Talmudic Metrology III

Units of Measure of Volume and Capacities

Abstract

In the absence of precise Talmudic traditions, the Rabbis have used natural units of measurement i.e. the volume of the average egg of a hen (beitsa) and the breadth of thumb (etsba). Indeed the Talmud expresses the reviit with respect to these natural sizes through the relationship 1 reviit = 10.8 e^3 = 1.5 eggs (B Pesahim 109a and Erubin 83a). Since the fourteenth century, the contradiction between these two methods of evaluation of the units of capacity has been evident. The capacities determined through the breadth of the thumb are twice those estimated through the use of the volume of eggs. A third method of evaluation, based on a passage in Y. Terumot X: 8, according which the weight of two zouz of forbidden fish represents 1/960 of the weight of a pickle of two seah, leads, according to the traditional commentators, to capacities three times greater. This third method has been however considered a marginal opinion which was not taken too seriously and which could be neglected. The method of evaluating the capacities through the use of the etsba, leading to larger units of capacity, has gained more and more importance while the older evaluations were founded on the principle of smaller units of capacity. Because of the link between the Talmudic units of capacity and the Roman units of capacity, (Mishna Kelim XVII: 11) the latter are thoroughly dealt with in this paper. Different Talmudic passages connected with the use of units of capacities and units of weight are thoroughly examined. We demonstrate that the third method of evaluation, correctly understood, is correct, and is in concordance with the big units of capacity found through the use of etsba. It allows for a definitive definition of the Talmudic units with respect to the Roman units of capacity. The use of a principle proposed in its time by Bornstein, which was neglected and not taken seriously, explains and reconciles the two first methods of evaluating the units of capacity, and allows for an understanding of the origin of the divergence between the two methods. It concerns the method of measuring a volume in eggs. Finally we examine the metrology of Maimonides and we raise a contradiction between his estimation of the weight of the Egyptian dirham in his commentary of the Mishna and his Hibbur.

Talmudic Metrology III [1]

Units of Measure of Volume and Capacities

1. Different Units of Volume in the Talmud and their Evolution over Time.

When we consider units of length, we observe great diversity among types of the same unit. We have a cubit of five tefah, a cubit of six tefah or 24 etsba (a rigorous cubit). In the entrance of the Temple Court, at the Gate of Sushan there was a cubit of 24.5 etsba and another of 25 etsba.[2] There was also a generous cubit (which could be one of the precedents). But apparently there were no geographical differences; all of Palestine used the same units of length. Furthermore, we do not hear about evolution over time of the length of these units.
In the case of the units of capacities, the situation seems completely different; there were different units of measurement in the main towns of Palestine. Furthermore, we learn from the Talmud, that there was also sometimes an evolution in these places over time.

1. Units of Moses (Midbarit), of Jerusalem and of Tsipori.

B. Erubin 93a writes:

תנו רבנן: סאה ירושלמית יתירה על מדברית שתות ושל ציפורית יתירה על ירושלמית שתות, נמצאת של ציפורית יתירה על מדברית שליש

The basic units of volume are called Midbarit, or units of Moses. In Jerusalem, the units of volume or capacity[3] were increased by 20 percent (the Talmud also says by 1/6 of the new values) and therefore the units of capacity of Jerusalem are 6/5 = 120 percent of the basic units of Moses.[4] The new units of Jerusalem were still increased by 20 percent in Tsipori (1/6 of the new values) and therefore the units of Tsipori were 6/5 = 120 percent of the units of Jerusalem.[5]
The units of Tsipori are then 36/25 = 144 percent of the units of Moses. They have been increased by 44 percent or by 44/144 = 0.306 of the new units. The Talmud simplifies and writes by 1/3 (of the new units).[6] These modifications must be very old, probably before, or at the latest at the very beginning of, the period of the Mishna.[7] Apparently the older units of capacity of Tsipori were equal to the new units of measure of Jerusalem; the new units were therefore 120 percent of the older ones. There was however a special situation in Tsipori regarding the measure of muries, i.e. brine or pickle containing fish-hash, for which they were still using an old unit equal to the log of the desert, the unit of

Moses. There is a mention of this unit in the following Talmudic passage: B. Pesahim 109a:

אמר רבי יצחק קסתא דמורייסא דהוות בציפורי היא הוות כמין לוגא דמקדשא

2. Units of volumes of Tiberias.

    1. The old units of Tiberias.

The old units of Tiberias were the units of Moses. Indeed, Y. Pesahim X: 1, Y. Shekalim III: 2 and Y. Sabbath VIII: 1 writes:

תני חצי שמינית טיבריינית הישנה, אמר רבי יוחנן, הדא דידן הוות ולמה לא אמר עתיקתא, בגין דהוות ביומוי.

The prescribed cup of wine of one reviit is 1/16 of the old measure[8] of Tiberias. Therefore, the ancient units of Tiberias were equal to the measures of Moses, and the basic unit of Tiberias was the kav.

    2. The modern units of volume of Tiberias.

The modern units of capacity were introduced in Tiberias in the second half of the third century during the lifetime of Rabbi Johanan.[9]
The units of measure of volume were diminished to 80 percent of the old value i.e. they were diminished by 20 percent (in the Talmud it says by 25 percent of the new value). This can be deduced by the following passage in B. Pesahim 109a

אמר רבי יוחנן תמניתא קדמיתא דהווה בטבריא הוות יתירא על דא ריבעה ובה משערין רביעית של פסח

Which must be understood as follows: the eighth part of the ancient kav of Tiberias, or the ancient eighth part of the kav of Tiberias, which is equal to ½ log or two reviit of Moses[10], has been diminished by 20 percent (25 percent of the new capacity). This allows us to determine the reviit of the Torah, being its half.
Now Rashi and Rashbam believe we get the reviit shel Torah by evaluating the difference between the old and the new measurements. Actually the difference between the old and the new measurements is equal to 2 reviit-1.6 reviit or 0.4 reviit. So 2.5 * the difference is equal to the reviit shel Torah. But Rashi and Rashbam probably understood that ריבעה, in the former passage, means the reviit and not a fourth.
This exegesis seems difficult to accept. Indeed, the old measure was two reviit, so the new measure must then be one reviit, if we want the difference to be one reviit. In this case, the diminution of the capacity would have been of 50 percent! And it would have been simpler to say that the new eighth of the kav of Tiberias is a reviit shel Torah. Now if the new measure was 80 percent of the ancient measure, 5/4 of the new measure would be equal to the ancient measure. Therefore, the following passage quoted in the three references in the Talmud of Jerusalem mentioned above:

כמה שעורן של כוסות, טיטרטון ורביע. is referring to the situation existing in Tiberias at the end of the life of Rabbi Johanan and later, when 5/4 of the new reviit (tetartron) was equal to the old reviit or reviit shel Torah.[11]

2. Relationship between the Talmudic Units of Capacity and the Roman Units of Capacity.

1. Introduction.

Mishna Kelim XVII: 11 writes:

ויש שאמרו במדה דקה , מדות הלח והיבש שעורן באיטלקי

It is accepted, on the basis of this Mishna that the Talmudic units of capacity, more precisely the units of capacity of Moses or of the desert (in opposition to the units of capacity of Jerusalem and those of Tsipori) were equal to the Roman units of capacity. We find a similar statement in Tossefta Ketubot V: 7

המשרה את אשתו על ידי שליש, לא יפחות לה מקביים חטין או מארבע קבין שעורים, וכולם במדה האיטלקי

This passage is parallel to Mishna Ketubot V: 8 and differs only by this additional remark that the units of capacity mentioned in the Mishna, which are understood as units of the desert, are equal to the Roman units of measurement.
Based on this principle, Zuckerman (1887) proposed identifying the log with the Greek xestes on the basis of the passage in B. Pesahim 109a, mentioned above:

אמר רבי יצחק קסתא דמורייסא דהוות בציפורי היא הוות כמין לוגא דמקדשא

But the objection is that it is uncertain whether this kesta [12] is a xestes. It could perhaps represent, as proposed by the Arukh, a certain receptacle, but it is not established that this receptacle had the capacity of a xestes.[13] More generally, modern authors like Benish and Weiss accept the principle of the correspondence of Talmudic units of capacities with Roman units of capacities, but Benish maintains that it is not possible to fix this correspondence; a doubt subsists and it is not possible to decide whether the log is equal to the Greek xestes (equal to the roman sextarius) or to the Greek kotyle (equal to the Roman hemina). On the contrary, Weiss adopts the smaller units of capacity.[14]

2. Extra Talmudic References about the Correspondence of the Jewish Units of Capacity with the Latin and Grecian Units of Capacity.

1. Septuagint.

In the translation of Parashat Metsora, the log is translated five times as kotyle (half of the kestes). However, II Chronicles IV: 5 translates בתים by metretes.

There is a variant reading[15] of Lev. XIV: 10 where the log is translated by xestes.[16] It seems that kotyle is clearly Septuagintal; xestes, in the variant reading, appears to stem from the Hexapla.[17]

2. Josephus.

In his Antiquities Book 8; II: 9 he translates בת by metretes.
In his Antiquities Book 3; VIII: 4 he translates הין by two chous.
In his Antiquities Book 9; IV:5, he writes that one seah is equal to 1.5 Italian modius.
However, in his Antiquities Book 3; VI: 6 he translates עישרון by seven kotyle, instead of seven xestes.

3. Vulgate.

In Metsora, the log is translated by sextarius.

4. Conclusion.

Even the Jewish books of the Septuagint and of Josephus reached modern hands through an unknown route and no confidence can be granted to the extant texts. Particularly because there are internal contradictions in each[18] of them, they cannot help us solve the problem.[19]

3. Other Evidence about the Correspondence of the Log and the Xestes or Sextarius.

Despite the former argument, there is evidence establishing a correspondence between the log and the xestes.
It is interesting to compare two passages: B: Taanit 30a,
כיצד ממעט, אם היה רגיל לאכול ליטרא בשר, יאכל חצי לטרא, היה רגיל לשתות לוג יין, ישתה חצי לוג
and the parallel passage in Y. Taanit IV: 6 (ed. Vilna).
Y. Taanit IV: 10 p. 69a (ed. Krotoshin).
מהו ישנה, יחלף: אין הוה יליף אכיל ליטרא דקופד ייכול פלגא, אין הוה יליף שתי קסט דחמר, ישתה פלגא
From the parallelism[20] between these two passages, it appears that log is translated by kestes in the Yerushalmi.
In B. Berahot 44b, Rashi explains קייסי as a measure containing a log.[21]

4. About the Reviit.

The reviit is the fourth part of the log; it plays a central role in the halakha and the Talmud. B. Nazir 38a writes א"ר אלעזר: עשר רביעיות הן and enumerates these different cases : 1: the reviit of wine for the nazir, 2: the reviit of concentrated wine for the four cups of Pessah, which after dilution has in each of the four cups a capacity of one reviit. 3: he who drinks a reviit is not proper to judge 4: he who drinks a reviit of wine and enters the temple is culpable for death 5: the reviit of blood from a death is impure 6: a reviit of oil is necessary for the confection of the hallot accompanying the korban Toda 7:

a reviit of oil for the confection of the hallot brought by the nazir at the end of his nazirate. 8: a reviit of water is necessary for the sacrifice of the metsora. 9: a reviit of impure water can make impure another liquid or a man. 10: a reviit is the quantity for which one is culpable on the Sabbath for bringing it from the public domain to the private domain or vice versa.
If we refer to the third case, the quantity of wine that makes someone improper to judge and to teach the law, we find in many instances[22] the same quantity expressed as רביעית באיטלקי "the fourth expressed in the Italian measure" and referring without a doubt to the quartarius, the corresponding Roman measure, which is the fourth part of the sextarius. If we refer to the second case, relative to the capacity of the cups of Pessah, which is one reviit, and the quantity of concentrated wine necessary for the four cups together, we find in many instances[23] this quantity of one reviit expressed as
רביעית יין באיטלקי "the fourth of the Italian measure," referring again to the quartarius or the fourth part of the sextarius.

5. Tetraton Ureviya טיטרטון ורביע

The Talmud of Jerusalem writes:

כמה שעורן של כוסות, טיטרטון ורביע.

In Y. Pesahim X: 1 the dictum is mentioned in the name of Rabbi Mana. In Y. Sabbath VIII: 1 and Y. Shekalim III: 2, it is mentioned in the name Rabbi Abin. This passage is referring to the situation existing in Tiberias at the end of the life of Rabbi Johanan and later, when 5/4 of the new reviit (tetraton) was equal to the old reviit or reviit shel Torah. This proves again that the reviit was once equal to the Roman quartarius.[24]

6. The quantity of two meals for an Eruv: Mishna Erubin VIII: 2.

When preparing an eruv, we must bring the necessary quantity of food for two meals for each participant. It is accepted that this quantity must be considered the minimum quantity required for a meal. According to Rabbi Johanan ben Beroka we need a bread of half a kav, of which the baker takes half to remunerate his work and the cost of his oven. Therefore, there remains a bread of 1/4 of a kav which suffices for two meals i.e. a bread of 1/8 kav per meal.[25] On the other hand, Rabbi Simeon says we need for the eruv 2/3 of a bread of 1/3 kav i.e. for each meal we need a bread of 1/9 kav. In the account of Rabbi Simeon, it deals with net quantities after remuneration of the baker. The difference between the two opinions is slight. The kav is a unit of capacity and the meaning of the kav in the estimation of the size of the bread is the volume of wheat used in its confection. According to the data given by Maimonides,[26] the density of whole wheat is about 0.78[27] and therefore if we consider a whole meal bread, a bread of 1/8 kav is made with 0.78 * 80 = 62.4 denarius whole meal or 212.78 gr. whole meal, and it weighs about 274 gr., because it can be assumed that 1gr. meal makes about 1.29 gr. bread.[28] This data was calculated on the basis of a kav equal to 4/6 congius. These results are likely; 274 gr. bread per meal seems a minimal quantity but a quantity of bread of 137 gr. per meal, which would correspond to the equalization of a log to a hemina would not be acceptable.[29] We have thus understood that a bread of 1/8 kav is a bread confectioned

with 1/8 kav whole wheat, the meal being measured by its volume. Another explanation, although farfetched, would involve bread which weighs 1/8 kav of water or 80 denarius i.e. 272.8gr. According to this second explanation, the unit of capacity is used as a unit of weight, representing the weight of the water restrained in this capacity. It appears that both explanations give, in this particular case, equivalent results, and it is difficult to decide which of them is correct.

7. Two Meals of the Poor who Travels from Place to Place.

In Mishna Peah VIII: 7 it writes about the poor who travel from place to place and to whom one must give the amount of food necessary for two meals, that he receives bread made with half a kav of whole wheat, which allows him to eat two meals of bread made with 1/8 kav of whole wheat, taking into account that half of the bread has to be given to the baker. This is again in accordance with the opinion of Rabbi Johanan ben Beroka. The quantity to give to the poor is then the same as the quantity necessary for the eruv and represents 274 gr. of bread per meal. This is the minimum quantity needed to satisfy the poor person's hunger.

8. Two Meals of the Poor on the treshing floor.

Mishna Peah VIII: 5 writes about the poor person who passes on the treshing floor, to whom one must give half a kav of wheat.[30] This allows him to eat two meals of bread made with 1/8 kav of whole wheat per meal, taking into account that half of the bread has to be given to the baker. This conclusion is again in accordance with the opinion of Rabbi Johanan ben Beroka and grants him 274 gr. of bread per meal. A quantity of 137 gr. of bread would be insufficient.

9. The Meals of the Wife of the Poor who is Away During the Week, Mishna Ketubot V: 8.

We will now deal with the same Mishna which we already considered above.
The wife receives, each week, two kav of wheat with which to make bread. This quantity must suffice for 16 meals: 14 meals for herself and two additional meals for her husband on Sabbath or, according to others, for the poor or for guests. Therefore, she has 1/8 kav of whole wheat per meal. We know that one kav of water weighs 640 denarius. Therefore, two kav of wheat of a density equal to 0.78, will weigh 0.78 * 2 * 640 = 998.4 denarius or 3405.54 gr.
For each meal, she has 212.78 gr. of whole wheat, which allows her to bake 1.29 * 212.78 = 274 gr. of bread.[31] This result is in full accordance with the conclusion of the former paragraph, following Rabbi Johanan ben Beroka, on condition that the husband provides his wife with the wood or coal necessary for baking the bread. So the baking of the bread is her responsibility, while the poor person is not able to or in a state to bake his

own bread.[32] This quantity of 274 gr. per meal, twice a day, without fish or meat, and completed by a very limited quantity of vegetables and fruits, represents indeed a minimal livelihood. A quantity of 137 gr. per meal, twice a day, would be nearly a subsistence regime.

10. קב גרוגרות ומנה דבלה Mishna Ketubot V: 8 and Mishna Peah VIII: 5.[33]

In Mishna Ketubot V: 8, we are dealing with a poor man working during the week far from his home, who entrusts someone with the responsibility of providing a living for his wife. The Mishna enumerates the quantity of different foods that this man must provide to his wife. Among them are figs, dried figs, which are like the other elements measured by their volume, and a bread of figs, which must be measured by its weight.[34]
In Mishna Peah VIII: 5 we are dealing with the quantity of food that one must give to the poor in the barn when one distributes מעשר שני. From this enumeration it appears that both quantities should be equivalent. We know that according to the Sillian Plebiscitum, the weight of the water contained in one congius is 10 libra or 960 denarius and the weight of one sextarius is 10/6 libra or 160 denarius. If, as already seen above, one log is equal to one sextarius, then 1 log water = 160 denarius and a kav water = 4*160 = 640 denarius. If we assume that the density of dried figs is about 1.2 then the weight of one kav of dried figs is 768 denarius or about 2,619 gr. These figures should be divided by about 1.5 in order to take into account the empty space between the dried figs, i.e. 512 denarius or 1,746 gr. Now one mana is equal to 100 denarius and weighs 341 gr. The only way to solve this discrepancy is to consider that the capacity of one kav, mentioned in this passage, relates to the original fresh figs, which become, after drying, the considered groguerot.[35]

11. The Litra, a Unit of Weight used as a Unit of Capacity.

The litra is a unit of weight used in the Talmud. It is equal to 96 denarius and is thus very similar to the mana which is worth 100 denarius. In the Talmud both units are often confused.[36]
The Mishna Terumot X: 8 writes about the quantity of unclean fish which forbids a pickle of fish

דג טמא שכבשו עם דג טהור כל גרב שהוא מחזיק סאתים, אם יש בו משקל עשרה זוז ביהודה שהן חמש סלעים בגליל דג טמא, צירו אסור

Y. Terumot X: 8[37] writes

כמה סאתא עבדא, עשרין וארבע לוגין, וכמה לוגא עביד תרתין ליטרין, וכמה ליטרא עבדא מאה זינין, נמצא כל זין וזין אחת מתשע מאות ושש

These passages have not been understood correctly.[38] We will show that the units of capacity quoted in this passage, seah and log, are Jerusalem units of capacity.[39] Indeed,

we know that a log of water weights 160 denarius i.e. 160 zouz, not 200 zouz, but the Jerusalem log of water is 20 percent greater and weighs 192 denarius i.e. two libra (the Talmudic litra). The statement of the Talmud of Jerusalem that a log is two litra is thus rigorously correct if we consider a Jerusalem log. Now the statement of the Talmud of Jerusalem that the litra is 100 zouz is only approximate. Although the litra is often confused with the mana, here the litra is rigorously 96 zouz and therefore the two Jerusalem seah (of water) weigh exactly 9,216 zouz and the proportion leading to forbid the pickle of fish is actually 1/921.6 in weight as long as the density of the mixture is one. Now if the density of the mixture is 1.04, then the weight of the Jerusalem log of pickle is actually 200 denarius i.e. two mana, and the two Jerusalem seah of pickle indeed weigh 9,600 denarius. The proportion is then 1/960.

In conclusion, the litra is equivalent to the Roman libra, weighs 96 denarius, and represents the weight of half a Jerusalem log. The units of capacity mentioned in this Mishna are Jerusalem units of capacity. The litra, which is generally[40] used as a unit of weight, can also be used as a unit of capacity;[41] it represents the capacity of water weighing a libra or pondo. It is equal to half a Jerusalem log. We have already observed that in Roman metrology, there is a relationship between the units of capacity and the units of weight, that a congius of water weights one pondo. Therefore it makes sense that in the Talmudic metrology, the units of capacity are also used as units of weight representing the weight of the water restrained in this capacity. But this is contrary to the accepted notion the litra is equal to ½ log[42] of Jerusalem or to 2.4 reviit of Moses, and not to ½ log of the desert or two reviit of Moses, as is generally accepted. Furthermore, this passage of Y. Terumot proves that the units of capacity are the big units and not the little units, the log being equal to the sextarius.

The exegesis of this Mishna raises the problem of the correct interpretation of the type of unit of capacity mentioned in each Mishna. In our Mishna, according to the interpretation of the Talmud of Jerusalem, we are dealing with the units of capacity of Jerusalem. It is often difficult to decide whether we are dealing with units of Moses or with others; it even happens that in one Mishna two different types of units of capacity appear.[43]

12. About the Modius.

The modius is a Roman measurement of the capacity of dry contents; it is cited a few times in the Talmud. B. Erubin 83a writes that Bonios sent Rabbi a modius of artichokes that came from Nausa.[44] Rashi and R' Hananel explain that the modius is a seah. The modius is actually equal to 16 sextarius while the seah is equal to 24 log, or now that we have demonstrated that the log is equal to the sextarius, to 24 sextarius. It is then, at first glance, strange to find the equating of the modius and the seah.[45] There is a principle in the Talmud that in dry capacities, the matter heaped up above the utensil used to measure capacity, גודש, represents half of the capacity of the utensil, i.e. a third of the total capacity.[46] If we apply this principle to the modius we see that the utensil itself has a capacity of 16 sextarius, but the heap above the utensil is eight sextarius and the total is then 24 sextarius.[47] This gives us an acceptable justification of the use in the Talmud of the Roman modius for the seah [48] and confirms our equating of the log with the sextarius.

13. The Load of 30 Log Oil lifted up on a Ladder of Fifty Cubits by Young Priests.

Mishna Sukkot V: 2 tells about the festivities on the evening following the first day of Sukkot. Four branched candlesticks were erected in the courtyard of the temple, with a vessel at their top, at a height of 50 cubits.[49] Four ladders were placed in front of the candelabra and four young priests each lifted a utensil of 30 log of oil onto the ladder and poured the oil into the vessel on top of the candlestick. The Talmud[50] says that these young men were more praised than the son of Martha, the daughter of Boethos, who was able to raise the two flanks of an ox and bring them on the altar. It was then considered a true achievement. Therefore it seems that a log of 0.545 l is more likely than a log of 0.272 l because the lifting of a load of about eight kg does not seem to be an exceptional achievement. On the contrary, lifting a load of 16 kg on a ladder at a height of about 26 m is more impressive.

14. The Washing and Purification of the Hands with a Reviit of Water.

The beginning of the first Mishna in Yadayim writes:מי רביעית נותנין לידים לאחד, אף לשנים
Two men can purify their hands, one after the other, with one reviit of water. According to the plain explanation of the Mishna, each of them must wash his hands a first time (מים ראשונים) and then a second time (מים שניים). In other words, two hands must be wetted twice on both sides, on all their superficies, included the area between the fingers. This seems again to militate in favor of the bigger measure of one reviit equal to about 139 cm^3. This is all the more true because the Mishna describes the washing of people's hands by servants[51] and because of the ruling that if it appears that the first washing is incomplete,[52] the entire washing cannot be completed.[53]

15. Conclusion.

One of the big challenges raised by Talmudic metrology is the determination of the Talmudic units of capacity. We have succeeded to fix definitively the Talmudic units of capacity with regard to the Roman units of capacity.

1 eifah = 1 bat = 3 seah = 6 hin = 18 kav = 72 log = 144 touman = 288 reviit.

1 metretes = 3 urna = 4.5 modius = 9 semimodius = 12 congius = 72 sextarius = 144 hemina = 288 quartarius.

eifah = metretes
seah =urna
hin = 2 congius
1.5 kav = 1 congius
log = sextarius
touman = hemina
reviit = quartarius

3. Fundamental Relations of the Talmudic System of Units.

1. Relation between the Talmudic Units of Capacity and of Weight.

We have seen that the Talmudic units of capacity are equal to the Roman units of capacity; similarly the Talmudic units of weight are equal to and have the same name as the Roman units of weight. We can depart from the fundamental relationships of the Roman System:
1 congius = 10 pondo; 1 sextarius = 10/6 pondo = 160 denarii.
We can then write: 1 sextarius = 160 denarii.
1 miqveh = 960 sextarius = 153600 denarii = 1600 pondo = 523,920 cm^3.

2. Relationship between the Talmudic Units of Capacity and the Talmudic Units of length.

The Talmudic units of capacity are equal to the Roman units of capacity, and the Talmudic units of length are directly deduced from the Roman mile. We can depart from the fundamental relationship of the Roman system
(1 Roman foot)^3 = 1 amphora.
(f)^3 = 1 amphora = 48 sextarius.
Now 1 Roman mile = 5000 f = 2000√2 c. f = Roman foot; c = Talmudic cubit
Thus f = 0.4 c √2 and therefore we get the relationship: (0.4c√2) ^3 = 48 sextarius
Or: 3.62 c^3 = 960 sextarius = 1 miqveh.
Conclusion: we can deduce the fundamental relationship of the Talmudic system from the fundamental relationship of the Roman system of measurement.
1 miqveh = 960 Log = 3.62 c^3
This relationship has been established under the assumption that the quadrantal relationship is rigorously exact. If we consider that the cubit c is equal to 52.38 cm. and the log is equal to the sextarius, which is equal to (327.45 * 10)/6 = 545.75 cm^3, then the relationship becomes
1 miqveh = 960 Log = 3.6456 c^3
We can compare this relationship to that given in the Babylonian Talmud
1 miqveh = 960 Log = 3 c^3
We must then consider several possibilities:

1. The relationship given in the Talmud that the dimension of the Miqveh is three cubic cubits, which the Sages estimated to be forty seah, is a very rough estimation. Nevertheless, the Rabbis throughout history have considered this relationship to be precise. Therefore we will rule out this possibility.
2. The estimation that the Miqveh is three cubic cubits is ancient, but it was maintained, and it remained valid after the alignment of the Talmudic system of units with the Roman system of units, because the units of Moses were very near to the Roman units. This alignment happened

without notable change. Then in order to reconcile the two contradictory formulas, we must assume that the relationship between the seah and the cubit is expressed in generous cubits. The relationship given by the Talmud was probably at its origin an exact relationship; it was preserved after the alignment with the Roman units, on condition that it would now be expressed in generous cubits.

3. The estimation that the Miqveh is three cubic cubits is recent; it was made during the Talmudic period, after the alignment of the Talmudic system of measurement with the Roman system. We must also admit in this case that the relationship between the seah and the cubit is expressed in generous cubits.
   The ratio between generous and strict cubits will be the cubic root of (3.6456/3) = 1.067
   This ratio is close to the ratio of 1.05 proposed by R' Jacob Emden.[54]
4. The estimation that the Miqveh is three cubic cubits is ancient and is certainly anterior to the alignment of the Talmudic system of units with the Roman system of units. The difference between the coefficient 3 of the original situation and the coefficient 3.6456 of the new situation accounts for this evolution: the cubit diminished slightly and the units of capacity increased slightly. For example, the cubit diminished by about 5 percent and passed from an original value of 0.55 m to the new value of 0.5238 m, whereas the units of volume increased by about 5 percent and the log passed from 519.92 cm^3 to 545.75 cm^3. The volume of the Miqveh equal to 960 log passed from 499,123.2 cm^3 to 523,920 cm^3 and the ratio Miqveh/cubic cubit passed from 3 to 3.6456.
   According to this assumption, the original cubit was about 55 cm; it was multiplied by 0.95 and reduced to 52.38 during the alignment with the Roman system of units. This reduction is at the security side for the limit of Sabbath (because the thum Sabbath will be undervalued). But in other cases, such as Sukkah or Kilaim, this is not the case, and therefore we must use in these cases a generous cubit of 1.05 cubits in order to find the lengths prescribed by the Torah.
   The original log was about 519.92 cm^3, and it was multiplied by about 1.05 and fixed at 545.75 cm^3. This is generally at the security side especially for the obligation of Miqveh (because the practical Miqveh will then be greater than the minimum theoretical dimension).Nevertheless, in the case of the estimation of the reviit to determine the quantity of wine that may be drunk by the Rabbi who learns or judges, we are not at the security side and it is likely that in this case the difference was neglected. This seems to also be the case for the determination of the volume of the pastry from which hallah must be taken. In this particular case, it is possible that Rabbi Yanai lowered the minimum capacity of the pastry submitted to hallah in order to ensure that no submitted pastry could escape its obligation. See infra.[55]

5. Conclusion.

The different solutions described above rest on two divergent assumptions. The first assumption is that the units of capacity of Moses, or more precisely most of the units of capacity of Moses, were equal to the corresponding Roman units of capacity. This is indeed the position of Rabbi Samson ben Abraham of Sens in his commentary on Mishna Kelim XVII: 11. The relation 1 miqveh = 960 log = 3 cubic cubits must then be understood with generous cubits of about 1.06 strict cubits. It would nevertheless be strange to have such a coincidence not only for the system of units of capacity but also for the units of length (the same mile) and for the units of weight. In this last case, we are nevertheless speaking, according to the Gaonim and R' Samson of Sens,[56] about the weights of Moses, which are equal to the Roman weights of the first century, while the units of capacity and length were more stable and not subject to modifications because of the interest of the Prince. I therefore believe that the second assumption is more likely: the units of Moses and of Rome were completely independent from one another, but were actually only slightly different. It is the Sages around the time of the beginning of the Common Era, at the end of the second temple, who decided, volens or nolens (whether on their own initiative or despite their objections), to attach the Talmudic units of measurement to the Roman system of measurement, and to adapt the former units by a few percent. It is certain that by the time of Rabban Gamliel of Yabneh the equality between the Talmudic and the Roman units of measurement was an accepted fact.[57] The relationship of 40 seah = 3 cubic cubits was at the origin of a rigorous formula understood with strict cubits. After the adaptation it must be understood with generous cubits of about 1.05 strict cubits.

3. Back to the Units of Tsipori.

Now that we have demonstrated that the log is equal to the Roman sextarius and to the Greek xestes, let us come back to the following passage in B. Pesahim 109a:

אמר רבי יצחק קסתא דמורייסא דהוות בציפורי היא הוות כמין לוגא דמקדשא

The log is actually equal to a sextarius or to a Greek xestes, and therefore the kesta used for measuring the muries in Tsipori in former times was indeed a xestes. Let us now consider the following passage in Y. Pesahim X: 1:

לוגא דאורייתא תומניתא עתיקתא דמורייסא דציפורין

It must be corrected: indeed we now know that the old measures of muries of Tsipori were aligned with the units of capacity of Moses, its xestes being equal to a log, and the

eighth part of the kav used for the muries in Tsipori was necessarily equal to half a log. Therefore the text should be corrected[58] to

פלגא לוגא דאורייתא תומניתא עתיקתא דמורייסא דציפורין

or to לוגא דאורייתא קסתא עתיקתא דמורייסא דציפורין

which is parallel to the passage in B. Pesahim 109a, mentioned above.

4. Back to the Units of Tiberias.

We have seen that the units of Tiberias where equal to the units of Moses until the third century, during the life of Rabbi Johanan, when they were devaluated by 20 percent, so that the reviit shel Tora was now 5/4 of the new quartarius. Y. Hallah II: 6[59] writes:

ר' אמי בשם ר' ינאי: קב טבריני חייבת בחלה, חד חליטר שאל לרבי יוחנן אמר איזיל עבד ארבע ופליג, ויאמר ליה תלתא ופליג, אמר ר' זעירי קבייא באתריהון ריבעא אזדרון, ויאמר ליה חמישה פרא ציבחר, שלא יבוא לידי ספק חיוב חלה.

Rabbi Ami said in the name of Rabbi Yanai: a pastry of a kav of Tiberias is liable to Hallah. A certain Halitar asked Rabbi Johanan which pastry he could prepare without it being submitted to Hallah. He answered him 4.5 log. But he should have answered 3.5 log (in order to remain under a kav). R' Zeiri said, in their place (in Tiberias) the kav was devaluated by 20 percent (25 percent of the new value) and therefore the kav which is submitted to Hallah is actually five new log. He should then have advised him to prepare a pastry of a little less than five new log! He wanted to give him security in order not to transgress the obligation of Hallah.[60]

We are thus still dealing with the consequences of the devaluation of the units of capacity of Tiberias during the third century. Now the problem is why did Rabbi Yanai and his pupil Rabbi Johanan decide that a pastry of one kav is liable for Hallah according to Shamai, and not two kav according to Hillel or 1.8 kav according to the Sages (and the Halakha)?[61]

I propose the following answer. According to our former assumption, when the Sages decided to attach the Talmudic units of measurement to the Roman units of measurement by a slight adaptation of a few percent (the diminution of the units of length and the increase of the units of capacity by about 5 percent), some pastries that were between 1.7 and 1.8 modern kav[62] could escape the obligation of Hallah. Instead of creating a new limit of 1.7 kav, which has no basis in the Mishna, they probably decided to adopt the limit of one kav, as taught by Shamai, in order to make sure that no submitted pastry could escape its obligation.[63] The reason behind this ruling was later forgotten and neglected. If our assumption is exact, we can pinpoint the epoch of the adaptation of the Talmudic units of measurement to the Roman units of measurement. This epoch seems to be posterior to Hillel and Shamai. On the other hand, we already mentioned that by the time of Rabban Gamliel of Yabneh, the grandson of the grandson of Hillel, the equivalence between the Talmudic units and the Roman units was an accepted fact. Apparently scholars like Rabbi Yanai were still aware of the original slight difference, and therefore Rabbi Yanai ruled according to the opinion of Shamai.

5. The Relationship between the Etsba and the Reviit.

If we consider the relationship of 1 miqveh = 40 seah = 3 cubic cubits,[64] we can write:
1 miqveh = 960 log = 3840 reviit = 3 (24e) ^3 = 41,472 e^3 e = etsba
or 1 reviit = 10.8 e^3
We find also in the Talmud a similar relationship[65]: the reviit is 2e * 2e * 2.7e = 10.8 e^3.
The Talmud of Jerusalem mentions in many instances[66] a different relationship:[67]
1 reviit = 2e * 2e * 1.833e = 7.333 e^3
Tossafot[68] suggest that the relationship of the Talmud of Jerusalem refers to the units of capacity of Tsipori. We know indeed that the units of capacity of Tsipori are 1.44 times the corresponding units of Moses. Therefore 10.8 e_m^3 = 10.8/1.44 e_t^3 = 7.5 e_t^3
7.333 is thus an approached value of 7.5 which would have been the correct coefficient.
In other words, the expression in units of Tsipori of the reviit, corresponding to the definition of the Babylonian Talmud should be 1 reviit = $2e_t$ * $2e_t$ * $1.875e_t$ which corresponds to $7.5e_t$^3. On the other hand, the relationship of the Jerusalem Talmud is equivalent to 1 miqveh = 3840 reviit = 2.933 cubic cubits. As we know that the exact relationship is 1 miqveh = 3.6456 cubic cubits, we can conclude that the relationship of the Jerusalem Talmud is less accurate than the relationship given in the Babylonian Talmud.

6. Units of Capacities used as Units of Weight.

We have already seen in connection with the littra that the Talmud used the littra, a unit of weight, also as a unit of capacity i.e. the volume of water weighing a littra.[69] Similarly we find cases where units of capacity are used as units of weight i.e. the weight of the water restrained in this capacity.

1. The Load that the People of the Generation of the Exodus Could Carry.

We are actually dealing with the generation following the generation of the exodus, the generation entering the holy land.
According to B. Sota 24b, they were able to raise stones weighing 40 seah. This represents a weight of about 960 * 0.546 = 524 kg.

2. The Load that an Average Man Can Carry.

In B. Baba Metsia 80b, Rashi writes that a man can carry, when he has been loaded, a weight of 30 kav. This is based on the following reasoning: a donkey can carry 15 seah and one is responsible in case of an injury caused by an overloading of 3 kav or 1/30 of the load it may carry. According to a Braita,[70] in the case of a man, one is responsible as soon as the overloading is one kav, therefore we may assume that a man can carry 30 times more or 30 kav = 5 seah. This load represents 5 * 24 * 0.546 = 65.52 kg.

3. The Load that an Average Man Can Raise.

The load that a man can raise by himself from the ground is much less than the load he can carry when he is loaded.[71]
From B. Sota 24a, it seems that a man can carry three times the load that he can raise. On the other hand, it appears from Leviticus Rabbah XVI: 14 that it is only two times as much. This load would then be between 21.84 kg and 32.76 kg.

4. The Load that one is not Allowed Carry when Praying.

In B. Baba Metsia 80b, it writes that when a man carries on his shoulders a load of less than four kav, he may pray carrying the load. But if it reaches four kav, he must unload it and lay it down on the ground because it is assumed he will be unable to concentrate on prayer. The load of four kav of Moses is 4 * 4 * 0.546 = 8.73 kg.

5. The Sheaf of Corn in which there is Two Seah.

Mishna Peah writes that a sheaf in which there is two seah is too important to be considered as a forgotten sheaf; it sill belongs to the owner and not to the poor.
In their commentary, R' Isaac ben Malkitsedek[72] and R' Samson ben Abraham of Sens, explain that such a sheaf is too heavy to be raised at once. Both quote the Sifrei § 149 on Deuteronomy XXIV: 19,
לא תשוב לקחתו: כולו כאחד וכמה יהיה בו? שערו חכמים בעושה פחות מסאתיים. מכאן אמרו העומר שיש בו סאתיים ושכחו, אין שכחה.
According to this Sifrei, the expression שיש בו סאתיים must be understood as עושה סאתיים, which means a sheaf that weighs two seah, because it represents the weight that a man can raise at once.[73] This can actually be indirectly deduced from Mishna Peah VI: 7.
Two seah are 48 log and represent a weight of 48 * 0.546 = 26.20 kg.
This is also the explanation given by R' Sirilio[74] as mentioned in his commentary on the Mishna Melekhet Shelomo. But he identifies these two seah with the two seah considered in Mishna Terumot X: 8. According to this understanding, we are then dealing with two seah of Jerusalem weighing 1.2 * 26.20 = 31.44 kg.[75]
This seems to be the correct interpretation[76] of this Mishna and the figures are perfectly likely. This would not be the case if we considered the little units of capacity, equating the log with the Roman hemina. A weight of 13.10 or 15.72 kg can surely not be considered the maximum weight that a man can raise.[77]

7. The Mouthful and the Reviit.

B. Yoma 80a writes about the Mishna Yoma VIII: 1 "or if he drank a mouthful, he is culpable (of karet)." Rav Judah[78] said in the name of Samuel: not really a mouthful; but so much that if he moves it to one side, it looks like a mouthful. But we learned "a mouthful," say as much as a mouthful. The Talmud objects then with a Braita that says: how much must one drink to become culpable? Beit Shammai says: one reviit, Beit Hillel says: one mouthful, Rabbi Judah in the name of Rabbi Eliezer says: as much as a mouthful, Rabbi Judah ben Bathyra says: as much as can be swallowed at a time. The Talmud pursues: is the quantity required by Beit Hillel (in the Braita) greater than the

quantity required by our Mishna (which we explained as meaning that it looks like a mouthful)? It answers: here also we can explain that it looks like a mouthful. But if so it is the same opinion as that of Rabbi Eliezer. There is actually a difference: for Beit Hillel it is enough if it is looks like a generous mouthful, but Rabbi Eliezer requires (and is therefore more lenient) that we have the appearance of an exact mouthful. Rav Hoshayah[79] objected to this: if so (that a mouthful means enough that if he moves it to one side it looks like a mouthful) then there would be another case in which Beit Shammai takes the more lenient view and Beit Hillel the more severe one (see Mishna Edouyot IV). He[80] replied to him: When this came up for discussion, it came up in connection with Og, king of Bashan. (Therefore in the Braita that concluded this discussion, Beit Shammai takes the more severe view).
Maimonides writes that one is culpable if one drinks a mouthful, which is less than a reviit. It seems therefore that he accepts the point of view of Samuel, as he explained in Mishna Yoma VIII: 1 in his commentary. The Sefer ha Hinuch[81] writes that this quantity is the volume of an egg (about 50 cm^3). Rashi and Tossafot understand that the mouthful, in its strict meaning, is greater than a reviit. It is only because it was reduced according to the understanding of Samuel that Beit Shammai takes the more lenient view. Obviously, Rashi and R' Tam considered a little reviit[82] of about 75 cm^3 (actually the value of Maimonides). This paper demonstrates however that a reviit is at least about 136.44 cm^3.
Furthermore, we can estimate that the volume a man swallows at one time is about 40 cm^3. The volume corresponding to כמלא לוגמיו is about 50 cm^3. The maximum volume it is possible to store in the mouth is about 70-75 cm^3, but it is still possible to move it to one side. Therefore, מלא לוגמיו is either about 70-75 cm^3, the volume which can be practically stored in the mouth, which is about 105-115 cm^3,[83] or the theoretical volume of the mouth, both cheeks being extended to the maximum.

Therefore it seems likely that מלא לוגמיו, a mouthful, is less than a reviit, but this inequality is less evident than for כמלא לוגמיו. Therefore the objection of Rav Hoshayah should be understood in the following way. Now that you say a mouthful means like a mouthful, it is certain that this quantity is less than a reviit and therefore Beit Shammai takes the more lenient view. But in fact, although less evident,
מלא לוגמיו is also less than a reviit and therefore the objection of Rav Hoshaya can also be used against the contradictors of Samuel, who understand the Mishna and the Braita following their plain meaning.

Conclusion.

The formal deduction from the objection of Rav Hoshaya (see Rashi and Tossafot ad locum) is that a mouthful is more than a reviit. This is surely in agreement with the opinion of those who advocate for a little reviit. Nevertheless we have established that the Talmudic units of capacity correspond to the Roman units of capacity, the log corresponding to the sextarius and therefore, the reviit corresponds to the quartarius and is at least 136.44 cm^3. It is possible to understand the objection of Rabbi Hoshaya in a slightly different way so that the mouthful of average people is less than a reviit. This

exegesis is contrary to that of Rashi, R' Tam and probably Maimonides because they considered a little reviit of about 75 cm^3. Our exegesis is justified by the actual capacity of the reviit of 136.44 cm^3. Our exegesis is very similar to that of Tossafot Rid:

שם מתקיף לה רב הושעיא א"א הו"ל מקולי ב"ש ומחומרי ב"ה כו' פי' התינח אי אמרת דב"ה מלא לוגמיו דוקא קאמרי. יש לומר שמרכין ראשון על הכלי שלא יבלע וממלא לוגמיו ויכילו יותר מרביעית. אבל כדי שיסלקנו לעולם לא יתכן שיסלק רביעית לצד אחד וגם בשני לוגמו אם יתכן שיכילו יותר מרביעית דוקא שירכין ראשו ולא יבלע. אבל אם עומד ראשו זקוף אין אדם בעולם שיוכל לתפוש רביעית כמלא לוגמיו שלא ירדו המים בגרונו והדבר מנוסה ובדוק. והנכון בעיני דל"ג א"כ ועל הכל מקשה אפי' אם תאמר מלא לוגמיו דוקא אינו רביעית משקין. ואמרי' נמי המברך אם טעם מלא לוגמיו יצא ואם לאו לא יצא. וכל שיעור הנכנס היא רביעית א"כ מלא לוגמיו פחות הוא מרביעית:

Tossafot Rid believes that a mouthful is less than a reviit; he necessarily considered a big reviit. The origin of their different exegesis is probably caused by the different capacity of their reviit. Tossafot Rid proposes to suppress the words אם כן and he justifies that a mouthful is less than a reviit both by experience and also by the ruling of the Talmud that one must drink a mouthful of the cup of benediction which contains a reviit. Tossafot Rid understands and rules differently than R' Tam[84] and Tossafot Yeshanim[85] about the quantity of the cup of wine that one must drink on the Seder or after Kiddush. We can conclude that although the classical exegesis of this Talmudic passage seems to support the thesis of the little reviit, it can be perfectly understood following the conclusions of this paper which advocate the theory of the big reviit, the reviit being equal to the Roman quartarius. Furthermore, R' Isaiah ben Mali of Trani is probably the first Rishon[86] to advocate the theory of the big reviit.

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4. The Problem of Eggs in Talmudic Metrology.

In the Talmud, the egg plays an important role as a basic measurement of volume in different ritual laws, similar to the olive, fig and date. The way of determining its volume is described in Mishna Kelim, which explains that one determines the arithmetical mean between the volumes of a big and a little egg, determined by the volume of displaced water. Furthermore, the egg plays another fundamental role in the rabbinic metrology; it is the reference unit for all greater units because it is the only natural unit to which we can refer. Nevertheless, the use of the egg as a fundamental and practical unit for all the units of capacity does not seem usual in the Talmud. The relationship between the egg and the other units of capacity is known through one only reference[87] in B. Eruvin 83a where it writes that a seah corresponds to 144 eggs. This seems to be the only reference in the Talmud to the connection of the traditional units of capacity and the egg. This seems to be connected to the situation in the Talmudic time. The units of capacity were understood through the well-known Roman units of capacity; it was not necessary to use eggs to understand different units of capacity. During the period of the Gueonim, knowledge of the Roman units, particularly those of capacity, was forgotten. The Rabbis had no solution other than the use of the eggs, a natural unit, to master the Talmudic units of capacity. As the measure of volumes through the volume of eggs is not easy, the

Gueonim tried, in order to make things easier, to establish the weight of the water displaced by a mean egg in order to determine its volume and the volume of the other units of capacity. The tradition of the weighing of R' Hilai Gaon has been conserved and viewed as authoritative for many centuries.

It was only in the fourteenth[88] century that Rabbi Simeon ben Tsemah Duran noted for the first time that the Miqveh determined by the volume of three cubic cubits[89] leads to much bigger eggs than the normal mean eggs.[90] He supposed that eggs have different sizes in different areas. Nevertheless, we never see him disqualifying an existing miqveh.[91]

This contradiction was evident at different periods in different places.[92] The first to raise the problem in Europe,[93] among Ashkenazi Rabbis, was R' Ezekiel Landau from Prague.[94] He observed that the volume of pastry liable for hallah, determined by the volume of 43.2 eggs, is half of that volume if it is measured by 43.2 * 7.2 = 311.04 e^3. He concluded that either the breadth of men's thumbs had increased or the eggs had diminished.[95] He preferred the second assumption, as he was persuaded that men are diminishing, not only morally but also physically. The problem remains open and unsolved until today.

The only way to solve this contradiction is to realize that B. Erubin 83b does not write that a seah has the same volume as 144 eggs, as was always understood, but that it fits to 144 eggs.[96] The meaning is then probably that in a box of one seah it is possible to place 144 eggs.[97] If we assimilate an egg to a revolution ellipsoid of which the half axes are a and b, then its volume is 4/3 * π b a^2. The overall dimension of the egg is 2a *2a * 2b = 8 b a^2. The ratio egg/overall dimension is π/6.

When we take this new data into consideration, as well as the fact that the exact relationship between the units of capacity and length is 1 Miqveh = 3.65[98] cubic cubits or 1 reviit = 12.44 e^3[99], then all the problems are solved. The log is equal to the sextarius and is at least about[100] 545.75 cm^3, and it contains six eggs. The overall dimension of an egg is at least 545.75/6 = 90.96 cm^3 but the volume of an egg is at least 90.96 * π/6 = 47.63 cm^3. This is very close to the value of Rabbi Hilai Gaon and Maimonides. The origin of this paradox could then be the following. When the knowledge of the Roman units of capacity disappeared, the Rabbis used the volume of the mean egg to reconstruct the whole Talmudic system.[101] But they considered erroneously that the seah has a volume of 144 eggs instead of a volume of 144 * (6/π) eggs, or about 275 eggs. The Talmud B. Erubin 83b actually gives the number of eggs that it is possible to place in a box which has a capacity of one seah. This was the cause of an undervaluation of all the units of capacity. During the Gaonic period until the fifteenth century, when the most important Rabbis lived in Arabic countries, the problem of a contradiction between the units of capacity and length was not raised, probably because the consecutive units of length were compatible with the Arabic units of length. Rashi and Tosafot also accepted the little units of capacity and were apparently not bothered by this problem. This problem, which was raised for the first time in the fifteenth century, has undermined all the Talmudic metrology and introduced an element of incertitude. According to the conclusions of this paper, the objections which were raised were legitimate and lead us today to propose a definitive solution to this internal contradiction.

5. The Metrology of Maimonides.

1. The units of Capacity.

The metrology of Maimonides is now known with precision thanks to the research of Yakov Meshorer about the Palestinian coinage in the Time of the Mishna and the research by R' Y.G. Weiss about the old coinage of the countries where the Jews lived in the Middle Ages and at the beginning of modern times. When we compare the data given by R' T.H. Eisenstadt (1950)[102] and that given in Weiss (1984), we can see how much our knowledge has increased. The book of Weiss is difficult of access but it is a mine of information.
The metrology of Maimonides is an elaborate construction that has required much attention. He comes back to the subject in many passages in his commentary on the Mishna and his Hibbur.

1. Commentary on the Mishna.

The elements of the metrology of Maimonides are scattered throughout his commentary on the Mishna. The main elements related to the problems of the units of capacity and the units of weight can be found in his commentary to the following Mishnas: Peah VIII: 5; Sheviit I: 2; Hallah II: 6; Terumot X: 8; Eduyot I: 2; Menahot, introduction, 5th part; Menahot IX: 2; Bekhorot VIII: 8;[103] Kelim II: 2; Miqvaot III: 1.
The main features are the following: the dinar is 96 barleycorns and the Egyptian dirham is 61 barleycorns.[104] The reviit of water weighs about 27 dirham, the reviit of wine weighs about 26 dirham, the reviit of corn weighs 21 dirham, the reviit of meal weighs about 18 dirham and the issaron of Egyptian meal weighs 520 dirham.[105]
One dinar has the same weight as 1.573 dirham. If the dinar weighs 4.25 gr. then the dirham weighs 2.70 gr.

2. Hibbur.[106]

רמב"ם הלכות עירובין פרק א

הלכה יב

ליטרא האמורה בכל מקום מלא שתי רביעיות, ועוכלא חצי רביעית, ומנה האמורה בכל מקום מאה דינר, והדינר שש מעין, והמעה משקל שש עשרה שעורות, והסלע ארבעה דינרין, והרביעית מחזקת מן המים או מן היין משקל שבעה עשר דינרין וחצי דינר בקירוב, נמצא הליטרא משקל חמשה ושלשים דינר, והעוכלא משקל תשעה דינרין פחות רביע.

הלכה יג

סאה האמורה בכל מקום ששת קבין, והקב ארבעה לוגין, והלוג ארבע רביעיות, וכבר בארנו מדת הרביעית ומשקלה, ואלו השיעורין שאדם צריך לזכור אותן תמיד.

רמב"ם הלכות ביכורים פרק ו

הלכה טו

כמה שיעור העיסה שחייבת בחלה מלא העומר קמח בין מאחד מה' מינים בין מחמשתן כולם מצטרפין לשיעור, וכמה הוא שיעור העומר שני קבין פחות חומש, והקב ארבעה לוגין, והלוג ד' רביעיות והרביעית אצבעיים על אצבעיים ברום אצבעיים וחצי אצבע וחומש אצבע, וכל האצבעות הם רוחב גודל אצבעות של יד, נמצאת למד שהמדה שיש בה י' אצבעות על י' אצבעות ברום שלש אצבעות ותשע אצבע בקירוב הוא העומר, וכן מדה שיש בה שבע אצבעות פחות שני תשיעי אצבע על ז' אצבעות פחות שני תשיעי אצבע ברום שבע אצבעות פחות שני תשיעי אצבע היא מדת העומר, ושתי המדות כאחד הם עולים, וכמה מכילה מדה זו כמו ארבעים ושלש ביצים בינוניות וחומש ביצה והם משקל ששה ושמונים סלעים ושני שלישי סלע מקמח החטים שבמצרים, שהם משקל חמש מאות ועשרים זוז מזוזי מצרים בזמן הזה, ומדה שמכילה כמשקל הזה מקמח החטים הזה בה מודדין לחלה בכל מקום.

רמב"ם הלכות מתנות עניים פרק ו

הלכה ח

כדי שבעו כמה אם מן החטים נותן לא יפחות מחצי קב, ואם מן השעורים לא יפחות מקב, ואם מן הכוסמין לא יפחות מקב[107], ומן הגרוגרות לא יפחות מקב, ואם מן הדבלה לא יפחות ממשקל חמש ועשרים סלע, ואם מן היין לא יפחות מחצי לוג, ואם מן השמן לא יפחות מרביעית, ואם מן האורז רובע הקב, נתן לו ירק נותן לו משקל ליטרא והוא משקל חמשה ושלשים דינר, מן החרובין שלשה קבין, מן האגוזים עשרה, מן האפרסקין חמשה, מן הרמונים שנים, אתרוג אחד, ואם נתן לו משאר הפירות לא יפחות מכדי שימכרם ויקח בדמיהן מזון שתי סעודות.

It appears that there are some slight differences between the Commentary on the Mishna and the Hibbur. We will show that the dirham which weighs 61 barleycorns in the Commentary of the Mishna weighs 64 barleycorns in the Hibbur. Maimonides writes indeed in his Hibbur[108] that 1 omer of Egyptian meal weighs 86 2/3 sela or 520 Egyptian zouz. Thus 1 sela = 6 egyptian zouz or 1 dinar = 1.5 Egyptian zouz and 1 Egyptian zouz = 96 / 1.5 = 64 barleycorns. In the Mishna and the Talmud the zouz is equivalent to the dinar[109] but in the Commentary of Maimonides on the Mishna and here also in this passage of Hilkhot Bikkurim, the denomination of the zouz corresponds always to the dirham.[110] In the introduction to his Commentary to Menakhot, Maimonides writes that 1 omer of Egyptian meal weighs 520 Egyptian dirham.
In his Hibbur[111] Maimonides writes that 1 omer of Egyptian meal weighs 520 Egyptian zouz. Again we acknowledge that the two denominations relate to the same coin.
Let us then examine these changes between the Commentary on the Mishna and the Hibbur. In Mishna Bekhorot VIII; 8, Maimonides writes that the Egyptian dirham weighs 61 barleycorns; but in his Hibbur, as explained above, he writes that the Egyptian zouz weighs 64 barleycorns. This Egyptian zouz is nothing else than the Egyptian dirham and it weighs now 64 barleycorns. In Kaftor ve-Ferakh chap 16, it mentions both the dirham

of 61 barleycorns and later the dirham of 64 barleycorns without any remark about this contradiction. Kessef Mishneh[112] writes that the Egyptian zouz is a dirham weighing 2/3 of a dinar or 64 barleycorns. This position is confirmed in Shulhan Arukh.[113] The weight of the dinar, the international and fixed denomination, remained thus unchanged but the weight of the dirham increased by 5% (this is a rather rare event) and the ratio dirham/dinar increased consequently. In his Commentary of the Mishna, the weight of the reviit of water was originally 27 * 61/96 = 17.16 dinar = 72.91 gr. The volume of the reviit was then 72.91 cm^3.

In his Hibbur the weight of the reviit of water is 17.5 dinar = 26.25 dirham =74.375 gr. The volume of the reviit is now 74.375 cm^3.

Thus the ratio dirham/dinar has been adapted. The dirham which in the Mishna weighed 4.25 *61/96 = 2.7 gr., weighs in his Hibbur 4.25 * 64/96 = 2.833 gr.

The weight of the reviit of water has been diminished in relative value from 27 to 26.25 dirham and in absolute value it has increased from 17.16 to 17.5 dinar or from 72.91 gr. to 74.375 gr.

It is strange that the weight of the reviit of water expressed in dinar, changed. It should have remained 17.16 dinar, now equal to 25.73 dirham. Why did Maimonides change the weight of the reviit expressed in dinar and increased it by 2%, from 17.16 to 17.5 dinar? We know that the weight of a reviit of water of 17.5 dinar is exactly the value adopted by some Gaonim who gave for the weight of the volume of water displaced by an average egg 16.666 Babylonian dirham and for a reviit of water 25 Babylonian dirham with the relationship 25 Babylonian dirham = 25 * 7/10 = 17.5 dinar.[114] It is likely that Maimonides submitted himself to this tradition[115] and did not rest on his own appreciation of the reviit, which he had measured on his own as the average breadth of a thumb.[116] But what becomes incomprehensible is why he did not adapt his figures to the new situation, preserving at least the densities he had carefully measured. In his first measures he had found a density of 18/27 and more precisely 18.06/27.[117] Therefore the weight of one issaron meal should now be, according to his new data, 28.8 * 26.25 * 18/27 = 504 dirham,[118] or with more precision

28.8* 26.25 * 18.06/27 = 505.68 dirham. Maimonides seems to have increased the volume of the reviit in order to agree with the Gaonic volume but he did not adapt the weight of the meal contained in this volume, expressed in dirham, and practically he has artificially increased the weight[119] and the density of the Egyptian meal.[120]

The problem is a real conundrum. Apparently we have three independent elements:

1. A change of the weight of the Egyptian dirham, it is probably an external event.
2. An increase, by Maimonides, of the volume of the reviit by 2%, from 72.91 cm^3 to 74.375 cm^3, probably to agree with the Gaonic value.
3. A lack of adaptation of the weight of the Issaron of Egyptian meal to the new data: increase of the weight of the dirham and of the volume of the reviit.

Anyhow, the problem remains a true conundrum: we are confronted with an undeniable and yet incomprehensible increase of the weight of the dirham between the commentary of the Mishna and the Hibbur but we cannot account for the treatment of the consequences or more accurately for the absence of adequate taking into account of its consequences by Maimonides, i.e. the adaptation of the different figures to the new situation.

2. The Units of Length.

Maimonides has made many efforts to give a complete definition of the etsba[121] or breadth of a thumb, but despite these efforts and his precise wording, a doubt subsists about the length of his etsba and there are still discussions on the subject. The common way to calculate the etsba is to use the formula: 1 reviit = 10.8 e^3. With 1 reviit = 74.375 cm^3, we find e = 1.9025 cm. This gives a cubit of 45.66 cm and a mile of 913.2 m.[122]

Prof. A.Y. Grienfield (1986)[123] has proposed to calculate the length of the cubit[124] through the calculation of the weight of the Kaporet, subtracting the weight of the different other golden objects from the total of the weight of gold used in the Tabernacle. This method does not refer to Maimonides but claims to be general. In Talmudical Metrology I we took already exception to this method.

1. This method relies on a Talmudical Sela of 17 gr. and a Biblical Shekel of 14.1 gr. This value is the Gaonic and hilkhatic weight but the historical value of the Talmudical Sela according to the historical coins is 14.16 gr.[125] and this would correspond to a Biblical Shekel of 11.7 gr;
2. This method relies on different assumptions about the thickness of the different plates.
3. This method relies on the assumption that the Keruvim were in wood covered with gold according to Ibn Ezra, but against Rashi.
4. There is a discussion in the Talmud[126] whether the cubits considered in the measures of the Ark of Covenant are cubits of 5 handbreadths (Rabbi Judah) or of 6 handbreadths (Rabbi Meir).
5. The Kaporeth is assumed to be a homogeneous rectangular prism of one handbreadth height. This assumption relies on nothing: The Kaporeth could also be a non homogeneous rectangular prism of one handbreadth height with empty holes or a plate of less than one handbreadth thickness, with a peripheric edging of one handbreadth total height.

In Weiss (1984), the author has tried to demonstrate that the cubit used by Maimonides has a length of about 59-60 cm. His first argument is the passage of Hilkhot Kiddush ha-Hodesh[127] from which it results that people could cover 3° of meridian in seven days or 47.62 km per day. A second argument is that Maimonides writes that one can cover the distance between Jerusalem and Mitsrayim, which seems to be the town of Fostat, in 10 days.[128] This would also correspond to a similar distance per day.[129] If one compares this data with a maximum distance covered of 40 miles per day,[130] this will give 1,190 m for a mile and 59.56 m for a cubit. In order to solve this contradiction, Weiss proposed that the Miqveh of 1 cubit * 1 cubit * 3 cubits, and the reviit of 2 etsba * 2 etsba * 2.7 etsba considered in the Talmud, have the shape of half of a revolution ellipsoid. Its volume is 1/2 * 4/3 * π * 1 * 2.7 e^3 = 5.65 e^3 instead of 10.8 e^3. Therefore e = 2.36 cm and the cubit is c = 56.65 cm. Fixler (2001) affirms that the mile used by Maimonides in his introduction to the commentary of the Mishna and in his commentary on the first Mishna of Berakhot is the same as his legal mile of 2000*24*1.9 cm = 912m, and he concludes that Maimonides underestimated the dimension of the earth. This explanation would answer the first argument but surely not the second. Anyhow such an argument is

untenable as we know that already Greek astronomy[131] and later Arab astronomy[132] had correct knowledge about the size of the earth. Maimonides used the halakhik mile but in rare occasions he used also the geographical mile of the Arab Geographers.[133]
I personally would have been content with a reviit in the shape of a cylinder of two etsba diameter and 2.7 etsba height. Its volume is 8.48 e^3 and it leads to e = 2.06 cm and a cubit c = 49.49 cm. This value is much more acceptable and nearly coincides with the Arab cubit of 49.38 cm, 1/3000 of the Roman mile.[134]
Let us now examine the ingenious solution proposed by Weiss (1984).[135] Among the numerous descriptions in Maimonides' Commentary of the Mishna of the volumes of halakhik capacities like the reviit and log, expressed in cubic etsba, let us consider Mishna Peah VIII: 5; מדה שיש בחללה ארבע אצבעות על ארבע אצבעות ורומה שני אצבעות ושבע עשיריות מאצבע ויהיה זה האצבע ששיערו בו מאצבעות היד הגודל וזה המדע אשר יש בחללה זה השיעור שזכרנו אחר (אחד)[136] שיהיה מרובע או עגול או משולש או זולתם מן התבניות, הוא נקרא לוג.....

and the introduction to Mishna Menahot : המדה שיש בכללה ד' אצבעות באורך וד' אצבעות לרוחב ברום שתי אצבעות ושבעה עשיריות מעצבע.....

These two passages seem to contradict the assumption of Weiss (1984).[137] The text of the second seems to describe a rectangular prism, not a cylindrical prism, because of the use of the terms length, breadth and height, which do not fit for a cylindrical prism and fit still less for a volume in the shape of half of an ellipsoid.[138] Similarly the first passage seems to describe a prism with a basis of 16 square cubits, not a circle of four cubits in diameter. The assumption of Weiss that the volume of the reviit, or here the volume of the log, is a revolution volume and further that it is not prismatic but ellipsoidal, as well as my own assumption that it is a cylindrical volume, do not seem to be the genuine interpretations.
What about the two arguments in connection with the length of the mile that the travelers, who cover 47.6 km per day, ride?[139] It seems nearly impossible to walk and cover 47.6 km per day during seven or ten consecutive days. I had hoped to remove any doubt using a passage of Maimonides according to which the distance between his house in Fostat and the palace of the governor of Egypt situated in al- Qahira is two Sabbath distances.[140] However the localization of this last place seems difficult. The problem of the direct determination of the cubit and the etsba of Maimonides remains difficult. The best and most accurate method of determination of the etsba remains the use of the weight of the reviit of water which Maimonides fixes in his commentary of the Mishna to 17.16 dinar or 72.91 cm^3 giving an etsba of 1.89 cm. In his Hibbur he fixes it to 17.5 dinar or 74.375 cm^3 giving an etsba of 1.903cm.

3. The Quantity of Food for the Meals of the Poor, the Wife and the Eruv.[141]

Maimonides rules according to the opinion of Rabbi Johanan ben Beroka in Mishna Erubin VIII: 2: the bread of the eruv, corresponding to two meals, is made with a volume of 1/4 kav whole meal and half of this bread, פרס, represents a meal of 1/8 kav whole meal or three eggs.[142] According to Maimonides, this volume of six eggs represents the quantity of two meals, whatever the nature of the food. Therefore Maimonides rules that two meals are also 18 dried figs,[143] which have a volume of six eggs. Maimonides

considers as equivalent to two meals 18 dried figs,[144] a mana of deveila and a kav of groguerot.[145] In order to explain the last equality, we must accept that a kav of deveila means the dried and pressed figs obtained with a kav of fresh figs.[146]

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Appendix.

1. Tables of Ancient Units of Measure of Capacities and Weights.

    1. Talmudic Units of Measure of Volumes and Capacities.

Dry	יבש		Liquid	לח
Big Volumes				
Kor	כור	= 10 Bat	Kor	כור

Eifa	איפה	= 3 Saah	= 72 Log	Bat	בת
Seah	סאה	= 2 Hin	= 24 Log		
Tarkav	תרקב	= 3 Kav	= 12 Log	Hin	הין
Issaron	עשרון	= 0.1 Eifa	= 7.2 Log		
Kav	קב		= 4 Log		
				Log	לוג

Little Volumes

Kav	קב		= 4 Log		
Rova	רובע	= 1/4 Kav	= 1 Log	Log	לוג
Touman	תומן	= 1/8 Kav	= 1/2 Log	Litra	
ליטרא		= 1/16 Kav	= 1/4 Log	Reviit	
רביעית					
Ukhla	עוכלא	= 1/20 Kav	= 1/5 Log		
Beitsa	ביצה	= 1/24 Kav	= 1/6 Log		
			= 1/36 Log	Meshura	משורה
			= 1/64 Log	Kortov	קורטוב

Remarks.
The units of capacity of dry contents and of liquids are often interchangeable. The best example is the Miqveh of 40 seah, which is a unit of dry contents.[147]
Ukhla. 1/5 log: B. Baba Batra 90a, Rashi B. Eruvin 29a.
or 1/8 log: Rambam, Hilkhot Eruvin I: 12.

2. Greek Units of Measure of Volumes.[148] Attic System.

	Larousse
Liquids	Liters
Cyathos	= 0.045
Tetartron	= 0.135
Kotyle	= 0.27
Kestes	= 0.54
Hemichure	= 1.62
Chous	= 3.24
Amphora	=19.44
Metretes	=39.3

Dry	Liters
Kyathos	= 0.136
Kotyle	= 0.27
Hemichoiikion	= 0.54

Choenix = 1.08
Hemiekton = 4.30
Hekteys = 8.60
Medimnos = 51.8

3. Roman Units of Measure of Volumes

	Larousse	Italian encyclopedias
Liquids	Liters	Liters
Cyathus	= 0.046	0.045
Hemina	= 0.274	
Libra	= 0.327	
Sextarius	= 0.547	0.545
Congius	= 3.283	3.27
Urna	= 13.132	
Amphora	= 26.2635	26.20
Culleus	= 525.27	
Solids	Liters	
Acetabulum	= 0.068	
Quartarius	= 0.137	
Hemina	= 0.274	
Sextarius	= 0.547	0.545
Semodius	= 4.377	4.37
Modius	= 8.754	8.73

4. Greek Units of Weight.

	Larousse Gram weight	Italian Encyclopedias Gram weight
Chalque	= 0.09	
Hemiobole	= 0.36	
Obole	= 0.72	
Drachme	= 4.32	4.36
Mine	= 432	436
Talent	= 25.920 kg	26.160 kg

Roman Units of Weight.

	Gram weight
Chalcus	= 0.071
Siliqua	= 0.189
Obolus	= 0.568

Scrupulum	= 1.137
Drachma	= 3.411
Sicilius	= 6.822
Uncia	= 27.288
Sextans	= 54.78
Quadrans	= 81.86
Triens	=109.56
Semis	= 163.72
Libra (Pondo)	= 327.45

Kg.

Dupondius	= 0.655
Decussis	= 3.275
Centussis	= 32.745

5. Talmudic Units of Weight.[149]

Drachma		= 3.411 gram weight	דרכמון, דינר
Libra	= 96 Denarius	= 327.45 gram weight	ליטרא
Mina	= 100 Denarius	= 341.1 gram weight	מנה

6. Remarks

The value of 0.547 l for the sextarius is taken from the Encyclopedia Larousse. The great Italian Encyclopedias[150] writes for the sextarius: 0.545 l and the Great Spanish Encyclopedia gives 0.533 l. The dictionary of Bailly (p 1342) writes that the xestes is 0.54 l. The dictionary of Stuart Jones and Mc Kenzie (p 1189) writes that the xestes is nearly a pint of 0.567 l. Weiss (1984) p 27-28 assigns the following data: J. Greaves or Grovius (1647), in his Latinized name, referred to the measure of the congius of Farnese of 3,405.888 ml. and consequently the sextarius was 567.65 ml. Hultch (1862) writes of a measure of the same congius of 3,371 ml. and consequently the sextarius measures 561.83 ml. In the Encyclopedia Britannica the congius is 3,387.75 ml. and the sextarius is 564.63 ml.
The weight of the denarius is calculated according to a libra of 327.45 gr. On the basis of the weight of old coins i.e. shekalim of about 14.16 gr. and uncia of about 28.33 gr.[151] a weight of the denarius of 3.54 gr. has been advocated. In the present paper I have followed the universally accepted weight of the libra of 327.45 gr. Incertitude of nearly 4 percent subsists.

2. Analysis of the Roman System of Units of Measurement.

1. Units of Capacity.

Solids.

1 modius = 2 semodius[152] = 16 sextarius = 32 hemina = 64 quartarius = 128 acetabulum

Liquids.

1 culleus = 20 amphora
1 amphora = 8 congius = 48 sextarius = 80 libra = 96 hemina = 576 cyathus.

2. Units of Weight.

1 centussis = 10 decussis = 50 dupondius = 100 libra .
1 libra = 2 semis = 3 triens = 4 quadran = 6 sextarius = 12 uncia = 48 sicilus = 96 drachma = 288 scrupulum = 576 obolus = 1728 siliqua = 4608 chalcus.

We assumed in the present paper, devoted to the study of the Talmudic units of capacities, that the units of weight used in the Talmud are the same as the Roman units of weight. This position is justified by the Mishna Sheviit I: 2, ככר דבילה של ששים מנה באיטלקי from which it appears that the Talmudic mana was equal to the Roman mina.[153] We find the same expression: ככר דבילה של ששים מנה באיטלקי In Y. Sheviit I: 1 and II: 1.The system of the Talmudic units of weight was coupled with the Roman system and the Talmudic mana was identical to the Roman mina[154] and was equal to 100 denarii.

3. Fundamental Equations of the Roman System of Units of Measurement.

1. Relation between the Units of Weight and the Units of Capacity.

There is preserved by Festus,[155] the Silian plebiscitum of unknown origin, a method of regulating the weights and measures to the following effect: that the quadrantal (amphora) should contain 80 pounds (libra) of wine, and the congius 10; and that the sextarius should be 1/6 of the congius and 1/48 of the quadrantal. The quadrantal was subdivided into two urna, eight congius, 48 sextarius, 96 hemina, 192 quartarius, 384 acetatbula, 576 cyathus and 2,304 lingula . As compared with the dry Roman measures, the quadrantal was three times the modius. The only measure larger than the quadrantal was the culeus of 20 amphorae, which was used, as was the amphora itself, in estimating the produce of a vineyard.

2. Relationship between the Units of Capacity and the Units of Length.

The quadrantal was connected with the measures of length, by the law that it was the cube of the foot, hence its name quadrantal, or as other writers call it, using the Greek kubos instead of the Latin quadrantal, amphora cubus.[156]
There are two questions of interest connected with the Roman quadrantal: (1) whether the equality to the cubic foot was originally exact or only approximate and (2) whether there was any exact ratio between the Roman and the Grecian measures. The discussion of these questions would be inconsistent both with the limits and with the chief object of this paper. A general statement of this dispute can be found under Mensura in the Dictionary of Greek and Roman Antiquities (1888).

4. About the Capacity of the Congius and the Weight of the Pondo or Libra (Pound).

There is a congius in existence, called the congius of Vespasian, or the Farnese congius, bearing an inscription that states that it was made in the year 75 C.E., according to the standard measure in the Capitol, and that it contained, by weight, ten pounds. This congius is one of the means by which attempts have been made to fix the weight of the Roman pound or libra. Greaves (1647) writes that its capacity is 3,405.88 cm^3, giving a libra of 340.59 grams and a sextarius of 567.65 cm^3. Boeckl (1838) considers its capacity to be 3,380 cm^3 giving a libra of 338 grams instead of the accepted value of 327.45 grams. He mentions also the sextarius of Dresden and the congius of Ste Genevieve, which give greater values. Now the Roman theory of the amphora being the cubic foot makes it 26,013 cm^3, if we consider a foot of 29.63 cm, leading to a congius of 3,251.66 cm^3, a libra of 325.16 grams, and a sextarius of 541.94 cm^3, or decidedly less than the actual measure. The other theory, that the amphora contains 80 libra of water, would make it 26,196 cm^3 leading to a congius of 3,274.5 cm^3, giving a libra of 327.45 grams and a sextarius of 545.75 cm^3, again too low for the measurement. Anyhow, it appears that, probably because of the surface tension, it is difficult to measure the capacity of the Farnese congius. Further, it appears that its caliber has not been determined with sufficient precision according to modern metrology. The results of the measure of its capacity have important ramifications for the Roman pound (libra) and for the capacity of the Greek metretes, which are known more exactly by other information. One can consider as sufficiently approximate the result given by Hultsch: the amphora is about 26.26 liters, the congius has a capacity of about 3,283 cm^3 and the sextarius is about 547.17 cm^3.
What about the libra? We know from the calculations of Letronne from the comparative weighing of 27 consular monies and from 27 solidus of Constantine that the libra is about 327 gr. Finally, from the same calculations slightly modified, Boeckh has proposed the value of 327.45[157] gr. which has been universally adopted for the Roman pound.

[1] This paper is dedicated to the blessed memory of my late parents. My father R' Eliezer Ajdler (Warsaw 1901- Brussels 1999) had a traditional education: heder and beit ha midrash . In 1919 he was conscripted

and had to be enrolled at the end of that year in order to fight against Russia. He spent six months in Ostrowiec, at the house of the Admor, Rabbi Meir Jehiel ha Levi Holtzstock (1851- 1928). He studied under him Mishnayot Kodashim and Teharot. With his benediction he succeeded in running away to Germany where he joined the Yeshiva of R' Moses Schneider in Frankfurt. He was among the few Polish young men to receive semikha from R' Solomon Zalman Breuer. But his personal pride was the semikha that the Rabbi of Ostrowiec wrote for him afterwards. He was assistant-rabbi in a German community for a year but soon entered into business. He left Germany in 1933 and settled in Brussels. He married in late 1940. In late 1942 my parents had to hide themselves in a gentile family's attic and I was placed with a gentile family in a suburb. After the war, my father went on importing plywood from Finland. He was among the founders of a Jewish day school in Brussels. For nearly 25 years, he gave a public two-hour lesson in Talmud twice a week at his home. His strength was based on a deep comprehension of Rashi and Tossafot and in this field he was equal to the strongest. He was modest and never noted his degrees. My mother Bianca Steinfeld (Brakha Bluma) (Antwerp 1913-Brussels 1997) was among the first Jewish girls to receive a university education (in business). She was deeply marked by the calamities of the war. On Friday evening, August 3, 1943, her father R' Israel Steinfeld (Warsaw 1885-Auschwitz 1943), her mother, Antonia Figatner (Antwerp 1888-Auschwitz 1943) and her brother Saul Steinfeld (Antwerp 1920-Antwerp 1943) were carried off and her brother died on the same evening, suffocated in an overcrowded bus, together with three other boys, in front of their parents. His tomb is at the entrance of the cemetery of Mahzike ha- Dat in Putte, Holland.
תהיינה נשמותיהם צרורות בצרור החיים, עם נשמות אברהם יצחק ויעקב, שרה רבקה רחל ולאה, עם שאר צדיקים וצדקניות שבגן עדן,ונאמר אמן.

I want to thank R' Y.G. Weiss for reading and commenting on this paper with his invaluable remarks.
[2] See Mishna Kelim XVII: 9, B. Pesahim 86a and B. Menahot 99a.
[3] In B. Erubin 83a it speaks about the seah, a unit of capacity of dry stuff. But this must also be the case for all other units of capacity. See Mishna Hallah II: 6, the pastry submitted to Hallah has a volume of 1.25 kav or five log of Tsipori; they are equal to 1.5 kav or six log of Jerusalem and to 1.8 kav or 7.2 log of the desert. See also Mishna Menakhot VII: 1 and B. Menakhot 76b, Tossafot בד"ה התודה . From these references, it appears, without doubt, that the whole system of units of capacity was increased in Jerusalem and later in Tsipori. Weiss (1984) p 291 doubts whether this increase also concerned the units of capacity of liquids. For me, it is evident that this is the case for the simple reason that many units of capacity are common for dry and liquid stuff. There is also even stronger evidence: The expression of the volume of the reviit shel Torah in the Babylonian Talmud 2e * 2e * 2.7 e and in the Jerusalem Talmud 2e * 2e * 1.833e implies that the reviit of Tsipori is 1.44 greater than the reviit of the desert. See remark 6868.
[4] See Mishna Menakhot VII: 1.
[5] See Mishna Eduyot I : 2, from which we can deduce that the units of Jerusalem were already used in the time of Hillel and shamai and that the units of Tsipory were introduced only later.
[6] B. Eruvin 83a.
[7] See Dorot ha Rishonim, book I, c; p 225. He establishes that the measure of Jerusalem had already spread by the time of Hillel and Shamai, because they used this measure. See Mishna and Tossefta Eduyot I, 2. Actually, only the Sages, who were opposed to Hillel and Shamai, used the Jerusalem kab while Hillel and Shamai still used the kab of the desert.
[8] The old measure used was a kav.
[9] See the passage in Y. Pesahim mentioned supra. Rabbi Johanan used the ancient measure, but not the antique measure, because the ancient measure was still in use during his time.
[10] According to the passage of the Talmud of Jerusalem mentioned above.
[11] This exceptional explanation was given by Borenstein (1887). It must be noted, however, that the Aruch's version is טטרטון and therefore it refers simply to the reviit of the desert.
[12] It is symptomatic that the names of different units of capacity are at the origin of the denominations of utensils, the kestes : kesta or kist, the chous (1/2 kestes) : khouza (Mishna Tamid III : 6 ; B. Sabbath 33b ; B. Baba Metsia 40a ; B. Baba Batra 96b) ; the log : louga (B. Yoma 83b).
[13] R' Benjamin Mussaphia (~1602-Amsterdam 1675) refrained from calling kestes a measure.
[14] He called my attention to the fact that R' Abraham ben David Portaleone (1542-1612) in his opus magnum, שלטי הגיבורים Mantua 1612, writes that the weight of a sextarius of wine is 20 ounces (that of a chemist of about 28 gr. which gives a weight similar to the weight of Grovius), the weight of the hemina of

wine is 10 ounces (see p.74a) and the weight of a log of wine is 9 ounces (see p.93b, 94 and 97). So he opted for the little capacities and he was not disturbed by the lack of correspondence between the log and the hemina.

[15] This reference is mentioned in the Hebrew-Aramic Dictionnary by Prof. Ezra Melamed.

[16] I thank Prof. Albert Pietersma, Professor of Septuagint and Hellenistic Greek at the University of Toronto, for this information.

[17] The Hexapla is a polyglot edition of the Hebrew Bible prepared by Origen (c. 185- c. 255 C.E.). It was generally printed in six columns: a Hebrew text (Massoretic?), a Greek transliteration of it, and four Greek versions: those of Aquila, Symmachus and Theodotion, and a revised version of the Septuagint. According to Schurer (1973) (vol III, part 1, p 493), Aquila and Theodotion were Jewish, while Symmachus was not Jewish; he was, according to Eusebius, an Ebionite Christian. Schurer writes that the translation of the Septuagint prevailed among Jews of the Greek-speaking Diaspora as the main sacred version of the Bible until the beginning of the second century C.E. The period of its predominance coincided with the golden age of the Jewish community in Alexandria. In the second century C.E., however, it suffered near extinction, and the translation of the Bible, which it had championed, fell into disfavor among Jews. This process was aided by two factors: an increase of the prestige of rabbinic commentators outside Palestine and the successful advance of Christianity. An important symptom of this change can be found in the new Greek translations of the Bible, which were intended to provide Greek-speaking Jews with a translation based on the authoritative Hebrew text. These translations are also a memorial of the struggle between Judaism and Christianity, since they were to provide the Jews with a polemical weapon in the battle against Christian theologians, who exploited the uncertain text of the LXX in their own interest.

[18] Schurer (1973) (vol III, part 1, p 474) writes that the Septuagint was not the work of a single hand. What was brought together under this name at a later time is not only the work of different translators, it also came about at different times and therefore the affirmation about internal contradiction must be considered with reservation. Schurer notes (p 482) that a great number of "hexaplaric" readings found their way into the text of the LXX so that the elimination of the hexaplaric additions is one of the chief tasks of septagintal research. The Aristeas legend refers apparently only to the Pentateuch. It was reported in the Talmud: B. Megila 9b B. Sofrim I: 8.

[19] It is not impossible that the Septuagint (third century B.C.E.) adopts the principle of the little units of capacity while the Hexapla adopts, in accordance with the prevailing opinion of the epoch of the Mishna and later the Talmud, the opinion of the great units of capacity.

[20] The parallelism between these two passages is not fortuitous. One must remember that there were Rabbis traveling between the academies of Palestine and Babylonia, which allowed these institutions to know the teachings of the others. See Dorot ha Rishonim (1897-1939, reprinted 1967) vol.7 pp. 467-473 by R' Isaac Halevy.

[21] But he also equates a log to a litra in B. Erubin 29a.

[22] See the following references: Tossefta Pesahim II: 9, Y. Aboda Zara VII: 2, Leviticus Rabbah 37: 3.

[23]See the following references: Y. Pesahim X: 1, Y. Shekalim III: 2 and Y. Sabbath VIII: 1

[24] The Arukh deletes Ureviya and considers that Tetraton is the equivalent of the reviit.

[25] This explanation is confirmed by the Mishna Ketubot V: 8 where the wife receives two kav for 16 meals i.e.1/8 kav for one meal. This proves that the quantity of bread is measured by the volume of the constitutive whole wheat.

[26] See Mishna Eduyot I: 2.

[27] According to the Mishna Eduyot I: 2 the density of wheat is 21/27 = 0.78 and the density of meal is 18/27 = 0.67. As the wife of the poor worker receives corn, I have supposed that she mills the corn, just as it is, without any sifting. It is likely that poor people ate wholemeal bread.

[28] See Benish (1987) p.290 remark 114*.

[29] In fact, we must remain cautious in this particular case because the Sages were lenient, in some instances, in the fixation of the necessary quantity of the meals necessary for the eruv. The demonstration is more convincing when dealing with the quantities allowed ensuring the subsistence of the poor or of the wife of the workman.

[30] In Peah VIII: 5 the Mishna enumerates the different categories of food on an additive manner, as if the poor person had a right to all these foods: a half of kav of wheat, one kav of barley and a kav of dried figs. Maimonides in H. Matanot Aniyim VI: 8 enumerates the same foods on an exclusive manner, half a kav of weat or one kav of barley or one kav of dried figs or one mana of pressed figs. He probably justifies his

understanding of the Mishna by the comparison with Mishna Ketubot V: 8, where the wife of the poor worker receives two kav of wheat or four kav of barley. Furthermore, she receives only a kav of dried figs or a mana of pressed figs for a whole week, corresponding to 18 dried figs for 16 meals. Maimonides has thus logically concluded that the unknown poor need not receive more than the wife of the worker. It is therefore not necessary to justify the ruling of Maimonides by a different version of the text of the Mishna as proposed by Radvaz.

[31] This is practically her ration. She still has a half kav of chickpea (0.25 of the quantity of bread) and a little more than one dried fig per meal. This is really a minimum to live on.

[32] We have seen that the minimum quantity of bread per meal is 274 gr. This quantity can be compared with the quantity of Man that the people received in the desert i.e. one issaron a day or 7.2 log a day or 3.6 log per meal. This seems to be a lot compared to the quantity of bread allowed to the wife or to the poor. This question has been raised in Tossafot Rid in B. Ketubot 64b. Tossafot Rid brings the answer of R' Shalom Gaon who says that one should not confuse the minimal quantity with the maximal quantity. Nevertheless the minimal quantity is 1/8 kav while the maximal quantity is 0.9 kav, which gives a ratio of 7.2! A better, or at least a complementary, explanation is perhaps that the Man was probably a substance similar to snow with a very low density. If we consider a density of 0.1, then the weight of this meal would be 3.6 * 0.546 * 0.2 = 0.39 kg. The importance of the volume of the meal of the Man had already puzzled Cardinal Cumberland and William Whiston, both English authors of the seventeenth century. In connection with the Issaron of the desert, the following passage raises difficulties. In B. Erubin 83a, it says: מכאן אמרו האוכל כמדה זו הרי זה בריא ומבורך, יתר על כן רעבתן פחות מכאן מקולקל במעיו

The issaron represents, according to Maimonides: 0.074375 * 4* 7.2 = 2.142 dm^3. This volume of the meal weighs about 1.43 kg and allows for preparing 1.83 kg of bread. According to the conclusions of this paper, the issaron is equal to 7.2 * 0.54575 = 3.93 dm^3 and this volume of the meal weighs 2.62 kg and allows for preparing 3.38kg of bread. This seems a rather great quantity, and certainly not an average and recommended quantity. R' Jacob Emden seems to encounter this objection and writes: certainly for average people, but evaluated according to their generation (of the exodus) he brings some examples of their great capacity for eating. Similarly the cakes that Abraham commanded Sarah to prepare were made with three seah meal representing one eifa equal to 3 * 24 * 0.54575 = 39.29 l weighing 26.20 kg!

[33] The fresh fig or תאינה when it is dried, is called גרוגרת. It is also cut up in slices which are dried and called קציעות, then they are pressed together in order to get a bread of dried figs, called דבילה.

[34] Rashi writes explicitly in B. Erubin 29a and in B. Ketubot 64b:

לאחר שנדרסין בעיגול קרי להו דבלה ושוב אינו מוכר במדה אלה במשקל

[35] In Mishna Terumot IV: 10: בדורס ליטרא קציעות על פי הבד, Maimonides writes: ליטרא משקל ידוע וקציעות התאנים היבשות ואומר כי מי שלקח ליטרא תאנים וכשתן..... Our assumption is thus likely, and is accepted by Maimonides. Now according to B. Erubin 80b, 18 dried figs constitute two meals. According to Maimonides, two meals represent a volume of food of three eggs (H. Erubin I: 9 and H. Sabbath VIII: 5), but according to Rashi a normal meal is a volume of food of four eggs (see B. Pesahim 44a, Rashi in two places, and B. Erubin 4a in Rashi). Rashi writes: הלכה למשה מסיני דחצי כיכר של שמונה ביצים הוא זעודה. Therefore the volume of a dried fig is 0.44 eggs. If we assume that a fresh fig has the same volume as three dried figs then one fresh fig is 1.32 egg and 18 figs are about 24 eggs and correspond to one seah. In fact, Rashi in Menahot 54b writes that a fresh fig is at least two dried figs: דכלי המחזיק מאה גרוגרות לא מחזיק טפי מחמישים תאנים. Furthermore some commentators who consider a normal meal to be a volume of four eggs of food also consider it a necessity to have 24 dried figs for a normal meal: see Tossefot Yom Tov on Mishna Kelim IV: 2 based on R' Ovadia of Bertinoro, on Mishna Erubin VIII: 2.

[36] In B. Sanhedrin 70a: נמצא תרטימר חצי מנה , but in the parallel passage in Y. Sanhedrin VIII : 2 : אמר רבי יוסי: טרטימר חצי ליטרא הוא.

[37] Y. Terumot X: 5 in the edition of Vilna.

[38] This passage has always been understood as dealing with the seah midbarit. R' Yom Tov Lipman Heller thought that the weights of the Talmud of Jerusalem are 2.87 times greater than those of the Rambam. The truth is that the log of Maimonides is 4 * 74.375 = 297.5 cm^3 while the sextarius is about 545.75 cm^3. This gives a ratio of 1.834. The apparent ratio is 100/35 = 2.857, because the lira is equal to 100 denarius in the Talmud of Jerusalem and to 35 denarius according to Maimonides. Now let us take into account the following points: the littra is actually 96 denarius, the litra is equal to 2.4 reviit and not 2 reviit and therefore the littra is equal to 80 denarius, and not to 100 denarius, the dinar in the Talmud is about 3.41 gr. and not 4.25 gr. Then the corrected ratio will become: (80/100) * (3.41/4.25) * 2.857 = 1.834. See

Madanei Yom Tov Berahot III: 30 $ 80. We see therefore that the data of Y. Terumot X: 8 is, if we neglect the approximation littra = mana, rigorously exact and gives us a full confirmation of our theory that the log is equal to the sextarius. If this passage had been correctly understood, particularly in that the capacities are capacities of Jerusalem, then many problems would have been solved.

[39] This passage shows how we must be cautious in the interpretation of the Mishna when dealing with units of capacity. There are many references showing that the Mishna uses, without clear distinction, the different types of units of capacity, even sometimes, different types in the same Mishna.

[40] Practically all the mentions of the litra in the Talmud and Midrashim concern the unit of weight. See for example B. Bava Battra 89a and Sifrei 162 (on Deuteronomy XXV:13).

[41] The littra appears as a unit of capacity in our passage in Mishna Terumot X: 8. It is also probably a unit of capacity in the following quotations: B. Nedarim 59a, ליטרא בצלים; B. Erubin 29a, עוכלא תבלין וליטרא ירק; B. Hulin 84a, ליטרא ירק, ליטרא בשר, B. Sanhedrin 94 ליטרא ירק בסעודה.....מ' סאה גוזלות בקינוז סעודה . In all these cases, we are dealing with the measure of a quantity of stuff that can be measured by standard receptacles. This is unlike the case of rigid items like bread or bread of figs, which cannot be measured this way and requires weighing. It seems they tried to avoid the weighing whenever possible. In B. Erubin 29a, Rashi writes explicitly that littra means a unit of capacity of vegetables, but in B. Hulin 84a, he writes: the weight of one littra vegetables. Maimonides, who writes that littra always means half of a log, nevertheless writes in Hilkhot Matanot Aniim VI: 8 a litra of vegetables i.e. the weight of 35 dinars (35 * 4.25 = 148.75 gr.).

[42] As already noted, the Rabbis did not believe that we are dealing in this Mishna with the measures of Jerusalem. Maimonides writes in Hilkhot Eruvin I: 12 that the litra is always ½ log. Therefore, according to him ad locum, 1 mana = 100 denarius and 1 litra weighs only 35 denarius, in contradiction with Y. Terumot X: 8.

Rashi writes in B. Erubin 29a that the litra, as unit of capacity, is worth one log. The position of Rashi, although in contradiction with Y. Terumot X: 8, is coherent. We know indeed that Rashi had a good knowledge of the Talmudic weights because he lived in the Roman Empire. He knew that the littra was about 340gr. and 0.96 of the mana, and he could equalize this volume of 340 cm^3 water only with a log because Rashi, as most of the Rishonim, considered little units of capacity. Therefore the correction by the Gra is not consistent with the commentary of Rashi.

[43] See Mishna Eduyot I: 2, where Shamai considers that a pastry of 1 kav (of Moses) is submitted to Hallah while Hillel considers that only a pastry of 2 kav (of Moses) is concerned. But the Sages fix the volume of the pastry submitted to Hallah to 1.5 kav (of Jerusalem) or 1.8 kav of Moses. Similarly in Mishna Yoma IV: 4, according to Rav Ashi, the Mishna should be understood on the following way: בכל יום היה חותה בשל סאה (מדברית) ומערה לתוך שלושת קבין (ירושלמיות).

[44] According to Jastrow, the modius was copied from the standard measure of the temple of Nausa.

[45] Josephus in Jewish Antiquities, book IX, chap. IV, sect. 5, says that the seah is equal to 1.5 Italian modius.

[46] See B. Erubin 14b and B. Sabbath 35a: האי גודשא תילתא הוי.

[47] If the heap above the utensil represents 50 percent of the actual capacity of the utensil, this utensil must be quite flat. Rashi explains that the utensils were cylindrical with a height equal to the radius. If H is the height of the cylinder, R its radius and h the height of the heap, then the volume of the cylinder is: π h R^2 and the volume of the heap is 1/3 π h R^2. The condition is then: π H R^2 = 2* 1/3 π h R^2.
According to Rashi, H = R, we then have the condition: h = 3/2 R. The slope of the heap is then α with tang α = 3/2 and α = 56.31 °. Of course such a heap, with a slope of 56.3° will be instable and will slide; the assumption of Rashi about the shape of the utensil of dry capacity is not realistic. If we consider that the height H of the utensil is equal to R/2, then the capacity of the utensil is ½ π R^3 and the condition is now the following: ½ R^3 = 2/3 π h R^2 and therefore h =3/4 R; tang α = 3/4 and α = 36.87°. Even this slope of 36.87° is too large and at the limit of the instability. The slope should be less than 30°. The only way to get a satisfactory solution is to consider a utensil in the shape of a portion of a sphere.

[48] This proves that the capacity of this modius, which Rabbi estimated to be 144 eggs, was not, as is generally accepted, the volume of liquid of the box, but rather it represents the number of eggs that can be stored in it, multiplied by 1.5 to take the heap into account (see the chapter about the problem of the eggs in Talmudic metrology). Now it is generally accepted that the seah, which is a unit of both dry and liquid capacities, always has the same volume. It seems that it is only because of the lack of Roman correspondent

unit that they used the modius, equal to 16 sextarius, as a correspondent unit of the seah, equal to 24 sextarius, although the seah is 1.5 modius, on account of the principle האי גודשא תילתא הוי. There is nevertheless a strange passage in Y. Terumot V: 1, which mentions in the name of Rabbi Abbahu the following: כמה סעה עבדה, תשעין ושית בעין , the seah thus represents 96 eggs while in B. Erubin 83a it is said that the seah of the desert represents 144 eggs (in B. Erubin 83a also, we are dealing with a unit of dry capacity). If we consider the following passage: Y. Terumot V: 1(R' Abbahu):
קבא כמה עבד? עשרין וארבע ביעין, כמה סאה עבדה? תשעין ושית ביעין. , then 1 seah = 4 kav = 96 eggs. This passage contradicts Y. Terumot X: 8: כמה סאתא עבדא? עשרין וארבע לוגין from which we can deduce the generally accepted equation 1 seah = 6 kav = 24 log.

The only plausible explanation is that if generally the modius was considered as synonymous with theseah, in this passage however, Rabbi Abbahu has identified the seah with the modius. This quotation is probably the origin of the following passage of the Kalir in אז ראית וספרת belonging to the Yotser of Parashat Shekalim יוצר לפרשת שקלים: וסאת יבש חסרה שליש בלח וסאת הלח אחד משלשה בבת . Anyhow, this citation of Rabbi Abbahu remains a very difficult passage. Sperber (1965) p 270, basing himself on Epiphanius, has suggested the possible existence of another parallel standard: 1 seah = 4 kav = 16 log = 96 eggs instead of the accepted standard: 1 seah = 6 kav = 24 log = 144 eggs. It would be strange, however, that such a parallel standard would appear in only one case, as late as the end of the third century in the time of Rabbi Abbahu. There is other evidence in the Talmud that 1 seah = 6 kav = 24 log = 96 reviit. In B. Pesahim 109b (also in many other places) it writes that a miqveh is three cubic cubits and in the same way it writes in B. Pesahim 109a that a reviit is 2 * 2 * 2.7 = 10.8 e^3. From these two equivalent relations we can conclude that 40 seah = 3 * (24) ^3 = 41472 e^3. Therefore 1 seah = 41472/10.8*40 = 96 reviit and necessarily one seah is equal to six kav. There is other evidence in both the Talmudim that one seah is six kav. In B. Baba Battra 89b and 90a (and similarly in Tossephta Baba Battra V: 4, in B. Sotah 8b and in Y. Sotah I: 7) we find the following passage (according to the corrected text in the Steinzalts edition):
אבל עושה הוא סאה תרקב וחצי תרקב וקב וחצי קב ורובע ותומן וחצי תומן ועוכלא ובמדת הלח הוא עושה הין וחצי הין ושלישית ההין ורביעית ההין ולוג וחצי לוג ורביעית ושמינית ואחד משמונה בשמינית וזהו קורטוב.
See also a very similar enumeration in Rambam, Hibbur, Hilkhot Guenivah VII: 7. In the first enumeration there is a transition from the submultiples of the seah to the kav because the seah is worth six kav, not four. Similarly, in the second enumeration there is a transition from the submultiples of the hin to the log because the hin is worth 12 log. If the seah was worth four kav, then חצי תרקב would be equal to a kav.
In conclusion: 1 kav = 24 eggs (Y. Terumot V: 1); 1 seah = 6 kav (above); 1 seah = 24 log (Y. Terumot X: 8) and finally 1 seah = 144 eggs. This confirms that in B. Erubin 83a the modius of 144 eggs was equal to a seah, as Rashi writes that the modius is the designation of the seah. Now the passage in Sifrei 163 on Deuteronomy XXV: 14, יכול לא יעשה קב תרקב וחצי תרקב ורביע תרקב is more problematic because the two last denominations represent respectively 1.5 and 0.75 kav.

[49] See B. Sukkot 52b.

[50] Ibidem.

[51] נותנין לידים means that a servant washes your hand, נוטלין לידים means you wash your own hands (see Mishna I: 5 and Tosephta I: 7. Therefore the correct reading in Mishna I: 5 must be והקוף נותן לידים.

[52] Mishna Yadaym I: 1, if the superficies of the hands are not correctly wetted, the hands must be dried and the washing must begin again. Therefore, the servants, although parsimonious in the use of the precious water, could not afford themselves such an affront.

[53] It must nevertheless be observed that there are many divergent opinions about this Mishna.

1. Maimonides understands that Mishna Yadaym I: 1 deals with מים שנים, but normally a man needs a whole reviit for washing his hands correctly whether he washes for eating Hulin (Hilkhot Berakhot VI: 4, he must pour water only one time on each hand), or whether he washes for eating Terumah (Hilkhot Mikvaot XI: 3 and 8, he must pour water twice on each hand). All other commentators understand differently (see especially Rabad on Hilkhot Mikvaot XI: 8).
2. Maimonides does not clarify the meaning of the superior boundary of the hand עד הפרק, (see Hilkhot Berakhot VI: 4 and Hilkhot Mikvaot XI: 4). It is generally accepted that he follows the opinion of the Rif (see infra) and believes the hands must be washed until the articulation of the arm (see Kessf Mishneh on Hilkhot Berakhot VI: 4) . It should be noted in support of this opinion that he writes in his commentary on Mishna Erakhin V: 1, אף על פי שהיד ודאי הוא עד פרק הזרוע.
3. There are also divergent opinions about the meaning of עד הפרק, the limit to which the hand must be washed.

1. The Rif believes that one must wash the hands in all instances until the articulation of the arm. This is not clear according to our text of the Rif in Berakhot , but this was the reading of the Ran (Ran on the Rif in Berakhot 41b) and of R' Karo (Kessef Mishneh on Hilkhot Berakhot VI: 4).
2. R' Gershom, in B. Hulin 106b, understands: the first articulation of the fingers for Hulin, the second articulation of the finger for Teruma.
3. Rashi, in B. Hulin 106b, understands: the second articulation for Hulin, the third articulation for Terumah.
4. See also Tossafot in B. Hullin 106b, אמר רב.
5. In B. Bekhorot 45a, in a completely different subject connected with physical disabilities of priests, Rashi writes: האמצעי של האצבעות :עד הפרק.

4. There is a serious objection against the opinion of Maimonides, that when washing for Hulin, one needs to pour water on the hands only one time, from B. Sota 4b where the Talmud writes about washing for Hulin: צריך שיגביה ידיו שמא יצאו המים חוץ לפרק ויחזרו ויטמאו את הידים. It appears clearly that even when washing for Hulin one needs מים ראשונים and מים שניים . Futhermore, Maimonides has, incomprehensively, written this law in Hilkhot Berakhot XI: 16 when this law, according to his opinion, applies only when washing for Terumah. The justification of this law is found in Hilkhot Mikvaot XI: 4. This objection, to the best of my knowledge, has never been raised.

It appears that even Maimonides, who considers pouring water only one time on both hands for Hulin to be adequate, in the case of Terumah needs to completely wash both hands twice, until the articulation of the hand on the arm with one reviit. His reviit of about 75 cm^3 seems barely enough for that purpose. Nevertheless, because of all these contradictory opinions, this point is probably not the most convincing evidence about the capacity of the reviit.

[54] See Weiss (1984) p. 213.
[55] See infra: Back to the Units of Tsipori.
[56] See his commentary on Mishna Sheviit I: 2.
[57] See the account of the journey of Rabban Gamliel to Kziv. See following references: Tossefta Pesahim II: 9, Y. Aboda Zara VII: 2, Leviticus Rabbah 37: 3. See also a divergent reading in B. Erubin 64b.
[58] This is contrary to the explanation of Weiss (1984) p. 291; p. 377 rem 5; p. 380.
[59] Y. Hallah II: 5 in the edition of Vilna.
[60] This luminous explanation was proposed by Borenstein (1886).
[61] See Mishna Eduyot I: 2.
[62] 1.7 modern kav corresponds to 1.8 ancient kav or the original kav of Moses and taking Hallah is required.
[63] R' Weiss objects about the consecutive brakha levatala. I don't know if one can speak of brakha levatala when one follows another Tanaitic opinion.
[64] References: B. Pesahim 109a, B. Hagiga 11a, B. Yoma 31a, B. Erubin 4b and 14b.
After the redaction of this paper, Asher Grossberg, the renowned researcher of the old miqva'ot of the Mishna period, fetched my attention on the miqva of Massada which had a working volume of about 420liters. We can assume that this working volume of 420 liters corresponded probably to a theoretical volume of about 332 liters or even less. This volume is much less than the theoretical volume of 40 seah = 960 log = 960 sextarius = 960 * 545.75 cm^3 = 523,920 cm^3 = 524 liters.
This Miqveh was built shortly before the destruction of the Temple. It does not fit the Talmudic standard of 1 log = 1 sextarius = 545.75 cm^3. This Miqveh seems to have been devised according to the rules of the Mishna Miqva'ot and the Halakha. However its volume is not in agreement with the Talmudic standard. As already mentioned it is not impossible that there was already differences of opinions whether the log is equal to the sextarius or to its half, the Miqveh of Massada belonging to the minority opinion. One must emphasize that the people of Massada were behaving according to the highest standards of purity, they were: אוכלי חולין על טהרת הקודש, and were certainly following their traditions.
[65] References: B. Pesahim 109a
[66] References Y. Pesahim X: 1 (near the end) , Y. Shekalim III: 2, Y. Sabbath VIII: 1.
[67] In the Yozer of Sabbath Shekalim the Kalir brings the same quantity in a slightly different form. The Kalir leaved in Palestine and probably did not know the B. Talmud. As we have proposed in Talmudic Metrology I, the etsba and the cubit of the Kalir are the same as ours and he probably considered a little

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reviit. Stranger is the fact that the Arukh (Rome, eleventh century) who knew both Talmudim, has chosen the enunciation of the Talmud of Jerusalem, see the entry רבע.

[68] Tossafot, B. Pesahim 109a examines the two contradictory formulations, in the Babli: אצבעיים על אצבעיים ברום אצבעיים וחצי אצבע וחומש אצבע and in the Yerushalmi: אצבעיים על אצבעיים ברום אצבע ומחצה ושליש אצבע.
This Tossafot has puzzled all the Rabbis, especially those who had a good understanding of the subject. Rabbis like Hohmat Manoah (seventeenth century) and the Rashash (R' Samuel Strashun, nineteenth century) did not find a satisfactory solution. Weiss (1984) p 253, explains this Tossafot by the introduction of units of length of Tsipori equal to 1.44 of the same unit of the desert. Let us consider this interesting Tossafot, which indisputably contains a mistake. The first part of the passage tries to derive the reviit of 2e * 2e * 2.7e from the miqveh of 1c * 1c * 3c. Tossafot tries to show this derivation geometrically. We know that 1 miqveh = 3840 reviit. 1 Miqveh = 3 * (24) e ^3 = 41472 e^3, therefore 1 reviit = 10.8 e^3.
Tossafot observes that the height of 3 cubit = 72 e. If we take 3/80 of it we get 2.7 e. If we take 1/12 of both sides of the square base of 1 cubit = 24 e, we get 2 e.

72e * 3/4 * 1/20 = 2.7e
24e * 1/12 = 2e
24e * 1/12 = 2e

Therefore the volume of 2e * 2e * 2.7e represents
3/4 * 1/20 * 1/12 * 1/12 = 1/3840 of the miqveh or 1 reviit. The second paragraph of this first part of the Tossafot seems to be redundant, describing a division slightly different.

72e * 1/24 * 9/10 = 2.7e
24e * 1/12 = 2e
24e * 1/12 = 2e

(40 seah * 1/24 * 9/10) * 1/12 * 1/12 = 1/3840 Miqveh = 1 reviit.
The third paragraph of the first part of Tossafot seems to be corrupted and proposes a third way, practically the same, of division of the 40 seah.

72e * 1/4 * 3/4 * 1/5 = 2.7e
24e * 1/12 = 2e
24e * 1/12 = 2e.

In a second part beginning with ולפי תלמוד שלנו Tossafot tries to justify the formulation of the Talmud of Jerusalem by the introduction of fictive units of length of Tsipori equal to (1.44)^0.33, cubic root of 1.44, equal to 1.1292. The volume of 10.8 e^3, must be divided by 1.44 in order to be expressed in units of Tsipori; this gives 7.5 e_t^3 or 2e_t * 2e_t *1.875 e_t. Practically we can express all three dimensions of volume in units of Tsipori and divide either one of the dimension by 1.44 or each of the dimension by 1.1292. The first solution gives 2e_t * 2e_t *1.875 e_t, the second solution would give 1.77e_t * 1.77e_t * 2.39 e_t or with a slight excess 1.8 e_t * 1.8e_t * 2.4 e_t. Tossafot uses the first method, but the division by 1.44 is performed in dividing two times by 1.2. The first division gives 13.5/6, the second division gives 11.25/6 or 2 - 0.75/6. Tossafot observes that the result, 1.875, is bigger than the value of the Yerushalmi, 2-1/6 by 0.25/6.
A third part beginning with וכמו כן צריך למעט must be suppressed ; it is out of the context. We will however come back later to this passage which was accidentally introduced into the Tossafot by an editor who did not clearly understand the problem.
A fourth passage begins with ועוד מפרש דבירושלמי. It proposes to work in natural units, or units of Moses, and to consider the volume described in the Talmud of Jerusalem as a cylinder of 1.833e height with a circular basis circumscribed to a square of 2e sides. The basis has an area of 2π and the volume is 1.8333 * 2π = 11.519 e^3 instead of 10.8 e^3. The theoretical height of the cylinder should be 1.7189e. Tossafot find 1.8e and say that the difference with 1.833 is slight.
Let us come back to the third part. It says that the circle inscribed in the square of side equal to 2 e_t (etsba of Tsipori) is slightly greater than the square of side equal to 2 e (natural etsba).
The area of the circle is π * e_t^2 = π 1.1292 e * 1.1292 e = 4.0061 e^2.
The area of the square is 4 e^2. The difference is 0.0061. Tossafot gives a difference of 1/9 = 0.111.
In other words, Tossafot writes that π * (1.44) ^ 2/3 = 4.111 instead of 4.0061. This result is impossible to find with π = 3. It would give 3 * 1.17 * 1.17 = 4.111, but (1.17) ^3 = 1.60 instead of 1.44! I suppose that they used π = 22/7 and (1.44) ^ 1/3 = 1.144. Anyhow, the result is remarkable and proves that they were able to proceed by trial and error to find a good approximation of the square of a cubic root. When it was necessary, they could use a better value than 3 for π. Now this proves also that they were well aware that the etsba of Tsipori is equal to about 1.1292 e, and not as has been suggested, to 1.44 e. But what was the

original purpose of this interesting, but off-topic, passage? Perhaps this passage was part of a mathematical development of a Tossafist proving that the reviit can be considered a cylinder with a circular basis inscribed in the square with a side of two etsba and a height of 2.4 etsba. This last detail has probably been lost to the editor, and this passage has been introduced. It is perhaps the testimony of a greater ability, in calculus, of the Tossafists that one can believe.

[69] In Y. Sota VII: 5 (32b in the edition of Vilna) the commentary Korban ha Eda writes clearly that 40 seah means the weight of 40 seah of water.

[70] See B. Baba Metsia 80b and B. Sabbath 52 b.

[71] In B. Sota 24a, Tossafot גמירי brings a quotation of the Y. Sota VII: 2 stating this fact.

[72] He was an Italian Rabbi of South Italy, (about 1090-1160), from the town of Siponto in Apulia. He is the author of one of the first commentaries on the Mishna. His commentary was known in France by R' Tam, Rash and Rabad of Posquière.

[73] R' Yom Tov Lipman Heller (Tossefot Yom Tov ad locum) believes one cannot raise this sheaf of corn because of its important volume and not because of its weight. He rests on the weight of 40 seah that the men were able to raise under Joshua. R' Moses Zacuto in Hidushei ha Remez retorts that the data connected with the generation of Joshua is an exaggeration; the reason here is that it exceeds the weight that a man can raise at once.

[74] R' Solomon Sirilio was a Spanish Rabbi, expelled in 1492 from Spain. In about 1544 he succeeded R' Levi ben Haviv as Rabbi of Jerusalem. He is celebrated as a commentator on the Talmud of Jerusalem.

[75] We can write: 2 seah = 48 log = 96 littra = 96 * 96denarius = 96 * 96 * .00341 = 31.42 kg. According to the approximation of the Talmud of Jerusalem, Y. Terumot X: 8, the weight is 96 * 100 * .00341 = 32.74 kg.

[76] R' Israel Lifshitz, in his commentary Tiferet Israel, has proposed another explanation. He understands literally: a sheaf of corn in which there is two seah of grains of wheat. If we consider two seah of Moses, their capacity is about 26.26 l. We know that one sah gives about 8 t of grain of wheat (density about 0.78) and 5 t of straw (density about 0.15). Thus two seah of grain weighs: 26.26 * 0.78 = 20.48 kg. The total weight of the sheaf of corn is 20.48 * (13/8) = 33.28 kg. This result is of the same scale of sizes as the first explanation. Nevertheless this explanation, at first glance nearer to the text of the Mishna, actually seems farfetched because we must value the sheaf of corn according to its supposed production of grain and not according to its own characteristics (i.e. its weight). It is possible that this explanation was inspired by the commentary of R' Moses Zacuto: Kol ha Remez, who takes into account the weight of the grain and the weight of the straw.

[77] This is the reason why the Remez, R' Moses Zacuto in his commentary on the Mishna, he follows the system of little units of Maimonides, and considers the weight of the grain and the weight of the straw. In order to understand his commentary we must mention that in Venezia, there were three pounds, 1° the little pond (libra sottile) for the chemists of about 301.2 gr. and the corresponding ounce of 25.1 gr. 2° the libra or pondo del marco for gold and silver of about 358 gr. and the corresponding ounce of 29.83 gr.and 3°the libra grossa of about 476.4 gr. and the corresponding ounce of 39.7 gr. see Grande Dizionario Enciclopedico UTET, entry: misura, p 759. See Weiss (1984) p. 33. The Remez writes that an Egyptian man, an expert in measures, told him that the Issaron meal weighs about 4 Venetian pounds and therefore 2 seah , 6.6667 times more, about 26 libra grossa (more exactly 26.667 pounds), corresponding to 12.7 kg. This is actually a weight which is easy to raise. But if you add the weight of the straw, you will get three times more or 3 * 26.667 = 80 pounds or 38.1 kg and an average man cannot raise it. Actually two seah of Egyptian meal, according to Maimonides, weighs 74.375 * 4 * 48 * 0.667 = 9.52 kg, less than the 12.7 kg of the Remez. It is likely that the Egyptian man had spoken of libra del marco, leading to a weight of 26.667 * 0.358 = 9.55 kg (a good estimation of an expert) but the Remez had taken the libra grossa, leading to a more advantageous value. This commentary of R' Moses Zacutto is also brought in Shoshanim le David on Tossefot Yom Tov Peah VI: 6. This passage shows the quasi veneration of R' David Pardo for R' Moses Zacuto, see with a play of words the expression זכותו יגן עלנו, and the contempt against R' David Corinaldi.

[78] Rav Judah bar Ezekiel

[79] A contemporary of Rav Judah bar Ezekiel

[80] Rav Judah bar Ezekiel

[81] The Sefer ha Hinuh is an anonymous book written in Barcelona in the 14th century, which gained much popularity.

[82] This Talmudic passage has already been considered by R' Israel Meir Kagan in Biour Halakha Orah Haim 271: 13. He mentions that כמלא לוגמיו is the volume of an egg (about 50cm^3) and that מלא לוגמיו is the volume of two eggs (100 cm^3). He concludes that a reviit is still today comprised between one and two eggs, in contradiction with the thesis of R' Ezekiel Landau of Prague. If the latter was right, the capacity of the mouth should be more than three eggs, if as he states, eggs diminished by half. Of course this argument is also against the theory of the Hazon Ish, who shares a similar opinion. The latter (Kabalat ve hakhnassat Sabbath 15) objects that the maximum capacity of the mouth is indeed more than three eggs. Therefore the Talmudic passage, understood according to the classical exegesis of Rashi and Tossafot, does not contradict his theory of the big reviit. We propose below to accept that a mouthful is less than a reviit without contradicting the theory of the big reviit. At the end of the redaction of this paper, Eng. Y. Loewinger has referred me to the commentary of Tossafot Rid on B. Yoma 80a, giving a similar explanation. Although different than my proposition, it grants it legitimacy.

[83] Benish (1987) p. 271 remark 72, indicates the value of 109 cm^3.

[84] B. Yoma 80a, Toss beginning with הכי נמי
B. Pesahim 107a, Toss beginning with אמ טעם

[85] B. Yoma 80b, אם כן הוה ליה

[86] Rabbis living before the sixteenth century.

[87] There is also a parallel reference in the Jerusalem Talmud Terumot V, 1: קבא כמה עבד: עשרין וארבע ביעין how much is a kab? 24 eggs. Furthermore we find in Y. Terumot X, 1: כמה סאתה עבדא: עשרין וארבע לוגין .

[88] Already nearly a century before, R' Solomon ben Menahem Meiri of Perpignan noted on two occasions that the determination of volumes, for example for the taking of the Hallah, is safer when estimated by inches than by eggs. See Beit ha Behira Pesahim 109a (ומכאן אתה למד) and Erubin 83b (שיעור חלה הוא).

[89] Determined from the breadth of thumb (etsba); another available measurement of natural data.

[90] See Tashbeetz (Tshuvot Shimon Bar Tsemah), Part III: 33.

[91] It can be proved that until his time, and even much later, the whole Jewish world was using the data of Maimonides. We have already seen that Rashi and Tossafot considered, like Maimonides, little units of capacity. Furthermore, in a responsum sent by R' Isaac bar Sheshet of Valencia, the leading Rabbi of Spain, to his friend R' Vidal Ephraim of Majorca, the martyr (he was killed during the riots of 1391C.E.), also the revered and beloved master of R' Simeon bar Tsemah, in connection with miqvaot, R' Isaac writes that the volume of an average man is 20 seah and not 10 seah as proposed by R' Vidal. He added with some humor, that their difference came from the fact that each of them had made his estimation according to his own body. According to the value of Maimonides of 1 reviit = 74.375 cm^3, 10 seah = 960 * 0.074 = 71.4 l. Therefore we may assume that R' Vidal was an average man of 71.4 kg. (the density of men and animals is about 1 kg/l) while R' Isaac was more corpulent. It was probably a joke and an exaggeration when he said about himself that he had a volume of 20 seah and weighed about 140 kg. Anyhow, it is certain that he evaluated the seah according to Maimonides. Despite the doubt of R' Simeon bar Tsemah expressed about the Volume of the Jewish capacities, we never heard that he made any objection or disqualified a miqveh in Spain or in Algiers. As he was not tender with his older colleague, in Algiers, R' Isaac bar Sheshet, he would not have deprived himself of reacting.

[92] Already nearly a century before R' Solomon bar Tsemah, R' Solomon ben Menahem Meiri notes (Beit ha Behira, Erubin 83b and Pesahim 109a) that the measure of volumes from the etsba (Jewish inch) is safer than with the eggs. He doesn't mention any weight as Maimonides did.

[93] The problem was already raised in different instances. See Benish (1987) pp. 63-68 and Weiss (1984) p 372. See also the introduction to Mikraot Gedolot, Venice 1648.

[94] However, a century before, R' Yom Tob Lippman Heller noted already (see Madanei Yom Tov, Berakhot III: $30; 80) that the volumes of Y. Terumot X: 8 are three times the little volumes of Maimonides, more precisely 100/35 = 2.8571. This was actually already the same objection as that of the Noda bi Yehuda, asked differently. R' Heller did not have a precise estimation of the weight of the dinar of Maimonides and therefore he rested on his own measure of the weight of barleycorns. He had measured that 384 barleycorns weigh a pound of Prague (Lot) = 15.85 gr. 6.76% less than the 17 gr. of Maimonides. We have already seen in remark 38 that because of many approximations and the imprecision of the ratio 100/35 = 2.8571 was actually 1.834. Because of the impression of exaggeration it gave, this passage of the Talmud of Jerusalem was not generally taken seriously; it was considered as a particular opinion, not followed by the Rabbis and by Maimonides (see Shoshanim le David , Peah VI: 6).

[95] In his commentary on the Mishna, Beit David, published in 1742, R' David Corinaldi thought that he had demonstrated that halakhik eggs cannot be the eggs of a hen. He articulates this is Y. Terumot X: 8. one litra weighs 100 dinar. Like Tossefot Yom Tov, he does not know the weight of the dinar, but he knows that one dinar is 96 barleycorns; he assimilates these barleycorns with Venetian grains and he can then write that one litra is 9,600 grains and one egg is 3,200 grains. In the Venetian system 1 uncia del marco = 144 carats = 576 grains. Therefore 1 egg = 3200/576 = 5.555 uncia del marco = 5.555 * 29.83 = 165.7 gr. This egg is surely not the egg of a hen, he says. References: Beit David Peah VI: 6; Terumot X: 8, Kelim XVII: 11and Baba Metsia VI: 5. It should however be added that in so doing, R' David Corinaldi has still increased the "exaggerated" value of the Talmud of Jerusalem by 17 percent, increasing the exaggeration from 156 percent (2.8571/1.834) to 182 percent. Indeed the barleycorn of Maimonides weighs 17/384 = 0.00443 gr. while the Venetian grain weighs 29.83/4*144 = 0.0518 gr.

[96] In fact the box was a modius in which one can store 96 eggs. The 144 eggs must be the result of a multiplication by 1.5 in order to take the heap into account.

[97] This solution has been suggested by Bornstein (1887). The glory of this discovery is to his credit.

[98] And not 3.

[99] And not 10.8.

[100] We have seen that there is a little margin of incertitude, as the sextarius ranges between about 545 cm^3 and 566 cm^3.

[101] R' Solomon Ben Menahem Meiri notes this fact very clearly in Beit ha Behira, Erubin 83b, last paragraph before the second Mishna. He writes: "As we have no more the measures of Moses, of Jerusalem and of Tsipori, we must come back to the evaluation in eggs."

[102] R' Tsvi Hirsh Eisenstadt (Warsaw 1901- New York 1966) was an important Talmudic scholar, devoting much time to studying the works of Nahmanides. He had the same age as my late father R' Eliezer Ajdler (Warsaw 1901- Brussels 1998) and they were friends from heder.

[103] In Mishna Bekhorot VIII : 8, we find the following data:

1 Egyptian dirham = 61 barleycorns. (1)
1 sela = 6.25 dirham + 0.25 kirt (2)
5 sela = 31.5 dirham (3)
30 sela = 188.875 dirham (4)
50 sela = 314.75 dirham. (5)

All these relations prove that the dirham weights indeed 61 barleycorns. The second relation is however problematic. Indeed 1 sela = 384 barleycorns. In the second member 6.25 dirham + 0.25 kirt = 6.25*61 + 1 = 382.25 barleycorns. The approximation is relatively important; the exact equation is
1 sela = 6.25 dirham + 0.6875 kirt.
In Kaftor ve-Ferah (ha-Mahon le- Limudei ha-Aretz, Vol 3, 1997, p. 217) the author mentions the contents of Maimonides' commentary. The first equation is mentioned, 1 Egyptian dirham = 61 barleycorns.. The second relation is brought slightly differently: 1 sela = (6.25 + 1/16) dirham. This equation is also approximate and should be 1 sela = (6.25 + 1/22) dirham.

[104] Maimonides' commentary on Mishna Bekhorot VIII : 8..

[105] Maimonides' commentary on Mishna Eduyot I : 2.

[106] The text is according the Vilna-Warshaw edition.

[107] This was the reading of the edition of Radvaz, he was puzzled and considered the possibility that Maimonides had a different reading in the Mishna. The correct reading is : מקב וחצי as mentioned in the edition Shabtai Fraenkel.

[108] Hilkhot Bikkurim VI: 15.

[109] Or occasionally to the provincial dinar.

[110] This denomination of the dirham fits different coins or weights;.

1. A dirham or a zouz of 16 barleycorns; see Mishna Baba Kama IX; 7 (zouz), Mishna Peah VIII; 7 (zouz), Mishna Kiddushin I; 1 (dirham), Mishna Bekhorot VIII; 8 (dirham). Thus 1 dirham = 1 zouz = 16 barleycorns.
2. A dirham of 36 barleycorns: see Mishna Sheviit I; 4 (dirham).
3. A Egyptian dirham or Egyptian zouz weighing about 2.70 gr.

[111] Hilkhot Bikkurim I ; 15.

[112] Kessef Mishneh on Hilkhot Bikkurim VI: 15 and on Hilkhot Kelei ha-Mikdash III: 3.

[113] Shulhan Arukh Yoreh Deah 294, 6: 1 Maah weighs 16 barleycorns = 0.25 dirham and Shulhan Arukh Yoreh deah 305, 1: 5 Sela = 120 Maah = 30 dirham.
[114] One Babylonian dirham = 0.7 Dinar. See Rashi, B. Bekhorot 49b and 50a.
[115] Maimonides adopted a similar position in the counting of the sabbatical year. See Hilkhot Shemita ve Yovel X: 6.
[116] Weiss (1984) makes a similar assumption p. 201.
[117] 520/28.8 = 18.06 Dirham/reviit. The issaron is 7.2 log or 28.8 reviit.
[118] This represents 336 Dinar or 1428 gr. The weight of the issaron in the Mishna was 520 * 61/96 = 330.417 dinar = 1404.27 gr.
[119] The weight of the issaron of Egyptian meal has increased from 520 * 61/96 * 4.25 = 1404.27 gr. to the weight of 520 * 64/96 *4.25 = 1473.33 gr.
[120] In the Mishna this density was 18/27 = 0.6667, now it is (4.25*520/1.5) / (28.8 * 74.375) = 0.688. In the last formula the numerator is the weight in gram of an issaron Egyptian meal and the denominator is the volume of an issaron = 7.2 log = 28.8 reviit.
[121] See Hilkhot Sefer Torah IX : 9.
[122] The mile is 2000 cubits ; see Hilkhot Tefila IV: 2 and his commentary on Mishna Yoma VI: 4.
[123] Grienfeld, A.Y. (1986). תחומין התאמת האגודל ליתר אמות המדה. Alon Shavut.
[124] Or at least an upper limit of this length.
[125] The opinion of Rashi seems to agree with this value; see Rashi on Ex. 21: 12 and Ex. 25: 39. See also Rashi on B. Bekhorot 49b.
[126] Mishna Kelim XVII: 10 and B. Baba Batra 14a.
[127] Hilkhot Kiddush ha Hodesh XI: 17.
[128] Hilkhot Kiddush ha Hodesh V: 10 and 11 in conjunction with Hilkhot Kiddush ha Hodesh III: 13.
[129] See Weiss (1984) pp 333-334.
[130] Hibbur, Hilkhot Evel VII: 4.
[131] It is generally accepted that the Greeks had a good knowledge of the size of the earth. Eratosthenes (284-192 BCE) was noted for having determined the size of the earth. Cleomedes (1st century BCE) gave an extensive description of the method used. In the town of Syene (Assuan) the bottom of a deep vertical pit was illuminated by the sun only on the longest day of the year so that the sun then stood exactly at the zenith. In Alexandria, situated farther north, at about the same longitude, the shadow cast on a hollow sundial on that day was 1/50 of the total circle (an angle of 7.2°). Thus the distance between the two towns must be 1/50 of the circumference of the earth. Since the distance was estimated to 5000 stadia, the earth's circumference must be 250.000 stadia. In modern times there has been much discussion on the length of the stadia used. If we take 157 m as the most probable value, Eratosthenes' result of 39250 km comes very near to the true figure. Cleomedes mentions also Posidonius (1st century BCE) as having applied a similar principle and found a circumference of 240.000 stadia or 37680 km. A last measure of the earth's size is the measure of Ptolemy (~ 90 ~168 CE). He found a circumference of 180.000 stadia, but the stadia are different than those used in the former measures. It is not impossible that this last measure was never performed and was the measure of Posidonius adapted to a stadia of ~ 210 m. Anyhow it is generally accepted that the ancients had a good knowledge of the size of the earth. See G. Bigourdan (1851-1932): L'Astronomie, Flammarion, Paris 1916 and A. Pannekoek (1873-1960) A History of Astronomy, Dover, N.Y. 1989.
[132] There was much confusion in Arab geodesy about the meaning of the mile once the exact meaning of the Roman mile was forgotten. Some considered in their geodesic measures 56.66 miles per degree of meridian (Arab mile of 1972 m), others 66.66 miles per degree (Arab mile of 1666,66 m) and others considered 75 miles per degree (Arab mile of 1481.5 m). Because of this confusion about the mile used, new measures of the dimension of the size of the earth were undertaken under Caliph al-Mamun (786-833 CE). His astronomers found that 1° of latitude equals 56 2/3 Arabic miles, each of 4000 "black ells" of 0.493 m. Thus 1° of latitude measures 56.66 * 1.972 = 111.746 km and the circumference of the earth must be 40229 km.
[133] Maimonides writes in the introduction to his Commentary on the Mishna that the circumference of the earth is 24000 miles. Maimonides certainly refers to an Arab mile of 1666.66 m, 66 2/3 miles per degree. This indication is parallel to the dictum of Rava in B. Pesahim 94a according which the circumference of the earth is 6000 Parsah or 24000 miles. If we consider that Rava still used Roman miles this would correspond to a circumference of 35556 km i.e. an undervaluation of about 10%.

[134] This is not without interest; the Roman mile is equal to 2,828.43 Jewish cubits and to 3,000 Arab cubits.
[135] P 254.
[136] In parentheses, my correction.
[137] P 254.
[138] Weiss (1964) p. 245 brings examples where, for example, the expression: 2 amot * 2 amot represents a circle: B. Erubin 56b or Tossafot in B. Pesahim 109a (Reviit). But here Maimonides writes explicitly: length, breadth and height.
[139] They must ride horses, rather than donkeys, to be able to cover such a distance per day. See the following reference relative to the annulment of the fixation made by Hanania, the nephew of Rabbi Joshua. The annulment was announced by messengers riding horses .קם, רכב סוסיא, הן דמטא מטא והן דלא מטא נהגין בקילקול. Y. Sanhedrin I: 2 (6a in the edition of Vilna) and Y. Nedarim VI: 8 (23a in the edition of Vilna). Even if the donkey was more common, (see II Regum IV: 22 and 24) we see that they used horses for the announcement of the new moon.
[140] This passage comes from a letter of Maimonides to R' Samuel ben Judah Ibn Tibbon, See Iguerot ha Rambam, Edition Isaac Shilat, p 550. This passage can be found in English translation in Encyclopedia Judaica Vol 11, p 757.
[141] This paragraph aims at explaining some Talmudical passages, considered above, according to Maimonides. Indeed we had considered them as justifiying the great measures and we feel obliged to reexamine them according to Maimonides.
[142] H. Erubin I: 9.
[143] According to B. Erubin 80b. The correct version is discussed: see Meiri, Rashba and Ritva ad locum.
[144] H. Erubin I: 9, one dried fig has the volume of 1/3 egg and the 18 figs represent a volume of six6 eggs.
[145] H. Erubin I :10 according to Mishna Peah VIII: 5.
[146] This explanation seems likely. First Maimonides rules also that a kav of fresh dates represents also two meals. Second if we refer to the Mishna Terumot IV: 10,בדורס ליטרא קציעות על פי הבד , Maimonides explains: ליטרא משקל ידוע וקציעות התאנים היבשות ואומר כי מי שלקח ליטרא תאנים מתרומה וכשתן ונתנן על פי כד..... Maimonides explains that litra refers to the weight of the fresh figs. I do not know why he feels obliged to consider a litra weight, contrary to his principle, expressed in H. Erubin I: 12.
[147] See Genesis XVIII: 6.
[148] Reference: the big Encyclopedia Larousse, 7 Vol, undated, about 1905.
[149] The problem of the Talmudic weights is a whole chapter in itself. We give for the moment some elements necessary to understand the present chapter.
[150] Grande Dizionario Encyclopedic Utet.
[151] See Weiss (1984) p. 28.
[152] In this paper, all the Latin units used will be used in the nominative singular form.
[153] Those Rabbis who follow the theory of the Gaonim (shekel of 17 gr. instead of 14.16 gr.) explain that the units of weight and coins of the generation of Moses were equal to the Roman units: See R' Samson ben Abraham of Sens in Mishna Sheviit I: 2. Maimonides, ibidem seems to refer to the equality between the units of the time of the Talmud to those of Italia shel Yavan, the Grecian Italy (Sicily) under Grecian influence, corresponding to the Greek units.
[154] Boeckl mentions the existence in the Roman system of measures of weight, of the mina (of Greek origin) of 100 denarii, often confused with the Roman libra of 96 denarii.
[155] Lex Silia de ponderibus publicis (244-204 B.C.E.) Publica Pondera. Festus, L.
[156] Priscanus Medicus : Carmen de ponderibus et mensuris.
[157] A pondo of 327.45 gr. gives an Uncia of 27.29 gr. and a denarius of 3.41 gr. This last value is a little weak with regard of the weight of the Selaim of the two revolts. On the basis of these weights a denarius of 3.54 gr. would fit better. For this reason Weiss (1984) pp 25-29 prefers to adopt the congius of Greaves of 3,405.88 gr. a sextarius of 567.5 gr. a libra of 340.59 gr. a mina of 354.78 gr. and a denarius of 3.55 gr. I personally prefer to remain cautious and do not stray from the universally accepted value of the pondo of 327.45 gr. It is actually possible that the Sela or Talmudic Shekel weighed about 14.16 gr. and the dinar 3.54 gr. according to the Tyrian standard. But after the end of activity of the Tyrian mint and the increasing importance of the Roman standard the difference between the Roman denarius of 3.41 gr. and the Tyrian dinar of 3.54 gr. was neglected. This is the explanation why during the revolt, Roman coins of one or two denarius were restruck into Jewish coins. In other words it is possible that the Roman denarius was actually

3.41 gr. and the Tyrian dinar was 3.54 gr. Nevertheless the difference was considered negligible and both were assimilated.