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Oral health and its implications on male-female dietary differences: A study from the Roman Province of Macedonia

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ABSTRACT

This paper examines the permanent dentition of sixty-one individuals from the Pontokomi-Vrysi Roman rural population of the *Provincia Macedonia* (1st–4th c. CE) aiming to explore differences in the oral health between males and females of the assemblage. All teeth were macroscopically examined for dental pathologies and dental wear, and observations were compared at an intra-assemblage level, between males and females, as well as against published data from two Roman-Italian and two Graeco-Roman sites. Results show a homogenous pattern in the oral health of the Pontokomi-Vrysi population, pointing to a rather undifferentiated diet between the two sexes, characterized mainly by the consumption of carbohydrates and to a lesser extent by the supplementary intake of protein-deriving food sources. Comparison of the results with those from the other Greek and Italian sites reveals complex oral health and dietary profiles for these populations. This paper suggests caution when universal oral health and dietary patterns for the inhabitants of the Roman Empire are sought.

1. Introduction

Food and differential access to food sources hold a central place in archaeological research because of their influence on both the physical and social substance of past individuals (Chrzan and Brett, 2019). In Roman history and archaeology, the properties of food have been investigated using various strands of evidence (Erdkamp and Holleran, 2019). Recent developments in the field of bioarchaeology have greatly contributed to elucidating the dietary preferences of the heterogeneous inhabitants of the Roman Empire (Killgrove, 2018; Bourbou, 2019). Nonetheless, the geographic focus of current bioarchaeological studies is skewed towards the consumption profile of the population of Rome and the north-western provinces of the Empire, while the diet of populations from the south-eastern provinces largely remains a *terra incognita*. Especially for the Roman Province of Macedonia, which is the focus of the current paper, the only studies are by Malama and Triantaphyllou (2003), Michael and Dotsika (2017) and Dotsika and Michael (2018). The former addresses the topic as part of the biological and palaeopathological analysis of the Amphipolis population and the latter two carried out stable isotope analysis for the population of Edessa. No study exists for the rural populations of Roman Macedonia, and, in general, these populations remain largely invisible in bioarchaeological research agendas.

Teeth constitute the most well-known and direct bioarchaeological tools for assessing past human diet (Hillson, 2008a). Dental pathologies and dental wear, in particular, have been largely used in conjunction with contextual information to investigate the way differential access to certain food sources can create distinct dietary profiles between various social identities, among which gender holds a pivotal role (Lukacs, 2017). The present study examines both these strands of evidence with the aim to explore differences in the oral health and dietary patterns between males and females in the Pontokomi-Vrysi Roman rural population of the *Provincia Macedonia.* The results of this study are expected to lay the groundwork for future contextual and stable isotope analysis and to contribute to the debate about the complex relationship between diet, social inequality and gender in the Roman Province of Macedonia.

2. Food and social order in the Graeco-Roman world

The framework in which the Imperial Graeco-Roman Macedonian

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society was modulated can be seen as a multifaceted patchwork of social identities (Papazoglou, 1983). However, there is no information about the consumption profile of men and women in the rural groups of the region. Attempts can be made to approach this question by eliciting information from the textual sources but much of the recorded literature suffers from an urban elite male bias and contains hardly any references to the lower classes or the rural populations (Beerden, 2019). The epigraphic record is perhaps more representative, but contains little information on diet and food. What we know, however, is that in both the pre-Roman and provincial Macedonian society, assigned social roles were a predominant force mandating all aspects of everyday life; food as a basic subsistence constituent cannot be excluded from this general rule (Peachin, 2012). Sociological work on the role of food as a medium through which 'inequalities are sustained, reproduced, and naturalized in daily practice' (Burnett and Ray, 2012, p. 9) comes to add another aspect in the way we conceptualize the dynamics of food in past societies. Drawing from Bourdieu and his study on the dominant forms of taste dictated by those in charge of the high social and cultural capital (i.e. social status) (Bourdieu, 1984), access to food in Roman times rural populations and subgroups among them is anticipated to have been an arena of social struggle mandated by existing power relations, having thus multiple implications about lifestyle and health status.

The above approach is limited given that we tend to think about past people as being divided into strictly bounded homogenous groups. Especially for historical times, when gender and food are considered, a biased presumption exists and is influenced by research in the prehistoric field perception that women experienced unequal access to certain food resources due to either prescribed gender roles or their marginalized position within ancient society (Lukacs and Thompson, 2008). However, these dichotomous generalizations are neither constructive nor considerate towards the multifarious economic, cultural and social forces that shape human societies. As such, the Roman Macedonian society should not be treated as a clearly defined container with rigid boundaries separating its inhabitants. Several studies on Anglo-Saxon Roman history and archaeology have demonstrated that the conceptual space between the dichotomous notions of unity and diversity is not as straightforward as previously thought and that the dynamics of the people residing in the Roman Empire were multifaceted with diverse and changing power relations between the various subgroups (Blagg and Millett, 1990; Versluys, 2014; Wolf, 1982). Within that framework, studies concerning the history and archaeology of Macedonia should always acknowledge unity and diversity as being integral parts of processes of transformation for all social strata, thus, putting more color to the province's map of social history.

3. Oral pathologies and diet

Dietary nutrients play a vital role in the maintenance of physiological homeostasis in humans (Calder and Yaqoob, 2013). At the same time, a synergistic relationship exists between malnutrition and poor health that has been primarily dictated by both clinically and historically detected cultural, economic and geographical constraints (Goodman, 2017; Keusch, 2003; Scrimshaw, Taylor and Gordon, 1959; Solomons, 2013). The relationship between nutrition and oral health depends upon the ingested food entering the mouth cavity and the absorbed nutrients (König, 2000). Food texture and consistency, along with nutritional disturbances change the homeostatic equilibrium in teeth and/or surrounding bone tissue, resulting in the manifestation of one of the following dental pathognomonic oral features: periodontitis, antemortem tooth loss (AMTL), periapical cavities, caries, calculus, and dental wear (Hillson, 1979, 1996, pp. 254–287).

Periodontitis is a chronic inflammatory response to bacterial activity and may be traced by the progressive recession of the bone tissues that support the teeth (Hillson, 2008a). Various local and systemic factors can predispose an individual to periodontitis, such as nutritional stress, caries and dental wear (Hillson, 1996, pp. 262–263). *Antemortem tooth loss* (AMTL) is the loss of a tooth during an individual's lifetime. This loss may be caused by systemic (stress, diet), pathological (periodontitis, caries, periapical cavities), behavioral (dental wear) or traumatic factors (Hillson, 1996, pp. 254–287; Mays, 2002, 2014). *Periapical cavities* are inflammatory responses to the bone tissue surrounding the tooth when infection due to caries, dental wear and/or trauma exposes the pulp to pathogenic oral bacteria (Dias and Tayles, 1997). *Caries* results when the plaque bacteria ferment ingested carbohydrates and produce acids that progressively demineralize the dental tissues (Hara and Zero, 2010). The relationship of caries with diet is well established in the clinical literature, but in reality the aetiology behind their expression is complicated (Hillson, 2008b). However, when diet is taken into account, it is primarily the direct consumption of carbohydrates, and especially sugars, that leads to the manifestation of carious lesions (Hillson, 1979). *Calculus* is expressed as mineralized plaque deposits on the crown and/or the root surfaces of the teeth. Its formation is facilitated by bacterial activity, oral pH levels, the chemical composition of the oral fluids and other factors (Hillson, 1996, pp. 255–260). The clinical literature points to a complicated aetiology for its manifestation (Mandel, 1995; Akcalı and Lang, 2018). However, when diet is taken into account, the consumption of proteins is considered a key cause for calculus formation (Lieverse, 1999). Lastly, we examine *enamel hypoplasia*. Being a condition suggestive of non-specific stress rather than an actual dental disease, enamel hypoplastic defects manifest in the form of localized linear lines, pits and/or grooves on the tooth surfaces, caused by the imperfect mineralization of the tooth crown during its development (Goodman, 2017). These defects are associated with systemic factors causing periods of physiological stress during childhood that the affected individual needed to endure and survive in order for the defects to form (Guatelli-Steinberg, 2016). Thus, enamel hypoplasia is an indicator of non-specific stress, but the causal effect of diet to this stress is not straightforward (Goodman, 1991; Guatelli-Steinberg, 2016). There are various factors that can cause physiological stress and malnutrition can be one of them (König, 2000). The inferences, however, to its effect on the manifestation of enamel hypoplasia are subtle and can only be made in conjunction with other dietary-induced pathological indicators (Guatelli-Steinberg, 2016; König, 2000).

Dental macrowear is also considered in this study. Dental wear is the irreversible reduction of the tooth's hard tissues that proceeds in a progressive manner with advanced age, along with a number of anatomical, physiological, chemical and/or behavioral factors (Burnett, 2016; Hillson, 2005). The mechanisms that operate during its expression are erosion, attrition and abrasion, which are caused by acids, natural friction between opposing teeth, and external mechanical masticatory or non-masticatory forces, respectively (Lussi, Jaeggi and Zero, 2004). The relationship of dental wear and past diet is well established within the clinical and bioarchaeological literature as it reflects the texture of the food that was eaten and the chewing forces this food required (Lussi, Jaeggi and Zero, 2004; Schmidt and Watson, 2019).

4. Materials

The human skeletal remains examined in this paper come from Vrysi, an archaeological site near the village of Pontokomi, located in a semi-mountainous area at the ancient *Eordaea* of Kozani's Prefecture in Western Macedonia, Greece (Fig. 1). The first excavations at the site brought to light a Roman building with a cistern in its center (*impluvium)*, a *stoa* with surrounding rooms, and a kiln (Karamitrou-Mentessidi, 2009). Later on, the floor plan of seven more buildings, a second cistern, parts of the water supply system with pipes, two burial areas with Roman and earlier dated graves, respectively, and an enclosure demarcating the eastern side of the Roman graves were revealed (Karamitrou-Mentessidi, 2001, 2002, 2004, 2009). Despite the lack of clear stratigraphy and the mixing of pottery of various ages (from the Neolithic to Late Roman times), the date for six of the buildings suggested by the excavator is the 1st – 2nd c. CE, for the seventh building

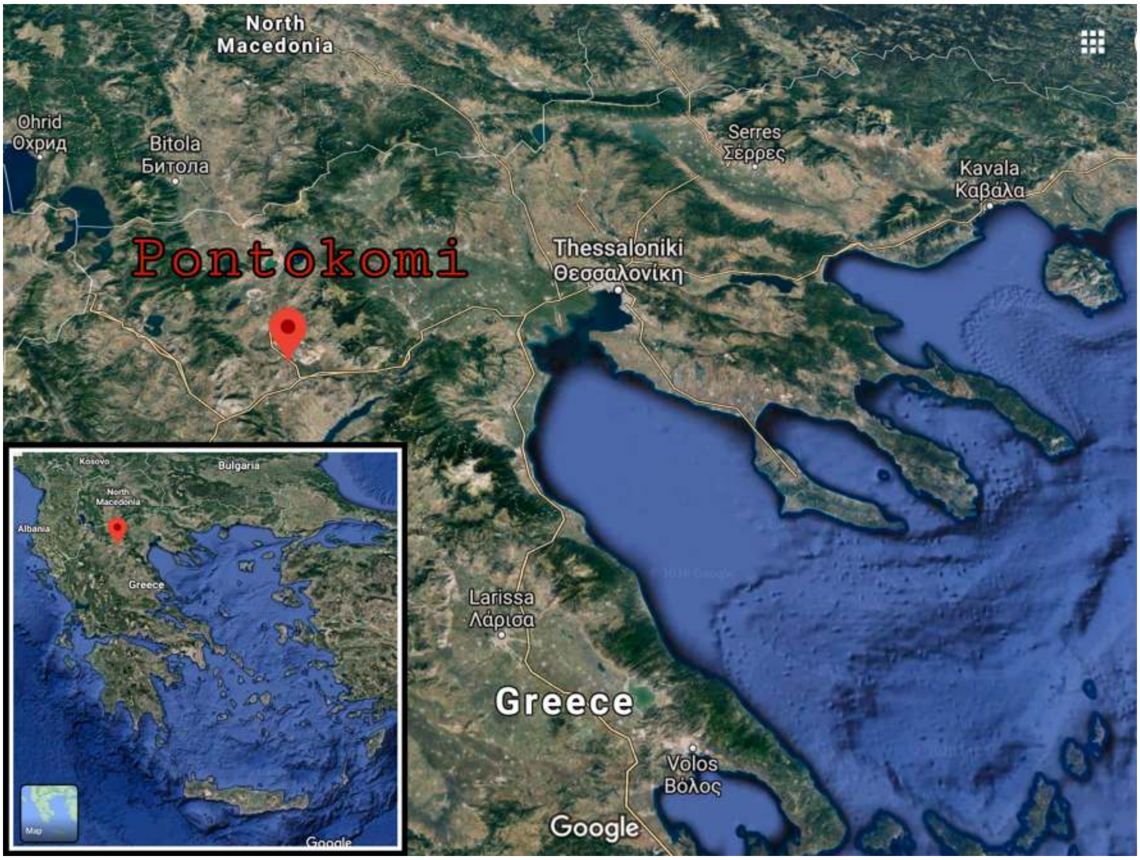

Fig. 1. Map of Macedonia showing the location of Pontokomi.

the Late Hellenistic times and for the two cemeteries the Late Archaic – Classical and the Roman period, respectively (Karamitrou-Mentessidi, 2001, 2002, 2009).

Only the Roman period cemetery (1st – 4th c. CE) was considered for this study, consisting of 101 burials. The majority of the graves were pit graves either dug into the natural bedrock or cut into the earth, containing primary single interments with the skull placed to the west (Karamitrou-Mentessidi, 2002). Variations in grave type (six tile-covered graves and two cist graves) and number of interments (few double interments) did exist but they were few compared to the general pattern (primary supine inhumations in pit burials) (Karamitrou-Mentessidi, 2002). Most of the dead were accompanied by grave-goods usually placed next to the feet with pottery vases (mostly *oinochoai*, small *oinochoai* and *lagenoi*) constituting the majority of them (Karamitrou-Mentessidi, 2002). Glass and bronze vases were also present but in much lesser numbers (Karamitrou-Mentessidi, 2002). Jewellery (bronze, silver, glass), some iron agricultural tools, pins made of bone, and bronze coins placed either on the torso or on the mouth of the deceased were also included among the grave-goods (Karamitrou-Mentessidi, 2002). Two exceptional grave-goods were found in a female pit and a male tile-covered burial; a Venus figurine and a pottery cup inscribed with the name *Glafkos* (Greek: Γλαύκος, Latin: Glaukos), respectively. Overall, the archaeological data support the existence of a socially undifferentiated rural population, practicing the same mortuary customs for both sexes (Karamitrou-Mentessidi, 2001, 2002, 2009).

The preservation of the skeletons, studied according to Behrensmeyer (1978) and Bello et al. (2006), ranged from moderate to excellent, making this assemblage favorable for macroscopic analysis. In specific, the representation for the majority of the anatomical regions was excellent with the exception of the hand and foot bones, followed by the ribs, sacra and vertebrae. Similarly, the cortical bone surface was generally well preserved in all anatomical regions and bones exhibited none to mild weathering. Very importantly, all teeth not lost ante- or post-mortem were excellently preserved, allowing the identification and recording of dental conditions.

5. Methods

Only adult skeletons were included in this study as the emphasis was on dental disease and wear. For age-at-death estimation, emphasis was placed on degenerative alterations on the iliac auricular surface (Buckberry and Chamberlain, 2002) and the pubic symphysis (Brooks and Suchey, 1990), supplemented by the degree of fusion of the late-fusing epiphyses (e.g. iliac crest) (Buikstra and Ubelaker, 1994), while less reliable methods that examine the degree of closure of the ectocranial, endocranial and palatal sutures (Mann, 1987; Mann, Symes and Bass, 1987; Mann et al., 1991; Meindl and Lovejoy, 1985) were adopted tentatively. Sex estimation used methods that evaluate specific traits on the skull and os coxae (Bruzek, 2002; Buikstra and Ubelaker, 1994; Klales, Ousley and Vollner, 2012; Phenice, 1969; WEA, 1980). Emphasis was given to the pelvic traits while cranial sexual dimorphism was only used complementarily or cautiously when the former did not provide conclusive results. Long bone measurements were also used for adult sex estimation (Bass, 1987; Buikstra and Ubelaker, 1994; Spradley and Jantz, 2011). In specific, the cut-off values proposed by Bass (1987) for the femoral, humeral and radial head diameters were used in metric sex estimation. Table 1 provides the demographic profile of the adult sample, as well as the number of alveoli and teeth analyzed per age and sex group.

All pathologies were recorded with regard to their location and degree of expression, as briefly explained below. However, the recorded information was converted to present/absent scores prior to statistical analysis since the rather small sample sizes would not allow more refined categories of expression to be effectively used. For periodontitis

Table 1
Age and sex distribution of the sample and number of examined teeth/alveoli.

Age categories	Number of individuals				Number of alveoli				Number of teeth			
	M	F	?	Total	M	F	?	Total	M	F	?	Total
YA	7	13	0	20	222	412	0	634	134	283	0	417
MA	9	8	2	19	286	254	60	600	163	152	21	336
OA	7	6	0	13	218	192	0	410	134	70	0	204
A	4	4	1	9	128	126	32	286	62	33	0	95
Total	27	31	3	61	854	984	92	1930	493	538	21	1052

Key: YA = young adult (20–34 yrs); MA = middle adult (35–49 yrs); OA = old adult (50 + yrs); A = adult (18 + yrs); M = male; F = female; ? = indeterminate sex.

to be present, the distance between the cementoenamel junction and the alveolar crest (0. 0–2 mm, 1. 2–5 mm, 2. > 5 mm), the extent of alveolar bone resorption (0. none, 1. <½ of the root exposed, 2. >½ of the root exposed, 3. complete resorption), and the form of the interdental septum (0. no grooves or foramina, 1. foramina, grooves and ridges on the cortical surface, 2. breakdown of septal contour, 3. deep septal defect) were evaluated (Lukacs, 1989; Strohm and Alt, 1998). In the rare occasions where root exposure was not associated even with slight changes to the alveolar bone and interdental septum, periodontitis was deemed absent since root exposure may have been the result of continued tooth eruption. For periapical cavities, the location (1. buccal/labial, 2. lingual) and size of the cavity (1. < 3 mm diameter 2. > 3 mm diameter) as well as the texture of the walls (1. smooth, 2. rough) were examined (Dias and Tayles, 1997), while for AMTL, the texture of the alveolar walls and the degree of alveolar resorption were considered (1. socket depth > 2 mm, irregular socket walls, 2. socket depth < 2 mm, irregular socket walls, large pores on alveolar bone, 3. complete socket obliteration) (Gilmore, 2013). To differentiate between cases of congenitally missing teeth and teeth lost antemortem, we evaluated a) evidence of alveolar remodeling and b) evidence of dental disease in adjacent teeth (e.g. extensive carious lesions that may have also affected the missing tooth and caused AMTL). For the third molars, we also took into account the distance between the second molars and the retromolar fossa of the mandible or the posterior margin of the alveolar process of the maxilla. We should stress that the inclusion of incompletely resorbed alveoli in the AMTL category could overestimate AMTL since tooth roots could have still been present in the partially resorbed sockets. In the case of the Pontokomi assemblage this is not an issue because the skulls were very well preserved and collected by the excavators without compromising the articulation between the crania and the mandibles. Thus, during laboratory work, they were meticulously cleaned and all soil was sieved, a process that proved to be effective for the retrieval of small skeletal and dental elements, including tooth roots. Once retrieved, the roots were assigned to their respective tooth via macroscopic fitting, and a special recording number was given to them (4 = tooth present-only root). For calculus, the location (1. supragingival, 2. subgingival), size (0. absent, 1. < 1/3 of the crown covered, 2. 1/3–2/3 of the crown covered, 3. > 2/3 of the crown covered) and thickness (0. 0 mm, 1. 1–2 mm, 2. 2–4 mm, 3. > 4 mm) of the deposits was recorded (Dobney and Brothwell, 1987), and for enamel hypoplasia, the location (1. cusp, 2. mid-crown, 3. neck) and type of the defect (0. absence, 1. enamel opacity, 2. linear horizontal grooves, 3. linear horizontal pits, 4. arrays of pits, 5. single pits, 6. altogether missing enamel, 7. other) (Fédération Dentaire International, 1982). Dental caries was recorded following Hillson's (2001) guidelines with regard to location and degree of expression (occlusal/buccal/lingual/interproximal caries: 0. no caries, 1. small enamel cavity but no penetration to the dentin, 2. cavity penetrates the dentin, 3. cavity penetrates the pulp chamber; root surface caries: 0. no caries, 1. shallow cavity following the line of the CEJ or confined to the root surface, 2. cavity penetrates the pulp chamber/root canal; gross caries: 0. no caries, 1. cavity too large to determine if it originated in the crown or root, 2. same as stage 1 but penetrating the pulp chamber or root canal). The caries frequencies, however, can be significantly affected by AMTL, especially in older individuals (Hillson, 2001). To compensate for caries underestimation biases, the Diseased-Missing Index (DMI) after Moore and Corbett (1971) was applied. The index operates on the premise that higher than the caries DMI values relate to higher AMTL. Finally, tooth wear was recorded using the Smith (1984) scheme for incisors, canines and premolars, and Scott (1979) for molars.

Descriptive statistics were used to provide the frequencies of each type of dental pathology per individual, jaw and tooth type; chi-squared tests were applied to examine the association between sex and dental disease. Mann-Whitney U tests were adopted to examine sexual dimorphism in dental wear, and paired Wilcoxon signed-rank tests to explore bilateral asymmetry. All statistical analyses were performed using SPSS, Version 23. Statistical significance was set at $p < 0.05$.

The results on the frequency of each oral condition in the Pontokomi-Vrysi assemblage are discussed against the respective frequencies of four other published sites: the neighboring rural cemetery (6th–7th c. CE) at Sourtara Galaniou in Kozani (Western Macedonia, Greece) (Bourbou, 2009); the Roman assemblage of the eastern cemetery of the city of Amphipolis (Eastern Macedonia, Greece) (Malama and Triantaphyllou, 2003); the extra-urban cemetery (1st–4th c. CE) in Quadrella (Molise, Italy) (Bonfiglioli, Brasili and Belcastro, 2003); and the skeletal assemblage of the rural town of Lucus Feroniae (1st–3rd c. CE) (central Italy) (Manzi et al., 1999). The criteria for selecting these sites were as follows: for Galani-Sourtara, the geographic proximity, similar semi-mountainous micro-ecology and rural character, as well as temporal continuity; for Amphipolis, the diametrically opposite geography, micro-ecology and topography, and temporal overlap; and, for Quadrella and Lucus Feroniae, the temporal overlap, and similar rural and semi-rural character, respectively. In addition, Quadrella has a similar to Pontokomi-Vrysi mountainous micro-ecology. Note that Sourtara and Amphipolis are the only skeletal assemblages from Macedonia for which there is published data on dental conditions.

At this point we must stress some of the key biases that may arise from the comparison of the Pontokomi-Vrysi assemblage to any other published assemblages. Firstly, most dental diseases are age-progressive, while sex differences have also often been identified in their prevalence (Hillson, 1996, pp. 254–287). Therefore, differences in the demographic profile of the assemblages under comparison may result in differences between them in the frequency of dental diseases, irrespective of the dietary patterns of these groups. The publication of Amphipolis does not provide any information regarding the sex or age-at-death distribution of the assemblage. All remaining comparative assemblages and Pontokomi-Vrysi exhibit a balanced representation between males and females, with the exception of Sourtara, which had 12 males and merely 3 females. Regarding the age-at-death distribution, Pontokomi-Vrysi shows a very similar pattern to Lucus Feroniae whereby there is an almost equal representation of young and middle adults and a smaller number of old adults. The Pontokomi-Vrysi assemblage appears also similar to Sourtara for which the author only provides the average age for males (ca. 42 years) and females (ca. 35 years). Finally, there is a difference to Quadrella where old adults outnumber young and middle adults, which are almost equally represented in the assemblage, as in Pontokomi-Vrysi. Therefore, overall the impact of demographic factors in the observed patterns is anticipated to have been rather limited, though it must be kept seriously in mind in any interpretation of the results. Another potentially important limitation pertains to the diagnostic criteria used by different researchers to record dental pathologies. All studies included in this paper have used very similar and well-established diagnostic criteria; nonetheless, any comparison must be and will be cautious as subtle differences also existed and it is not possible to test inter-observer error rates.

6. Results

6.1. Periodontitis

The frequency of periodontitis in the Pontokomi-Vrysi individuals was 90.1% (Table 2). In terms of sex and age, both sexes displayed almost equal rates with a slight precedence in both middle adult groups. Furthermore, no statistically significant difference was detected in the frequency of the disease between sexes per age group.

6.2. Periapical cavities

Periapical cavities were present in 55.7% of the individuals (Table 2) and 4.8% of the teeth (Table 3) in the Pontokomi-Vrysi sample (Figs. 2 and 3). They were more common in females when examined per individual but more common in males when examined per alveolus. Nonetheless, the difference between males and females was very small and did not appear to be statistically significant. It can be also seen that the frequency of the cavities advanced strongly with age. A significantly higher affliction of the maxilla compared to the mandible was found ($\chi^2 = 26.700$, $p = 0.000$, Tables 4 and 5) and when examined per alveolus, this involved the first incisors, canines and third premolars (I1: $\chi^2 = 7.207$, $p = 0.014$; C: $\chi^2 = 17.646$, $p = 0.000$; PM3: $\chi^2 = 5.754$, $p = 0.030$).

6.3. Antemortem tooth loss (AMTL)

More than half of the Pontokomi-Vrysi individuals had lost at least one tooth during their lifetime (59%, Table 2). AMTL affected also 13.7% of the teeth in the assemblage (Table 3) (Fig. 4). The condition progressed strongly with age, while in terms of sex biases, no striking difference in its frequency was identified between males and females, as also supported by the lack of any statistically significant difference between sexes. AMTL was more common in the posterior teeth (Tables 4 and 5) but no significant difference was identified between maxillary and mandibular teeth.

6.4. Calculus

The overall calculus frequency in the Pontokomi-Vrysi individuals was 82% (Table 2). When examining the condition per tooth rather than per individual, affected teeth accounted for just over half of the sample (58%, Table 3). The disease did not progress with age. Statistically significant differences were found between sexes only for the middle adult group (m. 63.1%; f. 44.1%, $\chi^2 = 11.564$, $p = 0.001$, Table 3). In terms of jaw and tooth type, mandibular teeth exhibited significantly more calculus (max. 51.8%; mand. 62.9%, $\chi^2 = 15.311$, $p < 0.001$) with the incisors primarily conforming to this pattern (I^1. 46%; I_1. 72.1%, $\chi^2 = 8.222$, $p = 0.004$; I^2. 41.7%; I_2. 65.3%, $\chi^2 = 7.538$, $p = 0.006$, Tables 4 and 5).

6.5. Enamel hypoplasia

Enamel hypoplasia was also very common in the sample, especially when examining the condition per individual (82%, Table 2) but even when using tooth frequencies (47.6%, Table 3). No age related pattern could be seen for the individuals of Pontokomi-Vrysi. The disease was more common in males, though when the observed teeth are considered, females were affected more, and the difference between sexes was statistically significant in the old adult group (m. 32.1%; f. 48.3%, $\chi^2 = 4.211$, $p = 0.040$, Table 3). Enamel hypoplasia predominated in most tooth types of the maxilla compared to the mandible (Tables 4 and 5), but this pattern was statistically significant only for the first incisors, and the second and third molars (I^1. 64.4%; I_1. 39.1%; $\chi^2 = 6.809$, $p = 0.009$; M^2. 52.5%; M_2. 34.3%; $\chi^2 = 4.399$, $p = 0.036$; M^3. 54.3%; M_3. 30.8%, $\chi^2 = 4.811$, $p = 0.028$).

6.6. Caries

Caries afflicted almost three-quarters of the Pontokomi-Vrysi assemblage (67.2%) (Table 2), but the total frequency of the affected teeth was relatively low (12.9%) (Table 3) (Figs. 2 and 3). In terms of age patterns, the condition can be seen to increase with age in females but not in males. In terms of sex patterns, females exhibited more caries than males, both per individual (m. 59.3%; f. 77.4%, Table 2) and per tooth (m. 9.5%; f. 14.9%, Table 3). In the middle adult (MA) and old adult

Table 2
Frequency of affected individuals by age and sex.

Age categories	M	F	?	Total	M	F	?	Total
	Periodontitis				AMTL			
YA	6/7 (85.7%)	12/13 (92.3%)		18/20 (90%)	2/7 (28.6%)	4/13 (30.8%)		6/20 (30%)
MA	9/9 (100%)	8/8 (100%)	1/2 (50%)	18/19 (94.7%)	6/9 (66.7%)	6/8 (75%)	1/2 (50%)	13/19 (68.4%)
OA	6/7 (85.7%)	6/6 (100%)		12/13 (92.3%)	5/7 (71.4%)	5/6 (83.3%)		10/13 (76.9%)
A	4/4 (100%)	3/4 (75%)	0/1 (0%)	7/9 (77.8%)	4/4 (100%)	3/4 (75%)	0/1 (0%)	7/9 (77.8%)
Total	25/27 (92.6%)	29/31 (93.5%)	1/3 (33.3%)	55/61 (90.1%)	17/27 (63%)	18/31 (58%)	1/3 (33.3%)	36/61 (59%)
	Periapical cavities				Caries			
YA	4/7 (57.1%)	6/13 (46.2%)		10/20 (50%)	5/7 (71.4%)	8/13 (61.5%)		13/20 (65%)
MA	3/9 (33.3%)	4/8 (50%)	1/2 (50%)	8/19 (42.1%)	5/9 (55.6%)	7/8 (87.5%)	1/2 (50%)	13/19 (68.4%)
OA	5/7 (71.4%)	5/6 (83.3%)		10/13 (76.9%)	3/7 (42.9%)	5/6 (83.3%)		8/13 (61.5%)
A	3/4 (75%)	3/4 (75%)	0/1 (0%)	6/9 (66.7%)	3/4 (75%)	4/4 (100%)	0/1 (0%)	7/9 (77.8%)
Total	15/27 (55.6%)	18/31 (58.1%)	1/3 (33.3%)	34/61 (55.7%)	16/27 (59.3%)	24/31 (77.4%)	1/3 (33.3%)	41/61 (67.2%)
	Calculus				Enamel hypoplasia			
YA	6/7 (85.7%)	11/13 (84.6%)		17/20 (85%)	6/7 (85.7%)	10/13 (76.9%)		16/20 (80%)
MA	8/9 (88.9%)	8/8 (100%)	1/2 (50%)	17/19 (89.5%)	9/9 (100%)	7/8 (87.5%)	2/2 (100%)	18/19 (94.7%)
OA	5/7 (71.4%)	5/6 (83.3%)		10/13 (76.9%)	4/7 (57.1%)	5/6 (83.3%)		9/13 (69.2%)
A	3/4 (75%)	3/4 (75%)	0/1 (0%)	6/9 (66.7%)	4/4 (100%)	3/4 (75%)	0/1 (0%)	7/9 (77.8%)
Total	22/27 (81.5%)	27/31 (87.1%)	1/3 (33.3%)	50/61 (82%)	23/27 (85.2%)	25/31 (80.6%)	2/3 (66.7%)	50/61 (82%)

Key: as in Table 1.

Table 3
Frequency of affected teeth by age and sex.

Age categories	M	F	?	Total	M	F	?	Total
	AMTL				Periapical cavities			
YA	13/222 (5.9%)	19/412 (4.6%)		32/634 (5.1%)	11/222 (5%)	16/412 (3.9%)		27/634 (4.3%)
MA	60/286 (21%)	44/254 (17.3%)	2/60 (3.3%)	106/600 (17.7%)	8/286 (2.8%)	12/254 (4.7%)	1/60 (1.7%)	21/600 (3.5%)
OA	39/218 (17.9%)	44/192 (22.9%)		83/410 (20.2%)	12/218 (5.5%)	14/192 (7.3%)		26/410 (6.3%)
A	18/128 (14.1%)	25/126 (19.8%)	0/32 (0%)	43/286 (15%)	13/128 (10.2%)	6/126 (4.8%)	0/32 (0%)	19/286 (6.6%)
Total	130/854 (15.2%)	132/984 (13.4%)	2/92 (2.2%)	264/1930 (13.7%)	44/854 (5.2%)	48/984 (4.9%)	1/92 (1.1%)	93/1930 (4.8%)
	Caries				Calculus			
YA	13/134 (9.7%)	17/283 (6%)		30/417 (7.2%)	93/134 (69.4%)	200/283 (70.7%)		293/417 (70.3%)
MA	15/163 (9.2%)	38/152 (25%)	9/21 (42.9%)	62/336 (18.5%)	103/163 (63.1%)	67/152 (44.1%)	1/21 (4.8%)	171/336 (50.9%)
OA	13/134 (9.7%)	17/70 (24.2%)		30/204 (14.7%)	64/134 (47.8%)	42/70 (60%)		106/204 (52%)
A	6/62 (9.7%)	8/33 (24.2%)		14/95 (14.7%)	27/62 (43.5%)	13/33 (39.4%)		40/95 (42.1%)
Total	47/493 (9.5%)	80/538 (14.9%)	9/21 (42.9%)	136/1052 (12.9%)	287/493 (58.2%)	322/538 (59.9%)	1/21 (4.8%)	610/1052 (58%)
	Enamel hypoplasia							
YA	72/124 (58.1%)	145/282 (51.4%)		217/406 (53.4%)				
MA	70/148 (47.3%)	66/145 (45.5%)	19/20 (95%)	155/313 (49.5%)				
OA	35/109 (32.1%)	28/58 (48.3%)		63/167 (37.7%)				
A	13/54 (24.1%)	13/29 (44.8%)		26/83 (31.3%)				
Total	190/435 (43.7%)	252/514 (49%)	19/20 (95%)	461/969 (47.6%)				

Fig. 2. Male young adult maxillary right second and third molars showing caries and periapical cavities; Tomb 40 of the Pontokomi skeletal assemblage, Kozani, Greece, 1st to 4th c. CE (photo by Vergidou C. with the kind permission of Dr. Karamitrou-Mentessidi).

(OA) groups the difference between sexes was statistically significant (MA: m. 9.2%; f. 25%; $\chi^2 = 14.02$, $p < 0.001$; OA: m. 9.7%; f. 24.2%; $\chi^2 = 7.797$, $p = 0.005$). However, when the DMI was applied, frequencies for both sexes were almost the same (m. 20.7%; f. 21.5%, Table 6). Finally, no statistically significant difference was found between the two jaws, which were almost equally affected by caries (Tables 4 and5).

6.7. Dental macrowear

Analysis by jaw and tooth type showed moderate occlusal wear for all teeth in the sample, which increased slightly with age (incisors, canines, premolars: 3.65–5.08; molars: 13.00–25.92, Tables 7 and 8). Bilateral asymmetry was examined using paired Wilcoxon signed-rank test to identify any differential use of the mouth in masticatory activities. Statistically significant differences were found in the maxillary second molars and the mandibular canines (M^2 Z = −1.941, $p = 0.052$; C_1 Z = -2.066, $p = 0.039$). When sex, jaw, tooth type and tooth side were considered (Table S1), males showed clearly higher rates of wear than females with statistically significant results in the maxillary left second incisors and canines (I^2 U = 71.000, $p = 0.053$; C^1 U = 96.000, $p = 0.011$), the right first and second molars (M^1 U = 80.000, $p = 0.053$; M^2 U = 53.000, $p = 0.013$) and the mandibular right first molars and left second and third molars (M_1 U = 50.000, $p = 0.046$; M_2 U = 74.5000, $p = 0.003$; M_3 U = 46.500; $p = 0.018$).

Fig. 3. Female young adult right mandibular first molar showing gross caries and pariapical cavity; Tomb 114 of the Pontokomi skeletal assemblage, Kozani, Greece, 1st to 4th c. CE (photo by Vergidou C. with the kind permission of Dr. Karamitrou-Mentessidi).

7. Discussion

Dental conditions showed an overall homogenous distribution between individuals in the Pontokomi-Vrysi assemblage with occasional statistically significant differences only when the analyses took place at the tooth rather than the individual level. The frequencies of periodontitis in the Pontokomi-Vrysi individuals are striking. Research in dry bones has shown that overestimation biases arise when continuous eruption to compensate for occlusal wear is mistaken for periodontal disease (Hillson, 2008a). Although wear-related continuous eruption may have resulted in a certain overestimation of periodontitis in the Pontokomi-Vrysi assemblage, the average dental wear is not pronounced enough to justify the observed pattern. In addition, since the

Table 4
Dental conditions by maxillary tooth type.

Dental condition	I^1	I^2	C	PM^3	PM^4	M^1	M^2	M^3
AMTL	9/122 (7.4%)	10/122 (8.2%)	9/122 (7.4%)	19/122 (15.6%)	18/122 (14.8%)	28/122 (23%)	21/122 (17.2%)	27/115 (23.5%)
Periapical cavities	7/122 (5.7%)	7/122 (5.7%)	19/122 (15.6%)	12/122 (9.8%)	7/122 (5.7%)	14/122 (11.5%)	1/122 (0.8%)	4/115 (3.5%)
Caries	1/50 (2%)	1/60 (1.7%)	1/69 (1.5%)	5/73 (6.8%)	11/70 (15.7%)	14/65 (21.5%)	15/62 (24.2%)	12/36 (33.3%)
Calculus	23/50 (46%)	25/60 (41.7%)	33/69 (47.8%)	35/73 (47.9%)	37/70 (52.9%)	41/65 (63.1%)	35/62 (56.5%)	21/36 (58.3%)
Enamel hypoplasia	29/45 (64.4%)	30/49 (61.2%)	40/59 (67.8%)	28/65 (43.1%)	21/65 (32.3%)	22/59 (37.3%)	32/61 (52.5%)	19/35 (54.3%)

Table 5
Dental conditions by mandibular tooth type.

Dental condition	I_1	I_2	C	PM_3	PM_4	M_1	M_2	M_3
AMTL	10/122 (8.2%)	6/122 (4.9%)	5/122 (4.1%)	10/122 (8.2%)	20/122 (16.4%)	33/122 (27.1%)	19/122 (15.6%)	20/107 (18.7%)
Periapical cavities	0/122 (0%)	2/122 (1.6%)	1/122 (0.8%)	3/122 (2.5%)	3/122 (2.5%)	10/122 (8.2%)	3/122 (2.5%)	0/107 (0%)
Caries	3/68 (4.4%)	4/75 (5.3%)	6/78 (7.7%)	6/82 (7.3%)	9/76 (11.8%)	16/62 (25.8%)	16/73 (21.9%)	16/53 (30.2%)
Calculus	49/68 (72.1%)	49/75 (65.3%)	49/78 (62.8%)	52/82 (63.4%)	39/76 (51.3%)	42/62 (67.7%)	43/73 (58.9%)	37/53 (69.8%)
Enamel hypoplasia	25/64 (39.1%)	38/71 (53.5%)	58/73 (79.5%)	41/74 (55.4%)	25/69 (36.2%)	13/58 (22.4%)	24/70 (34.3%)	16/52 (30.8%)

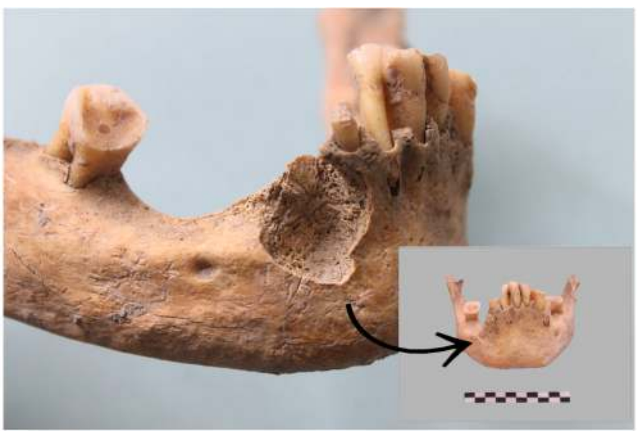

Fig. 4. Male middle-aged adult right mandibular ramus and dentition showing the presence of severe AMTL, dental wear and periapical cavities; Tomb 65 of the Pontokomi skeletal assemblage, Kozani, Greece, 1st to 4th c. CE (photo by Vergidou C. with the kind permission of Dr. Karamitrou-Mentessidi).

Table 6
Comparison of caries index and DMI by age and sex.

Caries index*	M	F	?	Total
YA	9.7	6.0	–	7.1
MA	9.2	25.0	42.8	18.4
OA	9.7	24.2	–	14.7
A	9.6	24.2	–	14.7
Total	9.5	14.8	42.8	12.9
*DMI***				
YA	11.7	8.7	–	14.2
MA	26.2	17.3	18.3	28.0
OA	23.8	31.7	–	27.5
A	18.7	26.1	–	22.4
Total	20.7	21.5	11.9	20.7

Key: as in Table 1.
*Total number of carious teeth × 100/total number of observed teeth.
**Total number of carious teeth and teeth lost ante-mortem × 100/total number of teeth and sockets observed.

teeth in this study display low caries frequencies, the indirect relationship of periodontitis to diet is in question for this assemblage and alternative causes for its high prevalence may be sought. Both clinical and archaeological studies suggest a strong relation of periodontitis to males and advanced age (Hillson, 1996, pp. 266–269) but this was not the case for the individuals of this study as both sexes displayed almost equal rates with a slight precedence in both middle adult groups. A similarity in AMTL rates is also evident between age and sex groups in the Pontokomi-Vrysi assemblage, while the clinically attested progression of the disease with age (Mays, 2014) is also broadly seen. Similarly, periapical cavities progress with advanced age but only for females with the male middle adult age group displaying lower rates than old adults. The difference between males and females did not appear to be statistically significant, agreeing with the homogenous pattern observed in the other diseases as well. Calculus frequencies in the Pontokomi-Vrysi individuals were striking but it should be noted that the condition was mostly present in relatively small deposits and in the form of a creamy-yellowish film attached as a band on the buccal and lingual surfaces. The disease did not progress with age, which would have been the expected pattern, but biases may emerge from the post-depositional loss of calculus deposits. The disease seems also to favor women, but sex differences were statistically significant only for the teeth of the middle adult group where males predominated. Enamel hypoplastic defects favored men but statistically significant results were found only for the teeth of the old adult group. Caries tend to be more common in women, but statistically significant differences were found only between the teeth of

Table 7
Average tooth wear scores per jaw, tooth type and side.

Tooth Type	Side	Maxilla: No of Teeth	Maxilla: Wear score	Maxilla: Average score – pooled sides	Mandible: No of teeth	Mandible: Wear Score	Mandible: Average score – pooled sides
I1	R	25	5.08	4.94	33	4.84	5.25
	L	25	4.88		37	4.78	
I2	R	28	4.85	3.47	35	4.42	5.16
	L	32	4.84		40	4.50	
C	R	30	4.46	4.36	36	3.72*	3.78
	L	39	4.20		39	4.23*	
PM3	R	30	3.96	4.12	41	3.65	4.06
	L	39	4.10		43	3.83	
PM4	R	34	3.82	4.36	36	3.86	4.14
	L	38	4.23		39	3.79	
Total		320	4.44		379	4.20	
M1	R	34	24.44	24.55	28	25.92	25.8
	L	31	24.67		34	25.70	
M2	R	31	16.54*	17.53	32	20.78	21.1
	L	31	18.51*		38	21.36	
M3	R	18	13.00	13.8	27	16.59	16.54
	L	17	14.64		28	16.50	
Total		162	19.18		187	21.14	

*Statistically significant bilateral differences.

Table 8
Average tooth wear scores and number of teeth observed by age and sex.

Jaw	Sex	Age	I1		I2		C		PM3		PM4		M1		M2		M3	
Maxilla			Wear	N	Wear	N	Wear	N	Wear	N	Wear	N	Wear	N	Wear	N	Wear	N
	M	YA	4.55	9	3.16	6	3.00	8	2.25	8	3.00	8	17.87	8	13.88	9	11.42	7
		MA	5.60	6	5.44	9	5.45	11	4.55	9	4.81	11	30.10	10	22.60	10	17.60	5
		OA	6.40	5	6.33	9	5.81	11	5.91	12	5.55	9	36.20	5	24.11	9	15.80	5
		A	6.00	3	6.20	5	5.00	4	5.00	4	5.00	6	29.00	3	18.00	1	17.00	1
		Total	5.63	23	5.28	29	4.81	34	4.42	33	4.59	34	27.38	26	20.20	29	14.66	18
	F	YA	4.07	13	3.42	14	2.87	16	2.72	18	2.84	19	19.63	19	13.55	18	11.58	12
		MA	4.50	8	4.11	9	4.10	12	4.50	12	3.92	13	26.07	13	16.75	12	10.00	4
		OA	6.30	3	6.00	3	5.66	3	4.00	1	7.00	1	28.50	4		0		0
		A	6.00	2	7.00	2	4.50	2	4.66	3	4.66	3	14.00	1	27.00	1	40.00	1
		Total	5.21	26	5.13	28	4.28	33	3.97	34	4.60	36	22.70	37	15.22	31	12.88	17
	?	YA		0		0		0		0		0		0		0	0	0
		MA	4.00	1	6.00	3	4.00	2	4.00	2	4.00	2	22.00	2	14.50	2		0
		OA		0		0		0		0		0		0		0		0
		A		0		0		0		0		0		0		0		0
		Total	4.00	1	6.00	3	4.00	2	4.00	2	4.00	2	22.00	2	14.50	2		0
Mandible	M	YA	4.10	10	3.70	10	3.10	10	2.27	11	3.18	11	22.40	10	17.72	11	11.50	8
		MA	5.27	11	5.30	10	5.08	12	4.50	14	4.69	13	32.44	9	28.18	11	22.41	12
		OA	6.00	7	5.44	9	5.22	9	4.80	10	4.77	9	31.00	7	28.88	9	25.25	4
		A	6.00	4	4.75	4	3.00	5	4.33	6	4.66	3	33.00	1	21.50	2	20.00	2
		Total	5.34	32	4.79	33	4.10	36	3.97	41	4.32	36	28.37	27	24.48	33	19.30	26
	F	YA	3.88	18	3.52	19	2.58	17	2.45	20	2.42	19	21.61	21	15.90	21	12.44	18
		MA	4.77	9	4.33	12	3.88	9	3.50	10	3.33	9	23.50	6	20.00	8	12.16	6
		OA	5.00	9	5.00	8	5.00	8	5.25	8	5.66	6	30.50	6	24.16	6	17.75	4
		A	7.00	2	6.00	2	5.50	4	5.75	4	5.00	4	23.00	1		0	40.00	1
		Total	5.16	38	4.71	41	4.24	38	4.23	42	4.10	38	23.55	34	18.25	35	14.06	29
	?	YA		0		0		0		0		0		0		0		0
		MA		0	6.00	1	3.00	1	4.00	1	4.00	1	33.00	1	15.00	2		0
		OA		0		0		0		0		0		0		0		0
		A		0		0		0		0		0	0	0		0		0
		Total		0	6.00	1	3.00	1	4.00	1	4.00	1	33.00	1	15.00	2		0

Key: As in Table 1; N = number of observable teeth.

the older age groups. Whereas females manifested an increase in caries frequency with advancing age, men displayed a decreasing trend that cannot be attributed to their greater propensity in AMTL since both AMTL and DMI rates were not found to be statistically significantly different between sexes.

Sample biases, particularly the rather small sample of adult skeletons available from Pontokomi-Vrysi, may be responsible for the overall seemingly equal distribution of the oral conditions between individuals of the two sexes. However, we may indeed be dealing with a socially homogenous community where all individuals experienced the same lifestyle, a pattern also seen in the archaeological record (Karamitrou-Mentessidi, 2002) and encountered as well often in low economic status communities (Bonfiglioli, Brasili and Belcastro, 2003). At this point we must stress that the aim of this paper is to explore gender-related dietary differences in Roman Macedonia; however, gender is a socially ascribed identity, hence it cannot be skeletally assessed. Therefore, our examination of sexual dimorphism in the expression of dental disease and wear is a proxy for gender differences, but we fully acknowledge that the two dimensions do not always overlap.

The frequencies of dental disease in Pontokomi-Vrysi display some

Table 9
Dental pathology frequencies per individual in Pontokomi-Vrysi and comparative assemblages.

Dental Pathology	Sex	Vrysi	Sourtara[1]	Amphipolis[2]	Quadrella[3]	Lucus Feroniae[4]
Caries	M	59.3%	Overall prevalence of oral diseases: Males 48% Females 12%	–	84.6%	48.0%
	F	77.4%		–	71.4%	56.0%
	Total	67.2%		–	71.6%	52.0%
AMTL	M	63.0%		–	72.0%	68.0%
	F	58.0%		–	56.0%	28.0%
	Total	59.0%		–	60.0%	48.0%
Periapical cavities	M	55.6%		–	26.9%	12.0%
	F	58.1%		–	14.3%	12.0%
	Total	55.7%		–	20.3%	12.0%
Periodontitis	M	92.6%		–	–	81.0%
	F	93.5%		–	–	47.8%
	Total	90.1%		–	–	63.6%
Calculus	M	81.5%		–	88.5%	62.3%
	F	87.1%		–	82.1%	70.8%
	Total	82.0%		–	83.6%	66.7%
Enamel hypoplasia	M	85.2%		–	92.0%	84.0%
	F	80.6%		–	100.0%	83.3%
	Total	82.0%		–	95.2%	82.0%

Key: 1 = Bourbou (2009); 2 = Malama and Triantaphyllou (2003); 3 = Bonfiglioli, Brasili and Belcastro (2003); 4 = Manzi et al. (1999).

Table 10
Dental pathology frequencies in Pontokomi-Vrysi and the comparative assemblages by sex/pooled.

Dental pathology	Sex	Vrysi	Sourtara[1]	Amphipolis[2]	Quadrella[3]	Lucus feroniae[4]
Caries	M	9.5%	–	15.0–16.0%	18.4%	6.2%
	F	14.9%	–	14.0%	13.9%	5.9%
	Total	12.9%	8.0%	12.5%	15%	6.1%
AMTL	M	15.2%	–	4.0–5.0%	14.1%	13.5%
	F	13.4%	–	11.0%	12.5%	11.0%
	Total	13.7%	39.7%	5.0–6.0%	12.5%	12.4%
Periapical cavities	M	5.2%	–	–	1.3%	0.5%
	F	4.9%	–	1.0%	0.8%	0.6%
	Total	4.8%	0.6%	1.0%	13.0%	0.6%
Calculus	M	58.2%	–	–	49.6%	23.9%
	F	59.9%	–	–	52.5%	30.1%
	Total	58%	14.2%	–	50.8%	26.9%
Enamel hypoplasia	M	43.7%	–	6.0–7.0%	57.6%	54.2%
	F	49.0%	–	–	62.4%	37.6%
	Total	47.6%	4.9%	6.0–7.0%	58.9%	46.0%

Key: 1 = Bourbou (2009); 2 = Malama and Triantaphyllou (2003); 3 = Bonfiglioli, Brasili and Belcastro (2003); 4 = Manzi et al. (1999).

interesting patterns when compared against other Roman Italian and Graeco-Roman assemblages (Tables 9 and 10). In all three rural sites, individuals (Table 9) display high frequencies in caries, AMTL, periodontitis, periapical cavities and calculus, but deviations do exist between them denoting a geographic variation in the expression of these diseases, linked with the diet of these past populations and other factors that cannot be controlled for, such as oral hygiene. The Pontokomi-Vrysi frequencies are overall intermediate to those of the other two sites with the exception of those for periapical cavities where the number of affected individuals from Pontokomi-Vrysi is greater, indicating perhaps lower oral hygiene standards compared to the individuals of the two Italian sites. When examining dental pathology frequencies per tooth (Table 10), the Pontokomi-Vrysi results are again comparable to those of the two Italian comparative assemblages. The analogues in the oral health between these assemblages may not be coincidental but the result of the operation of common economic, social and environmental pressures that imposed the practice of similar subsistence activities. Note that the lower frequency of dental diseases in Lucus Feroniae, as suggested by Manzi et al. (1999), p. 337, points to a better diet sustained by both the locally operated agricultural activities and the geographical and economic links with a large urban center, such as Rome.

In terms of sex biases, comparisons of the Pontokomi-Vrysi male and female dental disease frequency per individual with that of the Italian sites reveals a complicated picture. Caries and AMTL show the highest frequency among Quadrella males followed by Pontokomi-Vrysi females, while in the latter assemblage both sexes show an additional high frequency in periapical cavities. The overall periodontitis frequencies are high for Pontokomi-Vrysi and Lucus Feroniae but the former prevails for both sexes. The patterns emerging are more straightforward for sexual dimorphism in calculus, with Quadrella and Pontokomi-Vrysi showing the same high frequencies for both sexes when compared to Lucus Feroniae. The above results underline the effect of the regional environment in the expression of oral conditions in the groups under comparison, with the expression of the diseases likely being dictated by climate, microecology, subsistence economy, status and other factors. Current global epidemiological studies have shown that sex plays a secondary role in the prevalence of oral diseases, while age, geographic variation and income are more responsible for their frequency and distribution (Marcenes et al., 2013; Frencken et al., 2017), a case probably seen in the ancient groups studied here.

Based on available published data, it is not possible to compare the frequency of dental diseases per individual and by sex between Pontokomi-Vrysi and the other two Greek sites. The comparison, however, of the affected frequencies per tooth shows some interesting results (Table 10). While temporally different, Pontokomi-Vrysi and Galani-Sourtara rural populations belong to the same semi-mountainous region of western Macedonia. Despite that, Galani-Sourtara frequencies on caries, periapical cavities and calculus are notably lower than the Pontokomi-Vrysi ones while AMTL is much more frequent. It is difficult to explain the difference between the two assemblages, but it might be related to an early Byzantine population experiencing better living conditions that led to a consequent better oral health regime and possibly better diet. In view of these, the higher AMTL frequencies for the Galani-Sourtara population necessitates the search of a variety of other possible explanations, which are not currently available. The second assemblage, while contemporaneous to Pontokomi-Vrysi, comes from the important Macedonian city of Amphipolis that displays a contrasting micro-ecological and geopolitical profile as it is located in an important strategic location at the mouth of the river Strymon in eastern Macedonia (Koukouli-Chrysanthaki, 2011). Considering the diametrically opposite rural character of Pontokomi-Vrysi to that of urban Amphipolis, their similarity in the caries frequencies is notable. However, the lower frequency of periapical cavities, AMTL, and calculus in Amphipolis suggests a better diet and oral hygiene practices in this site.

As already discussed in the Methods section, small differences in the demographics of the assemblages under comparison, coupled with the generally small sample sizes, render the above results and associated interpretations tentative. Ancient Graeco-Roman literature supports the importance of carbohydrates in past diet, as further attested by the oral health profile of Pontokomi-Vrysi and the comparative assemblages (Donahue, 2015). Having this in mind, the differences in the frequencies between the studied sites may be more easily explained. While carbohydrate-based staples such as cereals, fruits and vegetables formed the basic dietary constituent of those inhabiting the vast Graeco-Roman world, universal dietary patterns should not be expected when a combination of diverse or interrelated social, economic, geographical, environmental and/or genetic factors were at play in each region. Instead, what can be assumed, is the unique adaptive response of each population to certain local pressures mandating the adoption of particular subsistence strategies influencing subsequently their oral health and consumption profile. In this way, for example, the differences and similarities between Pontokomi-Vrysi, Galani-Sourtara and Quadrella may be explained.

The supplementary, however, consumption of protein-based foodstuffs should not be excluded for the Pontokomi-Vrysi population when both the high frequency of calculus and geographically and environmentally induced dietary choices are taken into consideration. The area where the cemetery was found once belonged to the Upper Macedonian lands of *Eordaea,* which in Roman times became part of the fourth administrative republic of the Roman Province of Macedonia

(Hammond, 1972, p. 110). The area consists of small fertile plains and lakes surrounded by mountains and hills connected with the neighboring regions through a well-organized road system centered on the *Via Egnatia* (Hammond, 1972, pp. 106–110). The Pontokomi-Vrysi cemetery was found in the semi-mountainous area of *Eordaea* residing at the eastern foothills of the mountain range of *Askion* or *Siniatsikos*, an area characterized by limited forest cover and extensive bare areas (Ntassiou and Doukas, 2019, p. 165). This semi-mountainous environment favors livestock breeding and transhumance practices, which have a long history in the region (Hammond, 1972, p. 15; Ntassiou and Doukas, 2019). Taking into account the micro-ecology of the site, it is possible that the Pontokomi-Vrysi community relied on a mixed subsistence economy, depending on both small-scale agricultural activities and animal husbandry. As such, cereals, vegetables, but also meat, all must have been basic dietary elements and the oral health profile of the Pontokomi-Vrysi assemblage seems consistent with this pattern.

While a dietary profile like the one presented above may seem ideal to maintain a healthy lifestyle, stress levels in Pontokomi-Vrysi are high, as indicated by the frequency of enamel hypoplasia, pointing to general systemic stress factors. The semi-mountainous environment might be good for the flocks during summer but the winter in the region is harsh with heavy snow affecting the higher plains (Ntassiou and Doukas, 2019). Given, also, the harsh limited routes across the mountains, communication of the Pontokomi-Vrysi inhabitants with the other parts of *Eordaea*, *Via Egnatia* and Upper Macedonia must have been limited, thus restricting access to other important for healthy maintenance food resources (Thomas, 2010). In that context, the enamel defects observed in Pontokomi-Vrysi might be indicative of the environmental stress that its population had to endure daily.

8. Conclusions

This study set out to explore differences in the oral health between males and females in the Pontokomi-Vrysi Roman rural population of the *Provincia Macedonia.* Analysis revealed an overall homogenous oral health profile for the assemblage, pointing to a rather undifferentiated lifestyle and dietary profile between the two sexes. These findings will be scrutinized by future isotopic analysis, but they are significant in at least one major aspect; they provide one of the first detailed accounts of the most important oral conditions for the Roman times in North Greece.

CRediT authorship contribution statement

Chryssa Vergidou: Conceptualization, Formal analysis, Project administration, Writing - review & editing, Writing - original draft. **Georgia Karamitrou-Mentessidi:** Conceptualization, Resources. **Sofia Voutsaki:** Conceptualization, Funding acquisition, Supervision. **Efthymia Nikita:** Conceptualization, Funding acquisition, Supervision, Methodology, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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