Talmudic Metrology I:
The Mile as a Unit of Length

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Abstract

It is generally accepted in the rabbinic world that a mile is equivalent to 2,000 cubits and represents a length ranging from about 900 to 1,160 meters. In this paper, we intend to prove that the mile mentioned in the Talmud is actually always the Roman mile of about 1,481 m.

To find the definition of the cubit, we derive from the Mishna Yoma VI: 4 and 5, that the limit of Sabbath is a Roman mile, which is equal to 2,000 $\sqrt{2}$ *cubits. This would correspond perfectly to the opinion of R' Tam on the matter if it were not for the definition of the mile, which he considered equal to 2,000 cubits based on Rashi's interpretation.*

We analyze a number of Talmudic passages to show that they are compatible with our thesis. We further analyze a variety of Midrashim to determine at what stage the mile of 2,000 cubits length first appeared—in other words, when they forgot that the mile is the diagonal of 2,000 cubits, i.e., 2,000 $\sqrt{2}$ *cubits, and identified it instead with 2,000 cubits. We analyze two contradictory piyutim of R' Eleazar ha- Kalir and try to reconcile them on the assumption that he was still aware of the true definition of the mile. Finally, we show that the cubit of 0.524 meters, deduced from the mile, is compatible with the supposed height of the average man in the Talmudic period, according to the Talmudic saying that men have a height of three cubits.*

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I. Introduction

The units of length used in the Talmud are well known and do not give rise to any controversy about their relative values.

Units of length:
1 parsah = 4 miles
1 mile = 2,000 amah (cubit)
1 amah = 6 tefah (breadth of the hand)
1 tefah = 4 etsba = 4 agoudal (thumb)

Problems begin when we try to express these lengths in absolute values, for example, in the metric system. For nearly the past century, the accepted value of the etsba ranges from 1.90 cm[1] to 2.4 cm.[2] The first value is derived from the volumes of the reviit[3] and of the egg[4] deduced from data given by Maimonides,[5] and the second value represents the average breadth of men's thumbs. By contrast, in the nineteenth century and in the first decades of the twentieth century, the accepted value for etsba was 2.2 cm. The supposed length of the etsba has thus varied throughout history and also from region to region.

Opinions regarding other Talmudic units of length have varied similarly, and indeed rabbis in Russia or those under Russian influence considered the Jewish mile to be equal to the Russian itinerary unit, the verste[6] (1,067 m).[7] As a result, there is much confusion and concomitantly a broad margin of uncertainty about the true length of the Talmudic mile.

In the present paper, we reexamine the question and show that the uncertainty about the true values of the Talmudic units of length is of post-Talmudic origin. In the Talmud, there is no doubt and no controversy about these lengths. This paper rediscovers these lengths based on distances expressed in the Talmud in miles.[8]

II. Distances Expressed in Miles in the Talmud

A few distances between towns are expressed in miles in the Talmud. By comparing these measurements to modern measurements, where possible, we can obtain likely values for the Talmudic mile.

A. The Distance Between Modiim[9] and Jerusalem

1. Talmudic References.—B. Pesahim 93b is concerned with the distance between Modiim and Jerusalem, because anyone who is beyond Modiim on the eve of Passover at sunrise[10] is considered to be sufficiently far away,[11] as to be exempt from going to

Jerusalem to sacrifice the paschal lamb. Such a person is permitted to postpone the sacrifice until the following month (Pessah Sheni).

It is clear in the Talmud that, according to Ulla, the time necessary to walk from Modiim to Jerusalem is six hours. Concerning the distance between Modiim and Jerusalem, the Talmud also introduces Ulla's testimony that the distance is 15 miles. Due to the fact that this data can be verified and also probably to the fact that Ulla traveled much and was therefore reliable,[12] it has always been accepted that the distance between Modiim and Jerusalem actually is 15 miles.[13] This is despite the fact that another part of Ulla's statement was rejected[14] and that the Talmudic passage[15] apparently settles on a distance of 20 miles between the cities.

Modiim is also mentioned in B. Hagiga 25b, where Rashi writes that Modiim is located 15 miles from Jerusalem, as is mentioned in B. Pesahim.[16]

2. *Later References to Modiim*.—Modiim is mentioned in Kaftor Vaferah,[17] chap 11.[18]

למערב בית שען כמו שעה היא מודיעית הנזכרת במסכת קידושין פרק האומר גבי אמו של ינאי המלך, דאמרינן אמו נשבית במודיעית. ואין זה מודיעים הנזכר סמוך לירושלם, שהרי מודיעית לחוד ומודיעים לחוד, וקורין לה מידעה, ואמרינן פרק מי שהיה טמא, אמר עולא מן המודיעין ולירושלם חמישה עשר מילין הויא, והוא קרוב למהלך חצי יום, כי היום כלו הוא מהלך מ' מיל.

Kaftor Vaferah seems to consider the town of the Maccabim, which he calls Modiit,[19] to be a few kilometers west of Beit Shean, while the Modiim of the Talmud Pesahim seems to be near Jerusalem. It is not certain whether Midda, mentioned by Kaftor Vaferah, refers to Modiit or to Modiim.[20] R' Y. Schwartz[21] held that it refers to Modiim, which he places at a distance of 4.5 hours from Jerusalem.[22] According to him, there were three different places: Modiit near Beit Shean; Modiim of Pesahim and Hagiga, near Jerusalem[23]; and Har Modiim of the Hasmoneans, which he places near the Arab village of el-Midyeh.[24] This opinion is accepted by two editors of Kaftor Vaferah, R' A.M. Luncz (1897) and R' Y. Blumenfeld (1954). However, the last edition of Kaftor Vaferah admits that there exists only one common place corresponding to el-Midyeh,[25] about 10 km east of Lod, and this is also the opinion of Pinhas Neeman (1972) and Prof. Z. Vilnai (1997).[26]

3. Analysis.—Modiim had already been described as east of Lod (Diaspalis) by the early Christian writer Eusebius[27] and it was also placed east of Lydda on the Madaba map.[28] The supposed historical site of Modiim is represented on the new road atlas of Israel (scale 1:100,000): 28, J17, east of Maccabim Junction, and it is thought to correspond to the town of the Hasmoneans. The straight distance between Modiim and Jerusalem is about 28 km, and the road distance, taking into account the deviations of the roads, must be at least 30-31 km. This corresponds to a distance of 20 Roman miles.[29] At a speed of 18 minutes per mile,[30] it takes six hours to travel this distance. As the conclusion of the Talmudic discussion is indeed that it takes 18 minutes to walk a mile,[31] a distance of 20 Roman miles between Modiim and Jerusalem is a proper conclusion. Thus, Ulla's estimate of the walking time is vindicated, though his estimate of the distance is not. In any event, the mile considered in this Talmudic passage is equal to a Roman mile.[32]

B. The Distance Between Tiberias and Tsipori

The distance between Tiberias and Tsipori is listed as 18 miles in the Jerusalem Talmud and in the Midrash.[33] The distance as the crow flies is about 25.15 km. Therefore, a true ground distance of 18 Roman miles (18*1.4815 = 26.667 km) is very likely.

C. The Distance from Kfar Khananya to Tsipori

According to B. Behorot 55a, the distance from Kfar Khananya to Tsipori is16 miles. The historical site of Kfar Khananya[34] is represented on the road atlas of Israel: 5, P6 and Tsipori on the same map: 9, M8. This distance, measured on the Israeli map, is about 23.2 km. The road distance is then about 25 km, a little more than 16 Roman miles.

D. The Distance from Tsipori to Kfar Otnai

According to B. Behorot 55a, the distance from Tsipori to Kfar Otnai is 16 miles. According to the Encyclopedia le Geographia Talmudit, t II, Kfar Otnai is identified with Kfar Lajun, 1.5 km south of Megido. On the Israeli road map, there is mention of the ruins of Kfar Otnai: 15, L9. The distance from Tsipori is about 21.75 km for the straight distance, and therefore a ground distance of about 24 km or 16 Roman miles remains likely.

E. The Distance Between Khziv and Sulama de Tsur (or Sulamei Tsur)

The distance between Khziv and Sulama de Tsur (or Sulamei Tsur) is three Roman miles. Khziv is a small place at the mouth of the river Nahal Khziv, north of Acco. It is mentioned in Tanah,[35] Mishna,[36] Tossefta,[37] Talmud,[38] and Maimonides.[39] There is no doubt about its location.[40] It must not be confused with another town of the same name in the territory of the tribe of Judah.[41]

Sulamei Tsur, literally, the ladder of Tyre, designates the steep road of steps cut in rock, which connected the territory of Acre with that of Tyre and formed part of the coastal road passing the twin capes of Rosh ha-Nikra (Ras en Naquira) and Rosh ha-Lavan (Ras el-Abyad). It also designates a little village at the foot of the cape of Rosh ha-Nikra which must correspond, more or less, with Kfar Rosh ha-Nikra. It is mentioned in several locations in the Talmud.[42]

From the account of a journey of Rabban Gamliel, originally from Acco to Khziv, but continued until Sulamei Tsur, we learn that the distance between Khziv and Sulamei Tsur is 3 miles.[43] This distance is about 4.5 km,[44] and therefore we are again dealing with the Roman mile. The account of this journey has been reproduced, with slight variants, several times in the Talmudic literature, because of the various teachings deduced from it.[45]

F. Distance from Jerusalem to the Rock

Mishna Yoma: VI:4 and 5 says that the distance from Jerusalem to the rock is 90 ris, as the carrier of the scapegoat covered a distance of 90 ris between the Temple and the rock. The Roman mile was divided in 8 stadia, but in Jewish and Arab metrology (and even in some Roman sources) it was divided in 7.5 ris[46]; 90 ris are equivalent to 12 miles, which was the width of the camp of Israel in the desert and the maximum distance permitted on the Sabbath by biblical law. All the people who went part of the way to the rock with the carrier of the scapegoat walked one mile, a Roman mile, corresponding to the limit of the Sabbath according to rabbinical law. In B. Yoma 67a, there is a divergent opinion of Rabbi Judah and Rabbi Jose, according which the distance is only 10 miles.

G. Distance Between Jerusalem and Jericho

The distance between Jerusalem and Jericho is 10 parsaot.[47] The straight distance between the towns is about 24 km, and the road distance cannot be more than 30 km or 20 Roman miles, which equal 5 parsaot. Perhaps we have here a transcription error[48] or an exaggeration, as is often the case with Rabbah bar Bar Hannah.

H. Distance from Beitar to the Sea

Rabbi Johanan says the distance from Beitar to the sea is 40 miles.[49] The ruins of Beitar are represented by the road atlas of Israel at: 29, L19, west of Batir. The distance between Beitar and the sea is about 46.75 km. It is possible that the mentioned distance concerns the distance covered by the blood of the victims of Beitar along the Nahal Sorek stream as it flowed to the sea, and therefore the distance is much longer than the straight distance and represents the length of the river's path to the sea. This distance seems more compatible with 40 miles or about 59.25 km.

I. Distance Between Ono and Lod

The distance between Ono and Lod is 3 miles.[50] Ono and Lod are two old neighboring towns which are known from the period of the Second Temple.[51] Ono is considered a fortified town from the time of Joshua.[52] According to Neeman (1972), the old town of Ono corresponds to the Arab village of Kfar Ana, 9 km from Lod. The distance of 3 miles mentioned in the Talmud is equal to 4.5 km, but, according to Pinhas Neeman, there is another reading in the text of Ketubot: it may read 5 miles, which better corresponds to a distance of 7.5 km.

J. Other Distances

There are many other distances expressed in miles in the Talmud, but it is not possible to use them to confirm our thesis because the places are not known with precision:

- The camp of Israel from Beit ha-Yeshimot until Evel ha Shitim is 3 parsaot or 12 Roman miles.[53]
- The distance between Migdal Lougia and Tiberias is 1 mile.[54]

- The distance between Hamtan (warm springs) and Tiberias is 1 mile.[55]
- The distance between Jerusalem and Beit Khidoudo is 3 miles.[56]

K. The Talmudic Mile

The mile, in Hebrew מיל, is a unit which was borrowed from the dominant Roman civilization. Its meaning is 1,000 double steps (the distance between the extremity of the heel of one foot and the next position of the same heel as one walks). More commonly, the mile is 2,000 steps (the distance between the extremity of the heels[57] as one walks or, in other words, the distance between the right heel and the left heel while walking).

In the rabbinic tradition, the definition of the mile seems different: it is the length of 2,000 cubits. It is only incidentally, thanks to the dictum of Rav Nahman (B. Erubin 42a), that we know that the length of a normal step is a cubit. The mile is then also 2,000 normal steps. It is generally agreed that the Talmudic mile ranged between 900 and 1,150 meters, according to the length usually adopted for the Talmudic cubit. The Talmudic mile would then be a proper Talmudic unit, without doubt inspired by the definition of the Roman mile but completely independent of it.[58]

But now we have seen that in the Talmud, the different measurable distances given in miles are actually expressed in Roman miles. Borenstein (1885) therefore thought that the two miles, the Roman and the Jewish miles, are used simultaneously in the Talmud. This conviction of Borenstein was founded on an erroneous estimation by him of the distance between Modiim and Jerusalem. Indeed, although he correctly placed Modiim 10 km east of Lod, he incomprehensibly estimated the distance from Modiim to Jerusalem at only about 22.5 km (instead of the actual minimum of 28 km), corresponding to 15 Roman miles or 20 Jewish miles. Thus, Borenstein proposed to explain the contradiction between Ulla and Rabbi Judah in B. Pesahim 94a by saying that Ulla fixed the distance between Modiim and Jerusalem at 15 Roman miles, while Rabbi Judah fixed it at 20 Jewish miles. Beside the fact that this ingenious solution is actually based on a material error, the conclusion of Borenstein is impossible. If this were the explanation of the divergence between Ulla and Rabbi Judah, the Talmud would not have rejected the opinion of Ulla without emphasizing this point. The Talmud does not actually recognize the existence of two different miles.

For this reason, we propose another solution: that there has never been a Jewish mile, and that the Talmudic mile is the Roman mile. The Rabbis of the Mishna presumably understood that the only way to give a future to Judaism was to express the different units of measure—of volumes, capacities, weight, and money, but especially of length—according to the Roman standards.

In summary, contrary to the generally accepted opinion,[59] all the miles considered in the Talmud are Roman miles. Nevertheless, this seems to have been forgotten very soon thereafter.[60] This important conclusion[61] requires that we reexamine all distances, especially those expressed in cubits, to find the relation between the mile and the cubit.

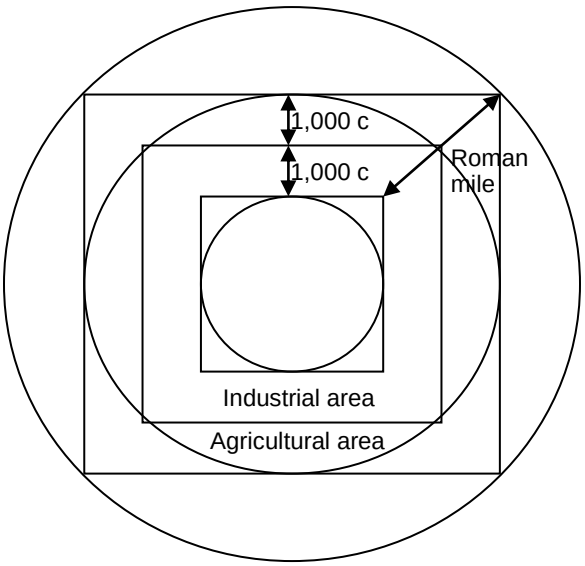
III. The Cubit in Biblical and Talmudic Literature

A. The Industrial and Agricultural Area Around the Levitic Towns

The distance of 2,000 cubits is mentioned in Num. 35:5 in the context of delimiting the agricultural and industrial areas around the Levitic towns. The Levitic towns were surrounded by a 1,000 cubit-broad ring reserved for industrial activities and by a second ring, immediately beyond the first, which was of the same breadth and which was reserved for agriculture. Both rings together had a breadth of 2,000 cubits.[62] If the town had a circular shape, then we consider the square that circumscribes it. The industrial sector then comprises the area between this first square and a second, concentric square, of which the sides are distant from the sides of the little square by 1,000 cubits; and the agricultural sector comprises the area between the large second square and a new, still-larger, concentric square, of which the sides are distant from the sides of the second square by another 1,000 cubits. The area between the smallest square and the greatest square thus makes up the artisan area (the industrial and agricultural areas together) of the Levitic town. If the town were reduced to a point, then the artisan area would form a square of 4,000 cubits per side.

Shown below is a scheme of a circular town: the smallest square, which circumscribes the smallest circle, is the basic border of the town. Around it we see a first square band which represents the industrial area of the Levites and a second, external, square band, which represents their agricultural area. As we will see in the next paragraph, the laws of the limits of Sabbath, regarding to the distance that one may walk, are derived from the laws of the Levitic towns and from the configuration of their artisan areas.[63]

In this scheme, the largest square represents the domain in which one may walk according to Rashbam and most Rishonim. The circle which circumscribes this largest square represents the limit of Sabbath according to R' Tam, and the circle inscribed in this square represents the limit of Sabbath according to Rabbi Hanina ben Antignos.



B. The Area of 4 Cubits by 4 Cubits

According to the principle : ד' אמות על ד' אמות ברשות הרבים

in the public domain, one has a permitted area of 4 cubits by 4 cubits in which to walk and to carry (Mishna Eruvin IV:5; B. Eruvin 51a; and Tor Shulhan Aruch, Orah Haim 349:1 and 2).[64] The Talmud explains further that a man who goes outside the limit of Sabbath may walk during the Sabbath only in an area of 4 cubits by 4 cubits (B. Eruvin 48a).[65] The Talmud explains that he needs 3 cubits for his body and a 4th cubit to extend his arms and feet,[66] or according to another opinion, to take something from under his feet to put beneath his head. There is also a contradictory opinion of Rabbi Hanina ben Antignos, that the limit of 4 cubits by 4 cubits is a circle of which the diameter is 4 cubits.[67]

In Babli Eruvin 51a, it says

המעביר ארבע אמות ברשות הרבים אינו חייב עד שמעביר הן ואלכסונם

This passage is understood variously. Rashbam[68] and R' Moshe ha Kohen[69] and, according to Ritva,[70] R' Abraham ben David, understand the authorized area to be a square of 4 cubits by 4 cubits aligned with the cardinal directions (north, south, east and west). Accordingly, in the cardinal directions one may carry for a distance of 4 cubits, while in the diagonal directions one may carry as far as $4\sqrt{2}$ cubits.

Rambam[71] does not consider square limits but circular limits. He rules that one is authorized to carry for a distance of 4 cubits, in any direction, and if the distance is between 4 cubits and $4\sqrt{2}$, then it is forbidden but not punishable. If the distance is greater than $4\sqrt{2}$ cubits, then it is punishable.[72] Maimonides relies on the formal ruling mentioned above, from which we get the impression that it is not authorized lekhathila, but only bediavad, to carry for a distance greater than 4 cubits. But there is a parallel passage in Y. Eruvin IV:1:

כשהו נפנה נפנה מן הצד וכשהוא מתפלל לוכסן

It says of a man who went outside the Tehum, and who may therefore move only in the area of 4 cubits by 4 cubits:
When he turns, he turns to the side (he lays the excrement down on the corner of an imaginary 4 cubit square, on the circle of radius $2\sqrt{2}$ cubits) and when he prays he places himself on the symmetrical point, still on the circle of radius $2\sqrt{2}$ cubits.
It becomes evident that he may move aside lekhathila לכתחילה as much as $4\sqrt{2}$ cubits[73] to withdraw by more than 4 cubits from embarrassing excrement and to be able to pronounce his prayer.[74]

Rashi[75] and R' Tam[76]—and in a case of emergency, also Rabbi Abraham ben David[77]—think that one is authorized to carry in any direction for a distance less than $4\sqrt{2}$ cubits.

Apparently, they consider that the 4-cubit square has no privileged orientation and that therefore one may always consider oneself to be walking its diagonal.

Ritva notes that the position of Rashbam, who considers the authorized limit to be 4 cubits in a cardinal direction and 5.66 cubits in a diagonal direction, is very weak because of the general formulation of Rav Akha bar Jacob. The latter should have been more specific if he wanted to differentiate according to the direction of the displacement.

C. The Limits of the Sabbath Beyond the Town

In Mishna Eruvin IV:8, it says

ואמר שביתתי במקומי, זכה לו מקומו אלפים אמה לכל רוח עגולות, דברי רבי חנינה בן אנתיגנוס, וחכמים אומרים מרובעות כתבלא מרובעת כדי שיהיה נשכר לזויות.

If he says that he takes his residence, for the Sabbath, in the place where he stands, then this place gives him a domain (where he can walk but not carry) of 2,000 cubits, circular in all directions, says Rabbi Haninah ben Antignos, but the Sages say that this domain is a square so that he wins the corners.[78]

If we reduce the town to a point, we can summarize the positions as follows: R' Haninah ben Antignos authorizes a person to walk in the circle of radius 2,000 cubits, while the Hahamim authorize him to walk inside a 4,000 cubit square. If the town is like a Levitic town, one is authorized to walk outside it in the industrial and agricultural areas.

Rashbam[79] understands this square, like the smaller square of 4-by-4 amot, to be oriented along the cardinal directions. Maimonides shares this opinion, as do Rashi and Rabbi Abraham ben David, although the last two shared the opinion of R' Tam about the 4-cubit square in the public domain.[80] On the other hand, R' Tam considers this larger square to have no privileged direction; he holds that it can be oriented in any direction and that therefore the area in which one is allowed to walk is a circle with a radius of $2{,}000\sqrt{2}$ cubits. There is a serious argument for R' Tam, which was not invoked by the Rishonim: although carrying outside the 4-cubit square is forbidden by the Torah, most of the Rabbis have accepted an extension of the authorized domain to a circle with a radius of $2\sqrt{2}$ cubits. When one walks outside the square of 4,000 by 4,000 cubits, we are dealing with a proscription of the Sages, not the Torah, and they should certainly have allowed walking in a circular domain of radius equal to $2{,}000\sqrt{2}$ cubits.[81]

Ritva, in his novellae on B. Eruvin 51a, notes that the position of R' Tam is indeed a logical extension of his position in the matter of 4-by-4 cubits in the public domain. But he also notes that this position is very difficult, because there is no relevant affirmation by any Amora which would be parallel to Rav Akha bar Jacob's affirmation with regard to the 4-cubit square. Ritva therefore prefers the position of Rashi, who does not share the position of Rashbam in the matter of the 4-by-4 cubit square in the public domain and who also does not share the position of R' Tam in the matter of the 2,000 cubits around the town. Had Ritva imagined that a mile could be something other than 2,000 cubits (i.e., that it could be 2,828 cubits), then, because there is a Mishna in Yoma

VI:4 clearly stating that the limit of Sabbath is 7.5 ris or 1 Roman mile, he would certainly have adopted R' Tam's conclusion.

D. Analysis of Tossafot

In B. Yoma 67a Tossafot וכולן על ידי עירוב, Tossafot writes:

.....מכאן משמע דתחום שבת מיל והיינו אלפים ותו לא, כמו שהוכיח רשי, מיהו יש לומר דסימנא בעלמא הוא מיל כמו בכל דוכתא דנקט אלפים אף על גב דיהבינן ליה אלכסון, הכי נמי הכא נקט מיל אף על פי דיהבינן ליה אלכסון

[It has been explained in the beginning of this Tossafot that according to R' Tam, one is allowed to walk a distance of $2{,}000\sqrt{2}$ cubits. Tossafot continues] *that this point of view is difficult in the present context (the text of the Mishna Yoma VI:4 and the Gemara) because we see that the man who was going part of the way with the one in charge of the scapegoat was allowed to walk 1 mile, which represents 2,000 cubits as Rashi has demonstrated it, and not more. Nevertheless, we can say that the mile mentioned here is only an indication in the same way as it is only an indication whenever 2,000 cubits are mentioned, although we give them a diagonal (and 2,000 cubits are actually 2,828 cubits). Here also, in the same way, it mentions a mile, although we give him a diagonal, and the different people going with the man in charge of the scapegoat are allowed to walk 2,828 cubits.*

Tossafot, in B. Eruvin 51a, has mentioned the opinion of Rashbam and of R' Tam. According to the latter, the square of 4,000 by 4,000 cubits has no privileged orientation, and the radius of the authorized domain around a town which is supposed to be reduced to a point, is 2,828 cubits. In the same way, when the Mishna, Yoma VI:4, fixes the limit of Sabbath to 1 mile, it is actually 1.414 miles. R' Tam was trapped by the equation 1 mile = 2,000 cubits, which was accepted by Rashi and Rabbenu Hananel (Yoma 67a), which prevented him from discovering the true solution to the problem.

It must be observed, however, that Rashi did not accept this relation without due consideration; he demonstrates it on the basis of a piyut of Eleazar ha Kalir based on a Braita of Deuteronomy Sifrei. It seems to me that it is here that we are faced with the true problem. Because of a lack of understanding, the mile has been identified as 2,000 cubits, but this is not possible, as the Roman mile is about 1,481.5 meters. This equation would give a cubit of 74 cm.

The mile (the Roman mile) is actually the true limit of Sabbath, and it is equal to the diagonal of 2,000 cubits (see the drawing above). R' Tam was right when he said that the 2,000 cubits actually is the diagonal of 2,000 cubits, but the mile represents the Roman mile, the diagonal, and not the 2,000 cubits.

Therefore, the relation between the mile and the cubit is the following:

1 Roman mile = 2,828.427 cubits.
1 cubit = 52.4 cm.

E. Relationship Between the Cubit and the Mile

What is the origin of the equation by Rashi: 1 mile = 2,000 cubits? Of course, when Rashi considered that the limit of Sabbath is a square of 4,000 cubits per side (we always consider a town reduced to a point), it is logical to identify 2,000 cubits with the mile, which is also presented in Yoma VI:4 as the limit of Sabbath. But Rashi does not propose this argument in Yoma 67a. He relies on a Braita of Deuteronomy Sifrei, Haazinou 12, from which he proves that 1 mile is equal to 2,000 cubits. It is likely that this is the reason he decided to consider the domain of Sabbath as a fixed square, like Rashbam and unlike R' Tam. He was committed to the equation 1 mile = 2,000 cubits, and he considered that the mile mentioned in the Mishna Yoma is a mile, in its strict meaning, and not $\sqrt{2}$ mile.

IV: EXAMINATION OF DIFFERENT TALMUDIC PASSAGES

The foregoing in mind, we reexamine several other Talmudic passages to clarify this divergent concept and to confirm our main thesis:

1 mile = 1,481.5 m
1 mile = 2,828 cubits
1 cubit = 0.524 m
Tehum Sabbath = limit of Sabbath = 1 mile = 2,828 cubits.

A. B. Yoma 67a

Mishna Yoma VI: 4 does not offer any discussion on this subject; the limit of Sabbath is 7.5 ris or 1 mile. The mile in the Talmud is always the Roman mile. This Mishna is surely in contradiction with Rabbi Hanina ben Antignos. It seems in accordance with the opinion of R' Tam, but it can also be considered in accordance with Rashbam as long as we accept that the distance of 90 ris or 12 miles covered by the scapegoat was always along the diagonals of a square oriented North-South and was thus bisecting the cardinal directions. This interpretation nevertheless seems farfetched.

B. B. Eruvin 42a

אמר רב נחמן אמר שמואל, היה מהלך ואינו יודע תחום שבת, מהלך אלפים פסיעות בינוניות וזו היא תחום שבת

Rav Nahman said in the name of Samuel: If a man was walking outside of the town and he did not know the limit of Sabbath, he might walk (from the limit of the town) two thousand average steps, and this gives him the limit of Sabbath.

This ruling has been accepted by Maimonides[82] and by Shulhan Aruch O.H. §397:2. The rabbis have always considered the limit of Sabbath to be 2,000 cubits; it is now also 2,000 average steps; hence, 1 cubit is equal to such a step. Rashi writes that the normal step of a man is a cubit.[83] The accepted value of the rabbinical cubit is about 52

cm and it is surely not greater than 55-56 cm.[84] One should walk 2,000 such steps[85] to reach the limit of the Sabbath.

In fact, however, such a step is not by any means an average step. It is almost impossible to walk with such small steps unless one is physically ill. To paraphrase R' Y. G. Weiss[86], if you want to experiment and walk in such a way, with steps of about 52 cm, do not do it in your neighborhood, nor on Shabbat on your way to synagogue, because your acquaintances will worry about your health. Steps smaller than 65 cm are not normal steps and it would be difficult, if not impossible, to walk a long distance with a regular step of only about 52 cm. An average step actually has a length of about 75 cm, and a length of 90 cm is possible, although not normal. Therefore, the 2,000 steps proposed by the Talmud for the distance that one may walk outside the town on Sabbath approximates the Roman mile well. The Roman mile of 1,481.5 m actually represents 2,000 steps of 75 cm.

This view is confirmed by the fact that the traveler on the eve of Passover, on 14 Nissan, leaving Modiim at 6 a.m. and arriving in Jerusalem at the gate of the city at noon,[87] walks a distance of 20 Roman miles in 6 hours, which corresponds to 1 Roman mile every 18 minutes or 4.938 km/h. At this rate, the traveler normally makes 110 steps of .75 m per minute. A step of 75 cm is therefore most probable, and this seems to support the opinion of R' Tam. Rashbam could still argue that this is the maximum distance that may be walked in the bisecting line of the cardinal directions, but that seems farfetched.

C. B. Eruvin 42a

ואמר רב נחמן אמר שמואל: שבת בבקעה והקיפוה נכרים מחיצה בשבת, מהלך אלפים אמה.....

Rav Nahman says in the name of Samuel: if someone has elected residence for the Sabbath in the plain, and during the Sabbath non-Jews surround it with a wall, he may walk up to a distance of 2,000 cubits inside the perimeter of the wall.

This reference, as with all those to 2,000 cubits, means the hypotenuse of the 2,000-cubit square. This, at least, is the opinion of R' Tam.

D. Y. Eruvin V:1

כמה הוה רחיק, רבי יצחק אמר מיל

At what distance (from the camp of Israel) did Moses establish his tent? At a distance of one mile. This distance nevertheless allowed the people to come and consult him on Sabbath.

This excerpt also seems favorable to the opinion of R' Tam.

E. Y. Eruvin V: 5

כמה היא מידת התחום ? ארבעים חבלים

What is the length of the limit of Sabbath? Forty ropes (of 50 cubits each).

According to R' Tam, this passage concerns the length of the basic dimension of 2,000 cubits, but the true distance is 2,828 cubits, and the question is then the length of the 2,000 cubits of which we must calculate the diagonal. As they used only ropes of 50 cubits, they were obligated to construct a right triangle of 2,000 cubits per perpendicular side to find the true value.

In any event, all these passages support, or at least do not refute, the equation, 1 mile = 2,828 cubits. The mile is the diagonal of the 2,000-cubit square and the radius of the circle circumscribing the 4,000-cubit square.

V. Examination of Passages in Midrashim, Classified Chronologically[88]

A. Sifrei to Deuteronomy, Haazinu 12

שעתידים ישראל ליטול אורך מן המזרח למערב עד רוחב כ"ה אלפים קנים, שעורן ע"ה מיל

In the future, (each tribe of) Israel will take a space from the East to the West of a breadth of 25,000 kanim, corresponding to 75 miles.

One kane is equal to 6 cubits[89]; 25,000 kanim are equal to 150,000 cubits, corresponding to 75 miles if 2,000 cubits are equal to 1 mile. It is difficult to decide whether the author of this Braita still thinks that 1 mile is equal to alakhson of 2,000 cubits[90] and that therefore an alakhson of 25,000 kanim represents 75 miles; or whether, instead, the author already equates the mile with only 2,000 cubits. The Sifrei on Numbers and on Deuteronomy were probably arranged in Israel no earlier than the end of the fourth century CE.[91] Therefore, they belong to the early Midrashim. The same text is found verbatim in Yalkout Shimoni 944. It is apparently on the basis of this Braita, as he calls it, that Rashi was persuaded that the mile of Yoma 67a is equal to 2,000 cubits, and therefore he concluded in Eruvin that the domain in which one is allowed to walk around the town is an area of 4,000 by 4,000 cubits, because one may walk a mile and not more. R' Tam agrees with the equation 1 mile = 2,000 cubits as "Rashi has demonstrated,"[92] but he accepts that the mile is mentioned symbolically, in the same way as the 2,000 cubits, and actually means this quantity multiplied by $\sqrt{2}$.

B. Genesis Rabbah 53:13.

ותלך ותשב לה מנגד נאמר כאן 'ותשב לה מנגד' ולהלן הוא אומר 'מנגד סביב לאהל מועד' 'הרחק' הכא את אומר 'הרחק כמטחוי קשת' ולהלן את אמר 'אך רחוק יהיה ביניכם וביניו כאלפים אמה במדה' הא למדנו נגד מנגד ורחוק מרחוק. אמר ר' יצחק 'כמטחוי קשת' שני טוחים בקשת מיל.

By the use, twice, of the hermeneutic rule[93] *"Gezera Shava" based on the words* מנגד *and* רחוק, *we deduce that she (Hagar) moved off a distance of 2,000 cubits, in order not to see the death of Ishmael.*

Rabbi Isaac said that because of the plural form one must understand two times the range of a bow. At first glance, we already have the equation 1 mile = 2,000 cubits. But this is far from definite. On reflection, it seems we have here two independent

opinions. R' Isaac is probably the same R' Isaac who says in Y. Eruvin V:1 that Moses removed his tent from the camp by 1 mile, probably to remain in contact with the people on Sabbath. Apparently, R' Isaac considers that רחוק means 1 mile without seeing any need to find scriptural justification through the use of hermeneutic rules. Now as it seems that the range of a bow is smaller than 1 mile, he uses the artifice of the plural form, and he equates twice the range of the bow with 1 mile.[94] For him, the mile is still the Roman mile, which was still known in Palestine in the fifth century CE.

On the other hand, we have for the first time and in contradiction with the former interpretation, another way of reading this passage. This reading uses hermeneutic rules, based on the analogy of the same word or root occurring in two different sentences, to transpose a distance found in one sentence to the second. In our case the process is used twice, and it is allowed to apply the distance of 2,000 cubits of the last sentence from Joshua to the distance considered in the first. It is then very likely that the two declarations are independent and contradictory, and the two distances are not the same.

We have here two contradictory positions not only regarding the method of reasoning but also regarding the distances under consideration. Of course, the distinction between the mile and the 2,000 cubits will not hold up for long. All of the elements required to create confusion are gathered here, and, in the next stage, the contradictory aspects of the two interpretations will be forgotten. Instead, both positions will be combined into one interpretation which collects the hermeneutic rule, the 2,000 cubits and the mile. So it appears in later Midrashim.

C. Midrash Tanhuma, Exodus 33:7

מנגד ורחוק מרחוק. אמר ר' יצחק 'כמטחוי קשת' שני טוחים בקשת מיל.

R' Isaac says that the tent of Moses was at a distance of one mile, as it is written (Joshua 3:4): but there will be a distance of 2,000 cubits between you and the ark.

This passage parallels the passage of Y. Eruvin mentioned above, but the support brought from Joshua proves that the mile was now surely identified with 2,000 cubits.

D. Targum Jonathan, Exodus 33:7

Moses established his tent outside of the camp, at a distance of 2,000 cubits from the border of the camp of Israel, which was beyond communication. The limit of Sabbath is now 2,000 cubits, no longer 1 mile.

E. Midrash Tanhuma Numeri 2:2

וכן את מוצא ביהושע, כשהלך להחריב את יריחו, ויאמר יהושע לישראל: עתידין אתם לעמוד שם ולעשות את השבת שם. אלא אם תרחיקו מן הארון, לא תרחיקו יותר מאלפים אמא לכל רוח, למה שתהיו רשאין לבא ולהתפלל לפני הארון בשבת: וכן הוא אומר – יהושע ג' ד'- : אך רחוק יהיה ביניכם וביניו כאלפים אמא....

And similarly you find with Joshua when he went to destroy Jericho. He said to Israel: In the future you will be there and you will keep there the Sabbath. Therefore, if you move away from the ark, do not move away more than 2,000 cubits. Why? In order that you may come and pray in front of the ark on Sabbath, as it is written in Joshua: But there will remain between you and it a distance of 2,000 cubits.

Here also the limit of Sabbath is 2,000 cubits without any reference to the mile. There seems to be a formal contradiction between this Midrash and the Midrash for Exodus 33:7. In Exodus it seems that all the people may walk in the camp of 12 miles by 12 miles,[95] but they are not allowed to walk more than 2,000 cubits outside of the camp. In Numeri, on the contrary, it seems that even inside the camp, people might not walk to the Tabernacle if it was more than 2,000 cubits from the sites of the surrounding tribes.[96]

F. Examination of Two Piyutim[97] of R' Eleazar ha Kalir[98]

1. Piyut of the Office of the Second Day of Sukkoth Morning.—This begins with

כי אקח מועד
ברוחב שבעים וחמשה מיל חריצותיה.....גבול כל שבט ושבט כך יעלו בנפוצותיה.

This passage is based on the passage of Sifrei on Deuteronomy mentioned above.Rashi has understood it according to the following relations:

1 mile = 7.5 ris = 2,000 amot = 333.33 kane
1 kane = 6 amot
1 ris = 44.44 kane = 266.667 amot

Rashi did not justify the relation 1 kane = 6 amot, but this is his position in his commentary on Ezekiel 40:5, where he follows the Targum Jonathan; Radak uses the same equation.

2. Piyut of the morning office of Sabbath Shekalim.—This begins with

אז ראית וספרת והכנת וחקרת ומדדת.....
ומדת המיל שבעה ומחצה ריס , ובשלשים קנים הוא קצב הריס. ושעור הקנה שש אמות וזרת, כל אמא מודדת שליש בזרת.

Rashi has already observed in B. Yoma 67a that this piyut is in contradiction with the former; it is based on the following relations:

1 mile = 7.5 ris
1 ris = 30 kane
1 kane = 6.333 amot
1 mile = 7.5*30*6.333 amot = 1,425 amot

The origin of the relation, 1 kane = 6.33 amot, is not clear. It is probably his interpretation of Ezekiel 40:5 and 41:8. Radak writes the same relation in his commentary on Jeremiah 31:39, in contradiction to his own commentary on Ezekiel 40:5.

It would be possible to reconcile these two piyutim if we accept certain assumptions. First, in the piyut of Sukkot, we must assume that the author of the Braita, as well as R' Eleazar ha-Kalir, was still aware of the difference between the mile and 2,000 cubits. When he connects 25,000 kane with 75 miles, he does not mean that 75 miles are equal to 25,000 kane, he actually means that each tribe will receive alakhson of 25,000 kane, which are equal to 75 miles. We then have the relations:

1 mile = 7.5 ris = 2,828 amot = 471.40 kane
1 kane = 6 amot
1 ris = 377 amot = 62.85 kane

If we now consider that the Kalir on the one hand used an approximate value of $\sqrt{2}$ and equated 1 mile with 2,850 amot, and on the other hand, used the relation 1 kane = 6.33 amot (the relation 1 kane = 6 amot is actually from Rashi, but not necessarily from the Kalir), we will have the relations:

1 ris = 60 kane = 380 amot
1 kane = 6.33 amot
1 mile = 7.5 ris = 2,850 amot = 450 kane

What about the piyut of Sabbath Shekalim? We must accept that a slight corruption was brought to the text (already before the time of Rashi)[99] and we should suppress the ל and read

ובששים קנים הוא קצב הריס

The relations would then be:

1 ris = 60 kane = 380 amot
1 kane = 6.33 amot
1 mile = 7.5*60*6.333 amot = 2,850 amot = 450 kane.

We now have perfect coherence between the two piyutim. In his commentary on Jeremiah 31:39, Radak writes that 1 ris = 70 kane. This is at least not too far from the relation, 1 ris = 60 kane. Thanks to these slight adaptations, we have succeeded in reconciling the two piyutim of ha-Kalir. This strengthens our conviction that the mile mentioned in Deuteronomy Sifrei, and probably also in the passage of Genesis Rabbah cited above, is still the Roman mile, and that R' Eleazar ha-Kalir was aware of the difference between the mile and 2,000 cubits. Our slight adaptation solves all of the problems and has the benefit of rendering useless all speculation about an imaginary metrical system proper to the Kalir. The confusion of the mile and 2,000 cubits appears as soon as the Roman mile loses its true significance, probably first in Babylonia[100] and later in Palestine. We observe a similar situation in Arab metrology and geodesy.[101] Nevertheless, the Roman mile, which would be abandoned with the fall of the Roman Empire, would yet have an influence in the evolution of the metrology of the major European countries.[102]

VII. Discussion About the Value of 52.4 cm for the Amah

The cubit and man's height

According to the Talmudic literature, there is a fixed relation between the height of a man and the cubit. In B. Eruvin 48a, it says:

והני ארבע אמות היכא כתיבא? כדתניא "שבו איש תחתיו" כתחתיו: גופו שלוש אמות ואמה כדי לפשות ידיו ורגליו דברי רבי מאיר. רבי יהודה אומר גופו שלוש אמות ואמה כדי ליטול חפץ מתחת מרגלותיו ומניח תחת מראשותיו. מאי בינייהו? איכא בינייהו ארבע אמות מצומצמות.

So four cubits represent the minimal place that allows a man to subsist during the Sabbath. When he is immobilized in this little area, three cubits are for his body and an additional cubit allows him to stretch his legs, according to Rabbi Meir. Rabbi Judah says that this additional cubit is intended to give him the possibility of taking something from below his legs and placing it beneath his head. Now, what is the difference between R' Meir and R' Judah? The one[103] *considers rigorous cubits (*מצומצמות, עצבות*) while the other considers generous cubits (*שוחקות, מרווחות*).*

Regardless, we see that the height of a man is considered to be three cubits. There are actually divergent opinions among the Rishonim whether the three cubits represent the total height of the man or whether this height of three cubits measures the man only up to his shoulders. From the above passage, however, it is clear that the three cubits represent the total height of the man. If they measured him only up to his shoulders, his total height would be more than four cubits. Indeed, when a man stretches his arms, he adds more than one cubit to the height of the shoulders, because his arm (arm + forearm + hand) represents more than one cubit.[104]

We proceed to examine the heights of men to find a plausible metric equivalent for the cubit.[105] During the last century, an increase in height of about 1.5 cm has been observed in every decade. Scientific observations were made in France and Belgium for about a hundred years, and the height of men is now about 15 cm greater than one hundred years ago. This increase in men's average height is related to industrial development and the improvement of standards of living, nutrition, and improvement in health and hygiene. This increase in height during the last century resulted primarily from the lengthening of the long bones of the legs. Similarly, the arms are lengthening (not, however, the breadth of the fingers). The proportion between the lengths of these long bones and the total height of the body is thus increasing.

Today, Belgian men have an average height of 1.78 m, while in 1900 it was about 1.63 m. Beyond these variations, there are also regional differences; for example, it is agreed that Mediterranean people are shorter than people from continental Europe.[106] Under these conditions, though it is difficult to be precise, it is very likely that in the Talmudic period,[107] the average height of Jewish men was about 1.6 m.[108] This would be compatible with a cubit of 52.4 cm and the rule that the average height of men was 3 cubits, especially if we adopt the opinion that these 3 cubits are generous.

VII. COMPARISON WITH OTHER PUBLICATIONS DEALING WITH THE SAME SUBJECT.

The study of the Talmudic and Biblical units of length is still very much in the news and therefore different papers were published during the last years with the aim to specify the subject. However their approach is fundamentally different from the direct approach of the present paper in which we tried to clarify different Talmudic passages quoting distances that could be verified. This method seems direct and reliable and it isn't dependant on any assumption. Now what about these other articles, some[109] tried to approach the problem of the Jewish units of length on an indirect way by examining archeological remnants of the Temple and of the mount of the Temple and comparing them with the measurements given by the Mishna Midot. Other articles[110] have tried to determine the dimensions of the Ark of Covenant through the evaluation of the weight of the gold used in the construction of the Tabernacle. This method rests however on several questionable assumptions and it must furthermore be remembered that there is a discussion[111] 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).

VIII. CONCLUSIONS

Moses's cubit (אמה מדברית) must have been very close to 52.4 cm. When the early Tanaim, at the end of the Temple period, decided to adopt the Roman units of length, or more precisely, to bind the Jewish system of units of lengths to it, they could identify the Roman mile with the diagonal of a 2,000 cubit square.[112] This gives us a cubit of 52.4 cm, practically identical with the Royal Egyptian cubit.

This cubit is compatible with the Talmudic saying that the average height of men is equal to 3 cubits; with the Talmudic saying that, in the absence of other information, one may walk 2,000 feet on Sabbath; and also with the results of archeological research on the Temple and the Temple Mount.

It would appear that the Talmudic system of units of length, like the systems of other civilizations, was originally founded on parts of the human body but subsequently became independent of the human body. Nevertheless, as the rabbis had observed, the etsba of about 2.2 cm is a very good value for the breadth of a thumb. This is the reason why many rabbis succeeded in using a cubit very near to the correct amah.[113]

IX. REFERENCES

Benish, H.P. (1987). ספר מדות ושיעורי תורה. Jerusalem.
Bornstein, H.Y. (1886). Haasif 2, p 728.
Estori ha Parhi, (1851). Kaftor Vaferah, Berlin. Ed Ts. H. Edelman
Estori ha Parhi, (1897). Kaftor Vaferah, Jerusalem. Ed. A.M. Luncz.
Estori ha Parhi, (1958). Kaftor Vaferah, New York. Ed Y. Blumenfeld.
Estori ha Parhi, (1994-99). Kaftor Vaferah, Jerusalem. Ed. Hamahon Lelimudei ha Aretz.
Eveleth, B.B. and Tanner, J.N. (1990). Worldwide Variation in Human Growth.
Cambridge University Press.

Mercier, R. (1992). Muslim Geodesy in History of Cartography ed. By Harley, J.B. and Woodward, D. (Chicago): vol 2, book I: Cartography in the traditional Islamic and South Asian Societies, pp 175-188.
Neeman, P. (1972). Encyclopedia le Geographia Talmudit. Tel Aviv.
Schwartz, Y. (1885). תבואת הארץ Jerusalem.
Vilnai, Z. (1997). Encyclopedia l'Idiat Eretz Israel.
Weiss, Y.G. (1985). מדות ומשקלות של תורה. Jerusalem.

[1] This value is considered the minimum possible value and is the value given by Maimonides.
[2] This rather high value is considered the maximum possible value and is suggested by R' Abraham Karelitz.
[3] The reviit has, according to Maimonides, a volume of 74.375 cubic cm. One reviit = 10.8 d^3 = 74.375 cm^3 and d = 1.9025 cm.
[4] One reviit is equal to 1.5 eggs. The volume of an egg is, according to Maimonides, 49.58 cm^3. The reference to the egg is justified because the egg is a natural volume to which the rabbis often referred.
[5] Maimonides indicates with precision the weight of the fundamental units of volume filed with water. This allows us to know the volume of these capacities with the same precision as his units of weight. But the golden Arab Dinar is well-known, and its weight is 4.25 g.
[6] This was based on the principle that the etsba, the Talmudic inch, is a natural size, and that the value is therefore derived from the statistical measure of the breadth of the thumbs.
[7] It is a common practice to try to equate Talmudic and local units. In Russia, rabbis equated the Talmudic mile with the vestre, so 2,000 cubits = 1,067 m; 1 amah = 0.53 m; and 1 etsba = 2.22 cm. Arukh ha-Shulkhan, Y.D. 201:3. R' David Feldman on Kizur Shulhan Arukh. Yalkut ha-Guershuni. In Benish (1987), p 91, other references are given. R' Moses Feinstein gives a similar value.
[8] I express my profound dependence on the earlier books and studies written on this subject, especially the last books of R' Jacob Gershon Weiss and R' Haim Pinhas Benish.
[9] There are different versions of this name: Modiim, Modiin, Modiit (Misna Hagiga III: 5), Modiot (Y. Hagiga), and even Modaim (Graetz (1968)). Modiim is mentioned in B. Kiddushin 66a, where Rashi writes that Modiim is the town of the Hasmoneans. Modiim, the town of the Maccabim, is mentioned several times in the book of the Maccabim, in the Jewish Antiquities of Josephus, and in the beginning of the Wars of Josephus. The book of the Maccabim mentions that Simon the Hasmonean built a mausoleum there in honor of his father and his brothers. It was an important building visible to the sailors. I Macc XII:29.
[10] This is the opinion of Maimonides. According to Rashi, the traveler begins his walk at noon and must reach Jerusalem before sunset, at about 18h.
[11] See Num. 9:10.
[12] See the commentary on the Mishna: Shoshanim le David by R' David Pardo.
[13] The origin of the disagreement between Ulla and Rabbi Judah about the distance between Modiim and Jerusalem is uncertain. It can result from:

- A bad estimate of the distance due to the political situation and the impossibility of going from one place to the other.
- A change of the roads for political reasons.
- Doubt about the exact location of Modiim.

[14] His opinion that a traveler can walk 30 miles between sunrise and sunset, 5 miles during astronomical dawn, and 5 miles during astronomical twilight, was rejected.
[15] According to the conclusion of the passage, the travelers walk at the rate of one mile in 18 minutes, and therefore the distance of Modiim to Jerusalem covered in 6 hours is 20 miles. Nevertheless, according to the interpretation of Rashi and Tossafot, the distance is only 15 miles.
[16] According to the conclusions of Rashi and Tossafot, one can walk 16 miles in six hours. Nevertheless, they accept that the distance is only 15 miles. Therefore, Tossafot suggests that there was a border to cross between the two towns, which took the traveler out of his way. In any case, Rashi and Maimonides (see his commentary on Mishna Hagiga III:5) agree that Modiim is the same place in both Hagiga and Pesahim.
[17] Kaftor Vaferah was written by R' Estori ben Moses ha-Parhi of Florenza (Perah), Andalusia, south of Spain, 1280-1355.

[18] p 47, bottom, in the edition of Edelman (1851), p 291 in the edition of Luncz (1897), p 418 in the edition of Blumenfeld (1958) and p 62 in the edition of the institute for the study of the Mitsvot of Israel.
[19] In our printed edition, we read Modiim in B. Hagiga, in B. Pesahim, and in B. Kiddushin. This is also the case in Rashi. In B. Kiddushin 66a, Rashi explains that Modiim is the town of the Hasmoneans. R' Hananel writes about the same place, but he calls this place Har Modiit, apparently like Kaftor Vaferah. But in B. Pesahim, R' Hananel speaks about Hamodiit.
[20] R' Y.G. Weiss seems to connect it to Modiit, near Beit Shean. I prefer to connect it with Modiim, near Jerusalem.
[21] See Schwartz (1885) p 54 and Borenstein (1886) p 727.
[22] Kaftor Vaferah, followed by Schwartz, seems to consider that a normal walker covers 40 miles (Jewish miles) in 12 hours and, consequently, the 15 miles between Modiim and Jerusalem in 4.5 hours. Ulla's theoretical traveler walks slowly and needs 6 hours to cover the 15 miles between Modiim and Jerusalem. This opinion seems to accord with Maimonides who considers that a man can cover 40 miles in a day: Hilkhot Evel VII:4, although the traveler, on the eve of Passover, is supposed to cover only 15 miles in 6 hours, when walking at a slow rate.
[23] It is situated on an isolated mountain in the Wadi Tsour. R' Y.M. Weiss identifies this description as Etanim, a mountain on which the broadcasting authorities placed a relay station with high antennas, about 12 km by air from the walls of Jerusalem. According to Borenstein, the village of Midan is even nearer, at about 11 km from the walls of Jerusalem.
[24] This opinion of J. Schwartz seems contradictory and untenable. First, he places Modiit west of Beit Shean and Modiim of the Hasmoneans at the correct place of el-Midyeh. But Modiim, in B. Kiddushin, is actually the place of the Hasmoneans as explained by Rashi ad locum. Second, he places Modiim of B. Pesahim at a straight distance of about 12 km and a true distance of about 14 km from the walls of Jerusalem. Borenstein, who contested the conclusions of Schwartz and placed Modiim at el-Midyeh, the supposed place of the Hasmoneans, accused Schwartz of forgery because there is never a distance of 4.5 hours between Midan and Jerusalem. According to the words of Borenstein, Schwartz adapted the foot to the shoe and not the shoe to the foot.
[25] On a map from 1948, I see the name Midya at this location, about 10 km east of Lod, corresponding to the historical site of Modiim, the town of the Maccabim.
[26] The latter does not seem to be completely convinced. He mentions that, in the Middle Ages, people thought that the Maccabean tombs were in the Latrun Area. Indeed, Madden (1864, p 30) mentions that the site of Modiim has always been considered uncertain but that medieval and modern tradition place it at Soba. This place was identified either as Latrun or Kubab. The former is 24-25 km from Jerusalem and the latter 3 km farther. The true ground distances are about 28 and 31 km. Equating them with 20 miles would give us a mile of 1.4 km in the first hypothesis and 1.55 km in the second. These locations are still compatible with a distance of 20 Roman miles from Modiim to Jerusalem.
[27] Eusebius (260-339) wrote the Onomasticon in about 330. It contains place names mentioned in the Bible and in the Christian Gospels, which he arranged alphabetically and by books of the Bible. He sometimes identifies them with places existing in his time, and sometimes he includes their distance from nearby locations. At the end of the 4th century, the Onomasticon was translated into Latin by Jerome (Hieronimus). Of course he is not, a priori, a more reliable source than his contemporary Ulla. In the case of the distance between Tsipori and Tiberias, Eusebius gives a faulty distance of 10 miles.
[28] This is a Mosaic map discovered in 1884 which represents the biblical holy land and neighboring regions.
[29] The length of a mile was always considered to be 1,478 m. In the most recent edition of the French encyclopedia Larousse, the length of the mile is 1,481.5 m or 1,481.75 m.
[30] It corresponds to a rate of a little less than 5 km per hour.
[31] See a comprehensive examination of this Talmudic passage in J. Jean Ajdler, Talmudic Metrology: The Mile as a Unit of Time (forthcoming).
[32] Furthermore, this new element completely changes the comprehension of the text, because one mile in 18 or 22.5 minutes (Rabbi Judah) or in 24 minutes (Ulla and Rabbi Johanan) corresponds, respectively, to a speed of 4.9, 3.95, or 3.7 km/h. Particularly, the traveler of Rabbi Judah who walks 20 Roman miles in 6 hours (the distance from Modiim to Jerusalem) covers 1 mile in 18 minutes. It appears that 4.9 km/h is a fast speed and only good walkers will be able to reach Jerusalem in time at noon, after a walk of 20 Roman miles in six hours. Maybe we are dealing with theoretical walkers who can walk at the rate of 4.9 km/h

without fatigue during six or even twelve hours, without even taking the time to break for a meal. That means that normal people who are walking at the average speed of 3.7 km/h (it was accepted that the average speed of walkers, over long distances, is one German league in two hours) will arrive after a walk of 8 hours, at 14 h. We must then conclude that Maimonides was right to have people travel in the morning. Otherwise, those people would not arrive in Jerusalem before the beginning of Passover.

[33] Y. Taanit; IV, 5. See also Midrash Ekha, Treni II:2.

[34] Kfar Khananya is also mentioned in B. Eruvin 51a.

[35] Joshua 19:29; Judges 1:31.

[36] Sheviit VI:1; Hala IV:8; Demay I:3.

[37] Tosefta Sheviit IV,4

[38] B. Gitin 7b

[39] Rambam, Hilkhot Terumot I:7 and 8.

[40] It is generally believed that Khziv is south of the mouth of the Nahal Khziv. From Tosefta Sheviit IV:4, one would think that Khziv was on the north side of the mouth of the river. R' David Pardo, in Hasdei David, thought that the text of the Tosefta was corrupt, because he thought that there was no river at this place.

[41] Genesis 38:5; Chronicles I, 4:22; Joshua 15:44; Micah 1:14.

[42] B. Sabbath 26a; Tossefta Pesahim I:28; B. Eruvin 80a; B. Baba Metsia 43b.

[43] Rabban Gamliel was riding, just after Passover, from Acco to Khziv in the company of Rabbi Illai and of his servant Tavi. After ending dinner in Khziv, Rabban Gamliel was approached by a man who asked to be freed from a vow. As Rabbi Illai confirmed to Rabban Gamliel that he had drunk a quartarius of wine (a reviit be-Italkit), Rabban Gamliel told the man to follow them until the effects of the wine wore off. After riding 3 miles, they arrived in Sulamei Tsur, where Rabban Gamliel dismounted, donned his talit, and dealt with the matter.

[44] G. Weiss (1984) p 315 writes that Sulama de Tsur is 5.1 km from Khziv. Apparently, he places this village north of Kfar Rosh ha-Nikra. If he were right, the distance would correspond to 3.4 miles which they rounded down to 3 miles. It is remarkable that all the distances in the Talmud are expressed in whole numbers.

[45] Leviticus Rabbah 37; B. Eruvin 64b; Y. Aboda Zara I:9; Tossefta Pesahim II:9.

[46] The ris is equivalent to the stadium.

[47] B. Yoma 39b and B. Yoma 20b.

[48] Eng. Yakov Loewinger has forwarded me the main extant manuscripts, and they all agree with the accepted reading of 10 parsaot. They are: manuscripts EMC 218270 and EMC 1623271 of Beit ha Midrash le Rabanim, 95 Munchen, Harl 5508(400) British Museum and the first edition of Venise.

[49] Y. Taanit IV:5.

[50] B. Ketubot 111b.

[51] I Chronicles VIII:12; Ezra II:33; and Nehemia VII:37.

[52] Mishna Erahim IX:6.

[53] Numeri 33:49; B. Eruvin 55b; Y. Eruvin V:4 and III:4; Y. Sheviit VI:1; B. Yoma 75b; Targum Jonathan Numeri 2:3; Rashi in Berahot 54b.

[54] B. Pesahim 46a.

[55] B. Meguilah 2b.

[56] Mishna Yoma VI:8.

[57] See Rashi, B. Yoma 67a; R' Hananel, B. Yoma 67a; and Maimonides, Commentary on the Mishna, Yoma VI:4.

[58] Even under this assumption, which is still generally accepted today, the parsah must be equal to 4 Roman miles. This the only way to understand the dictum of Rava in B. Pesahim 94a, according to which the Earth measures (i.e., has a perimeter of) 6,000 parsah = 24,000 miles = 35,556 km with an undervaluation of only 10 percent.

[59] With the exception of Borenstein.

[60] For example, Rashi and R' Hananel in B. Yoma 67a write that 2,000 cubits = 1 mile. The fact of the matter was probably forgotten in Babylonia about the 5th or 6th century and in Palestine about the 8th century.

[61] In a text still in manuscript, R' Raphael Levi from Hanover writes that he found in old books that the Talmudic mile was equal to the Roman mile. But as he still accepts that a mile is 2,000 cubits, this gives

cubits of nearly 75 cm! Similarly see Weiss (1985) about other rabbis who proposed a mile of a similar length and consequently an exaggeratedly long cubit.
[62] The subject is studied in Babli Erubin 56b.
[63] B. Eruvin 51a.
[64] Rambam, Hilkhot Sabbath 12:15-19.
[65] Rambam, Hilkhot Sabbath 27:11-13.
[66] This is the opinion of Rabbi Meir and Maimonides. Hilkhot Sabbath 12:15.
[67] Bemidbar Rabbah II:9 and Midrash Tanhuma Bemidbar 9.
[68] Rabbi Samuel ben Meir (12th century).
For the opinion of Rashbam, see Tossafot in B. Eruvin 51a and B. Yoma 67a.
[69] Rabbi Moshe ha Kohen of Lunel (South of France) lived in the twelfth century, where he wrote Hassagot, or critical scholiae, on the Hibbur of Maimonides. Rabbi Joseph Karo brings them up in his commentary Kessef Mishneh. R' H.D. Azoulai has seen a manuscript of these Hassagot. A manuscript is still extant in the Bodleian library in Oxford. For the opinion of R' Moshe ha Kohen, see Maimonides, Hilkhot Shabbat 12:19.
[70] Rabbi Yom Tov ben Abraham Ishbili (c 1250-1330), was considered to be the spiritual leader of Spanish Jewry after the death of his teachers, Solomon ben Abraham Aderet and Aaron ha-Levi of Barcelona.
[71] Hilkhot Shabbat 12:18 and 19.
[72] This ruling seems to contradict Hilkhot Sabbath 12:15, where Maimonides says that one may move lekhathila, in all, a square of 4 by 4 cubits.
[73] The commentators of the Yerushalmi have understood that this passage follows Rashi and R' Tam (who consider that the 4-cubit square has no privileged orientation). It is nevertheless possible to understand the passage according to Rashbam, for whom the square has a fixed orientation.
[74] See Mishna Berahot III:5 and B. Meguila 27b. See also Maimonides Hilkhot Kriyat Shema III:2 and 8.
[75] B. Eruvin 51a.
[76] B. Eruvin 51a, Tossafot כזה יהו כל שומרי שבת
B. Yoma 67a Tossafot וכולן על ידי עירוב
[77] According to my understanding of his hassagah on Hilkhot Sabbath 12:19.
[78] There is an interesting, old piece of evidence of non-Jewish origin about the Sabbath limit, which shows that one was permitted, according to all opinions, to walk from Jerusalem to the Mount of Olives. Indeed, Borenstein mentions in Haasif 2, 5646, p 728 that the Acts of the Apostles I:2 states that the Mount of Olives is a distance from Jerusalem of a Sabbath limit. Borenstein mentions further that Apipanius (a Christian priest of Jewish origin) asserts that the Shabbat limit is 5 stadia. Borenstein also writes that Josephus, in his Antiquities, states that the distance from the Mount of Olives to Jerusalem is 6 stadia. In fact, 2,000 cubits = $(1/\sqrt{2})$*(8 ris) = 5.667 stadia. The rounding-off yields 5 stadia in one direction and 6 stadia in the other. I am grateful to R' Gershon Weiss from Jerusalem for drawing my attention to this paper and sending me a copy.
[79] See the same references as above, in Tossafot Eruvin 51a and Yoma 67a.
[80] This position is probably justified by the deduction of the domain of Sabbath from the industrial area around the Levitic towns.
[81] Hayé Adam 76:2.
[82] Hilkhot Sabbath 27:4.
[83] Rashi, B. Erubin 42a.
[84] This the maximum length adopted by the Rabbis.
[85] The length of a step is the distance while walking between the extremities of the heels of the two feet when they touch the ground.
[86] Weiss (1994) pp. 362-363.
[87] Now that we know that the traveler must walk about 30 km in 6 hours, it appears that many people will take more than 6 hours. It is therefore better to adopt the time schedule of Maimonides, so that the latecomers can still participate in the sacrifice.
[88] Sifrei Deuteronomy and Genesis Rabbah are the oldest Midrashim; their completion is dated to the fifth century CE. The completion of Midrash Tanhuma probably dates to the eighth century CE. The completion of Targum Jonathan also dates to the eighth century, while Exodus Rabbah and Numeri Rabbah are probably later. These last two Midrashim were unknown to Rashi. The literary crystallization of the

Midrashim was probably preceded by generations of development. See the introductions to the five books of the Bible in Midrash Rabbah ha Mevoar. See also Encyclopedia Judaica.

[89] Rashi B. Yoma 67a.

[90] The diagonal of 2,000 cubits or 2,828 cubits.

[91] See Midrash Rabbah ha Mevoar in the different introductions and Encyclopedia Judaica.

[92] Tossafot Yoma 67a.

[93] The Hermeneutic rules are the logical and grammatical rules used in the Talmud and Midrashei Halakha for the interpretation of the Torah.

[94] The range of a bow must not exceed 200 m. The long bows used by the English army against the French troops in the fifteenth century had a range of 200 m. There is some exaggeration in the estimation of the bow range. It is probably because he already sensed this difficulty that Rashi, on Genesis Rabbah, writes that anyone who cannot shoot an arrow of a bow a distance of 1/2 mile is not a professional archer.

[95] This is the conclusion of B. Eruvin 55b. See also Rambam, Hilkhot Sabbath 27:1.

[96] R' David Pardo raises this problem in his commentary on Rashi, Numeri 2:2. Maskil le David, Venice 1760.

[97] Piyutim are poetical and liturgical compositions, part of the ritual of the Ashkenazi rites.

[98] The exact period of ha Kalir is not known. He is known as Rabbi Elazar berabbi Kalir from Kiriat Sefer. He is supposed to have lived in Israel, perhaps Tiberias, at the end of the Byzantine period, in the first half of the seventh century CE, before the Arab period.

[99] This is because Rashi writes the equation 1 ris = 30 kane. See his commentary to Talmud B. Yoma 67a and to Genesis 14:17.

[100] In the Sheiltot of Rav Ahai of Shabha (about 680-752) we read, in the Sheilta 53:

דאילו מאן דבעי למיזל לקמיה בשבתא מאלפים אמה, משדר.....

The distance of the tehum is now 2,000 cubits.

[101] The first Arab scholars had bound their metrological system to the Roman mile. Their fundamental equations were: 1 farsakh = 4 Roman miles; 1 Roman mile = 3,000 Arab cubits, and therefore 1 Arab cubit = 0.493 meters. This equation is very similar to the rabbinic equation: 1 Roman Mile = 2,828 Jewish cubits. Later we find the following equations: 1 farsakh = 3 Arab miles; 1 Arab mile = 4,000 cubits = 1,972 m; 1 cubit = 0.493 m. In general, there was much confusion once the exact meaning of the Roman mile was forgotten. Some considered in their geodesic measures 56.66 miles per degree (Arab mile of 1,972 m), others 66.66 miles per degree (Arab mile of 1,666.66 m), and others considered 75 miles per degree (Roman mile of 1,481.5m). Because of this confusion about the mile, new measures of the dimensions of the earth were undertaken under the Caliph al-Mamun.

[102] We find the following data in the old European metrology, before the institution of the metrical system:
In France:

Common league = 4,444 m = 3 Roman miles
Marine league = 5,555 m = 3.75 Roman miles = 3 German miles
League of an hour = 4,872 m: distance walked in one hour.

This value is very close to the Talmudic mile in 18 minutes and to our 5 km/h.
In Germany:

Prussian league = 7,407 m = 5 Roman miles.
German mile = 1,852 m = 1.25 Roman miles.

[103] There are divergent opinions about who held which opinion. Rashi understands that R' Meir speaks of generous cubits and R' Judah of rigorous cubits. On the other hand, Maimonides decides in favor of R' Meir, whom he says considers rigorous cubits while R' Judah considers generous cubits.

[104] Novellae of R' Samuel Strashun ad locum.

[105] I am grateful to Martine Vercauteren, Professor of Anthropology at the faculty of sciences at the University of Brussels, for the information she provided me on this subject.

[106] Newton, in his Dissertation upon the Sacred Cubit of the Jews, London (undated), proved this from ancient statues. He noted that Polish Jews are shorter than Englishmen as well as English Jews. His booklet was written in Latin. An English translation was printed with the second edition of the works of John Greaves: Miscellaneous works of J. Greaves, London (1737). In his dissertation, Newton came up with a length of 52.33 cm for this "sacred" cubit.

[107] Our main point is the height of men (Jews and Romans) in the Talmudic period. The examination of statues (the method used by Newton) and of skeletons gives a sufficient answer to the question. The more

general subject of the evolution of the height of men during history and according to their geography remains a subject insuffficiently known and still debated. A recent article looks into the matter and shows the fundamental importance of the diet during three important periods of life. Indeed, people achieve their stature in three spurts: infancy, between the ages of six and eight , and in adolescence. Burkhard Bilgar, The Height Gap: Why Europeans Are Getting Taller and Taller and Americans Aren't, The New Yorker, May 4, 2004.

[108] There were of course also tall men, as it relates in B. Nidah 24b. Abba Saul was the tallest. Jewish people of Russia and Lithuania were particularly short at the end of the 19th century. Arukh ha-shulkhan, Y.D. 201:3, notes that the average height of men, apparently Jewish and non-Jewish, is officially 1.60 m (probably based on examination of the military recruits).

[109] 1. שתי אמות מידה בהר הבית ובמקדש השני, הרב ד"ר זכריה דור שב, תחומין ט, תשמ"ח
2 למידות הר הבית והמקדש, הרב זלמן קורן. תחומין ט, תשמ"ח
3. ואף על פי כן, שתי אמות מידה, הרב ד"ר זכריה דור שב, תחומין ט, תשמ"ח
4. איתור תחומי הר הבית ומקום המקדש, א. גרוסברג, תחומין תשנ"ו

According to this last article, the cubit which best fits the agreement between the archeological remains and the extant descriptions and measures from Mishna Midot and from Josephus is the cubit of 52.5 cm.

[110] 1. התאמת האגודל ליתר אמות המידה, פרופ' אברהם יהודה גרינפילד, תחומין ה' תשנ"ז.
2. גישה מדעית לקביעת שיעורי תורה, האמה. גרינפילד, בדד חוב 1, תשנ"ה
3. ערכי המידות בזמן מתן תורה, פרופ' אברהם יהודה גרינפילד, תחומין י"ח , תשנ"ח
4. מידה כנגד מידה, גרינפילד, מוריה גליון ז,ח, תמוז תשמ"ב

[111] See Mishna Kelim XVII: 10 and B. Baba Batra 14a.

[112] In Arab Geodesy, they used a cubit which was the 3,000th part of the Roman mile.

[113] Although the etsba of about 2.18 cm and the amah of 52.4 cm are not very popular today, similar values were used in the 19th and first half of the 20th century. For details, see note 7 *supra*.