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ANALYSIS AND INTERPRETATION OF NEOLITHIC PERIOD FOOTPRINTS FROM BARCIN HÖYÜK, TURKEY

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ABSTRACT

Presented here are a pair of preserved footprints discovered in 2014 at the site of Barcın Höyük, a Neolithic site located in northwestern Turkey. Found within the entrance of Structure 2a, the footprints date to approximately 6400 cal. BC. Footprints are rarely discovered in prehistoric settlements, adding significance to their study and to the conditions that led to their formation and ultimate preservation. This article provides anthropological estimations for the individuals who left the footprints and discusses the possibility of symbolism using contextual information and ethnographic and archaeological parallels. The measurements and analyses confirm that the footprints are the bare left and right foot of a single individual and provide clues about the biological profile of the individual. The footprint of the right foot produces various measurements such as footprint length, breadth and heel breadth. When compared with known standards, the print appears likely to be of an adult male 169.9 cm tall (with a 16.78 CI at 95% ranging from 153.1-186.66 cm) and weighing 71.9 kg (with a 31.14 kg CI at 95% ranging from 40.76 – 103.04 kg).

KEYWORDS: Barcın Höyük, Neolithic, footprints, sex determination, stature estimation, body weight estimation

1. INTRODUCTION

The analysis of footprints provides scientists working in various areas with new information. For instance, footprints provide the opportunity to determine the biological profile of the individual(s) who made them (Atamtürk 2010; Atamtürk and Duyar 2008; Jasuja et al. 1993; Robbins 1986). Prehistoric footprints allow us to determine the physical characteristics of ancient people and, in evolutionary cases, may even enable insights into the locomotor biomechanics of hominins and the evolution of the foot structure (Bennett and Morse 2014; Mietto et al. 2003; Webb et al. 2006).

Carved, painted and incised footprints are often considered sacred and the literature on their symbolism is wide ranging (Bertilsson 2013; Bradley 1997; Brown 1990; Dunbabin 1990; Hasan 1993; Ludowyk 2013; Takacs 2007; Thomas 2008; van Pelt and Staring 2017). Impressed footprints, on the other hand, may have an equally high ritual standing but they also carry the possibility of being unintentionally produced. Artwork depicting footprints carries symbolic connotations because it is often considered a sign either of an invisible deity or a revered holy person. Bertilsson (2013) and Bradley (1997) demonstrate that incised footprints are a cosmological pictogram cross-regionally in prehistoric rock art. In Ancient Egypt, priests graffitied their footprints and sometimes their names and titles onto temple roofs, often with an accompanying text stating that they would "remain forever in the presence of their god" (van Pelt and Staring 2017). Located at the entrance of the 8th Century BC Neo-Hittite temple of Ain 'Dara, the giant 1 meter long carved footprints likely carry ritual significance as their location suggests (Thomas 2008). Footprint engravings likewise continue through the Graeco-Roman Period, like those known from Kızıldağ in the Konya Plain of Central Anatolia, and have been interpreted as either a way to record the location of partakers in religious ceremonies (Rojas and Sergueenkova 2014) or the pilgrimage of the disciples of Craterus (Dunbabin 1990). In either case, footprints are associated with considerable symbolism (Takacs 2007). Hasan (1993) demonstrates how veneration of footprints transcends into Islam and explores the ritual of Qadam Rasul honoring the footprint of the prophet, and its antecedents in both Christianity and Judaism. Likewise, stylized footprints of the Buddha often incised in stone are revered across many Buddhist countries (Brown 1990; Ludowyk 2013).

Impressed footprints, on the other hand, are often simply preserved because of favorable natural and geological conditions. Such footprints show the mold of the foot by becoming fossilized in ash layers or the like. The most well-known is, of course, the 3.5-million-year-old Laetoli footprints from Tanzania providing important insights on foot morphology and the evolutionary development of the foot. Turkey, too, specifically the Kula Demirköprü Region houses over 200 fossilized Pleistocene footprints dating to approximately 26,000 B.P. and belonging to at least three different individuals (Kayan 1992; Ozansoy 1969; Westaway et al. 2006). Other examples like those from Willandra Lakes, Australia (Webb et al. 2006), Roccamonfina, Italy (Mietto et al. 2003), Koobi Fora and Ileret in Kenya (Dingwall et al. 2013, Roberts and Berger 1997), Jaguar Cave, Tennessee (Willey et al. 2005) Lake Managuq, Nicaragua (Brinton 1887), Namib Sand Sea, Namibia (Morse et al. 2013) and Pompeii, Italy (Mastrolorenzo et al. 2006) are also the result of accidental preservation situations. Many of these footprints have been studied in terms of stratigraphy, taphonomy and approximate dates (Scaillet et al. 2008; Grün et al. 2011; Bennett and Morse 2014). Fossilized footprints may make it possible to determine the foot structure and locomotion form as well (Tuttle 2008; Morse et al. 2013; Bennett and Morse 2014). In addition, the discovery of foot imprints prompts in some cases an interest in biological profiles including stature, body weight and gender of the individuals who left the prints, using forensic calculations and estimations (Capecchi 1984; D'Août et al. 2010; Dingwall et al. 2013; Mieto et al. 2003; Tuttle 2008; Webb et al. 2006; White and Suwa 1987).

More difficult to answer is whether strategically placed foot imprints carried symbolic meanings such as incised and etched footprints may have had. In other words, could an imprint of a foot be made specifically for a symbolic purpose? This question is addressed for the Barcın Höyük footprints by discussing whether they were implanted accidentally or deliberately and by placing the footprints in their archaeological context.

2. THE BARCIN HÖYÜK FOOTPRINTS

Preserving both the two dimensional and the three dimensional impressions of the foot, the footprints discovered at the settlement of Barcın Höyük were made by pressing the sole of the foot onto a soft surface. Discovered in 2014, they date to approximately to 6400 cal. BC. Barcın Höyük is located in NW Anatolia (Fig. 1) and at present represents the earliest farming settlement in the region (Gerritsen et al. 2013a, 2013b; Gerritsen and Özbal 2016; Özbal and Gerritsen 2015). Though practiced in Central and Southeast Anatolia already for over a millennium, the spread of farming and

animal husbandry to western Anatolia and from there to Europe did not take place before 6700 cal. BC (Düring 2013; Schoop 2005; Weninger et al. 2014). Barcın Höyük must therefore be viewed as a pioneer settlement and represents the first farming groups that left these core areas to explore new horizons. The footprint was not discovered in the earliest level of occupation dating to 6600-6500 cal. BC but to Phase VId1, which represents the occupational phase immediately thereafter. Excavated structures in this phase were aligned linearly in a row. From the four aligned structures, it appears that larger structures ranging in size around 23 m^2 and smaller structures about half the size were placed alternatingly (Fig. 2). Both of the smaller structures 21 and 2a were burnt, allowing for good preservation of interior characteristics which in both cases included plastered wood and loam platforms and *in situ* finds. The footprints were discovered near the entrance zone of Structure 2a, positioned as if exiting the structure.

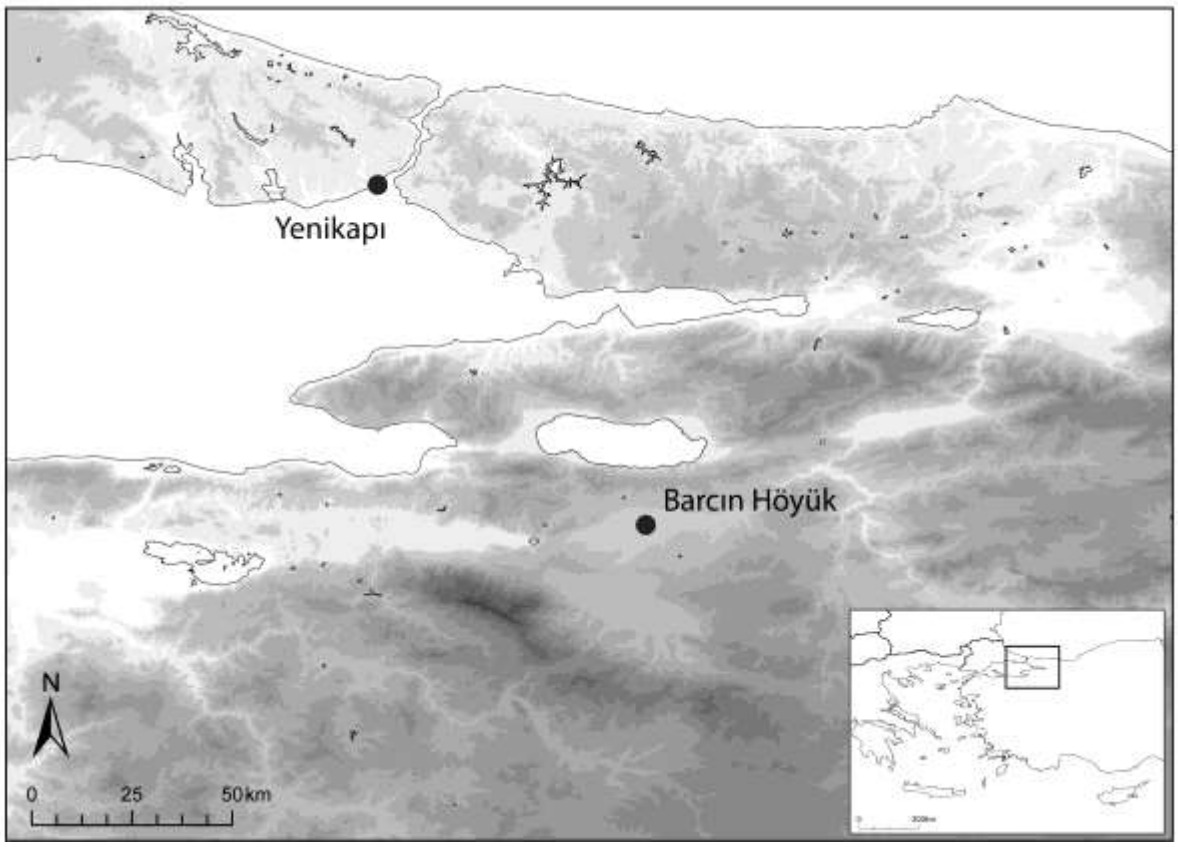

Figure 1 : Map showing the location of Barcın Höyük and Yenikapı both mentioned in the text

It is worth noting that this is the second set of footprints found dating to the seventh millennium from the Marmara region. Excavations at the site of Yenikapı in İstanbul yielded over 2000 footprints, some barefooted and others wearing some sort of footgear (Kızıltan and Polat 2013:118). Those from Barcın are a few centuries older and unlike those from Yenikapı, come from an indoor context (Özbal and Gerritsen 2015). Perhaps more significant may be the circumstances of their production; while those from Yenikapı represent accidentally preserved prints by inhabitants walking about in every which way, those from Barcın may carry other connotations.

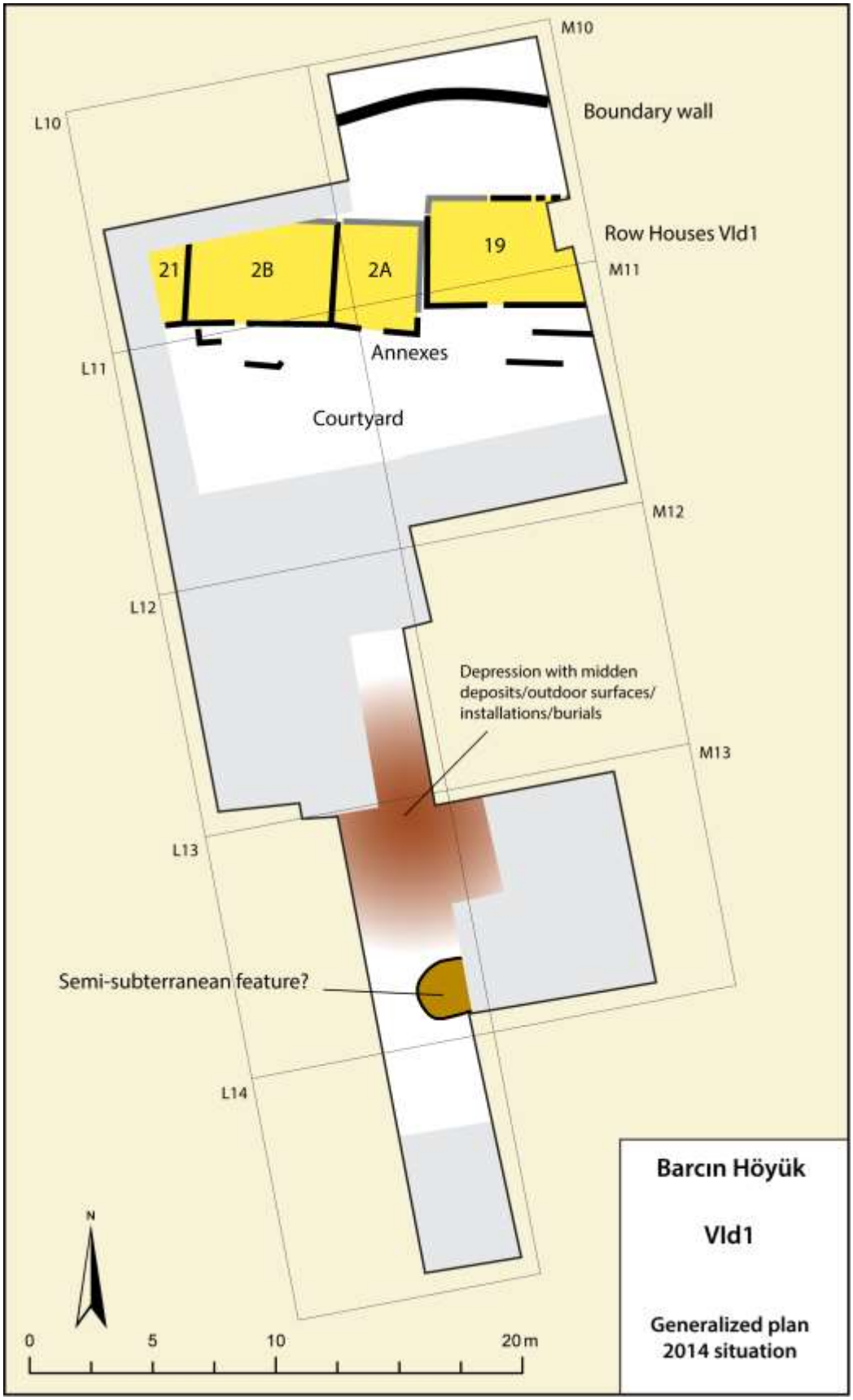

Figure 2: Schematic plan of Barcın Höyük Level VId1 showing structure 2a

Figure 3: Photo of both footprints at Barcın Höyük

The conditions of preservation of the Barcın Höyük footprints are noteworthy. They were impressed within a freshly plastered floor in the room (Fig, 3). The plaster was made of loam with straw mixed in. However, thereafter another layer of floor plaster had been placed on top, hiding them from view. The burning of the structure caused the uppermost plaster layers of the floor to be fire-hardened and as a consequence, preserved the footprints. Following excavation, the footprint was consolidated, removed in a single piece, placed in a wooden box specifically made for the feature, and transported to the local museum. A silicon mold and a plaster replica of the footprint were made of the footprint, enabling later study of the feature. One factor that complicated the removal of the footprint was the discovery of a cattle skull located immediately beneath the plaster under the left footprint. The resistence from underneath prevented the left footprint, located about half a foot's length in front of the right footprint, from forming a deep impression and resulted in a shallow and superficial print. Measurements taken, as explained below, comfirm that both prints belonged to the same individual. Even though the left footprint remains shallow, the right foot was firmly sunken into the clay which enabled an impression that showed all five toes, the heel and the arch (Fig. 4).

3. MATERIALS AND METHODS

Depending on the condition of the ground, footprints in soft surfaces are classified as "positive" footprints and footprints left on a hard surface are classified as "negative" footprints. While the right footprint at Barcın Höyük made by stepping into the wet freshly plastered floor must be classified as a "positive footprint" (Figure 4 and Figure 5), the other one, which faced the resistance of the animal skull below is, consequently, a negative footprint, impressed into hard ground. All the contours and lines were clearly visible and well-maintained in the print of the right foot as it plunged into freshly applied plaster although such delineations were much less clear in the left one. Nonetheless, measurements and calculations and morphological observations, indicate that the two Barcın footprints, most probably, belong to the same individual.

Figure 4: Photo of the right footprint

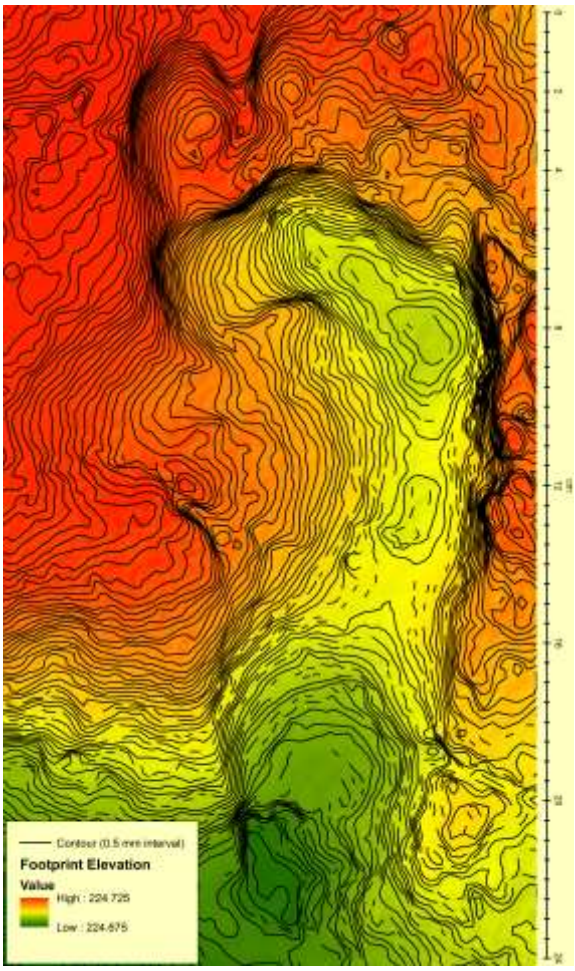

Figure 5: An elevation diagram of the right footprint

It is well-known that footprints differ significantly from the actual foot size of the individual who made the imprint. Some studies examine this difference; Dingwall et al. (2013), for example, state that the footprint length could vary approximately 1.7-14.5% from the actual foot length such that the footprint length on average may be as much as 10% smaller than the actual length of the foot. Atamtürk (2003), likewise, put forward that the difference between the actual length of the foot and the size of its corresponding print could differ by about 2 cm in length and about 1 cm in breadth. Consequently, in order to minimize the error rate, in this article, the footprint size rather than actual foot size has been taken into consideration.

Generally, when determining an individual's gender, stature and body weight, the footprints' length, breadth and the heel breadth measurements are collectively taken into consideration (Abledu et al. 2015; Hemy et al. 2013; Ukoha et al. 2013). Because the right footprint found at Barcın Höyük was so clear, anthropometric measurements were taken from the right footprint. The sizes have been obtained in the following manner (Laskowski and Kyle 1988):*Footprint length* (FPL) is measured as the direct maximum distance from the most posterior point of the heel to the tip of longest toe.

Footprint breadth (FPB) is the linear distance between the points of maximum lateral obtrusion of the fifth foot bone and the most medial point of the first toe of the foot.

Footprint heel breadth (FPHB) is the distance between the uppermost lateral obtrusive points of the heel.

These measurements given in Table 1 provide the biological profile of the footprint's owner determined using these values. To minimize the error

margin, calculations are based on equations deriving from right foot measurement values.

Table 1: The measurement values for the Barcın Höyük right footprint in mm

	Right footprint
Footprint length (FPL)	245
Footprint breadth (FPB)	97
Footprint heel breadth (FPHB)	66

4. ANALYSES AND EVALUATION

Although less well preserved, the measurements indicate that the left foot belongs to the same person. Because foot size grows synchronically with the other parts of the body until the end of puberty (Liu et al. 1998), the size of a footprint can only be useful in determining the age of pre-adults Based on cross-cultural ethnographic analogies (Atamtürk 2010; Hemy et al. 2013; Krishan 2008), our measurements indicate that the Barcın Höyük footprints belong to an adult individual, completely grown. Nonetheless, whether this person was a young or middle-aged adult or elderly individual cannot be ascertained.

4.1. ESTIMATION OF SEX

While experiments to determine whether the pressure exerted on the ground differs in the footprints of males and females have yielded inconclusive results (Putti et al. 2010), sex identification can, in fact, be made by measuring the absolute and proportional dimensions of a footprint (Atamtürk 2010; Fessler et al. 2005; Wunderlich and Cavanagh 2001; Krishan 2008).

Table 2: Comparison of anthropometric figures from a range of different populations

	Barcın Höyük	Turkey (Atamtürk 2010)		Australia (Hemy et al. 2013)		India (Krishan 2008)
Variable	Male	Males	Females	Males	Females	Males
Footprint length (mm)	24.5	24.99±1.22	22.77±1,04	25.48±1.33	23.01±1.17	24.13±3.26
Footprint breadth (mm)	9.7	10.03±0.62	9.21±0,67	9.95±0.63	8.97±0.57	8.69±1.90
Footprint heel breadth (mm)	6.6	6.20±0.53	5.76±0,58	5.59±0.46	5.06±0.46	4.92±1.39

Our study of the Barcın Höyük footprints uses the anthropometric dimensions obtained from different populations and discriminant functions obtained from these measurements to identify sex. While genetic factors help to determine the form of the general structure of the foot, many studies emphasize the importance of environmental factors in the shaping of the foot. Consequently, one notes particular differences in foot measurements and forms across different communities (Anıl et al. 1997; Rocke and Davila 1972; Rutishauser 1968). Data from the three aforementioned studies have been applied (Table 2). The measurements of the Barcın Höyük footprints have been compared to the sizes of adult individuals living in Turkey (Atamtürk 2010; 254 males and 262 females), in Western Australia (Hemy et al. 2013; 90 males and 110 females) and in Northern India (Krishan 2008; 1040 males). Measurements indicate that the length, breadth and heel size of the Barcın footprint equates more closely with male individuals' measurements in the studied populations.

In addition to the abovementioned studies, the Barcın footprint's measurements were compared to the right footprints of 126 Ghanaian males and females varying in age from 18-30 years as a further step in the sex determination of the Barcın footprints' owner (Abledu et al. 2015; Table 3). The table indicates that all the three equations targeted to determine the sex of the individual fall within the range of an adult male.

Table 3: Regression equations used for sex estimation

Researchers	Equations	Estimated sex
Atamtürk (2010)	0.847 x Footprint length – 20.155 = 187.36 (mid-point 23.78)	Male
	1.553 x Footprint breadth – 14.829 = 135.812 (mid-point 9.55)	Male
	1.768 x Footprint heel breadth – 10.533 = 106.155 (mid-point 5.96)	Male
Hemy et al. (2013)	(0.606 x Footprint length + (0.533 x Footprint breadth) – 19.544 = 0.473 (section point – 0.130)	Male
Abledu et al. (2015)	0.828 x Footprint length – 20.205 = 0,081 (section point – 0.057)	Male

4.2. ESTIMATION OF STATURE

There are many studies addressing body height estimation from bare foot length (Atamtürk and Duyar 2008; Giles and Vallandigham 1991; Martin and Saller 1957; Robbins 1986; Rutishauser 1968; Saxena 1984). However, height estimation studies using only the right foot was considered in the Barcın case in order to reduce the estimation error (Atamtürk and Duyar 2008; Krishan 2008; Ukoha et al. 2013). Given that the Barcın footprint likely belonged

to a male individual, only male regression equations of bare footprint length were used.

While studies unanimously agree that measurements taken from long bones give better results in the estimation of stature (Duyar and Pelin 2003; Sjøvold 2000; Trotter and Gleser 1952, 1958), foot size too can likewise be used to successfully estimate stature (Atamtürk and Duyar 2008). The stature of the individual who left the Barcin footprint was calculated using the regression equations developed in three different studies based on maximum footprint length. The first study is based on the sizes taken from 127 males living in Turkey (Atamtürk and Duyar 2008), the second, on the foot sizes of 100 males ages 18-30 from Nigeria (Ukoha et al. 2013) and the third on 50 adult males living in Northern India (Krishan 2008). The research estimates deriving from these studies suggests that the Barcın footprint was left by an adult male between 169.9-173.2 cm tall, as indicated in Table 4. Despite the genetic distance between the modern and ancient Anatolian populations this study uses the equations derived by Atamtürk and Duyar (2008) and assumes an estimated stature of 169.88 cm given that the other equations values derive from geographically distant studies. With a SEE (standard error of the estimate) of 8.56 cm, the stature of the individual who left the footprint based on a 95% confidence interval (confidence interval, CI 95% = 16.78 cm) would hence range between 153.1 and 186.66 cm.

Table 4: Estimated stature of the Barcın Höyük footprint using different height calculation equations.

Researcher	Equations	Estimated stature (cm)
Atamtürk (2003)	5.014 × Footprint length + 47.041 ± 8.557	169.88
Ukoha ve ark. (2013)	3.080 × Footprint length + 95.042 ± 4.842	170.50
Krishan (2008)	3.510 × Footprint length + 87.214 ± 2.16	173.21

Anthropological analyses of Barcın Höyük human skeletons were carried out by Alpaslan-Roodenberg (Alpaslan-Roodenberg et al. 2013). In the stated study, the stature was estimated using the Trotter and Gleser (1952, 1958) equation of the left radius length of four elderly individuals (3 females, 1 male). While the females in Barcın Höyük varied between 146.8–159.21 cm tall; the single male was found to be 166.5 ± 4.66 cm. The stature of the Barcın Höyük male footprint owner is 3.5 cm taller than the other male whose stature was calculated from his radius bone.

At this stage, we must seek the meaning of these stature estimates for the Barcın community in terms of the Anatolian prehistoric past. Angel (1984) carried out one of the most comprehensive evaluations on this subject. According to this researcher, studies carried out on skeletons from the Eastern Mediterranean region, the average stature value of males in the Late Paleolithic period is 177.1 cm. This value decreases to 172.5 cm in the Mesolithic period, to 169.6 cm in the Early Neolithic period and to 167.3 cm in the Late Neolithic period. There is an obvious decrease in the average stature in the time slice from the Late Paleolithic period to the Late Neolithic period. Since the Barcın Höyük footprint belongs to an adult male 169.9 cm tall, his calculated height complies with the biological profile put forward by Angel.

4.3. ESTIMATION OF BODY WEIGHT

There are also studies estimating body weight from foot size. Studies have shown a certain correlation between foot width and body weight (Atamtürk 2003; Atamtürk and Duyar 2008; Robbins 1986). Using this information, the width of the Barcın Höyük footprint (the footprint metatarsal width and the footprint heel width) were used to estimate body weight.

Table 5: Body weight estimations calculated based on provided equations

Researcher	Equations	Body weight estimation (kg)
Atamtürk (2003)	7.60 × Footprint breadth – 1.830 ± 15.370	71.89
	5.23 × Footprint heel breadth + 41.957 ± 11.845	76.48
Krishan (2008)	2.86 × Footprint breadth + 37.63 ± 3.51	65.37
	3.94 × Footprint heel breadth + 39.55 ± 3.74	65.55

The results are presented in Table 5. As shown, the body weight values calculated using Atamtürk and Duyar are much higher than the values based on comparisons with values from northern India. Table 5 shows that footprint metatarsal width yields better results than the footprint heel width (Atamtürk and Duyar 2008). Accordingly, it can be assumed that the body weight of the owner of the Barcın footprint was 71.89 kg. Because of the study's SEE (standard error of the estimate), the value of the equation is 15.37 kg, the body weight of the individual who left the footprint estimated with a 95% confidence interval (CI 95% = 31.14 kg) ranges between 40.75 – 103.03 kg.

4.4. FOOTPRINTS AND SHOE USAGE

As described above, the footprints were made with bare feet. While this could indicate that there

was no shoe usage in that period or that shoe use was not widespread, this is not likely. Since the indirect (anatomical) proof of shoe usage extends up to the Upper Paleolithic period in the Eurasia region (Trinkaus 2005; Trinkaus and Shang 2008), one assumes that shoe or sandal usage was widespread in Anatolia in the Neolithic period. Likewise, about 2080 footprints dating to ca. 6200 BC were found in Late Neolithic layers of the not too distant Yenikapı excavations (Kızıltan and Polat 2013). In the vast majority of these footprints, one finds clear signs of shoe usage and bare footprints constitute only a small part of the total footprints found. Consequently, it seems likely that the owner of the Barcın footprints followed a no-shoes-indoors custom, or because the symbolic message he wanted to convey through the footprints required bare feet.

5. FOOTPRINT POSITION AND SYMBOLIC MEANING

In addition to their anthropological weight and height estimates, the footprints may offer further evidence regarding symbolism and purpose and there may be additional reasons to consider these footprints as the products of an intentional, symbolically-charged act. This includes, first of all, the fact that the footprints were a result of standing and not walking; these prints were not haphazardly placed here in midstride as the indivial accidentally walked on the fresh plaster as he exited the building. Moreover, in addition to the smaller than usual stride length, the fact that the footprints were formed by firmly pressing the sole of the foot into the ground and with the distribution of the body weight fully between the heel, metatarsus, foot and toe bones further supports this idea of intentionality and, hence, potential symbolic significance (Bennett and Morse 2014; Robbins 1986).

Secondly, worth mentioning here is their spatial location because at least the left foot, as stated above, was positioned immediately above a buried cattle skull (Özbal and Gerritsen 2014, 2015). In the Neolithic of Anatolia, the use of bucrania within structural complexes are often equated with ritual significance (Russel 2012). At the contemporaneous site of Çatalhöyük, located in Central Anatolia, the most elaborate houses were decorated with bucrania which were placed in association with platforms and are assumed to have endowed the spaces with a ritual character (Mellaart 1967). Though the bucranium discovered at Barcın Höyük was hidden from sight, it could still have been placed in this location to provide the space with some symbolic attributes. Foundation deposits are a known phenomenon for sanctifying spaces (Tsuneki 2002). Nevertheless, with the exception of goat bucrania located on the floor to the east of the entrance, this small structure seems to lack other obvious clues for ritual symbolism (Özbal and Gerritsen 2015).

Furthermore, their positioning near the entrance area of structure 2a may also carry symbolic significance. The practice of placing footprints into doorways resembles historical cases of footprint engravings in religious settings such as those found in the Ain 'Dara temple in Syria. Footprints may have been imprinted here perhaps with the idea of marking for posterity the presence of the deity represented (Thomas 2008). Together these lines of data and the fact that the footprints were made with bare feet immediately after the floor had been renewed makes accidental walking on a moist floor unlikely and may suggest that the replastering of the floor atop the bucranium marked a time of symbolic renewal.

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