Harappan Weights

The data of Marshall (1934) about Harappan weights shows that they were standardised with an uncertainty of 6%. This fluctuation within each weight class may be a result of weathering and the original weights may well be more accurate. Within this pattern of uncertainty, they follow the octal system for small weights and decimal for larger weights.

There has been a lot of controversy about the standardisation of weights in Harappa. These weights are in the form of cubes of different sizes. While they are considered to be highly standardised, in reality, these weights stagger around the mean value (see e.g. Venkatachalam 2002). In order to estimate the accuracy of measurements, we attempt to quantify the accuracy of Harappan weights.

Data set

In table 1 we have reproduced the weight table from Marshall (1934) as given by Farmer on his website. This list a total of 357 different weights found by Marshall. We applied the following statistical test to the data set to search for the level of standardisation of weights in Harappa. However, before applying the tests we make one correction in the last column of the data. It makes one entry as 9.225. Keeping in view the general ordering of data it seems that the data should read 1.255. However, even if this change is not accepted, it will produce a minor change in the entire results. If this change is not accepted, it would only imply that 1 weight of 9.255 gm existed in Harappa. In the present analysis, it turns out that even the weight of 1.255 is unique. In (Fig. 1) we give a graph of the weights of found in Harappa against the serial number of the weight.

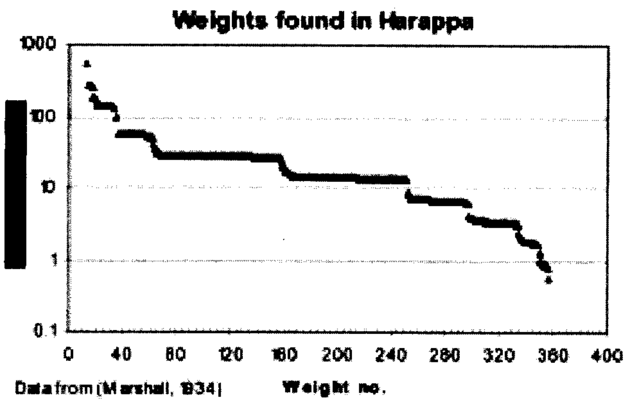

Fig. 1: Distribution of different Harappan weights. Data is from Marshall (1934). The weights are given in gm and the X-axis shows the serial number of the weights after arranging them in descending order of value and plotted in log scale.

We order the entire data set by decreasing order of weight. We then take the ratio of the weight to the previous weight and normalise it to the given weight. If this ratio is different from the earlier one by 10%, we assume that it indicates a new unit of weight. Based on this we divide the above data into 25 different class of weights. The results of our analysis are given in table 2 and figure 2. Column 1 gives the serial number of the class of weight, column 2 gives the number of samples

Table 1: List of different weights from Marshall (1934) Courtesy S. Farmer.

1	2	3	4	5	6
Weight.	Weight.	Woight	Weight.	Weight.	Weight.
11467·6	29·225	27·10	13·697	6·877	3·24
10262	29·00	27·10	13·690	6·87	3·24
6903	28·844	27·10	13·69	6·87	3·12
5556	28·603	27·096	13·680	6·87	3·03
2792	28·64	27·086	13·680	6·862	2·33
2735·8	28·620	27·070	13·677	6·85	2·07
2656	28·470	27·068	13·670	6·84	1·891
2576	28·463	27·06	13·67	6·84	1·86
1446	28·437	27·05	13·67	6·830	1·835
1431·7	28·366	27·06	13·666	6·83	1·815
1376	28·21	27·01	13·660	6·83	1·81
1375	28·083	26·995	13·656	6·824	1·79
546·7	28·020	26·93	13·65	6·82	1·754
275·2	27·85	26·92	13·642	6·82	1·750
274·9	27·825	26·884	13·64	6·817	1·734
264·5	27·75	26·88	13·64	6·802	1·70
258·5	27·749	26·85	13·625	6·80	1·70
185·5	27·68	26·836	13·621	6·791	1·69
174·5	27·667	26·79	13·62	6·79	1·684
151·4	27·575	26·597	13·62	6·781	9·255
137·8	27·527	26·490	13·62	6·78	0·98
136·75	27·515	26·312	13·62	6·779	0·928
136·5	27·50	26·050	13·62	6·774	0·879
136·25	27·498	25·354	13·62	6·77	0·87
136·20	27·496	25·31	13·62	6·769	0·867
136·06	27·462	24·50	13·610	6·76	0·813
135·86	27·45	20·370	13·61	6·76	0·550
135·60	27·440	17·970	13·600	6·73	
135·38	27·437	17·183	13·60	6·66	
135·28	27·43	16·640	13·60	6·65	
134·69	27·40	16·937	13·594	6·600	
133·50	27·40	15·264	13·589	6·31	
129·50	27·352	14·94	13·58	6·305	
123·86	27·35	14·90	13·575	3·96	
96·476	27·35	14·59	13·556	3·93	
56·872	27·336	14·46	12·54	3·90	
55·900	27·333	14·41	13·512	3·780	
55·062	27·33	14·35	13·50	3·604	
54·653	27·326	14·290	13·49	3·556	
54·617	27·30	14·188	13·459	3·554	
54·611	27·30	14·177	13·456	3·520	
54·510	27·295	14·094	13·451	3·51	
54·500	27·293	14·028	13·450	3·49	
54·498	27·29	14·019	13·447	3·484	
54·452	27·28	14·001	13·440	3·48	
54·45	27·276	13·972	13·407	3·465	
54·45	27·25	13·970	13·399	3·44	
54·400	27·25	13·964	13·373	3·44	
54·32	27·229	13·95	13·372	3·44	
54·297	27·227	13·917	13·37	3·43	
54·080	27·22	13·914	13·284	3·43	
54·077	27·22	13·91	13·113	3·424	
54·076	27·21	13·90	13·079	3·422	
54·05	27·203	13·873	8·850	3·418	
53·986	27·200	13·87	7·900	3·414	
54·01	27·177	13·85	7·310	3·405	
53·820	27·174	13·81	7·296	3·394	
53·627	27·164	13·79	7·27	3·39	
52·861	27·150	13·78	6·98	3·39	
52·776	27·15	13·768	6·957	3·381	
49·73	27·139	13·766	6·932	3·38	
47·30	27·120	13·757	6·92	3·362	
40·402	27·12	13·71	6·91	3·343	
33·563	27·117	13·709	6·90	3·320	
31·964	27·113	13·70	6·89	3·313	
30·813	27·103	13·70	6·880	3·30	

Table 2: Mean weights and their ratios

Sr. No.	No. of Samp-les	Mean weight (gm)	Std. Dev. (gm)	% error	To 0.55 gm			To 0.89 gm			From Hemmy, (1938) (g)	Frac. diff. bet. Col 3 and Hemmy
					Normal	Round	Diff (gm)	Normal	Round	Diff (gm)		
1	1	11467.60	-	-	20850.18	20000	-467.60	12892.19	13000	95.90	-	-
2	1	10262.00	-	-	18658.18	19000	188.00	11536.82	11000	-477.50	10970.0	0.069
3	1	6903.00	-	-	12550.91	12500	-28.00	7760.54	8000	213.00	6856.0	0.007
4	1	5556.00	-	-	10101.82	10000	-56.00	6246.21	6250	3.37	5485.0	0.013
5	4	2689.95	94.26	3.50	4890.82	5000	60.05	3024.11	3000	-21.45	2742.4	0.019
6	4	1406.93	37.32	2.65	2558.05	2500	-31.92	1581.70	1600	16.28	1371.2	0.025
7	1	546.70	-	-	994.00	1000	3.30	614.61	600	-13.00	548.48	0.003
8	4	268.28	8.20	3.06	487.77	500	6.73	301.60	300	-1.42	274.24	0.022
9	2	180.00	7.78	4.32	327.27	330	1.50	202.36	200	-2.10	171.40	0.048
10	1	151.40	-	-	275.27	275	-0.15	170.21	170	-0.19	-	-
11	15	134.50	3.64	2.70	244.55	250	3.00	151.21	150	-1.08	137.12	0.019
12	1	96.48	-	-	175.41	175	-0.23	108.46	175	59.19	-	-
13	27	53.92	1.77	3.29	98.05	100	1.08	60.62	60	-0.55	54.848	0.017
14	1	40.40	-	-	73.46	75	0.85	45.42	75	26.31	-	-
15	89	27.48	1.11	4.03	49.96	50	0.02	30.89	32	0.99	27.424	0.002
16	1	20.37	-	-	37.04	37	-0.02	22.90	25	1.87	-	-
17	92	13.89	0.76	5.45	25.26	25	-0.14	15.62	16	0.34	13.712	0.013
18	1	8.85	-	-	16.09	16	-0.05	9.95	10	0.04	-	-
19	45	6.85	0.24	3.51	12.46	12	-0.25	7.70	8	0.26	6.856	0.001
20	31	3.45	0.19	5.59	6.28	6	-0.15	3.88	4	0.11	3.428	0.006
21	1	2.33	-	-	4.24	4	-0.13	2.62	2.5	-0.11	2.285	0.019
22	14	1.79	0.10	5.79	3.26	3	-0.14	2.01	2	-0.01	1.714	0.042
23	1	1.26	-	-	2.28	2	-0.16	1.41	1.5	0.08	-	-
24	6	0.89	0.06	6.46	1.62	1.5	-0.06	1.00	1	0.00	0.857	0.037
25	1	0.55	-	-	1.00	1	0.00	0.62	0.5	-0.11	-	-

in that class of weights. Column 3 gives the mean weight in the class while column 4 gives the standard deviation in the weight (when the sample size is more than 1). Column 5 gives the percentage deviations (standard deviation by mean ´ 100). As can be seen from the data, the fluctuation within a single weight class is less than 5% for all the weight classes except the three classes with the lowest weight where it goes up to 6%. Columns 6 to 8 give these values normalised to the smallest weight of 0.55 gm. Within this data, column 6 gives the ratio of the given weight to 0.55 gm, column 7 gives the nearest round off number and column 8 gives the fractional difference in weight from the mean. In most cases the difference is less than 1s of the mean value. Since only 1 weight of 0.55 gm is found, column 9 to 11 give the same values for normalisation to the weight of 0.89 gm. The rows with weights where more than 1 piece is found are given in bold.

We have compared the results of Hemmy (1938) in the last two columns. As can be seen from the table, the two measurements of weights independently by Hemmy

(1938) and Marshall (1934) are in agreement. Marshall (1934) consists of 357 weights while Hemmy (1938) consists of 331 weights.

Figure 2 gives the plot for all the weights normalised to 0.89 gm (Column 10) plotted in log scale against the mean weight. As can be seen from the figure, for higher weights, the weight of neighbouring units falls more steeply than for lower weights. This is consistent with the commonly held view that the higher weights follow decimal system while the lower weights follow octal system. This can also be seen in the data in table 2 where the number of samples is more than 1.

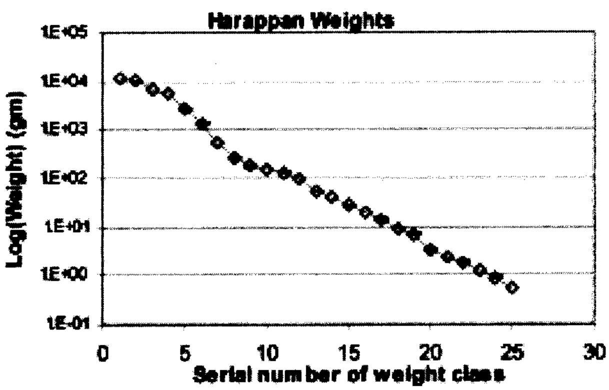

Fig. 2: Distribution of weight (in gm) of different weight units of Harappa. As can be seen from the figure, the spacing between consecutive weights is steep in the weights of 1000 kg class while it is much more gradual for lower weights of 100 gm or less. Lines with – are the ones with more than 1 weight in that unit.

Conclusion

The Harappan weights are highly standardised with less than 6 percent fluctuation within each weight class. A certain part of this fluctuation itself may have been a result of erosion and the original weights may have been even more standardised. The weights also seem to follow a fixed ratio from the minimum value. The commonly found weights seem to be in the ratio, 3000: 1600: 300: 200: 150: 60: 32: 16: 8: 4: 2: 1. The base is 0.89 gm as the lowest weight, which is the smallest amongst the commonly found weights. This clearly agrees with the generally given ratios for Indus weights. As can be seen from table 2, the error between the round off number and the average of the weights of that class is less than the standard deviation with in the class and amounts to about 6% error in the manufacture of the weights and may indicate the limits to Harappan technology. It seems that the binary weights may have been used for trading in small quantities of precious materials while decimal weights may have been used of larger objects.

An earlier study by Hemmy (1938) came to similar conclusions. Mainkar (1984), working on this data of Hemmy (1938) came to a similar conclusion. However, using subsequent excavated data of Rao (1973) from Lothal, Mainkar (1984) suggests that the weights in Lothal are similar to the weight units defined in Arthashastra. However, Venkatachalam (2002) suggest that this weight division may more akin to the ancient Tamil weights.

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