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CONTENTS

Ketubah of Antinoopolis, Letter of Resh Galuta and Aramaic Tombstone Inscriptions from Zoar

Or

What Was the Original Molad Calendar of Hillel Bar Yehuda?

Ari Belenkiy and Pavel Kuzenkov

Abstract: The paper describes the major reform of the Jewish calendar in 358/9 CE by Hillel Bar Yehuda, the historicity of which was recently questioned by Sacha Stern. This requires a separate assessment of the solar part (the intercalation cycle) and the lunar part (the timing of the mean lunisolar conjunctions) of the calendar that emerged after 358/9.

As for the solar part, evidence from several Christian sources from the late 4th century proves the intercalation cycle in the 360s differed from the modern one perhaps only in year 16. The dating of the 5th century Ketubah from the Egyptian city Antinoopolis implies that the difference disappeared by 417 CE.

New evidence from the Aramaic tombstone inscriptions from Zoar, a locality in Jordan, shows that year 9, not 8 as in the modern cycle, was intercalated from 372 to 467 or even 542. We conjecture that the original calendar of Hillel Bar Yehuda followed the cycle GUĤADZT counted from Tishri 311 BCE. We also conjecture that year 9, together with years 6 and 17, ceased to be intercalary during Emperor Justinian's reign (527–565) though years 6 and 17 recovered intercalary status sometime after 823.

As for the lunar part, the letter of Resh Galuta from 835/6 implies that the calendar of Hillel Bar Yehuda was a Nisan-based Molad calendar. The Julian date for the Passover in 387, given by two Christian authors, implies the presence of the rule Molad Zaqen for Rosh Ĥodesh Nisan at 18 hours and suggests that Molad Nisan was at least 19.5 minutes later than the modern one associated with Molad BaHaRaD.

We tested this Nisan-based Molad calendar with the sequences of (30–29)-day months, the rules LO B-D-U PESAĤ and Molad Zaqen and two variable months, Ĥeshvan and Kislev, against available historical data: the dates on 18 Aramaic tombstone inscriptions from Zoar from 392–526 and two dates from *Iggeret* of Sherira Gaon—and found a perfect agreement except for two cases which imply the rule LO U PESAĤ was absent in the original calendar of Hillel Bar Yehuda and was introduced after 506, requiring a third variable month, the role played by Tevet as seen from the letter of Resh Galuta.

The letter of Resh Galuta implies that the Nisan-based calendar lasted for almost 500 years. We conjecture that 823–836 was the time of transition to the modern Tishri-based calendar. We also give the reasons why Hillel Bar Yehuda's name was all but forgotten.

The reference epoch (the first Molad Nisan) of that calendar and the length of the calendar month will be established in a subsequent paper. This would allow us to pinpoint, with some exceptions, the Julian dates behind the Jewish dates from 360–836.

Keywords: Hillel Bar Yehuda, Ketubah of Antinoopolis, Zoar inscriptions, Alexandrian Jewish calendar, Letter of Resh Galuta, Molad Nisan, Molad Zaqen, LO B-D-U PESAĤ

1. ENIGMATIC CALENDAR REFORM IN 358/9 CE

The present-day Jewish calendar, known as the *Hebrew calendar* (הלוח העברי), is luni-solar. The lunar part is based on the notion of the mean conjunction, *Molad,* which symbolizes the beginning of a lunar month; the lunar year stretches over 12 or 13 *Moladot* separated by a *calendar month* of 29 days 12 hours 44 minutes and one *ĥelek*.[1] The reference epoch (עקר) is *Molad Tishri* of 3761 BCE, also known as *Molad BaHaRaD*, which acronym, 2-5-204, stands for the 2nd weekday, 5 hours and 204 *ĥalakim*.[2] The date is equivalent to proleptic Julian October 6, 3761 BCE, 23:11:40, though of uncertain local time. The solar part of the calendar is represented by a 19-year intercalation cycle GUĤADZT counted from BaHaRaD, wherein seven intercalary years of 13 months—3, 6, 8, 11, 14, 17, 19—follow each other in a rigid order 3-3-2-3-3-3-2.

Brought to Jerusalem from the Babylonian exile by Ezra the Scribe in mid-5th century BCE,[3] the lunar calendar with a 19-year intercalation cycle remained the calling card of the Pharisees throughout the Second Commonwealth.[4] The beginning of the months was fixed via verified reports of the first sighting of the new moon near Jerusalem. After the destruction of the Second Temple in 70 CE, the fixed intercalation cycle was compromised as agricultural phenomena (ripeness of barley and fruit of the trees) became an additional reason to intercalate, or not, an extra 13th month at the beginning of spring.[5]

The Jewish Diaspora was informed of the intercalations via special messengers. When, in the mid-4th century, the Roman Empire began waging a lengthy war with Persia, and travelling over the frontline became dangerous, the Jewish leadership in Tiberias introduced the fixed calendar, alluded to by Hai Gaon.

In the epistle of 992, answering a question about the origins of Molad BaHaRaD, the Jewish leader Hai Gaon, head of the Pumbedita academy in Baghdad, stated that the Jewish calendar of his time had been established by (the Palestinian Jewish leader) Hillel Bar Yehuda in 358/9:

> ...ואנו יודעים כי ראשונים כבר עברו שלא כסדר הזה וצוו אותנו להיות אוחזין בחשבון תקופות לכל מחזור ומחזור שעה ותפ״ה, וגם בחשבון מולד אוחזין לכל מחזור בי"ו תקצ"ה.
>
> ואע״פ שהן שנו בצרכיהן אנו אוחזין כסדר הזה לשנים הראשונים מלפני משה רבינו גם אחריו עד ימי הלל בר׳ יהודא בשנת תר״ע לשטרות, שמאותה שנה לא הקדימו ולא אחרו אלא אחזו הסדר הזה אשר היה בידם כי סוף חשבון הראשונים לכך הוא מגיע.[6]

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1 1 *ĥelek* = 1/1080 of an hour = 1/18 of a minute = 3⅓ seconds.

2 Plural for *ĥelek;* 204 *ĥalakim* = 11 ⅔ minutes.

3 B. Beitzah 6a and B. Rosh Hashanah 19b cite the testimonies of two leading sages: 'From the days of Ezra we have not found the month of Elul full [of 30 days].'

4 Ezra the Scribe could be behind one modification of the original Babylonian calendar: intercalation of seven Adars, not six Adars and one Elul as was standard in the Babylonian-based calendars adhered to by Persians and Seleucids; see Parker and Duberstein (1956), 35-46.

5 Tosefta Sanhedrin 2:2; Stern (2001), 70.

6 The full epistle is in Bar Ĥiyya (1851), 97. For its historical background see Jaffe (1930), א פרק; also Stern (2001), 175, Belenkiy (2010), Ajdler (2015).

> We know that already the *first sages* did not intercalate according to *this order* and ordered us to align it with the calculation of *tequfot* [and to add] in every cycle [of 235 months] one hour and 485 *ĥalakim*, [though] *Molad* advances [per cycle] 2 days, 16 hours and 595 *ĥalakim*.
>
> And though they changed it according to their needs, we keep *this order* for the very first years, from before Moshe Rabbeinu and also after him until the days of Hillel Bar Yehuda in year 670 of the Seleucid Era [358/9 CE], since from that year they *didn't advance it or delay*, but kept *this order* in their hands, as the counting of the *first sages* ended.[7]

Thus, according to Hai Gaon, there was a certain 'order' for counting years that was abused by the 'first sages' (הראשונים) who until 358/9 aligned Moladot in a certain way to the Julian calendar.

Indeed, 235 calendar months make 6939 days 16 hours and 595 ĥalakim, which is 1 hour and 485 ĥalakim short of 19 Julian years (6939 days and 18 hours). As shown by Belenkiy (2010), the 'first sages' were the Jewish sages from 2nd to 4th centuries—from Rabbi Meir and Rabbi Ĥanania to Mar Shmuel of Nehardea to Abayye of Pumbedita—who regarded the Julian year as the exact solar year and used a pseudo-lunar calendar known from Tosefta and the Babylonian Talmud as the Theory of Others (שיטת אחרים).[8] But how was the latter reformed in 358/9?

Since in Hai Gaon's epistle all attributes of the Hebrew calendar are present, it is widely believed that the Jewish calendar remained the same from Hai Gaon's time until now. And so the statement that its basic structure was established as early as 358/9 is of great interest. However, the precise nature and even the very fact of the reform are still hotly debated.

Indeed, Hai Gaon's statement left more questions than answers. Was the 19-year cycle in his time identical to the cycle of Hillel Bar Yehuda? Was the reference epoch in his time, Molad BaHaRaD, identical to the one of Hillel Bar Yehuda? And more basic: was the Molad calendar of Hillel Bar Yehuda Tishri-based?

The prevailing view among modern scholars is that Hillel Bar Yehuda introduced the same Tishri-based Molad calendar we use now, though the intercalation cycle and the original reference epoch were different from the present ones, while some of *deĥiyot*, or postponements of Rosh Hashanah, might have come later.[9]

However, there is a notable exception: Sacha Stern (2001, 176–9) goes so far as to question not only the *reliability of attribution* of the reform to Hillel Bar Yehuda but also the very *fact* of the reform in 358/9, claiming that 'transition from an empirical to a fixed calendar was only gradual and progressive' (ibid., 181), and even doubts the very fact of Hillel Bar Yehuda's *existence*. Stern (ibid, 179) concludes:

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7 Our translation. The translation of the first part follows Belenkiy (2010).

8 Tosefta Arakhin 1:11; B. Rosh Hashanah 6b, 20a, B. Arakhin 9b, B. Sukka 54b, B. Shabbat 87b.

9 There is also a debate on the length of the calendar month in Hillel Bar Yehuda's calendar with different assessments of Ravina's statement in B. Arakhin 9b; see Jaffe (1931), מג-מ; Stern (2001), 202.

> Late medieval rabbinic traditions about the foundation of the fixed calendar are thus so numerous and diverse that one wonders whether the Hillel tradition deserves the privileged status which, in the course of time, it eventually achieved…The very existence of a 'Hillel the Patriarch' in the mid fourth century may thus be treated as uncertain.

More recently, Stern (2014, 1885) doubled down on his earlier position:

> That this calendar was formally instituted by a Hillel in 359 CE is only one of several medieval legends. A partially fixed calendar is evident already in the Palestinian Talmud (late fourth century), but the complete, fixed rabbinic calendar that eventually became normative in Judaism took much longer to emerge and was not finalized until the early tenth century (Stern 2001).

'A medieval legend'! Challenging Hai Gaon's authority and Abraham Bar Ĥiyya's integrity, Stern again leaves the reader to wonder *what* 'a partially fixed calendar' actually means and *who* 'partially fixed' the calendar by the 'late fourth century.' Stern seems to entirely miss the historical significance of the exact date, 358/9 CE, attached to the would-be 'medieval legend.'[10]

This paper intends not only to eliminate these objections to the millennium-old tradition and restore Hillel Bar Yehuda's name in Jewish history, but also to reveal new, unexpected features of the original Molad calendar introduced by Hillel Bar Yehuda in 358/9. Our guides on this journey will be a marriage contract, a letter, 18 tombstone inscriptions and several underappreciated historical facts.

To properly assess Hai Gaon's statement, in Section 2 we discuss the intercalation cycle of the Hebrew calendar. In Section 3, we cite a number of 4th century Christian sources that shed light on the intercalation cycle before and after 358/9. In Section 4 we discuss Stern's vague date for the early Passover in 417 which he deduced from dating the Ketubah of Antinoopolis to 417 as per Sirat *et al.* (1986). Proposing that another Jewish calendar of that era might have been involved, we describe, in Section 5, the Alexandrian Jewish calendar. Using this calendar, in Section 6, we match the Ketubah's date to year 425; the decision to place the Ketubah in 417 rests on an authoritative reading of the Ketubah's inscription.

To discover the original calendar by Hillel Bar Yehuda, in Section 7, we analyze the letter of Resh Galuta from 835/6 which indicates it was a Nisan-based Molad calendar. In Section 8, trying to fit evidence from Christian sources about Passover in 387, we find that the rule Molad Zaqen at 18 hours was present in Hillel's calendar but the reference epoch for counting Molad was different than the present-day one. In Section 9, we discuss whether other aspects of the Hebrew calendar were also present in Hillel's calendar. Testing the Nisan-based Molad calendar against available historical data, mainly 3rd–5th century Aramaic inscriptions from Zoar, we confirmed the absence of the rule LO U PESAĤ until after 506. In Section 10, we discuss the implications of the recent discovery

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10 This date is perfectly in line with Maimonides' claim in *Sanctification of the New Moon* 5:3, that the fixed calendar was established after the time of Abbaye (d. 337) and Rava (d. 352). Moreover, his reference to the 'time when Eretz Israel lay in ruins' (בְּעֵת שֶׁחָרְבָה אֶרֶץ יִשְׂרָאֵל) may refer specifically to the aftermath of the ruinous earthquake in Galilee in May 363.

by Alexei Nizan that year 9, not 8, has been intercalary from 372 to 467 or even 542. In Section 11, we describe the background of the 358/9 reform and speculate why Hillel Bar Yehuda's name was all but neglected in the rabbinical tradition. In Section 12, we discuss the dating of the letter of Resh Galuta and conjecture that 823-836 was the time of transition to the Tishri-based calendar. The Summary concludes with two problems addressed to archival workers.

2. WHAT WAS AN INTERCALATION CYCLE IN 358/9?

Equating 235 lunar months to 19 solar years is known as a Metonic cycle, a backbone of many Near Eastern calendars, including all known Jewish ones.

The 'lunar month' was understood as the mean lunar month. The mean lunar (synodic) month of 29 days 12 hours 44 minutes and one *ĥelek* was popularized by the famous 2nd century Alexandrian astronomer Claudius Ptolemy who traced it back to the Babylonians,[11] and so it is not a surprise that the Bet Din in Tiberias introduced it in the Molad calendar as the calendar month.

The solar year is more difficult to estimate as one needs special astronomical tools to assess the timing of the *Tequfot* (equinoxes and solstices). There were different candidates for the solar year. However, no reasonable choice agreed with a fixed Metonic cycle for a long time but required a manipulation with the intercalary years—'advancing or delaying' either the individual years or the entire sequence, while preserving the order 3-3-2-3-3-3-2.

One choice would be the Julian year, specifically mentioned by Hai Gaon in his epistle. However, since every 19 years the Molad advances about 1 hour and 27 min against the Julian year, after 315 years the advance will be as big as 1 day. To prevent the earliest Passover from slipping before the Julian vernal equinox (Tequfah Shmuel), this year must be made intercalary via *advancing* the intercalation of the 13th month by one year (e.g., from year 9 to year 8).

If, however, the Bet Din would have perceived that 19 solar years are shorter than 235 calendar months, as was indicated by various agricultural phenomena, to keep Passover in the first astronomical spring month in all 19 years, the intercalation of the 13th month in the year with the latest Passover must be *delayed* to the next year (e.g., from year 8 to year 9), effectively moving this Passover a month earlier.[12]

Since the Hebrew calendar does not have a mechanism to make any of these changes automatically, each change must be done by decree—and this was done by the 'first sages' that preceded Hillel Bar Yehuda. According to Hai Gaon, Hillel Bar Yehuda abrogated this practice in 358/9. But which cycle did he retain?

The Hebrew calendar adds an extra month in years 3, 6, 8, 11, 14, 17, 19, or GUĤADZT, counted from 3761 BCE, the year of Molad BaHaRaD. Though not intercalary, two years, 5 and 16, play a special role in our story as these two years have the two earliest Passovers in the present-day 19-year cycle.

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11 Toomer (1998), 175-6.

12 Since the tropical year is established now fairly accurately, as 365 d 5 h 48 min 45 sec, to keep Passover within a month after the vernal equinox, this procedure must be done every 216 years.

For example, the earliest Passover in the previous 19-year cycle, 1997–2016, was on (Gregorian) March 25, 2013, which is year 16. In our story, year 16 is represented by 360, 379, 398, and 417. The second earliest Passover in the current 19-year cycle, 2017–2036, was on (Gregorian) March 27, 2021, which is year 5. In our story, year 5 is represented by 368, 387, 406, and 425.

Knowledge of the earliest Passover may reveal the structure of the entire cycle in that era. Alas!—the 4th century Jewish sources are not helpful in this regard, as the Palestinian Talmud was left unfinished sometime in the second half of the 4th century,[13] while the Babylonian Talmud was redacted in the 5th century[14] thus losing, no doubt, some of its valuable historical data. To find the earliest Passover in the calendar of Hillel bar Yehuda, we need to discover those historical facts that relate 4th century Passovers to their Julian dates. These facts are provided by several Christian sources, which we discuss below.

3. WHAT DO 4TH CENTURY CHRISTIAN SOURCES SAY REGARDING THE JEWISH CALENDAR?

Various Christian groups of the 4th and 5th centuries were keenly interested in the contemporary Jewish calendar: some to emulate it, others to distance from it. The reason for such attention must be explained.

As Socrates Scholasticus testifies in his *Historia Ecclesiastica* (HE 5.22), the apostles did not leave any written instructions on when to celebrate Easter, so customs across the Roman Empire varied widely. One was to emulate Jews by celebrating Easter on the day of the full moon, Nisan 14, regardless of whether it came on a Sunday. The sect following this rule was known as Quartodecimans (Those of the Fourteenth). They were excommunicated by Pope Victor in 199 with the approval of the Alexandrian Patriarch Demetrius. Christians were required to celebrate Easter on the first Sunday after the first spring full moon.

The final separation from the Jewish calendar practices came only after the Council of Nicaea in 325. As we know from a testimony of Pope Leo the Great, the Council of Nicaea granted the privilege to fix Easter for the entire Empire to the Alexandrian Patriarchs as they 'have the ancient science of astronomy.'[15]

However, as the Ethiopic Paschal tables attest, the Alexandrian Paschal calculus was quite primitive; the calendar was pseudo-lunar epact-based (see Appendix 1). The only astronomy-related feature was keeping the Paschal moons on or later than Phamenoth 25 ≡ March 21, which implies some familiarity with 2nd century *Mathēmatikē Syntaxis* (later known as *Almagest*) by Claudius Ptolemy of Alexandria.[16]

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13 There are different theories on when this happened, from 363 to 425, see Strack and Stemberger (1996), 170. The last historical event that can be identified therein is Emperor Julian's mobilization for his Persian campaign in 363. (Y. Nedarim 3:2, 37d).

14 B. Bava Metsiah 86a: 'Ravina and Rav Ashi, the end of horaah.'

15 Sancti Leonis Magni epistula CXXI (PL 54, 1056); Mosshammer (2008), 65.

16 Ptolemy placed the vernal equinox in 140 CE on March 22; see Toomer (1998), 138. At the turn of the 4th century, Ptolemy's equinox slipped to March 21 in the leap years; see Belenkiy (2016).

Meanwhile, the Roman church maintained a different Paschal calendar. Though the rules of the two calendars significantly differ, since the Pope and the Alexandrian Patriarch at the Council at Sardica in 343 agreed to make mutual concessions, for half a century their Easter dates ran synchronously. However, in 387 new calendar debates broke out in all major cities of the Roman Empire.

The reason for these debates was twofold. First, the Roman Paschal calendar was unable to produce a viable date for Easter in 387.[17] The Roman church could not accept the Alexandrian date, April 25, since the celebration of the founding of Rome on April 21, with its barbaric customs of gladiator and beast fights, would interrupt Holy Week. A celebration of Easter on March 21 was a better option but also undesirable, as in 387 the Jewish communities across the Roman Empire were going to have Passover on Sunday March 21. This fact is known from the writings of three Christian religious leaders and one Christian historian.

John Chrysostom, then a presbyter in Antioch, delivered several homilies in 387. In his *Third Homily*, known as *Adversus Judaeos* ('Against Jews'), he blasted Jews for celebrating Passover in 387 *too early*, on the day of the vernal equinox:

> ἡ πρώτη τῶν ἀζύμων εἰς κυριακὴν ἡμέραν ἐμπίπτει.
>
> The first day of *azyma* [i.e., of *unleavened bread*] falls on Sunday.[18]

Thus, the first day of the Unleavened Bread (i.e., Passover) in Antioch in 387 fell on Sunday March 21, while the Seder obviously was held a day earlier, at night of March 20. The indignant tone of the *Homily* implies that Jews indeed did something new and unforeseen.

The same date for Passover Seder in 387 in Milan, then the capital of the Western Roman Empire, is attested to by the famous Bishop Ambrose:

> Iudaei duodecimo, non primo mense celebraturi sunt Pascha, hoc est, decimo tertio Kalendas Aprilis.[19]
>
> The Jews intend to celebrate Passover [Seder] not in the first month but in the twelfth, on 13th calends of April [March 20].

In the *Prologue to Easter,* addressed to Emperor Theodosius I after his victory over Magnus Maximus in 388, the Alexandrian Archbishop Theophilus attacked 'those who don't know that spring begins on March 21.'[20] 'Those' were the Pope and the Roman church at large, which held Easter in 387 on March 21 despite the Roman Jewish community celebrating Passover on the same day.

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17 Mosshammer (2008), 212.

18 PG 48, 869; see also Stern (2001), 69.

19 PL 16: 1073B and 1078A, Epistle 23.15; see also Stern (2001), 145; Mosshammer (2008), 155.

20 Mosshammer 2017, 59.

Finally, Socrates Scholasticus described one Novatian group of Constantinople led by a convert from Judaism that celebrated Easter in some years a month earlier than Orthodox Christians albeit in the same week as Passover.[21] These were years 387 and 406, which indicate that a new and consistent pattern of early Passovers in year 5 of the cycle emerged.[22] But when did this pattern begin?

This same Socrates related how Novatians of Phrygia voted at their convention to keep Easter in the same week as Passover celebrated by local Jews. Socrates notes that 'this happened under Emperor Valens' (ἐπὶ τῆς βασιλείας Οὐάλεντος).[23] As Valens ruled from 364–378, Socrates' testimony proves that the changes in the Jewish calendar had already been in effect by 368, affecting either both years 5 and 16, if the Novatian convention was before 368, or only year 5, if after.

Indeed, advancing Passover from April to March in year 16 *cannot* be done without first advancing Passover from April to March in year 5—but not vice versa. If no change in the Jewish calendar happened in either 360 or 368, the earliest opportunity for change would have come only in the next year 16, 379, one year after Valens's demise, which would contradict Socrates' testimony. This contradiction proves that in 368 Passover was in March—the earliest evidence that year 5 stopped being intercalated in the Diaspora.

Though this argument is open to a possibility that the reform had also affected year 16, there is no direct evidence for 360, not even for 379 or 398. The status of year 16 in that era hinges on one single piece of evidence: an extant *Ketubah*, a 5th century Jewish marriage contract, from the Egyptian city Antinoopolis.

4. WHEN WAS PASSOVER HELD IN ANTINOOPOLIS IN 417?

According to Tosefta Ketubot 4:9, Jewish marriage contracts were written as early as the 1st century CE. Those that emerged from the Cairo Geniza at the turn of the 20th century belonged to the 10th century or later.[24] Yet one Ketubah, acquired by the University of Cologne in the late 1960s, was dated to the early 5th century and thus is especially valuable.[25] The text of the Ketubah is barely legible, and its content was deciphered only in 1986 by the valiant efforts of Colette Sirat and her colleagues.

The marriage was arranged between Samuel, son of Sampati, resident of Antinoopolis, and Metra, daughter of Leazar and Esther, a couple who had recently arrived in Antinoopolis from Alexandria. The Ketubah was signed on the 20th day of the Jewish month Kislev. The first line of the Ketubah has a single legible word, הנדאקאטון, i.e., ἑνδέκατον (*hendekaton,* 'eleventh'). Sirat *et al*. (1986) interpreted it as *eleventh consulate of Emperor Honorius*, which is known to have happened in 417.[26] In that year, the second

21 Socrates, *Historia Ecclesiastica* 4.28 and 5.21.

22 Belenkiy (2016).

23 Socrates, *Historia Ecclesiastica* 4.28.

24 See Friedman (1980), 3.

25 Surprisingly, this Ketubah's provenance is uncertain. Prof. Dr. Chariclea Armoni, the current head of the Papyrus collection at the Cologne Institute of Archaeology, could not provide the exact time of acquisition or even the exact place it was purchased from.

26 Mosshammer (2008), 63.

consul was Flavius Constantius—and his name and titles perfectly fill in the spaces in the second and third lines of the Ketubah where the words had been obliterated.

Sirat *et al.* also considered an alternative date, 425, the year of the eleventh consulate of Emperor Theodosius II, but ultimately rejected it due to the uncertain identity of the second consul.[27]

Though no civil date was added after the Jewish one, the reference to the weekday (Wednesday) in the Ketubah provides a chance to recover the Julian date of Passover in 417. This was first attempted by Sacha Stern.

Stern (2001, 138) began with assessing the visibility of the new moon in October 417. Failing to ascertain the date of the first sighting, he tacitly assigned the Ketubah to the most plausible Wednesday, November 14, and then, tacitly using the present-day structure of the Hebrew calendar, arrived at the date of Passover Seder (Nisan 14).

The Hebrew calendar (see Appendix 2) has 242 days between 14 Nisan and 20 Kislev: 236 days accumulate from eight alternating 30- and 29-day months between 14 Nisan and 14 Kislev, and the remaining 6 days from 14 to 20 Kislev. Noting that $242 = 4 \; mod \; 7$[28] (i.e., 242 days have *four* days more than the number of weeks) and counting four days back from Wednesday, Stern (2001, 87) arrived at Saturday and concluded that 14 Nisan was on Saturday March 17.[29]

This argument pointed to an early Passover in 417 with the Seder on March 17. However, perplexed by such an early date for 14 Nisan—as allegedly 'the rule of the equinox would have been breached'—but unable to support it on lunar visibility grounds, Stern (2001, 139) announced the Passover Seder was 'c. 17 March.'

This, of course, is not a date. The puzzling 'circa' before March 17 originated from Stern's belief that 5th century Jewish Diaspora, like the Jews of old, still observed the first sighting of the new moon instead of following a fixed calendar.[30] Yet proving visibility of the young crescent on a given night in the past is tricky as it depends on several assumptions about the Earth's rotation in the past and is further constrained by the unknown meteorological conditions. And in general, this method proved to be a dead end as Stern was unable to account for most of the known Passover dates across the Jewish world in the 4th–6th centuries.

To establish the proper date of the Passover Seder in 417 in Antinoopolis we need to tread a different path. Let us first consider the possibility that Antinoopolis followed the calendar of the Alexandrian Jewish community, as the city, since 381, belonged to the Diocese of Egypt with the capital in Alexandria.

5. THE ALEXANDRIAN JEWISH CALENDAR

Antinoopolis was founded in Middle Egypt by Emperor Hadrian in 130. The first Jewish settlers likely came from Palestine during the Bar-Kokhba revolt in 132–135. Because

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27 Sirat *et al.* (1986), 20, lines 1–4. Stern (2001), 137, concurs with this conclusion.

28 The expression 'b = r *mod* d' means that b and r differ by an integral multiple of d.

29 Stern also considered placing the Ketubah on Wednesday in mid-December 417, but rejected it on the lunar invisibility grounds. Indeed, in this case, an alternative date of the Passover Seder—Saturday April 14—would be three days away from the full moon.

30 Stern (2001, 146) expressed the same view on the practices of the Jewish community in Milan.

both Talmuds are almost completely silent on any connections between Palestinian rabbis and Egyptian Jews, the latter likely tended to look for guidance to the Alexandrian Jewish community.

The Greek-educated, intellectual Alexandrian Jewish community, which gave the world its famous philosopher Philo, kept their own calendar for several centuries. True, the Alexandrian community was greatly decimated during the suppression of the Diaspora revolt from 115–117, but by the 5th century it had recovered at least partially, as we know of its visible presence in the city from the report of Socrates Scholasticus about the great pogrom against the Alexandrian Jews instigated by Archbishop Cyril in 414.[31] Certainly, the calendar tradition could not have been easily lost in 117 and would have been still in use by 414. We must therefore check whether the Ketubah of Antinoopolis was composed according to the Alexandrian Jewish calendar, especially because the family of the bride was from Alexandria.

This calendar remained a mystery until 1979, when Otto Neugebauer, a foremost 20th century historian of ancient astronomy, published his work (a book and an article) on the Ethiopic Paschal calendar. He asserted the latter was an exact copy of the Alexandrian church's Paschal calendar and equated its Jewish part with the actual calendar of the Jewish Alexandrian community—otherwise it is impossible to explain the presence therein of the civil dates, lunar dates and even weekdays of Rosh Hashanah, Yom Kippur and Sukkoth (see Appendix 1).

The Alexandrian Jewish calendar was intrinsically linked to the reformed Egyptian calendar. The old classical Egyptian calendar had all years of 12 months of 30 days followed by 5 *epagomenal,* i.e., additional, days; 365 days altogether. The reformed calendar, known as the *Alexandrian calendar*, started on August 29 and had 365 days three years in a row and, like the Julian calendar, had 366 days every fourth year. The leap 366th day was added on August 29 in the years preceding the Julian leap years. The addition of 4 or 5 leap days brings the number of solar days in the 19-year cycle close to the number of lunar days, making it possible to arrange a simple pseudo-lunar calendar.

The Alexandrian calendar was introduced in Egypt by Octavian in the 20s BCE.[32] The Alexandrian Jewish calendar could have been introduced at this very time. The Alexandrian mathematician Sosigenes, who designed a solar-based calendar for Julius Caesar in 46 BCE, could have also advised, two decades later, the local Jewish community on how to adjust the lunar calendar to the Alexandrian calendar, creating in essence a pseudo-lunar calendar. Philo confirmed the use of the lunar calendar by the Alexandrian Jewish community in the 1st century CE.[33]

The Alexandrian Jewish calendar operated in the following manner: each year, every Jewish holiday moved 11 days earlier in the civil calendar. If the civil year was regular,

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31 Socrates (HE 7:13); Belenkiy (2016) pinpointed the exact date of the pogrom: April 19, 414.

32 Bennett (2011), 180, cites a reference for 26 BCE. Some place this event 4 years later.

33 The earliest mention of the lunar calendar in use by Alexandrian Jews goes back to the mid-2nd century BCE; see Stern (2001), 32. Yet, the pseudo-lunar calendar could be two centuries older than the Roman conquest of Egypt if linked to the Canopus reform by Ptolemy III in 238 BCE, which introduced a leap 366th day into the old Egyptian calendar for the first time. Though that reform did not endure, the pseudo-lunar calendar could still have remained in use by local Jews.

of 365 days, the overlapping Jewish year had 365 – 11 = 354 days, which were assembled into 12 alternating 30- and 29-day months. In the leap Alexandrian year, the overlapping Jewish year had 366 – 11= 355 days; the *extra day* was incorporated into one particular lunar month of 29 days.

To keep Passover after the vernal equinox, seven additional 30-day months were intercalated *before* the start of years 3, 6, 8, 11, 14, 17, 19, counted from 1 Tishri 284 CE, or, equivalently, years 3, 5, 8, 11, 14, 16, 19, counted from Molad BaHaRaD = 1 Tishri 3761 BCE. In years 5 and 16, the Alexandrian Passover was a month later than in the Hebrew calendar, while Rosh Hashanah was a month later in years 3, 5, 8, 11, 14, 16, 19.

Finally, to compensate for the one-day difference between 19 × 11 = 209 days, accumulated in 19 years due to the 11-day shortness of the lunar calendar year viz. the solar calendar year, and 7 × 30 = 210 days, coming from seven intercalary months, a 12-day shift (known in Medieval literature as *saltus lunae*) was implemented by dropping one day from one particular 30-day lunar month in the last year of the Alexandrian cycle, which is year 16 in the Hebrew calendar.

These corrections to a simple Metonic cycle allowed the lunar calendar to come to the same civil date after 19 years. But what was the practical implementation of these corrections? Which month was intercalary? Which months were variable, aiming to accommodate an extra day in the leap years and *saltus lunae*? Were they within the spring-summer batch: Nisan, Iyar, Sivan, Tammuz, Av, and Elul, or the fall-winter batch: Tishri, Ĥeshvan, Kislev, Tevet, Shevat, and Adar?

Analyzing the Ethiopic Paschal calendar, Neugebauer observed that between Rosh Hashanah and the following Passover Seder there were always 190 days: 177 days between 1 Tishri and 1 Nisan, from six alternating 30- and 29-day months, plus 13 days between 1 and 14 Nisan.[34]

A constant number of days between Tishri and Nisan implies two things. First, the intercalary month was not Adar I but Elul I added between Av and Elul in the seven years of the cycle discussed above. Second, the variable months were not the autumnal months Ĥeshvan and Kislev, as it is now in the Hebrew calendar, but two late summer months between Nisan and Tishri.[35] Appendix 1 helps identify these two months.

The Jewish leap day was 30 Elul, added every four years within a month after the leap day of the Alexandrian calendar, August 29.[36] This is seen from the uniform 24-day (*mod* 30) difference between the Alexandrian dates for 1 Elul (column 3a) and Rosh Hashanah (column 7a) for all years including the leap ones.[37]

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34 The 190-day difference is confirmed by the facts that Passover Seder always came on the weekday following Rosh Hashanah (see Appendix 1) and 190 = 1 *mod* 7.

35 This should not be a surprise—in a direct analog of the Alexandrian Jewish calendar, known as the Theory of Others, the two variable months were Nisan and Iyar, see Belenkiy (2010).

36 Blackburn and Holford-Strevens (1999), 803, asserted a 'leap year was dealt with by repeating the lune of 5 Epagomenon on the 6th.' This shortcut would be appropriate for the Alexandrian church, unconcerned with dating its documents according to the lunar calendar, but could not be legitimate for the Jewish community where every calendar day had a different number.

37 The 24-day difference is the result of skipping the epagomenals: 29 – 5 = 24 or 30 – 6 = 24.

And finally, to implement *saltus lunae,* the last day of the month Av, 30 Av, was dropped at the end of the 19th year of the Alexandrian cycle.[38] This completes the description of the Alexandrian Jewish calendar (see Appendix 2).

6. THE KETUBAH: DECIDING BETWEEN 417 AND 425

The reconstructed Alexandrian Jewish calendar offers a better date for Passover in 417 and a more solid framework for dating the Ketubah. Since 417 was the last year of the Alexandrian Jewish cycle and was not the Alexandrian leap year, there was *saltus lunae* but no leap day between Passover and Rosh Hashanah. This implies that in 417, between 14 Nisan and 20 Kislev, there were only 241 days, one day less than calculated by Stern. Considering that 241 = 3 *mod* 7, and counting three days back from Wednesday, we arrive at Sunday. Therefore, the Passover Seder in 417 was held in Alexandria on Sunday March 18, the day of the Paschal full moon. The alternative Sunday, April 15, is two days away from the full moon on April 17.[39] Finally, counting 241 days forward from March 18 in the Alexandrian Jewish calendar brings the Ketubah to a familiar date, Wednesday November 14, 417.

Though the problem seems settled, an unexpected issue arises. This count presupposes that in 417 there was no extra 30-day month between Nisan and Kislev. Indeed, in such a case there would be 271 days between 14 Nisan and 20 Kislev. Since 271 = 5 *mod* 7, counting five days back from Wednesday would place the Passover Seder on a Friday, two days away from the full moon on Sunday March 18. Thus, there was no Elul I in the late summer of 417.

But an early Passover in 417 implies that intercalation must have happened before the next Passover! The obvious solution then would be an Adar I in the winter of 418, as in the Hebrew calendar. But the intercalary month in the Alexandrian Jewish calendar was Elul I. We seem to have reached an impasse.

Suddenly, another year comes to the rescue. If the Ketubah is placed in 425, the Alexandrian Jewish calendar secures a reasonable date for the Passover Seder.

Since 425 is the next year 5 in the chain of years 368, 387, and 406, with their early Passovers proven above, it too must have an early Passover in March, while having an intercalary month later the same year. With the additional 30-day Elul I and no *saltus lunae* in 425, there were 272 days between 14 Nisan and 20 Kislev. Since 272 = 6 *mod* 7, counting 6 days back from Wednesday we arrive at Thursday. And lo and behold—Thursday March 19 was indeed the most plausible day for the Paschal full moon in 425 according to the Alexandrian calendar.[40]

Finally, counting 272 days forward from March 19 in the Alexandrian Jewish calendar would bring the Ketubah comfortably to Wednesday December 16, 425.

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38 Blackburn and Holford-Strevens (1999), ibid., place *saltus lunae* in the 'penultimate' month of the 19th Alexandrian year. But since there was no Elul I at the end of that year, the 'penultimate' month could be only Av.

39 See Belenkiy (2016), Fig. 1, line 19, regarding the possible days for the Alexandrian Paschal full moon in 417.

40 See ibid, Fig. 1, line 8, where the Paschal full moon of March 19 was replaced in year 387 by March 20 according to the testimonies of the Christian authors (see Section 3 above).

The contest between 417 and 425 is determined by an authoritative reading of the Ketubah's inscription. Though both Honorius and Theodosius fit the first line equally well, the name and the title of Honorius' partner in consulship, Constantius, matches the second line better than the possible partners of Theodosius in 425, either Valentinian or Castinus.[41] Thus, the Ketubah was written in 417 and Adar I was the intercalary month.[42]

This means in 417 Antinoopolis did not follow the Alexandrian Jewish calendar. The only alternative was the Palestinian Molad calendar which Hai Gaon associated with Hillel Bar Yehuda. But what was the calendar of Hillel Bar Yehuda? For guidance let us look 500 years ahead in Baghdad of 836, then the headquarters of Resh Galuta (Head of the Jewish Diaspora).

7. THE LETTER OF RESH GALUTA FROM 835/6

As late as the 9th century, the Jewish Diaspora still received the annual festival roster from the Bet Din at Tiberias. The letter of Resh Galuta, recovered from the Cairo Geniza, was written as a response to the query from the Egyptian Jewish community about the recently received festival roster for 835/6.[43]

דלי הוי כולן וכל יש׳ אגודה [אחת בח]דשים
וכל מועדים כבהדין מנהגא ק[א מ]דברין א׳
אבהתן מתיבאתא עד הינא והי[א] שתה דהוה
שנת אלפא ומאה וארבעין ושבע שנין לש׳
לשטרות והיא שנת ארבעת אלפים וחמש
מאות ותשעים וחמש שנים לבראשית
אף על גב דילעינין מרחשון וכסליו
וטבת מתאחר סהרא דילהון אפילו הכין
משום סיהרא דניסן דקא מיתליד
בימא דתלתה בש[ב]ה בארבע [ש]עות
אי מעברינן שלימ[י]ן האוי קבעיה דניסן
בחמשה ומתחזי מן קמי קבעיה במערב
ומיקלקל מידי ושוינין כסדרן לא איפשר

41 Caesar Valentinian could not have been called 'patrician.' The case against Castinus is decided practically by one letter. An anonymous referee, an expert in papyrology, brought our attention to the fact that the reconstruction of Sirat *et al* fits well not only the lacuna at the beginning of the second line but also the traces of ink. The tiny traces of ink of the letters טי are visible and the last ו and the first א are clear; thus, the name in the second line is certainly קונסטאנטיאו (Constantius).

42 This dating also proves the Shmita cycle in 417 was the same as it is now.

43 First published by Jacob Mann (1922, II, 41), improved and translated by S. Stern (2001), 277. We provide our own translation, different from Stern's, italicizing the most important words.

דמיתרמי פסח בארבעה בשבה ולא בדו

פסח ולמה לא ב[דו] פסח וא ולא גהז עצרת

משום לא אדו ראש השנה

ולא סגיא דלא לשויינון ...

לירחי חסירין משום ניסן דלא ליקלקל

סיהרא ולא [מי]בעיא בהכי הדין מעשה

דכ[דין] עבדו ו. לקמי ראש החבורה

וב[ני] החבורה חסירין ד[ס]מכינן עליהון דלא

דלא איפשר לשויינון לא כסדרן ולא שלמין

אלא אפילו זמנין דאי עבדינן כסדרן ושל]מין[

או חסירין דאמי להדדי ולעולם עליהון סמכינן

דלא ליהוי ישראל אגודות אגודות

… that we and all Israel may be one community [regarding] months and all festivals.

This custom has been followed by our fathers and yeshivas until now, the year 1147 of the Seleucid Era and the year 4595 from the Creation. As for Marĥeshvan, Kislev and Tevet [of 835 CE], why their moons [months] made *short*, consider that the moon of Nisan [of 836 CE] [will] be born on the third (day) of the week (Tuesday) *at four hours of the daytime*. If we make them full, Rosh Ĥodesh Nisan will be set on the fifth day (Thursday) and [the new moon] *might be seen in the West before Rosh Ĥodesh*, and this matter [calendar] might be disrupted. And it is impossible to make them regular, for then Pesaĥ would occur on the fourth of the week (Wednesday), [but] *lo B-D-U Pesaĥ.* And why *lo B-D-U Pesaĥ* and *lo G-H-Z Atzeret*? Because *lo A-D-U Rosh ha-Shanah…*

Thus, there is nothing remains but to make them short—to avoid violation of the [rules for the] moon in Nisan. And this applies not only in this case, when they decided and ... before the head of the *havurah* and the members of the *havurah* … deficient—for we rely on them [the Bet Din]. It is impossible to make [this year] either regular or full—but in the matter whether (the year) is full, regular or deficient, we always rely on them [the Bet Din], so as to not split Israel into factions.

Year 1147 of the Seleucid Era began on October 1, 835; while year 4595 of Creation began on 1 Tishri 835, which was either Saturday August 28, if 834/5, year 16, was not intercalary (as per the dating of the Ketubah of Antinoopolis), or a month later, September 27, if it was. Resh Galuta penned his letter sometime between October 835 and March 836 as a response from the Diaspora Jews who had questioned the Bet Din's decision to keep three months—Ĥeshvan, Kislev and Tevet—short. The Bet Din set 1 Nisan in 836 on Tuesday March 21, not on Thursday March 23 as per the Hebrew calendar. Resh Galuta explained why it would be inappropriate to have 1 Nisan on Thursday—due to the potential sighting of the new moon on Tuesday night—and it would be impossible to have

1 Nisan on Wednesday—due to LO D PESAĤ—and finally approved the Bet Din's ruling 'lest Israel be split into factions.'

There are several important points in this letter. It speaks of three variable months: Ĥeshvan, Kislev and Tevet. It mentions postponement LO B-D-U PESAĤ (Passover = 15 Nisan cannot fall on the 2nd, 4th, or 6th day of the week) on par with LO A-D-U ROSH (Rosh Hashanah = 1 Tishri cannot fall on the 1st, 4th or 6th day of the week); the presence of both rules means there were exactly 163 days between Passover and Rosh Hashanah with no variable months between them.

But the most remarkable feature of the letter is that Resh Galuta speaks exclusively of Molad Nisan as the starting point to deal with the other months. Moreover, he places Molad Nisan in 836 on Tuesday at 'four hours of the daytime' (10 am), i.e. only 15 min off its modern count: Tuesday 9:45:03.[44] The proximity of the two times redoubles the importance of Resh Galuta's letter.[45]

Although we know about the debate between Tannaim over the proper beginning of the Jewish year, Tishri or Nisan, and 1 Nisan was declared as 'the new year for months and intercalations,'[46] the letter of Resh Galuta offers the first solid proof that there was a real Nisan-based calendar.

This should come as no surprise, since the 4th century Jewish community in Galilee remained largely agricultural, and agricultural festivals, Passover, Shavuot and Sukkoth, were ranked higher than (popular in the Diaspora) spiritual ones, Rosh Hashanah and Yom Kippur. By the end of the 8th century, agriculture was all but forsaken by Jews in the Middle East.[47]

Notice that the weekday of Rosh Ĥodesh Nisan is the same as the weekday of Passover and so LO B-D-U PESAĤ = LO B-D-U ROSH ĤODESH NISAN, the latter being the original formulation of this rule as Rosh Ĥodesh Nisan was the cornerstone of Hillel Bar Yehuda's calendar.

8. MOLAD ZAQEN AND THE TIMING OF MOLAD

The letter of Resh Galuta leaves open the question of whether an important rule, Molad Zaqen, which requires moving Rosh Ĥodesh to the next day if Molad falls after 18 hours (i.e., after 12:00), was present in 835/6. The answer became a point of contention among the Tishri-oriented scholars.

If Rosh Ĥodesh Nisan in 836 remained on Tuesday, the forthcoming Rosh Hashanah would be on Thursday. But if Molad Nisan was on Tuesday 10 am, then Molad Tishri would be 2.5 hours after noon on Thursday, which necessitates a postponement of Rosh Hashanah to Saturday. Scholars were divided on how to explain this outcome—some

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44 The Hebrew calendar places Molad Nisan in 836 at 3-15-811. Stern (2001, 206) misquoted the number of *ĥalakim* as 861.

45 The very fact of invoking Molad helps to resolve the debate on the identity of Resh Galuta—see Walter (2003, 242)—was he David Ben Yehuda as per J. Mann (1920, I, 50) or his Karaite contender Daniel Ben Shaul Ben Anan, the grandson of the founder of the Karaite sect, as per M. Gil (1997, I, 220). Since Karaites did not use Molad but fixed the beginning of each month upon sighting the new moon, a Karaite could not have written that letter.

46 B. Rosh Hashanah 7a: תְּנוּ רַבָּנַן: בְּאֶחָד בְּנִיסָן רֹאשׁ הַשָּׁנָה לְחֲדָשִׁים, וּלְעִיבּוּרִין.

47 See Ben-Sasson (1985), 388.

questioned the timing of Molad Nisan, others the presence of Molad Zaqen. Stern (2001, 196) concluded that 'as late as 835/6, the rule of Molad Zaqen (for Rosh Hashanah) was not yet observed.'[48]

However, the eminent 20th century scholars, Ĥayim Yehiel Bornstein of Warsaw and Zvi Ĥirsh Jaffe of Smolensk considered Molad Zaqen as a basic rule that must be present at the inception of the fixed calendar. So instead, they questioned the timing of Molad Nisan in 836. Bornstein (1922a, 347) interpreted the word בימא as 'in the day'—not as 'in the daytime'—placing Molad Nisan in 836 earlier by 12 hours than the current one. No scholar supported this idea.[49]

The work of Zvi Ĥirsh Jaffe was published in 1931, 4 years after his death. Noticing that the first two letters in שעות (hours) are semi-legible, Jaffe (1931, צח) suggested an alternative reading שתות (one-sixth), a unit of 10 min, placing Molad Nisan in 836 at 6:40 am, 3.3 hours earlier than 10 am. In such a case Molad Zaqen for Tishri would not be applicable. Looking for an appropriate reference epoch (עקר) for this Molad in the time of Hillel Bar Yehuda, Jaffe (1931, נד) ingeniously suggested that the initial Molad Nisan was attuned to the solar eclipse of March 15, 359, visible in Tiberias as a partial eclipse reaching its maximum magnitude of 0.66 c. 18:00 local time. Though Jaffe's idea of the Molad's origin is of value, Stern (2001, 280) refuted Jaffe's alternative reading of 'hours' and so put his entire theory in disrepute.

None of these scholars considered the simple solution that the calendar was still Nisan-based.[50] Since Molad Nisan in 836 was on Tuesday c. 10 am, Molad Zaqen for Nisan was obviously not applied.[51]

While Molad Nisan in the time of Resh Galuta might have been different than the current one, it cannot be too far away from it. To pin it precisely, one must look to Hillel Bar Yehuda's time—the late 4th century. This will be done in a subsequent paper. Here we make a first step toward this goal.

The Jewish communities in two cities, Antioch and Milan, held Passover Seder in 387 on March 20. This same-day celebration in two faraway localities could have hardly resulted from the 'sighting of the new moon,' as Stern (2001, 146) imagined, but most likely from using the same calendar.

According to the Hebrew calendar, Molad Nisan in 387 is 7-17-729, i.e., Saturday at 11:40:30. This would place Rosh Ĥodesh Nisan on Saturday March 6 and Passover Seder on March 19. To move Nisan 14 in 387 from March 19 to 20 we must add *at least 351 ĥalakim* (i.e., 19.5+ minutes) to Molad BaHaRaD and then apply Molad Zaqen to the resulting Molad Nisan in 387. After doing that, Rosh Ĥodesh Nisan moves to Sunday

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48 Ajdler (2015), 148, n. 63, rightly disagreed with Stern though only on principle, believing that such an important rule could not have been added that late, while totally missing the idea of Molad Zaqen being present within the Nisan-based calendar.

49 See Stern (2001), 206; Ajdler (2015), 159.

50 With possible exceptions of Bornstein (1904, app. 3) and Cassuto (1943), who however deduced this idea from the dispute between Ben Meir and Saadia Gaon from 922–24 and *Midrash Sekhel Tov* (1139), not from Resh Galuta's letter.

51 On seeing a 12th century text, cited by Bornstein (1922b, 274), which discusses Molad Zaqen Nisan set at 18 hours, Shai Walter (2003, 235) tried to extrapolate this rule back to 836, but came out with an inconsistent Tishri-based calendar (ibid, 238).

March 7 and the Passover Seder to Saturday March 20.[52] Without the presence of Molad Zaqen, the initial epoch, Molad BaHaRaD, must be further augmented by 6 hours, which would be impossible to reconcile with Resh Galuta's letter.[53]

This discovery has several important consequences. First, the original reference epoch for Molad Nisan was incompatible with Molad BaHaRaD having been fixed *later in time* than the latter by at least 19.5 minutes, *not earlier* as per Bornstein and Jaffe. Second, the calendar month of Hillel Bar Yehuda could not have been shorter than the Babylonian-Ptolemaic synodic month, since even one missing *ẖelek* therein would necessitate shifting the reference epoch for Molad later by an additional 19.2 minutes, which would be already difficult to justify.[54] Third, Molad Zaqen for Nisan was an integral part of the original Nisan-based calendar by Hillel Bar Yehuda.

Though Molad Zaqen was not applied in Nisan 836, one can still discern its presence in 835/6 albeit indirectly. Resh Galuta stated that, with Molad Nisan at 10 am on Tuesday, the new moon would be potentially visible the same night, and so, by declaring Rosh Ĥodesh on Thursday, the 'matter would be disrupted'—an echo of the Talmudic explanation of the meaning of Molad Zaqen.[55]

9. OTHER ASPECTS OF HILLEL BAR YEHUDA'S CALENDAR

What was a permissible length of the year in the calendar of Hillel Bar Yehuda? Did it allow only years of 353-, 354- and 355-days, the differential managed by two variable months Ĥeshvan and Kislev, as it is in the Hebrew calendar? Or were there at least three variable months, Ĥeshvan, Kislev and Tevet, as per Resh Galuta's letter?

Three variable months imply the presence of a calendar year of either 356 or 352 days. Therefore, at least one of the minor postponements, ATRaD (אטר״ד) and ZaTUThaKPaT (זטותקפ״ט)—the analogues of the postponements for Rosh Hashanah, GaTRaD and BaTUThaKPaT—might not have been in place.[56] But these two postponements don't stand equally.

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52 Interestingly, Ajdler (2015), 144–45, arrived at the same dates for 1 Nisan and Passover Seder. However, his arguments, presented in Appendix D (ibid., 185), are puzzling: after computing his Molad Nisan as 7-13-792, i.e., Saturday March 6, 7:44, he, without any justification, concludes that 1 Nisan was the next day, Sunday March 7. It seems that Ajdler argued backwards from the Passover Seder on March 20 while his Molad computation is irrelevant to his conclusion.

53 The addition of 351+ ĥalakim changes Molad Nisan in 836 to 3-10-82+ or Tuesday 10:04:33+, rendering Resh Galuta's quote for Molad Nisan, 10 am, very accurate.

54 For 346 months in 28 years, 359-387, 1 *ẖelek* sums up to 346 *ĥalakim* (19 min 13.3 sec). The extra 346 ĥalakim would delay Molad Nisan in 836 further to 3-10-428+ or 10:23:46+, rendering Resh Galuta's quote for Molad Nisan, 10 am, quite inaccurate.

55 Rabbi Zeira's statement: 'if Molad comes *after* noon, we do not see the new moon the same night, but if *before*, we do.' (B. Rosh Hashanah 19b); see also discussion in Belenkiy (2002), 15.

56 GaTRaD (גטר״ד) requires postponing 1 Tishri before the regular year from Tuesday to Thursday if Molad Tishri is 3-9-204+. BaTUThaKPaT (בטותקפ״ט) requires postponing 1 Tishri after an intercalary year from Monday to Tuesday if Molad Tishri is 2-15-589+.

ZaTUThaKPaT would postpone 1 Nisan after an intercalary year from Saturday to Sunday if Molad Nisan is 7-15-589+. It is an unobtrusive postponement that delays 1 Nisan by a mere 6-8½ hours. This postponement comes quite naturally as after an intercalary year that started on Tuesday with all three variable months of 29 days, 1 Nisan would automatically land on Sunday, the outgoing intercalary year having 383 days instead of 382—no need for another variable month. In the period from 360–836 this postponement would have been applied only in four years: 445, 523, 692, and 770.

ATRaD would postpone 1 Nisan before the regular year from Sunday to Monday if Molad Nisan is 1-9-204+. It is a much more frequent and obtrusive postponement. With the rule LO B PESAḤ, it effectively delays 1 Nisan by two days, from Sunday to Tuesday. Therefore a celebration of Rosh Ḥodesh Nisan may easily occur a day after the first visibility of the new moon—a strong factor against ATRaD's presence in Hillel Bar Yehuda's calendar.

We tested the Nisan-based Molad calendar of Hillel Bar Yehuda against available historical evidence from that era: the dates from 18 Aramaic tombstone inscriptions from Zoar, a locality in Jordan, from the period 392–526 and two dates, for 499 and 506, from *Iggeret* (Letter) of Sherira Gaon.[57]

The results of the test are presented in Appendix 3:

With the rules LO B-D-U ROSH ḤODESH NISAN and Molad Zaqen and with variable months Ḥeshvan and Kislev, the Nisan-based Molad calendar with the (30–29)-day sequence of months perfectly agrees with 17 inscriptions and one date from *Iggeret* of Sherira Gaon. The two disagreements, with inscription #45 (N3) for year 503 and the date for year 506 from the *Iggeret,* suggest the rule LO U PESAḤ was not yet in operation, allowing Passover to fall on Friday.[58] Thus, this rule was introduced after 506, though certainly by 835/6, as it is mentioned in Resh Galuta's letter on par with the rule LO B-D PESAḤ.[59]

Inscription #40 (Z306=N16) for year 475 proves there was no ATRaD, which confirms our above analysis. The absence of ATRaD, with LO U PESAḤ present, allows a calendar year of 356 days and thus necessitates the third variable month, normally of 29 days, by making it full, of 30 days, on such an occasion. Assuming the 30- and 29-day months

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57 Y. Meimaris and K. Kritikakou-Nikolaropoulou (2016) list 69 Aramaic Zoar inscriptions; since then 9 more were discovered. Their description was attempted by many scholars. Only 18 carry all the necessary information for accurate dating. Stern (2001, 147) unsuccessfully tried to reconcile the inscription dates with his lunar visibility theory. Recently, in his PhD thesis, Alexei Nizan reevaluated most of the early dating; see Nizan (2025, 319, Table 10). The most common labeling is with the letter 'Z', introduced by archeologist K. D. Politis; those described by Joseph Naveh are labeled with the letter 'N', those by Stern with 'S'. Meimaris and, after him, Nizan use a new, chronological classification, to which we refer below with the sign #.

58 1 Nisan in 506 was Friday since 4 Adar was Sunday, as per Sherira Gaon; see Stern (2001), 182. There were various attempts to explain away the absence of LO U PESAḤ in 506 (ibid.), but new evidence from the inscription #45 (N3) from 503 render them irrelevant.

59 The necessity of LO U PESAḤ was constantly debated by the rabbis of the Talmud and after; see Stern (2001), 167, 195. Jaffe (1931, נד) assumed the rule was introduced c. 640 but this *ad hoc* date is nothing more than a mid-point between 506 and *Sheiltot* by Ahai Gaon, written c. 750, where the rule was explicitly mentioned; see Stern (2001), 187; Belenkiy (2002), 13.

alternated, this role in the above trio could have been played only by Tevet. This, in turn, also confirms the sequence (30-29)-day months in Hillel's calendar.[60]

N.B.! Since Molad Nisan in 506, after the addition of 351+ halakim, is 6-18-896+, the absence of LO U PESAH alone does not suffice to explain why 1 Nisan in 506 was set on Friday as Molad Zaqen had to be applied anyway, with 1 Nisan moving to Saturday. The solution will be discussed in a subsequent paper.

10. INTERCALARY YEAR 9 IN HILLEL'S CALENDAR

In his PhD thesis (2025) on Aramaic inscriptions from Zoar, written at Bar-Ilan University, Alexei Nizan discovered that year 9, not 8, was intercalated from 372 to at least 467 but not after 542, when intercalation was switched to year 8.

The proof for intercalation of Adar I in year 9 from 372 to 467 comes from the inscriptions #8 (Z99), #71 (Z454), #27 (Z246=N21), and #35 (Z68=N11), dated to 372, 429, 448, and 466/7, respectively;[61] whereas inscription #41, dated to 542, shows that year 8, not 9, was intercalated.[62] This situation raises many questions.

Since 370/1, year 8, was not intercalated, Passover in 371, as per Hillel's calendar, must have been on Thursday March 17. Such a strikingly early date seems to be a partisan decision of a remote Jewish community, disengaged from mainstream events. Yet the similarity of the decorations on Zoar tombstone inscriptions to those from the ancient cemetery from Beit Shearim (an important town in Galilee, a seat of the Bet Din c. 200), suggests that the Jewish community at Zoar was in contact with Galilean Jews.[63] Besides, there were direct contacts between Zoar and Galilee: a deceased person in inscription #9 for 372 being referred to as 'from Beit Shearim near Sepphoris.'[64] If so, intercalation of an extra month in 372 instead of 371 was not a haphazard partisan decision of a remote community but a faithful following of Hillel's calendar introduced in 358/9.

Accepting intercalation in year 9 at face value, the rigid structure of the Jewish calendar immediately implies that years 6 and 17 also became intercalary as early as 372. Importantly, as shown by inscription #42 (Z101) for 477, year 19, was intercalary and,

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60 This conclusion seems to contradict an inscription from Catania from 383 that carries the date 'October 21, Friday, 8 [Ĥeshvan]'; see Wasserstein (1991/2). However, this inscription is contaminated by an error as October 21, 383, was Saturday, not Friday. Stern (2001, 133) proposed that the written date must be amended to 'October 20, Friday.' Then, with Molad Nisan in 383 on 2-17-752 and 1 Nisan on Tuesday March 21, to have 8 Ĥeshvan on Friday requires 29 days in Tishri. This option was briefly considered but then rejected by Stern (2001, 136, n. 113) using largely irrelevant arguments about lunar visibility in 383. Since Tishri had 30 days, the written date on the inscription must rather be amended to 'October 21, Saturday, 8 Ĥeshvan'.

61 See Nizan (2025), 317, Table 9. Though the weekday on the first three inscriptions is missing, an independent verification for the dating comes from their positions within the Shmita cycle.

62 See Nizan (2025), 317, Table 9. Note that Meimaris and Kritikakou-Nikolaropoulou (2016), 98, suggested a different, somewhat garbled reading and inferior dating of inscription #41.

63 A usual set of decorations included one or two menorot, ark of covenant, shofar, and four species of Sukkoth; Alexei Nizan, private communication.

64 Nizan (2025), 32; Meimaris and Kritikakou-Nikolaropoulou (2016), 46, made a typo 'Beit Sharon'.

therefore, intercalary year 9 was the only deviant year from the modern cycle. Thus, during 372–467, or even 372–541, only in three years of the cycle: 5, 8, and 16, was Passover Seder held before March 21 and only in the two latter years before the true equinox, March 19/20.[65]

But according to which principle did the Bet Din choose the cycle? Obviously, residing in the Diocese of the Orient with the capital at Antioch, the Bet Din in Tiberias chose the Seleucid cycle 1, 4, 7, 9, 12, 15, 18 from Tishri 312 BCE,[66] or, equivalently, GUḤADZT: 3, 6, 8, 11, 14, 17, 19 from Tishri 311 BCE.[67] Comparison of this cycle with the modern cycle GUḤADZT counted from BaHaRaD, shows only one difference: intercalation in year 9 instead of 8.[68]

On the other hand, in al-Khwarizmi's work of 823 we see the cycle 3, 5, 8, 11, 14, 16, 19 from 322 BCE.[69] Since this reference year is equivalent to BaHaRaD, it means years 5 and 16, not 6 and 17, were intercalated.

Only in the late 10th century work by al-Biruni and the 992 letter by Hai Gaon do we see count 3, 6, 8, 11, 14, 17, 19 from BaHaRaD. This means that sometime in history, between 360 and 823, years 6, 9 and 17 lost their intercalary status, though sometime later, between 823 and 990, years 6 and 17 recovered it. All this paradoxical back and forth movements require explanation.

A plausible answer comes from observing the time of the first confirmed change (from year 9 to year 8) in the intercalary cycle: 541/2 belongs to the reign of Emperor Justinian (527–565) who is known to have unleashed persecutions on the Byzantine Jews for celebrating Passover before the vernal equinox as calculated by the Church, i.e., before March 21. Procopius of Caesarea reports in chapter 28 of his *Anecdota* (c. 550):

> (16) The emperor [Justinian] did the same thing every day and not only with the laws of the Romans, but he also did his best to abolish the laws revered by the Hebrews. (17) Whenever their cycle of times happened to bring the Passover Feast *before* that kept by Christians (ἦν γάρ ποτε αὐτοῖς ἐπανιὼν ὁ χρόνος τὴν Πασχαλίαν ἑορτὴν πρὸ τῶν Χριστιανῶν ἀγαγὼν τύχοι), he did not permit the Jews to celebrate this Feast at the proper time (οὐκ εἴα ταύτην τοὺς Ἰουδαίους καιροῖς τοῖς καθήκουσιν ἄγειν), nor to dedicate anything to God that day, nor to perform any of their customary rites. (18) And many of them were punished by the

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65 Therefore Stern's (2001, 87) claim that 'as late as the sixth century, Jews were still widely observing Passover before the equinox' is an exaggeration.

66 This Seleucid cycle was found by F.X. Kugler (1907), 214, but for the different epoch, 311 BCE; see details in Parker and Dubberstein (1956), 35. Kugler believed Seleucids counted years from Nisan, but Samuel (1972, 142), distinguishes between the Seleucid calendars in Syria (Tishri-based) and Babylonia (Nisan-based).

67 One can count these cycles as well from Nisan, yet on the authority of Rabbi Zeira: 'The first of Tishri is the New Year for years with regard to calculating the cycles of the sun and the moon' (B. Rosh Hashanah 8a).

68 This is because the difference between 3761 BCE and 311 BCE = 11 *mod* 19.

69 The rule for the reference epoch was to 'add 9 to the number of complete years of the Alexander [Seleucid] era'; see Kennedy (1962), 56, last line. As the 'complete years' seems to be the extension from 312 BCE to 313 BCE, the only sensible interpretation is to count 9 years from 313 BCE back, i.e., 322 BCE. The cycle: 3-5-8-11-14-16-19 is cited in Langermann (1987), 164.

> officials with heavy monetary fines for eating the flesh of lamb at this time, charged with an offence against the laws of the State.[70]

Well, Passover always happened *before* Easter; here Procopius obviously meant *a month before* Easter, i.e. the Emperor banned those Passovers that fell before March 21. Then the reason for advancing intercalation in three years of the cycle a year sooner could have had the following background. Two Passovers at the beginning of Justinian's reign, on March 18 in 531 (year 16) and on March 20 in 539 (year 5), could have caused the emperor's ire and led to the persecution, which forced Jewish leaders, in order to avoid Passover on March 18 in 542, to add Adar I in 542 (year 8) instead of 543 (year 9) as was intended in the original calendar of Hillel Bar Yehuda. As well, the intercalation was advanced from years 6 and 17 to years 5 and 16 and remained there for the next 300 years.

11. THE BACKGROUND OF THE CALENDAR REFORM IN 358/9

According to the calendar of Hillel Bar Yehuda, Passover in 417 was on Sunday March 18,[71] the date Stern initially ran into but then rejected as *too early*, allegedly 'breaching the equinox rule.' However, it is exactly the strikingly early Passover in 417, and even the earlier Passovers on March 17 in 371 and 390, that may answer the question of *why* the reform was initiated by Hillel Bar Yehuda in the first place—due to growing rabbinical distrust of any contemporary popular day for the vernal equinox, including March 21, and consequently distrust of the Julian year as a true representative of the solar year—the fact emphasized by Hai Gaon.

For that reason, the lunar Molad calendar designed by Hillel Bar Yehuda was set free of loyalty to any of the solar Julian-year-based calendars adopted everywhere in the world where Jewish Diasporas were found. The gut feeling—from the observations of various agricultural phenomena—that the vernal equinox comes earlier than March 21—could have sought support from contemporary astronomy, as the 350s was the time when the Alexandrian astronomer Theon was active.[72]

Though Palestinian rabbis contacted the Alexandrian Jews prior to 359, as shown by Rabbi Abbahu's visit and Rabbi Yose's message,[73] the Alexandrians might not have been ready in 359 to adopt a new calendar, protesting, e.g., against the postponements as lacking biblical support or the changes in the intercalation cycle. Yet the rest of Egypt could have been more receptive to Hillel Bar Yehuda's appeal. Indeed, after Diocletian's reforms at the turn of the 4th century, both Egypt and Palestine from 305–380 were provinces of the Diocese of the Orient with the capital at Antioch. Thus in 359, Egypt was

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70 Procopius (1935), 332–35; see also Belenkiy (2002), 11.

71 See Appendix 3. Since 417/8 was an intercalary year, postponement ATRaD was not applicable. Also, this calendar, absent LO U PESAḤ, puts Passover in 425 on Friday (March 20) and 20 Kislev on Monday, which disqualifies the alternative dating of the Ketubah to 425.

72 In 356, the vernal equinox occurred around midnight March 19 Jerusalem Time. But the accuracy of the equinox observations in antiquity was not better than 6 hours; see Toomer (1998), 133. For the practical challenges facing the equinox observers of that era see Belenkiy (2016).

73 Y. Erubin 3:9, 21c; also Stern (2001), 173.

not subordinate to Alexandria politically or culturally, and so Egyptian Jews could have developed their own contacts with the Palestinian Jews and the Bet Din in Tiberias.

Though the Alexandrian Jews might not be willing to adopt a new calendar in 359, the situation certainly changed after the pogrom and expulsion of the Jewish community from Alexandria in 414. The Alexandrian Jewish calendar most likely ceased to exist together with its community. After 414 there remained in the Jewish world no viable alternative to the Palestinian Molad calendar. That's why the Alexandria-born parents of the bride, refugees in Antinopolis, agreed to sign the Ketubah in 417 according to the calendar of Hillel Bar Yehuda.

The question why Hillel Bar Yehuda is not mentioned by name in contemporary Jewish sources was partially answered by Stern (2001, 179) himself. He knows of a reference to 'Iulus the Patriarch' in one of Emperor Julian's letters addressed to the Jewish community of Antioch:

> And since I wish that you should prosper yet more, I have admonished my brother Iulus, your most venerable patriarch (τὸν ἀδελφὸν Ἴουλον, τὸν αἰδεσιμώτατον πατριάρχην), that the levy which is said to exist among you should be prohibited, and that no one is any longer to have the power to oppress the masses of your people by such exactions; so that everywhere, during my reign, you may have security of mind, and in the enjoyment of peace may offer more fervid prayers for my reign to the Most High God, the Creator, who has deigned to crown me with his own immaculate right hand.[74]

Stern also knows a story about the alleged apostasy of the Patriarch Hillel related by Epiphanius of Salamis in his treatise *Panarion*.[75] While possibly a fabrication, as the evidence comes from a Patriarch Hillel subordinate, himself a convert to Christianity, rumors that followed its publication could have scandalized the Jewish world.

This story may explain why the Palestinian Talmud was not extended beyond the 360s, why the Babylonian Talmud was redacted in the 5th century, and why the founder of the Molad calendar disappeared from Jewish literature of that era almost without a trace. Hillel Bar Yehuda's (rumored) apostasy made him the subject of censorship by the redactors of the Babylonian Talmud and only an incidental mention by Hai Gaon in one of his epistles restored Hillel's name to Jewish history.[76] While the patriarch might not have been involved in the calculations personally, he certainly authorized the Bet Din's work and it is quite reasonable that his name was attached to the new emerging calendar.[77]

12. TOWARD THE HEBREW CALENDAR

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74 See Wright (1923), 178–79. Wright identifies 'Iulus the Patriarch' with Hillel II, aka Hillel Bar Yehuda, then dates the letter to 362 and suggests that at that time Hillel was about 70.

75 *Panarion* 30, 4: πατριάρχης κατ' ἐκεῖνο καιροῦ Ἑλλὴλ; see Epiphanius (1915), 1.338–39; also Stern (2001), 179, n.100.

76 Note that Hai Gaon referred to Hillel without due reverence: not as Hillel ha-Nasi, Hillel the *Patriarch*, as one might expect, but as *commoner* Hillel Bar Yehuda. A hint of scandal was still present.

77 In the same way as earlier the Julian calendar was named after Julius Caesar, and not Sosigenes, and later the Gregorian calendar was named after Pope Gregory XIII, and not the members of his calendar commission.

Let us determine when Resh Galuta's letter was written, in 835 or 836.

Notice that the expression 'delayed moon' (מתאחר סהרא) for the months Ĥeshvan, Kislev and Tevet implies that all three months must be of equal length in the year in question. The key is the mention of Tevet. As we have seen, a full Tevet was intended only to support a calendar year of 356 days but we do not see the possibility of such a year in the 830s. Thus Tevet in that year must be short, 29 days, and so too Ĥeshvan and Kislev. As it turns out, such a configuration works well only for these three months of 835 but not for those of 836.[78]

As we know, the Bet Din set 1 Nisan of 836 on Tuesday March 21. Yet, due to uncertainty over the intercalation cycle in the period 823–836, it is unclear when 1 Nisan was in 835 (see Appendix 3). If Adar I was added in 835 (year 16), Hillel's Molad Nisan in 835 was 6-7-286+ and, due to LO U PESAḤ, 1 Nisan was on Saturday April 3. If Adar 1 was added only a year later, in 836 (year 17), Hillel's Molad Nisan in 835 was 4-18-573+ and, due to Molad Zaqen, 1 Nisan was on Thursday March 4. Thus, in the former case, Jewish year 835/6 was 353 days, in the latter, 383 days; in either case, Ĥeshvan, Kislev and Tevet in 835 must be all short, as required. To the contrary, as 1 Nisan in 837 was on Sunday March 11, Jewish year 836/7 was 355 days, requiring a full Ĥeshvan and Kislev in 836—leaving Tevet short—which invalidates this option.

Thus, the mid-Ĥeshvan (October-November) of 835 is the most historically sound timing for Resh Galuta's letter that addressed the urgent calendar inquiry from the Diaspora of why the three winter months of 835/6 went short. But why was there such an inquiry from the Diaspora in the first place? The most obvious answer is that the 830s was the time of the calendar change.

Bornstein (1904) speculated that the Hebrew calendar was established in the 830s at the meeting between Palestinian and Babylonian sages convened to adjust Molad Tishri and the calendar month after a new Arabic translation of Ptolemy's *Almagest* appeared in 829/30.[79] Later, after the publication of Resh Galuta's letter, Bornstein (1922a; 1922b) and Jaffe (1931, קג) narrowed the window for such a meeting to the late 830s. This scenario is quite possible: the very inquiry from the Diaspora into the Bet Din's calendar ruling for 835/6 indicates that some changes were already in the making though not yet finalized. And the major change was the transition from a Nisan-based calendar to a Tishri-based calendar.

The latter calendar, missing the reference epoch for Molad Tishri, is first known to be described by the celebrated Muslim scholar al-Khwarizmi who was likely contacted by the Jewish leaders to ensure the ensuing calendar would have been sound. Year 823/4, mentioned in al-Khwarizmi's work, could have been the time of this contact and the possible starting point of the transition.[80] The modern reference epoch for Molad Tishri, Molad BaHaRaD, as we showed above, is incompatible with Molad Nisan in Hillel Bar Yehuda's calendar used by Resh Galuta in 835/6 and therefore would have been established only after 836.

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78 Stern (2001), 281, n. 34, cautiously speaks of 'three winter months of 836/7'.

79 The translation actually happened two years earlier, in 827/8; see Ajdler (2015), 161.

80 Kennedy (1964); see also Stern (2001), 185.

Surprisingly, we can see other signs of the transition: Yaakov Ben Shimshon, a rabbi from France, in his *Sod Haibbur* (1123), preserved in the only extant copy (at Oxford), ascribes to Meshullam Ben Kalonymus a variant of the Nisan-based calendar with LO B-D-U PESAĤ where Molad Zaqen for Nisan, ATRaD and ZaTUThaKPaT were reduced by 4h 438 ĥalakim, the fraction of the day on top of 177 days that separates Molad Nisan from the following Molad Tishri.[81]

Thus, the calendar of Meshullam Ben Kalonymus, contemporary of Sherira Gaon and Hai Gaon, who flourished in the late 10th century in Mainz, was the last vestige of Hillel Bar Yehuda's calendar, a historic link between his and the Hebrew calendar. It seems the Ashkenazi communities in Europe became so accustomed to the Nisan-based calendar for centuries that they were unwilling to immediately switch to the Tishri-based calendar but agreed to reduce all Nisan-based postponements by 4 h 438 ĥalakim so as to be in tune with the rest of the Jewish world.

13. SUMMARY AND CONCLUSION

In this paper we reaffirmed the historical belief in the appearance of the fixed Molad calendar in 358/9 and its attribution to Hillel Bar Yehuda, both of which facts were recently challenged by Sacha Stern without proper justification. For that we made separate assessments of the solar part (the intercalation cycle) and the lunar part (the timing of the mean lunisolar conjunction, Molad) of the Jewish calendar after 359.

Evidence from several Christian sources shows the Jewish intercalation cycle in the 360s differed from the modern one perhaps only in year 16. Year 17 became intercalary no later than 417 as we learn from the dating of the Ketubah of Antinoopolis. But Alexei Nizan's discovery (2025) that year 9, not 8, was intercalated as early as 372, implies that year 17 became intercalary as well from 372, or even from 360. Hillel's original intercalation cycle was GUĤADZT counted from Tishri 311 BCE. This cycle, as we conjecture, was in operation by 542 when the intercalation in year 9, and likely in years 6 and 17 as well, was advanced by a year to prevent Passover in years 5, 8 and 16 from falling before March 21, so as to avoid Emperor Justinian's persecution. Years 6 and 17, as we surmise, again became intercalary sometime between 823 and 992.

As became clear from the letter of Resh Galuta from 835/6, the original Molad calendar was Nisan-based, i.e., sought to establish the day of Rosh Ĥodesh Nisan. Its particular features emerged from the analysis of the evidence from two Christian sources from 387 and the Aramaic tombstone inscriptions from Zoar, a locality in Jordan. They are: 1) the rule LO B-D ROSH ĤODESH NISAN; 2) the rule Molad Zaqen for Rosh Ĥodesh Nisan at 18 hours; 3) Molad Nisan was *at least 351 ĥalakim* (*19.5 minutes*) *later* than the present one associated with Molad BaHaRaD; 4) the calendar month was not shorter than the Ptolemaic synodic month of 29 days 12 hours 44 minutes and 1 *ĥelek*; 5) there were two variable months, Ĥeshvan and Kislev, and the calendar year had 353–355 days; 6) postponement ZaTUThaKPaT was present while ATRaD was not; 7) the rule LO U PESAĤ was absent, allowing 1 Nisan to fall on Friday.

This latter rule was introduced sometime between 506 and 835, leading to the possibility of calendar years of 356 days, which required an extra variable month, Tevet.

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81 Bornstein (1922b), 233; also Walter (2003), 229, for details of the manuscript's whereabouts.

The two latter features were eliminated after 836 in the Tishri-based Hebrew calendar by introducing the postponement GaTRaD.

Our attempt to re-date the Ketubah of Antinoopolis from 417 to 425, based on the Alexandrian Jewish calendar, led to new insights into the calendar of the Alexandrian Jews before their acceptance of the Palestinian Molad calendar of Hillel Bar Yehuda. While the Egyptian Jews, together with the Diaspora at large, adopted the Molad calendar in 359, the Alexandrian Jews adopted the Molad calendar only after the destruction of the Alexandrian Jewish community in 414.

Hillel Bar Yehuda must be recognized as the actual founder of the Hebrew calendar, though three changes in his original intercalation cycle, and possibly the rule LO U PESAḤ, were introduced by mid-6th century Byzantine rabbis during Emperor Justinian's reign (527–565). The letter of Resh Galuta from 835/6 proves his Nisan-based Molad calendar was operational for about 475 years. Its reference epoch (the first Molad Nisan) and the length of the calendar month will be established in a subsequent paper.

P.S. We seek help in unearthing the Ethiopic Paschal list for 310/1–367/8, announced but never published by Otto Neugebauer (1979a; 1979b). It may offer unique insights into the Alexandrian Paschal calendars in the Ante-Nicene era.

P.P.S. We also seek help to clarify the provenance of the Ketubah of Antinoopolis, currently at the Papyrus collection of the Cologne Institute of Archaeology.

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APPENDIX 1. A modern Ethiopic Paschal table

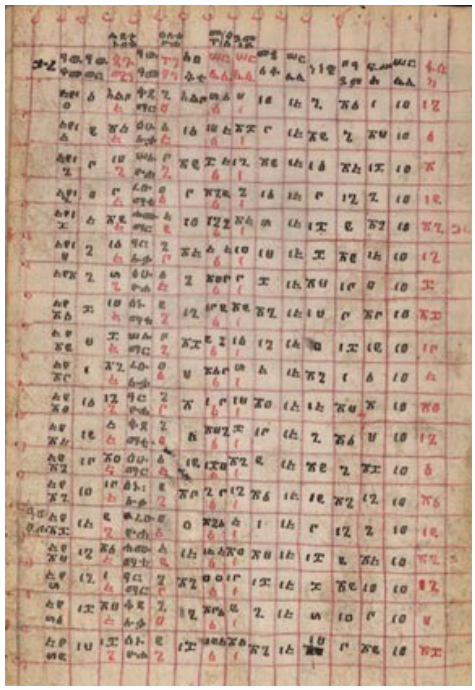

Fig. 1. *The Ethiopic Paschal table for 1937/8–1955/6 from the Library of Congress and its transcription below. The numbering of the columns is from the first filled column.*

1	*2*	*3a*	*3b*	*4*	*5a*	*5b*	*6*	*7a*	*7b*	*7c*	*8a*	*8b*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*Easter*
514	1	-	5	Mc	7	4	0	30	1	1	9	10	14	15	*7*	21	10	14	16	*11.4.1938*
515	2	25	5	Lc	1	5	11	19	5	1	28	10	3	15	22	6	29	14	1	*27.3.1939*
516	**3**	**14**	**6**	**Jo**	**3**	**7**	**22**	**8**	**5**	**1**	**17**	**10**	**22**	**15**	***11***	**25**	**18**	**14**	**20**	***15.4.1940***
517	4	3	5	Mt	4	1	3	27	2	1	6	10	11	15	*3*	17	7	14	12	*7.4.1941*
518	5	22	5	Mc	5	2	14	16	6	1	25	10	30	15	18	2	26	14	27	*23.3.1942*
519	6	11	5	Lc	6	3	25	5	5	1	14	10	19	15	*8*	22	15	14	17	*12.4.1943*
520	**7**	**30**	**6**	**Jo**	**1**	**5**	**6**	**24**	**3**	**1**	**3**	**10**	**8**	**15**	**29**	**13**	**4**	**14**	**8**	***3.4.1944***
521	8	19	5	Mt	2	6	17	13	2	1	22	10	27	15	*19*	3	23	14	28	*23.4.1945*
522	9	8	5	Mc	3	7	28	2	6	1	11	10	16	15	*4*	18	12	14	13	*8.4.1946*
523	10	27	5	Lc	4	1	9	21	3	1	30	10	5	15	26	10	1	14	5	*31.3.1947*
524	**11**	**16**	**6**	**Jo**	**6**	**3**	**20**	**10**	**3**	**1**	**19**	**10**	**24**	**15**	***15***	**29**	**20**	**14**	**24**	***19.4.1948***
525	12	5	5	Mt	7	4	1	29	7	1	8	10	13	15	*7*	21	9	14	16	*11.4.1949*
526	13	24	5	Mc	1	5	12	18	4	1	27	10	2	15	22	6	28	14	1	*27.3.1950*
527	14	13	5	Lc	2	6	23	7	3	1	16	10	21	15	*12*	26	17	14	21	*16.4.1951*
528	**15**	**2**	**6**	**Jo**	**4**	**1**	**4**	**26**	**7**	**1**	**5**	**10**	**10**	**15**	***3***	**17**	**6**	**14**	**12**	***7.4.1952***
529	16	21	5	Mt	5	2	15	15	5	1	24	10	29	15	18	2	25	14	27	*23.3.1953*
530	17	10	5	Mc	6	3	26	4	4	1	13	10	18	15	*8*	22	14	14	17	*12.4.1954*
531	18	29	5	Lc	7	4	7	23	1	1	2	10	7	15	30	14	3	14	9	*4.4.1955*
532	**19**	**18**	**6**	**Jo**	**2**	**6**	**18**	**12**	**5**	**1**	**21**	**10**	**26**	**15**	***19***	**3**	**22**	**14**	**28**	***23.4.1956***

Column 1: year's position within the 532-year Easter cycle. The numbers 514–532 represent the last 19-year sub-cycle of the cycle. Since the cycle starts in 1424/5, the years are 1937/8–1955/6.

Column 2: year's position within the 19-year cycle.

Column 3: contains two numbers: one in black and one in red.

The black number (3a), known as The Gate of Epact, shows the Ethiopian/Egyptian date of the first day of the 12th Jewish month Elul. It falls either in the 12th Ethiopian month Nähase / Alexandrian month Mesore, or on one of the epagomenal days. The missing value in the first line means '0'.

The red number (3b) indicates the number of epagomenal days in the Alexandrian civil year: five in the regular years of 365 days or six in the leap years of 366 days.

Column 4: the Gospel for the annual liturgical reading.

Column 5: contains two numbers:

a) weekday of the first day of the 1st month Mäskäräm / Thoth, i.e., August 29 or 30, depending on the number of epagomenal days, 5 or 6, respectively;

b) tontheon (τῶν θεῶν), or '[days] of gods': the weekday of either August 26 or 27, i.e., the day that comes three days before Mäskäräm 1 / Thoth 1; it is also the weekday of the following March 24.

Column 6: epact: the age of the moon on Mäskäräm 1 / Thoth 1.

Column 7: contains three numbers: two black above and one red below .

The first black number (7a) shows the civil date of Rosh Hashanah (matqe'e = Yom Hatkia); the dates numbered from 15 to 30 belong to the 1st month Mäskäräm / Thoth, the dates numbered from 1 to 13 belong to the 2nd month Ṭəqəmt / Phaophi; the second option happens only in the intercalary years.

The second black number (7b) shows the weekday of Rosh Hashanah. E.g., in the first row stands 1 = Sunday.

The red number (7c) is the lunar date of Rosh Hashanah, 1 Tishri.

Column 8: civil date of Yom Kippur, 10 Tishri, and (in red) its lunar date.

Columns 9–10: civil date and the lunar date of Sukkoth, 15 Tishri.

Column 11: beginning of the three-day Fast of Nineveh that commences 69 days before Easter in either the 5th month Ṭərr / Tubi or, in italics, the 6th month Yäkatit / Mekhir.

Column 12: beginning of the eight-week Fast that commences 55 days before Easter in either the 6th month Yäkatit / Mekhir or the 7th month Mägabit / Phamenoth.

Columns 13–14: civil date and the lunar date of Passover (fishiha), i.e., 14 Nisan.

Column 15: civil date of Easter (fasika), the first Sunday after 14 Nisan.

Note that though the weekday of Passover is not specified, one can infer it comparing the dates of Passover and Easter. E.g., in the first row Passover is on day 10 of the 8th month Miyazya / Pharmouthi, while Easter is on day 16. Thus, Nisan 14 is on Monday. Since Rosh Hashanah is on Sunday, this is consistent with 190 days count between Rosh Hashanah and 14 Nisan (because 190 = 1 *mod* 7).

Note that all epagomenal days were in Elul. Note a uniform 24-day (*mod* 30) difference between the dates for 1 Elul (column 3a) and 1 Tishri (column 7a) for all years, which implies an extra day in Elul in leap years—to compensate for the extra epagomenal day.

APPENDIX 2. The internal structure of three Jewish calendars

Season	Months	Hebrew calendar	Alexandrian calendar	Hillel B. Yehuda calendar	Festivals
Spring	Nisan	30	30	30	14: Passover Seder 15: Passover
	Iyar	29	29	29	
	Sivan	30	30	30	6: Shavuot (Atzeret)
Summer	Tammuz	29	29	29	
	Av	30	30 (29*)	30	
	Elul I	–	30	–	
	Elul	29	29 (30**)	29	
Autumn	Tishri	30	30	30	1: Rosh Hashanah, 10: Yom Kippur, 15: Sukkoth
	Ĥeshvan	29 (30)	29	29 (30)	8: Catania inscription
	Kislev	30 (29)	30	30 (29)	20: Ketubah of Antinoopolis
Winter	Tevet	29	29	29	
	Shevat	30	30	30	
	Adar I	30	–	30	
	Adar	29	29	29	13: Purim

Table 2. *Comparison of the (modern) Hebrew calendar, the Alexandrian Jewish calendar and the calendar of Hillel Bar Yehuda.*

The twelve Jewish months are arranged in trios for each of the four seasons.

In the Hebrew calendar, the two variable months are Ĥeshvan and Kislev. The extra month, Adar I, is added in years 3, 6, 8, 11, 14, 17, 19, counted from Molad BaHaRaD = 1 Tishri 3761 BCE.

In the Alexandrian Jewish calendar, * shows implementation of *saltus lunae* in Av (normally of 30 days), while ** shows the addition of a leap day in Elul (normally of 29 days) in the pre-leap Julian years. The extra month, Elul I, was added before years 3, 6, 8, 11, 14, 17, 19, counted from 1 Tishri 284 CE, or, equivalently, before years 3, 5, 8, 11, 14, 16, 19, if counted from Molad BaHaRaD.

In the calendar of Hillel Bar Yehuda, the two variable months were Ĥeshvan and Kislev. The extra month, Adar I, was added in years 3, 6, 8, 11, 14, 17, 19, counted from 1 Tishri 311 BCE or, equivalently, in years 3, 6, 9, 11, 14, 17, 19, if counted from Molad BaHaRaD.

APPENDIX 3. Comparison of Hillel's calendar vs. historical data

Year CE	Historical date & Source	Molad Nisan acc. Hillel	Postpone-ments	1Nisan acc. Hillel	Same historical date acc. Hillel & (30-29) months
383 reg	1 Ĥeshvan = Sat.??[82]	2-18-23+	MZ	Tue.	1 Ĥeshvan = Sat.
387	1 Nisan = Sun.[83]	7-18-0+	MZ	Sun.	1 Nisan = Sun.
417 i reg	1 Kislev = Fri.[84]	1-14-443+	--	Sun.	1 Kislev = Fri.
425 i reg	1 Kislev = Fri.??	6-3-111+	lo U?	Fri.	1 Kislev = Wed.
Zoar Aramaic Inscriptions					
392 def	1 Iyar = Sat.[85]	4-15-566+	lo D	Thu.	I Iyar = Sat.
415 i	1 Shevat = Wed.[86]	6-20-851+	MZ	Sat.	1 Shevat = Wed.
429 ful	1 Tevet = Thu/Fri.[87]	5-15-880+	--	Thu.	1 Tevet = Fri. (Ĥeshvan 30d.)
430 ful	1 Elul = Wed.[88]	3-0-676+	--	Tue.	1 Elul = Wed.
438	1 Nisan =Sat.[89]	7-13-343+	--	Sat	1 Nisan = Sat.
441 reg	1 Tevet = Sun.[90]	1-4-524+	--	Sun.	1 Tevet = Sun.
454	1 Adar = Mon.[91]	2-14-757+	lo B	Tue.	1 Adar = Mon.
454 reg	1 Tevet = Tue.[92]	2-14-757+	lo B	Tue.	1 Tevet = Tue.
466* ful	1 Tammuz = Tue.[93]	5-3-401+	--	Thu.	1 Tammuz = Tue.
466* ful	1 Kislev = Wed.[94]	5-3-401+	--	Thu.	1 Kislev = Wed. (Ĥeshvan 30 d.)

82 The Catania inscription (CIJ no. 650); (Stern 2001, 133: 8th lunar day (Oct 21) = Fri. or Sat.).
83 John Chrysostom, Hom. 3: Passover on Sun.; Ambrosius, Ep. 23.15: Passover on March 21.
84 Ketubah of Antinoopolis: 20 Kislev = Wed. (Sirat *et al.* 1986; Stern 2001, 139).
85 Zoar #12 (N7=Z69): 3 Iyar = Mon. (Naveh 1995; Stern 2001, 147).
86 Zoar #16 (N20): 27 Shevat = (Mon.?) (Nizan 2025, Table 10); (Naveh 2010: 10 Shevat = Mon.).
87 Zoar #20 (Z144): 16 Tevet = Fri./Sat.(Nizan 2025, ibid.); (Stern 2001, 147: 16 Tevet = Fri.).
88 Zoar #21 (N10=Z315): 9 Elul = Thu. (Nizan 2025, ibid.); (Stern 2001, 147: 17 Elul = Tue.).
89 Zoar #23 (Z305): 15 Nisan = Sat. (Misgav 2006).
90 Zoar #25 (N28): 5 Tevet = Thu. (Stern and Misgav 2004).
91 Zoar #29 (N22): 3 Adar = Wed. (Naveh 2010; Meimaris 2016).
92 Zoar #30 (N4): 25 Tevet = Fri. (Naveh 1995; Stern 2001, 147).
93 Zoar #34 (S14=Z177): 20 Tammuz = Sun. (Nizan 2025, ibid.); (Stern 2001, 147: 20 Elul = Thu.).
94 Zoar #35 (N11=Z68): 3 Kislev = Fri. (Naveh 1995; Stern 2001, 147).

467 def	1 Tevet = Wed.[95]	4-0-990+	lo D	Thu.	1 Tevet = Wed. (Kislev 29d.)
469 ful	1 Nisan = Sat.[96]	7-7-295+	--	Sat.	1 Nisan = Sat.
475 ful	1 Ĥeshvan = Thu.[97]	1-13-657+	AT?	Sun.	1 Ĥeshvan = Thu.
477 ful	1 Sivan = Sun.[98]	4-19-1042+	MZ	Thu.	1 Sivan = Sun.
499 reg	1 Sivan = Wed.[99]	1-3-738+	--	Sun.	1 Sivan = Wed.
503 def	1 Elul = Sat.[100]	6-3-715+	lo U?	Fri.	1 Elul = Sat.
514 def	1 Av = Wed.[101]	4-7-563+	lo D	Thu	1 Av = Wed.
526 reg	1 Av = Sat.[102]	1-8-1000+	--	Sun.	1 Av = Sat.
Iggeret of Sherira Gaon					
499 reg	1 Kislev = Fri.[103]	1-3-738+	--	Sun.	1 Kislev = Fri.
506	1 Adar = Thu.[104]	6-18-896+	MZ? lo U?	Fri.	1 Adar = Thu.
Justinian's reign					
531	??	3-17-773+	--	Tue.	15 Nisan = Mar. 18
539	??	1-6-440+	--	Sun.	15 Nisan = Mar. 20
542 i	Nisan 6, Adar I present[105]	1-21-621+	MZ lo B	Tue.	15 Nisan = Apr. 15
Resh Galuta's letter					
835 def i?	??	4-18-573+ 6-7-286+	MZ lo U	Thu. Sat.	1 Nisan = Mar. 4 1 Nisan = Apr. 3
836 ful	1 Nisan = Tue.[106]	3-10-81+	--	Tue.	1 Nisan = Mar. 21
837	??	1-0-958+	--	Sun.	1 Nisan = Mar. 11

Table 3. *Matching the original Nisan-based calendar against the available historical data: first, the Catania tombstone inscription of 383, Christian testimonies of 387, Ketubah of Antinoopolis of 417 (425); next, 18 dates from Zoar Aramaic tombstone*

95 Zoar #36 (Z88): 21 Tevet = Tue. (Stern 2001, 147).
96 Zoar #37 (S15=Z308): 6 Nisan = Thu. (Stern 2001, 147: year 468).
97 Zoar #40 (S16=Z306): 26 Ĥeshvan = Mon. (Nizan 2025, ibid.); (Stern 2001, 147: 10 Ĥeshvan = Mon.)
98 Zoar #42 (Z101): 11 Sivan = Wed. (Nizan 2025, ibid.).
99 Zoar #39 (Z312): 19 Sivan = Sun. (Nizan 2025, ibid); (Stern 2001, 147: year 471).
100 Zoar #45 (N3): 11 Elul = Tue. (Naveh 1985; Stern 2001, 147).
101 Zoar #48 (N31=Z304): 5 Av = Sun. (Nizan 2025, ibid.); (Misgav 2006: 5 Av = Thu.).
102 Zoar #47: 6 Av = Thu. (Nizan 2025, ibid.); (Meimaris 2016: 20 Elul = Thu.).
103 *Iggeret* of R. Sherira Gaon (Stern 2001, 184): 13 Kislev = Wed., 811 SE (499 CE).
104 *Iggeret* of R. Sherira Gaon (Stern 2001, 182): 4 Adar = Sun., 817 SE (506 CE).
105 Zoar #41 (Nizan 2025, Table 9).
106 Mann (1922, II, 41); Stern (2001, 282).

inscriptions; next, 2 dates from Iggeret of Sherira Gaon; next, 3 dates related to Justinian's reign; finally, 3 dates related to Resh Galuta's letter.

Here: 'def', 'reg', 'ful' = deficient (353 d.), regular (354 d.), full (355 d.) years, respectively. They are determined by comparing 1 Nisan in this and the following year and reflect on whether, as a result, Ĥeshvan and Kislev were 29 or 30 days. Their actual importance is only for the dates in Kislev and Tevet.

Indication whether the year was intercalary is skipped except when the historical date belongs to Shevat or Adar, as the matching calendar date was computed from the coming Nisan backward; the presence of Adar I in 415 was indicated with 'i'.

Asterisk * over 466 indicates that this year, year 8, unlike in the modern cycle, was non-intercalary.

The presence of the rule LO U PESAĤ in 425, 503 and 506 and the postponement ATRaD in 475 is questioned with '?'.

The uncertain historical dates in 383, 425, 531, 539, 835 and 837 are marked with '??'.

For Zoar inscriptions: label 'Z' stands for the classification by Politis; 'N' for Naveh; 'S' for Stern; # for the classification by Meimaris (2016) and Nizan (2025).

Corrigenda

N. 53: ‘3-10-82+’ should be ‘3-16-82+’

N. 54: ‘3-10-428+’ should be ‘3-16-428+’

Appendix 3:
Line for year 417: ‘417 i reg’ should be ‘417 reg’

Line for year 425: ‘425 i reg’ should be ‘425 reg’

Line for year 542: ‘1-21-621+’ should be ‘3-10-334+’; ‘MZ’ and ‘lo B’ should be removed.

Line for year 836: ‘3-10-81+’ should be ‘3-16-82+’