

BUKTI KORESPONDENSI

ARTIKEL JURNAL INTERNASIONAL TERAKREDITASI Q3

Judul artikel : The Occurrence Of Onamel Hypoplasia, Porotic Hyperostosis And Cribra Orbitalia In Three Prehistoric Skeletal Assemblages From Indonesia

Jurnal : Jurnal Bulletin of the International Association for Paleodontology Vol 12 No 2; December 2018; Hal 33-40

Penulis : 1. Toetik Koesbardiaty, 2. Delta Bayu Murti, 3. Dessytri Ayu Herina, 4. Ayu Ambar Sari

No.	Perihal	Tanggal
1	Bukti konfirmasi submit artikel dan artikel yang disubmit	28 Oktober 2018
2	Bukti konfirmasi review dan hasil review	21 November 2018
3	Bukti konfirmasi submit revisi & artikel yang disubmit	14 Desember 2018
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No.	Perihal	Tanggal
1	Bukti konfirmasi submit artikel dan artikel yang disubmit	28 Oktober 2018

Workflow

Publication

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Original Paper

**The Occurrence of Enamel Hypoplasia, Porotic Hyperostosis and Cribra Orbitalia in
Three Prehistoric Skeletal Assemblages from Indonesia**

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Abstract

Enamel hypoplasia (EH), porotic hyperostosis (PH) and cribra orbitalia (CO) have frequently been used to indicate the presence non-specific stress during child-growth periods. They are routinely assessed to investigate health along with patterns of morbidity and mortality of past populations. This study aims use macroscopic analyses to describe and analyse the presence of EH, PH and CO in three prehistoric populations that lived in different environments - coastal and mountainous.

For this study, we analysed human skeletons from Melolo, Lewoleba and Liang Bua- three sites situated in Nusa Tenggara Timur, Indonesia. The first two sites, Melolo, Sumba Island, and Lewoleba, are coastal sites whereas Liang Bua is located on a mountainous range in Flores.

Excavations in Melolo, East Sumba, conducted in the 1930s, discovered 19 human skeletons buried in urns. Three individuals from the Melolo skeletal sample displayed EH (16%), 21% individuals were recorded to possess CO and 26% experienced PH. Excavation of the Lewoleba site, Lembata Island, were conducted in 1961 and yielded 5 human skeletons. No EH was observed in the Lewoleba sample but 40% displayed PH and xxx displayed CO. The excavation of Neolithic skeletons from Liang Bua, Flores, yielded 7 individuals who displayed PH, CO, and EH (57%, 57% and 14% respectively). Surprisingly, the study in Liang Bua depicted the highest percentage compared to that of in Melolo and Lewoleba populations.

Keywords:

Enamel Hypoplasia, Porotic Hyperostosis, Cribra Orbitalia, Prehistoric populations in Indonesia

Introduction

The study of paleopathology leads to a deeper comprehension towards the occurrence, causes, and frequency of particular diseases and incidence of physiological stress in past populations (refs). Additionally, palaeopathological investigations can also provide further information about health, trauma, lifestyle, activity, nutrition, ancestry and working conditions in ancient times (refs).

Enamel Hypoplasia (EH) is one of the most common indicators of non-specific stress that are observed in both prehistoric and modern humans from around the world (1,2,3,4). Kanchan et al. (5) states that dental enamel hypoplasia is a developmental anomaly caused by perturbed amelogenesis. Its presence is obvious if matrix formation is affected and may manifest as pitting, grooving or even a total absence of enamel. Linear enamel hypoplasia are grooves or pits on the enamel of tooth resulted from the disruption in the formation of the enamel during a prolonged period of stress during the time of tooth formation (i.e. infancy and childhood) (4). Ortner (6) further elaborated that the normal formation of dental tissue can be

affected by several infectious diseases, primarily congenital syphilis and tuberculosis, metabolic and endocrine disorders. Therefore, EH is a useful indicator in investigating systemic disturbances of childhood growth, and the analysis of EH is routinely implemented to investigate patterns of morbidity and mortality in the past populations (refs).

Porotic hyperostosis (PH) is thought to develop as a result of anaemia, commonly caused by nutritional stress. According to Aufderheide and Rodriguez-Martin (7), PH is observable from the presence and distribution of small, pinpoint cranial lesions involving the outer table of the frontal, parietal, and much less frequently, the occipital bones of the skull, usually in a symmetrical manner (i.e. both sides of the cranium). In the fully developed lesion, the involved areas of the skull are thickened by the expansion of the diploic layer of the cranium, while the outer table overlying the lesions will have completely been resorbed. This permits the direct visualization of the trabeculae of the expanded diploic bone, and the appearance of the coarsening trabeculae. Aufderheide and Rodriguez-Martin note that PH has also been referred to as symmetrical hyperostosis, hyperostosis cranii, and spongy hyperostosis. Moreover, Cribra Orbitalia (CO) belongs to PH which is Hyperostosis Spongiosa Orbita (clarify this sentence and ref). CO is commonly found in the orbital roof, especially in the narrow space along the anterolateral portion of the superior orbit. According to Aufderheide and Rodriguez-Martin, 90% of the recorded cases of CO appear as bilateral lesions. It is also further clarified by these researchers that the appearance of PH is often followed by CO is more frequently discovered than PH (clarify this sentence). Hence, CO is considered by Aufderheide et al (date) to be a more sensitive indicator of non-specific stress in childhood.

The purpose of this study is to describe the occurrence of EH, PH and CO in prehistoric populations from the sites of Melolo, Lewoleba and Liang Bua, Indonesia, and use this information as a proxy for understanding childhood health. Also, this study was designed to analyse the correlation between the presence of EH, PH, and CO among the three subjected populations (clarify this).

Materials and Methods

The skeletal samples analysed in this study are from archaeological sites in the eastern province of Nusa Tenggara Timur, eastern Indonesia (Fig. 1).

Melolo

In terms of its natural resources, Melolo is considered to be one of the richest sites in terms of resources because of the longer dry season compared to the rainy season (expand on why this makes it richer). Moreover, Melolo is overgrown with mangroves and other plants such as palm and coconut trees. Sites in Melolo also contain thin lime and tuff soils (9) (what does this mean in the context of the site?). A number of excavations have been conducted in the Sumba region, including Melolo, that found in human skeletal remains in burial jars (10). The skeletal assemblage analysed for the present study are from the 1939 excavation conducted by W.J.A. Willems and the 1949 excavation conducted by A. Buhler. The remains are currently curated in Department of Anthropology, Universitas Airlangga, Indonesia. Snell (ref) documented the 19 individuals in the assemblage represented by skulls. No postcranial skeletal elements are present in the Melolo skeletal collection. The current condition of the Melolo skulls is fragmentary and a total of xxx were analysed for the current study. (Mention dates for the site)

Lewolaba,

Lewolaba is located on Lembata Island, East Flores, Nusa Tenggara Timur province. It is situated in on the south side of a bay next to a formation of sand-cliffs (11). Geologically, the bay is an unstable site because its formation is relatively new. This can be indicated by the changes of the coastal lines along with the rare existence of sea algae (clarify this) (11). Bemelen (9) states that this type of environmental condition occurs as a result of frequent earthquakes, which are typical to the region because it is located in the Pacific Ring of Fire. Several kilometres from the coastal line there is a hill composed of limestone containing calcite

made up of Mollusc fossils, Echinoidea, and other shells of dead marine organism (say why this is important). Several stone-tools made from obsidian, basalt, calcedon, and jasper were found at the site (11) (say why this is important-e.g. means that it is Neolithic community).. The living conditions on Lembata Island is improved by its close proximity to other small islands such as Alor, Solor, Pantar and Adonara, which can be reached by crossing ocean straits. Sukadana (8) explained that commodities in Lewolaba did not come from the island, rather they were imported from nearby islands. Therefore, as a result of the trade and exchange of food with nearby islands, the nutrition requirements of Lewolaba islanders can be fulfilled (in modern times/prehistoric?). Additionally, there is temperate rainforest across Lewoleba that contains a variety of (edible/non edible?) plant, including a high density of thicket (scientific name) and thicket (scientific name)(used for building supplied?). The first excavation on Lewolaba Island was conducted by T. Verhoeven in 1961. He discovered five human skulls that were later C¹⁴ dated to 2990±160 BP (state lab etc) (9) and are representative of the Neolithic period for the region. Faunal remains from shellfish and animal bones were found at the site (expand on this). The skeletal human remains from the Lewoleba site are currently curated in Department of Anthropology, Airlangga University.

Liang Bua

Liang Bua, a cave-site, is approximately 11 kilometres away from Ruteng, the capital city of the West Manggarai region. It is situated deep in a rural about 500 metres above sea level in karst topography. Surrounding the cave is a vast spread of temperate rain forest along with heterogeneous forest (explain what this is) supports a wide range of wildlife including (mention some of the animals) (12). The first excavation of Liang Bua site was conducted in 1965 by T.H. Verhoeven, who discovered five skeletons, which are now curated at the Department of Anthropology, Airlangga University. In (state year) an excavation was conducted by Arkenas (National Institute of Archaeology) that yielded 9 human skeletons, only two of which had a skull. These two skulls are curated at the Laboratory for Biological

Anthropology and Palaeoanthropology, University of Gadjah Mada, Yogyakarta. Some of the faunal remains (bones and seashells) found during the most recent excavation are believed to be the remains of food (refs).

The research method employed in this study was macroscopic analysis with the use of a magnifying glass (state magnification) to assess the prevalence of EH, PH, and CO in each skeletal sample. Sex and age of the subjects was previously determined (state method and refs). In terms of age, there are six classification as infants and children (0-7 years), juveniles (8-16 years), older adolescents (17-22 years), young adult (23-30 years), mid adult (30 to 50 years) and old adult (older than 50 years) (13) (there are all these age categories but most people appear as an 'adult' in the tables).

Provide a summary of how you identified EH, PH and CO (e.g. the extent of pitting, the teeth analysed etc.).

Results

Table 1 presents the occurrence of EH, PH and CO observed in the Melolo skeletal assemblage (see also Figs 2,3,4). Of the 19 individuals assessed, 4 individuals displayed CO (21%), 5 displayed PH (26%), and the 3 were affected by EH (16%). One individual displayed both CO and PH (Table 4). There does not appear to be any pattern in the prevalence of EH, PH, and CO in age or sex or age groups (but there is only one adult age group detailed). The average age which could be identified belong to adult group ranging from 23 to 30 years old (see comment in other response).

Table 2 details the occurrence of EH, CO and PH in the Lewoleba skeletal sample. Unlike in that of Melolo sample, CO and EH were not observed in the Lewoleba assemblage. In total, 40% (2/5) of the individuals from Lewoleba displayed PH. It was also implied from these subjects that the appearance of PH was not correlated to any particular sex (but only males were affected and there was only one female, clarify this). All but one of the individuals from

the Lewoleba skeletal sample were categorised in the 'adult' age group and only the adults displayed evidence for PH..

Table 3 details the occurrence of CO, EH, and PH in the Liang Bua skeletal sample. In total, 4/7 individuals (57%) displayed CO. The same number of individuals (4/7, 57%) displayed PH; only one individual (1/7, 14%) displayed EH. Two of the seven individuals from Liang Bua (29%) had both CO and PH and only one individual (14%) had the combination of PH and EH. Both males and females from the Liang Bua sample were affected by PH and CO, but only one male had EH. All but one of the individuals in the Liang Bua sample, were adults and therefore it is not possible to assess potential age-related difference in the prevalence of EH, CO, and PH.

Discussion

The difference in the prevalence rates of CO, PH, and EH between the three skeletal samples (Table 4) indicates that the individuals from Lewoleba were less affected, not affected at all, by these pathological conditions. Compared to that of Liang Bua and Melolo, Lewoleba displayed only PH, whereas PH, CO, and EH were present in both the Liang Bua and Melolo skeletal samples.

In line with Aufderheide and Rodriguez-Martin (ref year) and Ortner (ref year), PH and CO were the most commonly observed conditions in the skeletal samples. If PH and CO in these assemblages developed as a result of nutritional stress, it is possible that a contributing factor may be a micronutrient deficiency which can cause anaemia (e.g. iron) and contribute to compromising the immune response (refs). PH and CO develop during childhood as a result of non-specific stress that may cause a disruption in growth (refs). It is suggested that the possible nutritional deficiency that resulted in the development of PH and CO, may have caused a disruption in enamel formation (EH) in the Liang Bua and Melolo samples. It is known that malnutrition can retard physical growth and development, which in turn negatively influences the morbidity and mortality profiles of a population (refs). PH, CO and EH conditions are the

result of episodes of physiological stress during childhood (16, 17). Therefore, the high frequency PH and CO observed in all the three skeletal samples suggests compromised childhood health, possible malnutrition and environmental stress (14,15).

Another possibility is the influence of certain parasitic diseases on the development of PH and CO. Bahn et al. (18) state that diseases such as malaria (**add scientific name**) and hookworm (**add scientific name**) may act to exacerbate the negative health effects of malnutrition. Dale (19) elaborate that PH and CO are formed as a result of episodes of anaemia during childhood. This hypothesis is also supported by Stuart-Macadam (17) who proposed that iron deficiency anaemia may be more related certain infections rather than diet.

The risk of malnutrition and certain diseases, especially malaria, is closely associated with the environment a person lives in. Because of the close proximity to the ocean, the populations from Melolo and Lewoleba would have been coastal dwellers and the population from Liang Bua would have lived inland (figure 1). The results of the current analyses indicate that the dwellers of mountainous range, Liang Bua, experienced a higher frequency of PH, CO, and EH than the populations living in coastal areas, Melolo and Lewoleba. This evidence contradicts that of Suby (20), who suggests that people with terrestrial diets are less susceptible to the development of PH and CO compared to people with marine and mixed marine/terrestrial diets. The current study found that the inland population from Liang Bua, who ate a presumably terrestrial diet because of the distance of the site from the sea, were more vulnerable to the development of PH, CO, and EH compared with the coastal population (**expand on why you think this is, malnutrition, malaria, hookworm?**).

The explanation of why the Melolo population, who lived in the coastal area and presumably ate a diet with a high proportion of marine foods in it, also exhibited a high prevalence rate of PH, CO, EH (and the combination of PH/CO) is possibly a result to exposure to parasites that can be found in marine foods (**expand on this**). Intestinal parasites can cause nutritional deficiencies and intestinal bleeding, which can lead to anaemia (**refs**). **Discuss**

Lewoleba here and why they did not display a high rate of the conditions. As discussed above, although the locations of the excavated sites are near the coast, the level of interaction of the people from Melolo with other communities may have been lower than that known to have occurred on Lewoleba. Could trade and exchange of foods mediate the stress observed in childhood? Discuss malaria and hookworm in the coastal population. Is malaria endemic to all area? Could the Lewoleba people experienced very high acute stress in childhood that killed them and therefore there is no record, eg no LH, CO or PH?

There were several limitations of this study, including the small sample sizes and fragmentary nature of some of the remains. More research is needed to determine the diets of the populations under study. Future research will include stable isotope analysis to assess palaeodiet and strontium isotope and ancient DNA analyses to help address migration and ancestry of these prehistoric Indonesian populations.

Conclusion

The number of pathological markers, especially PH, CO and EH in human skeletal remains from Melolo, Liang Bua and Lewoleba show a large proportion of the analysed individuals experienced stress in childhood. This stress may have been caused by malnutrition and parasites which put the individuals at risk of developing anaemia. The highest percentage of PH and CO was observed in the Liang Bua individuals who lived at an inland site, possibly a result of environmental stress related to food resource availability. Lower frequencies of these conditions were observed in the Melolo and Lewoleba individuals, who were coastal dwellers. Parasites in their marine diet may have played a role in the development of these conditions in these coastal dwelling populations (why the difference between Melolo and Lewoleba? What about malaria and hookworm). The different environmental conditions at each site, types of subsistence, food resource availability, disease presence, cultural practices such as the length of breastfeeding and time of weaning, and susceptibility to disease all likely played a role in the

stress experienced during childhood, observable from the presence of EH, CO and PH, in the these three prehistoric populations from Indonesia.

Acknowledgement

We thank to FISIP Fakultas Ilmu Sosial dan Ilmu Politik, Universitas Airlangga, for giving us the fund from RKAT 2017. We would like to thank Rusyad Adi Suriyanto for allowing us to study the two skull of Liang Bua under his care.

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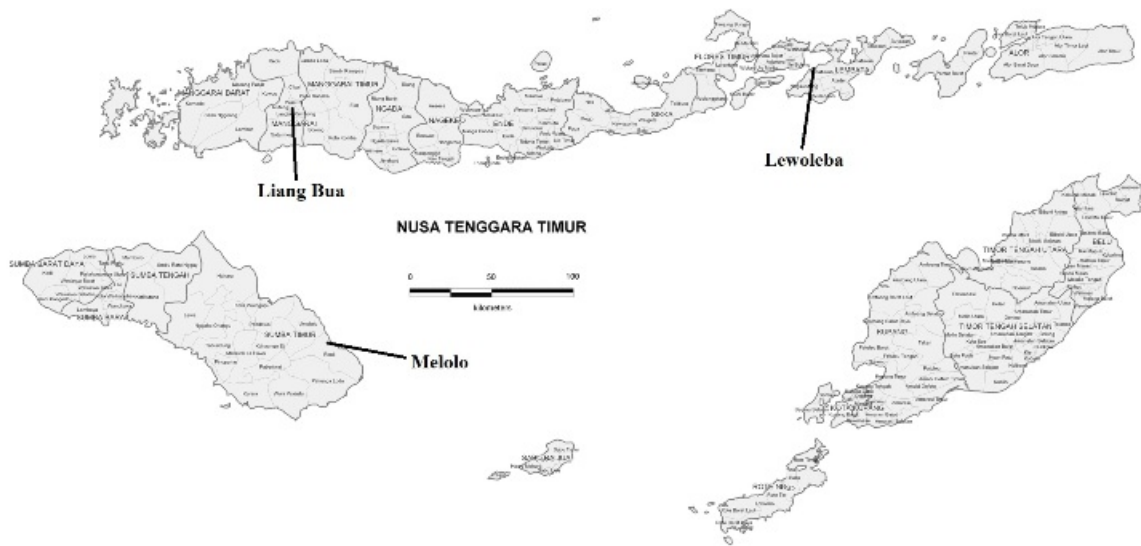


Figure 1. Location of Melolo (Sumba Island), Liang Bua (Flores Island) and Lewoleba (Lembata Island) in the Nusa Tenggara Timur Province.

Table 1. The occurrence of EH, PH and CO in Melolo skeletal sample

Individual	Age	Sex	PH	CO	EH
Urne 1	Infants	?	--	V	--
Urne 2.1.	Adult	Male	V	--	--
Urne 2.2	Adult	Female	--	--	V
Urne 2.3.	Adult	Female	--	--	--
Urne 3	Adult	Male	--	--	V
Urne 5.1.	Adult	Female	V	--	--
Urne 5.2.	Adult	Female	--	--	--
Urne 8.1.	Adult	Female	V	--	--
Urne 8.2.	Adult	Female	--	--	--
Urne A	Adult	Female	--	--	--
Urne B	Adult	Male	V	--	--
Urne E.1.	Adult	Male	--	--	V
Urne E.2.	Adult	Female	--	--	--
Urne E.3.	Adult	Female	--	--	--
Urne G.1.	Adult	Female	--	--	--
Urne G.2.	Juvenile	Female	--	--	--
Urne H	Adult	Male	--	V	--
Urne J	?	Male	--	V	--
Urne Buhler	Adult	Male	V	V	--

Table 2. The occurrence of EH, PH and CO in Lewoleba skeletal sample

Individual	Age	Sex	PH	CO	EH
LL I.1	Juvenile	Female	--	--	--
LL I.2	Adult	Male	--	--	--

LL I.3	Adult	Male	V	--	--
LL I.4	Adult	Male	V	--	--
LL I.5	Adult	Male	--	--	--

Table 3. The occurrence of PH, CO and EH in Liang Bua skeletal sample

Individual	Age	Sex	PH	CO	EH
LB/1	juvenile	Male	--	V	--
LB/2	adult	Female	--	V	--
LB/3	adult	Male	V	V	--
LB/5	adult	Male	V	--	V
LB/6	adult	Female	V	V	--
RIV	adult	Male	V	--	--
RVI	adult	Male	--	--	--

Table 4. The percentage of EH, PH, and CO in each of the three skeletal samples

Situs	EH	PH	CO	EH/PH	EH/CO	PH/CO	EH/PH/CO
Melolo	16	26	21	--	--	5	--
Lewoleba	--	40	--	--	--	--	--
Liang Bua	14	57	57	14	--	29	--



Figure 2. EH on I¹ teeth of Melolo Urne 2 (A); EH on C-M² teeth of Melolo Urne E.1 (B); EH on canine teeth of maxilla (left and right) of LB/5 (C).

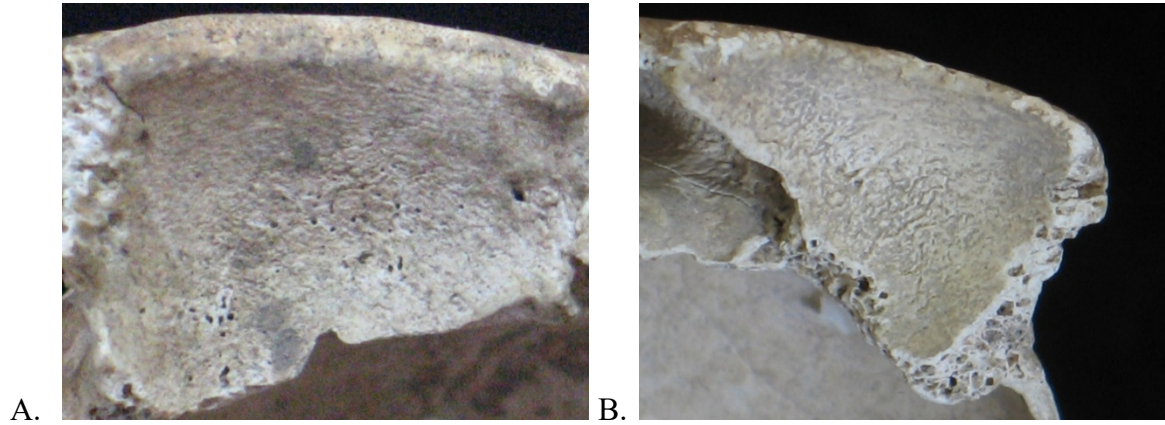


Figure 3. CO on right eye orbits of LB/3 (A), and CO on left eye orbits of Melolo Urne J (B).

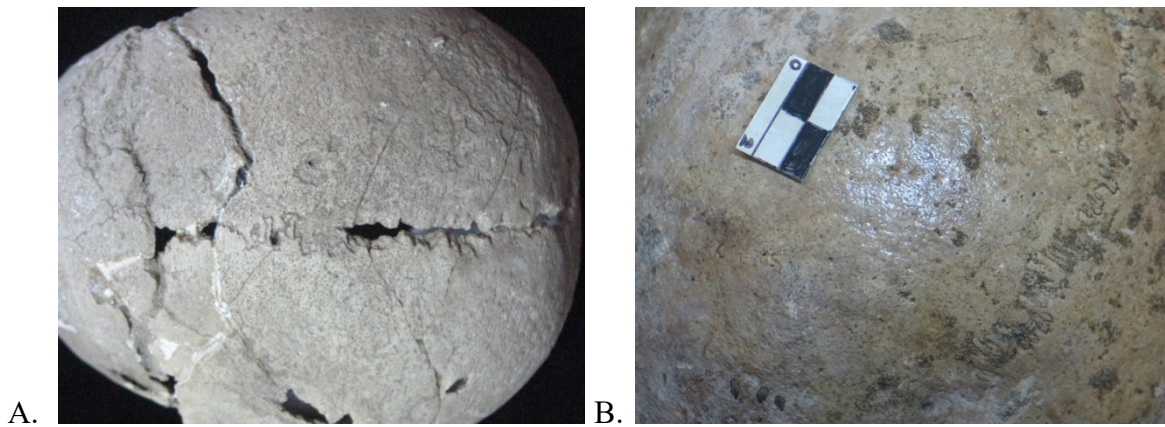


Figure 4. PH on parietal bones of Melolo Urne 2 (A), and PH on left parietal bone of LL 1.4 (B)

BUKTI KORESPONDENSI

ARTIKEL JURNAL INTERNASIONAL TERAKREDITASI Q3

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No.	Perihal	Tanggal
2	Bukti konfirmasi review dan hasil review	21 November 2018

Reviewer's Attachments

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November
21, 2018

Notifications



[Bull Int Assoc P] Editor Decision

2018-11-26 09:00 AM

Toetik Koesbardiati, Delta Bayu Murti, Delta Bayu Murti, Desytri ayu Herina, Ayu Ambar Sari:

We have reached a decision regarding your submission to Bulletin of the International Association for Paleontology, "The The Occurrence of Enamel Hypoplasia, Porotic Hyperostosis and Cribra Orbitalia in prehistoric people in Indonesia".

Please read reviewers comments and perform requested changes. Please submit your revised manuscript as soon as possible but not later than December 10th 2018. Thank you

Marin Vodanović
vodanovic@sfzg.hr

Reviewer A:

Recommendation: Revisions Required

[Bull Int Assoc P] Editor Decision > Kotak Masuk x



Marin Vodanović vodanovic@sfzg.hr [lewat](#) srce.hr
kepada saya, Delta, Desytri, Ayu ▾

26 Nov 2018, 15.00 ☆ ↶ ⋮

Toetik Koesbardiati, Delta Bayu Murti, Delta Bayu Murti, Desytri ayu Herina, Ayu Ambar Sari:

We have reached a decision regarding your **submission** to Bulletin of the International Association for Paleodontology, "The The Occurrence of Enamel Hypoplasia, Porotic Hyperostosis and Cribra Orbitalia in prehistoric people in Indonesia".

Please read reviewers comments and perform requested changes. Please submit your revised manuscript as soon as possible but not later than December 10th 2018. Thank you

Marin Vodanović
vodanovic@sfzg.hr

Reviewer A:
Recommendation: Revisions Required

CATEGORY OF MANUSCRIPT

original scientific paper

TITLE OF PAPER: Clear, concise

Yes

ABSTRACT: Concise, informative

Yes

INTRODUCTION: Concise

Yes

INTRODUCTION: Focusing on problem

No

OBJECTIVE(S): Clear

No

OBJECTIVE(S): Important

Yes

STUDY DESIGN: adequate

Yes

METHODS: appropriate

Yes

METHODS: Precisely documented

No

MATERIALS: Numbers adequate

No

STATISTICS: Methods appropriate

N/A

STATISTICS: Interpretation correct

N/A

RESULTS: All presented

Yes

RESULTS: Without bias and repetition

Yes

TABLE(S): All necessary

Yes

TABLE(S): Delete (specify)TABLE(S): Legend(s) clear

Yes

FIGURE(S): All necessary

Yes

FIGURE(S): Delete (specify)FIGURE(S): Legend(s) clear

Yes

DISCUSSION/CONCLUSIONS: Clear, concise

No

DISCUSSION/CONCLUSIONS: Without repetition

Yes

DISCUSSION/CONCLUSIONS: Supported by the data

Yes

REFERENCE TO PREVIOUS WORK: Complete

No

REFERENCE TO PREVIOUS WORK: Add (specify)

Need to add more references (noted in the uploaded document)

REFERENCE TO PREVIOUS WORK: Up to date

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Yes

Additional comments regarding English language (if any)

I have corrected grammatical mistakes in the uploaded document

Concept(s) of the study/manuscript

New

Importance of the manuscript

High

Scientific quality of the manuscript

High

Study within the scope of the Journal

Yes

Final Recommendation:

Acceptable with suggestions for minor revision

Comments for authors (if any)

Dear editor and authors,

This paper is an investigation of non-specific stress of prehistoric Indonesian people through the analysis of enamel hypoplasia, porotic hyperostosis and cribra orbitalia. It is one of the first comprehensive research studies of this topic in the region. This study provides important information about the childhood stress observed in populations from different environments.

I have made corrections to the manuscript to correct grammatical mistakes but my track changes stopped working. I have uploaded the manuscript with my amendments.

Some other comments (many comments are directly highlighted in the text) :

Abstract:

The reasons for undertaking the study should be explicitly stated in the abstract and introduction.

Say why you are interested in looking at stress in populations from different environments.

Note the dates of the sites in the text.

Note when the Liang Bua excavation occurred to stay consistent with the other site descriptions.

Say how many total individuals were included in this study for each skeletal sample.

Say in the abstract why you think there were differences in the prevalence rates between the coastal and mountain dwellers.

Introduction

The first paragraph needs references to support the statements.

Elaborate on the suggested causes of CO.

More corrections are identified in the text.

At the end of the introduction, state the sites are located in different environments (like in the abstract) and say why this is important. You could introduce some hypotheses here about how the different environments may affect health.

Say what the overall purpose of the study is at the end of the introduction.

Materials and Methods

There are two spellings for Lewoleba in the text (also spelled Lewolaba), just make the spelling consistent throughout.

State the number of individuals assessed in this study for each skeletal sample. If the individual did not have orbits or a cranial vault, they cannot be said to NOT have PH or CO. It should be detailed on the table who had the skeletal elements available for analysis. This may affect the prevalence rates.

Clarify if Sukadana's study was of modern or prehistoric people, it is not clear from the text.

Expand on what the wide range of food would be.

The reason for breaking the ages up in those groupings should be explained as only the 'adult' age range is detailed in the tables for the adults.

The method for the identification of PH, CO and EH needs to be discussed more. How much of the skull or orbit needed to be present to make an assessment of PH and CO? Were all the teeth assessed (usually people only use the anterior teeth). How much pitting needed to be present to positively identify PH and CO. Were healed lesions included? How many teeth, overall, needed to be present to include them as an "individual" in the analysis?

Results

It seems that there is mostly the Adult age category for Melolo, but how was this estimated as there were only fragmentary skulls available? Is it an undefined Adult age category? This is fine, but just note this in the text. Also, how was the sex determined from fragmentary remains? It is ok to have an unknown sex estimate.

The age definitions should be amended in the tables to the correct wording (corrected in the 'Methods' section).

Discussion

The results do not need to be repeated in the discussion (eg prevalence rates). I have removed the repeated parts.

How do the results fit into the concepts of the Osteological Paradox? This may help tease out the interpretations from the results.

There needs to be a discussion about what the diet at each site would likely be from other lines of evidence (like horticultural foods, root veggies, hunted food, inshore marine foods etc)

If marine parasites are suggested as being the reason that there is a high prevalence of the conditions, this does not support why Liang Bua shows a high prevalence rate and Lewoleba shows a low prevalence rate (as Lewoleba would have been eating marine foods, presumably). Malaria and hookworm were mentioned earlier, these should be discussed. Maybe different risks in different areas because of the environments?

Thank you.

The following message is being delivered on behalf of Bulletin of the International Association for Paleodontology. _____

Original Paper

**The Occurrence of Enamel Hypoplasia, Porotic Hyperostosis and Cribra Orbitalia in
Three Prehistoric Skeletal Assemblages from Indonesia**

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Abstract

Enamel hypoplasia (EH), porotic hyperostosis (PH) and cribra orbitalia (CO) have frequently been used to indicate the presence non-specific stress during child-growth periods. They are routinely assessed to investigate health along with patterns of morbidity and mortality of past populations. This study aims use macroscopic analyses to describe and analyse the presence of EH, PH and CO in three prehistoric populations that lived in different environments - coastal and mountainous.

For this study, we analysed human skeletons from Melolo, Lewoleba and Liang Bua- three sites situated in Nusa Tenggara Timur, Indonesia. The first two sites, Melolo, Sumba Island, and Lewoleba, are coastal sites whereas Liang Bua is located on a mountainous range in Flores.

Excavations in Melolo, East Sumba, conducted in the 1930s, discovered 19 human skeletons buried in urns. Three individuals from the Melolo skeletal sample displayed EH (16%), 21% individuals were recorded to possess CO and 26% experienced PH. Excavation of the Lewoleba site, Lembata Island, were conducted in 1961 and yielded 5 human skeletons. No EH was observed in the Lewoleba sample but 40% displayed PH and CO was not found in the Lewoleba samples. The excavation of Neolithic skeletons from Liang Bua, Flores, yielded 7 individuals who displayed PH, CO, and EH (57%, 57% and 14% respectively). Surprisingly, the study in Liang Bua depicted the highest percentage compared to that of in Melolo and Lewoleba populations.

Keywords:

Enamel Hypoplasia, Porotic Hyperostosis, Cribra Orbitalia, Prehistoric populations in Indonesia

Introduction

The study of paleopathology leads to a deeper comprehension towards the occurrence, causes, and frequency of particular diseases and incidence of physiological stress in past populations (1). Additionally, palaeopathological investigations can also provide further information about health, trauma, lifestyle, activity, nutrition, ancestry and working conditions in ancient times (1).

Enamel Hypoplasia (EH) is one of the most common indicators of non-specific stress that are observed in both prehistoric and modern humans from around the world (1, 2, 3, 4). Kanchan et al. (5) states that dental enamel hypoplasia is a developmental anomaly caused by perturbed amelogenesis. Its presence is obvious if matrix formation is affected and may manifest as pitting, grooving or even a total absence of enamel. Linear enamel hypoplasia are grooves or pits on the enamel of tooth resulted from the disruption in the formation of the enamel during a prolonged period of stress during the time of tooth formation (i.e. infancy and

childhood) (4). Ortner (6) further elaborated that the normal formation of dental tissue can be affected by several infectious diseases, primarily congenital syphilis and tuberculosis, metabolic and endocrine disorders. Aufderheide and Rodriguez-Martin (7) stated that malnutrition is the most causes cited. Others are environmental factors such as haemolytic disease, premature birth, major febrile infection, dietary deficiencies of vitamin A, C and D. Therefore, EH is a useful indicator to investigate the childhood growth and the patterns of morbidity and mortality in the past populations (8)

Porotic hyperostosis (PH) is thought to develop as a result of anaemia, commonly caused by nutritional stress. According to Aufderheide and Rodriguez-Martin (7), PH is observable from the presence and distribution of small, pinpoint cranial lesions involving the outer table of the frontal, parietal, and much less frequently, the occipital bones of the skull, usually in a symmetrical manner (i.e. both sides of the cranium). In the fully developed lesion, the involved areas of the skull are thickened by the expansion of the diploic layer of the cranium, while the visualization of the trabeculae of the expanded diploic bone, and the appearance of the coarsening trabeculae. Aufderheide and Rodriguez-Martin note that PH has also been referred to as symmetrical hyperostosis, hyperostosis cranii, and spongy hyperostosis. CO is commonly found in the orbital roof, especially in the narrow space along the anterolateral portion of the superior orbit. According to Aufderheide and Rodriguez-Martin, 90% of the recorded cases of CO appear as bilateral lesions. It is also further clarified by these researchers that the appearance of PH is often followed by CO. Hence, CO is considered by Aufderheide (1990) to be a more sensitive indicator of non-specific stress in childhood.

The purpose of this study is to describe the occurrence of EH, PH and CO in prehistoric populations from the sites of Melolo, Lewoleba and Liang Bua, Indonesia, and use this information as a proxy for understanding childhood health. Also, this study was designed to analyse the relationship between the presence of EH, PH, and CO among the three subjected populations and the geographical environment (coastal and mountainous regions).

Materials and Methods

The skeletal samples analysed in this study are from archaeological sites in the eastern province of Nusa Tenggara Timur, eastern Indonesia (Fig. 1).

Melolo

A number of excavations have been conducted in the Sumba region, including Melolo, that found in human skeletal remains in burial jars (9). The skeletal assemblage analysed for the present study are from the 1939 excavation conducted by W.J.A. Willems and the 1949 excavation conducted by A. Buhler. The remains are currently curated in Department of Anthropology, Universitas Airlangga, Indonesia. Both, W.J.A. Willems and A. Buhler submitted their findings from Melolo to Snell (10). Snell documented the 19 individuals in the assemblage represented by skulls. No postcranial skeletal elements are present in the Melolo skeletal collection. The current condition of the Melolo skulls is fragmentary and a total of 19 were analysed for the current study. The date of this site is 2870 ± 60 BP (Centrum voor isotope Onderzoek Groningen) (11)

Lewolaba,

Lewolaba is located on Lembata Island, East Flores, Nusa Tenggara Timur province. It is situated in on the south side of a bay next to a formation of sand-cliffs (11). Geologically, the bay is an unstable site because its formation is relatively new. Bemelen (12) states that this type of environmental condition occurs as a result of frequent earthquakes, which are typical to the region because it is located in the Pacific Ring of Fire. The living conditions on Lembata Island is improved by its close proximity to other small islands such as Alor, Solor, Pantar and Adonara, which can be reached by crossing ocean straits. Sukadana (9) explained that commodities in Lewoleba did not come from the island, rather they were imported from nearby islands. Therefore, as a result of the trade and exchange of food with nearby islands, the nutrition requirements of prehistoric Lewoleba islanders can be fulfilled. Additionally, there is

temperate rainforest across Lewoleba that contains a variety of edible plant, including coconut trees (*Cocos nucifera*), bananas (*Musa*) and palm trees (*Borassus flabellifer*). The first excavation on Lewolaba Island was conducted by T. Verhoeven in 1961. He discovered five human skulls that were later C^{14} dated to 2990 ± 160 BP (Centrum voor Isotopen Onderzoek, Groningen, Netherland) (11) and are representative of the Neolithic period for the region. Faunal remains from shellfish and animal bones were found at the site, indicating the source of food in the region. The skeletal human remains from the Lewoleba site are currently curated in Department of Anthropology, Universitas Airlangga.

Liang Bua

Liang Bua, a cave-site, is approximately 11 kilometres away from Ruteng, the capital city of the West Manggarai region. It is situated deep in a rural about 500 metres above sea level in karst topography. Surrounding the cave is a vast spread of temperate rain forest that supports a wide range of wildlife including giant rat, stegodon and varanus (13). The first excavation of Liang Bua site was conducted in 1965 by T.H. Verhoeven, who discovered ten skeletons, but there are only five skulls that have been successfully reconstructed. These skulls are now curated at the Department of Anthropology, Universitas Airlangga. In 1978-1989, an excavation was conducted by Arkenas (National Institute of Archaeology) that yielded 9 human skeletons, only two of which had a skull. These two skulls are curated at the Laboratory for Biological Anthropology and Palaeoanthropology, University of Gadjah Mada, Yogyakarta. Some of the faunal remains (bones and seashells) found during the most recent excavation are believed to be the remains of food (10).

The presence and absence of PH, CO and EH was macroscopically examined in all skulls, without considering the severity (see table 1,2,3,4). Selected skulls were sexed following the methods proposed in Buikstra and Ubelaker (1994) (14) based on dimorphic structure of skull. Age was estimated according to the method of Brothwell (1965). Age was

categorized into non-adult (2.5-17) and adult (20-50) according to Lewis (2006) (15). In this study, most subjects are categorized as adult (Melolo, 84%; Liang Bua, 86%; Lewoleba, 80%)

Results

Table 1 presents the occurrence of EH, PH and CO observed in the Melolo skeletal assemblage (see also Figs 2,3,4). Of the 19 individuals assessed, 4 individuals displayed CO (21%), 5 displayed PH (26%), and the 3 were affected by EH (16%). One individual displayed both CO and PH (Table 4). There is one non-adult who suffers from CO, while the rest subject were adult groups. Of the 19 individuals assessed, 37% affected subject were male and only 16% were female. The average age which could be identified belong to adult group ranging from 20 to 50 years old

Table 2 details the occurrence of EH, CO and PH in the Lewoleba skeletal sample. Unlike in that of Melolo sample, CO and EH were not observed in the Lewoleba assemblage. In total, 40% (2/5) of the individuals from Lewoleba displayed PH and the most affected subjects were male. All but one of the individuals from the Lewoleba skeletal sample were categorised in the 'adult' age group and only the adults displayed evidence for PH.

Table 3 details the occurrence of CO, EH, and PH in the Liang Bua skeletal sample. In total, 4/7 individuals (57%) displayed CO. The same number of individuals (4/7, 57%) displayed PH; only one individual (1/7, 14%) displayed EH. Two of the seven individuals from Liang Bua (29%) had both CO and PH and only one individual (14%) had the combination of PH and EH. Both males and females (29%; 57% respectively) from the Liang Bua sample were affected by PH and CO, but only one male had EH. All but one of the individuals in the Liang Bua sample, were adults and therefore it is not possible to assess potential age-related difference in the prevalence of EH, CO, and PH.

Discussion

The difference in the prevalence rates of CO, PH, and EH between the three skeletal samples (Table 4) indicates that the individuals from Lewoleba were less affected, not affected at all, by these pathological conditions. Compared to that of Liang Bua and Melolo, Lewoleba displayed only PH, whereas PH, CO, and EH were present in both the Liang Bua and Melolo skeletal samples.

In line with Aufderheide and Rodriguez-Martin (7) and Ortner (6), PH and CO were the most commonly observed conditions in the skeletal samples. If PH and CO in these assemblages developed as a result of nutritional stress, it is possible that a contributing factor may be a micronutrient deficiency which can cause anaemia (e.g. iron) and contribute to compromising the immune response (6). PH and CO develop during childhood as a result of non-specific stress that may cause a disruption in growth (6). It is suggested that the possible nutritional deficiency that resulted in the development of PH and CO, may have caused a disruption in enamel formation (EH) in the Liang Bua and Melolo samples. It is known that malnutrition can retard physical growth and development, which in turn negatively influences the morbidity and mortality profiles of a population (16). PH, CO and EH conditions are the result of episodes of physiological stress during childhood (17, 18). Therefore, the high frequency PH and CO observed in all the three skeletal samples suggests compromised childhood health, possible malnutrition and environmental stress (19).

Another possibility is the influence of certain parasitic diseases on the development of PH and CO. Bahn et al. (16) state that diseases such as malaria and hookworm (*Ancylostoma Duodenale*) may act to exacerbate the negative health effects of malnutrition. Dale (20) elaborate that PH and CO are formed as a result of episodes of anaemia during childhood. This hypothesis is also supported by Stuart-Macadam (21) who proposed that iron deficiency anaemia may be more related certain infections rather than diet.

The risk of malnutrition and certain diseases, especially malaria, is closely associated with the environment a person lives in. Because of the close proximity to the ocean, the populations from Melolo and Lewoleba would have been coastal dwellers and the population from Liang Bua would have lived inland (figure 1). The results of the current analyses indicate that the dwellers of mountainous range, Liang Bua, experienced a higher frequency of PH, CO, and EH than the populations living in coastal areas, Melolo and Lewoleba. This evidence contradicts that of Suby (15), who suggests that people with terrestrial diets are less susceptible to the development of PH and CO compared to people with marine and mixed marine/terrestrial diets. The result of Walker's study (22) also stated that there were differences in the frequency of the appearance of PH and CO in a population based on marine food resources and terrestrial resources. Walker said that the population living on the coast had more PH and CO than the populations that used terrestrial food resources. The current study found that the inland population from Liang Bua, who ate a presumably terrestrial diet because of the distance of the site from the sea, were more vulnerable to the development of PH, CO, and EH compared with the coastal population. On the other hand, people living in coastal region, which ate marine-based-diet also experience PH and CO in high percentage.

The explanation of why the Melolo population, who lived in the coastal area and presumably ate a diet with a high proportion of marine foods in it, also exhibited a high prevalence rate of PH, CO, EH (and the combination of PH/CO) is possibly a result to exposure to parasites that can be found in marine foods. It is known that Nusa Tenggara Timur is an endemic of hookworm and malaria. There is also traditional habit to consume sea worm (*Eunice fucata*) named *Palolo*. But there is no recent research related to the effect of consumption of *Palolo*.

Intestinal parasites can cause nutritional deficiencies and intestinal bleeding, which can lead to anaemia (23). If parasite enters the human body, it can cause blood loss and direct iron deficiency anemia. The main cause of iron deficiency according to Farid et al is worm infection,

including hookworm. In this case it is suspected that hookworm infection is the cause of iron deficiency in Melolo population.

The same infection was also considered to occur in the Lewoleba population. On the other hand, food sources seem not only from the sea but also from terrestrial food so that hookworm infections are less than in Melolo. Another thing that is suspected to be the cause of potential emergence of PH, CO and EH is malaria. The NTT region is not only an endemic area for hookworm but also endemic of malaria. As mentioned above, malaria is an infectious disease that has the potential to cause stress that can disrupt growth and affect health status especially children. In Lewoleba there are no remains of non-adult human skeletons. This is probably the result of high mortality in children.

There were several limitations of this study, including the small sample sizes and fragmentary nature of some of the remains. More research is needed to determine the diets of the populations under study. Future research will include stable isotope analysis to assess palaeodiet and strontium isotope and ancient DNA analyses to help address migration and ancestry of these prehistoric Indonesian populations.

Conclusion

The number of pathological markers, especially PH, CO and EH in human skeletal remains from Melolo, Liang Bua and Lewoleba show a large proportion of the analysed individuals experienced stress in childhood. This stress may have been caused by malnutrition and parasites which put the individuals at risk of developing anaemia. The highest percentage of PH and CO was observed in the Liang Bua individuals who lived at an inland site, possibly a result of environmental stress related to food resource availability. Lower frequencies of these conditions were observed in the Melolo and Lewoleba individuals, who were coastal dwellers. Parasites in their marine diet may have played a role in the development of these conditions in these coastal dwelling populations. The different environmental conditions at each site, types of subsistence, food resource availability, disease presence, cultural practices such as the length

of breastfeeding and time of weaning, and susceptibility to disease all likely played a role in the stress experienced during childhood, observable from the presence of EH, CO and PH, in the these three prehistoric populations from Indonesia.

Acknowledgement

We would like to thank to FISIP Fakultas Ilmu Sosial dan Ilmu Politik, Universitas Airlangga, for giving us the fund from RKAT 2017. We would like to thank Rusyad Adi Suriyanto for allowing us to study the two skull of Liang Bua under his care.

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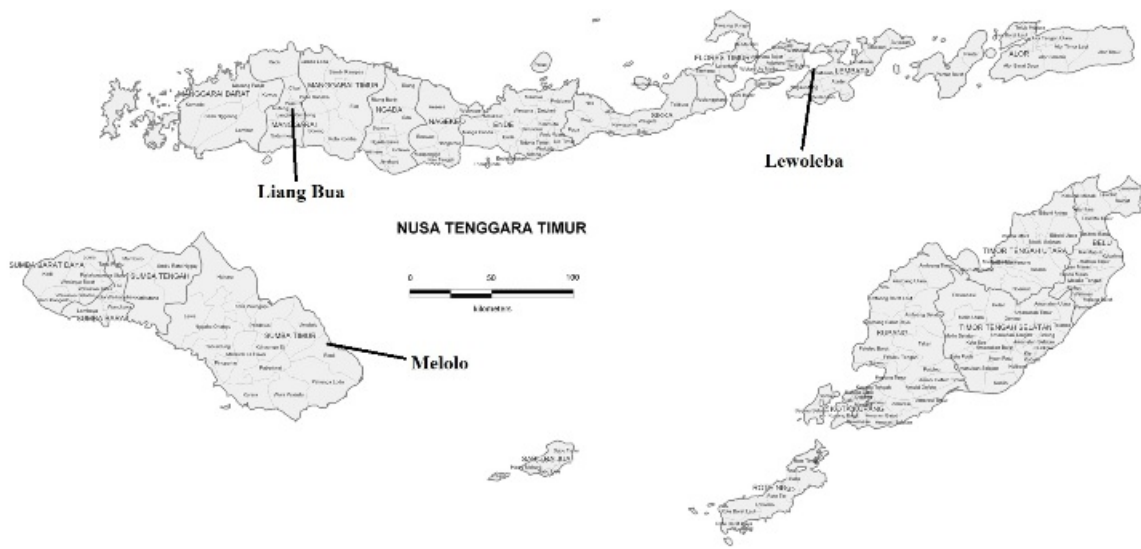


Figure 1. Location of Melolo (Sumba Island), Liang Bua (Flores Island) and Lewoleba (Lembata Island) in the Nusa Tenggara Timur Province.

Table 1. The occurrence of EH, PH and CO in Melolo skeletal sample

Individual	Age	Sex	PH	CO	EH
Urne 1	Non-adult	?	--	V	--
Urne 2.1.	Adult	Male	V	--	--
Urne 2.2	Adult	Female	--	--	V
Urne 2.3.	Adult	Female	--	--	--
Urne 3	Adult	Male	--	--	V
Urne 5.1.	Adult	Female	V	--	--
Urne 5.2.	Adult	Female	--	--	--
Urne 8.1.	Adult	Female	V	--	--
Urne 8.2.	Adult	Female	--	--	--
Urne A	Adult	Female	--	--	--
Urne B	Adult	Male	V	--	--
Urne E.1.	Adult	Male	--	--	V
Urne E.2.	Adult	Female	--	--	--
Urne E.3.	Adult	Female	--	--	--
Urne G.1.	Adult	Female	--	--	--
Urne G.2.	Non-adult	Female	--	--	--
Urne H	Adult	Male	--	V	--
Urne J	?	Male	--	V	--
Urne Buhler	Adult	Male	V	V	--

Table 2. The occurrence of EH, PH and CO in Lewoleba skeletal sample

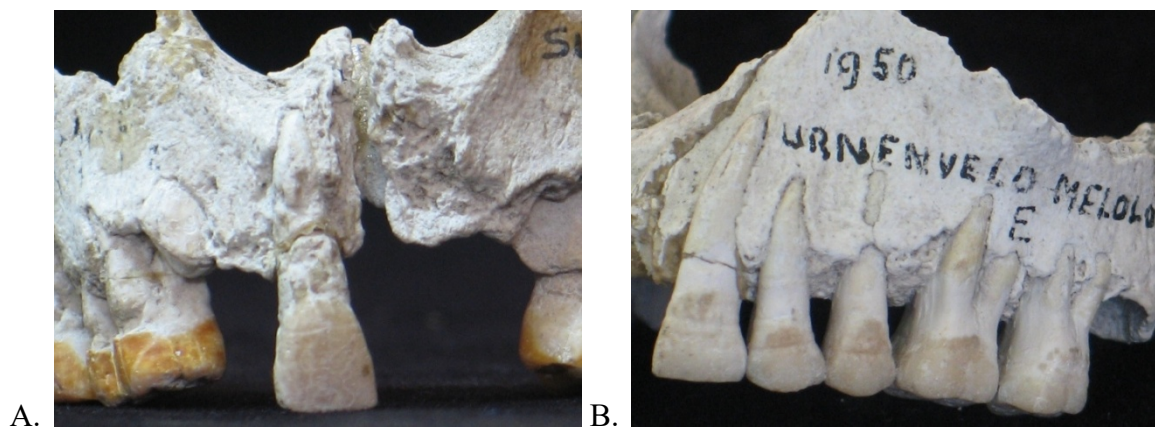
Individual	Age	Sex	PH	CO	EH
LL I.1	Non-adult	Female	--	--	--
LL I.2	Adult	Male	--	--	--
LL I.3	Adult	Male	V	--	--
LL I.4	Adult	Male	V	--	--
LL I.5	Adult	Male	--	--	--

Table 3. The occurrence of PH, CO and EH in Liang Bua skeletal sample

Individual	Age	Sex	PH	CO	EH
LB/1	Non-adult	Male	--	V	--
LB/2	Adult	Female	--	V	--
LB/3	Adult	Male	V	V	--
LB/5	Adult	Male	V	--	V
LB/6	Adult	Female	V	V	--
RIV	Adult	Male	V	--	--
RVI	Adult	Male	--	--	--

Table 4. The percentage of EH, PH, and CO in each of the three skeletal samples

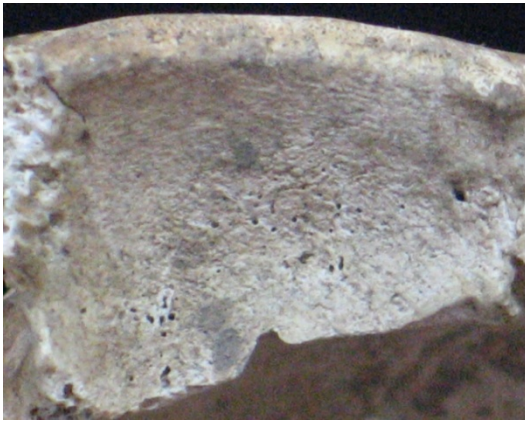
Situs	EH	PH	CO	EH/PH	EH/CO	PH/CO	EH/PH/CO
Melolo	16	26	21	--	--	5	--
Lewoleba	--	40	--	--	--	--	--
Liang Bua	14	57	57	14	--	29	--



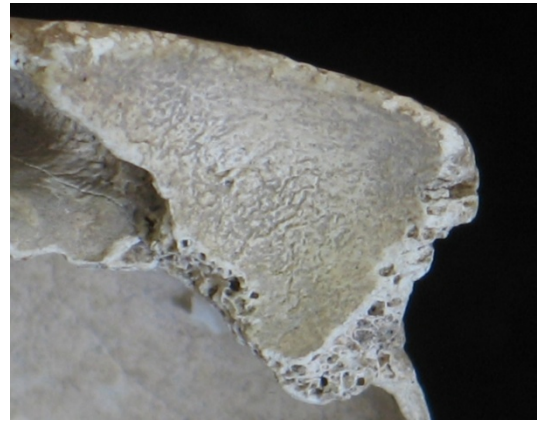


C.

Figure 2. EH on I¹ teeth of Melolo Urne 2 (A); EH on C-M² teeth of Melolo Urne E.1 (B); EH on canine teeth of maxilla (left and right) of LB/5 (C).

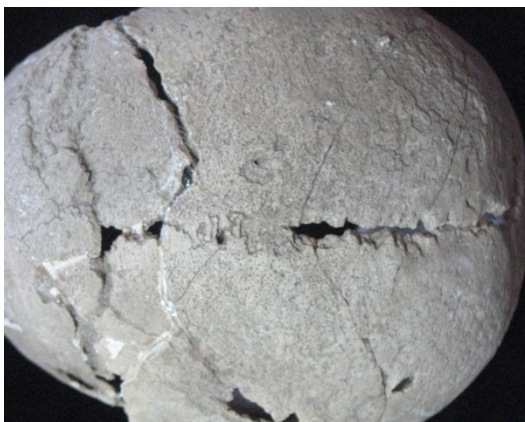


A.



B.

Figure 3. CO on right eye orbits of LB/3 (A), and CO on left eye orbits of Melolo Urne J (B).



A.



B.

Figure 4. PH on parietal bones of Melolo Urne 2 (A), and PH on left parietal bone of LL 1.4 (B)

BUKTI KORESPONDENSI

ARTIKEL JURNAL INTERNASIONAL TERAKREDITASI Q3

Judul artikel : The Occurrence Of Onamel Hypoplasia, Porotic Hyperostosis And Cribra Orbitalia In Theree Prehistoric Skeletal Assemblages From Indonesia


Jurnal : Jurnal Bulletin of the International Association for Paleodontology Vol 12 No 2; December 2018; Hal 33-40

Penulis : 1. Toetik Koesbardiati, 2. Delta Bayu Murti, 3. Dessytri Ayu Herina, 4. Ayu Ambar Sari

No.	Perihal	Tanggal
3	Bukti konfirmasi submit revisi & artikel yang disubmit	14 Desember 2018

Revisions

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▶	 25872-1	Article Text, A-Koesbardiati et al ex Reviewer-1aa.docx	December 10, 2018	Article Text
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Notifications



[Bull Int Assoc P] Editor Decision

2018-12-14 10:25 AM

Dear authors:

We have reached a decision regarding your submission to Bulletin of the International Association for Paleontology, "The The Occurrence of Enamel Hypoplasia, Porotic Hyperostosis and Cribra Orbitalia in prehistoric people in Indonesia".

Our decision is to accept your paper. It will be published in the coming issue.

Kind regards

Marin Vodanović
vodanovic@sfzg.hr

The following message is being delivered on behalf of Bulletin of the International Association for Paleontology. _____

[Bull Int Assoc P] Editor Decision > Kotak Masuk x



Marin Vodanović vodanovic@sfzg.hr [lewat](#) srce.hr
kepada saya, Delta, Desytri, Ayu ▾

14 Des 2018, 16.25 ☆ ↶ ⋮

Dear authors:

We have reached a decision regarding your submission to Bulletin of the International Association for Paleodontology, "The The Occurrence of Enamel Hypoplasia, Porotic Hyperostosis and Cribra Orbitalia in prehistoric people in Indonesia".

Our decision is to accept your paper. It will be published in the coming issue.

Kind regards

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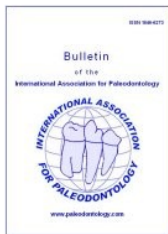
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Original scientific paper

The occurrence of enamel hypoplasia, porotic hyperostosis and cribra orbitalia in three prehistoric skeletal assemblages from Indonesia

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Abstract

Enamel hypoplasia (EH), porotic hyperostosis (PH) and cribra orbitalia (CO) have frequently been used to indicate the presence non-specific stress during child-growth periods. They are routinely assessed to investigate health along with patterns of morbidity and mortality of past populations. This study aims use macroscopic analyses to describe and analyse the presence of EH, PH and CO in three prehistoric populations that lived in different environments - coastal and mountainous. For this study, we analysed human skeletons from Melolo, Lewoleba and Liang Bua - three sites situated in Nusa Tenggara Timur, Indonesia. The first two sites, Melolo, Sumba Island, and Lewoleba, are coastal sites whereas Liang Bua is located on a mountainous range in Flores. Excavations in Melolo, East Sumba, conducted in the 1930s, discovered 19 human skeletons buried in urns. Three individuals from the Melolo skeletal sample displayed EH (16%), 21% individuals were recorded to possess CO and 26% experienced PH. Excavation of the Lewoleba site, Lembata Island, were conducted in 1961 and yielded 5 human skeletons. No EH was observed in the Lewoleba sample but 40% displayed PH and CO was not found in the Lewoleba samples. The excavation of Neolithic skeletons from Liang Bua, Flores, yielded 7 individuals who displayed PH, CO, and EH (57%, 57% and 14% respectively). Surprisingly, the study in Liang Bua depicted the highest percentage compared to that of in Melolo and Lewoleba populations.

Keywords

Enamel hypoplasia, porotic hyperostosis, cribra orbitalia, prehistoric populations, Indonesia

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The occurrence of enamel hypoplasia, porotic hyperostosis and *cribra orbitalia* in three prehistoric skeletal assemblages from Indonesia *

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Abstract

Enamel hypoplasia (EH), porotic hyperostosis (PH) and *cribra orbitalia* (CO) have frequently been used to indicate the presence non-specific stress during child-growth periods. They are routinely assessed to investigate health along with patterns of morbidity and mortality of past populations. This study aims use macroscopic analyses to describe and analyse the presence of EH, PH and CO in three prehistoric populations that lived in different environments - coastal and mountainous. For this study, we analysed human skeletons from Melolo, Lewoleba and Liang Bua- three sites situated in Nusa Tenggara Timur, Indonesia. The first two sites, Melolo, Sumba Island, and Lewoleba, are coastal sites whereas Liang Bua is located on a mountainous range in Flores. Excavations in Melolo, East Sumba, conducted in the 1930s, discovered 19 human skeletons buried in urns. Three individuals from the Melolo skeletal sample displayed EH (16%), 21% individuals were recorded to possess CO and 26% experienced PH. Excavation of the Lewoleba site, Lembata Island, were conducted in 1961 and yielded 5 human skeletons. No EH was observed in the Lewoleba sample but 40% displayed PH and CO was not found in the Lewoleba samples. The excavation of Neolithic skeletons from Liang Bua, Flores, yielded 7 individuals who displayed PH, CO, and EH (57%, 57% and 14% respectively). Surprisingly, the study in Liang Bua depicted the highest percentage compared to that of in Melolo and Lewoleba populations.

Keywords: Enamel hypoplasia; porotic hyperostosis; *cribra orbitalia*; prehistoric populations; Indonesia

* Author is responsible for language correctness and content.



Introduction

The study of paleopathology leads to a deeper comprehension towards the occurrence, causes, and frequency of particular diseases and incidence of physiological stress in past populations (1). Additionally, palaeopathological investigations can also provide further information about health, trauma, lifestyle, activity, nutrition, ancestry and working conditions in ancient times (1).

Enamel Hypoplasia (EH) is one of the most common indicators of non-specific stress that are observed in both prehistoric and modern humans from around the world (1, 2, 3, 4). Kanchan et al. (5) states that dental enamel hypoplasia is a developmental anomaly caused by perturbed amelogenesis. Its presence is obvious if matrix formation is affected and may manifest as pitting, grooving or even a total absence of enamel. Linear enamel hypoplasia are grooves or pits on the enamel of tooth resulted from the disruption in the formation of the enamel during a prolonged period of stress during the time of tooth formation (i.e. infancy and childhood) (4). Ortner (6) further elaborated that the normal formation of dental tissue can be affected by several infectious diseases, primarily congenital syphilis and tuberculosis, metabolic and endocrine disorders. Aufderheide and Rodriguez-Martin (7) stated that malnutrition is the most causes cited. Others are environmental factors such as haemolytic disease, premature birth, major febrile infection, dietary deficiencies of vitamin A, C and D. Therefore, EH is a useful indicator to investigate the childhood growth and the patterns of morbidity and mortality in the past populations (8).

Porotic hyperostosis (PH) is thought to develop as a result of anaemia, commonly caused by nutritional stress. According to Aufderheide and Rodriguez-Martin (7), PH is observable from the presence and distribution of small, pinpoint cranial lesions involving the outer table of the frontal, parietal, and much less frequently, the occipital bones of the skull, usually in a symmetrical manner (i.e. both sides of the cranium). In the fully developed lesion, the involved areas of the skull are thickened by the expansion of the diploic layer of the cranium, while the visualization of the trabeculae of the

expanded diploic bone, and the appearance of the coarsening trabeculae. Aufderheide and Rodriguez-Martin note that PH has also been referred to as symmetrical hyperostosis, hyperostosis cranii, and spongy hyperostosis. CO is commonly found in the orbital roof, especially in the narrow space along the anterolateral portion of the superior orbit. According to Aufderheide and Rodriguez-Martin, 90% of the recorded cases of CO appear as bilateral lesions. It is also further clarified by these researchers that the appearance of PH is often followed by CO. Hence, CO is considered by Aufderheide (1990) to be a more sensitive indicator of non-specific stress in childhood.

The purpose of this study is to describe the occurrence of EH, PH and CO in prehistoric populations from the sites of Melolo, Lewoleba and Liang Bua, Indonesia, and use this information as a proxy for understanding childhood health. Also, this study was designed to analyse the relationship between the presence of EH, PH, and CO among the three subjected populations and the geographical environment (coastal and mountainous regions).

Materials and Methods

The skeletal samples analysed in this study are from archaeological sites in the eastern province of Nusa Tenggara Timur, eastern Indonesia (Figure 1).

Melolo A number of excavations have been conducted in the Sumba region, including Melolo, that found in human skeletal remains in burial jars (9). The skeletal assemblage analysed for the present study are from the 1939 excavation conducted by W.J.A. Willems and the 1949 excavation conducted by A. Buhler. The remains are currently curated in Department of Anthropology, Universitas Airlangga, Indonesia. Both, W.J.A. Willems and A. Buhler submitted their findings from Melolo to Snell (10). Snell documented the 19 individuals in the assemblage represented by skulls. No postcranial skeletal elements are present in the Melolo skeletal collection. The current condition of the Melolo skulls is fragmentary and a total of 19 were analysed for the current study. The date of this site is 2870 ± 60 BP (Centrum voor isotope Onderzoek Groningen) (11).

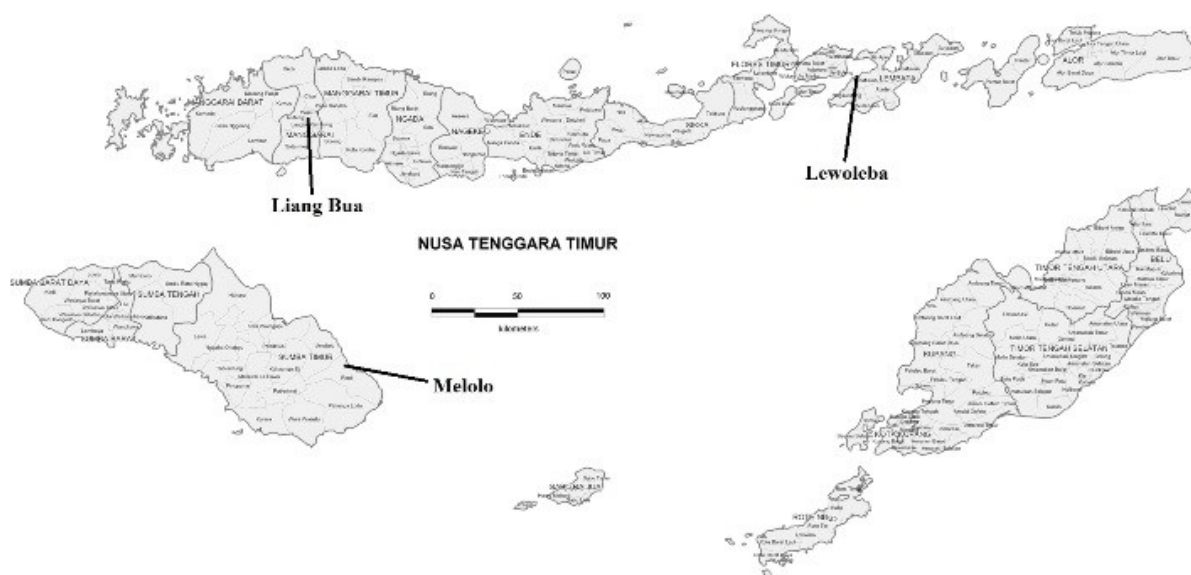


Figure 1 Location of Melolo (Sumba Island), Liang Bua (Flores Island) and Lewoleba (Lembata Island) in the Nusa Tenggara Timur Province.

Lewolaba Lewolaba is located on Lembata Island, East Flores, Nusa Tenggara Timur province. It is situated in on the south side of a bay next to a formation of sand-cliffs (11). Geologically, the bay is an unstable site because its formation is relatively new. Bemelen (12) states that this type of environmental condition occurs as a result of frequent earthquakes, which are typical of the region because it is located in the Pacific Ring of Fire. The living conditions on Lembata Island is improved by its close proximity to other small islands such as Alor, Solor, Pantar and Adonara, which can be reached by crossing ocean straits. Sukadana (9) explained that commodities in Lewoleba did not come from the island, rather they were imported from nearby islands. Therefore, as a result of the trade and exchange of food with nearby islands, the nutrition requirements of prehistoric Lewoleba islanders can be fulfilled. Additionally, there is temperate rainforest across Lewoleba that contains a variety of edible plant, including coconut trees (*Cocos nucifera*), bananas (*Musa*) and palm trees (*Borassus flabellifer*). The first excavation on Lewolaba Island was conducted by T. Verhoeven in 1961. He discovered five human skulls that were later C¹⁴ dated to 2990±160 BP (Centrum voor Isotopen Onderzoek, Groningen, Netherland) (11) and are representative of the Neolithic period for the region. Faunal remains from shellfish and

animal bones were found at the site, indicating the source of food in the region. The skeletal human remains from the Lewoleba site are currently curated in Department of Anthropology, Universitas Airlangga.

Liang Bua Liang Bua, a cave-site, is approximately 11 kilometres away from Ruteng, the capital city of the West Manggarai region. It is situated deep in a rural about 500 metres above sea level in karst topography. Surrounding the cave is a vast spread of temperate rain forest that supports a wide range of wildlife including giant rat, stegodon and varanus (13). The first excavation of Liang Bua site was conducted in 1965 by T.H. Verhoeven, who discovered ten skeletons, but there are only five skulls that have been successfully reconstructed. These skulls are now curated at the Department of Anthropology, Universitas Airlangga. In 1978-1989, an excavation was conducted by Arkenas (National Institute of Archaeology) that yielded 9 human skeletons, only two of which had a skull. These two skulls are curated at the Laboratory for Biological Anthropology and Palaeoanthropology, University of Gadjah Mada, Yogyakarta. Some of the faunal remains (bones and seashells) found during the most recent excavation are believed to be the remains of food (10).

The presence and absence of PH, CO and EH was macroscopically examined in all skulls, without considering the severity (see table

1,2,3,4). Selected skulls were sexed following the methods proposed in Buikstra and Ubelaker (1994) (14) based on dimorphic structure of skull. Age was estimated according to the method of Brothwell (1965). Age was categorized into non-adult (2.5-17) and adult (20-50) according to Lewis (2006) (15). In this study, most subjects are categorized as adult (Melolo, 84%; Liang Bua, 86%; Lewoleba, 80%)

Results

Table 1 presents the occurrence of EH, PH and CO observed in the Melolo skeletal assemblage (see also Figures 2,3,4). Of the 19 individuals assessed, 4 individuals displayed CO (21%), 5 displayed PH (26%), and the 3 were affected by EH (16%). One individual displayed both CO and PH (Table 4). There is one non-adult who suffers from CO, while the rest subject were adult groups. Of the 19 individuals assessed, 37% affected subject were male and only 16% were female. The average age which could be identified belong to adult group ranging from 20 to 50 years old.

Individual	Age	Sex	PH	CO	EH
Urne 1	Non-adult	?	--	V	--
Urne 2.1.	Adult	Male	V	--	--
Urne 2.2	Adult	Female	--	--	V
Urne 2.3.	Adult	Female	--	--	--
Urne 3	Adult	Male	--	--	V
Urne 5.1.	Adult	Female	V	--	--
Urne 5.2.	Adult	Female	--	--	--
Urne 8.1.	Adult	Female	V	--	--
Urne 8.2.	Adult	Female	--	--	--
Urne A	Adult	Female	--	--	--
Urne B	Adult	Male	V	--	--
Urne E.1.	Adult	Male	--	--	V
Urne E.2.	Adult	Female	--	--	--
Urne E.3.	Adult	Female	--	--	--
Urne G.1.	Adult	Female	--	--	--
Urne G.2.	Non-adult	Female	--	--	--
Urne H	Adult	Male	--	V	--
Urne J	?	Male	--	V	--
Urne Buhler	Adult	Male	V	V	--

Table 1 The occurrence of EH, PH and CO in Melolo skeletal sample.



Figure 2 EH on I1 teeth of Melolo Urne 2 (A); EH on C-M2 teeth of Melolo Urne E.1 (B); EH on canine teeth of maxilla (left and right) of LB/5 (C).

Table 2 details the occurrence of EH, CO and PH in the Lewoleba skeletal sample. Unlike in that of Melolo sample, CO and EH were not observed in the Lewoleba assemblage. In total, 40% (2/5) of the individuals from Lewoleba displayed PH and the most affected subjects were male. All but one of the individuals from the Lewoleba skeletal sample were categorised in the 'adult' age group and only the adults displayed evidence for PH.

Table 3 details the occurrence of CO, EH, and PH in the Liang Bua skeletal sample. In total, 4/7 individuals (57%) displayed CO. The same number of individuals (4/7, 57%) displayed PH; only one individual (1/7, 14%) displayed EH. Two of the seven individuals from Liang Bua (29%) had both CO and PH and only one individual (14%) had the combination of PH and EH. Both males and females (29%; 57% respectively) from the Liang Bua sample were affected by PH and CO, but only one male had EH. All but one of the individuals in the Liang Bua sample, were adults and therefore it is not possible to assess potential age-related difference in the prevalence of EH, CO, and PH.

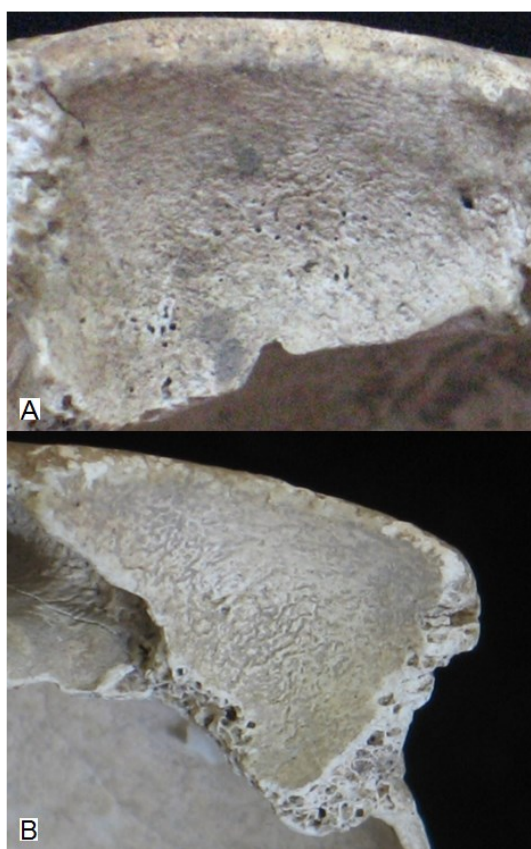


Figure 3 CO on right eye orbits of LB/3 (A), and CO on left eye orbits of Melolo Urne J (B).

Discussion

The difference in the prevalence rates of CO, PH, and EH between the three skeletal samples (Table 4) indicates that the individuals from Lewoleba were less affected, not affected at all, by these pathological conditions. Compared to that of Liang Bua and Melolo, Lewoleba

displayed only PH, whereas PH, CO, and EH were present in both the Liang Bua and Melolo skeletal samples.

In line with Aufderheide and Rodriguez-Martin (7) and Ortner (6), PH and CO were the most commonly observed conditions in the skeletal samples. If PH and CO in these assemblages developed as a result of nutritional stress, it is possible that a contributing factor may be a micronutrient deficiency which can cause anaemia (e.g. iron) and contribute to compromising the immune response (6). PH and CO develop during childhood as a result of non-specific stress that may cause a disruption in growth (6). It is suggested that the possible nutritional deficiency that resulted in the development of PH and CO, may have caused a disruption in enamel formation (EH) in the Liang Bua and Melolo samples. It is known that malnutrition can retard physical growth and development, which in turn negatively influences the morbidity and mortality profiles of a population (16). PH, CO and EH conditions are the result of episodes of physiological stress during childhood (17, 18). Therefore, the high frequency PH and CO observed in all the three skeletal samples suggests compromised childhood health, possible malnutrition and environmental stress (19).

Another possibility is the influence of certain parasitic diseases on the development of PH and CO. Bahn et al. (16) state that diseases such as malaria and hookworm (*Ancylostoma Duodenale*) may act to exacerbate the negative health effects of malnutrition. Dale (20) elaborate that PH and CO are formed as a result of episodes of anaemia during childhood. This hypothesis is also supported by Stuart-Macadam (21) who proposed that iron deficiency anaemia may be more related certain infections rather than diet.

The risk of malnutrition and certain diseases, especially malaria, is closely associated with the environment a person lives in. Because of the close proximity to the ocean, the populations from Melolo and Lewoleba would have been coastal dwellers and the population from Liang Bua would have lived inland (Figure 1). The results of the current analyses indicate that the dwellers of mountainous range, Liang Bua, experienced a higher frequency of PH, CO, and EH than the populations living in coastal areas, Melolo and Lewoleba. This evidence contradicts that of Suby (15), who suggests that people with terrestrial diets are less susceptible to the development of PH and CO compared to people

with marine and mixed marine/terrestrial diets. The result of Walker's study (22) also stated that there were differences in the frequency of the appearance of PH and CO in a population based on marine food resources and terrestrial resources. Walker said that the population living on the coast had more PH and CO than the populations that used terrestrial food resources. The current study found that the inland population from Liang Bua, who ate a presumably terrestrial diet because of the distance of the site from the sea, were more vulnerable to the development of PH, CO, and EH compared with the coastal population. On the other hand, people living in coastal region, which ate marine-based-diet also experience PH and CO in high percentage.

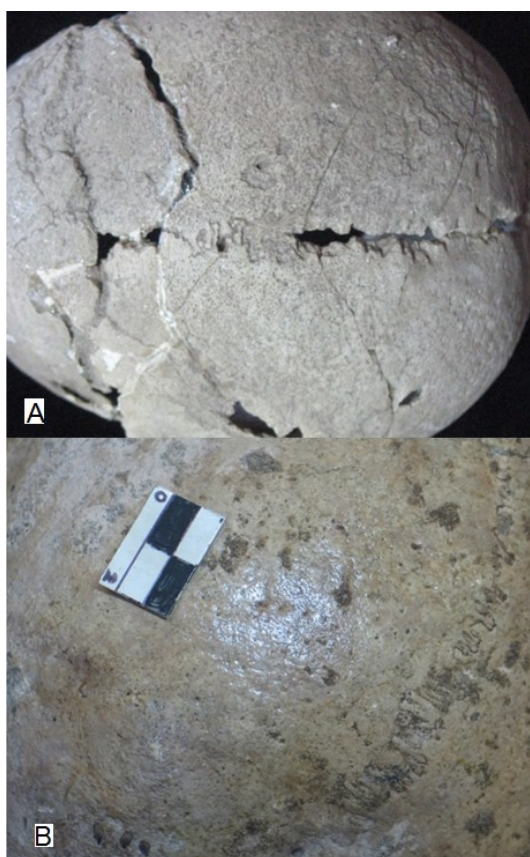


Figure 4 PH on parietal bones of Melolo Urne 2 (A), and PH on left parietal bone of LL 1.4 (B).

The explanation of why the Melolo population, who lived in the coastal area and presumably ate a diet with a high proportion of marine foods in it, also exhibited a high prevalence rate of PH,

CO, EH (and the combination of PH/CO) is possibly a result to exposure to parasites that can be found in marine foods. It is known that Nusa Tenggara Timur is an endemic of hookworm and malaria. There is also traditional habit to consume sea worm (*Eunice fucata*) named *Palolo*. But there is no recent research related to the effect of consumption of *Palolo*.

Intestinal parasites can cause nutritional deficiencies and intestinal bleeding, which can lead to anaemia (23). If parasite enters the human body, it can cause blood loss and direct iron deficiency anemia. The main cause of iron deficiency according to Farid et al is worm infection, including hookworm. In this case it is suspected that hookworm infection is the cause of iron deficiency in Melolo population.

The same infection was also considered to occur in the Lewoleba population. On the other hand, food sources seem not only from the sea but also from terrestrial food so that hookworm infections are less than in Melolo. Another thing that is suspected to be the cause of potential emergence of PH, CO and EH is malaria. The NTT region is not only an endemic area for hookworm but also endemic of malaria. As mentioned above, malaria is an infectious disease that has the potential to cause stress that can disrupt growth and affect health status especially children. In Lewoleba there are no remains of non-adult human skeletons. This is probably the result of high mortality in children. There were several limitations of this study, including the small sample sizes and fragmentary nature of some of the remains. More research is needed to determine the diets of the populations under study. Future research will include stable isotope analysis to assess palaeodiet and strontium isotope and ancient DNA analyses to help address migration and ancestry of these prehistoric Indonesian populations.

Conclusion

The number of pathological markers, especially PH, CO and EH in human skeletal remains from Melolo, Liang Bua and Lewoleba show a large proportion of the analysed individuals experienced stress in childhood. This stress may have been caused by malnutrition and parasites which put the individuals at risk of developing anaemia. The highest percentage of PH and CO was observed in the Liang Bua individuals who lived at an inland site, possibly a result of environmental stress related to food resource availability. Lower frequencies of these

conditions were observed in the Melolo and Lewoleba individuals, who were coastal dwellers. Parasites in their marine diet may have played a role in the development of these conditions in these coastal dwelling populations. The different environmental conditions at each site, types of subsistence, food resource availability, disease presence, cultural practices such as the length of breastfeeding and time of weaning, and susceptibility to disease all likely played a role in the stress experienced during childhood, observable from the presence of EH, CO and PH, in the these three prehistoric populations from Indonesia.

Individual	Age	Sex	PH	CO	EH
LL I.1	Non-adult	Female	--	--	--
LL I.2	Adult	Male	--	--	--
LL I.3	Adult	Male	V	--	--
LL I.4	Adult	Male	V	--	--
LL I.5	Adult	Male	--	--	--

Table 2 The occurrence of EH, PH and CO in Lewoleba skeletal sample.

Individual	Age	Sex	PH	CO	EH
LB/1	Non-adult	Male	--	V	--
LB/2	Adult	Female	--	V	--
LB/3	Adult	Male	V	V	--
LB/5	Adult	Male	V	--	V
LB/6	Adult	Female	V	V	--
RIV	Adult	Male	V	--	--
RVI	Adult	Male	--	--	--

Table 3 The occurrence of PH, CO and EH in Liang Bua skeletal sample.

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Situs	EH	PH	CO	EH/PH	EH/CO	PH/CO	EH/PH/CO
Melolo	16	26	21	--	--	5	--
Lewoleba	--	40	--	--	--	--	--
Liang Bua	14	57	57	14	--	29	--

Table 4 The percentage of EH, PH, and CO in each of the three skeletal samples.

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