

What was the size of the "Devil": Reflections on the body mass and stature of the Foresta hominin trackmakers (Roccamonfina volcano, Italy)

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Methods for Body Mass (BM) and Stature (ST) estimates

We inferred body mass (BM) and the stature (ST) of the hominin trackmakers who went down the Foresta ignimbritic slope, applying to their measurement data set [1] the regression equations and formulas proposed by Dingwall and colleagues [2] and Ruff and colleagues [3] for BM, Duveau [4] for ST, and Grivas and colleagues [5] and Domjanic and colleagues [6,7] for both BM and ST.

Grivas and colleagues [5] derived the equations they proposed for estimating BM and ST ($BM \text{ kg} = -71.142 + 5.259 \times \text{right rFL}$ and $BM = -70.385 + 5.217 \times \text{left rFL}$, where rFL = footprint length) and ST ($ST = 17.369 + 5.879 \times \text{right rFl}$; $ST \text{ (cm)} = 17.592 + 5.861 \times \text{left rFl}$), analyzing the centimetric length (rFL) of the right and left foot in modern *H. sapiens* Greek individuals of school age (4–18 years). The body size of the population of *Homo neanderthalensis* from Theopetra Cave (Greece, which dates to 130,000 years ago, was estimated using these equations. The equations were applied to estimate the population of *Homo neanderthalensis* at Theopetra Cave (Greece), dated to 130,000 years ago. The formulas were applied to the 3D laser scanned and measured length and width of the footprints, due to their suitability for estimating population size when sex and age information is unavailable. [8,9]. We applied these equations to the F/DT site, where the age and sex of human trackmakers are also unknown, for the same reason.

Dingwall and colleagues [2] developed some valuable formulas for morphometric estimations based on the analysis of experimentally created footprints of contemporary *Homo sapiens* groups of the Daasanach tribe, which live in the Ileret area. The formulas, derived directly from footprints and calibrated considering walking speeds, have been used both for the study of the *Homo erectus* Ileret footprints (Kenya) ($1.53 \pm 0.01\text{Ma} - 1.52 \pm 0.01\text{Ma}$) [2,10,11,12], and of *Homo antecessor* from the British site of Happisburgh (UK) ($1-0.78 \text{ Ma}$) [13]. We considered the most suitable and applied the Dingwall and colleagues' [2] so-called "walk-only" regression formulas." ($BM = 4.71 + 1.82 \times \text{average rFL}$, and $BM = 23.64 + 0.11 \times Fa$, where $Fa = \text{average footprint area}$) for estimating the trackmakers' body size at the Middle Pleistocene site of F/DT.

Ruff and colleagues [3] developed three equations for estimating BM equations ($BM = -0.250 \times Fa + 0.00099 \times Fa^2 + 59.1$; $BM = -21.9 \times rFl + 0.546 \times rFl^2 + 265.4$; $BM = -25.8 \times rFw + 1.84 \times rFw^2 + 133.3$). The equations were based on data (both the foot size and the body mass index) derived by the analysis of five samples with sufficiently well-known anthropometric and ontogenetic characteristics, belonging to populations that habitually walk barefoot. The authors noted that the samples "encompass a wide range of body sizes and shapes, with individual adult values of body mass ranging from 36 to 99 kg, stature from 135 to 192 cm, and BMI from 15.7 to 32.3 kg/m². Four of the five samples also included adolescents" [3]. They also developed some techniques for relating and converting foot dimensions to footprint measurements. Both the regression equations and the conversion ratio were applied to the Late Pliocene footprint sample from Laetoli (Tanzania), generally attributed to some *Australopithecus afarensis* specimens, and to four footprint samples, ranging in age from the Pleistocene to the Holocene, and whose trackmakers had been tentatively identified as *Homo erectus* (from Ileret, Kenya), *Homo antecessor* (from Happisburgh, UK), archaic *Homo sapiens/Homo neanderthalensis* (from Le Rozel, France), and *Homo sapiens* (from Barcin Höyük, Turkey) [3].

We decided to apply these equations to the pre-*sapiens* human footprints from the F/DT site due their widespread use and reliability at different sites with footprints attributed to pre-human and human genera and species [3].

Domjanic and colleagues [7] derived their equations for estimating BM ($BM = -80.4 + 15.3 \times rFw$; $BM = -97.4 + 2.44 \times rFl + 10.7 \times rFw$, where rFw = footprint width) and ST ($ST = 47.0 + 5.00 \times rFl$) analyzing the variables obtained combining the measurements and the geometric morphometric data of the scanned plantar foot of 134 individuals belonging to modern *H. sapiens* populations from central Europe, both males and females of different ages. The authors regarded the footprint width, measured between the first and the fifth metatarsal joint, as the best variable for estimating BM. Altamura and colleagues [14] applied the Domjanic and colleagues [7] equations to verify the authenticity of some Gombore II-OAM (Melka-Kunture, Ethiopia, Africa) human fossil footprints. We analyzed the F/DT data sets using the Domjanic et al. (2015) equations elaborated based on the dimensions most objectively measurable (i.e., rFl and rFw).

Webb [5] derived its formula ($ST = rFl \times 6.58$) from the anthropometric characteristics of recent Australian aboriginal populations (foot and stride length). The author used the formula for inferring ST of the trackmakers of the great number of human footprints and trackways left at the Willandra lake ichnosite (23-19 ka).

Fessler and colleagues [16] derived the ratio of foot length against the ST ($\times 100$) from the analysis of some published anthropometric dataset, based on the male and female foot dimensions belonging to several populations from different geographic regions, continents, and ethnic groups. According to the results obtained by the authors, the foot length might correspond to a percentage of stature ranging from 14.3% to 16.00 % of the and from 13.5% to 16.11% in males and in females, respectively. Since the gender of the F/DT trackmakers cannot be firmly determined, we estimate ST using a 15.25% value, assuming a rough equivalence between fleshy foot size and footprint size [17].

We also adopted some regression equations ($ST = 4.1 \times rFl + 66.9$; $ST = 4.9 \times rFw + 121.4$; $ST = 0.2 \times Fa + 137.9$) among those proposed by Duveau [4]. The author derived the equations from the dimensions and shape of 175 barefoot footprints, experimentally generated by 20 individuals of both sexes, who walked at a normal pace on a flat surface of fine- to medium-grained moist sand. "The 20 individuals ranged in age from 11 to 36 years (mean: 23 years), in stature from 146.0 to 182.3 cm (mean: 167 cm), and in foot length from 20.4 to 26.6 cm (mean: 23.3 cm)" [4]. The rather complex method is correctly based on the principle that a compelling estimate of human stature can be obtained by considering not only the footprint morphometric data but also the gait of trackmakers and the nature of the substrate on which the footprints were imprinted. The greatly influenced shape and dimensions of human footprints, even those left by a single trackmaker (e.g., [18]).

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