malformed children were occasionally considered bad omens preceding failing crops, natural disaster, and widespread illness. As a result, parents were often pressured into killing the cursed child by members of their community. However, this was not a universal or even commonplace practice. While many reasons exist for committing exposure or infanticide during antiquity, differentiating infanticide from natural death in the archaeological record remains a difficult task.

Table 2: Table of evidence used to diagnosis infanticide in the archaeological record.

Evidence	Description	Citation
Narrow Age Range	Most individuals should be infants (under 2 years old) and neonates. Can use dental development, bone development, and epiphyseal fusion to assess	Gowland, 2014; Smith and Kahila, 1992
Lack of Intentionality	Haphazard deposit without consistent ritual or orientation. Lack of grave goods. Highly fragmentary and comingled. Sherds of domestic pots used to carry bodies to location. Suggests indifference or urgency.	Smith and Kahila, 1992; Liston and Rotroff, 2013
Illicit Location	Location separate from formalized community burial space. Isolated and hidden from view in a sewer or well located in a back alley.	Smith and Kahila, 1992; Liston and Rotroff, 2013; Gowland et al., 2014
Trauma and Pathologies	Evidence of perimortem trauma such as head trauma, fractures, periosteal lesions, or blood in the dentinal tubuli. Evidence of pathologies, visible at birth such as cleft palate or hydrocephaly. May have been killed because death was imminent or because it was considered a bad omen.	Van Wyk, 1987; Smith and Kahila, 1992; Dasen, 2013; Liston and Rotroff, 2013

Most archaeologists consider four criteria when diagnosing an antiquitous assemblage as the result of widespread infanticide (Table 2). The first and most pertinent criteria to this study is that the deposit should almost exclusively contain infants (under two years of age). Evidence is stronger if, within the assemblage of infants, a high concentration of neonates and/or fetuses is observed because the first week of life is the most tumultuous and only legal period wherein infants could be killed or exposed. Age may be assessed via dental development (as in this study), the presence of a neonatal line, bone development and fusion, and long bone length (Smith and Kahila, 1992). While exceptions are possible, in a deposit intended for the victims of infanticide, the ages of the individuals should not deviate much beyond the narrow, one-year age range (Gowland, 2014).

The second criterion considers the intentionality of the deposition. Victims of infanticide are often interred in a haphazard and hasty way. Individuals are not differentiated, and burial is done with little care. Often, the skeletons are oriented haphazardly, and the remains are highly fragmented and comingled with other individuals as well as pottery sherds, likely from the domestic pot which caught the baby during birth or inconspicuously transported the body. The presence of domestic pots supports the idea that midwives likely did most of the disposal, particularly if the infanticide was ordered by the mother without the father's knowledge (Smith and Kahila, 1992; Liston and Rotroff, 2013). A lack of order and grave goods suggests indifference or urgency during the deposit (Smith and Kahila, 1992). However, another common occurrence is the inclusion of dog remains. Some researchers posit that dog sacrifice is part of a known purification ritual to appease the gods responsible for purification. Purification would be necessary if the child was perhaps deformed and considered a bad omen, as previously mentioned. It is important to note here that, like the criminalization of infanticide, the spirits of dead infants were not considered malevolent until the rise of Judeo-Christian ethics (Dasen, 2013).

The third criterion for diagnosis of a deposit of infanticide victims is location. Infanticide demands the abandonment of society's burial norms. Typically, the location of the assemblage reflects the exclusionary or illicit nature of infanticide. Deposition sites are usually separated from the formal communal burial space and instead are located in an isolated or out of way area such as in a well or a sewer in a side alley or behind a building (Smith and Kahila, 1992; Liston and Rotroff, 2013; Gowland et al., 2014). At an early Byzantine sewer deposit in Ashkelon, Israel, a formal cemetery space where infants were buried individually in urns sat only 200 yards away (Smith and Kahila, 1992). Typically, infanticide assemblages are excluded from sanctioned burial spaces.

Lastly, victims of infanticide often display evidence of trauma or pathology. For example, individuals in some assemblages show evidence of perimortem head trauma, fractures, and the periosteal lesions typically seen in shaken babies (Liston and Rotroff, 2013). Moreover, the teeth of babies who are the victims of drowning, smothering, or strangulation, popular methods of infanticide across time and space, may contain residual red-brown iron oxide stains from when the blood was forced into dentinal tubuli of the teeth during asphyxiation (Van Wyk, 1987; Smith and Kahila, 1992). Additionally, children with pathologies visible at birth such as hydrocephaly or cleft palate may have died very early in life or may have been killed to hasten their imminent death or to cleanse the community from the bad omen (Liston and Rotroff, 2013; Dasen, 2013). While there is evidence that people of antiquity cared for children with disabilities or deformities, they also knew that children with hydrocephaly or cleft palate would not live long and as previously mentioned, sometimes, malformed babies were thought to be a bad omen.

Even with these diagnostic traits, some archaeologists argue that typical infant mortality and occasional infanticide or abortion are difficult to distinguish from culturally widespread infanticide and disaster casualties. Sometimes an alternative burial space may be more indicative of social class, pathology, or general inclusion in society rather than of infanticide. In a 2nd century BC well in the Ancient Agora of Athens, a team recovered 449 infants, 1 adult, 1 older child, and 150+ dogs, along with numerous pottery sherds (Liston and Rotroff, 2013). The presence of an adult with serious pathology along with the frequency of hydrocephaly and cleft palate amongst the infants led them to interpret the site as a disposal area for people whose death and circumstances in life were considered a bad omen. The dogs, thought to be sacrificed in purification rituals, support this interpretation (Liston and Rotroff, 2013). Researchers do not reject the possibility that some of the infants in the assemblages were the victims of infanticide. Instead they propose that the well deposit cannot be explained exclusively as a byproduct of widespread infanticide.

An assessment of these four diagnostic criteria in the Kopila necropolis is necessary to explain the unusual assemblages but also to understand the role of children at Kopila. This study creates relative age profiles using dental age estimation methods to assess the age range of Tombs 1, 3 and 7 to test the likelihood that these deposits are the byproduct of widespread infanticide. With the sample historically contextualized, the following chapter will review the materials and methods required for this study, including a review of dental age estimation methods, description of the sample, and a detailed enumeration of the procedures used for data collection and analysis.

CHAPTER III: MATERIALS AND METHODS

3.1 Review of Dental Age Estimation Methods

Aside from providing essential demographic information, assessing the age-at-death of the individuals in a multiple inhumation tomb can reveal whether or not age was a primary criterion for differentiation in burial practices. Patterns in age-at-death may explain the unusual distribution and high proportion of sub-adults at the Kopila necropolis. In this paper, potential patterns of age-at-death are explored via dental age estimates of the individuals recovered from Tombs 1, 3, and 7. Selecting the appropriate method required a review of current methods and assessment of their suitability and limitations for this unique project.

Research in bioarchaeology, paleontology, and forensics required the development of accurate methods for estimating age via the dentition since teeth are often the best preserved and most numerous specimens in the fossil and archaeological records. Compared to most bones, teeth contain a significantly smaller proportion of organic material, thus they are harder and less susceptible to taphonomic processes.[9] Moreover, the number of teeth that an individual body contains (28-32 for adults and 20 plus developing teeth in-crypt for children) is comparable only to ribs, carpals, and tarsals. It follows that teeth are often the best preserved and most frequent bones in archaeological assemblages, particularly in highly fragmentary deposits.[10] Developing methods that capitalize on this disproportionately high frequency of teeth was crucial for many researchers who rely on data derived from recovered human remains. Beyond basic demography, in forensics, an accurate age-at-death estimate can be critical to legal proceedings and identification of victims (Liversidge, 1995; Scheuer and Black, 2004; Baker et al., 2005).

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[9] Hillson, 2002
[10] *Ibid.*

Moreover, many seminal studies on the evolution of the human life history pattern and assessments of the growth and development of fossil hominins rely exclusively on dental age estimates (Mann et al., 1990; Benyon and Dean, 1991; Mann et al., 1987,1991). Most dental age estimation methods were designed with one or more of these purposes in mind however orthodontics also played a critical role in early dental growth and development studies.

To develop these methods, researchers needed access to a wide array of long-term orthodontic longitudinal studies which were not intended for bioarchaeological use or to multiple bioarchaeological collections with individuals of known age-at-death. Samples that meet these standards and are statistically ideal are limited if not non-existent. The optimal sample would be large and composed of multiple, balanced populations with even distributions of both sex and age (AlQahtani et al., 2014). Ideally, the methods developed should be reproducible for all populations and ages, statistically sound, and precise enough to meet the standards of the court system for forensic investigations (Liversidge, 2015). This is a tall and, perhaps, unachievable order. Dental age estimation methods have a long history of refinement spanning the second half of the 20th century.

Dental aging methods can be categorized into three types, those based on (1) formation or development stage, (2) microscopic histology and enamel formation markers, and (3) metric data.

Formation or Development Stage Methods

Stage of development methods fall into two categories: atlas and scoring methods. Atlas methods assign an age range to an arbitrarily defined stage of development. Scoring methods require a full quadrant of teeth wherein each tooth is assigned a score, based on achieved development. The scores are then added up to get an overall maturity score which can be compared to other maturity scores and/or translated into a population specific dental age (Willems, 2001). In 1941, Schour and Massler (Fig. 7) published an atlas of dental age designed for quick reference purposes. While widely referenced, this chart is problematic for many reasons. First, details about the sample and procedures are mostly unknown except that the sample consisted of 29 individuals, 19 of which were under the age of two. The chart skips ages 13, 14, 16-20, and 22-34, leaving large data gaps for teens. Second, the chart does not include descriptions, not even defining the line of eruption as osteological or gingival. In 1944, Schour and Massler revised their atlas to include a range of ages for each stage rather than a single year estimate. Ubelaker further revised Schour and Massler's atlas in 1978 by defining the eruption line and including adjusted timelines for Native Americans and Aboriginal Australians. The amended chart is still used for quick reference purposes in many bioarchaeological textbooks and remains a good option for understanding the general pattern of dental development or when assessing a nearly complete set of teeth.

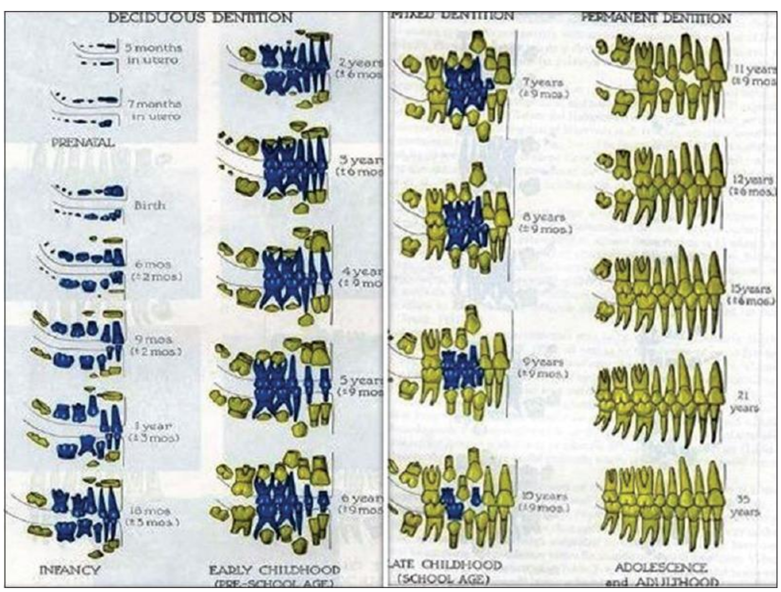


Figure 7: Dental age estimation chart by Schour and Massler (1941). Note the lack of descriptions and large gaps in time between teen stages.

In 1963, Moorrees and colleagues published an age estimation method which translates the developmental stage of each tooth into an age estimate (Fig. 8 and 9). To create this method, they analyzed radiographs from two collections. The Stuart Collection contains data from the Forsyth-Harvard longitudinal study, conducted in Boston during the 20th century, including series of radiographs taken at regular intervals for 134 individuals, 48 males and 51 females. Due to large gaps in the Forsyth-Harvard radiograph record during World War II, Moorrees and colleagues (1963a, 1963b) also included the Fels Collection in their database. The Fels Collection consists of 246 (136 male and 110 female) white, North American children of middle socio-economic status. The resulting age estimation method provided separate charts for males and females and established different developmental stages for single and multirooted teeth, with illustrations. Estimates were provided in ranges rather than point estimates. In this study, Moorrees' method is used to estimate age-at-death and serves as the primary guide for assessing stage of development in the Kopila sample.

TOOTH-FORMATION STAGES AND
THEIR CODED SYMBOLS

Stage	Coded Symbol
Initial cusp formation	C_i
Coalescence of cusps	C_{co}
Cusp outline complete	C_{oc}
Crown $\frac{1}{2}$ complete	$Cr._{1/2}$
Crown $\frac{3}{4}$ complete	$Cr._{3/4}$
Crown complete	$Cr._c$
Initial root formation	R_i
Initial cleft formation	$Cl._i$
Root length $\frac{1}{4}$	$R_{1/4}$
Root length $\frac{1}{2}$	$R_{1/2}$
Root length $\frac{3}{4}$	$R_{3/4}$
Root length complete	R_c
Apex $\frac{1}{2}$ closed	$A_{1/2}$
Apical closure complete	A_c

Figure 8: Stage definitions from Moorrees et al. 1963a and 1963b. See Figure 9 for illustrations.

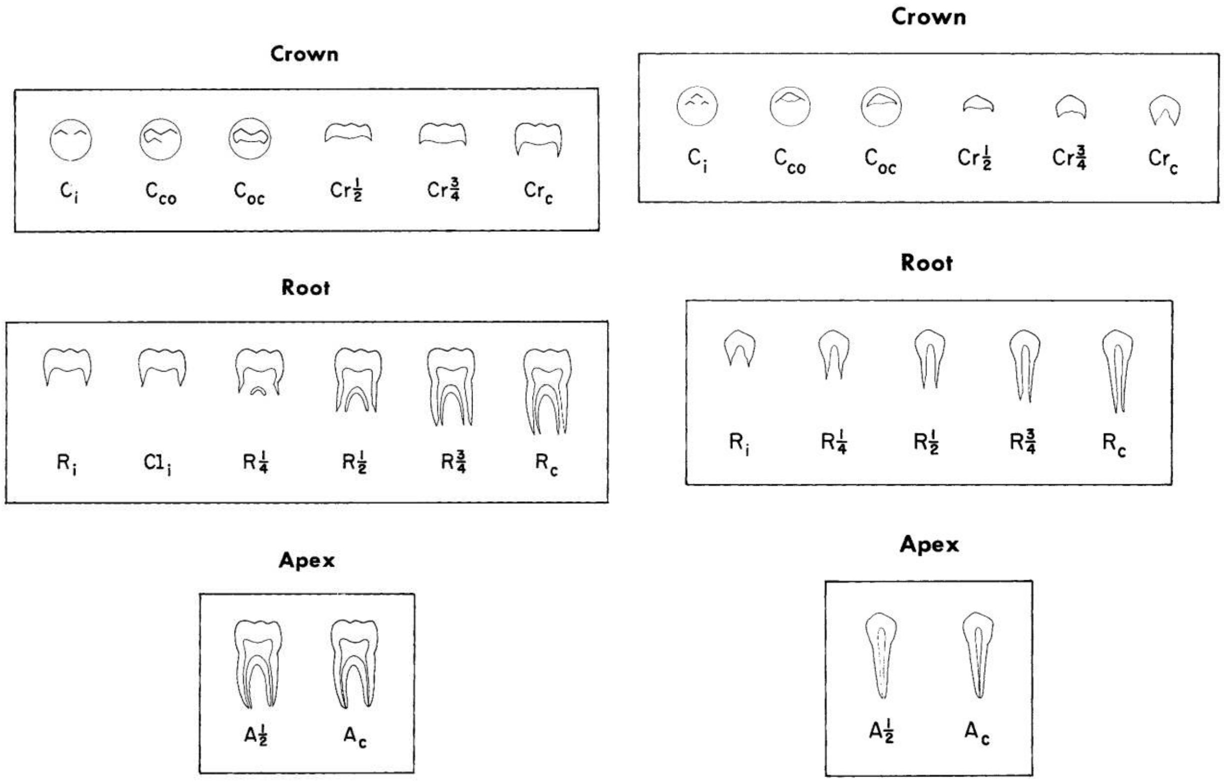


Figure 9: Dental stage illustrations from Moorrees et al., 1963a and 1963b. Illustrations for multi-rooted teeth are on the left and single rooted teeth are on the right.

About a decade later, Demirjian and colleagues (1973) presented a new system for dental age estimation. They based their method on a collection of radiographs taken from a French-Canadian longitudinal study that included 1446 boys and 1482 girls. Radiographs were taken of the left mandible at consistent intervals between the ages of 2 and 20 years old. Their assessment focused on the permanent teeth and measured the amount of dentinal deposit and size of the pulp chamber. As part of their system, they included lettered stages with thorough descriptions, including a definition of the line of eruption (gingival), wherein each stage is assigned a number of points. The points are then added up to calculate a maturity score which can be converted into a population-dependent age estimate. Demirjian and colleagues' (1973) system separates estimates by sex and is designed primarily for complete or nearly complete dentitions. These limitations suited their primary purpose which was to improve methods for orthodontics, forensics, and endocrine assessment. While well praised, this method is limited by populational specificity (Liversidge et al., 1993; Willems, et al. 2000) and the need for a nearly complete tooth row. Liversidge and colleagues (1993) concluded that Demirjian and colleagues' method was not accurate for an assemblage of 521 historical British children of known age-at-death. The direction and amount of divergence between estimate and known age-at-death varied unpredictably except for a tendency for the method to underestimate the age of the very young. Likewise, Willems and colleagues (2000) found the system inappropriate for a sample of Belgian children and provided the necessary numerical adjustments for accurate measurement of that population. They considered a sample of 2523 radiographs from Belgian longitudinal studies to calculate the proper adjustment.

In 2014, AlQahtani and colleagues at Queen Mary's University of London developed the London Atlas, an open access software available to the public, designed specifically for dental age predication with 31 illustrated and described developmental categories. The system is based on a large collection with uniform age distributions. When compared to both Shour and Massler (1941, 1944) and Ubelaker (1978), all methods underestimated actual age-at-death, but the London Atlas was consistently the most accurate. Under the age of 1, all methods were pretty accurate which is to be expected since they all have similar sample distributions for that age range.

In 2014, Irurita and colleagues combined the methods and data from Moorrees et al. (1963a, 1963b), Demirjian et al. (1973), and Liversidge (2004) to create a revised system of 11 defined stages of mineralization (Fig. 10). They wanted to combine the exceptional descriptions of Demirjian et al. (1973) with a system that was suitable for the analysis of isolated teeth, such as Moorrees et al. (1963a, 1963b). The impetus for the development of this system was to create a method that improved accuracy in the analysis of Mediterranean populations, specifically their historical research collection in Granada, Spain. The Granada collection contains 130 individuals, 80 males and 58 females, with a total of 1303 teeth. Based on records, the age range of this collection spans 24 weeks in utero to 6 years of age. Faced with many isolated teeth, they aimed to refine language used in Demirjian's (et al., 1973) stage descriptions to eliminate the focus on radiographically visible characteristics, instead emphasizing external morphology. In addition to mineralization stages, they also developed a sequence of alveolar eruption stages. The system developed by Irurita and colleagues (2014) is used in this study as an alternative age estimation method to Moorrees and colleagues' (1963a, 1963b).

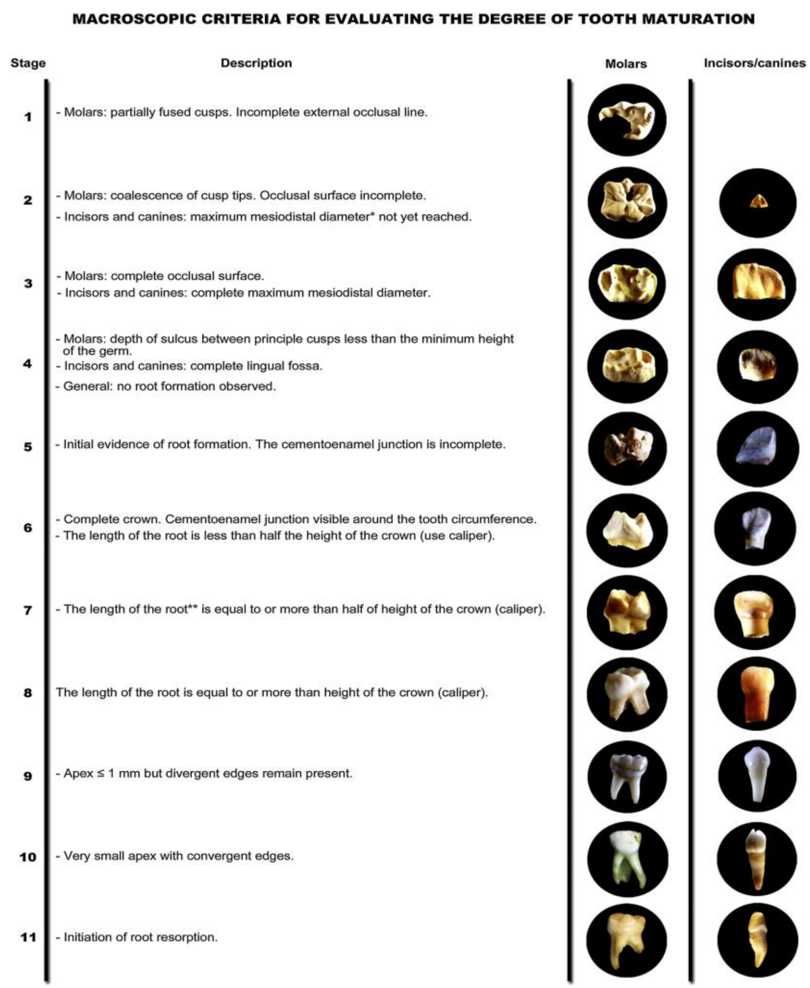


Figure 10: Descriptions and photographs of developmental stages created by Irurita et al. 2014.

Microscopic Histology and Enamel Formation Marker Methods

Histologically, perikymata are the externally visible lines on the surface of a tooth's crown which are believed to reflect striae of Retzius and demark incremental periods of enamel formation. By counting all of the perikymata or external lines in the enamel after the neonatal line (a line indicating the disruption of the growth process during the first couple days after birth) researchers can calculate an estimate for age-at-death (Mann et al. 1990). Controversially, this method assumes a consistent circadian and/or septacircadian rhythm of growth so that during every daily or weekly cycle a consistent amount of enamel is laid down throughout the entirety of development (Mann et al., 1990). Researchers disagree whether these episodes of amelogenesis are consistent from day-to-day or whether they vary at both the individual and population levels (Benyon and Dean, 1991; Mann et al., 1987, 1991). Along with debates on the consistency of amelogenesis timing, some argue that the enamel markers on the surface of a tooth may not represent the complete sum of all enamel formation events for that tooth (Mann et al., 1990). Furthermore, estimates may vary depending on which region of the tooth is assessed. While revolutionary for accessing information about growth and development in fossil hominins and primates, this method can be time consuming and thus cumbersome for the analysis of large bioarchaeological collections, particularly when specificity of age is not a priority.

Alternatively, enamel formation events can be recorded from a thin-section of a tooth. Each cross striation on an enamel prism is counted as a 24-hour period of enamel production. This method is too destructive for most fossils and many bioarchaeological collections. Like perikymata counting, it can be time consuming, and again assumes that intervals of growth are consistent and universal. Perikymata counts are most often used to analyze the teeth of fossil hominins and extant primates to answer questions about the evolution of the modern human life history pattern, to varying degrees of success (Lampl et al., 1990; Smith, 1989; Wolpoff et al., 1988; Bromage and Dean, 1985; Guatelli-Steinberg and Reid, 1985; Guatelli-Steinberg, 2009; Guatelli-Steinberg et al., 2005). Histological methods are not appropriate for this study.

Metric Methods

Table 3: Table of regression formulae from Liversidge and Molleson (1999), one of the methods used to estimate dental age in this study.

Tooth	b0	b1	b2	b3	b4	b5
I1	1.0627	−0.5654	0.1518	−0.00765	0.00012	
I^2	−0.4486	0.6520	−0.0080			
I_2	1.6016	−0.8697	0.2249	−0.01285	0.000233	
C	0.0644	0.2530	−0.0061	0.00962	−0.000724	0.0000147
P1	1.6140	0.5355				
P2	2.2326	0.5604				
M1	0.1258	−0.1992	0.1297	−0.00832	0.00017	
M2	0.1198	1.6049	−0.1141	0.00341		
M3	8.1775	0.6666				

NOTE: Age can be determined by measuring tooth length of an isolated tooth and substituting length in the following equation:

$$y = b0 + b1x + b2x^2 + b3x^3 + b4x^4 + b5x^5$$

Along with formation stage and histological enamel markers, metric data can be translated into dental age estimates. While metric data collection is standard in dental anthropology, the measurements are usually obtained for descriptive and comparative purposes. Inspired by the regression formulas developed to predict fetal age from crown measurements developed by Deutsch and Pe’er (1982, 1984, 1985), Liversidge and colleagues (1993) developed a series of regression formulas to estimate age from tooth length. Here, tooth length is defined as the measurement made “parallel to the long axis of the tooth from the central mammelon of incisor, or cusp tip of canine, and molar (mesiobuccal cusp of mandibular molars, palatal cusp tip of maxillary molars), to the developing mineralizing front of the crown or (incomplete) root margin” (Liversidge et al., 1993: 309). The formulas were developed in reference to a collection of 63 children of known age-at-death, likely the children of middle-class parishioners and textile workers, from Spitalfields, London. The sample included 573 isolated teeth (304 deciduous and 269 permanent). Measurements were plotted against known age-at-death from church records to generate a least squares regression formula. The regression formulae were linear for deciduous teeth and polynomial curves for permanent teeth. This difference in formulas may speak to differences in the pacing of development for deciduous teeth and permanent teeth. Liversidge and colleagues (1993) found that maxillary and mandibular teeth developed on the same timeline as their counterpart except for lateral incisors. Liversidge and Molleson refined the permanent regression formulas in 1999. The updated regression formulas for the permanent dentition are used in this study.

Age estimation by tooth length allows for the fractionation of stages and eliminates arbitrary or subjective stage boundaries. Additionally, the method accounts for asymmetric development of a tooth. However, despite the promise of increased objectivity, this method has received mixed reviews. Irurita and colleagues (2014) found that the formulas overestimated age in their Granada population (previously mentioned) but Hillson (2009) concluded that the method allowed for less subjectivity and increased consistency between observers. The updated regression formulas for the permanent dentition are used in this study.

Limitations

As with all methods, dental age estimation methods have limitations. First, most of them are based on poorly distributed samples. They may be large, but none are distributed evenly by age or sex. Additionally, an ideal sample would need to include sub-samples from multiple populations that are also evenly distributed to capture populational variation (Liversidge, 1995). One way to mitigate some of the challenges created by a poorly distributed sample is to generate a method that predicts a most likely age, based on tooth stage, rather than supplying a mean age estimate for all the people in a specific stage (Liversidge, 1995). The reframing of this approach can limit the impact of bias. Finding an appropriately distributed sample can be challenging because of the ethical problems with child autopsies and taking regular radiographs of the very young. Although safer, ultra sounds are less reliable (Hillson, 2009).

Variation is also a challenge. At both the individual and population level, variation in age of stage attainment and consistency of formation events can vary significantly. Variation in the length of gestation, inherited growth patterns, and environment can impact the correspondence of dental age and stage of development. Logically, the tooth or stage with the shortest window of development will provide the most accurate age estimates (Liversidge, 1995). Overall, these differences are pretty minor and are often consistent within a population. The same has been said about differences between sexes. Differences are observable but not particularly significant (Liversidge, 1995). This variation is most problematic for forensic scientists and paleoanthropologists, where accuracy is crucial, and a single age estimate can be the lynchpin of a legal or paradigm shifting argument.

Most of these methods were developed exclusively using radiographs wherein the complete tooth row is visible. Some methods even require the presence of a complete tooth row for an accurate estimate. Unfortunately, in most bioarchaeological assemblages, teeth are often isolated and tooth rows are usually incomplete making reliance on complete tooth rows troublesome. In a radiograph, the full tooth row can be conglomerated into a single estimate and assessment of each tooth can be contextualized by the development of its neighbors. To their detriment, radiographs can be susceptible to parallax, a type of graphical distortion that a physical specimen is not subject to (Hillson, 2009). On the other hand, isolated teeth are out of context and more likely to bias the record. Intraindividual variation may lead to two very different age estimates, as if from two different individuals, leading to statistical double representation. Additionally, the difference between the appearance of a living tissue and dry tissue may distort the perception of isolated teeth when using descriptions derived from radiographs (Hillson, 2009).

The thoroughness of descriptions can also impact subjectivity and interobserver error (Irurita et al., 2014; Liversidge, 1995). This is also true when defining eruption and completeness. Anytime observers have freedom to interpret, there is greater room for error. This problem has been greatly improved upon in more recently developed methods.

With these limitations, what bioarchaeological questions can these methods assess? If the hypotheses are about general demographics, as with this study, dental age estimation methods can generate a relative age profile. While the ages may not be exact, they provide a solid ballpark estimate of the age distribution for the sample (i.e. discrepancies between standards will not give an age estimate of less than a year for a teenager or over 5 for an infant, etc.). Overall, these methods provide a reasonable estimate of where all the teeth fit on a developmental timeline in relation to one another and can illuminate age-based criteria for inclusion in specific tombs.

3.2 Materials

The samples analyzed in this study are from a collection of human remains recovered during the excavation of the Kopila necropolis during the 2013-2017 excavation seasons. Excavations were led by Dr. Dinko Radić and the collection is temporarily curated by Dr. Davorka Radovčić at the Croatian Natural History Museum in Zagreb, Croatia. This study assesses 1171 of the 1177 teeth catalogued from Tombs 1, 3, and7 of the Kopila necropolis. All of the teeth were isolated. Prior to data collection, all teeth were cleaned, identified, labelled, and catalogued by Dr. Radovčić and colleagues. From this sample, 1177 teeth or tooth fragments were identifiable enough to be included in analysis; 556 from Tomb 1, 110 from Tomb 3, and

511 from Tomb 7. Nearly all of these teeth are deciduous or developing permanent teeth which initially suggested that the individuals present in the Kopila sample are mostly sub-adults.

3.3 Data Collection

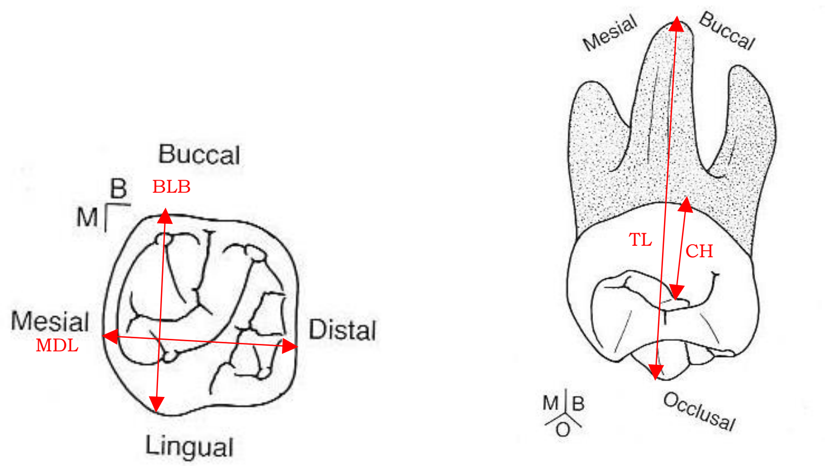


Figure 11: Dental Metrics. On the right is an occlusal view of an upper, left first permanent molar with mesial-distal length (MDL) and buccal-lingual breadth (BLB) marked in red. On the left, is a mesial-buccual view of the same tooth with crown height (CH) and tooth length (TL) marked in red.

Data collection took place during a two-week period in January 2018 in Dr. Davorka Radovčić's Lab at the Croatian Natural History Museum. All data was collected by Dr. Mica Glantz, Emily Orlikoff, and author, with the generous permission and collaboration of Dr. Radovčić. For each tooth, the catalogue number was recorded along with tooth type (class, side, mandibular or maxillary). After preliminary identification and cataloguing, metric data was collected. The measurements taken for each tooth were mesial-distal length, buccal-lingual breadth, crown height, and maximum height (or tooth length) (Fig. 11). Measurements were taken following the descriptions provided by Hillson (2002), except for maximum height which was taken based on the definition provided by Liversidge and colleagues (1993). Each tooth was assigned an ordinal stage of wear following the system developed by Smith (1984) and summarized by Hillson (2002). Using macroscopic criteria, teeth were assigned a stage of dental maturation following the system created by Moorrees and colleagues (1963a, 1963b). When necessary, the descriptions and images from the system developed by Irurita and colleagues (2014), which combines Moorrees et al. (1963a, 1963b), Demirjian et al. (1973), and Liversidge (2004), were referenced to clarify interpretations of the stages. Any abnormalities or problems were noted.

Following data collection, all molars from Tomb 1 were photographed using a Dino-Lite USB microscope. All photos were taken with a calibrated scale to confirm measurements and they serve as a preliminary sample for future non-metric trait assessment. Additionally, groups of teeth believed to belong to the same individuals were photographed with a Canon digital camera. Teeth were concluded to be from the same individual based on similarity in stage of development, size, and color. Of course, these composite individuals may not actually represent a singular individual, but they appear to.

3.4 Exclusion Criteria

During data collection, fragments of teeth were eliminated from analysis if they were too small to be identified to tooth type. When teeth were broken enough that accurate metrics could not be taken, and/or the extent of development was not determinable, tooth type and side were recorded, and the tooth was denoted as broken. For example, a tooth with a broken root is conclusively beyond the root initialization stage but how far past initialization is unclear, therefore that tooth cannot conscionably be assigned a stage of development. Similarly, if the crown of a tooth was broken, some measurements cannot be taken because the widest or longest part of the tooth is indeterminable.

Any unresolved teeth were left out of analysis. This eliminated 14 teeth from Tomb 1. Teeth that could not be identified to tooth type, side, and number were also eliminated. This process eliminated 6 teeth, 4 from Tomb 3 and 2 from Tomb 7. In sum, 20 teeth were eliminated from analysis. When performing analyses, teeth without data for the variable in question were eliminated from that analysis.

3.5 Age Estimation

After cleaning up the data, developmental stages and tooth length were translated into age-at-death estimates. Every deciduous canine, deciduous mandibular molar, permanent lower incisor, canine, premolar, and molar assigned a formation stage were then assigned a point estimate for age-at-death if male and an estimate if female based on Moorrees' system (1963a, 1963b). Moorrees and colleagues (1963a, 1963b) provide an age range for each developmental stage of a tooth class with separate ages for each sex. The average of the range was used as the point estimate to calculate age-at-death. Since the sex is unknown for all individuals in this sample, the female and male point estimates were averaged to create a single point estimate of age-at-death for that tooth. While turning a range into a point estimate and then averaging them may compound error, the consistent use of this method accomplishes the purpose of this study which is to create a relative age profile for each tomb.

Every deciduous tooth with an identifiable developmental stage was assigned an age estimate based on the system developed by Irurita and colleagues (2014) and then every permanent tooth with data for tooth length was assigned an age estimate using the regression formulas developed by Liversidge and Molleson (1999). Since the Irurita et al. (2014) estimates only included deciduous teeth and the Liversidge and Molleson (1999) estimates only included permanent teeth, these data were combined into a singular "Alternate Age" category for comparison to the estimates from Moorrees et al. (1963a, 1963b). The data was then organized by tomb to allow for intra- and inter-tomb analysis and comparison.

3.6 Data Analysis

Analysis focused on metric data, frequency of tooth type and stage, and age estimation. The frequencies calculated included the volume of teeth for each tomb followed by the frequency of each tooth type, by side, for each tomb. The sided tooth class frequencies were used to estimate a minimum number of individuals (MNI) for each tomb. The frequency of teeth assigned a stage of wear of 2 or higher was also explored in order to understand how many of the teeth had made it into long term occlusion. Following the calculation of frequencies and MNIs, metric data was summarized and compared to different populations. For each tooth type and side, a mean and standard deviation was taken for each measurement across all tombs and compared to means and standard deviations of contemporaneous regional populations as well as some contemporary populations. All of these procedures served a descriptive purpose, describing the contents of each tomb and contextualizing them within expectations.

To test the stated hypotheses, age estimates were taken from all possible teeth from Tombs 1, 3, and 7. Descriptive statistics were calculated used as a relative age profile for each tomb. A box and whiskers plot for each tomb and sides within each tomb was generated to get quartiles, range, and mean age estimates. Standard deviations were calculated using Excel. This process was completed for both the Moorrees et al. (1963a, 1963b) age estimates and the "Alternate Age" estimates. The descriptive statistics were compared between tombs, sides, and methods and tested for significance. Age estimates were divided into age groups for each tomb, by side, and the proportions of each age group were compared across tombs and tested for significance. Age estimates for the teeth suspected to be from the same individual were also compared. Results were then summarized and discussed in the context of the proposed hypotheses.

In the next chapter, the results of these procedures are presented and interpreted in the context of the initial hypotheses and the archaeological record. It will begin with the frequencies, wear and metric data and conclude with an analysis of the age estimate results.

CHAPTER IV: RESULTS

4.1 Frequency Data

Frequencies provide the necessary data to estimate the minimum number of individuals and generally characterize the composition of the tomb. They also illustrate the overall proportions of permanent versus deciduous teeth in the sample allowing for initial insights into the age distribution of each tomb. In total, 1171 of 1177 teeth were included in frequency calculations (Table 4 and 5).

Table 4: Deciduous tooth class frequencies. Table listing the frequencies of each deciduous tooth class by tomb and side (left in green, right in orange). The most frequent tooth types for each tomb and overall are highlighted in yellow.

Tooth Type	dm_2	dm^2	dm_1	dm^1	dc_1	dc^1	di_2	di^2	di_1	di^1	di^1	di_1	di^2	di_2	dc^1	dc_1	dm^1	dm_1	dm^2	dm_2	Total
Tomb 1	34	30	35	30	0	0	0	24	0	21	23	5	32	4	16	13	40	31	32	34	404
Tomb 3	6	1	3	3	1	1	1	1	0	0	1	0	4	1	0	1	3	2	7	8	44
Tomb 7	26	23	24	19	8	1	6	14	13	9	13	7	14	4	6	8	24	23	14	20	276
All	66	54	62	52	9	2	7	39	13	30	37	12	50	9	22	22	67	56	53	62	724

Table 5: Permanent tooth class frequencies. Table listing the frequencies of each permanent tooth class by tomb and side (left in green, right in orange). The most frequent tooth types for each tomb and overall are highlighted in yellow.

Tooth Type	M_3	M^3	M_2	M^2	M_1	M^1	P_4	P^4	P_3	P^3	C_1	C^1	I_2	I^2	I_1	I^1	I^1	I_1	I^2	I_2	C^1	C_1	P^3	P_3	P^4	P_4	M^1	M_1	M^2	M_2	M^3	M_3	Total
Tomb 1	0	1	0	0	8	7	1	1	1	1	17	19	25	1	10	5	6	4	1	8	3	8	1	0	2	1	11	10	0	0	0	0	152
Tomb 3	1	6	3	3	4	5	1	1	1	1	4	3	0	0	0	1	5	0	0	0	0	1	4	2	0	2	3	7	0	2	2	0	62
Tomb 7	0	2	1	1	14	11	0	0	2	5	11	12	10	21	10	13	25	11	20	9	14	5	4	3	0	1	17	8	1	1	1	0	233
All	1	9	4	4	26	23	2	2	4	7	32	34	35	22	20	19	36	15	21	17	17	14	9	5	2	4	31	25	1	3	3	0	447

Tomb 1 has the highest frequency of deciduous teeth with 404 deciduous teeth out of 556 teeth total. This proportion is consistent with the age estimate results which indicate that Tomb 1 is the youngest tomb on average. The most frequent tooth type in Tomb 1 was the right dm^1 with 40 specimens. A conservative estimate for the minimum number of individuals (MNI) in Tomb 1, based solely on teeth, would be 40 individuals. The most frequent permanent tooth class was the left I_2 with 25 specimens. Based on their stage of development, many of these incisors would not overlap with the developmental stage of the right dm^1s so the actual number of individuals buried in Tomb 1 is likely higher than forty. The post-cranial remains support this conclusion. With 89 left sided petrous portions and 46 unsided petrous portions current comprehensive MNI estimates for Tomb 1 are over 100 individuals.

The volume of teeth from Tomb 3 (110) was about 1/5 the volume seen in the other two tombs (556 and 511). Tomb 3 was the only tomb that had more permanent teeth than deciduous teeth. Out of 106 identifiable teeth, 44 were deciduous. The most frequent tooth class in Tomb 3 was the right dm_2 with 8 specimens. Thus, the conservative MNI estimate for Tomb 3 is 8 individuals. However, there were also 6 nearly crown complete left M^3's. The presence of a developing dm_2 and a nearly crown complete M^3 in the same mouth is unlikely so the true number of individuals represented is likely closer to 14. The MNI, including the post-crania is 22 individuals. The absence of adult teeth is congruous with the fragmentary nature of this deposit.

In Tomb 7, 276 of the 509 teeth are deciduous. This proportion is similar to Tomb 3, but deciduous teeth are more frequent than permanent teeth. The most frequent tooth type in Tomb 7 is the left dm_2 followed closely by the right I^1, with 26 and 25 specimens respectively. While there is some overlap between these two teeth it would be unlikely for them to develop in crypt at the same time. However, conservatively, the estimate for MNI is 26 individuals. The post-crania for Tomb 7 have yet to be analyzed.

In general, frequency assessments of the dentition indicate that all three of the tombs likely contain only or mostly sub-adults because most teeth are deciduous or developing. Tomb 3 is the only tomb which may include adults. From frequencies alone, Tomb 1 appears to have the highest MNI and the youngest constituents. Specific age estimates are compared in detail in section 4.4.

4.2 Comparative Population Metrics

Tables 6 (left) and 7 (right): Metrics. Averages and standard deviations for all measurements by tooth class. Data for left sided teeth is in Table 6 and data for right sided teeth is in Table 7.

Tooth Class	Number	Avg. M-D (mm)	Std. M-D (mm)	Avg. B-L (mm)	Std. B-L (mm)	Avg. Crown Height (mm)	Std. CH (mm)	Avg. Maximum Height (mm)	Std. MH (mm)
di^1	26	6.27	0.35	2.82	1.10	5.97	0.67	8.64	3.29
di_1	10	3.86	0.33	3.47	0.36	4.84	0.72	5.14	0.93
di^2	37	4.96	0.34	4.17	0.60	5.54	0.62	6.16	2.00
di_2	5	4.27	0.25	3.59	0.83	5.63	0.64	7.26	2.35
dc^1	1	5.65	-	3.56	-	4.75	-	-	-
dc_1	7	5.47	0.19	4.97	0.68	6.37	1.12	9.27	4.35
dm^1	41	6.93	0.97	7.58	0.81	4.82	0.89	5.68	2.49
dm_1	47	7.66	1.45	6.04	1.17	4.74	1.15	5.80	2.39
dm^2	37	8.34	0.94	8.98	1.07	5.18	0.88	6.59	3.05
dm_2	47	9.43	0.72	8.12	0.70	5.13	0.91	6.74	3.60
I^1	15	7.93	0.96	5.24	1.33	8.40	2.07	8.97	2.76
I_1	15	4.66	0.82	4.40	1.23	6.90	1.69	9.33	3.32
I^2	16	5.97	1.18	4.98	1.02	7.05	1.65	9.15	2.11
I_2	33	4.79	0.95	3.93	1.17	6.29	1.57	8.22	3.59
C^1	27	6.68	0.59	5.08	1.07	6.18	1.00	7.09	3.01
C_1	17	6.38	0.84	6.03	1.34	8.27	2.28	8.63	3.88
P^3	5	6.98	0.32	9.00	0.39	6.17	1.11	6.28	1.29
P_3	3	6.43	0.07	6.83	0.20	6.58	0.38	7.20	0.73
P^4	2	6.75	0.05	9.16	0.71	7.13	0.68	7.30	0.91
P_4	2	7.01	0.05	7.37	0.19	7.73	1.45	8.29	1.59
M^1	21	9.75	0.66	10.46	0.70	5.79	1.05	7.53	2.16
M_1	20	10.60	0.50	9.70	0.59	6.33	1.05	6.82	2.02
M^2	4	9.78	0.87	10.21	0.86	6.32	1.31	7.63	2.68
M_2	2	9.66	0.72	8.79	0.24	5.23	0.50	-	-
M^3	8	8.94	0.68	9.79	0.60	5.82	0.47	6.43	0.83
M_3	1	10.38	-	9.11	-	7.68	-	8.11	-

Tooth Class	Number	Avg. M-D (mm)	Std. M-D (mm)	Avg. B-L (mm)	Std. B-L (mm)	Avg. Crown Height (mm)	Std. CH (mm)	Avg. Maximum Height (mm)	Std. MH (mm)
di^1	29	6.17	0.55	4.62	0.41	5.92	0.69	6.35	0.69
di_1	12	3.73	0.27	2.41	0.98	5.04	0.53	6.03	2.76
di^2	49	4.97	0.48	2.70	1.05	5.62	0.74	7.51	2.80
di_2	8	4.00	0.27	2.78	1.02	5.42	0.76	6.13	1.78
dc^1	19	6.44	0.40	3.84	1.30	6.15	0.87	11.14	4.25
dc_1	13	5.63	0.49	5.30	0.32	6.95	0.41	8.88	4.40
dm^1	50	6.90	0.66	7.24	0.66	4.56	1.05	5.27	2.31
dm_1	48	7.74	0.52	6.07	0.64	4.52	1.30	5.11	2.78
dm^2	38	8.44	0.62	9.21	0.69	5.28	0.67	6.56	2.57
dm_2	49	6.19	0.86	4.93	0.89	5.28	0.92	6.46	2.49
I^1	29	7.49	1.20	4.79	1.27	7.99	2.17	8.27	2.02
I_1	12	4.78	0.70	3.76	1.20	6.37	1.62	8.85	4.00
I^2	13	5.60	1.08	4.78	0.90	6.71	1.68	8.33	2.72
I_2	14	4.84	0.92	4.38	1.31	6.75	1.70	9.86	3.68
C^1	14	7.02	0.66	5.78	1.56	7.02	1.82	8.17	3.41
C_1	8	6.04	0.51	5.22	1.42	7.55	1.79	7.47	2.13
P^3	9	6.83	0.43	8.76	0.65	6.52	1.13	6.46	1.64
P_3	4	6.58	0.20	6.57	0.32	7.25	0.23	8.55	1.05
P^4	2	6.98	0.21	9.23	0.29	6.51	0.11	6.51	0.11
P_4	4	7.10	0.79	7.38	0.68	5.52	1.63	5.19	2.16
M^1	24	9.63	0.85	10.50	0.82	5.86	0.85	7.07	1.98
M_1	21	10.64	0.67	9.54	0.52	6.13	0.95	6.40	1.65
M^2	1	9.71	-	10.94	-	7.27	-	7.86	-
M_2	3	10.37	0.20	9.51	0.25	6.41	0.42	7.52	2.25
M^3	3	10.91	1.27	8.51	2.20	6.02	0.44	6.36	0.22
M_3	0	-	-	-	-	-	-	-	-

Metric assessment included 1172 teeth across all three tombs (Tables 6 and 7). Data were derived from both left (n=579) and right sides (n=593) and included averages and standard deviations of all measurements taken during data collection.

In size, the teeth recovered from the Kopila necropolis are comparable to contemporaneous populations in the Mediterranean as well as contemporary samples from longitudinal studies of dental development in the United States. No comparative samples with a similar volume of developing and permanent teeth exist from the Iron Age Adriatic or from

Illyrians in general. When comparing the descriptive statistics of the Kopila sample to a sample of adults from Iron Age, south-central Italy (Coppa et al., 1998, see Table 8) the relative proportions of buccal-lingual breadth between the maxillary teeth and mandibular teeth were similar but the Kopila sample tended to run at least 1 mm smaller, on average. The average buccal-lingual breadth for all permanent incisors and canines in the Kopila sample were at least 1 mm smaller than the averages of the Italian sample. Averages of buccal-lingual breadth in the maxillary premolars of the Kopila sample were very similar to averages from the Italian sample but the lower premolars ran a bit smaller. Molars varied with some tooth classes falling in the same average range as the Italians and others measuring around 1 mm smaller on average. In general, the averages from the Kopila sample tended to be smaller than the averages from the Italians, likely because most of the permanent teeth in the Kopila sample are still developing while the Italian sample only contained adults.

Table 8: Table from Coppa et al. (1998) detailing the number, mean, and standard deviation in buccal-lingual breadth for the maxillary and mandibular dentition of 13 Iron Age, south-central Italian populations

TABLE 6. Comparative descriptive statistics of the bucco-lingual diameter for all teeth[1]

	Maxillary dentitions																							
	I1			I2			C			P3			P4			M1			M2			M3		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
CAA	21	7.01	0.441	20	6.15	0.516	26	8.08	0.731	30	8.66	0.616	27	8.79	0.596	36	11.17	0.614	34	11.05	0.701	22	10.18	0.849
CAB	35	7.20	0.404	38	6.43	0.525	40	8.37	0.502	47	8.84	0.531	43	9.13	0.651	45	11.33	0.630	44	11.00	0.746	23	10.73	0.882
CAC	63	7.07	0.380	80	6.30	0.463	97	8.23	0.501	104	8.76	0.563	95	8.95	0.566	99	11.19	0.590	98	11.11	0.783	58	10.43	0.984
ETB	19	7.21	0.425	18	6.57	0.590	27	8.22	0.552	39	8.85	0.571	39	9.11	0.653	35	11.40	0.563	39	11.40	0.754	30	10.68	1.296
ETC	25	7.06	0.539	31	6.13	0.510	35	8.16	0.645	41	8.76	0.611	36	9.00	0.602	37	11.45	0.543	37	11.43	0.847	19	10.68	1.123
LAA	13	7.19	0.454	12	6.37	0.436	14	8.20	0.602	14	8.89	0.466	17	8.88	0.499	15	11.23	0.583	17	11.53	0.518	11	10.28	0.908
LAB	7	7.05	0.463	10	6.10	0.209	12	8.10	0.746	21	8.57	0.577	17	8.92	0.471	16	11.36	0.648	21	11.21	0.699	15	10.59	1.105
LAC	3	7.37	0.252	5	6.58	0.472	6	8.21	0.504	5	8.85	0.173	4	9.28	0.366	7	11.30	0.382	5	11.34	0.776	5	10.16	1.595
MON	20	7.28	0.393	20	6.52	0.442	23	8.42	0.573	27	8.94	0.596	27	9.04	0.492	28	11.45	0.750	27	11.62	0.817	20	10.99	1.039
PCB	65	7.14	0.412	59	6.20	0.433	68	8.24	0.582	67	8.75	0.564	61	9.01	0.576	72	11.41	0.623	65	11.69	0.799	48	10.74	0.920
PCC	114	6.96	0.373	115	6.19	0.433	129	8.13	0.660	117	8.77	0.608	128	8.91	0.596	138	11.34	0.590	118	11.27	0.702	74	10.71	0.830
SAN	52	7.11	0.426	72	6.29	0.364	95	8.45	0.569	83	8.77	0.608	90	9.13	0.680	88	11.57	0.586	90	11.54	0.676	45	10.92	1.028
SUL	12	7.10	0.221	9	6.27	0.403	17	8.03	0.477	18	8.80	0.547	11	8.78	0.314	13	11.45	0.461	12	11.54	0.881	7	10.56	0.624
	Mandibular dentitions																							
	I1			I2			C			P3			P4			M1			M2			M3		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
CAA	20	5.82	0.378	29	6.13	0.302	28	7.49	0.660	32	7.37	0.552	31	7.83	0.624	36	10.29	0.508	31	9.73	0.604	20	9.52	0.792
CAB	41	6.07	0.446	43	6.53	0.405	50	7.81	0.580	50	7.59	0.581	47	8.06	0.666	51	10.47	0.624	46	9.91	0.732	35	9.75	0.805
CAC	96	5.94	0.375	113	6.30	0.355	126	7.72	0.560	129	7.53	0.475	119	8.07	0.498	112	10.41	0.487	112	9.94	0.542	75	9.66	0.657
ETB	23	5.82	0.326	27	6.23	0.359	39	7.70	0.591	47	7.55	0.495	42	8.11	0.614	38	10.47	0.454	35	9.99	0.467	33	9.56	0.571
ETC	25	5.92	0.426	40	6.22	0.376	47	7.65	0.605	54	7.53	0.522	49	8.20	0.509	53	10.34	0.521	50	9.87	0.606	40	9.57	0.762
LAA	9	5.84	0.533	11	6.27	0.424	15	7.60	0.520	16	7.60	0.524	15	8.32	0.491	15	10.45	0.439	15	10.05	0.623	15	9.43	0.708
LAB	7	5.57	0.280	11	6.13	0.331	13	7.31	0.516	15	7.52	0.475	16	7.95	0.512	13	10.17	0.412	15	9.87	0.628	14	9.496	0.705
LAC	6	6.07	0.320	5	6.50	0.481	10	7.89	0.722	7	7.56	0.416	6	8.40	0.381	6	10.34	0.206	6	10.17	0.282	6	9.45	0.698
MON	22	5.86	0.413	29	6.36	0.405	30	7.77	0.574	29	7.56	0.653	25	8.05	0.550	27	10.43	0.463	25	9.98	0.539	19	9.72	0.651
PCB	70	5.82	0.362	86	6.26	0.340	81	7.67	0.532	83	7.50	0.425	69	8.04	0.475	80	10.40	0.512	69	9.99	0.553	45	9.64	0.708
PCC	134	5.86	0.381	147	6.25	0.337	162	7.60	0.660	155	7.48	0.467	136	8.02	0.505	131	10.33	0.587	124	9.91	0.544	78	9.59	0.613
SAN	63	5.95	0.347	83	6.35	0.336	100	7.77	0.532	100	7.59	0.559	83	8.27	0.572	66	10.59	0.546	75	10.25	0.542	58	9.70	0.671
SUL	19	5.67	0.266	27	6.10	0.315	25	7.44	0.463	26	7.44	0.394	19	7.95	0.387	18	10.35	0.418	22	9.92	0.551	11	9.51	0.735

[1] Sample acronyms (LAA, LAB, etc.) are listed in Table 1.

Table 9: Table from Lease and Sciulli (2005) which includes the number, average, and standard deviation for mesial-distal length (top section) of the lower deciduous canines and molars. This table compares samples of African American children to samples of European American children selected from a 20th century longitudinal study of American children.

	African-Americans			European-Americans		
	N[1]	$\bar{x}$	SD	N[1]	$\bar{x}$	SD
lcmd	107	5.73	0.41	100	5.54	0.38
lm1md	110	7.99	0.49	100	7.43	0.38
lm2md	109	10.10	0.56	98	9.25	0.46
	N[2]	%[3]	w[4]	N	%	w
ui2td	114	0.04	0.04	99	0.16	0.17
ui2ss	116	0.73	1.26	99	0.90	1.63
uctd	115	0.40	0.69	100	0.56	0.85
um1cn	115	0.86	3.70	100	0.39	2.61
um2c5	114	0.04	0.04	90	0.12	0.12
lm2c6	112	0.24	0.42	96	0.07	0.08
lm2tc	104	0.25	0.25	97	0.10	0.10

[1] For metrics (lcmd, lm1md, and lm2md), N is sample size, $\bar{x}$ is mean, and SD is standard deviation.
[2] Sample size for morphological traits.
[3] Frequency of any degree of elaboration (score >0). For um1cn, frequency of scores 3, 4, and 5.
[4] Weighted average expression, $W = (\Sigma c_i x_i / \Sigma x_i)$, where c_i is expression value and x_i is number of individuals.

As no comparative samples with a similar volume of sub-adults exists from the Iron Age Adriatic, the metrics from Kopila were also compared to the metric data from a longitudinal study of 20th century American children. The descriptive statistics for this data collection were compiled in a study done by Lease and Sciulli (2005, Table 9) in which they determined whether or not African American children were statistically distinguishable from European American children via dental metrics and non-metric trait expression. When comparing mandibular mesial-distal length of the deciduous teeth, the Kopila sample almost always fell somewhere between the higher averages of African American children and the lower averages of the European American children. However, a few exceptions were noted. The left, deciduous canines had a lower average than the European American children by 0.2 mm and the right, deciduous second molars were much smaller than either average. However, the average mesial-distal length for the left, lower, deciduous second molars fell right in-between the two averages for 20th century American children, suggesting that sample bias is the cause of this unusual pattern. These results are consistent with the expectations created by previous studies of global trends in dental metrics which suggest that pre-industrial Europeans had larger teeth than post-industrial Europeans and that, in general, people with European ancestry have smaller teeth than people with African ancestry.

Table 10: This table from Pilloud et al. (2014) includes average, number, and confidence intervals for mesial-distal length and buccal-lingual breath of the entire adult dentition in three large regional groupings: people from Africa, Asia, and Europe.

	Africa				Asian				Europe			
	Mean	*N*	95% Confidence Interval		Mean	*N*	95% Confidence Interval		Mean	*N*	95% Confidence Interval	
UI1_MD	9.21	11	8.9379	9.4857	8.57	318	8.5132	8.6350	8.22	49	8.0805	8.3521
UI2_MD	7.26	17	6.9097	7.6009	7.17	391	7.1169	7.2311	6.49	66	6.3483	6.6253
UC_MD	7.89	48	7.7512	8.0375	7.89	509	7.8443	7.9257	7.34	91	7.2556	7.4282
UP3_MD	7.52	69	7.4254	7.6190	7.24	579	7.2035	7.2751	6.57	111	6.4887	6.6486
UP4_MD	7.11	68	7.0046	7.2230	6.92	568	6.8791	6.9568	6.44	118	6.3583	6.5206
UM1_MD	11.00	85	10.8554	11.1389	10.73	823	10.6848	10.7687	10.21	143	10.1013	10.3159
UM2_MD	10.39	84	10.2334	10.5502	10.07	757	10.0188	10.1154	9.41	146	9.3125	9.5092
UM3_MD	9.22	69	9.0354	9.3967	9.34	452	9.2642	9.4111	8.72	83	8.5810	8.8674
LI1_MD	5.50	16	5.3488	5.6599	5.50	296	5.4652	5.5427	5.12	58	5.0360	5.2106
LI2_MD	6.20	22	6.0205	6.3786	6.19	363	6.1481	6.2324	5.67	81	5.5860	5.7572
LC_MD	7.16	29	6.9737	7.3470	6.90	415	6.8545	6.9395	6.39	79	6.3034	6.4667
LP3_MD	7.43	42	7.2617	7.5917	7.08	488	7.0390	7.1154	6.47	91	6.3737	6.5634
LP4_MD	7.56	44	7.4148	7.7075	7.23	480	7.1816	7.2709	6.77	100	6.6672	6.8678
LM1_MD	11.74	47	11.6084	11.8789	11.49	587	11.4400	11.5391	10.73	88	10.5904	10.8682
LM2_MD	11.03	47	10.8256	11.2387	10.94	605	10.8769	10.9974	10.29	98	10.1566	10.4150
LM3_MD	10.91	43	10.6239	11.1877	10.79	424	10.7000	10.8862	10.26	66	10.0854	10.4437
UI1_BL	7.42	14	7.1535	7.6879	7.28	334	7.2249	7.3253	6.92	56	6.8028	7.0444
UI2_BL	6.67	24	6.4810	6.8515	6.62	395	6.5757	6.6660	6.25	72	6.1040	6.3999
UC_BL	8.46	48	8.3021	8.6138	8.23	506	8.1854	8.2754	7.79	90	7.6755	7.9043
UP3_BL	9.67	68	9.5502	9.7948	9.58	574	9.5330	9.6265	8.61	111	8.5092	8.7144
UP4-BL	9.63	68	9.4928	9.7705	9.37	560	9.3231	9.4194	8.78	119	8.6700	8.8916
UM1_BL	11.57	85	11.4579	11.6906	11.60	822	11.5549	11.6367	11.04	143	10.9428	11.1376
UM2_BL	11.77	84	11.6111	11.9236	11.50	752	11.4479	11.5484	10.92	146	10.8177	11.0292
UM3_BL	11.27	69	11.0789	11.4521	10.98	457	10.9017	11.0537	10.41	83	10.2407	10.5803
LI1_BL	5.55	17	5.3920	5.7009	5.80	315	5.7521	5.8409	5.63	67	5.5411	5.7243
LI2_BL	6.10	23	5.9357	6.2556	6.21	378	6.1731	6.2550	6.02	84	5.9422	6.1071
LC_BL	7.55	29	7.3523	7.7497	7.50	423	7.4546	7.5500	7.13	87	7.0199	7.2486
LP3_BL	8.22	42	8.0794	8.3702	8.08	484	8.0286	8.1271	7.30	91	7.1818	7.4281
LP4_BL	8.52	44	8.3364	8.7109	8.39	475	8.3411	8.4379	7.90	97	7.7959	8.0082
LM1_BL	10.72	47	10.5659	10.8707	10.73	592	10.6809	10.7705	10.11	93	10.0109	10.2007
LM2_BL	10.42	47	10.2418	10.5918	10.32	600	10.2695	10.3692	9.72	98	9.6101	9.8356
LM3_BL	10.16	42	9.9571	10.3581	10.14	425	10.0683	10.2087	9.55	64	9.3845	9.7186

U, upper; L, lower; I, incisor; C, canine; P, premolar; M, molar; BL, buccolingual; MD, mesiodistal.

In a final comparison, the means and standard deviations of the metric data from Kopila were compared to the compendium developed by Pilloud and colleagues (2014, Table 10) which compares dental metrics for permanent teeth at the continental level for people of African, Asian, and European descent. Overall, the Kopila data most closely resembled the European means (consistently the lowest average out of the three samples), however the Kopila data still trended lower than the lowest means in the study. This is unsurprising since this study focuses on fully developed adult teeth whereas the collection from Kopila is almost entirely made-up of deciduous and developing permanent teeth. In general, the anterior dentition of the Kopila sample ran anywhere from 0.5-2.0 mm smaller than the mean of the European sample. However, the dimensions of the premolars were often very similar to those of the European sample and occasionally they were slightly larger, even though many of those teeth are still developing. Again, these results are consistent with the expectation that the individuals at Kopila fit into the range of metric variation for pre-industrial Europeans. Future analysis would benefit from comparisons to other collections of sub-adults from the Adriatic, if ever they become available.

In general, the teeth from Kopila meet expectations for a pre-Industrial European population in that they are slightly larger than present day, European children's teeth and are also categorically smaller than other non-European populations. However, a lack of data for children in the Iron Age Adriatic limits the meaningfulness of these comparisons.

4.3 Wear

Wear assessment confirmed that the incompleteness of teeth analyzed in this study did not reflect resorption but rather incomplete development. In sum, 108 teeth out of 1177 (9%) were assigned a stage of wear at 2 or higher amongst the three tombs (Smith, 1984; Hillson, 2002). Tomb 1 had 27 deciduous teeth of all tooth types and 7 permanent teeth, incisors and canines, showing significant wear. Tomb 3 had 6 deciduous teeth, all molars, and 12 permanent teeth, all molars, canines, and premolars, showing signs of significant wear. Tomb 7 had 36 deciduous teeth of all tooth types and 20 permanent teeth, just incisors and canines, showing significant wear. Very few teeth from Tombs 1, 3, and 7 were in occlusion for long enough to be altered by significant wear and most teeth with wear were from the deciduous dentition which is expected considering the age groups represented in the sample.

4.4 Age Estimates

After initial demographic analyses, comparisons of the descriptive statistics from various dental aging methods generated age parameters for each tomb which were then tested against the criterion of these hypotheses:

H_0: Both adult and sub-adult remains are present.

H_1: Only sub-adult remains are present.

H_2: All individuals are estimated to be under 2 at death.

Table 11: Descriptive statistics of age estimates using Moorrees et al. (1963a, 1963b) for Tombs 1, 3, and 7, split by side.

	N	%	Avg. Age	Min. Age	Max.Age	Std.	1st Q	2nd Q	3rd Q	4th Q
Tomb 1										
Left	88	46.8%	1.76	0	10.85	2.34	0.35	0.675	2	3.95
Right	100	53.2%	1.21	0	8.9	1.68	0.3	0.6	1.35	2.9
Tomb 3										
Left	21	47.7%	3.36	0.1	12.8	3.33	0.8	2	5.31	8.9
Right	23	52.3%	2.79	0.275	7	2.08	0.9	2	5.1	7
Tomb 7										
Left	96	50.3%	2.95	0	9.375	2.68	0.675	2	4.7	9.375
Right	95	49.7%	2.98	0	8.9	2.65	0.6	1.925	5.1	7

Of the 1177 teeth available for analysis, only 1064 (Tomb 1-521, Tomb 3-86, Tomb 7-457) were complete enough to be assigned a stage of dental development. Of those, only 423 could be assigned an age at death estimate using the dental aging method developed by Moorrees and colleagues (1963a, 1963b) (Table 11). Tomb 1 had the lowest average age at death estimates (between 1 and 2 years) and the narrowest interquartile range, regardless of side. So, although all three tombs had similar ranges, Tomb 1 has the highest concentration of the very young and the least amount of variation. The statistics for Tomb 3 vary between sides. The left sided teeth from Tomb 3 have the largest range with estimates from the Moorrees' system and the highest average. This suggests that Tomb 3 has more older children than Tomb 1. However, the right sided teeth from Tomb 3 have similar statistics to Tomb 7. Tomb 7 has an average age at death of nearly 3 for both sides, falling in-between the high average of Tomb 3 and the low average of Tomb 1. Notably, none of the age estimates in Tomb 7 are identified as outliers. While the volume of Tomb 1 and Tomb 7 are more similar, the distribution of dental age estimates is more similar between Tombs 3 and 7. Using Moorrees' system, the difference in means between Tomb 1 and both Tomb 3 and Tomb 7 was statistically significant ($p < 0.05$) but the difference in means between Tombs 3 and 7 were not statistically significant ($p< 0.05$). Therefore, the differences observed between Tomb 1 and the other tombs are highly unlikely to be the byproduct of random sampling and is more likely the result of significantly different age distribution. This cannot be said about the differences between Tomb 3 and Tomb 7.

Table 12: Descriptive statistics of age estimates for Tombs 1, 3, and 7, split by side, using the "Alternate Age" category with estimates from Irurita et al. (2014) and Liversidge and Molleson (1999).

	N	%	Avg. Age	Min. Age	Max.Age	Std.	1st Q	2nd Q	3rd Q	4th Q
Tomb 1										
Left	231	48.0%	1.67	-0.04	12.12	2.27	0.21	0.93	2.19	4.95
Right	250	52.0%	1.16	-0.02	11.46	1.78	0.21	0.46	1	2.16
Tomb 3										
Left	32	50.0%	4.98	0.1	13.58	4.73	0.69	4.39	8.76	13.58
Right	32	50.0%	2.72	0.16	12.52	2.94	0.83	1.33	4.9	6.97
Tomb 7										
Left	169	51.8%	2.54	-0.19	16.67	3.21	0.21	0.93	4.17	9.97
Right	157	48.2%	2.28	-0.04	14.15	2.76	0.19	0.93	3.52	8.18

For comparison and to increase the number of teeth analyzed, the same statistics were calculated for a combined data set of age estimates generated using the methods of Irurita and colleagues (2014) for the deciduous teeth and Liversidge and Molleson (1999) for the permanent teeth (Table 12). By expanding the analysis to include the methods from Irurita and colleagues (2014) and Liversidge and Molleson (1999), 74% of the teeth in the sample could be assigned an age estimate compared to just 36% with the system developed by Moorrees and colleagues (1963a, 1963b).

In general, these results told a similar narrative to the Moorrees' system estimates. Again, Tomb 1 has the lowest averages falling between 1 and 2 years, as well as the narrowest interquartile range. The results were quite similar between methods but in all tombs, a slight expansion in range was observed. In Tomb 1, the maximum expanded by 2 years, from 10.85 to 12.12, increasing the amount of variation slightly. Discrepancy between statistics from right and left sided teeth increased likely because of the increased volume of teeth included in the analysis.

As with Moorrees' system, the statistics from Tomb 3 were inconsistent between sides. The left side had the highest average at nearly 5 years old, a high maximum of 13.6 years, and an interquartile range that encapsulates almost the entire range, suggesting high levels of variation. On the other hand, the right sided teeth retained their 2.7 average and an interquartile range intermediate to Tombs 1 and 7. This suggests that the oldest individuals from Tomb 3 are not represented in the right sided teeth.

Despite a massive increase in range, the other statistics for Tomb 7 such as range and interquartile range stayed remarkably similar to the statistics from the Moorrees data with averages around 2.5 years and most age at death estimates falling between 0 and 10 years. However, using the tooth length regression formulas extended the maximum age to almost 17 which is a 7-year increase in range. Again, the differences in means between Tomb 1 and Tombs 3 and 7 were statistically significant ($p<0.05$). However, the difference in means between Tomb 3 and Tomb 7 was only statistically significant for the left sided teeth which also differed significantly form the left sided teeth from Tomb 3. Tehrefore, it is inconclusive whether the differences between Tomb 3 and Tomb 7 may be the product of random sampling or truly different age distributions.

Based on dental age estimates alone, the null hypothesis is overturned for all three tombs. No adult age estimates were observed. Consequently, based off of teeth alone, the first alternative hypothesis is supported by all three tombs as all of the age estimates indicate the exclusive presence of sub-adults. The second alternative hypothesis is overturned by all three tombs. None of the tombs exclusively contain infants (children under the age of one). The interpretation and implications of these results will be discussed in the next chapter.

4.5 Distribution of Age Groups

Tables 13a-c: Number of teeth in each age group, divided by side, from each tomb. Age groups are color-coordinated with chart segments in Figures 12a-f.

TOMB 1		
Age	**Left**	**Right**
<2	174	210
2-4	40	29
5-9	19	13
10-13	4	2
14+	0	0
Total	237	254

(a) Tomb 1

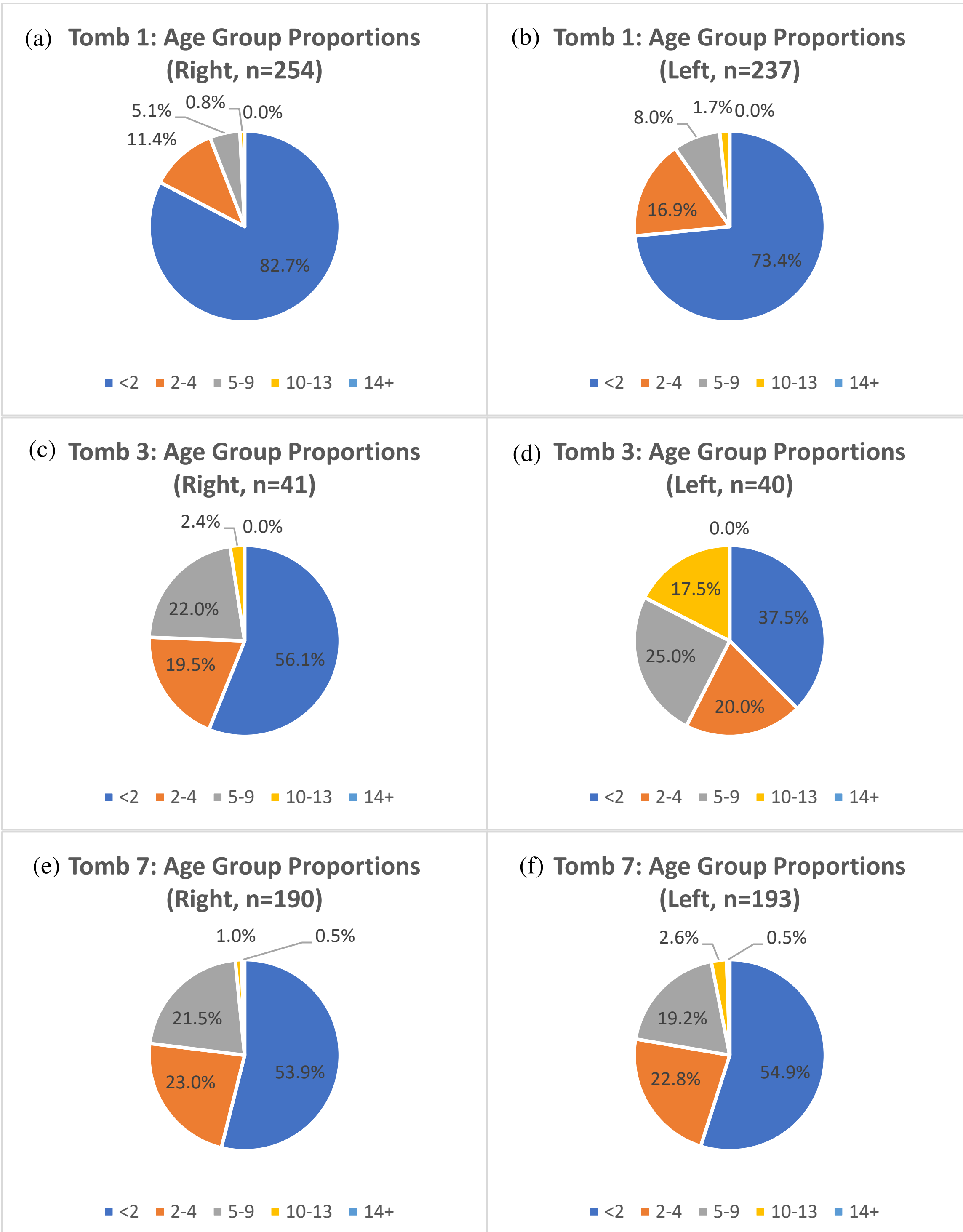
TOMB 3		
Age	**Left**	**Right**
<2	15	23
2-4	8	8
5-9	10	9
10-13	7	1
14+	0	0
Total	40	41

(b) Tomb 3

TOMB 7		
Age	**Left**	**Right**
<2	106	103
2-4	44	44
5-9	37	41
10-13	5	2
14+	1	1
Total	193	191

(c) Tomb 7

In order to better understand the distribution of age estimates in each tomb, the number of teeth in each age group, by side, was calculated (Tables 13a-c). Likewise, the proportions of teeth in each age group by tomb and side were also compared (Fig. 12a-f). Numerically, Tomb 1 and Tomb 7 are similar except for the <2 and 5-9 age groups. Tomb 1 has almost twice as many teeth in the youngest age group while Tomb 7 has almost twice as many teeth in the 5-9 age group. Despite similar volume and range, the different distributions explain why Tomb 1 has the lowest averages and narrowest interquartile range. Since Tomb 3 differs so dramatically in volume, it makes more sense to compare proportions. Regardless of side, Tomb 1 has the largest proportion of individuals under 2 at 82.7% and 73.4%. As observed in the descriptive statistics, the right sided teeth from Tomb 3 and the teeth from Tomb 7 have similar distributions with Tomb 7 having about 5% more teeth under 1 and about 5% fewer teeth in the 1-4 category. The left sided teeth from Tomb 3 have the largest proportion of teeth from the 10-13 age group explaining the unusual discrepancies between the left and right sided statistics for Tomb 3.



Figures 12a-f: Percentage of teeth in each age group, by side, for each tomb. For frequencies, see Tables 13a-c.

Overall, Tomb 1 is conclusively the youngest tomb with 90-95% of estimates falling between 0 and 5. Tomb 7 was the intermediate tomb with a more evenly distributed age estimates across age groups, fewer infants than Tomb 1 and fewer pre-teens compared to Tomb 3. In Tomb 7, 76-77% of age estimates fell into the 0-5 range while 97-98% of the estimates were under 10. Tomb 3 was the oldest and most evenly distributed tomb with only 67-75% of estimates under 5. Tomb 3 had the largest proportion of estimates over 10 at 17.5%. The similarity in proportions between Tomb 7 and the right sided teeth from Tomb 3 is curious. Such varied results suggest that each tomb may require a unique interpretation to explain the large volumes of sub-adult remains.

4.6 Individuals

During data collection, fourteen groups of teeth were identified as belonging to the same individual (Table 16). These individuals were selected based on tooth type, stage of development, metric similarity, and general appearance. Twelve of the groupings came from Tomb 1 and two came from Tomb 7. No individual groupings were observed in the sample from Tomb 3. Twelve of the fourteen individuals differed by less than a year across all age estimates. Individual 9 differed significantly between age estimation methods but not between teeth. Individual 12 differed dramatically between teeth with age estimates ranging from 1.91 to 8.6. This difference may be an error of identification. Two of the teeth are deciduous anterior dentition while one tooth is permanent. If the singular permanent tooth was misidentified as permanent, the age estimates would be inaccurate. However, the age estimates for the two deciduous teeth differ by over 2 years which supports the interpretation that these teeth did not belong to the same individual. Perhaps, similar size and coloration led to this incorrect interpretation.

Table 14: Teeth groupings identified macroscopically as belonging to the same individual.

Tomb	#	Tooth Type	Upper or Lower	Side	Mesial-Distal Lengthn (mm)	Buccal-Lingual Breadth	Crown Height (mm)	Maximum Height	Wear	Stage of Development	Average Age (Moorrees et al. 1963)	Alternate Age (Irurita et al. 2014 & Liversidge et al. 1993)
INDIVIDUAL 1												
1	152	dm_2	L	L	10.31	8.64	5.36	14.78	3	R3/4	1.75	
1	153	dm_2	L	R	10.23	8.75	5.99		2	R3/4	1.75	
INDIVIDUAL 2												
1	538	dm_2	L	L	9.72	8.35	6.64	6.64	0	Ri	0.9	0.93
1	539	dm_2	L	R	9.64	8.47	5.89	5.89	0	Ri	0.9	0.93
INDIVIDUAL 3												
1	524x	dm_2	L	L	10.87	9.43	5.38	5.38	0	Ri	0.9	0.93
1	535	dm_2	L	R	10.9	9.61	6.24		0	Crc	0.675	0.93
INDIVIDUAL 4												
1	536	M_1	L	R	10.64	9.25	5.58	5.58	0	Crc	2	1.77
1	537	M_1	L	L	10.68	9.35	6.25	6.25	0	Crc	2	2.17
INDIVIDUAL 5												
1	534	M_1	L	L	10.51	9.24	6.38	6.38	0	Crc	2	2.25
1	533	M_1	L	R	11.18	10.13	5.86	5.86	0	Crc	2	1.93
INDIVIDUAL 6												
1	529	P_4	L	R	6.9	7.5	6.71	6.71	0	Crc	6.1	5.99
1	530	P_4	L	L	6.97	7.23	6.7	6.7	0	Crc	6.1	5.99
1	527	P^4	U	R	6.83	9.43	6.43	6.43	0	Crc		5.84
1	528	P^4	U	L	6.78	9.66	6.65	6.65	0	Crc		5.96
INDIVIDUAL 7												
1	525	P^3	U	R	6.63	8.11	5.77	5.77	0	Cr3/4		4.70
1	542	P^3	U	L	-	-	4.83	4.83	0			4.20
INDIVIDUAL 8												
1	257	M^1	U	R	10.11	11.92	7.54	8.3	0	Ri		3.45
1	264	M^1	U	L	10.05	11.92	7.48	9.64	1	Ri		4.27
INDIVIDUAL 9												
1	497	I^1	U	L	7.58	6.44	9.47	9.47	0	Crc	5.1	8.61
1	502	I^1	U	R	7.68	6.9	9.86	9.86	0	Crc	5.1	9.06
INDIVIDUAL 10												
1	499	I^1	U	L	8.11	4.07	6.63	6.63	0	Cr1/2		5.36
1	504	I^1	U	R	8.02	4.06	6.66	6.66	0	Cr1/2		5.40
INDIVIDUAL 11												
1	482	I_2	L	L	6.94	6.32	7.46	7.46	0	Cr3/4		3.02
1	494	I^2	U	R	5.86	5.3	8.43	8.43	0	Cr3/4	4.5	4.48
INDIVIDUAL 12												
1	357	di^2	U	R	5.25	2.18	5.94	14.98	3	A1/2		1.91
1	461	I_2	L	L	4.52	4.19	5.56	15.01	4	A1/2	8.35	7.59
1	1940	dc^1	U	R	5.75	3.57	5.78	15.06	4	A1/2		4.17
INDIVIDUAL 13												
7	5	M^3	U	R	9.48	11.03	5.77	6.2	0	Cr3/4		12.31
7	10	M^3	U	L	8.89	10.39	5.21	6.73	0	Crc		12.66
INDIVIDUAL 14												
7	264	C^1	U	L	7.8	5	6.84	6.84	0	Cr1/2		3.22
7	265	C^1	U	R	7.85	5.08	6.92	6.92	0	Cr1/2		3.28

Figure 13: Individual #1 which consists of two deciduous lower second molars, right a left, with similar morphology, wear, and size from Tomb 1.

4.7 Summary

Overall, the Kopila necropolis contains an unusually large volume of sub-adult teeth, especially in Tombs 1, 3, and 7. Most of these teeth are deciduous or developing permanent teeth with very few permanent teeth reaching occlusion. Metrically, the Kopila teeth fit expectations for a pre-industrial European sample of sub-adults in that they are slightly larger on average than post-industrial European children and consistently smaller than the teeth from people of Asian and African ancestry. The teeth were smaller than contemporaneous Iron Age populations of adults, which is to be expected since the teeth were not completely developed. Although metrically inconspicuous, the age distributions of each tomb warrant further discussion.

In sum, all three tombs included teeth with age at death estimates spanning from birth to late childhood or early teens. Despite similar age ranges, Tomb 1 has the largest concentration of infants and generally has a younger demographic. The dental remains from Tomb 3 are the most evenly distributed with the highest proportion of pre-teens and lowest overall volume. Tomb 7 has a distribution and descriptive statistics that are intermediary to Tombs 1 and 3 with a heavy concentration of infants and young children but also a notable proportion of older children and preteens. Tomb 7 also has the widest overall range, suggesting a more evenly distributed sample than Tomb 1. Overall, the lack of adult age estimates allows these results to overturn the null hypothesis and support the first alternative hypothesis. Since all tombs have a substantial range of age at death estimate, beyond 2 years, the second alternative hypothesis is overturned by these results. However, the high concentration of infants in all tombs and the presence of adult post-cranial remains in Tomb 3 demands further explanation. The implications of these results will be discussed in the following chapter.

CHAPTER V: DISCUSSION

5.1 Interpreting the Age Profiles: Family Tomb, Differential Burial, or Infanticide

Table 15: Table summarizing the most inclusive relative age profiles for each tomb across all methods.

Tomb	Range of Average Age	Lowest Minimum Age	Highest Maximum Age	Largest Interquartile Range of Ages
Tomb 1	1.16-1.76	-0.04	12.12	0.21-4.95
Tomb 3	2.72-4.98	0	13.58	0.69-13.58
Tomb 7	2.28-2.98	-0.19	16.67	0.21-9.97

Across all three tombs, the highest dental age estimate was 16.67. All tombs had teeth with age estimates spanning from birth to late childhood and the ranges of Tombs 3 and 7 extended into the teens. Overall, Tomb 1 was consistently the youngest with the lowest averages regardless of method, narrowest interquartile range (5 years), and smallest maximum range. The age group distribution of Tomb 1 showed a high concentration of infants and children under 5. Tomb 3 had the most evenly distributed age groups with the widest interquartile range (13 years) and highest average. Despite having a narrower overall range than Tomb 7, the significant representation of preteens in the sample makes Tomb 3 the oldest tomb. Tomb 7, by most measures, is intermediary to Tombs 1 and 3 with mid-range averages, and a 10-year interquartile range. It has fewer infants than Tomb 1, fewer preteens than Tomb 3, and some of the largest proportions of 2-4-year-old individuals.

Based on dental remains alone, all three tombs overturn the null hypothesis and second alternative hypothesis and support the first alternative hypothesis. In other words, none of the dental age estimates include adult age estimates, from dental remains alone, and all three tombs appear to contain only sub-adults. However, none of the tombs exclusively contain infants (children under 2), therefore infanticide is an unlikely explanation for these unusually sub-adult dense tombs. Including post-cranial remains, Tomb 3 includes a fragment of an adult, male ilium as well as adult carpals and tarsals from at least 6 individuals. Therefore, including the post-crania, the null hypothesis is supported by the remains in Tomb 3. Consequently, the first alternative hypothesis is overturned, and Tomb 3 is not an example of a sub-adult only tomb. Likewise, the second alternative hypothesis remains overturned. Tomb 3 is definitely not a tomb reserved for infanticide victims, only. The large, ringed tomb structure, highly fragmentary nature of the assemblage, low volume of remains, and presence of adults in the tomb suggest that Tomb 3 is a typical, multi-inhumation, family tumuli that includes sub-adults. The low volume of remains and more evenly distributed proportions of age groups suggest normal mortality and poor preservation as the impetus for this assemblage.

In the archaeological record, deposits of human remains are posited to be the result of widespread infanticide if they have the following characteristics: (1) they consist exclusively of fetuses, neonates, and infants (Smith and Kahila, 1992), (2) they are deposited in a separate space from the primary burial space for children in the community, often in a discrete location out of view (Liston and Rotroff, 2013), (3) individuals are deposited haphazardly with no grave goods aside from pottery sherds from the household pot which they were transported in (Smith and Kahila, 1992), and (4) there is evidence of pathologies visible at birth or trauma which suggests intentional death (Smith and Kahila, 1992; Liston and Rotroff, 2013, Dasen, 2013). In the Iron Age Mediterranean, the presence of dog remains is also common in supposed infanticide deposits (Bourbou and Themelis, 2010; Liston Rotroff, 2013). Occasionally, historical texts mentioning infanticide contemporaneous with the assemblage supplement researchers' diagnoses of infanticide.

The deposits at Kopila do not conform to these diagnostic characteristics in any way (Table 16). All three tombs include children spanning at least 0-12 years of age. All of the tombs are contained within a sanctioned burial space, where adults are also buried, that is highly visible. Additionally, the construction of the tombs and inhumations of individuals clearly relies on a formalized ritual. Organization and construction of the tombs is intentional and consistent, the children are each deposited intentionally over a layer of sea pebbles, and all three tombs include a wide variety of grave goods, none of which include dog remains (Borzić et al., 2017). Moreover, from a cursory inspection, there is little to no evidence of trauma, pathology, or nutritional stress in this sample.

Table 16: Table assessing the applicability of the infanticide diagnosis criteria to the assemblages from the Kopila necropolis.

Evidence	Description	Kopila Sample
Narrow Age Range	Most individuals should be infants (under 2 years old) and neonates. Can use dental development, bone development, and epiphyseal fusion to assess	**FALSE:** Wide age ranges spanning childhood and early teens
Lack of Intentionality	Haphazard deposit without consistent ritual or orientation. Lack of grave goods. Highly fragmentary and comingled. Sherds of domestic pots used to carry bodies to location. Suggests indifference or urgency.	**FALSE:** Intentional tomb construction, many grave goods, layers of sea pebbles between inhumations for some tombs
Illicit Location	Location separate from formalized community burial space. Isolated and hidden from view in a sewer or well located in a back alley.	**FALSE:** Clearly visible from citadel and to anyone in the valley, adults included in nearby tombs. **MAYBE TRUE**: Tomb 1 and Tomb 7 constructed differently, intentional differentiation but not illicit
Trauma and Pathologies	Evidence of perimortem trauma such as head trauma, fractures, periosteal lesions, or blood in the dentinal tubuli. Evidence of pathologies, visible at birth such as cleft palate or hydrocephaly. May have been killed because death was imminent or because it was considered a bad omen.	**FALSE/To Be Determined**: Initial observations show no significant trauma or pathologies, particularly of the teeth. May change with further investigation of the post-crania

Notably, up to 83% of Tomb 1's constituents have age estimates under 2. Tomb 1 also has the highest volume of teeth and MNI. Therefore, one could argue that a large proportion of Tomb 1 could be infanticide victims following sanctioned ritual or trying times. Afterall, these tombs were used while the Illyrian Wars were taking place. Additionally, establishment of a community can make the difficult period of weaning even more difficult. Taking a deeper look at the four criteria, Tomb 1 may partially satisfy some of the requirements for diagnosing infanticide in the record. First, the criterion tested in this study is that the tomb should exclusively contain infants (children under 2). While the presence of older children is unconventional, the large proportion of infants and younger children is notable. Up to 83% of Tomb 1's teeth were assigned a dental age estimate of 2 or younger. Up to 95% percent of Tomb 1 is estimated to be under 5. However, it is important to note that the first five years of life were the most vulnerable for Iron Age Adriatic children. Infant mortality rates are estimated to have been 200-300 deaths before the first birthday per 1000 live births. After that, 35% of children did not make it to 5 (Parkin, 2013).

The third criterion is an illicit location. While Tomb 1 is included in the licit community burial place, highly visible and wedged between other tombs, it is shaped differently from most of the other tombs and does not share the same construction plan. Tomb 1 is rectangular and not round, and is wedged between Tombs 2, 3, and 6. It is also much smaller than the other tombs. So, while not illicit, it is less monumental and definitely different from the surrounding tombs. This may signify differential burial practices for some sub-adults, although the presence of sub-adults in the larger, more common tombs suggests that age was not the only differentiating factor between the members of Tomb1 and those of other tombs which include adults, like Tomb 3. Perhaps the sub-adults interred in Tomb 1 did not have a family tomb, either because of status or time, or perhaps the cause of their death warranted separation from the other dead. Perhaps sub-adults could only be buried in the larger tombs when they could be interred simultaneously with an adult. Maybe there was a religious rite that needed to be performed, like a baptism, if the dead were to be interred in the larger tombs. At this point, reasons for differentiating burial practices for different sub-adults is unclear. Overall, Tomb 1 appears to be a tomb designated for a distinct burial practice involving only sub-adults but the impetus for this separation is unknown. The wide range of ages suggests that while a large proportion of the tomb's constituents may be infanticide victims, infanticide was not the primary criterion for inclusion in Tomb 1.

The slightly lower volume and higher proportions of older children in Tomb 7, including young teens, suggests immediately that infanticide was not the primary impetus for the assemblage. Like Tomb 1, Tomb 7 includes similar evidence for intentionality such as grave goods, patterns of interment, and a clearly defined structure. And, as previously mentioned, the Kopila remains have yet to be analyzed for pathologies so not much can be said on that point. However, Tomb 7 also exclusively contains sub-adults sequestered from the large, typical tombs, in a smaller and less monumental tomb. Since neither Tomb 1 nor Tomb 7 contain adult remains and since their structure is unusual and their grave goods are similar, it is most parsimonious to conclude that they serve similar functions. Burial in Tomb 1 and Tomb 7 are differentiated from burial in any other tomb and Tombs 1 and 7 exclusively contain sub-adults, although not all sub-adults are restricted to Tombs 1 and 7. Thus, another compounding factor, beyond age, must distinguish those who are buried in Tombs 0, 2, 3, 4, and 6 and those buried in Tombs 1 and 7. Despite separation, visibility and inclusion in the community cemetery suggests membership in the community, generally. Differences in age distributions between Tomb 1 and 7 and likewise similarities in age distributions between Tombs 3 and 7 likely reflect differences in mortality between familial groups since Tomb 1 and 7 were used simultaneously. Further investigation into post-crania, grave goods, and other tombs may be able to explain this differentiation but for now it is a mystery.

Overall, none of the tombs from Kopila necropolis appear to be good candidates for infanticide, as summarized in Table 16. However, there is an unusual differentiation occurring in mortuary practices for sub-adults that warrants further investigation. Of course, these results do not preclude the possibility that some of the children interred in the Kopila necropolis are the victims of infanticide or abortion, but it is possible to eliminate widespread infanticide as the primary impetus for these unusually sub-adult rich deposits.

5.2 Age-at-Death Estimation Methods

Creating relative age at death profiles for each tomb using only isolated teeth from comingled deposits is challenging, regardless of method. When teeth are intact in the mandible or maxilla or in single-individual inhumations, a tooth can be compared to the entire tooth row to better contextualize their development. The ability to assess multiple teeth known to be from a single individual improves the resolution of age estimates and provides a more thorough understanding of that individual's pattern of growth and development. With isolated teeth recovered from co-mingled, multiple-inhumation burials, it is impossible to tell if a tooth is advanced or delayed in development compared to other teeth from that individual. As a result, teeth which are significantly advanced or delayed may bias the data or the reported minimum number of individuals.

Additionally, it is difficult to determine what proportion of a tooth is present without knowledge of that individuals typical tooth size. Half-crown development may look different from one individual to another depending on their complete crown size. Without other teeth available for comparison from the same individual, interpretation of stages can be subjective. Similarly, the relationship of the tooth to the eruption line, which shapes interpretations of the tooth's development, can be difficult to determine with a single, isolated tooth. In general, context can be helpful for clearly understanding a tooth's development and when working with isolated teeth, data collection can be more susceptible to subjectivity. Conversely, the benefit of collecting data from isolated teeth is that the entire tooth is observable. For teeth developing in crypt or teeth recovered intact in the mandible or maxilla, the complete extent of development may not be visible without radiographs or destruction of the bone.

Notably, the system developed by Moorrees and colleagues (1963a, 1963b) has served as a reference for many age estimation systems. It is fairly user-friendly with illustrations of the stages and charts for estimating age range, however it has been routinely critiqued for a lack of descriptions defining the stages. While collecting the Kopila data, the lack of descriptions in the Moorrees et al. (1963a 1963b) text occasionally proved challenging, in which case we referred to the interpretations provided in the descriptions of Irurita et al. (2014). In addition to the lack of descriptions, using Moorrees' system limited sample size significantly when compared to the combined alternate aging methods because they only include age ranges for a limited number of teeth. Combining estimates from Irurita and colleagues (2014) and Liversidge and Molleson (1999) allowed for a greater volume of estimates.

Additionally, the system developed by Moorrees and colleagues (1963a, 1963b) has been routinely criticized for consistently underestimating age. When compared to the estimates from the "Alternate Age" category, estimates using the system from Moorrees et al. (1963a, 1963b) consistently provided a lower age estimate and lower descriptive sample statistics. Using tooth length to estimate age, as described by Liversidge and Molleson (1999), was probably the least subjective method because it did not rely on arbitrarily defined stages. Irurita and colleagues (2014) provided helpful descriptions adapted from Demirjian's system (1973) of each stage along with exemplary photographs of teeth in each stage from the anterior and posterior dentition which were less subjective than the illustrations provided in Moorrees et al. (1963a, 1963b). Additionally, they removed any description of features that can only be seen in radiographs, such as the pulp chamber, to make the system more appropriate for the analysis of isolated teeth and bioarchaeological collections. The Irurita system was developed with Mediterranean samples in mind and may be better equipped for the Kopila sample than other samples from different regions of the world.

While combining methods was beneficial in that it dramatically expanded the sample, the impact on bias is uncertain and the challenge of using isolated teeth continues to impact the results. Without destructive and expensive DNA testing, identifying individuals in a collection of isolated teeth is going to remain a challenge. Increased research into variation in dental development patterns, population adjusted aging estimates, and refined methods will improve future efforts to estimate age at death in collections like the one recovered from Kopila.

5.3 Summary

Overall, the results of this study suggest that all three tombs contain a wide range of sub-adults spanning from birth to late childhood, with Tombs 3 and 7 extending into the teens and Tomb 3 have post-cranial adult remains. Therefore, Tomb 3 supports the null hypothesis and Tombs 1 and 7 support only the first alternative hypothesis. The second alternative hypothesis is overturned by all tombs. The difference in distribution, volume, and tomb construction between Tomb 3 and Tombs 1 and 7 suggest that Tomb 3 is a familial, multiple-inhumation tomb that included sub-adults while Tombs 1 and 7 were differential burial spaces intended only for sub-adults. The criteria for burying a sub-adult in a sub-adult only versus familial tomb are unclear, not age based, and require further investigation.

Strictly speaking, none of the tombs fit the criteria for an infanticide deposit (i.e. narrow age range, intentional burial, illicit location, traumas and pathologies). Therefore, it is unlikely that widespread infanticide was the impetus for the curiously infant-rich deposits in the Kopila necropolis. However, the large proportion of infants and young children in Tomb 1 could potentially include a large episode of infanticide but more likely reflects a typical Iron Age infant mortality rate as the 0-5 age group was the most susceptible to death during this period with nearly half of all children dying before their fifth birthday.

For dental age estimation methods, all three methods had benefits and limitations but combining multiple methods allowed for more robust results in this study. However, none of the methods were ideal for processing isolated, bioarchaeological teeth. All of these results spark new questions that deserve further investigation. In the following chapter the results will be compared to the initial hypotheses guiding this study and discuss areas for future research of the Kopila collection.

CHAPTER VI: CONCLUSION

This study was devised to test the following set of hypotheses using relative age profiles of dental age estimates for Tombs 1, 3, and 7 of the Kopila necropolis. The relative age profile of each tombs was tested against the following hypotheses:

H_0: Both adult and sub-adult remains are present.

H_1: Only sub-adult remains are present.

H_2: All individuals are estimated to be under 2 at death.

Support for the null hypothesis implies that the unusual distribution of sub-adults is likely the product of random sampling caused by the passage of time, preservation, and the bias of archaeological excavation. Support for the first alternative hypothesis indicates that the Kopila community required differential burial practices for the sub-adults in that tomb. Support for the second alternative hypothesis suggests that infanticide may be the impetus for the sub-adult rich assemblage in that tomb.

Solely based on the data from this study, which only calculated dental age estimates, all three tombs support only the first alternative hypothesis since no adult age estimates were observed and all tombs had age estimates ranging from birth to late childhood or even early teens. However, based on post-cranial remains, Tomb 3 contains at least 6 adults. This evidence cannot be ignored. Thus, when including post-crania, the remains of Tomb 3 support the null hypothesis and overturn both alternative hypotheses. The most parsimonious interpretation of the large proportion of sub-adults in Tomb 3 is that it was a multiple inhumation, family tomb that included sub-adult members of that family. Overtime, the tomb became highly fragmentary and unusual preservation factors preserved the sub-adult remains better than expected.

While Tomb 1 including a range of children from birth to late childhood, it has a remarkably large proportion of infants and young children. As mentioned previously, infant mortality rates were high (200-300 death before first year of life out of 1000 births) and 35-45% of children died before the age of 5 (Parkin, 2013). At best, only 52% of the children born in a year were making it to their fifth birthday, so a large proportion of children in this age group should be the expectation. Unfortunately, preservation and bias challenges often underrepresent this age group in the archaeological record. This trend makes a large assemblage of sub-adults seem sinister and incites speculation about nefarious reasons for such a robust sample of sub-adults. Even with a large proportion of infants, Tomb 1 is likely not the exclusive by-product of infanticide, however, it is possible that some or even a large proportion of the infants included in Tomb 1 are the victims of infanticide. And, while being victims of infanticide may factor into the inclusion of the infants in Tomb 1, it is unlikely to be the primary criterion since older children are also included.

The most parsimonious interpretation of Tomb 1 and Tomb 7 is that they exist as differential burial spaces for a specific group of deceased sub-adults. This interpretation is supported by the smaller and simpler designs of Tombs 1 and 7 compared to the other tombs in the Kopila necropolis that include adult remains and similarities in unique grave goods. Sub-adult remains are found in Tomb 3 and Tomb 6, alongside adult remains. However, large volumes of sub-adult remains are found in tombs that appear to be reserved exclusively for sub-adults such as Tombs 1 and 7. Based on the results of this study, age is unlikely to be the primary criteria for inclusion in the sub-adult only tombs at Kopila necropolis. If age is not the primary differentiating factor, then what is? Social status? Cause of death? Death of adult family members? Population of origin? Further research into non-metric trait expression, isotopic analysis, pathologies, and grave goods may illuminate a reason for differentiating sub-adult burial practices at Kopila.

Despite the wide range of hypotheses tested, this study only garners initial insights into the Kopila sample, providing a foundation that should be expanded upon during further research. Notably, most of the tombs excavated thus far at the Kopila necropolis display an unusual preservation pattern in which sub-adult remains are better preserved than adult remains. It is possible that the impact of multiple inhumation events and the layers of sea pebbles created a unique pattern of differential preservation, protecting the children's remains and destroying the adult remains, particularly in Tomb 3. Alternatively, adult remains may have been removed from the graves during consequent inhumations, looting, or early, undocumented excavations. An unlikely alternative scenario is that the families who used these tombs experienced a disproportionately low number of adult deaths during this period. Continued excavation and further taphonomic investigation are needed to answer these questions.

Such a large sample of teeth, particularly the number of developing permanent and deciduous teeth, make this collection an exceptional sample for the analysis of non-metric trait expression. Dental non-metric data may provide insight into the population affinity of the people living at Kopila, although other researchers have faced challenges conducting similar research in the ancient Adriatic because of the economic connections and constant movement of people throughout the region (McIlvaine et al., 2014). Even so, the data could be used to generate a non-metric profile for the community that may be useful for other studies exploring the relationship between genetic relatedness and non-metric trait expression.

With such an abundance of teeth, particularly deciduous teeth and developing permanent teeth, the collection at Kopila will also be a valuable source for comparing and critiquing age estimation methods for isolated teeth. In addition to the opportunity to develop age estimation methods, it may be possible to look at growth and development patterns amongst the Kopila people via teeth and post-cranial development. However, the lack of know ages at death and identifiable individuals may make life history research challenging.

Another study trying to assess rates of enamel accumulation via metric data is in the works. If possible, such a large collection of teeth may be useful for assessing differences in amelogenesis between permanent and deciduous teeth and between populations. Research into the evolution of the human life history pattern are often hinged on histological age estimation methods which rely on the assumption that development occurs in regular, consistent intervals (Bromage and Dean, 1985; Guatelli-Steinberg and Reid, 1985; Mann et al., 1987,1990, 1991; Wolpoff et al., 1988; Smith, 1989; Lampl et al., 1990; Benyon and Dean, 1991; Guatelli-Steinberg et al., 2005; Guatelli-Steinberg, 2009). If deciduous teeth do not develop in consistent intervals, then these methods may lead to incorrect interpretations of the fossil record.

The demography of the Kopila collection developed in this study may be further improved by sex estimations determined by enamel proteins, following the methods presented by Fincham and colleagues (1991), Stewart and colleagues (2017), and Parker and colleagues (2019). By estimating age by sex and determining the proportions of each sex in the sample, the accuracy of the age estimates would improve and questions about sexual dimorphism and the proportions of mortality by sex could be explored.

Lastly, the teeth were just a fraction of the remains recovered. Analysis of the cranial fragments and post-cranial remains could refine relative age profiles for each tomb and allow for a more robust demography of the remains. A discrepancy between minimum number of individuals and age estimates already exists between the teeth and cranial fragments recovered from Tomb 1. Further investigations may reveal the same in Tomb 7. Additionally, the post-crania could be used to assess health, stature, and population affinity as well as growth and development patterns in this population, providing a more comprehensive understanding of the phenotype and well-being of the Kopila people.

Despite their comingled nature, the remains recovered thus far from the necropolis at Kopila hillfort are rather remarkable. With such a large collection of sub-adult remains, researchers can ask questions about growth and development, demography, population affinity, and the lives of children in the Late Iron Age Adriatic. In fact, the Kopila necropolis the only known Iron Age, Illyrian necropolis with such a wealth of analyzable child remains. This study includes only a small fraction of the information that can be gained from analysis of this collection and future research promises to supply many more insights into the Kopila community.

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