Monetary Aspects of Bahmani Copper Coinage
in Light of the Akola Hoard

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The Bahmanis of the Deccan produced copper coinage from the very outset of the state's founding in AH 748/1347 CE, but it was clearly secondary to the silver *tankas* upon which their monetary system was based. By the first several decades of the fifteenth century, however, as John Deyell has shown, the relative production values of silver and copper coinage had reversed, and there was an enormous expansion in copper output, both in terms of the numbers of coins produced and in terms of the range of their denominations (Fig.1).[1] This phenomenon has attracted the attention of several scholars, but fundamental questions yet remain about the copper coinage and how it functioned within the Bahmani monetary system. Given the dearth of contemporary written documents shedding light on these matters, it is understandable that many would simply give up on trying to answer these questions. But to do so would be to ignore the physical, material evidence afforded in abundance by the coinage itself, including such aspects as its metrology and denominational structure, and most importantly, the indications of its usage patterns embodied within the composition and geographic distribution of individual coin hoards. Ultimately, we may wish to know *why* Bahmani copper coinage production should have undergone such a sudden expansion in the 1420s and 1430s, but in order to realize this goal, we must first address the physical nature of the coinage itself and what it can tell us about how it was used.

[1] John Deyell, e-mail communication, 23 May, 2013.

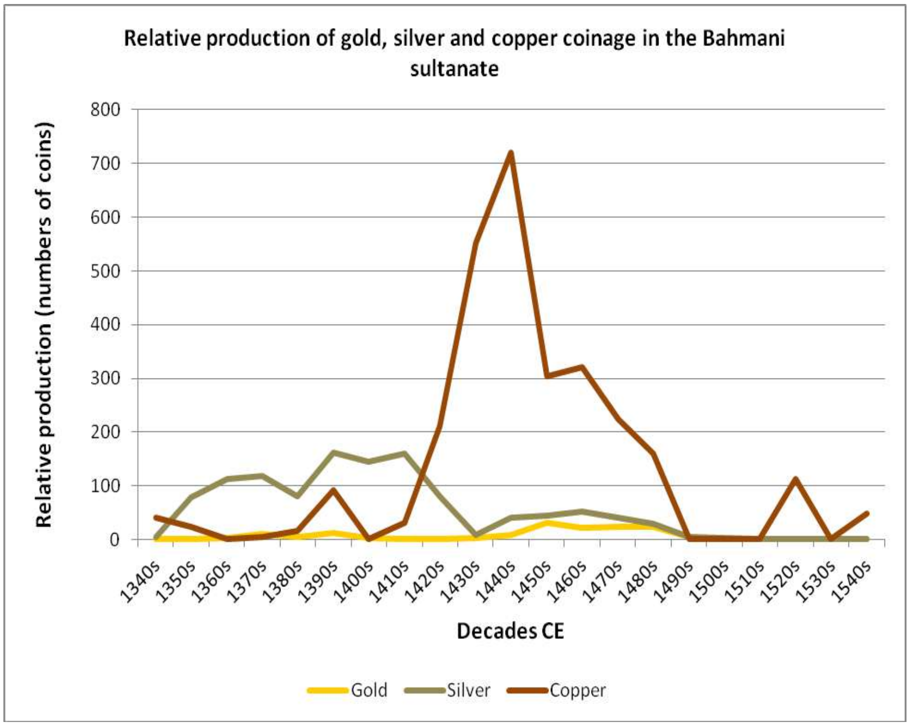


Figure 1 (courtesy of John Deyell)

This essay represents an attempt to move in this direction through detailed analysis of an intact hoard of 713 Bahmani copper coins from Akola in Maharashtra, now in the collection of the Indian Institute for Research in Numismatic Studies (IIRNS) in Nasik.[2] As the reader will see, the data provided by this hoard sheds light on the denominational structure of the Bahmani copper coinage and what that in turn implies about how these abundant copper coins were used, and my members of which social groups. The hoard also provides a sample of sufficiently large size to permit measuring the rate of weight loss through circulation, the variation in that rate from one denomination to another, and what this implies about the different velocities at which the various denominations circulated. Finally, the hoard has also afforded us the opportunity to develop a scientifically grounded method for determining the target mint weight for a given denomination through regression estimates.

[2] We gratefully acknowledge the hospitality and support afforded by Kamal K. Maheshwari, Amiteshwar Jha and the entire staff of IIRNS during our stay there in early 2016. The second author was in India on a Fulbright-Nehru Fellowship; that support is also gratefully acknowledged.

The limitations of a study restricted to a single hoard are of course considerable. For one thing, the non-existence of statistical data on other Bahmani copper hoards greatly constrains the specific types of analysis that we are able to offer here.[3] Comparative study of the structure of numerous hoards, for example—such as is possible with Roman coin hoards[4]—is simply not yet an option in the case of Bahmani hoards. Accordingly, we have little choice but to begin with a detailed analysis of a single intact hoard, and to hope that others will eventually come to light, making it possible to carry out more varied kinds of analysis in the future. It is clear from the treasure trove reports published annually in *Indian Archaeology—a Review* that substantial numbers of Bahmani hoards have been found and reported, even if they have not yet been properly published or subjected to statistical analysis, so it is not unreasonable to expect that other hoards will become available.[5]

Before going into the details of the Akola hoard, it may be useful to review briefly the salient features of the Bahmani currency system.[6] Bahmani coinage originated as an adaptation of that employed by the Delhi Sultanate in north India, which, by the time it was introduced to the Deccan with Delhi's conquests of the region in about 1300, had already been refined through nearly a century's use in the subcontinent. The Bahmanis' adaptation included two heavy gold denominations, the *dinār* and the

[3] It would appear that no hoard of Bahmani coppers has previously been subjected to fine-grained statistical analysis such as that presented here. Indeed, the only published hoard of Bahmani coppers of which we are aware is Khwaja Ghulamus Syedain's article on a smaller hoard (103 coins) from Ladkhed, also in Maharashtra. See Syedain, "Ladkhed Hoard of Bahmani Copper Coins from Maharashtra," *Studies in South Indian Coins* 7(1997): 95-104. Unfortunately, this does not record the weights or dates of the individual coins, but only provides an average weight for each type.

[4] See, for example, Kris Lockyear, "Multivariate Money: A Statistical analysis of Roman Republican coin hoards with special reference to material from Romania," University College London, doctoral thesis, 1996, and *idem*., *Patterns and Process in Late Roman Republican Hoards, 157 – 2 B.C.*, BAR International Series, vol. 1733, Oxford: 2007.

[5] On the utility of the Treasure Trove Reports, and for the details of a spatial database constructed by Wagoner in 2012-2013, which plots the findspots and compositions of over 300 hoards from the Deccan containing coins issued by the Bahmanis or by Vijayanagara, see Wagoner, "Money use in the Deccan, c. 1350-1687: The role of Vijayanagara *hons* in the Bahmani currency system", *Indian Economic and Social History Review* 51/4(Oct.-Dec. 2014): 457-480.

[6] The information in this paragraph is largely based on Stan Goron and J.P. Goenka, *The Coins of the Indian Sultanates* (New Delhi: Munshiram Manoharlal, 2001), pp.285-310.

tanka, weighing respectively 14 and 12 *māṣa*s[7] (12.85 and 11.02 g), and minted at close to 100 per cent purity. Because of the amount of gold they contain, these were clearly high-value coins that would have been useful only for the highest value monetary transactions, or else as a medium for storing wealth. For other purposes, the silver *tanka*, weighing 12 *māṣa*s (11.02 g) would have been used, together with four fractional silver denominations from the two-thirds unit down to the one-twelfth. Initially, a copper coin—minted at 4 *māṣa*s (3.67 g)—and its half and quarter fractions would have served for everyday transactions in the bazaar. This was soon augmented with a growing array of larger denominations, until by the middle of the fifteenth century as many as nine different copper denominations had been defined, seven of which were then being minted. But from 1458 until the final collapse of the Bahmani state at the end of the fifteenth century, only the four largest denominations—6-, 9-, 12-, and 18-*māṣa*s, working out to 5.51, 8.26, 11.02, and 16.52 g respectively—were regularly minted in quantity, and the smaller denominations were effectively discontinued.

Regardless of their metal and weight, all Bahmani coins are aniconic, as is the norm in most Islamic traditions of coinage. Instead of bearing figural imagery, they carry a calligraphic device consisting of the names and titles of the ruling sultan, covering both obverse and reverse in Persian script. Most of the larger denominations, as well as some of the medium-sized ones, carry the date of the coin's issuance, and in some cases the name of the mint as well, although these can be difficult to read since the die is usually imperfectly centered on the flan.

[7] The *māṣa* was a metrological unit commonly employed by medieval Indian moneyers. Credit goes to Marie Martin for first suggesting, on the basis of Thakkura Pheru's *Dravya-pariksha*, that the metrological unit used both by the Delhi Sultanate and by the Bahmanis in the Deccan was the *māṣa*, twelve of which equalled the weight of the silver tanka (10.9—11.00 g) See Marie H. Martin, *Bahmani Coinage and Deccani and North Indian Metrological and Monetary Considerations, 1200-1600* (Ann Arbor: University of Michigan, doctoral dissertation, 1980), pp. 131-133. She went on to propose a weight of 0.913 for the *masha*, taking the intermediate value of the very narrow weight range observed for silver tankas. More recently, John Deyell has established that 0.918 represents a more accurate value for the *masha* as used in the Bahmani Deccan. See John Deyell, *Living without Silver: The Monetary History of Early Medieval North India* (New Delhi: Oxford University Press, 1990), pp. 257-261. His value has been used in the analysis presented here. We will return below to the question of the relationship between the round *māṣa* value used as the "nominal" mint-weight, and what was likely the ideal mint-weight that the moneyers strove to attain in minting a given denomination.

The Akola Hoard

We turn now to the Akola Hoard, which was acquired by IIRNS in 1986. It consists of 713 coins,[8] all copper issues of the Bahmanis, with a gross weight of 8.56 kgs. The hoard was processed and accessioned by the IIRNS staff, each coin being kept in a separate envelope on which are noted accession number, name and dates of issuing ruler, date of issue (if given and legible), weight in grams, and diameter in centimeters. Examining each coin and working from this helpful information, we have additionally identified each coin by type number as given by Goron and Goenka (2001), and arranged all the data in a spreadsheet.[9]

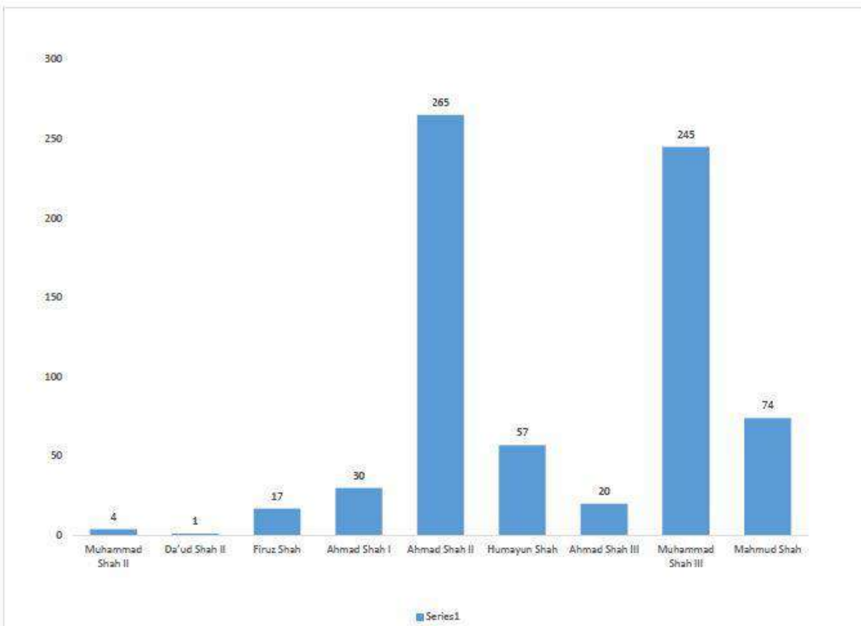


Figure 2: The Akola Hoard: Numbers of Coins, by Issuing Ruler

Figure 2 shows that the hoard contains coins issued by nine Bahmani rulers, from Muhammad Shah II (r.780-799/1378-1397) to Mahmud Shah (r. 887-924/1482-1518). Although Mahmud Shah technically ruled until 924/1518, the closing date for the hoard is likely a good deal earlier, since the latest certain date on Mahmud's coins from the hoard is 890/1485, and all the others cluster tightly in the

[8] The coins are designated by accessions numbers from 86.001 to 86.714, since one number (86.115) was inadvertently skipped in the accessioning.

[9] For the type numbers and legends represented by the coins in the hoard, arranged by denomination, see appendix 1.

early years of his reign—four coins dated to 887, and one each to 888, 889, 88[x] and 89[x]. If the third digit in the last date is 9, then the closing date could be as late as 899/1493; if it is zero, then it would work out to 890/1485.[10] In any case, the hoard includes coins that were minted over a period of approximately one century. The coins of Ahmad Shah II (r.1436-1458) are the most numerous—265—followed by those of Muhammad Shah III (r.1463-1482) as a close second, with 245 coins. The coins of the earliest rulers in the hoard are the smallest in number, and understandably so, since the numbers of those coins still in circulation a century later at the closing date of the hoard must have fallen off dramatically thanks to the processes of loss, hoarding, and official withdrawal of damaged and heavily worn coins.

*Māṣa*s	#coins	Percentage
18	342	48.0%
12	161	22.6%
9	172	24.1%
6	38	5.3%
TOTAL	713	100%

Fig. 3: Numbers and Percentages of denominations in Akola Hoard

The hoard contained coins of four different sizes, belonging to the 6-, 9-, 12-, and 18-*māṣa* denominations mentioned in the previous section. Their relative numbers were such that there seems to have been a preference for the highest denominations on the part of whoever it was who assembled the hoard. As figure 3 shows, the 18-*māṣa* denominations account for nearly half of the contents of the hoard (342 coins or 48%), the 12 and 9 *māṣa* coins account for about a quarter each (161 coins or 22.6% and 172 coins or 24.1%), and the 6 *māṣa* coins only a small fraction of the hoard (38 coins or 5.3%). How the relative proportions between the denominations changed in the coins of each issuing ruler is shown in figure 4. The coins of the first three rulers included only 6-*māṣa* denominations; 9-*māṣa* coins first appear in the coins of Ahmad Shah I, as do also 18-*māṣa* coins, although more tentatively. But in the reign of his successor Ahmad Shah II, the 12-*māṣa* denomination first appears, and the 18-

[10] For the regression analyses presented later in the essay, we chose the date of 892/1486 as the closing date for the hoard, for reasons explained below (see page 18).

māṣa denomination continues to grow at the expense of the smaller denominations, until it accounts for nearly 2/3rds of all the coins issued by the last four rulers.

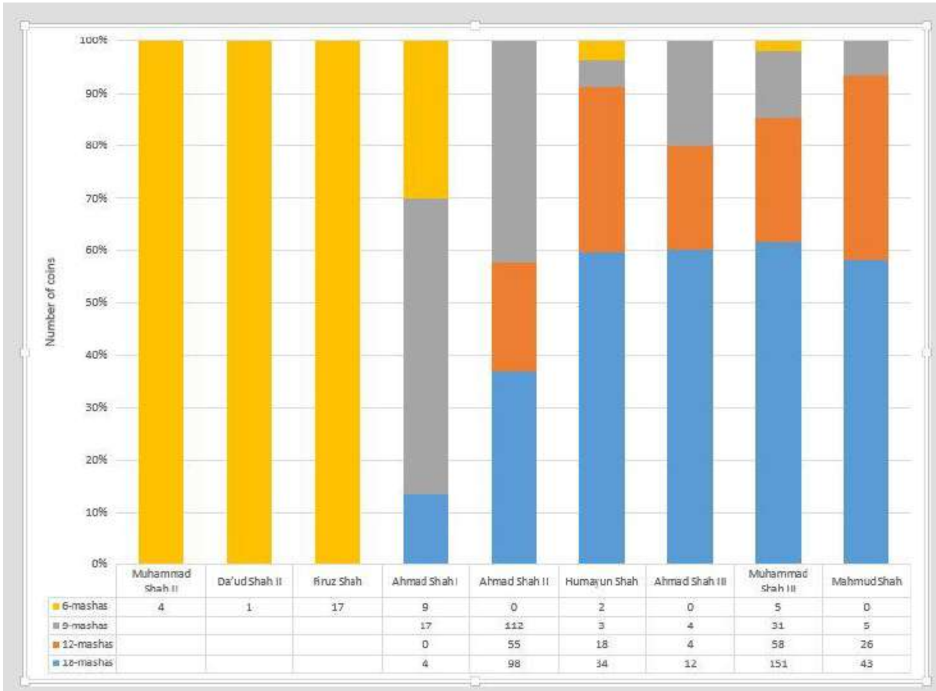


Figure 4: The Akola Hoard: Percentages of denominations by ruler

Using Denominations

At this point, it will be useful to think more explicitly about denomination sets, and how the ways in which they are structured enable certain types of monetary activity that would not be possible otherwise.[11] To this end, figure 5 presents the data of the hoard in yet another way, in the form of a frequency graph plotting the numbers of coins against weights (at 0.2 g intervals). The resulting histogram shows that the coins are tightly concentrated within four compact weight ranges, and that these are separated from each other by clear gaps with no coins in the intermediate ranges. (The sole exception is the anomalous coin at the 13 g mark, to which we will return below.) This tight clustering has implications that are simple but important: it permits coins that fall within the same narrow weight

[11] The term "denomination set" is borrowed from Robert Tye, who rightly states that from the perspective of social and economic history, "the appropriate unit of study should be the set of denominations available at a specific time, to a specific population." See Robert Tye, *Early World Coins and Early Weight Standards* (York: Early World Coins, 2009), p. 104.

range—even if they are in fact slightly different in size and weight—to be *seen and treated as the same*, and at the same time, to be *seen as different* from coins falling within adjacent ranges. This enables users of the currency to quickly identify, sort, and count out a certain number of coins within a given range in order to make a payment for some commodity. And they are able to do this on the basis of simple visual criteria—registering the relative diameter and thickness of the coins—and then confirming that judgement in a tactile manner by feeling the relative weights of the coins (fig. 6). There is no need for the coins to carry a number or name identifying their denomination, nor is it necessary for the ordinary user to be able to read Persian and decipher the multiple names and titles occurring on the different denominations.[12]

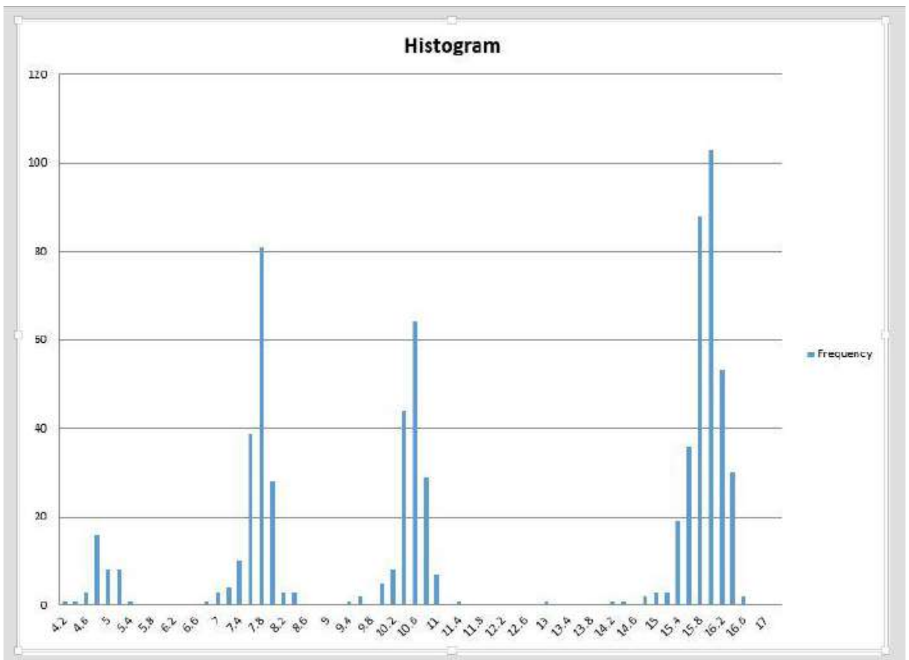


Figure 5: The Akola Hoard: frequency of coin weights showing denominational structure

[12] This is an important point—that recognition of the denomination does not depend on reading the legend—since each ruler differentiated his coins at a given denomination from those of his predecessors by varying the titles employed, and some rulers, most notably Mahmud Shah, issued certain denominations with legends of up to four different types. Indeed, if knowledge of the legends were a crucial component of the ability to recognize denominations, a user of the Bahmani copper currency would have needed to carry a mental catalogue of 28 different legends in order to identify the four denominations (see Appendix 1). But there would have been no need for anyone to do this—other than moneychangers and workers at the mint—since the direct physical properties of the denominations are such that the coins of different values can be easily distinguished—as the photograph in figure 6 clearly suggests.

Fig. 6: A stack of Bahmani copper coins:
6-mashas
9-mashas
12-mashas
18-mashas

There is an additional point of importance that emerges from inspection of this histogram. Each of the four weight ranges begins immediately to the left of the *māṣa* value that Marie Martin has taken as defining that denomination metrologically, represented by the four vertical lines inscribed at its gram equivalent on the weight axis of the histogram.[13] This suggests that the *māṣa* values of the four denominations—18, 12, 9, and 6—were taken as the nominal mint weights for their respective denominations, and that any coin falling into the weight range just to the left of one of these nominal mint weights—let us say, the 18-*māṣa* denomination—would be considered an 18-*māṣa* coin regardless of how much lighter it weighed, so long as it fell within the accepted range. Using these nominal values rather than the actual weights of the coins would have ensured that it was still possible to make use of the natural proportionate relationships obtaining between the denominations. For example, it would have been possible to pay for something with a price of 18 *māṣa*s with two 9-*māṣa* coins, even if the total of their two weights did not quite add up to a full 16.52 grams.

The points made in the paragraphs above can be made still clearer with two contrasting examples taken from two very different currency systems, neither of which bothered to strike coins within narrowly constrained weight limits, as the Bahmanis did. The first example is provided by the reform coinage minted by the Byzantine emperor Anastasius in 498 CE, based on the copper *follis* of 40 *nummi*,

[13] See note 7 above.

which was not struck to any particular weight standard.[14] Figure 7 shows a frequency chart for the weights of 259 Anastasian *folles*, plotting the numbers of coins against weights as in the Bahmani example in figure 5. The weight values of these coins—all representing a single denomination—range from 5.5 grams all the way to 12 grams, a distance within which the Bahmani mint was able to fit and differentiate two denominations. These Byzantine coins do not even remotely share a common weight, nor could their monetary value have been linked to the value of the copper from which they are struck. Rather, they represented a token or fiat coinage, in which the value was declared by the minting authority and had no relationship to the amount of metal it contained. The only way to permit clear recognition of these coins was to inscribe them with the numeral "40" (written as the letter "M")—the one thing they all share in common.

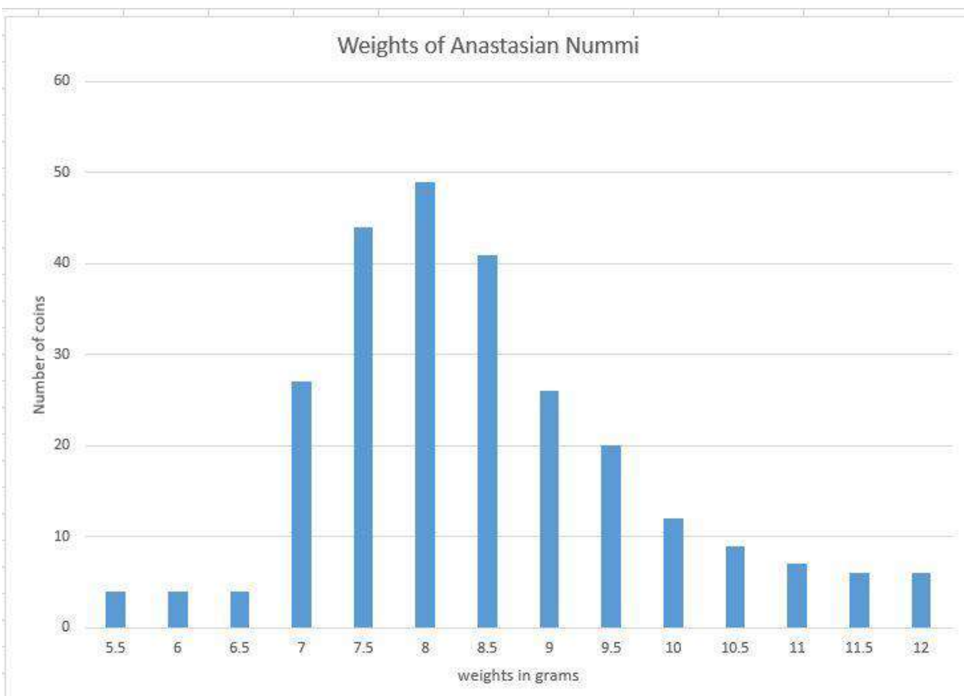


Figure 7: Frequency distribution of weights of Byzantine folles, a coin not struck to a particular standard

[14] D.M.Metcalf, *The Origins of the Anastasian Currency Reform* (Amsterdam: Adolf M. Hakkert, 1969), pp. 1-7; see also the discussion in Martin, *Bahmani Coinage*, pp. 64-65.

The second example is provided by Ghaznavid gold and silver coinage, which similarly was not minted to a strict weight standard. But this was not because it was a token coinage—to the contrary, it was a commodity coinage with its value based on that of the gold or silver it contained—but rather, because it passed not by count (tale) but by weight. In other words, the legend with which each coin was struck guaranteed the metal's purity, but not the amount of the metal it contained; in order to calculate the value of a given number of coins, it would have been necessary to weigh them out with a balance.[15]

These contrasting examples permit us to draw two conclusions about the Bahmani copper currency. First, the coinage must have been accepted by count, because there seems to be no other reasonable explanation for why the mint authorities would go to such trouble to mint the coins to so narrow a weight margin, and to separate the denominations by such carefully maintained intervals, if they were still to be weighed before each transaction. Striking according to such narrowly defined denominations can only have been for the purpose of making the coinage easier for ordinary people to use in market transactions. Second, the coinage must have functioned as something in between a commodity coinage, based on the value of its copper, and a token or "fiat" coinage with its value determined by the state and unrelated to the amount of copper it contained. If it had been purely a fiat coinage, then there would have been no reason to use more copper to make the higher denominations larger and heavier; instead, it would have been possible to mint all four denominations at the same size and then to differentiate them solely by means of numbers, in a manner akin to the Byzantine *folles*, but inverted (i.e., multiple numbers to differentiate identically sized coins, instead of, as with the *folles*, a single number to identify differently sized coins). On the other hand, it seems likely that the coins would have carried a small and variable amount of additional value over that of the amount of copper they contain, in effect guaranteeing that the lower weight coins would still carry a value equal to that of a

[15] Deyell, *Living without Silver*, p. 73.

coin realizing the ideal mint weight. For this type of coinage, we may use the term "fiduciary" coinage, as employed by Sargent and Velde.[16]

Interpreting the Bahmani copper coinage as a fiduciary coinage additionally helps make sense of the weight distributions in the denominational frequency chart. Any coin with a weight above the nominal mint weight for that denomination, would be, by definition, more valuable as a piece of copper than as a piece of money, creating an incentive for it to be taken out of circulation, melted, and restruck to a weight *below* the nominal mint weight. Conversely, with underweight coins, there would be no such incentive until one came to the most heavily underweight coins, at which point it would be expedient to take them back to the mint or moneychanger in exchange for coins within the expected normal weight range. This would account for the steeper slope of the weight distribution curve on the right side (higher weight values) and the more gradually tapering distribution curve on the left.

In this connection, we may recall that in the case of the 18 *māṣa* denomination, there was one unusually lightweight outlier located half way between the 18 and 12 *māṣa* distributions. Typologically—even if not by weight—this coin is an 18-*māṣa* specimen, but it is so light that one would expect it to have been taken out of circulation instead of ending up in this hoard. One suspects that had the coins in the hoard remained in circulation, the next time a moneychanger spotted that coin, it would have been culled and returned to the mint, since it would have been too ambiguous for the ordinary money user to decide whether it was supposed to be an 18- or a 12-*māṣa* coin.

To recapitulate the points made in this section, the Bahmanis' use of multiple, clearly differentiated denominations of copper coins would have had three related implications for how the money was used:

[16] Sargent and Velde define "fiduciary" money as that which is "overvalued", that is, taken for more than its intrinsic value. See Thomas J. Sargent and Francois R. Velde, *The Big Problem of Small Change* (Princeton: Princeton University Press, 2002), p. 375.

1) First, the tight clustering of individual coin weights within narrow denominational bands separated by clearly defined gaps would have facilitated visual and tactile recognition, sorting, and counting of the coins. This means that the coins could pass by count, instead of by weight, and that there would accordingly be no need for an intermediary with a balance to be interposed between buyer and seller.

2) The establishment of a fiduciary coinage, in which the coins carried a value somewhat greater than that of the copper they contained, made it possible for people to use underweight as well as full-weight coins, so long as they fell within the acceptable weight range for that denomination, and to refer to them equally with the nominal denominational value. This would have alleviated any qualms about wear having a negative effect on the coins' value.

3) The minting in a range of denominations, all expressed in terms of numbers of *māṣa*s exhibiting natural proportional relationships with each other, would have facilitated handling the money, making payments, and making change. For example, if one were going to the bazaar to make a more substantial purchase with the value of 180 *māṣa*s, it would make more sense to carry the sum as ten 18-*māṣa* coins, rather than as thirty 6-*māṣa* coins. Even though both sums would weigh approximately the same amount, and carry exactly the same value, it is far easier to count and keep track of 10 coins than it is of 30.

In sum, the analysis of the Akola hoard thus far suggests that the multi-denominational copper coinage it contained would have had the effect of facilitating and encouraging monetary transactions at the non-elite level.

Circulation and Weight Loss

Thus far, we have considered the Akola hoard synchronically, that is, as providing a glimpse into the workings of the Bahmani monetary system at a particular moment in time early in Mahmud Shah's reign, in about 1485-93, at which point the hoard was closed and deposited. Thus, each of the denomination distributions in figure 5 represents not only the coins that were minted at the end of the fifteenth century by Mahmud Shah, but also those of the same denomination issued by any of his predecessors who also minted that denomination. Yet, these are all amalgamated and not distinguished from one another. At this point it will be worthwhile to disaggregate the data for these different regnal periods so we can analyze them diachronically and gain a better sense of how the coinage changed over time. Here the most relevant factor to consider is weight loss, as this can reveal much about the velocity at which coins have circulated, which can in turn reflect the degree of monetization within a society.[17]

As D.D.Kosambi has demonstrated experimentally, populations of coins of a single type that have been minted to a common weight standard and put into circulation at the same time will exhibit two characteristics over time. First, their average weight will *decrease* due to the slow wearing away of metal through handling and exchange, and second, the spread between their lowest and highest weights will *increase* since some coins will inevitably experience more vigorous circulation (the lower weights) and others will see less (the higher ones). Visually, this can be expressed in a frequency chart, with weights on the x-axis and numbers of occurrences on the y-axis. The frequency distribution of the coin weights at the time of minting would have a high and narrow peak, theoretically centered over the ideal minting weight, and sides that fall off steeply. After they have circulated for some time, a distribution curve of the same coins would not only have shifted to the left (as their average weight declined) but

[17] There is of course no simple and direct link between velocity of circulation and the degree of monetization. Indeed, Nicholas Mayhew has recently called attention to the "counter-intuitive truth" that "velocity falls as one moves towards more modern times, even though it is clear that the use of money has generally become more and more prevalent over time… Increasing dependence on the use of money in society called for ever greater supplies of money, since all of us need to hold quantities of cash idle in readiness, if it is to be available at the moment when we choose to spend it. Thus Velocity falls the more we depend on the use of money (Nicholas Mayhew, "The President's Address, 19 June 2012: The Quantity Theory of Money: 3. Velocity", *The Numismatic Chronicle* 172(2012):397-403). Moreover, as Lockyear has noted, studies of relative monetization "have generally been hampered by a lack of definition" (Lockyear, *Multivariate Money*, p. 55). But we would agree with his cautious acknowledgement that "speed of coin circulation could still be a useful parameter to chart as it should partly reflect the uses to which coinage was put, and perhaps the degree of 'monetization' of an economy" (p.267-8).

also flattened at the same time, covering a greater range of different weights due to the differential effects of wear.[18]

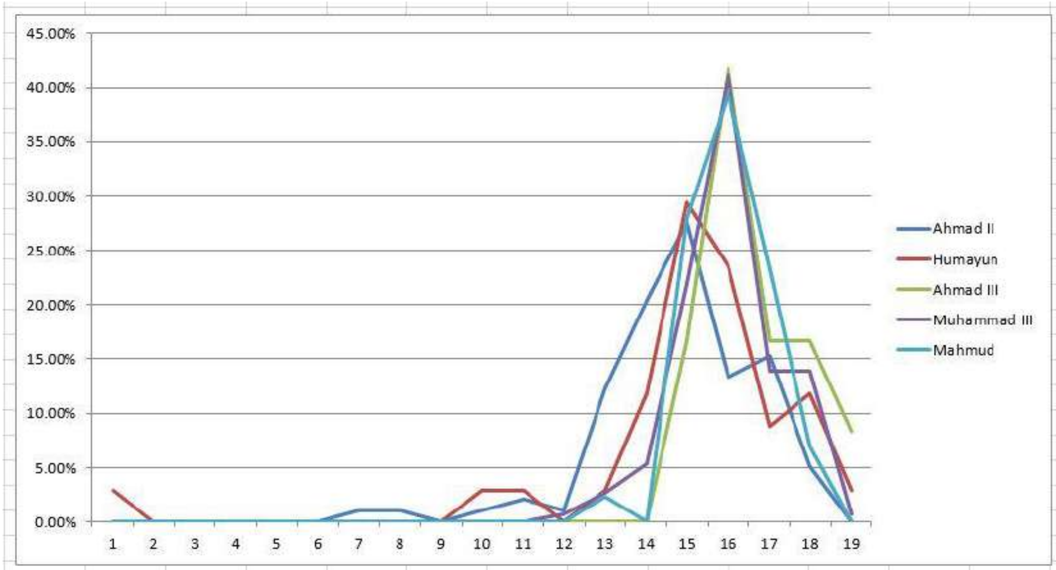


Figure 9: Weight loss in 18-*māṣa* denominations issued by five successive rulers over a period of 57 years: Ahmad II (1436-1458) to Mahmud (1482-1493)

Can we observe these characteristics—leftward shift and flattening of the curve—if we graph the distribution curves for the coins of a single denomination as minted by different rulers represented in the Akola Hoard? Figure 9 presents such a graph, showing the 18-*māṣa* weight and number distributions for 5 consecutive rulers. Although there is little to differentiate the three most recent rulers (moving backwards in time, Mahmud, Muhammad III, and Ahmad III, covering a span of approximately 30 years), there is a significant difference between their curves and those of the two earliest rulers, Humayun and Ahmad II, whose outputs covered the previous 25 years. In their cases, not only has the peak shifted to the left, but it has also been brought down lower than the peaks of the other three rulers, and is spread out more widely. What this means is that after being in circulation for only an additional 25 years, these coins vividly show the effects of wear.

[18] D.D. Kosambi, "The effect of circulation upon the weight of metal currency," *Current Science* XI (1942): 227-31, and "Scientific Numismatics," *Scientific American* (Feb. 1966): 102-111. Both articles have been reprinted in D.D.Kosambi, *Indian Numismatics*, New Delhi: Orient Longman, 1981.

It is one thing to say that the coins show weight loss, and yet another to be able to talk about that weight loss in a quantifiable manner. A simple way to do so would be to look at what is happening to the average weight of the coins in any particular denomination for earlier and earlier reigns. If wear is taking place, we would expect the average weight of the coins of a particular denomination to be lower for earlier reigns. Further, if the distribution of weights is flattening and moving to the left, we would expect the mode (the weight at which the distribution is at its highest, indicating the "most common" weight) to also be shifting to the left, but not so much as the mean weight which moves farther to the left due to the skewing of weights toward that direction. Figure 10 presents this data in the form of a table. In the table, the reigns are listed in chronological order, with later reigns occupying columns further to the right. For each denomination and for each reign, we provide the number of coins (n), the mean weight and the modal weight. We see that, except in cases where the number of coins in a category is so small that the sample could easily be non-representative, the average and modal weights decline with age and the mode remains to the right of the mean.

18-*māṣa*s						
Ruler		Ahmad II	Humayun	Ahmad III	Muhammad III	Mahmud
n		98	34	12	151	43
Mean		15.67	15.68	15.97	15.89	15.90
Mode		15.8	15.8	16	16	16
12-*māṣa*s						
Ruler		Ahmad II	Humayun	Ahmad III	Muhammad III	Mahmud
n		55	18	4	58	26
Mean		10.33	10.33	10.37	10.56	10.56
Mode		10.4	10.4	10.5	10.6	10.6
9-*māṣa*s						
Ruler	Ahmad I	Ahmad II	Humayun	Ahmad III	Muhammad III	Mahmud
n	17	112	3	4	31	5
Mean	7.57	7.63	7.60	7.73	7.77	7.86
Mode	7.7	7.8	7.67	7.8	7.8	7.8
6-*māṣa*s						
Ruler	Muhammad I	Da'ud II	Firuz	Ahmad I	Humayun	Muhammad III
n	4	1	17	9	2	5
Mean	4.65	4.64	4.70	4.82	4.91	5.14
Mode	4.75	4.8	4.8	4.8	5	5.2

Figure 10: Mean and Mode of Coin Weights, by ruler and denomination

A more formal way to quantify the weight loss phenomenon would be to run ordinary least square regressions on the data. Say we postulate a very simple process, that a coin loses, on average, a fixed, but unknown, proportion of its weight every year.[19] Of course this is over-simplified, but we are dealing with averages. Under this assumption, the weight of a coin in year 1 (w_1), one year after it was minted, could be represented as

$$w_1 = \theta w_0$$

where w_0 is the (unknown) weight in year 0 (the year the coin was minted), and θ is the fraction of the weight remaining after the weight loss. If there is no weight loss, $\theta = 1$; otherwise, it is a number less than 1 (say 0.99 if the weight loss is 1% per year). The weight loss factor, i.e., the fraction of weight that is lost each year, is $(1 - \theta)$.

Following this process, in year 2 the weight would be

$$w_2 = \theta w_1 = \theta^2 w_0$$

in year 3, it would be

$$w_3 = \theta w_2 = \theta^3 w_0$$

and so on; so that in year *t* the weight would be

$$w_t = \theta^t w_0.$$

Since this equation is not linear, we cannot apply linear regression techniques to it. However, it can be converted to a linear equation by a simple transformation: taking natural logarithms. Explaining what exactly a natural logarithm is would be difficult as it is quite technical and would take us too far off-subject; suffice it to say that this is a transformation that converts the exponential equation above into a linear one. The logarithmic transform of this equation is:

$$\ln w_t = t \ln \theta + \ln w_0.$$

[19] This assumption goes against the finding of Cope that the rate of wear of copper pennies in modern times increases over time, perhaps because there is a constant loss of thickness over time. However, a glance at the scatter diagrams in the Appendix, showing the relationship between age and weight of the coins in the hoard does not indicate this at all. The interested reader can look at the contrast between our scatter diagrams and Cope's to be convinced that his result does not apply to this medieval coinage. See R. G. Cope: "The Wear of U.K. Coins in Circulation," *Wear* 13 (1969), pp. 217-224.

We may rearrange this equation in the form

$$\ln w_t = \ln w_0 + (\ln \theta)\, t.$$

This is a linear equation of the familiar form

$$y_t = a + bx_t.$$

Here, our dependent variable y_t is the natural logarithm of the weight of a coin ($\ln w_t$), the independent variable x_t is the age of the coin (t), the coefficient of the independent variable t in the regression, b, is the natural logarithm of one minus the weight loss factor ($\ln \theta$), and the intercept a is the natural logarithm of the weight of the coin at the time of its minting ($\ln w_0$).

Now of course the age of a coin is not the only factor that determines its weight. Hand-struck coins would not have weighed the same at the time of minting, some coins might have been used much more often than others (and therefore worn more), and so on. As is customary, in order to render the equation amenable to the application of linear regression techniques, we rewrite it in the form

$$y_t = a + bx_t + \epsilon_t$$

where ϵ_t is the random error term, meant to capture all the other factors that would have affected the observed weight of the coin and assumed as usual to have a mean of zero and a variance σ_ϵ^2.

In running the regressions, we expect under the theory of weight loss that the regression coefficient b (or $\ln \theta$) would be negative, indicating that weight declines with the age of a coin. As a bonus, the regression for any denomination would yield an estimate of the average weight at time of minting w_0, since $\ln w_0$ is the intercept of the regression.

We of course had the weight of every coin in the hoard. For the closing date of the hoard, we selected the year AH 892/1486 CE, although in reality the closing date could be any year in between 890 and 898, because the last digit of the coin bearing this date is not legible. But since we need a fixed closing date in order to calculate the age of each coin in the hoard at the time of the hoard's closing, we chose 892 which appears to be a likely possibility given the other documented dates for the hoard's coins issued by the last ruler, Mahmud Shah.[20] When the date of a coin was legible on the coin itself, we calculated its age by taking the difference between 892 and the date on the coin. There were 156 coins (out of the 713 in the hoard) for which the date was fully legible. There were additionally 74 coins for which the date was only partially visible, the last digit being illegible. In these cases, we took the date to be the mid-point of the decade if the sultan ruled throughout the decade, or the mid-point of that portion of the decade under the sultan's rule if he ruled for only part of it. Finally, when not enough of any date was visible on the coin, we took its date to be the mid-point of that sultan's reign and calculated the age accordingly.

We ran four regressions, one for each denomination. Details of the results are presented in Appendix II, but the main results are summarized in Figure 11. All the slope coefficients were negative and statistically significant even at the 99% confidence level, giving powerful support to the weight loss hypothesis. The P-values (probabilities of getting the results we did under the null hypothesis of no weight loss)[21] are all considerably below 1%. The highest P-value was for the 6-*māṣa* regression, and even there it was a miniscule 0.006%, meaning that there was about a six-thousandth of 1% chance that we found the slope we did even though there was no weight loss. In short, it is virtually certain that our data verify weight loss. These results are as definitive as we could have hoped for.

Figure 11 presents a summary of the key results. We see the calculated slope for each regression in the first row. The second row presents the P-values, on which we have already commented, and show how strong the weight loss results are. The third row shows what the estimated slope tells us: the estimated rate of weight loss per year. This varies from a low of 0.042% for the 18-*māṣa* coins to a high of 0.120% for the 6-*māṣa* coins. The 12- and 9-*māṣa* denominations show weight loss in the 0.06% to 0.07% per year range. These numbers would indicate that the 6-*māṣa* coins circulated the most vigorously, at least among the users of this hoard's coins, while the 18-*māṣa* coins circulated the least

[20] See the discussion on page 6.
[21] The P-values are calculated based on an alternative hypothesis that the slope is less than zero (one-tailed test).

vigorously. That assumes that weight loss comes only, or at least primarily, from circulation, and that the speed of weight loss indicates the vigor of circulation. It is possible, however, that other factors also play a role in the speed of weight loss. For example, perhaps the slower speed of weight loss in the 18-*māṣa* coins is partly a consequence of their heavier weight, as compared to, say, a 6-*māṣa* coin. One way in which coins might lose weight is by striking against one another in a change purse or money bag. Just as an SUV suffers less damage than a sub-compact car if the two collide, it is possible that a heavier coin loses less weight from jostling against other coins than does a lighter coin. In any case, this hypothetical jostling of coins in a purse or money bag may itself be considered a part of circulation, in the sense that one needs to have coins accessible if they are to be used. If there is little likelihood of their being used, there is correspondingly less chance that they will be jostling about. But, having noted them, we will ignore these considerations.

	Denominations			
	18 *māṣa*s	12 *māṣa*s	9 *māṣa*s	6 *māṣa*s
Slope	-0.000424	-0.000676	-0.000596	-0.001204
P-value	<0.0001%	<0.0001%	0.0060%	0.0057%
Implied Rate of Annual Weight Loss	0.042%	0.068%	0.060%	0.120%
Intercept	2.769847	2.362156	2.057977	1.645922
Implied Average Weight at Mint	15.96 gm	10.61 gm	7.83 gm	5.19 gm
"Ideal" Mint Weight	16.524 gm	11.016 gm	8.262 gm	5.508 gm
Implied Weight as Percent of Ideal	96.56%	96.35%	94.77%	94.15%

Figure 11: Summary of Key Regression Results

It is worth thinking about what the numbers on weight loss tell us about how vigorously coins circulated in the Bahmani kingdom. Richard Duncan-Jones, in his landmark study of money in the

Roman Empire, found that the speed of weight loss for bronze *sestertii* was 0.18% per year.[22] Assuming that the "propensity to lose weight" was the same for Roman sestertii and Bahmani coppers, our results indicate that the vigor of money circulation was not as great in the Bahmani Sultanate as in the Roman economy, but it was nevertheless quite significant, with the 6-*māṣa* coins losing weight at the rate of 0.12% per year, two-thirds the rate found for Rome. Although the velocity at which the 6-*māṣa* coins circulated was not quite as high as that of the Roman *sestertii*, these findings do suggest a society that was relatively highly monetized, even if in some of its sectors other forms of exchange—such as barter or gift giving—may have continued to be important. We should also note that the denomination that circulated most vigorously, the 6 *māṣa* coin, was the smallest of the four Bahmani denominations and thus would have been the most accessible and useful coin for the least wealthy inhabitants of the Bahmani realm. This suggests that even the urban poor and lower middle classes would have been able to participate in the cash economy, reinforcing the points about non-elite coinage use made at the end of the previous section.

On the Relationship between Actual Mint-weight and Nominal Mint-weight

We have observed above that in the Akola hoard, the weights of the coins in each of the four denominations fall uniformly to the left of the nominal weights for their respective denominations. This raises the question of how we are to understand the relationship between the nominal weight in *māṣa*s and the actual weight that the mint workers were striving to realize in minting those coins. Here too the regression results provide us with some useful data. The last four rows in figure 11 show the results for the intercept term of the regressions. Since the intercept is the natural logarithm of the average initial (mint) weight of the coins, it needs to be converted to give that average weight at the time of minting. The last two rows show how the estimated mint weights from the regressions compare to the "nominal"

[22] Richard Duncan-Jones: *Money and Government in the Roman Empire*, Cambridge: Cambridge University Press, p. 191. During the period of the Empire, the *sestertius* was a large "bronze" or copper coin weighing about 15 grams. It is thus closely comparable in size to the the 18 *masha* Bahmani coin.

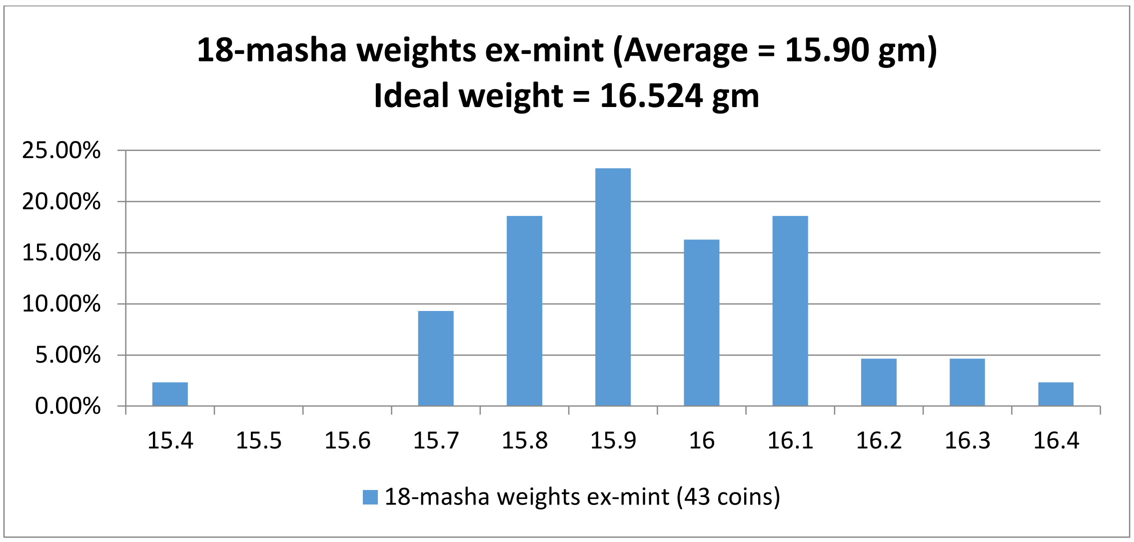
mint weight. We see that all the estimated mint weights are quite short of the nominal mint weights. The fact that the regressions yield these estimates of the average weight at the time of minting is a real bonus and benefit of the regression approach.

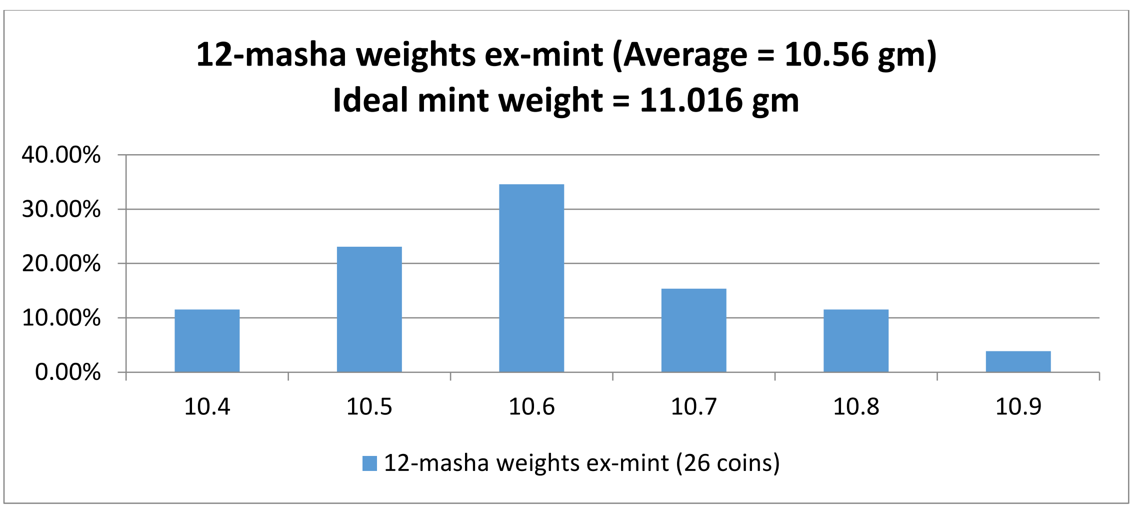
Of course, a more direct approach to find the average weight at time of minting would be to actually look at coins as they came out of the mint and to weigh them. Since we do not have the possibility of doing that, what we could do is to take the newest coins in each denomination and look at their weights. This would yield a close approximation to the average weight at time of minting, since these coins have not circulated that much. Looking at a number of "new" coins would also give us an idea of the distribution of the weights of newly minted coins. In the hoard, the newest coins would be those of Mahmud Shah, since the closing date of AH 892 implies that the hoard was buried relatively early in his reign (AH 886-923). So we took the coins of Mahmud Shah in each denomination (there were no 6-*māṣa* coins of Mahmud, so we had to leave that denomination out of this exercise) and looked at their average weight and distribution.

Denomination	Average Weight of Mahmud's Coins	Regression Estimate of Mint Weight	"Nominal" Mint Weight
18 *māṣa*s	15.90 gm	15.96 gm	16.524 gm
12-*māṣa*s	10.56 gm	10.61 gm	11.016 gm
9-*māṣa*s	7.86 gm	7.83 gm	8.262 gm

Figure 12: Average Weights of Mahmud Shah's Coins, Compared to Regression Estimates and the "Nominal" Mint Weights

Figure 12 presents the average weight of Mahmud Shah's coins (the "new" coins), compared to the regression estimates of the average mint weight and the "nominal" mint weight. We see that the average weights of Mahmud's coins are very close to the regression estimates and quite far from the "nominal" mint weights. Even more interesting are the distributions of the weights of Mahmud's coins, seen in Figure 13. We expected to see distributions that were skewed to the left, on the grounds that the mint would avoid producing coins that were too heavy but would nonetheless be trying to reach the "nominal" mint weight. On the contrary, the distributions are relatively symmetrical (except the 9-*māṣa*s, which is skewed to the right but in any case is not to be trusted because it is based on only five coins). Thus it appears that the mint was shooting for a weight well short of the nominal mint weight; the distribution around that "target" low weight would then be more or less normal.





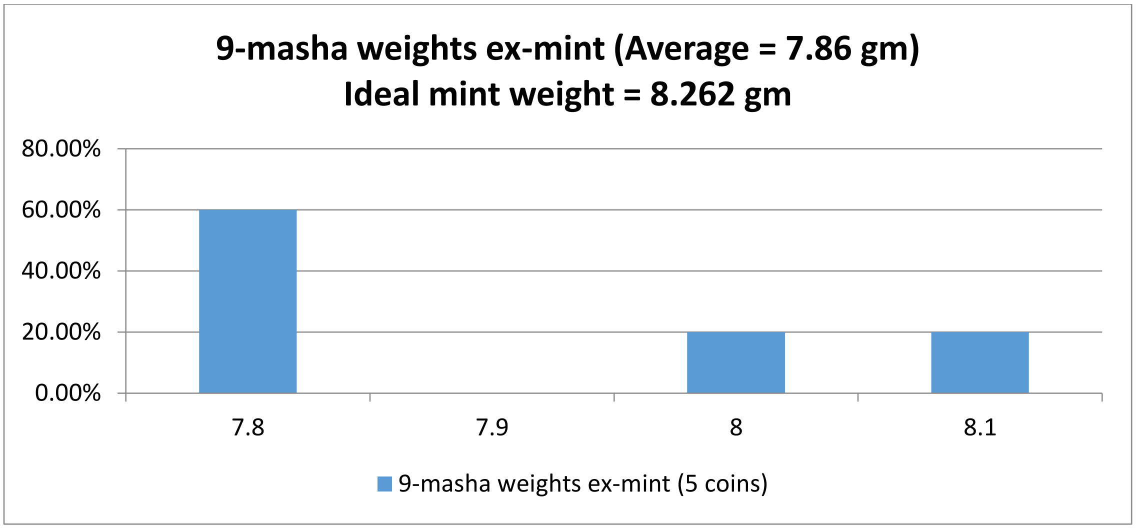


Figure 13: Distribution of the Weights of Mahmud Shah's Coins

One last item we look at in the context of the weight at time of minting is John Deyell's practice of estimating the mint weight by adding the standard deviation to the mean weight of the coins of a particular type in a hoard. In his excellent survey of methods of hoard analysis,[23] Deyell mentions that "for convenience sake … the upper standard deviation ($\overline{w}$ + s.d.) is taken as a good approximation of the ideal minting weight of any coin type." Deyell does not provide any theoretical justification for this measure; it is an *ad hoc* approach meant to counter any tendency to use the heaviest coin in the hoard to yield the estimate of the minted weight.

[23] John Deyell: *Living Without Silver*, Appendix D.

	Denominations			
	18 *māṣa*s	12 *māṣa*s	9 *māṣa*s	6 *māṣa*s
"Nominal" Mint Weight	16.524 gm	11.016 gm	8.262 gm	5.508 gm
Regression Estimate of Mint Weight	15.96 gm	10.61 gm	7.83 gm	5.19 gm
Average Weight of Hoard Coins	15.80 gm	10.45 gm	7.66 gm	4.79 gm
Standard Deviation	0.35	0.26	0.23	0.25
Deyell Measure of Mint Weight = Average + Standard Deviation	16.15 gm	10.71 gm	7.88 gm	5.04 gm
Implied Regression Intercept[24]	2.782202	2.371026	2.064600	1.617743
Estimated Regression Intercept[25]	2.769847	2.362156	2.057977	1.645922
95% Confidence Interval	2.765429 – 2.774264	2.355439 – 2.368873	2.045624 – 2.070329	1.605799 – 1.686045

Figure 14: Comparison of Regression Estimate with Deyell's Measure of Mint Weight

Figure 14 presents calculations of Deyell's measures of mint weight for the four denominations of coins in the Akola hoard and compares them to the regression estimates. The Deyell measure performs remarkably well; it is closer in all cases to the regression estimate than to the "nominal" mint weight. But, in statistical terms, its performance is mixed. In two out of the four cases (18-*māṣa*s and 12-*māṣa*s), the Deyell measure lies outside the 95% confidence interval around the regression estimate of the intercept. In other words, we would reject the null hypothesis that the true measure was the Deyell measure. However, in the other two cases (9-*māṣa*s and 6-*māṣa*s), the Deyell measure lies within the 95% confidence interval, and so we would be unable to reject the hypothesis that the Deyell measure was indeed the true measure. For an *ad hoc* measure with no real theoretical basis, that is a pretty good

[24] The "Implied Regression Intercept" is that value of the intercept that would have given rise to Deyell's measure of the mint weight. We would like to see if this falls within the confidence interval of the actual regression intercept, which would mean that Deyell's measure was more or less consistent with our estimate. If the "Implied Intercept" falls outside the confidence interval, we would say that, statistically speaking, Deyell's measure was different from our estimate.

[25] From Appendix II.

performance, but the mixed result underscores the benefit of our regression approach which yields estimates that are grounded more scientifically.

What are we to make of the considerable difference between the estimated mint-weights (as implied by the regression intercepts) and the nominal mint-weights in whole *māṣas*? There would appear to be at least four possible ways to account for this discrepancy. Namely, we could conclude that:

1) Martin was wrong and there was no correlation between Bahmani copper coin weights and whole *māṣa* values; or that
2) There *was* a correlation, but it was based on a different value for the *māṣa* than that used either by Martin or Deyell; or that
3) The gap between the nominal mint weights and the estimated mint weights might be accounted for in terms of weight loss from chemical cleaning of the hoard;[26] or that
4) We should think of the nominal mint weight not as an ideal target that the mint strove to attain, but as a weight in whole *māṣa*s slightly higher than the actual target weight so as to impute more value to the coin than the copper it contained, thus adding a fiduciary element to minimize the chances of the coins being melted down for their copper, while also preserving the natural proportions between the weights of the various denominations.

We remain uncommitted on this matter, although the first possibility can almost certainly be ruled out in view of the clear denominational structure exhibited by these coins. The second option might be a possibility, although the amount of variance would likely be too small to account for the size of the gap. The third possibility would appear plausible, although nothing is known about the cleaning of the hoard,

[26] Deyell has written that on average, there is a 2% reduction in the gross weight of a hoard from cleaning (1990: 283).

which was evidently done before IIRNS acquired it. The fourth option appears highly plausible, although in the end, it could well be that the discrepancy was produced by a combination of factors, such as those in the last two possibilities.[27]

Conclusions

There are many things we might like to know about the Bahmani currency system that must remain beyond our grasp, at least for the present, due to the dearth of contemporary written sources, whether historiographic, documentary, or epigraphic. For example, we still do not know with any certainty the contemporary names by which the copper denominations were known, nor do we have the kind of information about wages, commodity prices, and metal exchange rates that is available for Mughal north India, for example. Nonetheless, our materially based analysis of the Akola hoard does permit us to draw several tentative conclusions about the nature of the Bahmani copper currency. These are offered here in the hope that they may serve as a basis and point of departure for future studies as more evidence becomes available, whether in the form of previously unknown literary sources or in the form of more intact hoards.

1). From the clear, denominational structure witnessed by the coins in the hoard, and from the fiduciary nature of the coinage—by virtue of which the coins carried slightly more value than that of the copper they contained—it is clear that they would have passed by tale and not by weight. This would have simplified purchasing and payment transactions, as there would have been no need for a moneychanger (*sarraf*) to be interposed between buyer and seller.

[27] There is a theoretical fifth possibility, that the distribution of minted coins was normally distributed around the nominal mint weight, but that those coins which weighed more than the nominal mint weight were culled out as worth more than the coin's value. This would give rise to the *issued* coins all being lighter than the nominal weight and so naturally the average weight of the issued coins would be below the nominal mint weight. However, we can reject this possibility because it would imply a distribution of weights that would be highly skewed to the left, but the distribution of weights that we observe in Figure 13 is bell-shaped. Thus it does seem that the target mint weight lies below the nominal mint weight.

2) The availability of four commonly available denominations, manifesting natural proportional relationships with one another, would likewise have encouraged and facilitated cash transactions. If prices were expressed in terms of the largest, 18-*māṣa* unit, then the 12-, 9-, and 6-*māṣa* coins would have been available to serve as 2/3rds, half, and 1/3rd fractional units, facilitating the making of change or the buying of smaller amounts of a given commodity.

3) The fact that the different denominations could be clearly distinguished by simple visual and tactile criteria, without relying on written legends or identification in Persian, meant that the coinage could not only serve the elite, but also those who were not literate in Persian, whether because of their lower social status or their non-Muslim identity. This reliance on visual and tactile means of differentiating the denominations would have encouraged non-elite members of society to be drawn into the cash economy.

4) The weight-loss data generated by the regressions clearly indicate that the copper coins circulated vigorously, enough for the smallest of them to lose up to 0.12% of their weight through handling each year. This is a rate that is 2/3s that experienced annually by copper *sestertii* in Imperial Rome, a period characterized by high monetization by pre-Industrial standards. It is also significant that we see significant variation in the rates of weight loss, suggesting that it was the smaller denominations that circulated most vigorously, and the heaviest least vigorously, suggesting that the 18-*māṣa* coins were the ones more likely to drop out of circulation as they were pressed into service as a medium for storing value (much as in the Akola hoard, where 18-*māṣa* coins account for just under half of the hoard).

Appendix I: Coin types in the Akola Hoard and legends by denomination

6 mashas 6 different legends

Type (G&G)	Ruler	legend
BH 053	Muhammad Shah II	O: Muhammad Mahmud R: ‘Abd ma’bud
BH 058	Da’ud Shah I	O: al-mu’ayyad bi nasr Allah R: Da’ud Shah
BH 066	Firuz Shah	O: rājī riḍwān muhaimanī R: fīrūz shāh Bahmanī
BH 076	Ahmad Shah I	O: al-manṣūr bi-naṣr Allāh al-mannān R: abū’l-mughāzī aḥmad shāh al-sulṭān
BH 100	Humayun Shah	O: dārā’ī nigāhbān R: humāyūn shāh bin aḥmad shāh al-sulṭān
BH 117	Muhammad Shah III	O: al-mu ‘taṣim billāh shams al-dunyā wa’l dīn R: muḥammad shāh bin humāyū nshāh al-sulṭān

9 mashas 6 different legends

BH 074	Ahmad Shah I	O: al-mu’ayyad bi naṣr Allāh al-malik al-hannān R: abū’l-mughāzī Aḥmad Shah al-sulṭān
BH 087	Ahmad Shah II	O: al-wāthiq bi-ta’yīd al-malik lālah [sic!] abū’l-muzaffar R: Aḥmad shāh bin Aḥmad Shāh Bahmanshāh
BH 099	Humayun Shah	O: al-mutawakkil alā karam Allāh al-hannān al-ghanī R: humāyūnshāh bin aḥmad Shāh al-walī al-Bahmani
BH 106	Ahmad Shah III	O: al-muṭi’ al-mannān bi-amr Allāh R: abū’l-muzaffar aḥmad shāh al-sulṭān
BH 116	Muhammad Shah III	O: al-mu ‘taṣim billāh shams al-dunyā wa’l dīn R: muḥammad shāh bin humāyū nshāh al-sulṭān
BH 135	Mahmud Shah	O: al-mutawakkil alā’llāh al-hannān al-mannān R: maḥmūd shāh bin muḥammad shah al-sulṭān

12 mashas 8 different legends; 4 of them issued by same ruler (Mahmud)

BH 085	Ahmad Shah II	O: al-mutawakkil alā’llāh al-ghanī R: ‘alā’ al-dunyā wa’l-dīn Aḥmad Shāh bin Aḥmad Shāh al-sulṭān
BH 098	Humayun Shah	O: al-mutawakkil alā’llāh al-qawī al-ghanī abū’l-mughāzi R: ‘alā’ al-dunyā wa’l-dīn humāyūn shāh bin aḥmad shāh bin aḥmad shāh al-walī al-bahmanī
BH 105	Ahmad Shah III	O: al-rājī bi-ta’yīd al-raḥmān R: abū’l-muzaffar aḥmad shāh al-sulṭān
BH 115	Muhammad Shah III	O: al-mu ‘taṣim billāh shams al-dunyā wa’l dīn R: muḥammad shāh bin humāyū nshāh al-sulṭān
BH 128	Mahmud Shah	O: al-mutawakkil alā’llāh al-hannān al-mannān abū’l-mughāzī R: maḥmūd shāh bin muḥammad shah al-sulṭān
BH 129	Mahmud Shah	O: al-mutawakkil alā’llāh al-hannān al-mannān abū’l-mughāzī R: maḥmūd shāh bin muḥammad shah al-Bahmanī
BH 130	Mahmud Shah	O: al-mutawakkil alā’llāh al-hannān al-mannān R: maḥmūd shāh bin muḥammad shah al-Bahmanī
BH 131	Mahmud Shah	O: al-mutawakkil alā’llāh al-qawī al-ghanī R: maḥmūd shāh bin muḥammad shah al-Bahmanī
BH 133	Mahmud Shah	O: al-mutawakkil alā’llāh al-qawī al-ghanī R: maḥmūd shāh bin muḥammad shah al-Bahmanī (same as above but different arrangement)

18 mashas 7 different legends

BH 073	Ahmad Shah I	O: al-mustawthiq billāh al-hannān al-mannān al-ghanī R: al-sulṭān aḥmad shāh bin aḥmad bin al-ḥasan al-bahmanī
BH 084	Ahmad Shah II	O: al-mu'taṣim bi-ḥail Allāh al-mannān sammī khalīl al-raḥmān abū'l-muzaffar R: 'alā' al-dunyā wa'l-dīn Aḥmad Shāh bin Aḥmad Shāh al-sulṭān
BH 097	Humayun Shah	O: al-mutawakkil alā'llāh al-qawī al-ghanī abū'l-mughāzi R: 'alā' al-dunyā wa'l-dīn humāyūn shāh bin aḥmad shāh bin aḥmad shāh al-walī al-bahmanī
BH 104	Ahmad Shah III	O: al-mustanṣir bi-naṣr Allāh al-qawī al-ghanī R: aḥmad shāh bin humāyū nshāh al-bahmanī
BH 113	Muhammad Shah III	O: al-mu 'taṣim billāh shams al-dunyā wa'l dīn R: muḥammad shāh bin humāyū nshāh al-sulṭān khallada mulkahu
BH 114	Muhammad Shah III	O: al-mu 'taṣim billāh shams al-dunyā wa'l dīn R: muḥammad shāh bin humāyū nshāh al-sulṭān
BH 123	Mahmud Shah	O: al-mutawakkil alā'llāh al-hannān al-mannān abū'l-mughāzī R: maḥmūd shāh bin muḥammad shah al-sulṭān

Note that in three cases, coins of two or more different denominations share identical legends:

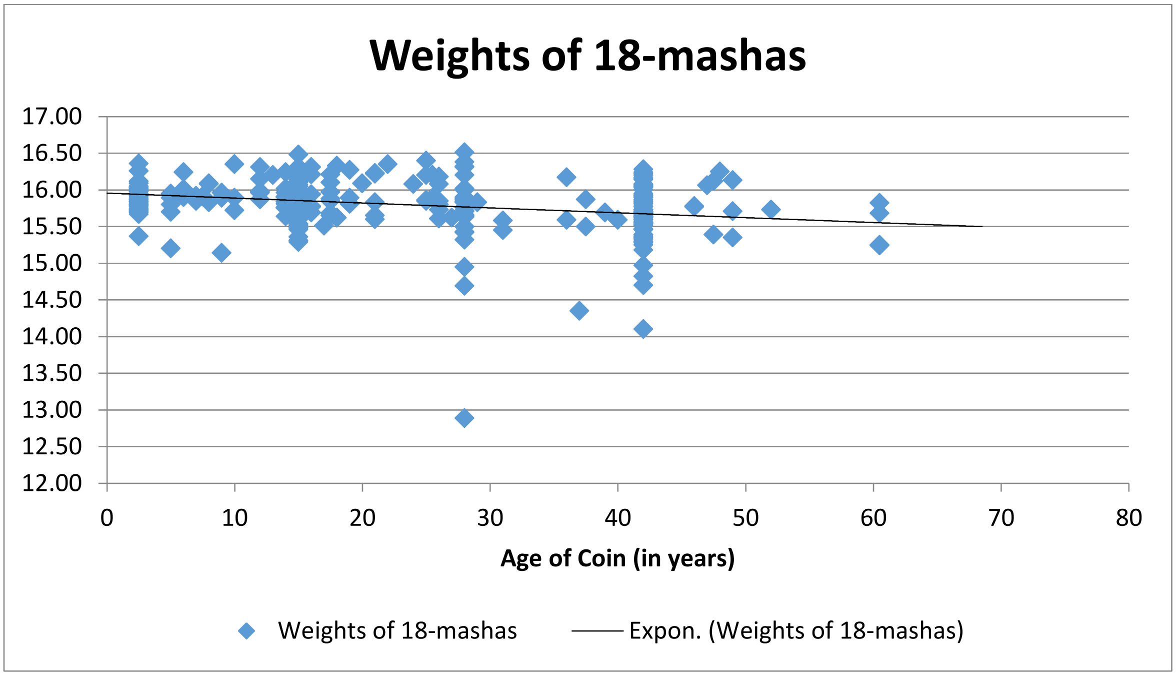
BH 97 (18-*māṣa*) and BH 98 (12-*māṣa*) (both issues of Humayun Shah)

BH 114 (18-*māṣa*), BH 115 (12-*māṣa*), BH 116 (9-*māṣa*), and BH 117 (6-*māṣa*) (all issues of Muhammad Shah III)

BH 123 (18-*māṣa*) and BH 128 (12-*māṣa*) (both issues of Mahmud Shah)

APPENDIX II
REGRESSION RESULTS

18-*māṣas*



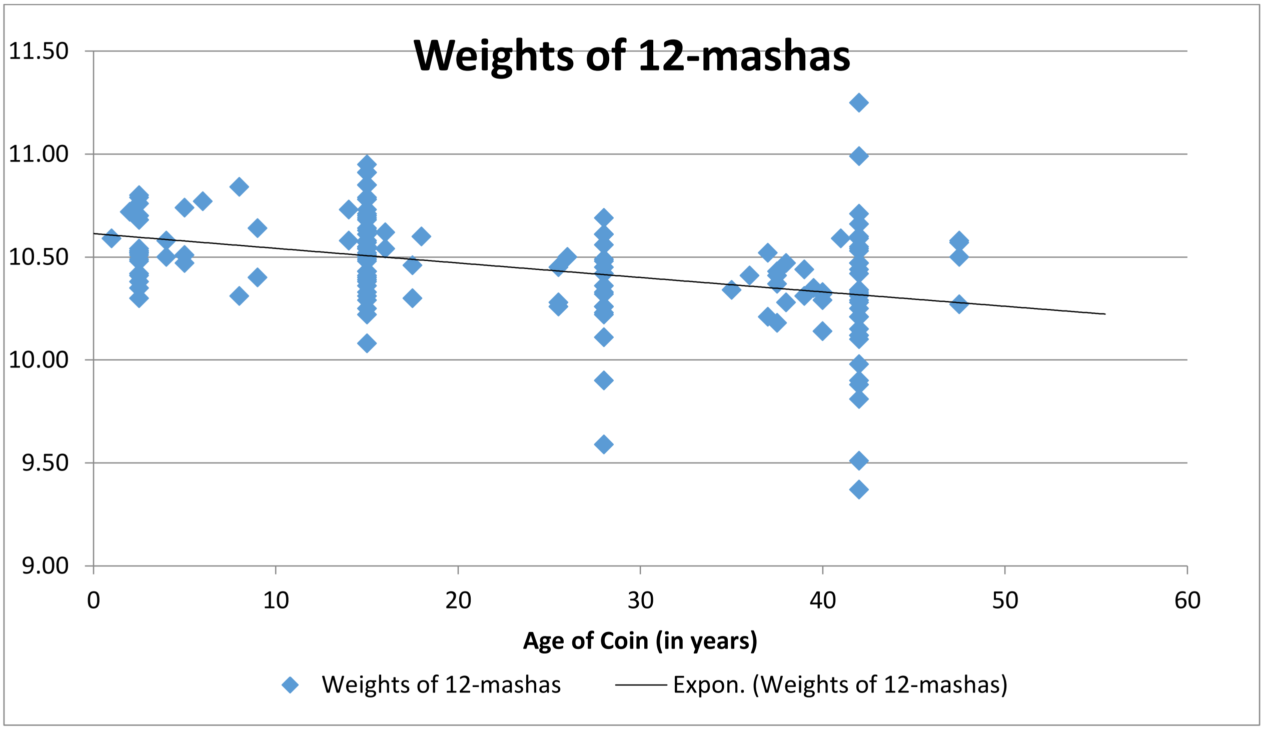
Regression Statistics	
Multiple R	0.2705
R Square	0.0732
Adjusted R Square	0.0705
Standard Error	0.0221
Observations	342

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	2.7698	0.0022	1233.2982	<0.0001
Slope	-0.0004	0.0001	-5.1812	<0.0001

Intercept	2.7698	Implied weight at time of minting[28]	15.96 gm
Slope	0.00042	Implied annual rate of weight loss	0.042%

[28] Since $e^{2.7698} = 15.96$.

12 *māṣas*

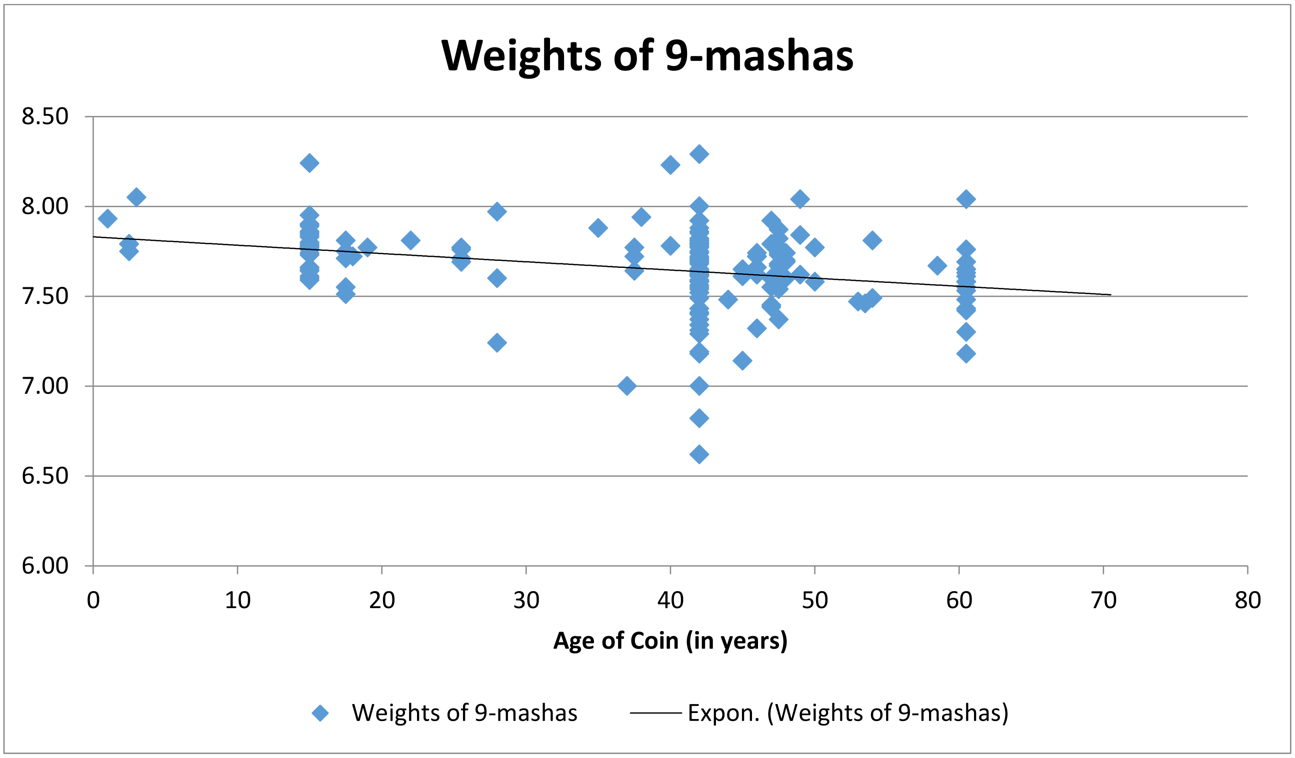


Regression Statistics	
Multiple R	0.3992
R Square	0.1594
Adjusted R Square	0.1541
Standard Error	0.0230
Observations	161

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	2.3622	0.0034	694.5855	<0.0001
Slope	-0.0007	0.0001	-5.4904	<0.0001

Intercept	2.3622	Implied weight at time of minting	10.61 gm
Slope	-0.00078	Implied annual rate of weight loss	0.068%

9 *māṣas*

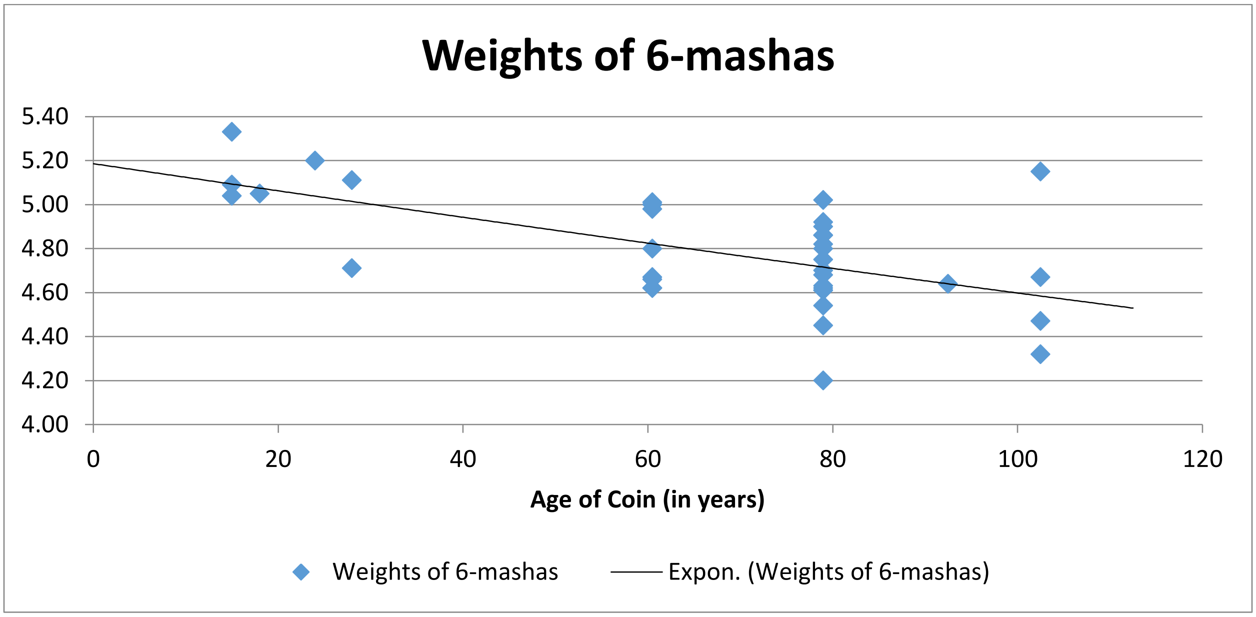


Regression Statistics	
Multiple R	0.2890
R Square	0.0835
Adjusted R Square	0.0781
Standard Error	0.0290
Observations	172

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	2.0580	0.0063	328.8815	<0.0001
Slope	-0.0006	0.0002	-3.9354	<0.0001

Intercept	2.0580	Implied weight at time of minting	7.83 gm
Slope	-0.0006	Implied annual rate of weight loss	0.060%

6 *māṣas*



Regression Statistics	
Multiple R	0.5854
R Square	0.3427
Adjusted R Square	0.3245
Standard Error	0.0430
Observations	38

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	1.6459	0.0198	83.1961	<0.0001
Slope	-0.0012	0.0003	-4.3327	<0.0001

Intercept	1.6459	Implied weight at time of minting	5.19 gm
Slope	-0.0012	Implied annual rate of weight loss	0.120%