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Foulds, Frederick, Shuttleworth, Andrew, Sinclair, Anthony et al. (4 more authors) (2017) A large handaxe from Wadi Dabsa and early hominin adaptations within the Arabian Peninsula. *Antiquity*. pp. 1421-1434. ISSN: 0003-598X

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1 The Recent Discovery of a Palaeolithic site at Wadi Dabsa, Saudi Arabia:
2 Implications for Hominin Adaptations in the Arabian Peninsula.
3

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25 *Introduction*

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1 Acheulean bifacial tools are considered one of the greatest enigmas of the Early Stone
2 Age (ESA) of Africa and the Lower Palaeolithic of Europe (Wymer 1982: 102). They
3 appear in the archaeological record from 1.76 million years ago (Asfaw et al. 1992;
4 Lepre et al. 2011; Quade et al. 2004) and persist for over one million years, presenting
5 an extensive period of technological stasis associated with a variety of hominin
6 species, landscapes, and environments. Wrapped within this technological enigma are
7 those overly large handaxes, whose excesses in both size and weight have confounded
8 archaeologists as to their exact nature and use (Wynn, 1995). Here we present the
9 recently discovered Palaeolithic site of Wadi Dabsa, Saudi Arabia and the recovery of
10 a large Acheulean handaxe from this location. The rich lithic assemblage from Wadi
11 Dabsa not only yields evidence of how hominin populations may have adapted to
12 varied landscapes and conditions during their dispersals out of Africa, but also
13 provides insight into how such large bifacial tools may have been used.

14
15 There is clear evidence that the Arabian Peninsula played host to Acheulean hominins
16 throughout the Early to Middle Pleistocene (c. 2 Mya–200 kya) (Petraglia, 2003;
17 Petraglia & Rose 2009 and references therein; Groucutt & Petraglia, 2012), and that
18 these hominins occupied landscapes and environments close to water and raw
19 material sources in the interior (Petraglia et al., 2009; Groucutt & Petraglia, 2012),
20 and coastal regions of the Peninsula (Field & Lahr, 2005; Bailey et al. 2007, 2015). It
21 is not clear whether a land bridge would have existed across the southern end of the
22 Red Sea at low sea-level stands during the Pliocene or Early Pleistocene. The long-
23 term rotation of the Arabian Plate away from Africa might imply progressive
24 widening of the sea channel and possible closure by extrapolation to an early stage in
25 this process. However, accommodation of plate motions by crustal deformation
26 mainly occurs in the Afar depression and along the Arabian escarpment rather than in
27 the area of the Red Sea Channel, and there are too many uncertainties about the
28 topographic impact of tectonic and volcanic activity at this early period to be certain.
29 At any rate, by the Middle Pleistocene, and certainly from about half a million years
30 ago, it is clear from the analysis of isotopic composition in deep sea cores and from
31 tectonic modelling of palaeocoastlines that a narrow and shallow sea connection to
32 the Indian Ocean would have persisted for long periods during lower sea levels in the
33 Hanish Sill region. This would have afforded the possibility of sea crossings of no
34 more than 4 km, and a very extensive area of potentially attractive lowland coastal

territory would also have been exposed on both sides of this channel (Siddall et al, 2003, Bailey 2009, Lambeck et al. 2011; Rohling et al. 2013; Bailey et al. 2015).

The significance of Arabia in the dispersal and evolution of hominins out of Africa is, however, much debated due to the lack of chronological certainty for many of its prehistoric sites; and though the use of the ‘Southern Dispersal Route’ during the Pleistocene is plausible, the lack of significant genetic input from this region within modern populations suggests that these migrations involved small populations (Cabrera et al., 2009). Regardless of their size, these groups would have migrated into, and along, what are now the Red Sea and Gulf of Aden coastlines. These regions, in particular those along the southern Red Sea coast with their added increment of territory made available at lower sea levels, would have presented hominins with a productive landscape of fauna, water and raw material sources comparable to those already experienced in the Horn of Africa, they would also have acted as refugia during periods of hyper-aridity when the Arabian interior would have become uninhabitable (Petruglia & Rose, 2009 and references therein; Winder et al. 2015).

The DISPERSE Project and Wadi Dabsa

The DISPERSE Project is concerned with the impact of sea level change and active tectonics on the early landscapes of human evolution and hominin dispersal within Africa and beyond (Bailey et al., 2012, 2015; Devès et al. 2014; Inglis et al. 2014, Kübler et al., 2016). Work has concentrated in particular on the southern Red Sea and the South-west Arabian escarpment, on reconstruction of prehistoric landscapes on land and under water, and on survey and investigation of Palaeolithic sites and later coastal middens in their landscape setting. This regional focus is informed by the hypothesis that South-west Arabia was an early centre of hominin settlement and a primary stepping-stone for range expansion out of Africa due to the similar tectonic and volcanic processes that have been shown to be advantageous in the earliest centres of human evolution in the East African Rift, proximity and accessibility to the Rift across a narrow sea crossing for long periods of the Pleistocene, and relatively beneficial climatic conditions and ecological diversity (King & Bailey 2006; Bailey et al. 2007, 2011, 2015; Reynolds et al. 2011; Winder et al. 2013, 2015).

1 The Harrat Al Birk is an extensive series of basaltic flows associated with numerous
2 cinder cones that extend along the present-day coastline for ~100km and stretch
3 inland for ~30km, where they meet the basement rocks of the foothills of the Western
4 Arabian Escarpment (Dabbagh et al. 1984; Prinz 1984). Wadi Dabsa, at present a
5 seasonally flowing watercourse, drains the western edge of the *harrat*, running for
6 ~7km to the sea (**FIGURE 1** and **FIGURE 2**). In its upper reaches, the wadi flows
7 through a small basin within the basalt, the base of which has been covered by tufa
8 deposition, around 2km² in total. The tufa was deposited during a past period of
9 consistent flow of carbonate-rich water, possibly fed by a number of small tributaries
10 draining the surrounding slopes, forming a series of dams and pools (Inglis et al.,
11 2015). The tufa formation suggests perennial water flow, and, given the limited
12 catchment of the basin, may be linked to past spring activity rather than runoff. No
13 matter the source, the presence of large volumes of water would have made the
14 locality particularly attractive to hominins in the past, something that is attested to by
15 the extraordinary accumulation of archaeological material recovered during survey of
16 the area.

17
18 *Figure 1 and Figure 2 to be placed somewhere around here*
19

20 Survey of the basin resulted in the surface collection of artefacts along a number of
21 transects across the tufa and surrounding basalt. Intensive survey using 5x5m grid
22 squares was also carried out at site L0106, where a dense lithic scatter was discovered
23 extending over about 100 m² of the tufa surface, near to an area where the basalt
24 outcrops through the tufa. Over 900 artefacts were collected from the survey area
25 across a 40x50m area, representing approximately a quarter of the area of this scatter.
26 In total, 1002 lithic artefacts were recovered from within the Wadi Dabsa basin area,
27 including the surrounding basalt outcrops as well as the tufa. These display
28 predominantly Early Stone Age/Lower Palaeolithic and Middle Stone Age/Middle
29 Palaeolithic affinities, although several Later Stone Age artefacts produced
30 exclusively on quartz were also found along the southern edge. The assemblage
31 primarily consists of flake debitage, but also includes a large number of cores and
32 several retouched tools (**TABLE 1**). Wadi Dabsa is the most productive location
33 found thus far. Here we provide an initial analysis of the Acheulean material and its
34 importance for elucidating early hominin landscape use within the Arabian Peninsula.

1
2 *Table 1 to be placed somewhere around here*
3

4 *The Acheulean assemblage of Wadi Dabsa*

5 A number of cores and retouched tools within the assemblage are typical of the
6 Acheulean including discoidal and simple flake cores with episodes of parallel
7 working, as well as bifaces and large cutting tools. Nineteen of the artefacts can be
8 classified as handaxes, cleavers, or fragments thereof. Most of these tools were
9 produced on large flakes, sourced either by deliberate flaking from large cores, or by
10 selection of local, naturally produced exfoliation flakes. This method of production
11 shares close similarities to other Acheulean sites within the Arabian Peninsula
12 (Petraglia et al. 2010; Shipton et al. 2014), although the majority of the tools evidence
13 an intense focus on reduction of the tip rather than the butt. High quality basalts,
14 almost certainly sourced from the surrounding lava fields, appear to be the
15 predominant raw material of choice, with andesite used in much lower quantities. The
16 local basalt from the lava fields, however, appears to vary in their porosity and
17 density, with finer grained materials to the north and poorer quality material along the
18 southern edge (Inglis et al. 2015). The predominance of higher quality raw materials
19 within the assemblage, therefore, appears to indicate a careful selection for the better
20 materials available on the part of the hominins present at the site.

21
22 *Figure 3 to be placed somewhere around here*
23

24 Within the assemblage, however, a single large bifacially worked tool stands out as
25 anomalous (**FIGURE 3**). This was recovered during surface collection along a 250m
26 transect at L0107, stretching from the north-western edge of the tufa to the top of a
27 basalt jebel that overlooks the basin and wadi. It is 266mm long, weighs 3598g, and
28 was produced from either a very large basalt flake or, more likely, a natural
29 exfoliation flake. On the basis of its size, it was originally interpreted as a large,
30 abandoned roughout or core. Its appearance shares affinities with Victoria West cores
31 (Sharon 2007, 2009; Sharon and Beaumont 2006), as well as with examples of cores
32 developed on bifacial tools (DeBono & Goren-Inbar 2001), albeit of a much larger
33 size. However, limited preparation of the ventral surface and a lack of any additional
34 examples from the site preclude this interpretation. Furthermore, the large scar on the

ventral surface appears to be a natural exfoliation surface, rather than an intentional removal. Evidence of bifacial retouch on the upper two thirds using a heavy, hard hammer, as well as extensive working of the tip, probably using a smaller hard hammer, indicate the imposition of a working edge. This suggests that the artefact should be considered as a finished tool, as opposed to an abandoned roughout, especially given that the pattern of reduction is closely comparable to similar examples of tip preparation seen on other bifaces recovered from the site.

Table 2 to be placed somewhere around here

Metrical analysis of large cutting tools (e.g. Sharon 2007) indicates that the large biface from Wadi Dabsa is well above average in terms of its size, even if it is not the largest currently known. A number of bifaces measuring at least 250mm have been found in both Europe and Africa, most notably those from Cuxton (Wenban-Smith 2004), Olorgesailie (Issac 1977, 134), Olduvai Gorge, site FLK (Roe 1994: 207), Isimila (Cole et al. 2016) and the Furze Platt giant (MacRae 1987), all of which provide examples surpassing 300mm. A comparison of the Wadi Dabsa handaxe with several of these known large handaxes is provided in **TABLE 2**, demonstrating that this new example fits well within the range of these previously collected artefacts, though it is generally broader and thicker than most. Whilst the size of the large handaxe from Wadi Dabsa is comparable to others, it is rare that such tools approach weights of 3000g or more, with only a few known examples from Africa (Kelley 1959; Petraglia & Shipton 2009; Sharon 2007). The excessive weight of the example from Wadi Dabsa would certainly have made it difficult to wield in the hand, begging the question of how this tool may have been used and for what purpose.

Discussion

In the context of the wider Acheulean occupation of the Arabian Peninsula, Wadi Dabsa is comparable to sites such as Wadi Fatima and Dawādmi to the north (Jennings et al. 2015; Petraglia et al. 2009), and those recently discovered in the Nefud Desert (Shipton et al. 2014). In addition, it can be added to the wider evidence for the Acheulean occupation of the Red Sea region produced by the DISPERSE project (Inglis et al. 2013, 2014, 2015) and previous studies (Zarins et al 1980, 1981). The location of Wadi Dabsa at the confluence of several tributaries and the potential

1 presence of a larger body of water conforms to the expectation that Acheulean sites
2 are associated with water sources (Potts et al. 1999, Shipton, 2011). This is
3 unsurprising, given that hominin ranges would have been constrained by access to
4 fresh water (Hardaker 2011). The surrounding basalt jebels would have provided
5 expansive views of the surrounding landscape extending as far as the Red Sea
6 coastline (**FIGURE 4**), which are equivalent to viewsheds reported for Wadi Fatima
7 and Dawādmi (Petraglia et al. 2009).

8
9 *Figure 4 to be placed somewhere around here*

10
11 The presence of large cutting tools produced on large flakes, such as handaxes, also
12 conforms to what has been described for other Acheulean assemblages within Arabia.
13 These cutting tools were produced using the abundant local raw materials, although
14 Wadi Dabsa displays clear evidence for the preferential selection of good quality raw
15 materials, specifically basalt clasts sourced to the north of the basin, which display a
16 more cohesive cryptocrystalline structure compared to that available along the
17 southern edge. This provides some evidence for a clear appreciation for the
18 conchoidal fracture properties of the lithic materials by local hominins living within
19 the region. The presence of a Large Flake Acheulean at Wadi Dabsa close to other
20 Near and Middle Eastern sites which have been linked to similar knapping strategies
21 seen at, for example, Gesher Benot Ya'aqov, suggests that these represent a new wave
22 of Acheulean-using hominins dispersing from Africa (Martínez-Navaro &
23 Rabinovich, 2011). If this is the case, then Wadi Dabsa has the potential to expand
24 this hypothesis to include the Arabian Peninsula.

25
26 *Table 3 to be placed somewhere around here*

27
28 The size and weight of the Wadi Dabsa handaxes fall within the range of variation
29 generally recorded for the Acheulean (**TABLE 3**). In terms of shape, however, the
30 handaxes found at Wadi Dabsa, including the large handaxe described above, show
31 clear and repeated focus in manufacture for a preferential reduction and finishing of
32 the tip, leaving the butt minimally worked suggesting an active selection of a
33 particular handaxe form. Variability in biface shape has long been a central topic
34 within Lower Palaeolithic research. It has been suggested that that variation in the

1 shape of bifaces can often be explained by the need to establish and preserve a sharp,
2 cutting edge (Lycett 2008). However, a suite of factors continues to be acknowledged
3 as influencing handaxe shape, including raw material selection, social pressures, and
4 the individual (e.g. Ashton & McNabb 1994; Callow 1994; Gamble 1997; White
5 1998; Kohn & Mithen 1999; Spikins 2012; Foulds 2014). In the case of the bifaces
6 from Wadi Dabsa, as well as the lithic artefacts from other sites examined as part of
7 the DISPERSE project, an emphasis on the creation of a good working edge is
8 notable. It remains to be seen whether this pattern of reduction in handaxes is due to
9 functional requirements, raw material affordance or the cultural transmission of
10 specific methods of lithic manufacture in general.

11
12 The large handaxe presented here currently represents a unique find within the
13 Arabian Peninsula and is the largest handaxe from this region that is currently known
14 to the authors. It falls within the range of variation seen amongst other examples of
15 overly large tools, despite its excessive weight. The occurrence of only a single large
16 biface at Wadi Dabsa, however, is more in keeping with the context in which such
17 bifaces have been discovered in Europe, where they are generally found as single
18 occurrences. However, the fact that large handaxes are generally found in isolation
19 may present a false indication of their individuality. It is clear from African sites,
20 where such large tools are found in an assemblage context, e.g. Olduvai (Roe 1994)
21 and Isimila (Cole et al. 2016), then multiple, similar examples can occur. This may
22 also be the case at Cuxton, where at least four handaxes over 200 mm in length were
23 recovered by Tester (Cole 2011; Shaw and White 2003), which compliment the two
24 large bifaces found during excavation by Wenban-Smith (2004).

25
26 The key question regarding the large handaxe is why it was produced. Several
27 hypotheses concerning the function of large bifaces have been put forward, including
28 their use as digging tools (Wymer, 1983, 103), expressions of knapping skill (Wymer,
29 1968, 225), and as artefacts incorporated into some form of social display (Kohn &
30 Mithen, 1999). None of these theories has been conclusively proven. The large
31 handaxe from Wadi Dabsa does not appear to represent the work of a highly skilled
32 knapper wishing to demonstrate the extent of their abilities, whereas those used to
33 support this hypothesis tend to be exquisitely worked (Wenban-Smith 2004). Prime
34 examples are the biface from Furze Platt and the ficron and cleaver from Cuxton,

1 which exhibit careful and controlled knapping to create a relatively well-thinned and
2 symmetrical edge.

3
4 The excessive size and weight of the Wadi Dabsa biface leads us to believe that it was
5 too large and unwieldy to be used in the hand, an observation that has been made of
6 similar large tools by others (Wymer 1968, 1982; Roe 1981). By the same token, it is
7 also unlikely that it was made with the intention of someone carrying it from site to
8 site. This might suggest that either its use as a hand held butchery tool, as is often
9 suggested for handaxes, was unlikely, or alternatively that our impressions of size and
10 weight are significantly different to those of hominins who made them (Wenban-
11 Smith 2004). There is the potential that it could be a large, bifacial core. However, as
12 discussed above, the lack of additional examples and limited preparation appear to
13 preclude this hypothesis. Moreover, given the lack of extensive reduction used in the
14 creation of the large handaxe from Wadi Dabsa, as well as its dimensions and
15 conformity in shape and working to other handaxes within the assemblage, most
16 notably in the intense reduction of the tip to create a cutting edge, it seems reasonable
17 to suggest that it was made for a clear utilitarian purpose. It might perhaps have been
18 employed as a static tool with hominins resting the handaxe on the ground, secured
19 between an individual's legs, and resources brought down on the tip for processing. In
20 this way it could have been used to process faunal remains so as to access meat and
21 marrow. Sites such as Isimila, Elandsfontein and Doornlaagte have provided
22 examples of similar tools that were found on their edges when excavated, as if pressed
23 into the ground (Wymer 1982, 103). While this is certainly plausible for the large
24 handaxe from Wadi Dabsa, its recovery as part of an unstratified surface collection
25 find from within the basalt fields means that this possibility cannot be substantiated.
26 Microwear analysis of the tip will be required to determine whether it was used for a
27 specific material or in a particular fashion.

28 29 *Conclusion*

30 Wadi Dabsa presents a highly concentrated area of Acheulean activity within the
31 Arabian Peninsula. It provided a wide range of resources, including raw materials for
32 tool production and a fresh water source that would have attracted animals suitable for
33 hunting. These resources were essential for hominin dispersal from the Red Sea
34 shoreline and deeper into the Arabian Peninsula. The site is made more extraordinary

1 by the large quantity of artefacts recovered, suggesting either the repeated or intensive
2 use of this locality. The large handaxe adds to the complexity and difficulty of
3 interpreting this newly discovered site, as well as presenting a new addition to the
4 known catalogue of these enigmatic bifacial tools. It is geographically unique, being
5 the only example currently known from within the Arabian Peninsula, while its
6 unusually excessive weight highlights its importance in comparison to similar overly
7 large tools. The use of such large bifaces is still a mystery that requires solving, and it
8 is hoped that the addition of the Wadi Dabsa specimen can contribute to this debate,
9 as well as further discussion regarding their dispersal throughout the Acheulean
10 world.

11 12 *Acknowledgements*

13 We thank HRH Prince Sultan bin Salman bin Abdul Aziz, President of the Saudi
14 Commission for Tourism and National Heritage (SCTH), KSA, Professor Ali Al-
15 Ghabban, Vice-President, and Dr Abdullah Al Saud, Director General for granting
16 fieldwork permission, as well as their interest in and support of our work in Saudi
17 Arabia. Grateful thanks are also extended to Dr Abdullah Al Zahrani, SCTH Riyadh,
18 and Mr Saeed Al Karni, Director of Antiquities in Asir, and Mr Haider Al Mudeer as
19 well as the staff of the SCTH offices in Abha and Sabiya.

20 The January 2015 fieldwork was carried out as part of the DISPERSE project, funded
21 by European Research Council Advanced Grant 269586, under the 'Ideas' Specific
22 Programme of FP7 to Geoff Bailey and Geoffrey C.P. King. For generous additional
23 funding for the fieldwork we thank the Gerald Averay Wainwright Fund for Near
24 Eastern Archaeology, University of Oxford, and the Department of Archaeology
25 Research Fund, University of York. This is DISPERSE contribution no. 37.

26

1 *Figure Captions*

2

3 Figure 1: Location of Wadi Dabsa on the southwest coastline of the Arabian
4 Peninsula.

5 Figure 2: Wadi Dabsa and associated geology and archaeological transects. L0107
6 (red highlight) indicates the location where the large handaxe was found.

7 Figure 3: (top) Photograph of the large handaxe from Wadi Dabsa, (bottom)
8 illustration of the handaxe, including profile view. Photograph taken by A.
9 Shuttleworth. Illustration by F. Foulds.

10 Figure 4: View from the top of a basalt jebel at the northern extent of L-0107, looking
11 south over the basalt surface and tufa exposure. Adapted from Inglis et al (2015).
12 Photo by R. Inglis.

13

14 *Table Captions*

15

16 Table 1. Distribution of artefact types within the Wadi Dabsa assemblage.

17 Table 2. A comparison of the large handaxe with other known handaxes of length
18 greater than 240mm. Part of the data for this table is based on Gowlett (2013). Data
19 for the Olduvai FLK handaxes is based on metrics recorded in Leakey and Roe
20 (1994).

21 Table 3. A comparison of the mean length, thickness and weight of the Wadi Dabsa
22 handaxes with examples from Europe, Africa, India and the Arabian Peninsula.
23 (*Figures in brackets provide the average and standard deviations for the Wadi Dabsa
24 assemblage with the removal of the large handaxe). Data gathered from Shipton et al.
25 (2014) and Petraglia et al. (2009).

26

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Type		Number found
Flakes/debitage		
	<i>Flakes</i>	475
	<i>Prepared core flakes</i>	96
	<i>Blades</i>	17
	<i>Utilised flakes</i>	28
	<i>Spinttered pieces/wedges</i>	3
	<i>Shatter</i>	89
Cores		
	<i>Cores</i>	140
	<i>Core fragments</i>	6
Bifacial tools		
	<i>Handaxes</i>	11
	<i>Cleavers</i>	4
	<i>Pics</i>	4
	<i>Broken handaxes</i>	4
Retouched tools		
	<i>Backed knife</i>	1
	<i>Burin</i>	2
	<i>Denticulate</i>	4
	<i>Notch</i>	9
	<i>LCTs</i>	16
	<i>Piercer/borer</i>	13
	<i>Points</i>	8
	<i>Scraper</i>	47
Other		
	<i>Clasts</i>	23
	<i>Hammerstones</i>	2
Total		1002

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TABLE 1

Locality	Length (mm)	Breadth (mm)	Thickness (mm)
Kilombe	248	120	53
Kilombe	258	151	56
Kilombe	243	111	55
Sidi Abderrahman Cunette	250	162	47
Sidi Abderrahman Cunette	241	107	73
Kalambo Falls	291	138	65
Cornelia-Uitzoek	240	124	73
Cornelia-Uitzoek	243	114	77
Holsdam	245	107	65
Peninj	265	119	81
Olduvai Gorge FLK	289	132	72
Olduvai Gorge FLK	268	124	83
Olduvai Gorge FLK	249	116	72
Olduvai Gorge FLK	277	129	69
Olduvai Gorge FLK	270	117	67
Wadi Dabsa	265	160	85

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2 **TABLE 2**

Locality	<i>n</i>	Mean Length (mm)	<i>n</i>	Mean Thickness (mm)	SD	<i>n</i>	Mean Weight (g)	SD
<i>Africa</i>								
Olduvai Gorge Bed II	21	195.39	17	66.92	19.2	17	1406.81	784.12
Kariandusi	58	157.94	35	43.6	14.74	35	571.02	369.8
Olorgesailie DE89A	63	180.76	60	46.23	10.43	60	877.82	381.8
Orlogesailie H9AM	13	199.77	10	36.2	7.53	10	770	426.54
Orlogesailie I3	62	97.95	57	33.54	9.28	57	225.12	197.48
Orlogesailie FB	16	98.81	15	34.6	8.44	15	180.87	116.11
Orlogesailie DE89C	69	158.7						
<i>Europe</i>								
High Lodge	68	116.51	63	35.15	14.01	63	259.89	208.83
<i>Arabia</i>								
Dawādmī 206-76	49	162.87	27	52.04	22.02			
Wadi Fatima	35	141.86	15	49.67	9.8			
Arzraq Lion Spring			42	43.97	9.68	42	216.43	86.11
Wadi Dabsa*	11	140.27 (127.80)	11	60.54 (58.10)	15.83 (14.33)	11	1105.72 (856.50)	993.39 (580.77)
<i>India</i>								
Hunsgi V	151	143.51	45	48.44	9.99	45	669	349.6
Hunsgi II	34	162.9	18	52.22	10.6	18	1041.94	551.14
Gulbal II	17	147.14	12	47.5	9.65	12	902.5	385.84
Mudnur VIII	9	227.78	9	61.11	9.28	9	1302.22	204.56
Yediyapur I	21	123.13	10	36	5.16	10	443	230.3
Yediyapur IV	20	132.94	11	42.73	11.04	11	626.82	415
Yediyapur VI	66	127.86	21	42.86	13.09	21	591.19	563.49
Fatehpur V	31	126.82	11	40.91	11.36	11	455.45	246.74
Teggihalli II	31	121.54						
Anagwadi	25	137.24	15	45.73	6.04			
Godavari	10	114						







