Stadium Meets *Stadion*: A Metrological Analysis of Roman Milestones in Asia Minor

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Abstract: Road networks were already established in the regions of Asia Minor that came under Roman domination from the late 2nd century BC. As a ready show of the new authority, milestones conforming in distance indications to Roman practice soon appeared along the roads. It may be wondered, however, whether some form of merger was involved in the actual implementation, rather than wholesale replacement of the pre-existing metrological system. This paper investigates whether issues relating to itinerary units can be recognized, and how they were possibly addressed. The study, based on comparative analysis of sources from the Roman period, earlier textual sources and archaeological finds, is made possible by the extensive corpus of milestone information available for Asia Minor, combined with the generalized availability of digitized geographical data and computer-based tools like Google Maps, that can provide acceptably accurate length estimates if properly used. Results suggest that the ratio of eight stades to the mile was used to convert distance indications whatever the actual length of the involved stade unit. In the Roman provinces of Asia Minor, where the *stadion* was based on the Philetaeric foot, this would produce an accordingly longer mile. This somewhat unexpected outcome is supported by the accuracy of distances restored under this hypothesis, that turns out to be generally rather good, and can explain why to a modern reader some reported distances may appear to be shrunk when the traditional Roman unit is assumed, resulting in a somewhat distorted perception of space.

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1. Introduction

Road marker stones are attested by archaeological finds in Asia Minor and the Eastern Mediterranean area since the 4th–3rd century BC at the latest, pre-dating Roman domination by a couple of centuries.[1] In fact, these regions did have their own road networks, although structures were not necessarily realized to the same levels of engineering standards as the Roman ones.

Milestones first appeared on a Roman road with *Via Appia*, whose construction began in 312 BC. Systematic use of milestones was later regulated by law in the 2nd century BC, supposedly by a *Lex Sempronia viaria*.[2] About in the same time period road development was progressing independently in several regions, until Roman expansion in the Eastern Mediterranean led to eventual integration into the extensive paved road network that became a symbol of Roman civilization. Since milestones also had political significance as a show of Roman authority, it may be assumed that in the new provinces action was readily taken to conform road indications to Roman practice. However, it may be realized that variety in pre-existing uses created a potential for confusion, particularly in Asia Minor.

The creation of the Roman province of Macedonia in 146 BC was the first instance of a merger between two road systems with established and different ways to indicate distances. Indeed, pre-Roman marker stones marked distances between neighbouring cities by multiples of ten *stadia*

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[1] Collart 1976; *I.Ephesos* VII/2, 305. In the 5th century BC Herodotus already explicitly provided distances in parasangs for distinct segments of the Persian Royal Road, as well as its total length (Hdt. 5.52-5.54). The careful and detailed study in French 1998 concluded that the road was indeed measured.

[2] Rotondi 1912, 311-312.

that corresponded to 6000 feet, hence the term *dekastadion* used to designate them.[3] Roman *miliaria*, on the other hand, indicated progressive distances from Rome or some other important city (the *caput viae*) by *milia passuum* [mp], where the *passus* was equal to five feet, resulting in intervals of 5000 feet. As the Roman foot was practically the same length as the "Attic" foot used in Macedonia, the spacing between marker stones differed as a consequence, since *dekastadia* marked intervals of 1.77 km, whereas one mile corresponded to 1.48 km.[4]

Attention could be drawn to a particular sentence by Strabo where, in discussion of the Via Egnatia across Roman Macedonia, the "usual" calculation is reported:

If, as most people do, one calculates eight stadia per mile, (...) (Strab. 7.7.4)

However, the author then added a remark about a different calculation that Polybius would use,

(...) *who adds two* plethra *(i.e. one third of a stadium) to the eight stadia,* (...) (Strab. 7.7.4)

which shows that even Strabo got confused in his reckonings. Indeed, it can be realized that Polybius referred here to the Greek "Attic" *stadion*, eight of which make 4800 feet, that is short of a Roman mile by 200 feet (two *plethra*). This is indeed the relation that follows from the two different foot counts with a common base unit, and Polybius correctly accounted and compensated for the resulting 4% difference. Strabo, on the other hand, mixed things up when he noted that two *plethra* are "a third of a stadium", which is true of a Greek *stadion*, whereas the ratio of eight stades to the mile would only be appropriate for the *stadium*. Considering the comparatively small relative difference, counting eight stades to a mile would yield a just marginally shorter mile value in any territory where the 'Attic' *stadion* of 177 m was formerly employed.

The territories of the kingdom of Pergamon were acquired by the Roman Republic on the death of the last Attalid king, becoming the province of Asia by 129 BC. There, road marker stones were also of the *dekastadion* type marking intervals of 6000 feet, but the foot unit used in Pergamon was significantly longer than the Roman one. Comparison among the two units is enabled by one of the *metrological tables* by Heron of Alexandria (*Geometrica* 4.3), where the foot called *Italikos* is said to be equal to 13⅓ fingers, whereas the foot unit of 16 fingers is designated *basilikos kai Philetaireios* (royal and Philetaeric). The Pergamene unit, called *Philetaeric* after the founder of the extinct Attalid dynasty, was then the same as the Egyptian foot, and can be further identified with the Samian/Ionic foot since, according to Herodotus (Hdt. 2.168), the Samian and Egyptian cubits were the same. The Philetaeric foot was then 350 mm long and in this case intervals between *dekastadia* would be 2.1 km long, as confirmed in Section 2.

Even in Roman times, Greek authors generally reported distances by the *stadion* in their texts.

[3] Nigdelis – Anagnostoudis 2017. In the following, the terms *stadion* and *stadium* are used, respectively, for the Greek and Roman units (plural *stadia* in both cases). When no specific unit value is assumed, "stade" (plural stades) is used as a generic term.

[4] The Roman foot is usually attributed a length of 296 mm. The "Attic" foot is often attributed a just slightly lower value in the range 293-295 mm (Wesenberg 1975-1976, 16), but for all practical purposes the common assumption that the "Attic" and Roman foot were essentially the same unit holds. It may be noted that positions of *dekastadia* and *miliaria* would match every 6 mp.

Lack of explicit indications about a specific unit value led in modern literature to an understanding that the *stadium*, intended as the Roman unit, may be involved.[5] Where Philetaeric units had been in use, application of the 8 : 1 ratio to convert stades into miles would result in an unusually long "mile". A trace of this possibility can be found in a statement by Plutarch, that is the opposite of what Strabo reported (7.7.4) and would in fact be entirely appropriate for intervals of eight 210-m stadia:

(...) *the mile is a little* short *of eight stadia.* (Plut. *Vit. C. Gracch.* 7.2).

The purpose of this paper is to investigate the issue by analysis of distance indications on ancient milestones, on the assumption that, if any peculiarity can be recognized, it may point to signs of transition or merger involving the itinerary length unit. Archaeological research over the last couple of centuries produced more than a thousand milestone finds in Asia Minor alone. Original distance indications can be read reliably from about 30% of the extant items, that represent the primary sources for this study. Inscriptions are also relevant here as far as they enable to accurately date the stone, usually by reference to emperors and key personalities in Roman administration.

For the Roman provinces of Asia Minor, an extensive corpus of milestone inscriptions has been collected by David H. French and is currently available as a set of on-line monographs by the British Institute of Archaeology at Ankara (BIAA)[6]. Most of them can be dated to the Roman imperial period, whereas Roman milestones of the republican period are just a small number,[7] and a single Hellenistic stone shows distances in stades.[8]

The relevance of milestones in the study of itinerary measures may have not always received due consideration, but it should be reminded that distance information would certainly be considered trusted and accurate at the time, since road marker stones were laid for a specific purpose in accordance with requirements of road administration. This justifies relying on them as independent information sources whose original uncertainty can be assessed, so that ancient length indications can be subjected even today to cross-checking and verification against modern distance estimates.

Other information essential to this study are concerned with the road course. The present state of knowledge about ancient roads and place locations does not allow reconstruction of paths with absolute certainty. For some of the better studied courses that are discussed in this paper, existing literature nevertheless enables the creation of a picture detailed enough to attempt a comparative study.[9] For selected roads, the broad availability of digital geographical data and of computer-based route tracing tools allows to define modern paths that are generally quite similar to those of ancient routes. Their lengths can be computed accurately enough, taking into account the *caveats* exposed in Section 3, to be useful for this kind of study.

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[5] The *stadium* of 625 feet was called 'Italicum' by Censorinus (*DN* 13.2). On the other hand, Pliny stated: 'Stadium CXXV nostros efficit passus, hoc est pedes DCXXV' (Plin. *HN* 2.21.85), which in the author's opinion justifies as well calling it 'Roman'. For completeness the dual adjective 'Roman/Italic' could perhaps be more appropriate. When any of the two is used singly in the paper, it is understood that the same length value is intended.

[6] https://biaa.ac.uk/publication/open-access-electronic-publications/roman-roads/, last accessed: August 2nd, 2024.

[7] French, *Roman Roads* III/1, 30-42.

[8] *I.Ephesos* VII/2, 305; French 1997a; Thonemann 2003, 95-96.

[9] Ramsay 1890; Talbert 2000; French, *Roman Roads* IV/1; Åhlfeldt 2020.

In most cases milestones pre-date written itinerary information even by some centuries, which might allow cross-checking with well-known historical references that are also considered in this discussion, namely, the *Itinerarium Antonini* and the *Tabula Peutingeriana*.[10]

At this point it may be useful to summarize the essential features of length units under discussion, that are presented in Table 1.

	foot (mm)	stade (feet)	stade length	marker stone	marked interval	stades to 1 mp
Roman/Italic	296 mm	625	185 m	*miliarium* (×8)	1.48 km	8
Greek ("Attic")	≅ 296 mm	600	177 m	*dekastadion* (×10)	1.77 km	8⅓
Philetaeric	350 mm	600	210 m	*dekastadion* (×10)	2.10 km	≅ 7

Table 1) *Itinerary units: Definitions and equivalences*

It should be noted that the correspondence between 7 stades and 1 mp given in the last line agrees with one of the definitions given in the Byzantine lexicon called *Suda*.[11] It is based on the 6 : 5 ratio between Philetaeric and 'Italic' foot provided by Heron of Alexandria (Heron *Geom.* 4.3) and yields 5040 Italic feet for the mile. On the other hand, Heron also derived a less accurate correspondence of 4500 Philetaeric and 5400 Italic feet to a *milion* from the ratio of four miles to a *schoinos*, hence 7½ stades per mile (Heron *Geom.* 4.13). The resulting length of 1.575 km is 8% greater than a Roman mile.

This illustrates the numerical difficulties faced by any attempt to merge two metrological systems where different sets of multiples and submultiples were in use. This is seldom commented upon in the literature, but appears to be one of the reasons for the seemingly inextricable variety of hypotheses on unit values, proposed since the late 19th century. In this paper a step backwards is taken in this regard, and even equivalences attested directly from ancient texts are scrutinized, although fundamental contributions by early works are not disregarded.[12]

Analysis is based on general principles of measurement science and relies primarily on the notion of *metrological compatibility*, whose application in this context is introduced in Section 3. Careful evaluation of uncertainty, applied to both ancient distance indications and modern length estimates, is essential to this approach. It allows to discuss the compatibility of values according to a well-defined metrological criterion, proposing interpretations of existing archaeological evidence that appear most likely on the basis of actual data.

Results point to the conclusion that the ratio of eight stades to the mile was commonly applied to distance indications, whatever the actual stade involved. In Asia Minor the original unit length of 210 m was retained, and the ratio resulted in a quite unusual conversion factor of 1.68 km to one mile. Its application to milestones, preserving distance figures at precise locations, consistently

[10] Talbert 2010; Rathmann 2022.

[11] Two alternative equivalences are given in the *Suda* for the *milion*, either: 10 miles contain 80 stades, or: a *stadion* has 600 feet and a *milion* has 4,200 feet. Both refer to *mille passus*, as the 1 : 8 mile to stade ratio can be recognized in the former case, whereas the latter gives the correspondence between 'Philetaeric' feet and a Roman mile. Suda On Line: https://www.cs.uky.edu/ ~raphael/sol/sol-entries/mu/1064/, last accessed: February 15th, 2025.

[12] For instance, Hultsch 1862 and Segrè 1928.

yields more accurate length values for the analysed courses up to the 3rd century AD at least. This opens the way to a revised analysis of later sources like itineraries, whose compilers' work was probably most affected by this peculiarity.

2. A road from Ephesus to Sardis

A road connecting the Greek city of Ephesus to the former Lydian and Persian regional capital Sardis assumes particular importance for this work, in view of the remarkable concentration of localized itinerary information referring to it. Indeed, distances between the two cities are documented in different forms, that is, a Hellenistic *dekastadion*, a few Roman milestones and the *Tabula Peutingeriana*.

The road has been fairly well analysed and this provides the ground for comparative analysis among sources spanning about six centuries. From Ephesus it proceeded eastwards through Thyaira (Tire) and the valley of river Cayster (Küçük Menderes) until Hypaepa, a town whose ruins lie near the present-day village of Günlüce. Two distinct paths could be followed to cross over from there to Sardis through the range of Mount Tmolus (Boz Dağ), these rejoining at some distance from Sardis into a final common tract.[13]

Along this road a pre-Roman marker stone was found at Mehmetler, giving distances in stadia to Ephesus (90) and Sardis (410) and most probably dated to the first half of the 2nd century BC.[14] The total of 500 stades should not be compared with the distance of 540 stades given by Herodotus (Hdt. 5.54), who was likely describing a major highway to Sardis that first led northwards from Ephesus and, after Metropolis (near Yeniköy, Torbali), crossed into the Hermus valley by way of the Karabel pass,[15] where a maximum elevation of no more than 450 m was reached. By contrast the road under consideration, although shorter, crossed the Tmolus range at over 900 m.

Roman milestone finds are recorded in the area of Belevi, where the road towards Hypaepa separated from the road to Metropolis and Smyrna.[16] Based on a findspot map for the area,[17] only the one bearing an 8 mp indication is considered here.[18] Another milestone, dated to 70 BC and found at Tire, is a much earlier example from the Republican period that bears an indication of 24 miles from Ephesus.[19]

Finally, a course with distances in miles is reported in the *Tabula Peutingeriana* (Grid square 8B5).[20]

A comprehensive discussion on the Mehmetler stone[21] referred to a calculated distance between Ephesus and Sardis of 94.4 km, that was obtained by tracing on a map the path shown by the thick

[13] Foss 1978, 29-30.

[14] Thonemann 2003, 95-96; *I.Ephesos*, VII/2. 3601 = *AE* 1997, 1440a-b = *SEG* 47, 1624.

[15] Magie 1950, 1: 39-40. Magie 1950, 2: 786.

[16] French, *Roman Roads* III/5, nos. 007a to 007e.

[17] *I.Ephesos* VII/1, 148.

[18] *I.Ephesos* VII/2. 3604 = French, *Roman Roads* III/5, no. 007a; EDCS-70200350.

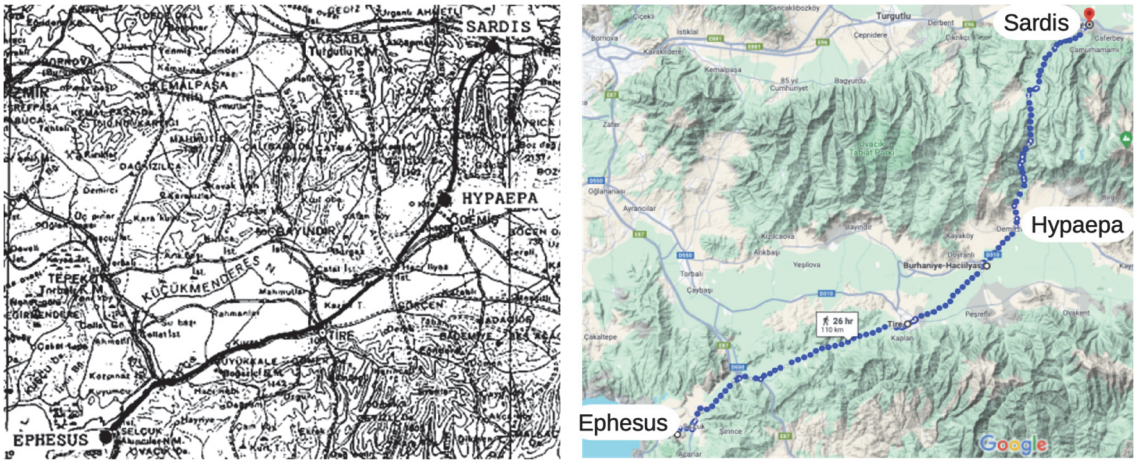
[19] Haussoullier, 1899; *I.Ephesos* VII/2. 3602 = French, *Roman Roads* III/1, no. 4; EDCS-24900125.

[20] Explore The Peutinger Map, *https://www.cambridge.org/us/talbert/*. Last accessed: February 22nd, 2025.

Database tp-online, KU Eichstätt–Ingolstadt, *https://www.ku.de/en/ggf/geschichte/lehrstuehle-professuren/ggf/geschichte/alte-geschichte/forschung/tabula-peutingeriana*. Last accessed: February 22nd, 2025.

[21] French 1997a.

black line in Fig. 1a. This pre-computer distance estimate was determined by measuring wheel on a Turkish 1:200,000 topographic map. If computer-based tools are used to compute a distance from a digital map for comparison, suitable criteria must first be set to produce a path that convincingly agrees with natural terrain features, like an ancient road would do. The issue is discussed in detail in Section 3. The path traced by the Google route planner for this road (shown by the blue line in Fig. 1b) is about 110 km long.[22]



(a) from French 1997a, 190. (b) from *Google Maps*

Fig. 1) *Maps showing the route from Ephesus to Sardis. The dotted line shows the present-day walking path (110 km)*

In a visual comparison between Fig. 1b and Fig. 1a the two paths appear quite similar, therefore the rather significant discrepancy of over 15 km between their estimated lengths needs to be analysed. A difference of just 5 km between Ephesus and Hypaepa (respectively, 68 km and 73 km) might still be attributed to minor discrepancies and uncertainty. On the contrary, when transferred onto a digital map the proposed estimate of 26 km between Hypaepa and Sardis[23] is readily realized to be an underestimate, illustrating a possible issue with "path smoothing" involved in manual map tracing. Correspondence could only be obtained by a straight single segment, whereas roads on mountainous terrain tend to be significantly more winding.

The likely course goes up the slopes of Mount Tmolus through Lübbey Kişla (Çamyayla) and Belezler, crossing some ancient settlements whose presence is attested by archaeological finds. Google Maps calculated length for this path is about 37 km, whereas the alternative course following some parallel valleys slightly to the east was assessed to be about 35 km long on foot.[24] Even assuming some overestimation in this case, actual total length between Ephesus and Sardis cannot then be much shorter than 110 km. Available itinerary information about this road are collected in Table 2, where modern distances, evidenced in bold characters, are given as a range of values to account for uncertainty due to resolution limits and possible slight variations of the path.

[22] Modern roads designed for car traffic tend to trade length for speed. From Ephesus to Sardis, distance by car through the Cayster valley would be nearly 130 km, but a planner would typically default to a faster and longer course of about 150 km through the Karabel pass and along the Hermus valley. This emphasizes the importance of a proper choice of options, and careful study of ancient sources.

[23] French 1997a, 192.

[24] Foss 1978, 32.

location name	closest location	Roman [mp]	*Tabula* [mp]	×1.48 [km]	**distance** [km]	Greek [*stadia*]	×210 m [km]
Ephesus	Efes	0	0	0	**0**	0	0
–	Belevi	8		11.8	**13–15**	–	(13.4)
–	Mehmetler	–	–	–	**18–20**	90	18.9
Thyaira	Tire	24		35.5	**38–40**	–	(40.3)
Anogome	?		34	50.3	–	–	(57.1)
Hypaepa	Günlüce		43	63.6	**68–73**	–	(72.2)
Sardis	Sart		63	93.2	**100–110**	500	105

Table 2) *Distances related to the road between Ephesus and Sardis*

It can be noticed that the distances indicated by Roman milestones and those read from the *Tabula Peutingeriana*, although presented in separate columns in the Table, may be regarded as a common set with coherently increasing values. Conversion by the usual factor of 1.48 km to the mile yields a uniformly *too short* set of lengths. On the other hand, if the length of 210 m based on the Philetaeric foot is assumed for the Greek *stadion*, converted values in the rightmost column provide almost exact matches with the modern length estimates.

At present this is the only archaeological evidence in the Anatolian region for which direct study of a pre-Roman itinerary measure is possible. The distance indications on the Hellenistic stone at Mehmetler are best matched by the 210-m *stadion*, whereas interpretation in terms of Roman units leads to discrepancies that are well beyond the uncertainty that can be reasonably attributed to the length values in Table 2. The existence of an attested pre-Roman *dekastadion* that provably does not match *mille passus* as length unit, points to the conclusion that the itinerary measure was originally unrelated to the Roman system and is enough to support the hypothesis of an already existing system of distance indications in the Pergamene kingdom.

It may also be realized that the total course length of 63 mp reported in the *Tabula Peutingeriana* could be obtained from the value of 500 stades by reckoning eight to one mile, as in Strabo, then rounding 500 ÷ 8 = 62.5 mp to the nearest integer. Conversely, indications on the Roman milestones as well as in the *Tabula* could be converted into 'Philetaeric' units yielding more accurate lengths, as shown in parentheses in the last column of Table 2.

If the possibility of more widespread adoption of the 8 : 1 conversion ratio is taken into account, a few additional considerations can be made:

- in a discussion of the Mehmetler marker stone it was suggested that the find location differed from its original position.[25] However, this followed from the assumed correspondence to the *stadium* of 185 m, based on which the indicated distance from Ephesus would be converted into 16.5 km, short by over 2 km. The discrepancy vanishes with the 210-m *stadion*;

[25] Callieri – Bernard 1995, 77-78.

- the Roman republican milestone from Tire bears an indication of 24 mp yielding 35.5 km, about 5 km short of the city.[26] Considerations about relocation of the stone were made also in this case, but the rather good overall correspondences evidenced in Table 2 suggest an alternative explanation by the 210-m *stadion* hypothesis;
- the *Tabula Peutingeriana* gives a distance of 9 mp between Hypaepa and the site of Anogome, a location supposedly on the Sardis–Ephesus road. A significantly different position on the Smyrna–Ephesus road is considered in the *Barrington Atlas*.[27] However, by reversing the 8 : 1 conversion ratio the distance of Anogome from Hypaepa could be restored to 70 stadia = 14.7 km that leads from Günlüce near a place rather high up the Cayster valley, whose present name is Burhaniye–Hacıilyas. It may then be suggested this was about the location of Anogome.[28]

Although the hypothesis disagrees with the *Barrington Atlas* and with cartographic reconstructions based on it,[29] it would not be in contrast with the disposition of graphical elements in the *Tabula Peutingeriana* and can better agree with the proposed interpretation of numerical values. Besides the road bifurcation at Belevi, a further junction is found just north of Metropolis.[30] As in the *Tabula* the segment through Metropolis has no distance indication, it might thus refer to a road running directly down the right side of the Cayster valley from Anogome.[31]

The analysis presented in this Section can support a conjecture that the 210-m *stadion* remained an established itinerary unit into Roman times, somehow pragmatically adopted and indeed employed on Roman roads in Asia Minor. If this was the case, it should be possible to find further traces of discrepancies between indicated and measured distances elsewhere, and on this basis the hypothesis, however unconventional, is pursued in the following sections of the paper.

3. Road lengths and itinerary units: uncertainty and compatibility

3.1. Uncertainty for ancient roads

Analyses in this paper are based on the notion of *compatibility* of values, according to the criterion that an ancient indication is considered compatible with a corresponding modern estimate if their relative discrepancy (that is, the ratio of difference to mean value) is smaller than a given threshold, based on uncertainty. This approach is made necessary by the limitations of our present knowledge on ancient roads and milestones. Accurate information are only available in a very few cases,[32] but this need not prevent the use of less accurate archaeological evidence, as long as the uncertainty that can be attributed to resulting data is properly evaluated.

The distance indication presented on a road marker stone (*miliarium* or *dekastadion*) would often be just an integer N, meaning a distance $d = N \cdot L$, where L is the length of the unit, either miles or

[26] French, *Roman Roads* III/1, 10.

[27] Talbert 2000. Map 61, E1.

[28] The location proposed here would be between Hypaepa and Larisa, in Talbert 2000. Map 56, F5.

[29] Åhlfeldt 2020.

[30] *I.Ephesos* VII/1, 148.

[31] In the assumed position Anogome could be a junction of some importance, with another road possibly leading further up the Cayster valley, to Dios Hieron (Birgi) or to the Kilbian plain. The hypothesis also implies that the shorter direct link between Belevi and Metropolis is not represented in the *Tabula Peutingeriana*, although its existence is attested by milestones.

[32] Grewe 2013, 12-13.

stades. Count N is always a multiple of the marked interval Δ given in Table 1, that means a resolution of $\pm\Delta$ can be associated to d, in any case about 2 km in modern units. The uncertainty contribution of finite resolution thus remains below 2% for any distance above 100 km.

The assumption that unit length L must be traceable to an established metrological system follows logically from the very fact that marker stones were laid. There can be little doubt that the whole effort of marking roads by milestones had to be metrologically based, and distances were traceable to an appropriate base unit.

Length uncertainty about the value of a 1-foot artifact would depend almost exclusively on the minimum detectable length variation. This *resolution limit* would be a fraction of the smallest sub-unit, the finger, for which sub-divisions down to 1/6 were usually determined. Relative uncertainty resulting from finite resolution would then be not less than 1/96 = 1% at best, corresponding for a foot to a compatibility range of ±3 mm. Similar considerations hold in general for any other ancient metrological system, therefore ±1% will be considered in the following the minimum uncertainty that can be attributed to the value of any ancient base unit (foot or cubit), based on available current knowledge.

Whether in miles or in stades, *itinerary* measures were referred to distances along some specific road, therefore length values depended on the particular course between the places of interest. When the issue of how distance could be measured is considered, it is not hard to conjecture the use of a properly laid measuring rope, possibly with suitably spaced marker knots. This may be the most rudimentary approach, still ropes could be calibrated to an uncertainty little greater than the base unit. Even accounting for undue stretching, deformation or deterioration, uncertainty for a one-mile interval L might be assumed to be not greater than 2–3%.

Our knowledge of ancient road measurements is further affected by uncertainty about the position of the reference point from which a distance is taken. Clearly defined and recognizable landmarks are known to have existed in Athens, Rome and later in Byzantium, but for other cities detailed knowledge may be lacking. The start could supposedly be taken from some main building or temple, or from a gate in the city walls facing the destination. For minor centres the reference might have been a point where a track to the town departed from the main course, while stations and major junctions along the road could also be taken as references. When this kind of *positional* uncertainty is relevant, based on analysis of a number of actual cases it appears reasonable to assume that the reference location falls within a radius of 3–4 km, and an uncertainty range of ±4 km will be assumed in the following.

One remaining issue concerns possible differences between the recorded find place of a milestone and its actual position along a road. It is sometimes argued, as a possible explanation for perceived discrepancies with other sources, that a stone find place may differ from its original location. Intentional removals did occur mainly as a form of reuse of building material, otherwise casual displacement even by few km would have to be convincingly explained, in view of the material impact of such heavy items. Reliance on assumptions of this kind is accordingly reduced as much as possible, to avoid possible arbitrariness in the interpretation of data. In the following, reported values are assumed to have mostly been correctly preserved up to the present time, unless shown otherwise.

3.2. Uncertainty for route calculation on digital maps

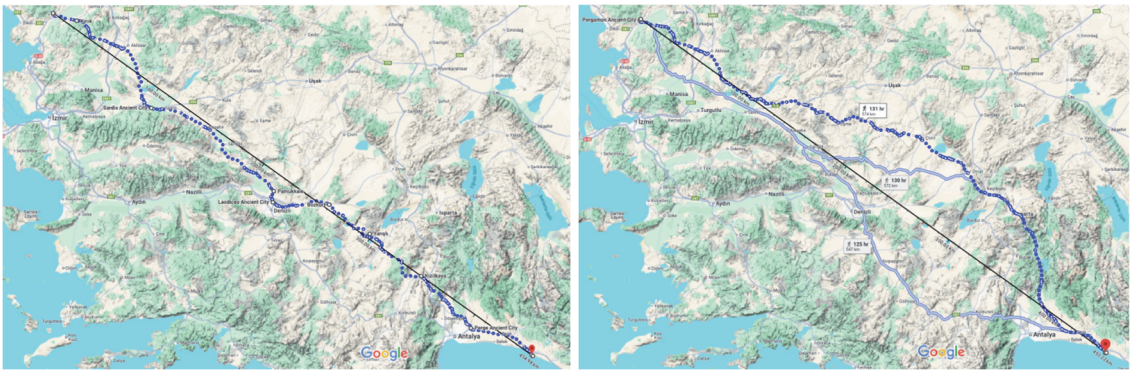
Throughout this paper distance indications drawn from ancient sources are compared with modern itinerary measurements, which may appear an obvious approach. However, it can also be argued that ancient road courses are seldom known exactly in their entirety, so that actual length remains an unknown quantity. Even when a study of itinerary length units refers to clearly recognizable routes, allowance has then to be made for inaccuracies, whose origins must be considered in detail:

- The positions of key settlements can often be determined with reasonably good accuracy today, and ancient road traces may still be visible in places. River crossings or mountain passages are often mentioned in ancient sources and, together with obvious obstacles and approximate positions of ancient cities, this can help shape a path;
- In some cases, modern roads still generally follow original courses and partly run over them. Modern cities may rise over ancient ones, or be located at just a few km from their remains. Several key archaeological sites in Asia Minor are reported on digitized maps, in many other cases exact locations are uncertain to some degree, however the area can at least be reasonably bounded within a few kilometres;
- Computer-based route planning tools may allow to draw paths that match known waypoints on the ancient road of interest and help obtain comparable length estimates. Discrepancies in length should be expected anyway even when care is taken in the process, therefore it is important to assess how large these may be.

Any path length is lower-bounded by the point-to-point distance calculated over the surface of the earth reference ellipsoid. Google Maps refers to WGS84 geodetic coordinates and available accuracy assessments agree on levels of positional uncertainty of few tens of metres at worst, that can be neglected for the purposes of this work. The algorithm by which Google Maps determines actual path lengths includes elevation information and combines sequences of shorter tracts. Its accuracy has been discussed for various applications (e.g., by joggers), but an assessment for length estimation of ancient courses may best be obtained by comparative analyses.

Discrepancies have to be expected, an example for the purpose of this discussion being provided by the road between Pergamum and Side. The blue line in Fig. 2a shows the proposed course reconstruction obtained by feeding the Google Maps route planner with suitable relevant locations.[33] Point-to-point distance between Pergamum and Side (black line) is 455 km, whereas reconstructed (blue line) course length is 575 km. The path, where elevation ranges from sea level to about 1500 m, is 26% longer than the "straight-line" distance. Fig. 2b shows instead a choice of three alternative end-to-end paths generated in "walking" mode, unconstrained by predefined waypoints. None of them agrees with the ancient road course, but the spread of length values is quite limited, much less than 10%. In particular, one of the paths is just 1 km shorter than the ancient course reconstruction, even though it mostly differs.

[33] French, *Roman Roads* III/1, 10.



(a) *Google Maps*, from French, *Roman Roads* III/1 (b) from *Google Maps*, only endpoints given

Fig. 2) *Alternative routes from Pergamum to Side. On the left, the dotted line shows the course reconstructed in French, Roman Roads III/1, 10 (575 km). Lengths of paths on the right are 547 km, 572 km and 574 km. The latter, marked by a darker dotted line, differs in length from the reconstructed course by just 1 km.*

For a comparison of different path-tracing tools, the case of reconstructed routes between Adramyttium (Ören) and Pergamum (Bergama) through the Kozak mountains can be discussed. A distance of LIII (53) [mp] between the two endpoints Adramyttium and Pergamum is reported in the *Itinerarium Antonini*,[34] which led to the formulation of two alternative hypotheses.[35] Least-cost path analysis yields a length of 71.17 km for the route passing Kytonion and 75.98 km for an alternative route via the ancient city of Perperene. Straight-line distance is just 46 km, while proposed paths are longer by over 50%, which is typical of the mountainous terrain involved in this case.

Corresponding lengths calculated by Google Maps through the two hypothesized waypoints are 72.6 km and 73 km respectively, with differences of less than 3 km (between 2% and 4% in relative terms). These values may only be understood as lengths of modern-day trekking trails on similar courses, it may be argued however that, in an approximate and unsophisticated way, least-cost path criteria are implicit to such trails as well. Neither of the two paths can be proved to coincide with an ancient road but, even though detail information is lacking, the spread of values remains comparatively limited, and discrepancies from the converted 53 mp length (78.44 km at 1.48 km per mile) are between -3% and -10%. It should also be remarked that conversion by the alternative factor of 1.68 km per mile yields 89 km. In this case the traditional Roman mile unit is a better match.

Summarizing, several factors can contribute to uncertainty of modern length estimates, but knowledge of a number of trusted waypoints is usually enough to reliably determine an approximate path even when it cannot be recovered exactly, which is most often the case for ancient roads. Partial knowledge can lead to a sufficiently close estimate of a course length, even based on estimates for paths that are only just similar. Adjustments introduced to include additional reference points into a specific path may cause variations of just a few km, therefore for lengths of at least 100 km the uncertainty of a carefully obtained estimate will usually hardly exceed a few percent.

3.3. Compatibility and acceptance criterion

It is useful for the purposes of this study to define a *compatibility* range, such that any length estimate within that range can be considered compatible with the ancient numerical indication,

[34] *It. Ant.* 335.3.

[35] Ludwig 2020, 9-10.

combined with the assumed length unit. This will be adopted as the acceptance criterion for the hypothesis that a road course may agree with an outlined path having a stated length and, in general, as a test for assumptions involving distance indications carved on ancient marker stones.

Uncertainty analysis suggests that, whenever the distance involved is in the order of a hundred km at least, lengths of road courses estimated by a route planner on a digital map and of reconstructions based on archaeological and textual information can be attributed comparable relative uncertainty. In other words, even when the assumed path is not a perfect match, the length estimate cannot be far from the intended distance indication.

Although the assessment is not exhaustive, it is reasonable to assume, based on present knowledge and the discussion in this Section, that for a well-documented ancient course the uncertainty of a modern length estimate can be no greater than 5%, and at most 10% in a worst case when, for instance, only a start and a destination are known. As a general guideline then, a tight *compatibility threshold* will be set to 5% for reasonably well-defined courses, and a second looser threshold at 10% for less documented ones. Uncertainties between 5% and 10% are considered inconclusive, unless further evidence can help point in one direction. Any relative discrepancy exceeding 10% is taken to indicate incompatibility of numerical values and will possibly require further study.

These thresholds are particularly significant for the analysis presented in this paper since, if there are reasons to believe that the Philetaeric *stadion* might be involved, any distance calculation based on the Roman length value would show significant underestimation (-12%). A positive choice between 185 m and 210 m stade lengths can then be based on the criterion of metrological compatibility, on condition that course lengths can be estimated with small enough uncertainty.

4. Roman republican roads in the province of Asia

Milestones already appeared in the earliest years of the new Roman province of Asia, archaeological surveys so far yielding eleven extant artifacts. The name of the first proconsul Manius Aquillius, inscribed on almost all of them, allows an early dating to 129–126 BC that is a sign of the importance attributed to prompt affirmation of Roman presence. Together with the broad difference in find places, quite far from Pergamum and Ephesus in some cases, this emphasizes the milestones' function as a show of Roman authority and of its pervasiveness in the territory.[36] The peculiar problem was that existing *dekastadia* marked different and longer intervals than a milestone did, and if the 8 : 1 ratio was applied to Philetaeric measures for conversion into miles, a significant difference would be involved. The presence of a pre-existing road network may however suggest the possibility of a transitional stage where this ratio was pragmatically adopted as a temporary measure. If this was the case, possible traces should be evidenced by comparative analysis of ancient and modern distances, provided sufficiently small uncertainties can be attributed to them. This prompts the discussion in this Section, where the non-standard value will be called a "long" mile for simplicity.

Surviving milestones from the republican period can be associated to four main designated roads in Asia, to which reference is made in the following:[37]

- **R.1**: Ephesus – Pergamum – Lampsacus;
- **R.2**: Ephesus – Sardis;

[36] Kolb 2011/2012.

[37] French, *Roman Roads* III/1, 28.

- **R.3** Ephesus – Tralles – Laodicia;
- **R.4** Pergamum – Thyatira – Sardis – Laodicia – Side.

Determination of the *caput viae*, usually an important city taken as the reference start point, is essential for analysis of Roman road lengths, as the name was often not reported on milestones.

Ephesus – Pergamum – Lampsacus (road R.1)

Three milestones may be referred to this road:

- French, *Roman Roads* III/1, no. 1; EDCS-02300001: milestone found at Sağlık, in the neighbourhood of the ancient Greek city of Metropolis, on which no distance figure could be discerned;
- French, *Roman Roads* III/1, no. 2; EDCS-25100882: a stone bearing a distance indication of three miles was found at Kazıkbağlari near Elaea, the port city for Pergamum, but this length is too short for numerical analysis;
- French, *Roman Roads* III/1, no. 3; EDCS-24900100: a distance of CXXXI (131) miles is carved on the milestone found at Dikili, in the proximity of the ancient Greek city of Atarneus.

The mile count on the Dikili milestone has proved difficult to explain.[38] Based on available evidence, the path from Ephesus would go through the cities of Metropolis, Smyrna and Elaea. From Elaea the main road went up the lower Kaikos (Bakırçay) valley to Pergamum, whence it reached the coast again near Atarneus. Google Maps estimates the length of this path to 215 km, whereas the indicated length of 131 mp would convert from Roman miles into 194 km. With a relative difference of 10%, the length match is acceptable but rather poor. A much better match is obtained if a "long" mile is assumed instead, the converted value being 220 km. In a purely data-oriented perspective the "unofficial" value of 1.68 km prevails, as it could meet by a good margin the tighter 5% compatibility threshold, within 2.5% of the estimated path through Pergamon, whereas for the value of 1.48 km the result is inconclusive.[39]

The assumed course implies some neglect for the importance of Pergamum, that would appear as a minor centre along the road.[40] On the other hand, the only course reported for this region in the *Itinerarium Antonini* starts from Lampsacus (Lapseki),[41] whose status as *caput viae* could be motivated by being the first city across the Hellespont in a land voyage from Greece (and Rome)[42]. On the reconstructed hypothetical course of road R.1, the distance of Dikili from Lampsacus as calculated by Google Maps is 225 km, showing that it is located about at the mid-point of the road. If the converted value of 220 km is considered, assuming once again 1.68 km to the mile, the

[38] Interpretation alternatives are offered in French, *Roman Roads* III/1, 9, where Ephesus is the assumed *caput viae*.

[39] A path directly across the lower valley of river Kaikos and by passing Pergamum would also be possible, but less likely. This shorter alternative being about 180 km, a poor match is obtained as well. The path is short by about 7.5% with the Roman mile, discrepancy with a "long" mile is of course even worse.

[40] French, *Roman Roads* III/1, 9.

[41] *It. Ant.* 334.1-337.2.

[42] In this regard it may be noticed that in Macedonia the mile count for the *Via Egnatia* did not start from the provincial capital Thessaloniki, but from the first port across the sea from Brundisium (Brindisi) (Romiopoulou 1974).

length indication of 131 mp would have the same 2.5% accuracy level. This shows how in this case compatibility analysis can also usefully contribute to investigating the *caput viae*.

Ephesus – Sardis (road R.2)

The road was thoroughly analysed in Section 2. Distances on the Roman milestones are too short to be considered, in a strict sense, according to the criteria defined in Section 3. However, the remark about their uniformly short indications in Roman miles should be remembered. Key results can be summarized thus:

- total length estimate is compatible with a distance indication of 500 stades if the 210-m 'Philetaeric' *stadion* is considered, but incompatible with the 185-m value of the Italic *stadium*;
- for the same length estimate, the total distance of 63 mp obtained from the *Tabula Peutingeriana* is incompatible with the 1.48-km value of the Roman mile, but would be compatible with a "long" mile of 1.68 km.

Given the well-studied characteristics of the course, a 5% compatibility threshold has been applied but, even with a more tolerant 10% threshold, conclusions would not change as discrepancies are well beyond the uncertainty range of length values in Table 2.

Ephesus – Tralles – Laodicia (road R.3)

Two republican milestones may be referred to this road:

- French, *Roman Roads* III/1, no. 5; EDCS-24700003: milestone found at Çamlık, a short distance from Ephesus, bearing a distance indication of five miles;
- French, *Roman Roads* III/1, no. 6; EDCS-24700004: milestone located to the west of Aydın (ancient Greek city of Tralles), which is an early find from the 18th century. The distance indication on it is XXVIIII (29) miles.

Because of the small numerical value, the Çamlık milestone is of no use for a check on alternative length units, as any discrepancy is likely to be within the assumed 2 km lower bound for uncertainty due to resolution. On the contrary, conversion for the Aydın milestone already yields two significantly different alternative values of 42.9 km and 48.7 km. The calculated distance between Ephesus and Aydın is 51.3 km according to Google Maps, but it should be remembered that the milestone findspot was slightly west of Aydın towards Ephesus.[43] Converted distance based on the "long" mile thus appears to be in better agreement.

The road may be considered the initial part of the "common road towards the east", whose description Strabo attributed to Artemidorus of Ephesus (Strab. 14.2.29). For the fraction going from Ephesus to the town of Carura (close to present-day Sarayköy) through Tralles and the valley of the river Meander (Büyük Menderes), a length of 740 stadia is recorded. Google Maps estimate is about 155 km.

Following here a reverse approach, conversion of the 29-mile indication on the Aydın milestone back into stadia at the standard 1 : 8 ratio, rounded to the next multiple of 10, yields a length of 230 stadia. If then the ratio of this value to the total number of 740 stadia is considered, one gets $\frac{230}{740} \times 155 = 48.5$ km that is almost exactly the value computed above for the milestone. Again, this

[43] *I.Ephesos* VII/1, 148.

suggests that distances would be uniformly shrunk if the proper Roman mile is assumed, whereas the "long" mile produces the best agreement.

For this course a much shorter distance estimate of about 134 km, obtained by tracing on a topographic map, has been proposed.[44] The value, transferred onto a digital map, turns out to be the length of a straight segment joining Ephesus with Carura, clearly an underestimate of the actual itinerary distance possibly due to excessive "path smoothing" that map tracing may introduce, as already noted in Section 2. However, conversion by the 185-m Italic *stadium* would yield a length of 136.9 km, seemingly an almost perfect match for the short estimate, emphasizing the need for careful checks to prevent possible unintended biases, that might follow in particular from familiarity with Roman units.

Pergamum – Thyatira – Sardis – Laodicia – Side (road R.4)

Five republican milestones were found along this road, four of which at nearby locations in the Turkish province of Burdur, district of Yeşilova. All are dated to 129–126 BC, at the start of Roman domination:

- French, *Roman Roads* III/1, no. 7; EDCS-56900214: found at Alanköy, with a distance indication of CCXIV (214) miles;
- French, *Roman Roads* III/1, no. 8; EDCS-56900215: found at Harmanlı, with a distance indication of CCXXI (221) miles;
- French, *Roman Roads* III/1, no.9a; EDCS-25100881: found at Yarışlı, with a distance indication of CCXXIII (223) miles;
- French, *Roman Roads* III/1, no. 9b; EDCS-56900216: found at Yarışlı, with a distance indication of CCXXVII (227) miles;
- French, *Roman Roads* III/1, no. 10; EDCS-02800005: found at Selimiye, with a distance indication of CCCXXXI (331) miles.

Milestone finds are peculiarly concentrated in the final third of this long road, whose reconstruction was presented in Fig. 2a. The *caput viae* was convincingly shown to be Pergamum, while the findspot of the final milestone is reportedly just 5 km before Side.[45] For homogeneity, the road segment between Yarışlı and Selimiye is considered here as well. The length estimate from Yarışlı to the location of the ancient city of Side is 195 km, from which the final 5 km must be subtracted. The two different values of 223 mp and 227 mp on the milestones found at Yarışlı imply that the segment length is between 104 mp and 108 mp in ancient units, a difference of 6–7 km that remains below the tighter threshold for compatibility. The mean value of 106 mp is considered for simplicity, and the following results are obtained:

- with the 1.48-km value of the Roman mile, conversion yields 157 km. This is shorter than the 190 km estimated distance by over 15%, thus incompatible with it, even taking the looser acceptance threshold;

[44] French 1998, 32.

[45] French, *Roman Roads* III/1, 10.

- with a "long" mile of 1.68 km, conversion yields 178 km. Relative discrepancy with the 190 km estimated distance is about 6%, which cannot be considered positively compatible, yet very close.[46]

Roman republican milestones appear to be pointing at the fact that Roman authorities in the 2nd century BC did apply the ratio 8 : 1 when converting distances from stadia into miles, regardless of possible differences in the *stadion* length in actual use. So far this has been conjectured as a sort of temporary measure allowing to quickly implement a changeover, in which case one would expect the practice to disappear as soon as Roman administration of roads was fully settled. It is of interest then to investigate next the earliest new-built Roman paved road in Anatolia, *Via Sebaste*, that linked Roman colonies in Pamphilia to the regional capital Perge and the Mediterranean coast.

5. Imperial milestones in Asia Minor

5.1. Early imperial milestones: Via Sebaste (6 BC)

At least five milestones along the course of *Via Sebaste* can be positively dated to 6 BC, as their inscriptions bear the name of legate Cornutus Aquila, who supervised works on behalf of emperor Augustus.[47] Table 3 lists them and provides distances in miles together with the two alternative conversions. Length estimates obtained by the Google Maps tool are reported in the last column for comparison. Once more, if a "long" mile is used ancient distance indications can agree with modern length estimates within about 5%. Lengths converted by the accepted Roman mile value appear too short, and the resulting inaccuracy would be so large as to make milestone indications useless.

French, *Roman Roads* III/6 and EDCS ID number	find location	indication [mp]	×1.48 [km]	×1.68 [km]	GMaps [km]
no. 07b; EDCS-70200258	Yarı	XXCIIX	130.2	147.8	156
no. 05a; EDCS-70200255	Boğaziçi	[X]CVII[48]	143.6	163	172.2
no. 04b; EDCS-10700083	Ürkütlü	CXIIII	168.7	191.5	211.7
no. 04a; EDCS-32500158		CXXII	180.5	205	
no. 02; EDCS-11400036	Döşeme Boğazı	CXXXVIIII	205.7	233.5	≅ 250
no. 01; EDCS-70200254		CXXXX[49]	207.2	235.2	

Table 3) *Roman imperial milestones from 6 BC found along Via Sebaste. Caput viae: Colonia Antiochia (Antiochia in Pisidia – Yalvaç)*

[46] For completeness, it must be reported that a length of 166 km, obtained by tracing a path on 1:200,000 maps, is claimed in French, *Roman Roads* III/1, 10-11. This would be just 5% longer than the point-to-point distance of 158 km and proved impossible to replicate on a digital map. Since underestimation was observed in other instances of map tracing, the Google Maps value is considered more reliable.

[47] French 1997b; French, *Roman Roads* III/6.

[48] On the basis of comparison with other distances, the uncertain presence of a leading 'X' appears to be confirmed (French, *Roman Roads* III/5, 30).

[49] Only the number of miles can be read on this stone, however inclusion in the list is suggested by its features (French, *Roman Roads* III/5, 26).

The situation is again confirmed for a later milestone of the Roman Imperial period that bears an indication of 88 mp from Ephesus, supposedly on the same road R.1 discussed above, dated to AD 75 and found at Kazıkbağları.[50] Estimated distance between Ephesus and Elaea is about 150 km in this case, and conversion from traditional Roman miles falls short by 20 km. On the other hand, if "long" miles are assumed instead, the converted value is 147.8 km, within 1.5% and a remarkably good match.

5.2. Late imperial milestones: Caesarea – Melitene

Turning to a later period enables to investigate how long the supposed use of a non-standard length value for the mile might have lived on. The road from Caesarea (Kayseri) to Melitene (Eski Malatya) is a suitable object for analysis since over 50 milestones, out of about 200 documented for Cappadocia, were found along its course.[51] An ancestor of the road already existed as part of the Persian royal road described by Herodotus (Hdt. 5.52.2) and, later, of the "common road towards the east" (Strab. 14.2.29). The milestones considered here were probably laid about four centuries later than the republican ones, and testify the extensive maintenance and renovation works carried out in the 3rd century AD under the Roman emperors confronting Parthians along the eastern frontiers of the empire.[52] It seems reasonable to assume that on this occurrence the road was measured from new, distances inscribed on milestones representing the situation at the time.

A detailed reconstruction of the Roman road[53] can be accurately transferred to the Google Maps route planner, which yields calculated lenghs of 110.6 km between Caesarea and Comana (Şar) and 256.4 km for the Comana–Melitene segment. As this can be considered a well-defined course, it seems reasonable to attribute an uncertainty not larger than 5% to the estimated length thus obtained.

A split in the *caput viae* occurs near the ancient city of Comana, the boundary being seemingly placed between two villages just 4 km apart, Elemanlı (Çakırlar) and Şar (both in the district of Tufanbeyli, Turkey). For the Comana–Melitene segment, milestones bear progressive distance indications from Melitene, with a highest value of 157 mp on a milestone found 2 km beyond Şar towards Elemanlı,[54] thus probably right at the boundary between the two parts of the road. On the Caesarea-Comana segment the highest known indicated value is 63 mp from Caesarea, on milestones found near Elemanlı,[55] though not necessarily at the end of that segment. Total length obtained from milestone indications is therefore at least 220 mp.

Lengths in kilometres calculated by the two alternative conversion factors are presented in Table 4. Milestone indications agree with Google Maps estimates to within 1% when 1.68 km per mile is used (evidenced in bold characters in the Table), which definitely supports the hypothesis that the non-standard "long" mile remained in use in imperial times.

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[50] French, *Roman Roads* III/5, 62-63. EDCS-70200357.

[51] French, *Roman Roads* III/3.

[52] A frequently found formula is: *vias et pontes vetustate conlapsas restituit/restituerunt* – he/they restored roads and bridges [that were] in ruins because of age (e.g., French, *Roman Roads* III/3, no. 089c; EDCS-31200805).

[53] French 1998, 28.

[54] French, *Roman Roads* III/3, no. 083; EDCS-60200027.

[55] French, *Roman Roads* III/3, nos. 080a, 080b, 080d and 080e; respectively: EDCS-60200021, EDCS-60200022, EDCS-60200024 and EDCS-60200025.

road segment	milestone indication [mp]	mp ×1.48 [km]	mp ×1.68 [km]	GMaps [km]
Caesarea – Comana	≥ 63	≅ 94	≅ 107	110.6
Comana – Mazaca	157	232	264	256.4
Total	≥ 220	≥ 326	≥ 370	367

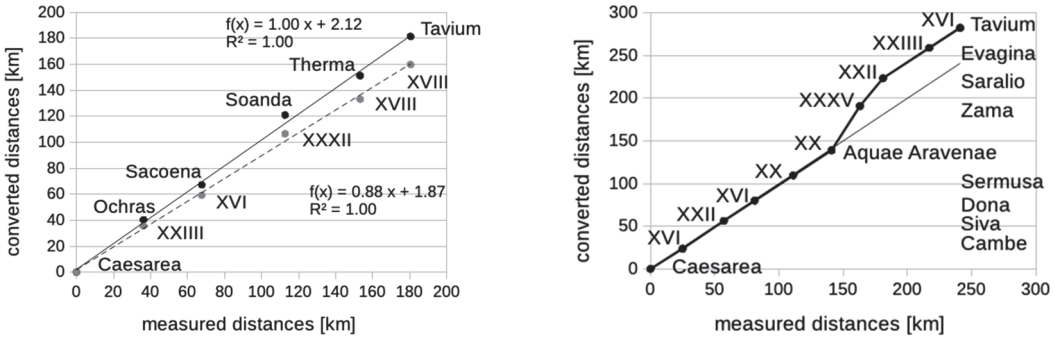
Table 4) *Lengths for the Roman imperial road between Caesarea and Mazaca*

6. *Itineraria* and related sources

The *Itinerarium Antonini* and the *Tabula Peutingeriana* are the two main itinerary sources considered in this paper. In accordance with the aims of the study, the focus remains here on numerical distance values provided by these documents. Far broader appraisals can be found in the extensive literature on ancient geography and cartography.[56] Milestones and distance tables mostly pre-existed and possibly provided source material for itineraries, whose origins are usually traced to the 3rd-4th century AD. A search for possible traces of the use of a "long" mile unit in *itineraria* then appears motivated.

Although a major source of geographical information, itineraries may contain mistakes in the form of omissions and wrongly recorded distances caused by transcription errors. It might be hoped that a copyist attention would be particularly focused on careful transcription of the key geographical information represented by the distance figure. However, a mis-spelt or mis-placed location name can also be a likely occurrence. The graphical presentation of information in the *Tabula Peutingeriana* made it harder to reproduce in copies and added the possibility of tracing errors. Supposed inaccuracies, together with additions and updates, have been noted in several points and these issues are often discussed in the literature.[57]

The road between Caesarea (Kayseri) and Tavium (Büyüknefes) in Galatia has been the object of at least two independent surveys and has already been analysed as a problem case.[58] The path recorded in the *Itinerarium Antonini* has a total length of CVIII (108) miles and is composed of five segments.[59]



(a) *Itinerarium Antonini* – CVIII mp. (b) *Tabula Peutingeriana* – CLXXXXI mp.

Fig. 3) *Converted distances versus measured distances on the road from Caesarea to Tavium. Points are labelled with location names and mile distances in Roman numerals taken from itineraries*

[56] e.g., Rathmann 2007; Geus – Rathmann 2013; Bianchetti *et al.* 2016; Harley – Woodward 1987.

[57] Talbert 2010; Rathmann 2016.

[58] Trojani 1974; French 1974.

[59] *It. Ant.* 201.8-202.5.

Comparison with milestone indications is not possible as no suitable finds are available, but the road course is characterized well enough that accurately recorded modern length values in km can be given.[60] This suffices for comparative analysis and, remarkably, modern calculations on the same path by Google Maps yield almost perfect agreement for its total length (to ±1 km).

When progressive distances in miles are converted into km at the proper ratio of 1.48 km per mile a mismatch is clearly evident as shown by grey dots in Fig. 3a, where converted values are plotted versus actual measured distances. The slope of the corresponding regression line (dashed) is 0.88 with a coefficient of determination practically equal to 1, evidencing that converted distances are *uniformly* short by about 12%. It was argued about these errors that scribal mistakes involving *at least two* segments out of just five would have to be conjectured in order to reconcile actual distances with the Roman mile.[61]

Coherently with the analysis in Section 5, consideration is given here to a different kind of mistake, namely, mis-interpretation caused by lack of information about the length unit. Indeed, the mismatch vanishes when distances are converted by the factor of 1.68 km per mile. Black dots in Fig. 3a and the associated regression line (continuous), whose slope is 1, suggest that the alternative interpretation may again be well-founded.

A completely different situation is evidenced by the analysis of data from the *Tabula Peutingeriana* (Grid squares 9B1–9B2). In Fig. 3b a similar plot of reported distances versus indications, converted into km at the ratio of 1.48 km per mile, shows that the path length between Caesarea and Aquae Saravenae (Kırşehir) is accurately reported in Roman miles, but indications diverge from there on. However, it can be noticed that between Saralium, assumed to be near modern Hashüyük and Tavium the plot remains parallel to the straight line with slope 1 (thin line), suggesting that indications in Roman miles may again be correct in that segment. Fig. 3b then confirms that issues originate in the tract between Aquae Saravenae and Saralium as already noted,[62] and the shape of the plot does point to some form of scribal error as a possible explanation.

In this case the Roman mile thus appears to be the correct unit and the result, combined with the analysis in Section 2, suggests that numerical values in the *Tabula Peutingeriana* might in general refer to either of the two values for the mile. The next example shows this is not a peculiarity of the *Tabula* alone.

Both the *Itinerarium Antonini* and the *Tabula Peutingeriana* describe a road between Caesarea and Mazaca, but the two courses appear to differ. Only the former is considered here, as it follows the course marked by milestones discussed in Subsection 5.2. The *Itinerarium Antonini* reports a total length of 228 mp, that is divided into 74 mp from Caesarea to Comana, and a further 154 mp from there to Melitene.[63] These values are reported in Table 5, together with the milestone indications from Table 4. For the Comana–Melitene part of the course, the discrepancy of 3 mp from the milestone count of 157 mp can be reconciled by remembering that milestones reached a few km beyond Comana, whereas the *Itinerarium Antonini* may refer to a point within the city. Length for the Caesarea–Comana segment should then drop correspondingly to 71 mp, however this is still 8 mp more than the milestone count of 63 mp. The discrepancy, that might be regarded

[60] French 1974, 146-147.

[61] French 1974, 146.

[62] French 1974, 147.

[63] *It. Ant.* 201.5-211.4.

as minor for the entire course, turns out to show a significant local inconsistency. In fact, other milestones found at Imirzaağa bear an indication of 58 mp,[64] but the distance from there to Şar is just 17 km, too short for any conceivable correspondence to 13 mp.

road segment	milestones	*It. Ant.*	mp ×1.48 [km]	mp ×1.68 [km]	GMaps [km]
Caesarea – Comana	≥ 63	74	**109.5**	124	110.6
Comana – Mazaca	157	154	228	**259**	256.4
Total	≥ 220	228	337	383	**367**

Table 5) *Distance comparison for the Roman imperial road between Caesarea and Mazaca*

The conclusion is that mile counts disagree and, if both milestone indications and Google Maps estimates are expected to be trustworthy, an explanation may be given by assuming a mixed use of length units in the *Itinerarium Antonini*, the Roman mile proper for the first segment of the road and the "long" mile in the second part. The combination actually achieves very good agreement with Google Maps estimates, as evidenced by underlined values in Table 5. Yet, non-uniform distance units are a hypothesis that, to the author's knowledge, had never been considered so far for an itinerary.

The brief analysis of the two *itineraria* suggests that road lengths in Asia Minor are not uniformly referred to the traditional Roman mile. In a recent review of distance indications in the *Itinerarium Antonini*, issues with accuracy were more commonly noted in the eastern part of the Roman empire, which is relevant to the subject of this work.[65] This might be at least partly explained by the unaccounted use of a different length unit, since the present analysis suggests a rather widespread reliance on the "long" mile. It is not known whether compilers of *itineraria* realized the difference. If they did, the presence of mixed numerical indications could perhaps be understood as a failed attempt to harmonize the use of itinerary units.

7. Conclusions

The outcome of the analysis can be considered a set of robust and reliable experimental results. Particular care was taken to thoroughly check them and avoid possible biases, taking into account all conceivable causes for error and uncertainty. Evidence suggests a continued use of the *stadion* of 600 Philetaeric feet as an itinerary unit in the Roman provinces of Asia Minor, to the point that on local milestones the "mile", though invariably a multiple of eight stades, was referred to this unit rather than to the Italic *stadium*. This seems to evidence a very pragmatic approach by the Romans in dealing with what in modern terms would be called *harmonization*.

The sentence by Plutarch about the length of the mile, mentioned in Section 1, was part of the description of a late 2nd-century BC road building programme, but the peculiarity of his statement has seemingly never been remarked upon. Although distinctly odd by accepted standards, the sentence would not be out of place for a "long" mile, in which case a marker stone might be appropriately called an "*oktostadion*". It has been remarked that, where the features of roads and the laying of milestones were illustrated, Plutarch may rather have described roads in his own time.[66]

[64] French, *Roman Roads* III/3, nos. 075(A), 075(D) and 075(F); respectively: EDCS-60100031, EDCS-60200003 and EDCS-60200005.

[65] Öberg 2023.

[66] Kolb 2011/2012, 56.

As a more direct hint that the *stadion* remained in use, Galen used this unit in his works to indicate distances. The distance he gave from Pergamum to Ergasteria (near Balya) is 440 stadia (Gal. *de simp. Med.* 9.3.21), that corresponds to a least-cost path of about 90 km,[67] while Google Maps calculated a "walking" path length of 97.6 km from Pergamum to Balya. Conversion yields 81.4 km for the Italic *stadium* and 92.4 km for the 'Philetaeric' *stadion*, once again a significant difference that strongly favours compatibility with the latter unit.[68]

For the selected cases presented in this paper, the analysis of milestones can return the impression of a uniform adoption of the "long" mile, but more extensive studies are needed to support this positively. The result is nonetheless surprising, since so far only the passing mention by Plutarch could remotely suggest the existence of a different unit value for the mile, whereas it is generally assumed that a smooth transition to the Roman system took place in the eastern provinces of the empire.[69]

Transition appears indeed to have been uneventful, and the question that immediately follows is why such difference was never evidenced, neither on milestones nor in *itineraria* and other textual sources. Only hypotheses can be made in this regard, the simplest one being that the difference was so widely known at the time to require no express mention, although it was possibly forgotten later.

The situation is harder to assess for the two written sources, the *Itinerarium Antonini* and the *Tabula Peutingeriana*. The Roman administration may be supposed to be a likely source of road data, but little is known about the intended users and the original compilers of these documents. Lack of specific information might be a reason for the uneven presentation of distances, but the possibility that such aspects were disregarded as minor details cannot be ruled out. Some useful new information could be obtained from a review of existing data in the different perspective proposed in this paper, emphasizing the importance of archaeological research on roads and milestones.

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[67] Ludwig 2020, 17.

[68] Similar considerations can be made for the reported distance of "little more than 100" stadia from Pergamum to the thermal springs in Allianoi (Çeltikçi) (Gal. *de san. tuen.* 6.9; Ludwig 2020, 18), although in this case the length is too short to argue about compatibility thresholds.

[69] e.g., Rathmann 2003, 115-116.

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***Stadium* ve *Stadion*: Küçük Asya'daki Roma Miltaşlarının Metrolojik Analizi**

Özet

Küçük Asya'nın Roma egemenliğine girdiği MÖ 2. yüzyılın sonlarından itibaren bölgede yol ağları zaten mevcut durumdaydı. Yeni otoritenin belirgin bir göstergesi olarak, mesafe ölçümleri Roma uygulamalarına uygun şekilde belirlenmiş olan mil taşları kısa sürede yollar boyunca görülmeye başladı. Ancak, mevcut ölçü sisteminin bütünüyle kaldırılması yerine, uygulamada bir tür birleşme olup olmadığı sorgulanabilir. Bu makale, güzergâh birimleriyle ilgili sorunların tespit edilip edilemeyeceğini ve bu sorunların nasıl ele alınmış olabileceğini araştırmaktadır. Çalışma, Roma dönemine ait kaynakların, daha erken tarihli yazılı belgelerin ve arkeolojik buluntuların karşılaştırmalı analizi temelinde yürütülmüştür. Araştırma, Küçük Asya için mevcut olan geniş kapsamlı mil taşı verileri ile dijital coğrafi verilerin genel erişilebilirliği ve Google Haritalar gibi doğru kullanıldığında kabul edilebilir uzunluk tahminleri sunabilen bilgisayar tabanlı araçlardan faydalanılarak gerçekleştirilmiştir. Elde edilen sonuçlar, mil uzunluğuna çevrim yapılırken, ilgili stadion biriminin gerçek uzunluğu ne olursa olsun, sekiz stadion'un bir mil olarak kabul edildiğini göstermektedir. Küçük Asya'nın Roma eyaletlerinde stadion, Philetaeros'un kullandığı ayak ölçüsüne dayandığından, bu durum doğal olarak daha uzun bir Roma mili ortaya çıkarmaktadır. Bu beklenmedik sonuç, bu varsayım altında hesaplanan mesafelerin genel olarak oldukça isabetli olmasıyla desteklenmektedir. Ayrıca, geleneksel Roma birimi esas alındığında bazı bildirilmiş mesafelerin modern okuyucuya daha kısa görünmesinin ve bu durumun mekânsal algıyı bir ölçüde bozmasının sebebini de açıklayabilir.

Anahtar Sözcükler: Roma mili; Philetairos ayağı; güzergâh ölçüsü; metroloji; belirsizlik; uyumluluk.