

## SHORT STATURE OR TALL STORY? HYPOTHESIS AND IMAGINATION IN BODY SIZE RECONSTRUCTION OF LB1 FROM FLORES, INDONESIA

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### INTRODUCTION

The LB1 partial skeleton was recovered in September 2003 at a depth of 5.9 m during archeological excavations at the Liang Bua site on the island of Flores, Indonesia [1]. The individual has been diagnosed as female and dated to about 18 kyr, an estimate bracketed by thermoluminescence dates of  $35 \pm 4$  kyr and  $14 \pm 2$  kyr, although these figures are disputed [2]. This specimen has been described as the holotype (to which an associated left mandibular  $P_3$  was referred) of a new hominin species, *Homo floresiensis*. Among the features used to support the creation of this new taxon are some estimated dimensions that are extreme in relation to other human populations from this time period, including an endocranial volume of  $380 \text{ cm}^3$  and a stature of 106 cm. Here we focus on alternative stature reconstructions and their implications.

### METHODS

In the original report, the extremely short stature of 106 cm for LB1 had been reconstructed [1] using an average of results from three regression formulae derived from human pygmies [3]: least squares (LS), 109 cm; major axis (MA), 104 cm and reduced major axis (RMA), 106 cm. Because this result differed so widely from other human population means and no justification was given for the choice of formulae, we surveyed the substantial existing literature for alternative methods that had been used on populations broadly comparable to LB1.

All results reported in the following section are based on the data originally reported in [1]:

LB1 femur length (FL) = 28.0 cm, tibia length (TL) = 23.5 cm

### RESULTS AND DISCUSSION

Details of alternative samples and methods for stature estimation are provided in specific references cited below.

[4] African Pygmies, regression lines:

Stature =  $1.74 (\text{FL}) + 84.5 = 133.2 \text{ cm}$

Stature =  $1.85 (\text{TL}) + 88.8 = 132.3 \text{ cm}$

Stature =  $1.31 (\text{FL} + \text{TL}) + 55.3 = 122.7 \text{ cm}$

[4] African Pygmies, correlation axis:

Stature =  $3.42 (\text{FL}) + 17.1 = 112.9 \text{ cm}$

Stature =  $3.29 (\text{TL}) + 37.8 = 115.1 \text{ cm}$

Stature =  $1.61 (\text{FL} + \text{TL}) + 32.6 = 115.5 \text{ cm}$

[5] Mongoloid, regression:

Stature =  $2.15 (\text{FL}) + 72.57 = 132.8 \text{ cm}$

Stature =  $2.39 (\text{TL}) + 81.45 = 137.6 \text{ cm}$

Stature =  $1.22 (\text{FL} + \text{TL}) + 70.37 = 133.2 \text{ cm}$

[6] Javanese females, regression:

Stature =  $36.5 + 2.98 (\text{FL}) = 119.9 \text{ cm}$

Stature =  $52.0 + 3.08 (\text{TL}) = 124.4 \text{ cm}$

The unweighted average of the preceding 11 estimates is 125.4 cm, far closer to the estimate of 120 cm [2], which in turn approximates the regression based on femur length for Javanese females, than it is to the original estimate of 106 cm [1]. A stature of 120 to 125 cm is low for extant humans, but is only moderately below those recorded for insular Asian populations exhibiting normally short stature, such as a sample of 15 Andaman Island females averaging 137 cm [7].

### CONCLUSIONS

Representation of LB1 as the holotype of a new hominin species [1] was challenged initially, with the alternative hypothesis that the specimen instead was a microcephalic individual [8] accounting for the extremely low endocranial volume, which is about one third the average of extant *Homo sapiens* and comparable to chimpanzees and Plio-Pleistocene fossil hominids. The microcephalic hypothesis has been buttressed by subsequent studies of LB1 [2] and our own research on previously known Flores human specimens, which are short (152 cm) but not dwarfed. The idea of individual abnormality rather than phylogenetic novelty gains additional support from other features of the LB1 skeletal remains, comprising a skull vault that exhibits early fusion of cranial sutures, as well as the presence of several dental abnormalities, including tooth crowding, with both maxillary  $P^4$ s being rotated parallel to the tooth row, plus a congenitally absent left  $M^3$ . These and other postcranial details support the hypothesis that the endocranial volume and stature of the LB1 individual are consistent with known microcephalic members in extant *Homo sapiens* populations [9] of small stature.

### REFERENCES

1. Brown P, et al. *Nature* **431**, 1055-1061, 2004.
2. Jacob, T. Personal communication, 17 December 2004.
3. Jungers WL. *Am. J. Phys. Anthrop.* **76**, 227-231, 1988.
4. Olivier G. *J. Hum. Evol.* **5**, 529-534, 1976
5. Trotter M, Gleser GC. *Am. J. Phys. Anthrop.* **16**, 79-123, 1958.
6. Bergman RAM, The TH. *Documenta de Medicina Geographica et Tropica* **7**, 197-214, 1955.
7. Quatrefages, A de. *The Pygmies*, Macmillan, New York, 1894.
8. Henneberg M, Thorne A. *Before Farming*, in press.
9. Hall JG et al. *Am J. Med. Genet.* **130A**, 55-72, 2004.

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