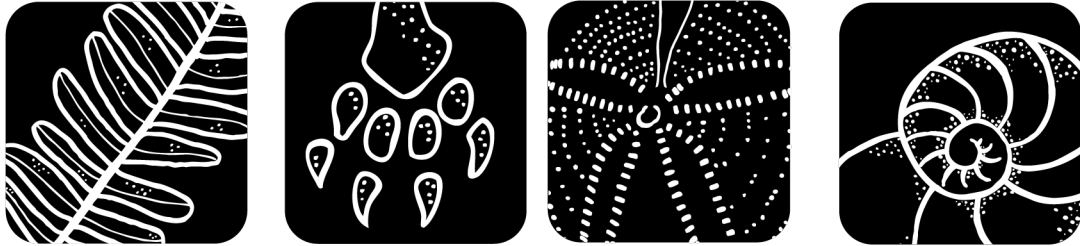


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Abstract Book

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THE ROLE OF VERY-ABUNDANT TAXA IN OVERPRINTING ECOLOGICAL SIGNALS IN FOSSIL ASSEMBLAGES

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The relative abundances of different taxa have been used to infer ecological gradients in a range of both modern and ancient settings using a variety of multivariate statistical techniques, such as cluster analysis, non-metric multidimensional scaling (NMDS), and detrended correspondence analysis (DCA). The inferred ecological gradients derived from these statistical techniques are typically controlled by the relative abundances of different taxa within each respective assemblage, as abundances of taxa usually track environmental and ecological conditions. In the majority of ecological analyses, the most common or abundant taxa modulate the patterns produced by these various statistical techniques. The role of less abundant taxa in controlling these patterns is not well understood and necessitates further study. To examine this question, we examined how very-abundant genera (i.e., >25% abundance in pooled samples) control ecological signals from different fossil samples using both cluster analysis and DCA. Our data were derived from bulk samples collected from five separate shell-rich horizons separated by unconformities in the Pleistocene Bermont Formation exposed in the Longan Lakes Quarry, FL. Samples from this locality are characterized by diverse, mollusk-rich fossil assemblages with an abundance of the bivalve *Chione* (Mühlfeld, 1811) and/or the gastropod *Cerithium* (Born, 1778), which together typically represent >50% of the fauna. We compared cluster diagrams and DCA plots that utilized datasets that both included and excluded *Chione* and *Cerithium* abundance data. The DCA plots show distinct patterns before and after the exclusion of *Chione* and *Cerithium*. Prior to elimination of these genera, most taxa on the DCA plot show an uninterpretable cluster isolated from *Chione* and *Cerithium*. When they are removed, an ecologically interpretable 'boomerang' pattern for samples and taxa becomes visible in the plot. In the cluster analysis, the five samples show a distinct clustering pattern before and after the removal of *Chione* and *Cerithium*. When the most common taxa are removed from the dataset used for the cluster analysis, the faunal similarities and differences become more apparent and appear to correspond to depth related changes that are also apparent in the lithostratigraphy of the Longan Lakes section. These scenarios reveal how the overall ecological and environmental pattern can be overprinted by the most abundant components of a fossil assemblage.

Session 8-Poster 18: Saturday, 4:45 PM

Presenter: V. J. Syverson

RECONSTRUCTING CYRTOCRINID ECOLOGY AND BIOLOGY BASED ON LIVING POPULATIONS OF HOLOPUS AND CYATHIDIUM

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The Cyrtocrinida (Crinoidea, Articulata) are the smallest and least well-known of living crinoid orders. Although they are known to have been common and highly diverse in the Mesozoic, only four extant species are known, all of which live cemented to hard substrates in deep water. Consequently, their biology and ecology are not very well understood, despite their interesting status as living representatives of a formerly important taxon and as living examples of the formerly common, but now rare, sessile crinoid life habit. Video footage of a hard-substrate continental slope community at Roatán, Islas de la Bahía, Honduras, has been obtained via submersible for two consecutive years (2012 and 2013). Hundreds to thousands of living individuals of the cyrtocrinids *Holopus* sp. and *Cyathidium* sp. (family Holopodidae) are recorded in the footage. Remains of dead individuals can also be discerned by the attachment structures still cemented to the substrate. This new source of information on living cyrtocrinids allows us to analyze the population structure of these populations using size-frequency distributions, live-dead counts, and spatial data, as well as recording changes in single individuals between the two years. We use these data to infer preferred orientations, reproduction and recruitment patterns, and life histories for both taxa.

Session 8-Poster 19: Saturday, 4:45 PM

Presenter: Theodorou Georgios

THE DEVELOPMENT OF ALLOMETRIC EQUATIONS FOR ESTIMATING THE DIMENSIONS OF THE *ELEPHAS TILIENSIS* SKELETAL ELEMENTS

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Excavations in Charkadio cave at Tilos Island have been held

for more than thirty years. Through 2012, excavations have unearthed more than 15,000 fossil bones of *Elephas tiliensis*. Our aim is to reconstruct a life-size model, according to the auspices of THALIS MSI380135, based on morphology, biometry, and rapid prototyping technologies such as CT and laser scanner. The first biometrical and morphological results of the study of *E. tiliensis* suggested sexual dimorphism in adult individuals. This study evaluates how different measurements of individual skeletal elements are correlated to each other. The relative value of different measurements was evaluated and only highly correlated measurements have been included in our analysis. Statistical analysis methods and multivariate allometry have been utilized in order to create mathematical equations representing the correlation of different skeletal elements. The aforementioned equations have been estimated by using either the formula of simple allometry or the curve estimation produced by the calculation of the best-fit line describing the data. This procedure contributed to the estimation of missing measurements due to fragmentary material or specimens of different ontogenetic stage. The optimal selection for the current research has been made so as to minimize the errors between the observed values and the estimated values derived from the allometric patterns.

Session 8-Poster 20: Saturday, 4:45 PM

Presenter: Louis G. Zachos

UPPER MISSISSIPPIAN (CHESTERIAN) ECHINOIDS FROM ALABAMA AND MISSISSIPPI

Zachos, Louis G., Geology and Geological Engineering, University of Mississippi, University, MS 38677

Upper Mississippian (Chesterian) sedimentary rocks in the Pride Mountain Formation Hartselle Sandstone and Bangor Formation (in ascending order) are well-exposed in quarries, road cuts, and natural outcrops in portions of Colbert County, northwest Alabama, and Tishomingo County, northeast Mississippi. Echinoid remains, consisting of scattered to isolated plates, spines, and lanterns, are common although not abundant. Disarticulated palaechinid remains (tentatively identified as *Melonechinus* sp.) are found in lowermost Pride Mountain Fm. sandy limestone associated with a diverse

megafauna of well-preserved rugose corals, brachiopods, crinoids, and blastoids (*Pentremites* sp.). The sedimentary setting is interpreted as a shallowing-upward, nearshore shelf environment. Scattered plates and spines of archaeocidarid echinoids (tentatively identified as *Lepidocidaris* sp.) are found in thin storm-lag deposits rich in blastozoan debris and bryozoans in what is interpreted as a distal ramp environment of the Bangor Formation. Paleozoic echinoids are notoriously ill-preserved in general, but their association with other echinoderm remains permits direct comparison of taphonomic histories and paleoecologic interpretation.

Session 8-Poster 21: Saturday, 4:45 PM

Presenter: Kathryn Estes-Smargiassi

A STRING OF SMALL KNOBS FROM THE UPPER TRIASSIC SHALES OF WESTERN EUROPE

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A string of small knobs was collected from the dark-colored Late Triassic (mid-Rhaetian) shales from the Eastern Netherlands, deposited in a near-coastal environment. The specimen was found in Quarry IV of the Winterswijk quarry complex, 180–200 cm below the Rhaetian-Oligocene contact. These Dutch Rhaetian shales are a part of the Sleek Formation, which is the lowermost unit of the Altena Group. The shales in this quarry contain bivalves (eight species, 689 specimens), ophiuroids (at least twenty individuals from a single species), and fish, as well as plant fossils including palynomorphs and one horsetail fragment, based on previous research. The specimen consists of a string of small knobs about 20 mm in length and 3.5 mm in width, with each knob of about 0.5 mm in diameter. The width of the string is not consistent throughout and the string is oriented parallel to the bedding plane. The knobs are present on both the top and the bottom of the string. This research will discuss possible hypotheses as to what this string of knobs may represent, including a string of eggs, larvae, or a fossil burrow.

Session No. 9: New advances and applications in sclerochronology (poster session)

Saturday Afternoon, 4:45 PM to 5:45 PM

Session 9-Poster 22: Saturday, 4:45 PM

Presenter: Justin McNabb

ESTABLISHING THE LIFESPAN OF THE PLIOCENE BIVALVE *ASTARTE CONCENTRICA* USING SCLEROCHRONOLOGIC ANALYSIS

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The extant genus *Astarte* exhibits decreasing size through geologic time. It is an ideal candidate for studying changes in longevity through time because of its wide temporal and

spatial distribution, ranging back to the Oligocene and today extending from the Arctic to the Caribbean. Our overall goal is to determine whether the observed change in size is accompanied with a change in longevity. To achieve this goal, we first established a methodology to identify annual increments in shell growth and estimate age using Pliocene shells from the Mid-Atlantic Coastal Plain, USA. Annual growth increments were identified using sclerochronologic analysis and ontogenetic changes were evaluated using von Bertalanffy growth equations. Previous studies have shown that modern species of *Astarte* live for about 20 years. Future work will determine if growth rates and longevity are similar throughout the genus, and whether changes in climate and/or water depth play a role in shell growth and longevity.

The development of allometric equations for estimating the dimensions of the *Elephas tiliensis* skeletal elements

G. THEODOROU, V. MITSOPOULOU, S. ISIDOROU, T. VASILOPOULOS, E. THEODOROU, S. ROUSSIAKIS, D. MICHAILIDIS

Introduction

Charkadio cave is located in Tilos Island, Greece. Several excavations carried out between 1971 and 2012 resulted in a rich fossil fauna comprised of dwarf elephant (*Elephas tiliensis*), deer (*Dama dama*), chelonian (*Testudo marginata*) and avian remains (Bachmayer *et al.*, 1976). Of particular interest are the remains of the last European elephant *E. tiliensis* (Theodorou *et al.*, 2007), dated from 45 ka to 3.5 ka (Bachmayer *et al.*, 1984). In total, more than 11.000 elephant skeletal remains were unearthed, representing at least 75 individuals (Table 1). These remains are mostly fragmentary and therefore the estimation of a mean value of specific adult skeletal elements is difficult to be determined (Fig. 1). **The aim of this study is the development of allometric equations in order to estimate lacking values of maximal length in tibias.** These estimations are applicable to the 3D reconstruction of a complete *E. tiliensis* skeleton (Research Funding Program THALES MIS 380135)

Methodology

A quantitative assessment of the relative proportions of the tibia in several specimens, leads to the conclusion that particular dimensions are highly correlated. The dimensions of the tibias were recorded with a series of measurements using precision calipers. Equations describing the mathematical relationship of highly correlated measurements are formulated.

Out of the twenty two measurements recorded, three highly correlated measurements were selected: the maximal length (no 2), the proximal transverse width at the epiphyseal line (no 4), and the minimal transverse diameter of the shaft (no 10) (Fig. 2). The metrical data recorded was transformed to logarithmic values and PCA analysis was applied. Additionally, the geometric mean for the aforementioned measurements was calculated.

The equation of simple allometry (Huxley, 1932) has been applied. Huxley, in order to estimate morphometric variations associated with size, composed the formula of simple allometry $y = bx^a$ where x and y are trait measurements, and b and a are constants (Jolicoeur, 1963; Gould, 1966; Klingenberg, 1996; Sukumar, 2003).

The log-transformed equation is as follows: $y = \log b + a \log x$

Constant a , which represents the slope in log-log plots of x and y is the allometric coefficient. The constants b and a have been calculated by using the multivariate generalization of the allometry equation (Jolicoeur, 1963). The equation of the latter can be expressed in terms of arithmetic coordinates as follows:

$$\left(\frac{X_1}{G_1}\right)^{1/\cos\theta_1} = \dots = \left(\frac{X_i}{G_i}\right)^{1/\cos\theta_i} = \left(\frac{X_j}{G_j}\right)^{1/\cos\theta_j} = \dots = \left(\frac{X_p}{G_p}\right)^{1/\cos\theta_p}$$

Where:

P = the number of variates,

X_i = the arithmetic value of the i_{th} variate,

G_i = the geometric mean of X_i ,

θ_i = the angle made by the first principal component of the logarithmic covariance matrix with the coordinate axis of the logarithm of X_i .

The association of any two terms of this P -dimensional relationship yields a two-dimensional relationship equivalent to the allometric equation:

$$X_i = \frac{G_i}{G_j^{a_{ij}}} X_j^{a_{ij}}$$

Where: $a_{ij} = \cos\theta_i / \cos\theta_j$ is the allometry exponent of the i_{th} variate relatively to the j_{th}

Huxley's equation has also been estimated by using the curve estimation (fitting) derived from SPSS.

Results

The results given by the aforementioned equations were tested by comparing the absolute error between the approximate values and the exact measurements recorded with the use of calipers.

Huxley's equation (**equation 1**), describing the relationship between measurements 2 and 10, when run through SPSS is as follows:

$$y = 21.116x^{0.707} \quad (\text{equation 1})$$

It can be observed that the equation shows negative allometry $a < 1$

Huxley's equation (**equation 2**), describing the relationship between measurements 2 and 10, when Jolicoeur method is applied, takes the form of:

$$y = 20.761x^{0.71} \quad (\text{equation 2})$$

It is also observed that the equation shows negative allometry $a < 1$

Huxley's equation (**equation 3**), describing the relationship between measurements 2 and 4, when run through SPSS is:

$$y = 9.023x^{0.753} \quad (\text{equation 3})$$

It can be observed that the equation shows negative allometry $a < 1$

Huxley's equation (**equation 4**), describing the relationship between measurements 2 and 4, when Jolicoeur method is applied, takes the form of:

$$y = 7.403x^{0.791} \quad (\text{equation 4})$$

It is also observed that the equation shows negative allometry $a < 1$

Elephas tiliensis Tibia		Table 1. The NISP and MNE units
NISP	132	
MNE	75	

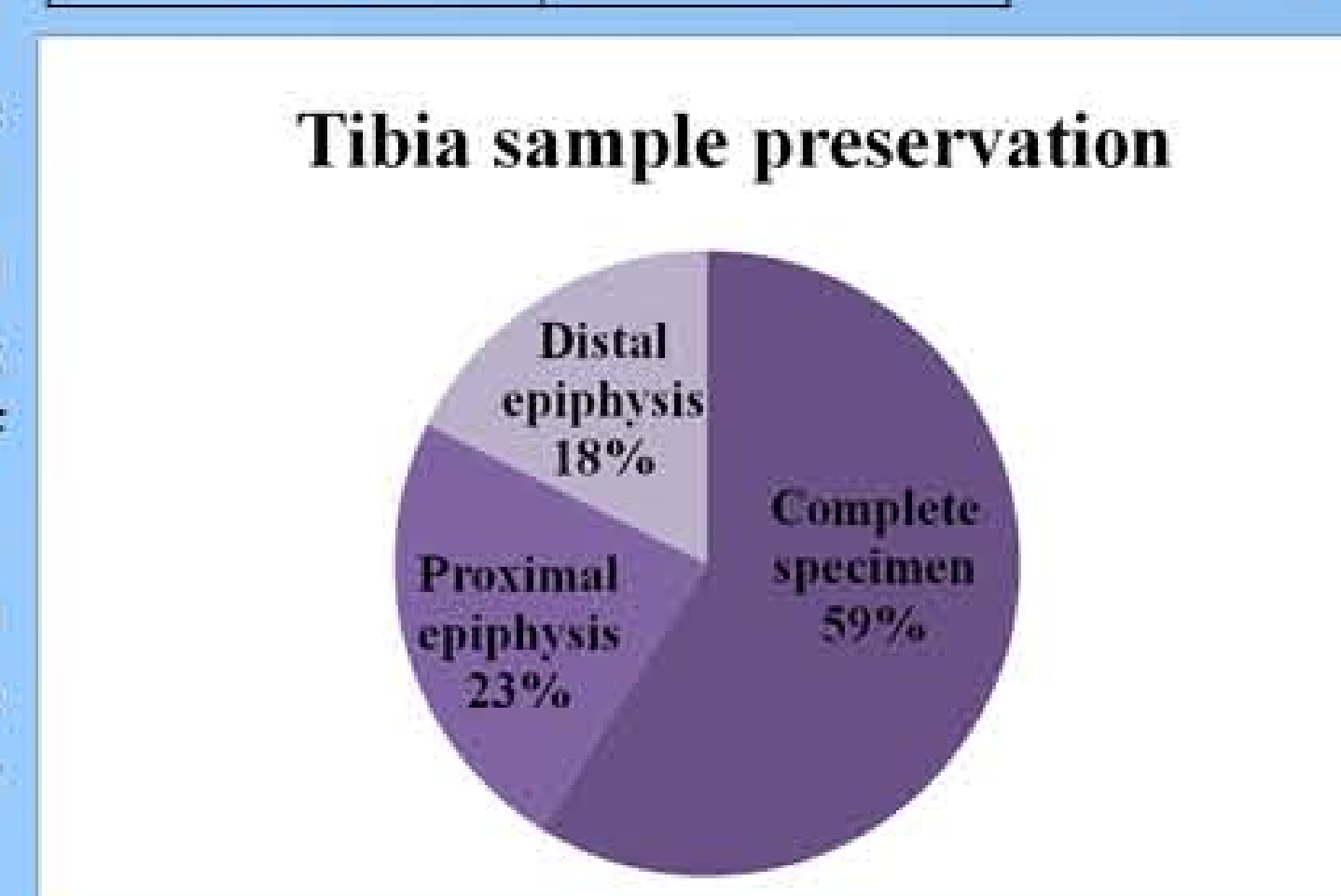


Figure 1. Rose diagram of skeletal element completeness for tibia

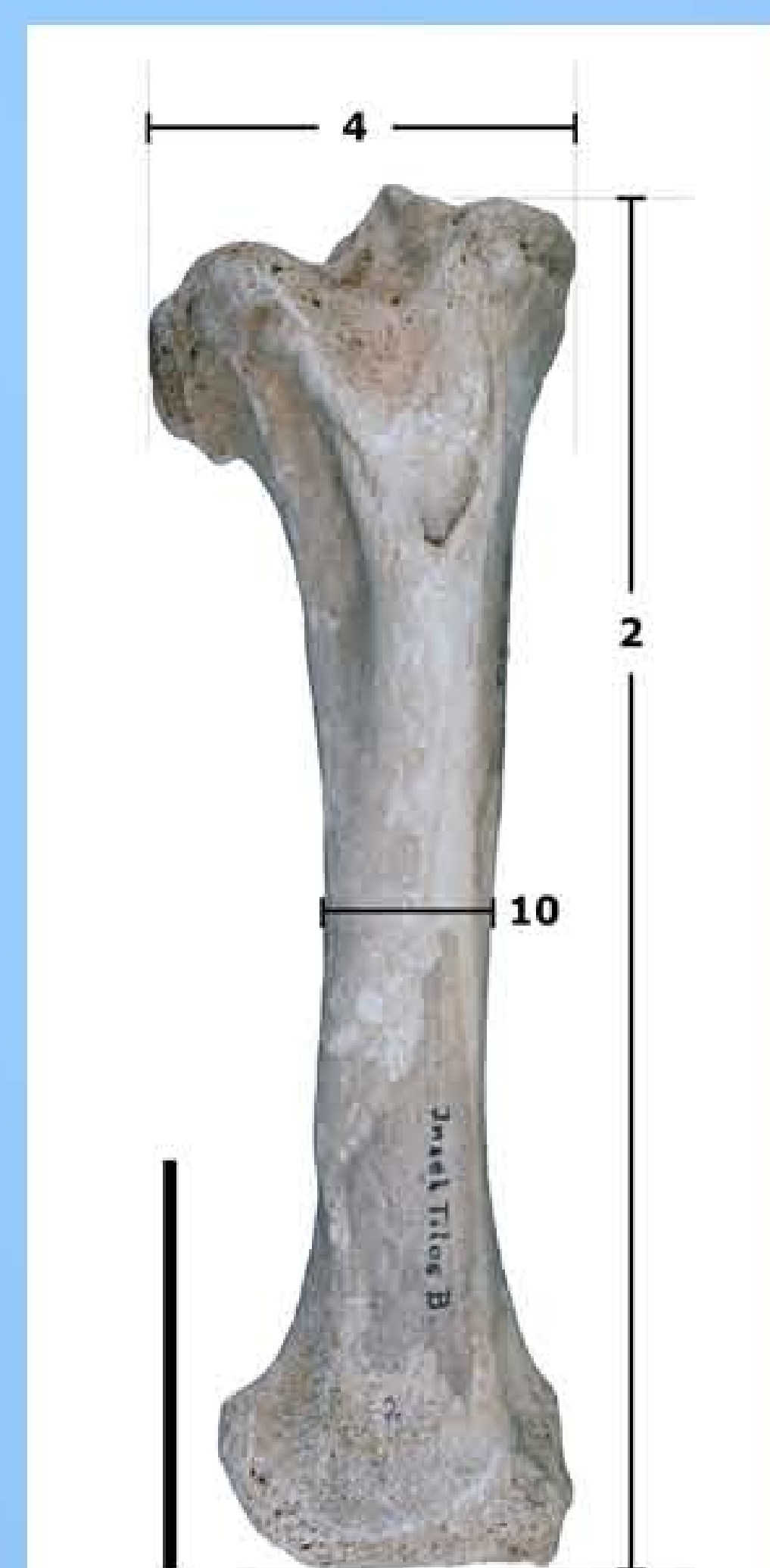


Figure 2. *E. tiliensis* tibia in anterior view. Measurements (2, 4, 10) are used in this study. Scale bar= 10cm

Table 2 displays the percentage of the absolute error for measurement 2 produced by 10 and 4 for the aforementioned equations (Huxley's run through SPSS, Huxley's adapted by Jolicoeur).

These equations were also used in order to estimate the missing values of measurement 2, first when measurement 4 was known and then when measurement 10 was known.

Table 3 illustrates the estimated values of selected specimens for measurement 2 derived from measurement 4 and 10, according to the two methods used.

Table 3. Estimated Values					
M10	M2 SPSS	M2 Jolicoeur	M4	M2 SPSS	M2 Jolicoeur
48.1	325.99	324.46	127.1	345.93	342.50
51.1	340.22	338.70	133.9	359.77	356.92
51.5	342.10	340.58	122.4	336.25	332.44
53.5	351.44	349.92	131.1	354.09	351.01
53.4	350.97	349.45	113.4	317.47	312.94

Specimen 25 (Table 3, values in bold) preserves measurements 10 and 4 and therefore the estimated results can be compared. When measurement 10 is used to estimate the value of measurement 2 according to equation 1, the estimated value is 342.10, and according to equation 2 the value is 340.58. In addition, when measurement 4 is used to estimate measurement 2, equation 3 estimated a value of 345.93 and equation 4 a value of 342.50.

Discussion

The two methods proposed are producing valid results both in terms of the rate of increase in the measurements used and in the estimation of missing values. However, the nature of the studied material introduces limitations.

For example the relatively small statistical sample (n=53) and the fragmentary nature of the material might have influenced the results. Measurement 2 records the maximum length of the tibia and is rarely preserved in the sample. Measurements 4 and 10 were preserved in the majority of the sample and they were statistically highly correlated to measurement 2.

In specimen 25, which preserved both measurements 10 and 4, both methods produced similar results in terms of the estimation of measurement 2. The above also confirms the validity of the methods. Furthermore, two alternative equations were used in an attempt to estimate the maximum height of tibias:

$$y = ax + b \quad y = e^{ax+b}$$

This study shows that in adult tibia specimens the maximum length increases at a slower rate than the width of the shaft. In other words, as tibias become longer they also become increasingly wider. Two hypotheses can be used to interpret the above results.

Firstly, the allometric growth pattern observed could be the result of skeletal maturity in the sample. In elephants, certain dimensions of the long bones continue to grow until late in their lifetime (Laws, 1966; Roth, 1984; Sukumar, 2003; Herridge, 2010). Two ossifying centers, one at the proximal epiphysis and another at the distal epiphysis, control the increase in the length of the tibia. An ossifying centre at the shaft controls the increase in width of the tibia. Longitudinal growth dramatically decelerates with the fusion of the epiphyses. However, the ossifying centre at the shaft remains active after the fusion of the epiphyses increasing shaft width.

Secondly, the allometric growth pattern observed could be influenced by sexual dimorphism. Long bones of extant male elephants are both longer and more robust than those of females due to delayed epiphyseal fusion on long bones of males (Lee and Moss, 1994; Poole, 1994). Therefore the allometric growth pattern observed, where the longitudinal growth of tibia increases at a lower rate than tibia width, could be due to the increased robustness observed in the adult male tibias.

The above hypotheses offer a plausible palaeontological interpretation of the mathematical growth patterns observed in the sample. The examination of the above hypotheses requires a similar analysis for all the long bones of adult *E. tiliensis* material, as the tibia might not accurately represent the typical skeletal growth pattern of this taxon.

This research has been co-financed by the European Union (European Social Fund - ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: THALES: Reinforcement of the interdisciplinary and/or inter-institutional research and innovation.

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