

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

Maria Rita Palombo<sup>1\*</sup>, Adolfo Panarello<sup>2</sup>

<sup>1</sup> CNR- Institute of Environmental Geology and Geoengineering (IGAG), unit Research Roma 1, via Salaria Km29.300, Monterotondo Stazione (Rome), Italy; Sapienza University of Rome, P.le Aldo Moro 5, 00185 Roma, Italy; mariarita.palombo46@gmail.com; mariarita.palombo@uniroma1.it

<sup>2</sup> Ancient History and Archaeology Research Lab, Department of Human, Social and Health Sciences, (University of Cassino and Southern Latium03043 Cassino (FR), Italy)

\* Correspondence: mariarita.palombo46@gmail.com

## SUPPLEMENTARY INFORMATION SI 2

### The intriguing issue of measuring the human footprint dimensions

Whatever the purpose of a study of human footprints should be, the reliability of the achieved results depends on the consistency of the dataset on which it is based. Indeed, the quality of the dataset is fundamental for correctly analyzing anatomical characteristics and estimating physical and pace dynamic parameters, as well as formulating reliable hypotheses about putative ecological and behavioral attitudes of hominins by means of mathematical models applied to footprint dimensions (e.g., [1–4], etc.). Hence, the scientific relevance of any study dramatically decreases if footprint dimensions have been taken following dissimilar measurement protocol and conventions. The discrepancy in measurement conventions becomes more evident in the computational procedures when the initial data are computed by means of multiple equations, generated for estimating hominin body size (Body Mass, BM, and Stature, ST) and other body parameters. For the purpose of minimizing these issues, researchers attempted to standardize the data collection and recording procedures. In 2018, a team of paleoichnologists published the first "Standard protocol for the documentation of modern and fossil ichnological data" [5]. The protocol would enable researchers to obtain results fitting each other (i.e., BM and ST estimates) because they were based on data sets obtained using the same measurement criteria. However, the measurements of some footprint dimensions, such as the footprint area, may still be problematic. For instance, at site Foresta/Devil's Trails, the area of the best-preserved footprints (Sample B) has been calculated with trivial approximation by drawing a rich point polyline, which represents the footprint's real perimeter ([6,7] and references therein). Contrariwise, multiplying the footprint length by the footprint width, the area value is overestimated because the obtained results correspond to the area of the parallelogram that includes the footprint.

The measurement of foot length has proven to be more reliable for the study of stature, but its measurement can be done in different ways, providing databases whose comparison may not be reliable enough, as it may occur for other anatomical landmarks (see [8,9] and references therein, for discussion).

The researchers have widely scrutinized issues related to the validity and reliability of footprint measurement approaches (e.g., [10–13] and references therein) and the best method for assessing the morphology of a footprint for obtaining more compelling measurements of human footprints (e.g., [14] and references therein). However, waiting for a solution universally accepted by the scientific community, how to attain reaching a survey's uniformity remains an unsolved question.

#### References

1. Dingwall, H.L.; Hatala, K.G.; Wunderlich, R.A.; Richmond, B.G. Hominin stature, body mass, and walking speed estimates based on 1.5 million-year-old fossil footprints at Ileret, Kenya. *J. Hum. Evol.*, **2013**, *64*, 556–568.
2. Hatala, K.G.; Roach, N.T.; Ostrofsky, K.R.; Wunderlich, R.E.; Dingwall, H.L.; Villmoare, B.A.; Green, D.J.; Harris, J.W.K.; Braun, D.R.; Richmond, B.G. Footprints reveal direct evidence of group behaviour and locomotion in *Homo erectus*. *Sci. Rep.*, **2016**, *6*, 28766.
3. Bennett M.R.; Bustos, D.; Odess, D.; Urban, T.M.; Lallensack, J.N.; Budka, M.; Santucci, V.L.; Martinez, P.; Wiseman, A.L.A.; Reynolds S.C. Walking in mud: Remarkable Pleistocene human trackways from White Sands National Park (New Mexico). *Quat. Sci. Rev.*, **2020**, *249*, 106610.

4. Stewart, M.; Clark-Wilson, R.; Breeze, P.S.; Janulis, K.; Candy, I.; Armitage, S.J.; Ryves, D.B.; Louys, J.; Duval, M.; Gilbert, J.; Price, G.J.; Cuthbertson, P.; Bernal, M.A.; Drake, N.A.; Alsharekh, A.M.; Zahrani, B.; Al-Omari, A.; Roberts, P.; Groucutt, H.S.; Petraglia, M.D. Human footprints provide snapshot of last interglacial ecology in the Arabian interior. *Sci. Adv.*, **2020**, *6*, eaba8940.
5. Falkingham, P.L.; Bates, K.T.; Avanzini, M.; Bennett, M.; Bordys, E.M.; Breithaup, B.H.; Castanera, D.; Citton, P.; Díaz-Martínez, I.; Farlow, J.O.; Fiorillo, A.R.; Gates, S.M.; Getty, P.; Hatala, K.G.; Hornung, J.J.; Hyatt, J.A.; Klein, H.; Lallensack, J.N.; Martin, A.J.; Mary, D.; Matthews, N.A.; Meyer, C.A.; Milàn, J.; Minter, N.J.; Razzolini, N.L.; Romilio, A.; Salisbur, S.W.; Sciscio, L.; Tanaka, I.; Wiseman, A.L.A.; Xing, L.D.; Belvedere, M. A Standard Protocol for Documenting Modern and Fossil Ichnological Data. *Palaeontology*, **2018**, *61*, 469–480.
6. Panarello, A. Rilevare, analizzare e interpretare le orme umane fossili. In *2001-2021: Vent'anni di ricerche sulle "Ciampate del diavolo". Dalla leggenda alla realtà scientifica*; Mietto P.; Panarello A.; Di Vito, M.A., Eds.; *Misc. INGV*, **2022**, *64*, pp. 107–122.
7. Palombo, M.R.; Panarello, A. How many hominins walked on the slope of the Foresta ignimbrite deposit (Roccamonfina volcano, central Italy)? *Journal of Mediterranean Earth Sciences*, **2023**, *15*, 229–271.
8. Hemy, N.; Flavel, A.; Ishak, N.-I.; Franklin, D. Estimation of stature using anthropometry of feet and footprints in a Western Australian population. *Journal of Forensic and Legal Medicine*, **2013**, *20*, 435–441.
9. Duveau, J. From footprint morphometrics to the stature of fossil hominins: A common but uncertain estimate. *L'Anthropologie*, **2022**, *126*, 103067.
10. Reel, S.; Rouse, S.; Vernon, W.; Doherty, P. Reliability of a two-dimensional footprint measurement approach. *Science & Justice*, **2010**, *58*, 113–118.
11. Reel, S.; Rouse, S.; Vernon, W.; Doherty, P. Estimation of stature from static and dynamic footprints. *Forensic Sci. Int.*, **2012**, *219*, 283e1-283e5.
12. Reel, S. Development and evaluation of a valid and reliable footprint measurement approach in forensic identification. Ph.D. Thesis, The University of Leeds, Leeds, UK; York St John University, York, UK; School of Health and Life Sciences, 2012; pp. 1–286.
13. Wiseman, A.L.A.; De Groote, I. One size fits all? Stature estimation from footprints and the effect of substrate and speed on footprint creation. *The Anatomical Record*, **2022**, *305*, 1692–1700.
14. Belvedere, M.; Bennett, M.R.; Marty, D.; Budka, M.; Reynolds, S.C.; Bakirov, R. Stat-tracks and mediotypes: powerful tools for modern ichnology based on 3D models. *PeerJ*, **2018**, *6*, e4247.