# PLEISTOCENE HOMINOID DENTAL VARIATION IN VIETNAM

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## ABSTRACT

*This paper examines quantitative diversity in samples of teeth of hominoids (Order Primates, Superfamily Hominoidea) from the Pleistocene in Vietnam. The study broadens Tattersall's (1986) general claim for hominids (Family Hominidae), that relatively more recent times in the prehistoric record may contain more species of human ancestors than have hitherto been recognised. This work supports the case made by Schwartz et al.l (1994, 1995) that in some parts of their distribution at least, in this case Vietnam, fossil hominoid assemblages contain more than a single species, often showing relatively high species diversity into quite late Pleistocene times.*

## INTRODUCTION

This paper is about quantitative diversity or variation in dental samples of Pleistocene hominoids from Vietnam. Schwartz *et al.* (1994) reported on variation in tooth morphology from a sample of Middle Pleistocene hominoids, from the cave at Tham Khuyen, held in the collections of the Institute of Archaeology in Hanoi, Socialist Republic of Vietnam. They re-examined a collection of teeth previously allocated to *Pongo pygmaeus*. By careful analysis and thorough description of morphology, taking note of such factors as wear, they were able to challenge the prevailing taxonomic allocation of this assemblage of isolated teeth.

They argued that the collection consisted of three different morphs. One of these was indeed *P. pygmaeus*. One other constituted a "dentally primitive species of *Pongo*" and had sub-groups or variants, which separated out principally on size and were thus thought to be males and females of the same species. The third morph appeared to be a hominoid belonging to a previously undescribed genus (Schwartz *et al.* 1994:4). A year later they published a study naming and characterising the new taxa, including four new sub-species of *Pongo pygmaeus*, the taxon present at most Pleistocene sites (Schwartz *et al.* 1995).

In Hanoi in 1995 we examined this collection again with a view to seeing how these new discoveries could be characterised quantitatively. We were interested to see if the findings of Schwartz *et al.* (1994, 1995), derived from descriptive morphology, were reflected in quantitative measures of variation.

We measured crown dimensions, the standard mesio-distal length (MD) and bucco-lingual breadth (BL), of all the Tham Khuyen teeth. In addition, we re-examined other collections from Late Pleistocene cave sites at Lang Trang, Tham Om, Hang Hum, Keo Leng and Dieu (see Figure 1), and measured these in the same way. Sample sizes for particular tooth measures at respective archaeological sites are shown in Table 1. We aim in this paper to present numerical measures of variation for these dental measurements, with a view to assessing how the morphological descriptions of Schwartz *et al.* (1994, 1995) compare against assessments of diversity obtained through quantitative methods.

## THE SITES

Tham Khuyen Cave is in Binh Gia District of Lang Son Province, close to the Chinese border (Figure 1). On the basis of faunal dating, the site is deemed to be 300-250 kyr BP in age. Breccias are thought to contain some five taxa on hon-hylobatid hominoids: *Homo* sp., *Pongo pygmaeus, P. hooijeri* (new species), *Langsonia liquidens* (new genus, new species), and *Gigantopithecus* (Schwartz *et al.*l 1995).

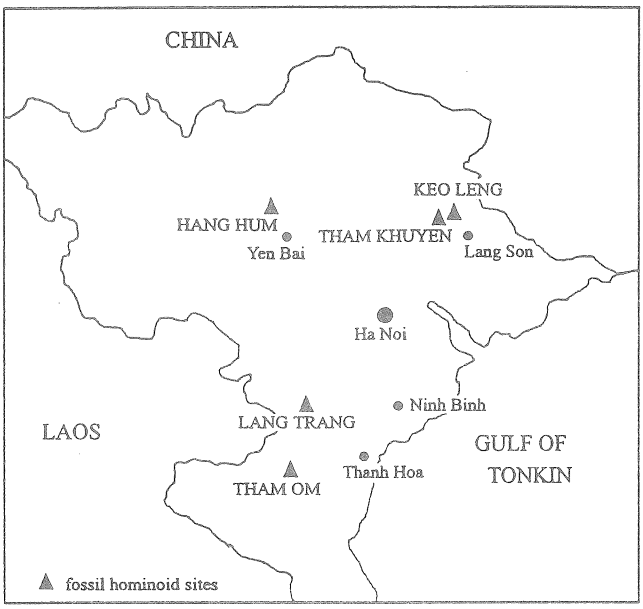


*Figure 1: Major Hominid Fossil Sites in Northern Vietnam.*

Table 1: Sample sizes for Vietnamese hominoid teeth measurements.

| Maxillary | MD | | | | BL | | | |
|---|---|---|---|---|---|---|---|---|
| | P3 | P4 | M1/2 | M3 | P3 | P4 | M1/2 | M3 |
| Tham Khuyen | 5 | 5 | 16 | 4 | 5 | 5 | 16 | 4 |
| Lang Trang | 18 | 16 | 32 | 6 | 19 | 14 | 31 | 6 |
| Tham Om | | | 15 | | | | 13 | |
| Hang Hum | 3 | 4 | 3 | 3 | 3 | 4 | 4 | 4 |
| Keo Leng | | 4 | 3 | 1 | | 4 | 3 | 1 |
| Dieu Cave | 3 | 1 | 3 | | 1 | 1 | 3 | |
| **Mandibular** | | | | | | | | |
| Tham Khuyen | 8 | 3 | 9 | | 10 | 3 | 9 | |
| Lang Trang | 19 | 18 | 21 | 19 | 19 | 18 | 22 | 17 |
| Tham Om | | | 22 | | | | 22 | |
| Hang Hum | 6 | 10 | 14 | 4 | 6 | 10 | 15 | 3 |
| Keo Leng | 1 | 4 | 9 | 1 | 1 | 4 | 9 | 1 |
| Dieu Cave | 3 | 2 | 2 | | 3 | 2 | 2 | |

Lang Trang is a large cave in Ba Thuoc District of Thanh Hoa Province. Despite initial estimates of an early age of 500 kyr BP (Ciochon *et al.* 1990), more recently excavated material suggests "that most of the fauna may be considerably younger than this" (Schwartz *et al.* 1995:6). It is now thought to be of Late Pleistocene age. With the exception of one *Homo sapiens* canine, Schwartz *et al.* (1995:6) judged the collection to be entirely *Pongo pygmaeus*. They claimed there is a marked disparity in size between males and females, as found "in modern orangutans" (Schwartz *et al.* 1995:6).

Tham Om Cave in Quy Chau District of Nghe An Province was excavated in 1977. Most of the mammal fossils and all of the hominoids derive from red sediments which are thought by some to date to later Middle Pleistocene age, ca 250-140 byr BP (Cuong 1985; Schwartz *et al.* 1995:7), or to slightly younger than this at about 125 kyr BP (recent estimate by VTL), making them lower Late Pleistocene. The site produced three large bodied hominoids: *Homo sapiens, Pongo pygmaeus* and *Gigantopithecus* (Schwartz *et al.* 1995:7). There were three other teeth which caused the analysts to have some doubt, because they were "non-orangutanlike", yet also not clearly *Homo* (Schwartz *et al.* 1995:8-10). In the end, because of provenance and the identity of the bulk of the assemblage, they were attributed to *Pongo* (Schwartz *et al.* 1995:9). The *Pongo* sample was judged to show a disparity in size between "putative males and females" which is "extreme" (Schwartz *et al.* 1995:7).

Hang Hum Cave was a solution cavity in Luc Yen District of Yen Bai Province which has now been inundated by an artificial lake. The hominoid specimens derived from the lower sedimentary phase of the deposit, around 140-80 kyr BP. That is, they are Late Pleistocene. The sample contains *Pongo* and *Homo*, as well as some differing teeth which were considered hominid "by default" (Schwartz *et al.* 1995:5). Schwartz *et al.* (1995:5) reported "considerable sexual dimorphism" in the orangutan collection.

The other sites shown in Figure 1 and discussed by Schwartz *et al.* (1994, 1995) contain measurable samples which were too small for definitive quantitative assessment. We took measurements where we could anyhow, for purposes of summing over the entire Vietnamese assemblage. These other sites are Keo Leng Cave (Late Pleistocene, possibly as recent as 30 kyr BP), and Dieu Rockshelter, thought on the basis of fauna to be of a similar age to Lang Trang. Keo Leng contained a few *Pongo pygmaeus* teeth and indeterminate and undiagnostic isolates (Schwartz *et al.* 1995:4-5). The Dieu assemblage was all *Pongo pygmaeus* with premolar sexual dimorphism evident (Schwartz *et al.* 1995:7).

## MEASURES OF VARIATION

The principal measure used to determine morphological variation is the Coefficient of Variation (CV), defined simply as the ratio between a sample's standard deviation and its mean, usually expressed as a percentage. Other measures such as the ratio between mean and range (R%) and the maximum to minimum ratio (MI) have been advocated as complementary or even more efficient statistics (Martin 1991). Here we present CV, R% and MI

values, together with frequency distributions of tooth length and breadth, in order to assess quantitative variation in dental variables.

Though Martin and Andrews (1984) argued that range-based statistics held some advantages over CVs, Cope (1989) and Plavcan (1990) "provided vigorous support for CV as the preferred statistic" (Martin & Andrews 1993:404). Both have advantages, and a combination of approaches "can only improve the accuracy of determinations of species numbers" (Martin & Andrews 1993:424).

It used to be thought that given certain conditions, such as similar measurements on skeletal elements in use, when CV values are greater than 10, there is strong evidence that more than one species is represented in a sample (Simpson, Roe & Lewontin 1960; Groves 1989). More recently, the complexity of this measure has led to different methods of assessment of species diversity. Cope (1993) and Plavcan (1993) have shown that this statistic behaves in complex fashion depending upon factors such as sample size and skeletal element dimension. However, in some cases at least, there does seem to be a relationship between the amount of variation as measured by CV and the number of species expected in a bone assemblage (Walters 1996). Nevertheless, it is now acknowledged that CV values for comparative samples from extant taxa can provide a threshold value for the judgment of species diversity, even though this is no longer simplistically equated to one single numerical value across variables, bones and taxa. Martin and Andrews (1993) provided measures of CV for dental variables in various hominoid taxa, showing that there are maximum recorded values for these extant species, above which the expectation that more than one species is present in an assemblage, is a reasonable conclusion.

However, this is mindful of the claim that CV

> can only be used to say that there is probably more than one species present. It cannot be used to confirm that a single species is present or to determine the number of species present (Martin 1983:49)

The single species interpretation is therefore the null hypothesis (Martin & Andrews 1993). This is then falsified against data concerning variation in extant assemblages of species. This applies equally to the R% and MI statistics. For

> if an R% or MI estimate in a small sample does exceed the single species maximum, it strongly suggests that more than one species is present, since both methods are highly biased against such an outcome (Cope: 1989:109)

The implication of these findings is that

> a study that compares reference maxima for large samples of extant forms with either corrected or uncorrected values for smaller samples of fossils is strongly biased against falsification of the single species hypothesis (Martin & Andrews 1993:406)

and thus

> a high degree of confidence can be attached to any values in the fossil sample that exceed the reference maxima. (Martin & Andrews 1993:407)

Reference maxima for CV, R% and MI statistics for hominoids are collated or calculated, and presented by Martin and Andrews (1993).

Frequency distributions can also be used to assess the single species hypothesis. While bimodal distributions of anterior teeth dimensions reflect sexual dimorphism, bimodally distributed lengths of posterior teeth usually indicate multiple taxa in a sample (Cope 1989; Martin & Andrews 1993:412).

Studies have shown that species diversity is often underestimated in palaeontological examination of primate collections. In fact in "recent years it has become almost axiomatic that palaeontologists will tend to underestimate the number of species in the fossil record" (Martin & Andrews 1993:394). Tattersall (1993) studied, from museum collections, cranio-dental variables from seven species of the genus *Lemur*. With skins available for strict taxonomic control, the examination involved some 37 characters of the skull and dentition across a sample of 77 specimens. He concluded that "a palaeontologist working with hard-tissue characters alone would underestimate the actual species diversity" (Tattersall 1993:175). He estimated that if confronted with complete skulls and dentitions of all the species studied, a palaeontologist would "hesitate to recognise more than three, or perhaps four, species in this assemblage" (Tattersall 1993:174).

Tattersall (1986) suggested that we may need greater flexibility in the recognition and acknowledgement of species diversity in hominid fossil samples. He suggested there needs to be a greater recognition of the meaning of variation. Here we follow these important recent findings to assess quantitatively the single species hypothesis for these Vietnam Pleistocene hominoid assemblages. All four methods, CV, R%, and MI statistics, as well as frequency histograms, will be used in an attempt to give meaning to observed levels of variation.

## VARIATION IN THE VIETNAMESE SAMPLES

### *(i) Coefficient of Variation*

CV values for all measures and all sites are presented in Table 2. Where sample sizes are larger and more statistically acceptable, at Tham Khuyen, Lang Trang and Tham Om, CVs are relatively high. At Tham Khuyen 3 out of 14 CVs exceed the reference maxima, at Lang Trang 7 out of 16, and at Tham Om 2 out of 4. As the reference maxima are from large extant samples, these data point to rejection of the null hypothesis that only a single species of *Pongo* is represented at each of these sites. At Hang Hum and the other sites with small sample sizes, Dieu and Keo Leng, the reference maxima were not exceeded except once at Dieu when n = 2.

Table 2: Coefficient of variation (CV) values for Vietnamese hominoid sites (bold indicates exceeds reference maximum of Martin & Andrews 1993).

| Maxillary | MD | | | | BL | | | |
|---|---|---|---|---|---|---|---|---|
| | P3 | P4 | M1/2 | M3 | P3 | P4 | M1/2 | M3 |
| Tham Khuyen | 6.7 | **11.5*** | 8.2 | 4.7 | 4.2 | 9.9 | 5.3 | 9.3 |
| Lang Trang | 6.7 | 9.9 | **11.3** | 11.2 | 8.2 | 9.3 | 9.5 | 11.7 |
| Tham Om | | | 10.2 | | | | 7.9 | |
| Hang Hum | 3.1 | 6.4 | 4.1 | 4.8 | 6.4 | 6.9 | 5.2 | 8.7 |
| Keo Leng | | 7.2 | 3.8 | | | 3.4 | 8.8 | |
| Dieu Cave | 5.6 | | 2.5 | | | | 5.1 | |
| **Mandibular** | | | | | | | | |
| Tham Khuyen | 11.1 | 10.2 | 7.9 | | 9.7 | 1.1 | **8.3** | |
| Lang Trang | 8.4 | 9.7 | **8.5** | **11.1** | 7.0 | 10.1 | 7.2 | **12.2** |
| Tham Om | | | **8.8** | | | | 9.5 | |
| Hang Hum | 8.9 | 3.5 | 6.0 | 5.2 | 12.2 | 8.7 | 7.6 | 9.6 |
| Keo Leng | | 4.9 | 6.6 | | | 7.4 | 4.6 | |
| Dieu Cave | 6.9 | | 3.8 | | 3.7 | | **9.2** | |

Tham Khuyen, the sample characterised by earlier work in descriptive anatomy as having surprising variety, shows no greater quantitative variation, as measured by CV values, than either of the other larger sample size sites. At Tham Khuyen 21% of CVs are greater than the reference maxima, while at Lang Trang 44% are greater, and at Tham Om 50% exceed.

CV values suggest that the Late Pleistocene assemblages at Lang Trang and Tham Om show more variation than the Middle Pleistocene site of Tham Khuyen. These data reject the null hypothesis of the presence of a single hominoid species in the Pleistocene of Vietnam. In a fashion similar to that proposed for Tham Khuyen by Schwartz *et al.* (1994), quantitative assessment shows that more than one species of large bodied hominoid appears to have been present in each of the two Pleistocene sites.

### *(ii) R%*

Range of mean (R%) values for the three sites with larger samples are presented in Table 3. Surprisingly, none of the 14 dental measures of R% for the Tham Khuyen assemblage exceed the reference maxima. This statistic fails to discriminate multiple taxa here and were this statistic to be used alone, the null hypothesis would have to be accepted. However, at Lang Trang and Tham Om the situation is very different. At the Late Pleistocene sites the reference maxima for R% are exceeded in 6 out of 16 and 2 out of 4 dental measures respectively. At these sites the null hypothesis is clearly rejected.

At Dieu and Keo Leng the reference maxima were not exceeded, and the sample applies for the small samples from Hang Hum, except once when sample size was a respectable 15.

### *(iii) MI*

Maximum to minimum (MI) values for the three sites with larger samples are also presented in Table 3. Again, surprisingly, none of the 14 dental measures of MI for the Tham Khuyen assemblage exceed the reference maxima. As before however, at Lang Trang and Tham Om the situation is very different. At these Late Pleistocene sites the reference maxima for MI are exceeded in 6 out of 16 and 3 out of 4 dental measures respectively. At these sites the null hypothesis is clearly rejected by this statistic as well.

The sites with small samples again showed no excess of reference maxima.

### *(iv) Frequency Distribution Histograms*

Where sample sizes permitted, we also prepared frequency distributions of tooth dimensions. These are graphed in Figures 2, 3 and 4 (all figures are printed following the text).

Figure 2 shows frequency distributions for Tham Khuyen upper and lower first and second molar mesio-distal (MD) and bucco-lingual (BL) dimensions. These teeth were combined to (a) increase sample size, and (b) because Schwartz *et al.* (1994) combined them, following a common convention. The distributions are relatively small, and the patterns mixed. Three show a distinct bimodality in the most conservative interpretation. Such a reading smoothes the histograms and imagines data filling some of the gaps where zero is shown in these figures. However, when they are interpreted literally and strictly, Figures 2b, 2c and 2d have trimodal distributions.

Figure 3 concerns Lang Trang. Figures 3a-3d show lower third and fourth premolar MD and BL dimensions,

Table 3: R% and MI values for Vietnamese hominoid sites (bold indicates exceeds reference maximum of Martin & Andrews 1993).

| Maxillary | MD | | | | | | | | BL | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P3 | | P4 | | M1/2 | | M3 | | P3 | | P4 | | M1/2 | | M3 | |
| | R% | MI | R% | MI | R% | MI | R% | MI | R% | MI | R% | MI | R% | MI | R% | MI |
| Tham Khuyen | 14.7 | 116 | 27.4 | 132 | 29.5 | 132 | 10.9 | 111 | 11.3 | 112 | 23.0 | 127 | 18.6 | 120 | 22.2 | 125 |
| Lang Trang | 23.9 | 112 | 35.6 | 143 | **41.1*** | **151** | 26.6 | 130 | **28.6** | 132 | **36.5** | 144 | **36.2** | **143** | 27.8 | 131 |
| Tham Om | | | | | **34.5** | **143** | | | | | | | 25.7 | 128 | | |
| Hang Hum | 5.7 | 106 | 14.5 | 116 | 7.7 | 108 | 9.3 | 110 | 12.8 | 114 | 15.3 | 116 | 12.4 | 113 | 19.9 | 122 |
| **Mandibular** | | | | | | | | | | | | | | | | |
| Tham Khuyen | 31.1 | 137 | 18.6 | 120 | 19.9 | 122 | | | 24.0 | 128 | 2.1 | 102 | 24.1 | 128 | | |
| Lang Trang | 25.9 | 129 | 31.5 | 137 | 31.0 | **136** | **37.9** | **148** | 20.9 | 123 | 37.4 | 147 | 29.4 | 134 | **40.8** | **152** |
| Tham Om | | | | | 29.1 | **135** | | | | | | | **38.1** | **147** | | |
| Hang Hum | 23.7 | 127 | 9.1 | 110 | 22.0 | 124 | 12.3 | 114 | 36.4 | 146 | 30.5 | 133 | **31.6** | 136 | 17.0 | 118 |

Table 4: Summary of descriptive and numerical findings.

| Site | Age (kyr BP) | Descriptive systematics | | Numerical methods | | | | Predictive Value |
|---|---|---|---|---|---|---|---|---|
| | | No. of Species | Possibles | CV | R% | MI | Frequency Distributuions | |
| Tham Khuyen | 300 - 250 | 5 | yes | 3/14 | 0/14 | 0/14 | >1 | variable |
| Hang Hum | 140 - 80 | 2 | yes | 0/16 | 1/4 | 0/4 | >1 | weak |
| Tham Om | 125 | 3 | yes | 2/4 | 2/4 | 3/4 | >1 | strong |
| Lang Trang | Late Pc | 2 | no | 7/16 | 6/16 | 6/16 | >1 | strong |

while Figures 3e and 3f graph upper first and second molar MD and BL. Some of these sample sizes are very healthy, four in the high teens and two higher again (3e: N=32; 3f: N=31). All show at least bimodality. Figures 3b, 3c, 3e and 3f show three modal peaks, while strictly, Figure 3d has four.

Figure 4 combines a number of sites in order to look at a generalised Vietnamese Pleistocene sample. These sample sizes are quite large and very acceptable (n=53 - 57). They all show at least bimodality, and with the exception of Figure 4b, are trimodal.

These graphs indicate strong dominance of at least bimodality in the distributions. Strict interpretations would infer more modes in many cases. Following the claims of Cope (1989) and Martin & Andrews (1993), such distribution patterns force us to acknowledge the presence of multiple taxa in the samples.

## VARIATION AND SPECIES DIVERSITY

These quantitative assessments support the descriptive work of Schwartz *et al.* (1994, 1995). Species diversity of large bodied non-hylobatid hominoids in Pleistocene Vietnam is far greater than was previously realised.

For the Vietnamese Pleistocene assemblage considered as a whole, the single species hypothesis is rejected by these quantitative assessments. The suggestion of Schwartz *et al.* (1994, 1995) that large hominoid non-

hylobatid taxa constitute a diverse fauna is strongly supported.

The Tham Om assemblage provides the best agreement between descriptive analysis and these quantitative measures (Table 4). Schwartz *et al.* (1995) suggested three definite taxa for this site with a possibility of more. All the quantitative indicators point strongly to this.

On the other hand, at Lang Trang where, apart from one hominid tooth, the sample was judged to contain only *P. pygmaeus*, the quantitative evidence for rejection of the single species hypothesis is very strong. All measures clearly indicate this. So there is some discrepancy here between the descriptive findings and the numerical assessment.

The Hang Hum teeth were defined descriptively as showing two species. However, the corresponding quantitative interpretations are somewhat unclear. At Hang Hum the measures give only a hint of multiple taxa, with one lone R% measure exceeding the reference maximum.

At Tham Khuyen three CV measures (21%) are greater than reference maxima, so in the strict sense of Martin (1991) the single species hypothesis can be rejected. Similarly, four frequency distributions are at least bimodal, and this again allows rejection of this hypothesis. But the R% and MI results are not convincing, and provide no help in judging the presence of multiple species. Were they used alone, the hypothesis could not be rejected.

So how valuable are the quantitative indicators? It appears they have value and reliability, at least in general. Had this work been done in the absence of descriptive anatomy of the kind undertaken by Schwartz *et al.* (1994, 1995), would it have led to interpretations of multiple taxa? The answer is yes, with qualifications.

The numerical assessments work very well for two sites, give variable results at another site, but show weak correlations with the site of greatest descriptive diversity. CV, R% and MI emerge as having about the same degree of predictive value, varying in quality of detection of multiple taxa from one sample to the next. The CV index is a strong predictor at three sites, while R% and MI are strong for two of the samples. Frequency distributions clearly indicate multiple taxa (ie. >1) at all sites, and may prove the best indicator to use, at least in preliminary analysis.

These results reinforce the advice given by Martin and Andrews (1993): it is best to make use of all these measures. Furthermore, it shows the value of using numerical and descriptive methods in concert. At Tham Khuyen and Hang Hum, frequency distributions indicate multiple species, and suggest the need for further assessment. However, such assessment shows divergence of interpretations between descriptive anatomy and quantitative analysis. At Tham Om and Lang Trang on the other hand, results from all methods agree, and it appears we can be quite confident of multiple taxa being represented.

Finally, the Vietnamese assemblage as a whole was found to contain a large amount of sexual dimorphism in *Pongo pygmaeus* (Schwartz *et al.* 1995). This could be seen to influence quantitative indicators of variation. Particularly at Lang Trang this seems to be the case. On the other hand however, at Hang Hum, where there is also considerable sexual dimorphism described, the quantitative assessments do not indicate variation in excess of any reference maximum. So there is no clear trend here. These samples of fossil *Pongo pygmaeus* may indeed be showing greater sexual dimorphism in the Pleistocene. But as Martin (1991:112) said, there is no quantitative method of judging this. The one path open to us is to say that the single species hypothesis is clearly rejected by measures exceeding the reference maxima and by bimodality in frequency distributions. This is clearly the case for Pleistocene hominoids in Vietnam.

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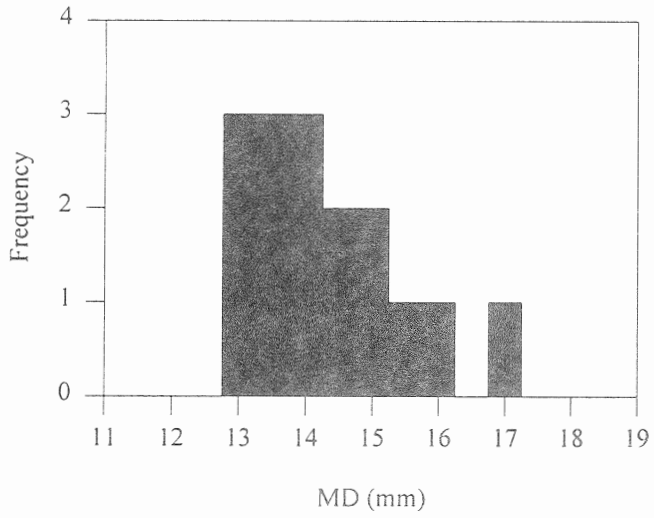


Fig. 2a: Tham Khuyen Upper First and Second Molar Mesio-Distal Dimensions

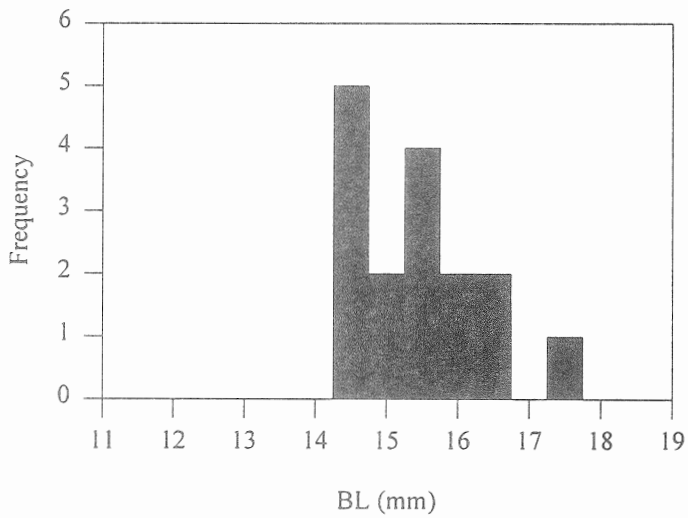


Fig. 2b: Tham Khuyen Upper First and Second Molar Bucco-Lingual Dimensions

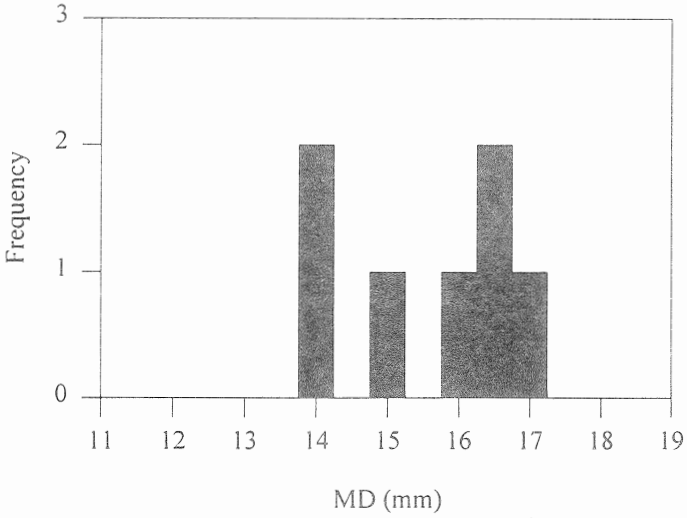


Fig. 2c: Tham Khuyen Lower First and Second Molar Mesio-Distal Dimensions

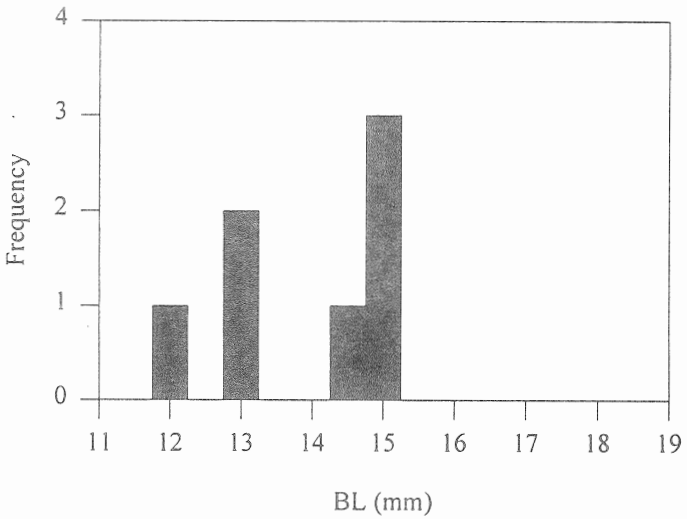


Fig. 2d: Tham Khuyen Lower First and Second Molar Bucco-Lingual Dimensions

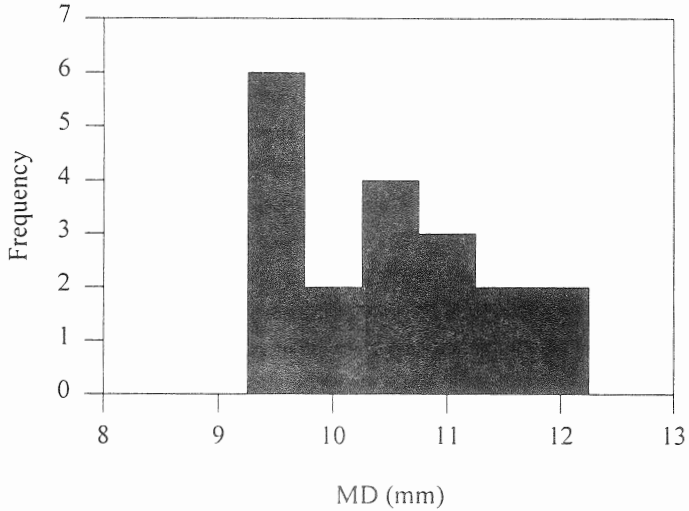


Fig. 3a: Lang Trang Lower Third Premolar Mesio-Distal Dimensions

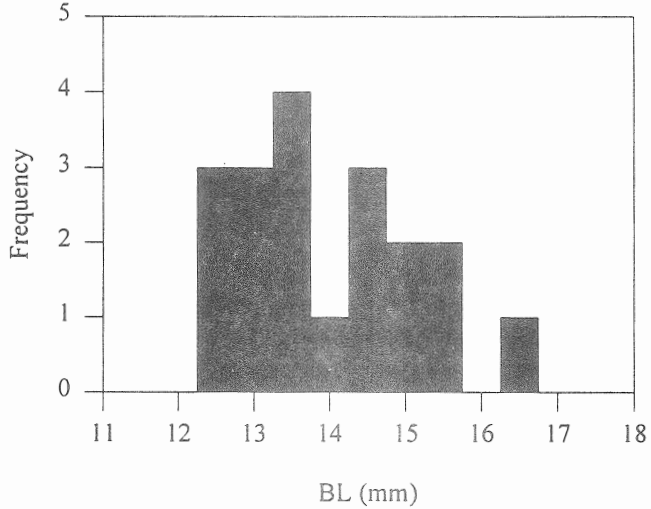


Fig. 3b: Lang Trang Lower Third Premolar Bucco-Lingual Dimensions

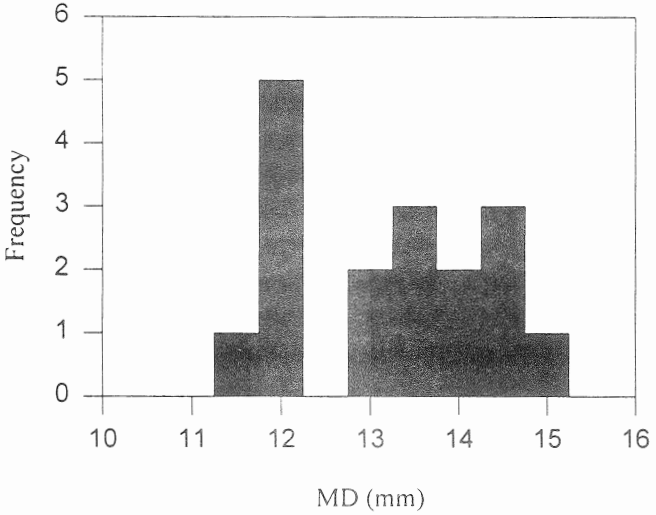


Fig. 3c: Lang Trang Lower Fourth Premolar Mesio-Distal Dimensions

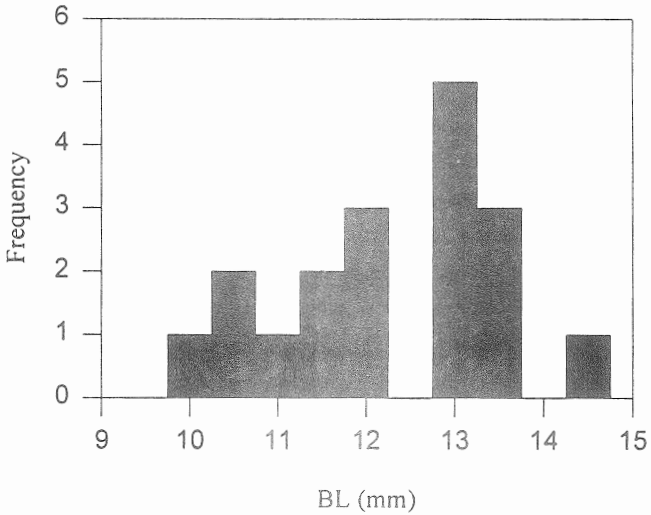


Fig. 3d: Lang Trang Lower Fourth Premolar Bucco-Lingual Dimensions

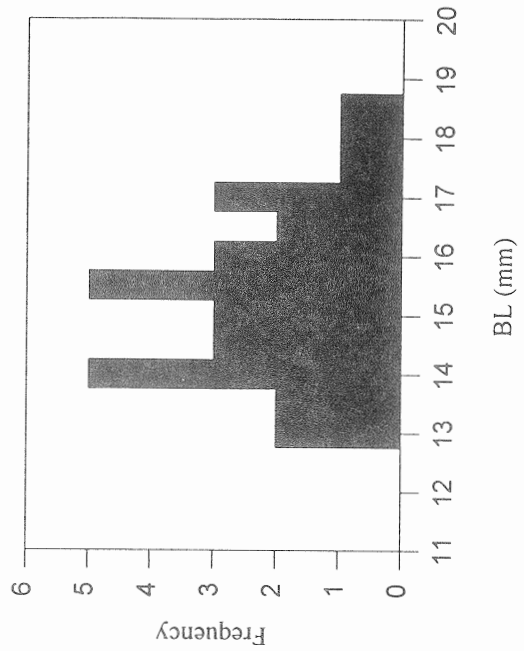


Fig. 3f: Lang Trang Upper First and Second Molar Bucco-Lingual Dimensions

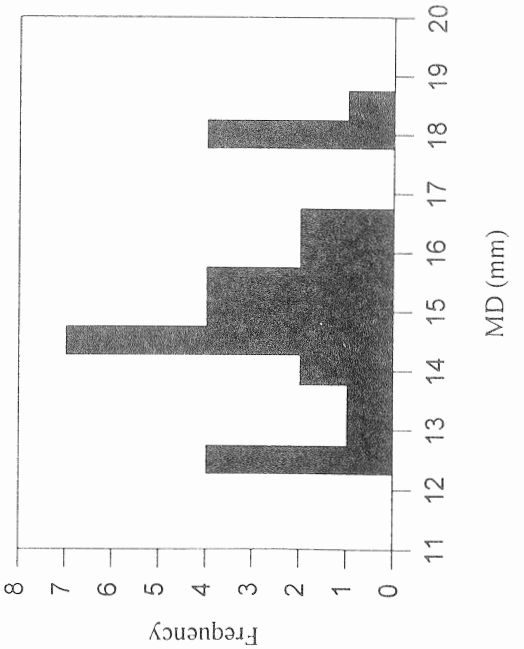


Fig. 3e: Lang Trang Upper First and Second Molar Mesio-Distal Dimensions

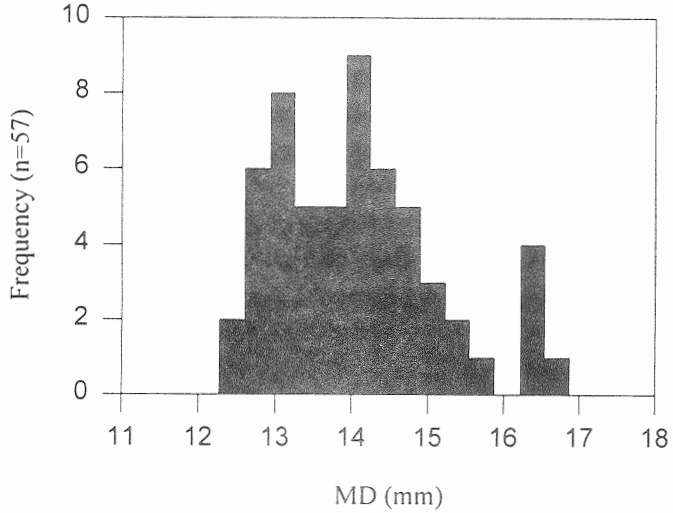


Fig. 4a: Combined Site* Upper First and Second Molar Mesio-Distal Dimensions

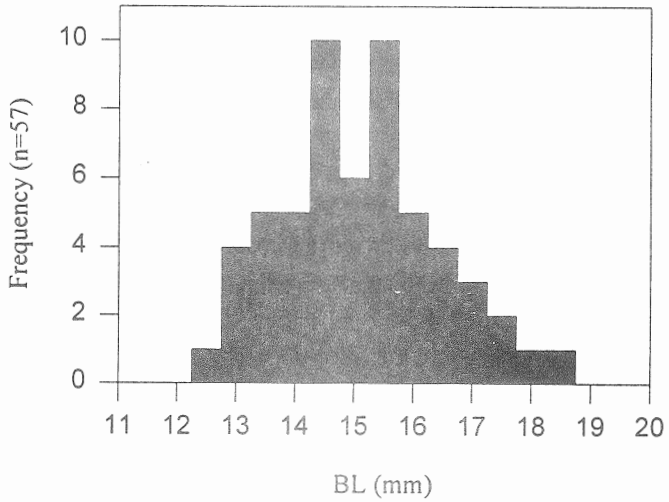


Fig. 4b: Combined Site Upper First and Second Molar Bucco-Lingual Dimensions

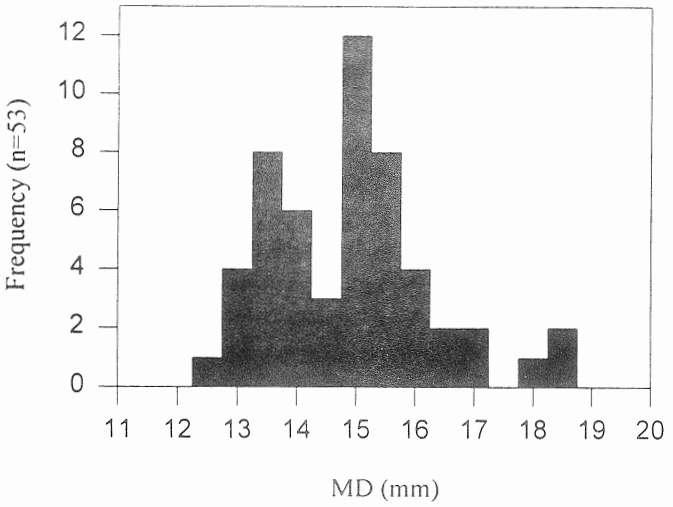


Fig. 4c: Combined Site Lower First and Second Molar Mesio-Distal Dimensions

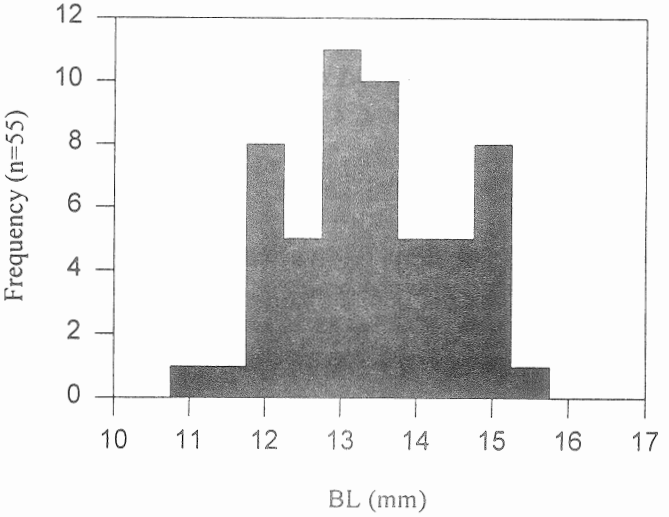


Fig. 4d: Combined Site Lower First and Second Molar Bucco-Lingual Dimensions

* Combined Sites: Dieu, Hang Hum, Keo Leng, Lang Trang, Tham Khuyen