METROLOGICAL NOTES.

III.—Had the People of Pre-historic Mycenae a Weight Standard?

In a former paper in this *Journal* (Vol. viii.) it was maintained that the Greeks had a weight standard long before the introduction of coined money from Asia, the unit of which was the same as the Attic-Euboic system (130–135 grains Troy) of historical times, and that in the Homeric poems the gold Talanton and cow represented the same value, the unit of metal being adjusted to the more primitive unit of barter. The evidence then adduced was of a purely literary nature, as it was not in my power to appeal to any actually existing weights. I have since obtained some data of a concrete kind which, I think, lends some support to my former contention.

Dr. Schliemann (*Mycenae and Tiryns*, p. 354) found (in the tomb south of the Agora at Mycenae) 'four spirals of thick quadrangular, and seven spirals of thick round gold wire, five plain gold rings, and a similar one of silver, of which a selection is represented under No. 529. 'I remind (adds Dr. Schliemann) the reader that similar spirals and rings of thick gold wire occur in the wall paintings of the Egyptian tombs. They are supposed to have served as presents, or perhaps as a medium of exchange.' These rings are now at Athens, and my friend Mr. E. A. Gardner of Gonville and Caius College, the Director of the British School at Athens, has kindly procured for me their weights.[1] Before going further I wish it to be clearly understood that I do not assume the rings to be what is called *ring-money*, but I think that I am justified in assuming that they are ornaments probably made on a given weight. It has been the custom in all countries for the person who desires to have an article of jewellery made to give to the goldsmith a certain weight of gold or silver, out of which the latter manufactures the desired ornament. Such is the practice at the present day in India; you give the goldsmith so many gold mohurs or sovereigns, or rupees, as the case may be, he squats down in your verandah, and with a few primitive tools quickly turns out the article you desire, which of course will weigh as many mohurs or sovereigns as you have given him (provided that you have stood by all the time, keeping a sharp look out to prevent his abstracting any of the metal). That in like fashion gold ornaments for ordinary wearing purposes were regularly of known weights in ancient times is shown clearly by the account of the

[1] I wish likewise to express my gratitude to M. Kumanudes for his kindness in giving Mr. Gardner every facility for weighing the rings.

presents given to Rebekah by Abraham's servant, 'a gold earring of half a shekel weight and two bracelets for her hands of ten shekels weight' (Genesis xxiv. 22). To take another example from a very different region, the golden ornaments of the ancient Irish (of which numerous specimens exist in the Museum of the Royal Irish Academy) were made according to specified weight. Thus queen Medbh is represented as saying: 'My spear-brooch of gold, which weighs thirty ungas, and thirty half ungas, and thirty crosachs and thirty quarter [crosachs].' O'Curry, *Manners and Customs of Ancient Irish*, iii. 112. But we need not go beyond Greek soil itself for such illustrations. The well-known story of Archimedes and the weight of the golden crown, which led to the discovery of specific gravity, is sufficient to show that the practice in Greece was such as I describe, and certainly no one will venture to maintain that the people of Mycenae were inferior in civilization to the ancient Irish. If the latter weighed the gold in their ornaments, surely the former, who so surpassed all that has been left by the ancient Irish in their pottery, sculpture and metal work, may well be assumed to have followed a similar practice.

I shall now proceed to tabulate the weights of the Mycenaean rings.

Metal.	Description.	Weight.	
		Grammes.	Grains Troy.
Silver	Plain ring	8·8	137
Gold	Spiral	8·5	132
,,	,,	9·9	153
,,	,,	10·8	167
,,	Plain ring	15·9	248
,,	,,	16·5	257
,,	,,	19·0	297
,,	,,	19·4	303
,,	Spiral	20 5	320
,,	,,	21·5	335
,,	Plain ring	22·0	340
,,	Spiral	29·3	452
,,	,,	39·0	612
,,	,,	39·5	617
,,	,,	41·5	643
,,	,,	42·2	654
,,	,,	42·3	655
,,	,,	42·8	662

Inspection of the table shows us a group of two rings weighing 132 and 137 grains respectively at the lowest, and a group of four weighing 643, 654,

655, and 662 grains respectively as the highest. It will at once be seen that the latter are the fivefold of the former. This is probably one of the most primitive of multiples, derived as it is from counting by the fingers, and we know that in Greek the word πεμπάζειν (lit. to count five, πέμπε Aeolic) was used as a general word for *counting*. The fivefold of 132 = 660, which is startlingly near 662. It is quite possible that the silver ring has gained rather than lost weight by oxydization. The third lowest group of two, 248 and 257, seem to be the double of the first group. From this it would seem as if 132—137 was the unit on which they are all scaled.

The two rings weighing 612 and 617 grains seem to group themselves along with the four heaviest, but the interval between 617 and 662 is considerable. Again the two rings weighing 153 and 167 ought to go with the lowest group, but the interval between 137 and 167 is considerable, and the same may be said of 297 and 303 in relation to 340. The ring weighing 452 grains occupies a distinct position approximating no other group. It seems to be $3\frac{1}{2}$ times the unit of 132—137.

It is perfectly possible that in those weights which are not more or less exact multiples of the unit we have to deal with halves and quarters of the unit, as I have already suggested in the case of the ring of of 452 grains. Thus 303 and 297 would represent very closely $2\frac{1}{4}$ times the unit 135 grains; and 617 and 612 = $4\frac{1}{2}$ times the unit; and 167 gives $1\frac{1}{4}$ times the unit. The unit 132—137 is of course identical with the light Babylonian shekel of 130 grains, and the *talent* of gold in Homer, which I have shown in a former number of this *Journal* to have been of like weight, and which was known as the Attic and Euboic standard in historical Greece. We need not be surprised to find $\frac{1}{2}$ and $\frac{1}{4}$ of this unit. In Homer (*Il.* xxiii. 751) we find a half-talent (ἡμιτάλαντον) of gold. Of course I do not pretend to say that I have absolutely proved the existence of a weight standard at Mycenae, for the data are too few to make a complete induction but I think that they are sufficient to make it very probable that such a standard did exist. Indeed on *a priori* grounds it is natural to expect it, for the existence of rings made on a given unit has been proved for Egypt and Syria. If my view should turn out to be correct, it puts beyond doubt the truth of my former proposition, that the Greeks employed a weight standard similar to the light Babylonian shekel and Euboic stater before they learned from the East the art of coining money.

IV.—How were the Primitive Weight Standards Fixed?

In previous articles I have shown that the oldest Greek unit of weight, the talent of gold in the Homeric Poems, was identical with the cow or value of a cow, that the same identity existed between the cow in Italy and the gold unit (itself the same as the Homeric Talanton) which lies at the base of the Roman system, and that the like relation existed between cow and gold unit in Sicily. I had further advanced the suggestion that we ought to seek

for the origin of the weight standard or standards from which probably all systems in the Old World, modern as well as ancient (save the modern French), have been derived, arguing that as the cow or ox was the most widely diffused common unit of barter, it was natural that when metals came into use as a medium of exchange, the metallic unit would naturally represent the value of the older unit of barter. Ordinary law of supply and demand would fix more or less accurately the amount of gold which one man would be willing to give, and another man be willing to accept for an ox. One point however I did not make clear, and that was how it came to pass that primitive men were able to fix with what practically was a high degree of accuracy the amount of gold which represented the value of an ox. It is, I think, this difficulty which is supposed to surround the process of fixing accurately the metallic unit thus derived which has induced metrologists to make up their minds that weight units could not have been arrived at empirically, and in consequence of this to seek their origin in the scientific astronomy of Babylonia.

We shall now endeavour to ascertain if the empirical method is so difficult, working on the only true scientific method in such inquiries, always back from the known to the unknown.

It is plain that if we could find a people who, whilst familiar with the use of gold, had as yet no system of weight, but had to resort to some other method for estimating the value of their wealth, we should thus get a clear idea of the conditions immediately preceding the invention of weights. From what I have said above, we cannot expect to find any such community in the Old World. The New World on the other hand supplies us with what we desire. When the Spaniards under Cortes conquered the Aztecs of Mexico, that people, although in a high state of civilization, had as yet no system of weights. In consequence of the want of weights the Spaniards experienced some difficulty in the division of the treasure, until they supplied the deficiency with weights and scales of their own manufacture. There was a vast treasure of gold, which metal, found on the surface or gleaned from the beds of rivers, was cast into bars, or in the shape of dust, made part of the regular tribute of the southern provinces of the empire. The traffic was carried on partly by barter, and partly by means of a regulated currency of different values. This consisted of transparent quills of gold dust, of bits of tin cut in the form of T, and of bags of cacao containing a specified number of grains (Prescott, *Conquest of Mexico*).

From this we get an insight into the first beginnings of weights. Some natural unit (and by natural I mean some product of nature of which all specimens are of uniform dimension) is taken, such as the quill used by the Aztecs. The average-sized quill of any particular kind of bird presents a natural receptacle of very uniform capacity. These quills of gold dust were estimated at so many bags containing a certain number of grains. The step is not a long one to the day when some one will balance in a simple fashion a quill of gold dust against seeds of cacao, and find how many seeds are equal in weight to the metal. Nature herself supplies in the seeds of plants

weight units of marvellous uniformity. If any one objects to my assumption that the Aztecs were on the very verge of the invention of a weight system, my answer is that another race of America, whose political existence ceased under the same cruel conditions as that of their Northern contemporaries, I mean the Incas of Peru, who were in a stage of civilization almost the same as that of the Aztecs, had already found out the art of weighing before the coming of the Spaniards, although they were inferior to the Mexicans in so far as they had not a well-defined system of hieroglyphic writing, nor of currency such as the latter possessed. Scales made of silver have been discovered in Inca graves. The metal of which they are made shows that they were only employed for weighing precious commodities of small bulk.

That my proposition that nature has supplied natural weight units in seeds is not a mere speculation of one defending a pet thesis I shall now proceed to demonstrate by unquestionable evidence.

Let us turn to the known, and by getting fresh touch with *fact* return again with new vigour to the more speculative parts of the subject. The very name *grain*, which we employ to express our lowest weight unit, would of itself suggest that originally some kind of grain was used in weighing, but as our *grain* is known as the *grain Troy*, and we do not as yet know its origin, it will not do to argue vaguely from etymology. But a little inquiry soon brings us to a time when the grain Troy did not as yet form the basis of English weight, and when a far simpler method of fixing the weight of the King's coinage was employed. It was ordained in 12 Henry VII. c. v. that the bushel is to contain eight gallons of wheat, and every gallon eight pounds of wheat, and every pound twelve ounces of Troy weight, and every ounce twenty sterlings, and every sterling to be of the weight of thirty-two grains of wheat that grew in the midst of the ear of wheat according to the old laws of this land (Ruding, II. 58).[1]

Going backwards we find by 8 Edward I. that the penny was to weigh 24 grains, which by weight then appointed were as much as the former 32 grains of wheat. By the *Statutum de Ponderibus* (of uncertain date, but placed by some in 1265) it was ordained that the penny sterling should weigh 32 grains of wheat, round and dry and taken from the midst of the ear (Ruding, I. 360.) Going back still a step further we find that by the laws of Ethelred every penny weighed 32 grains of wheat, and, as the penny of Alfred weighs 24 grains Troy, we need have no hesitation in assuming that it was likewise fixed on the same standard of 32 grains of wheat. Thus from Alfred (871—901) to Henry VII. (1485—1509) we find the penny fixed by this primitive method, and the actual weights of the time, as tested by the balance at the present day, afford proof positive of the practical accuracy of the method.

Now all the mediaeval standards were based upon the gold solidus of Con-

[1] I am indebted for all these facts relating to wheat grains in England to Mr. F. Seebohm, the author of the *English Village Community*.

stantine the Great (Marquardt, ii. 30) except that of Ireland, which seems to have been borrowed from Rome before the changes introduced by that monarch. The Irish system runs thus: the unga (*uncia*) is the highest unit and contains 24 *screapalls* (scrupuli), each *screapall* contains 3 *pinginns* (a name evidently borrowed from the Saxon invader), and each *pinginn* weighed 8 grains of wheat (ocht ngrainne cruithnechta comtrom na pinginne airgid, O'Donovan's Supplement, *s.v.* pinginn). Here as in England the grain of wheat is the basis of the system, whether introduced from Rome or (as I think more likely) already in use among the Kelts.

But the *solidus* of Constantine (of which 72 went to the Roman pound of gold) was divided into 24 *siliquae* or κεράτια (from whence comes *carat*). The *siliqua* or κεράτιον was the seed of the *carob* or *St. John's Bread* (ceratonia Siliqua L.). Thus the lowest unit in the Roman system, as usually given, is found to be a seed, and the same holds of the Greek system, for the drachm is given as containing 18 κέρατα or κεράτια (ἡ δὲ δραχμὴ κέρατα ιή. ἄλλοι δὲ λέγουσιν· ἔχει γραμμὰς τρεῖς· τὸ γράμμα ὀβολοὺς β'. ὁ δὲ ὀβολὸς κέρατα γ'. τὸ δὲ κεράτιον ἔχει σιτάρια δ'. Fragm. ap. Hultsch, *Metrol. Script.* 248). From this we see that the κεράτιον was further reduced to 4 σιτάρια, grains of wheat, and from another table of weights given by Hultsch, *Metrol. Script.* ii. 128, we learn that the *siliqua* equals 3 grains of barley (*siliqua grana ordei* iii.). Hence it appears that 3 grains of barley = 4 grains of wheat.[1] Thus both Greek and Roman systems finally rest upon grains of corn, as did the English and Irish.

Before passing on from the Greek and Roman systems, I may add that even higher denominations than the *siliqua* were expressed by seeds. The *lupinus*=2 *siliquae*, and its Greek representative the θερμός is given a like value (*Metrol. Script.* 81). In the *Carmen de Ponderibus*, ii. 16, *grana lentis* are made equal to 6 *siliquae*, and a like number of grains of spelt are given a similar value.

We shall next advance towards the East, and take up the Semitic systems. There can be little doubt (says Queipo, I. 360) that the Arab system of weight was based on the grain of wheat. The *habba* was their smallest unit. 4 *habbas* = 1 Karat, the latter of course represents the κεράτιον, and the former

[1] We saw above that 24 grains of Troy weight when introduced into England were equal to 32 grains of wheat, or in the proportion of 3 : 4. By the quotations given above we learn that the *siliqua* was equal to 3 grains of barley, and 4 grains of wheat; hence barley grains are to wheat as 3 : 4. From this it follows that the Troy grain is nothing more than the barleycorn, which had been used in preference to the grain of wheat in part of the Roman Empire. Furthermore this relation between barleycorns and wheat can be proved as an actual fact. In September 1887 I placed in a balance 32 grains of wheat, and 24 grains of barley, taken from ricks of corn grown on the same field, near Cambridge, and repeated the experiment thrice; each time they balanced so evenly that a half-grain weight turned the scale either way. Again it is easy to see that the same proportion exists between wheat grain and Troy grain. A grain of Scotch wheat = ·047 gramme, and the Troy grain = ·064 gramme. ·047 × 4 = ·188; ·064 × 3 = ·192. For all practical purposes therefore 4 wheat grains = 3 Troy grains with an error of .0024, less probably than the difference between individual grains.

the 4 *σιτάρια*, which are the equivalent of the *κεράτιον*. In the Hebrew system the *Gerah*, which also probably means a grain of some kind (weighing ·070 grammes), is the base.

Going farther Eastward we come to India, and there find a similar basis for the various systems in use among the Hindus. The *retti* (*Abrus precatorius*, Jequirity of pharmacists), the grain of gunja (= hemp, *cannabis*) or Karat, is the smallest unit in two systems, but in that used for weighing precious metals, corresponding to our Troy weight, there is a still smaller grain employed, called *yava*, which weighs ·014 grammes, and is one-tenth of the *retti*. Finally in the Chinese system a grain of millet of the panic kind forms the basis.[1]

We have now passed from the extreme west of Europe to the furthest east, and everywhere alike have we found the natural units afforded by various grains and seeds employed by various races as means of indicating weight. It is now easy to see that if once in the ordinary way of barter a certain portion of gold, arrived at by a crude process of guess-work probably at first, then possibly measured by some natural measure of capacity, such as the quill of the Aztec, or the egg-shell employed by the ancient Irish (somewhat analogous to the way in which rustics in the present day measure powder and shot by means of the bowl of a clay pipe), was regarded as the equivalent of an ox, or a slave, the next step, that is, to represent it by a certain number of grains of some kind of corn or plant in common use would easily follow. Seeds too were the primitive counters before the rise of arithmetic.[2]

If the objection is raised that all that I have said can be readily explained by supposing that, after all these various peoples became acquainted with the weight unit obtained scientifically by the Chaldaeans (by taking the weight in water of one-fifth of the cube of the Babylonian royal ell, which itself is supposed to be based upon astronomical observations), they adopted the method of preserving the standard accurately by comparing it with the weight of a certain number of seeds, my reply is that it is hardly likely that all those peoples should have uniformly remained unobservant of the natural means at their disposal till so late a period comparatively, especially when we recollect that those same natural objects are likewise universally employed as the smallest units of linear measure, as for instance our own barleycorn, and the kernels of grain with which the Chinese start their system; secondly that, according to most metrologists, the Chinese system of weights is independent of the Graeco-Asiatic, which prevailed everywhere else, and therefore the method of estimating weights by seeds has in this case certainly been employed before, annd independently of the Babylonian scientific system; and thirdly that beyond all doubt we found the Incas of Peru evolving a

[1] I owe this fact to the kindness of Sir Thomas Wade.

[2] My colleague, Professor Hartog, informs me that in Java, grain (padi or para) is not only unit of weight but also of numeration.

weight system for themselves in a region where there cannot be the slightest suspicion of Babylonian influence. If those Incas, who had not even developed a system of currency or a system of hieroglyphics, could devise a weight system, why should we deny to the Aryan and Semitic races the capacity to evolve such a system by some empirical process, analogous to that by which the Peruvians must have arrived at theirs?

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