Maya Numerology

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One tends to think of the study of pure number as an esoteric pursuit. But for the ancient Maya, particularly when it came to temporal matters, numbers were more than mere devices to tally units of time. In stark contrast to the Western calendar, in the Maya realm of timekeeping the duration between ritual events seems to have mattered as much as the times when the events themselves occurred. Moreover, the manner in which the daykeepers of the Maya codices sequenced the intervals followed well-defined patterns, which reveal an array of motives for the Maya way of structuring time. Among these motives were the need to: a) arrive at or avoid particular lucky or unlucky days; b) accommodate changing seasonal or other astronomical events; and c) set up numerological mirror symmetries, a characteristic that resonates with the Pythagorean philosophy of number. Thus the long-neglected study of Maya number offers insight into the chronological structure underlying ritual process, which finds parallels in contemporary Maya culture.

The Maya ontology of number

When Galileo refuted the Pythagorean notion that the human mind partakes of divinity *because* it comprehends numbers, he was credited by historians with paving the way toward our contemporary scientific understanding of nature. Wrote Galileo,

> I feel no compulsion to grant that the number three is a perfect number, nor that it has a faculty of conferring perfection upon its possessors …; neither do I conceive the number four to be any imperfection in the elements, nor that they would be more perfect if they were three; … it would have been *better* for him to prove his point by rigorous demonstrations such as are suitable to make in the demonstrative sciences; …these *mysteries* which caused Pythagoras and his sect to have such veneration for the science of numbers are the follies that abound in the sayings and writings of the vulgar. (Drake 1967, 11) (author's italics)

One of the central problems in ethnoscience and ethnomathematics lies in our attraction to concepts and ideas that resemble our own (cf. e.g. Ascher 2002, 1–4). We tend to seek the roots of our way of knowing not only in the history of our own culture, but also in that of the Other. We do this at the expense of paying too little attention to indigenous concepts that deal with quantitative knowledge of the natural world, largely because we do not tend to regard such knowledge as being related to science, a hallmark of Western culture. The study of ancient Maya documents offers an ideal example of this neglect. Our attraction to them is motivated in some measure by the passion Maya chronologists seem to have exhibited for precise, predictive astronomy and the detailed mathematical calculation that accompanied it. We search out aspects of our own approach to such enterprises in their past not only as a way of attempting to identify cultural universals but also, perhaps, to bolster the validity of the Western, rational outlook on nature which, in some measure, the Maya seem to have shared with us. This may be why close to half of what has been written on the some 300 so-called almanacs in the surviving Maya codices has focused largely on two of them: the Eclipse Table and the Venus Table, both in the Dresden Codex.

The extant scholarship concerning these predictive instruments deals with how they operate and especially on how Maya astronomers managed to arrive at the minuscule corrections necessary to link canonic to observed celestial events. Scholars have given particular attention to the determination of entry dates into various almanacs and the kinds of empiri-

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cal data upon which they might have been based (for an updated bibliography see Bricker & Bricker 2011).

Thanks in part to Galileo having helped condition those of us who focus on the history of Western science and ethnoscience, scholars have paid little attention to what we would term metaphysical principles that might have played a role in structuring the various instruments that make up the codices. Like the eminent dean of twentieth-century historians of science, George Sarton, who once labelled astrology 'so much superstitious flotsam of the Near East, and consequently not worthy of our attention' (for a full discussion, see Neugebauer 1983, 3), most researchers might be led to think the pursuit of such matters a waste of time.

I hypothesize that the Maya partook of the divinatory procedures implied in the texts of the codices in part because of the way they understood numbers. I shall test this idea by seeking a numerically based metastructure in Maya temporal tabulations, for it is almost exclusively in the realm of time that the Maya made use of number in these documents.[1] But lack of scholarly attention is not the only reason for opening the case, for if considerations of pure number entered into the way Maya scribes and daykeepers structured the codices, then those of us who study the Maya ought to know about it. Such an investigation could shed light on the divinatory procedures linked to Maya timekeeping of which it was a part, just as astrology is both a part of Western religion and science (cf. e.g. Campion 2009). While I cannot lay claim to having discovered the fundamental principles of Maya numerology, here I argue that a number of case studies offer strong support for my hypothesis.

Numerology, or the metaphysical use of number, in the Western perspective derives from *gematria*, the art of number magic. Examples include the Hebrew tradition in which one assigns a numerical value to each letter by virtue of its place in the alphabet. The sum of the values of the letters of a word make up its total number value. This form of numerology was employed in medieval times to interpret passages from the Talmud (Chrisomalis 2010, 159; Ifrah 1998, 250–56). Another form of number magic, largely derived from the Hindu tradition, attached numerical value to a set of words that yielded a relevant date (Chrisomalis 2010, 210). Thus, the non-practical use of number, often motivated by a need for secrecy, exhibits cross-cultural precedents.

That numbers were held in high esteem by the Maya can be gleaned from the various media, such as monumental inscriptions, ceramics and codices, through which they are presented and the vast quantity of inscriptional space devoted to them. Among the most revealing examples are the carved stone stelae that display head-variant and full-figure glyphs of the various numbers. Of the monumental images that reflect the Maya way of understanding time and number, few are more starkly revealing than Stela D of Copán (Fig. 1).

Standing erect in front of a stairway at the north end of a three-hundred-metre long plaza occupied by a dozen similar monuments, this larger than human-size monolith is dedicated to rituals conducted at the juncture of a series of seminal Maya time cycles. Eight squared-off images carved in high relief confront the eye at the top of the monument. Each depicts a humanoid figure that appears to be engaged in some sort of wrestling match with an animal — a bird in frames 1 and 2, a toad in 4, a long-snouted creature in 3, a simian-faced humanoid in 5, an amorphous mass (probably the pelt of a jaguar) in 7, and so on. A closer look reveals that the action is more akin to carrying. Each figure seems to be acting as a porter pictured in the act of transporting his burden. The men in frames 1 and 7 employ tump lines, common devices used by Maya peasants today for carrying a load of wood or a sack of citrus by tying their packs to a band that presses tightly about the forehead, thus leaving the arms to swing free and perform other tasks. The porter in frame 3, lying prone, cradles his conveyance in his left arm, bearing most of the weight on the left shoulder. The youthful carrier in frame 5 grips his load by its ultra-long left limb, while the old man in 2 almost seems to be making love to his avian cargo.

These porters represent numbers and the burdens they bear are packets of time. Thus, number nine (frame 1) is distinguished by the markings on that god's youthful chin. He wears a jaguar claw for an earplug. His freight is the heavy load of *baktuns* of time, 144,000-day periods consisting of 20 × 20 × 360 days.[2] As in our number-word system, teens imitate their cardinals. Thus, the god of number 15, shown in frame 2, resembles its cardinal 5, which appears in frame 3, with the exception that the former's jaw is bone, i.e. unfleshed. Both wear a button-cap year sign in their turbans and each sports a single tooth. Number fifteen hauls *katuns* (scores of 360-day periods) while tuns or 360-day years are the burden of the number five. The pair of zero deities in frames 4 and 5, recognizable by the hand held over the jaw, likely derived from a gesture denoting 'completion' that preceded writing, tote uinals or 20-day months (*uinals*) and days (*k'in*), respectively.

Fully translated, the introductory portion of Stela D reads: 'It was after the completion of nine baktuns, fifteen katuns, five tuns, zero uinals and zero kin, reckoned since the first day of the current era, that (...).'

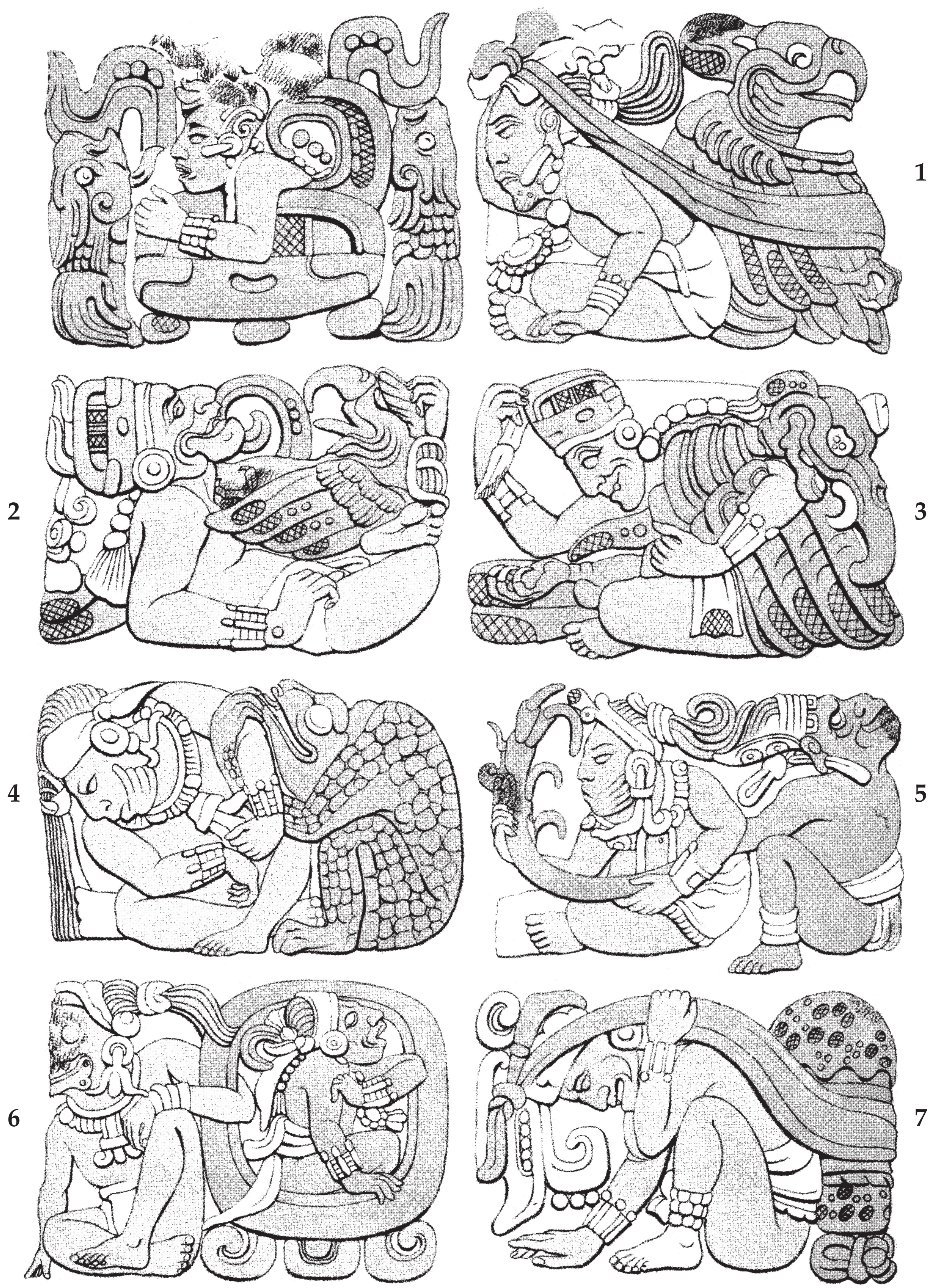

Figure 1. *Number gods adorn a Maya monument (Stela D, Copán). Each anthropomorphic figure (the left half of each compound hieroglyph) represents one of the twenty numerals, thus: 1) nine; 2) fifteen; 3) five; 4) and 5) zero. (Maudslay 1889–1902, I, pl. 48)*

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(author's translation). This interval — written 9.15.5.0.0 by epigraphers, which works out to 1,405,800 days, or approximately 3849 of our seasonal years since the zero point in the Maya Long Count calendar (akin to a day in our Julian Day calendar)[3] — is thought to have been borne across eternity as if in a relay race by deified numbers who serve as the great bearers of vigesimally-based packets of time. One can think of Stela D, then, as the resting place of these animated numbers at the end of their long journey. Here the number gods finally lay down their burden. But only some of them can rest, for there are other burdens of time that need to be borne. Thus, while number five will be replaced by six in the next cycle, number fifteen must persist for five more rounds of katuns and number nine for four more rounds of baktuns before the odometre of time releases them from their awesome duty.

We apprehend two additional seminal qualities about the meaning of time from the dynastic histories that comprise these number-laden time capsules wrought in stone. First, one has the sense that while the arrow of time points toward the future, it is very much pushed from behind rather than being tugged forward. The Maya preoccupation with intervals in calendric notation, a major focus of this study, incorporates the notion that the beginning of a cycle is as important as the end. These points in time are noted precisely and they are connected. These Maya attributes of time stand in stark contrast to the teleological or purposive forward pull of time embedded in the Judeo-Christian tradition. For the Maya, circumstances in the past, even before the beginning of the present era, had set the number gods on their journey. Second, it was those events, enacted in the realm of the ancestor gods, that would direct the future course of human history, the creation of the lineage and the journey of the founders of modern Maya culture to the proper places to build their cities.

The backward focus of Maya time thus emanates from a desire to link events of primordial with historical time in an effort to aggrandize the actions of the rulers by likening them to their ancestors; thus the journey of the Maya people parallels in space the long arduous track along the road of time undertaken by the number gods who bear their weighty freight. The *Popul Vuh*, the sacred book of creation of the Quiché Maya, states that the ancient word is the potential and the source for all that is done in the present world. '*How should it be sown, how should it dawn?*' (D. Tedlock 1985, 73), the gods ask themselves as they contemplate the creative act. Events that took place in the temporal realm of our creators, our founders, our so-called mother-fathers, are responsible for setting time on its course toward the present.

Post-conquest documents attest to the pre-Columbian concept of time travel writ large on Stela D. For example, Thompson (1950, 60) cites several examples of the idea of the year as a road travelled, and the so-called katun prophecies from post-conquest texts repeatedly refer to time as a burden: '*This is the removal of his burden ... fire is his burden ... (In reference to the fifth katun ...*'; the burden is attached to its bearer: '*On the day of the binding of the burden of Lord 5 Ahau ...* . Writes one chronicler: '*According to what [the Indians] say [these four first days] are those which take the road and bear the load of the month, changing in time.*' Time appears to be conceived as some sort of essence carried along an eternal cyclic roadway, finally seated or brought to rest at various stopping points: '*Heaven Born Merida was the seat of the katun (3 Ahau)*' (Edmonson 1982, 113); '*This katun, which is 5 Muluc, the time of his taking his road ...*' (Edmonson 1982, 78).

In the codices the Maya road of time is sometimes portrayed as a series of footsteps. For example, on pages 75 and 76 of the Madrid Codex (M.75–6) the toes of the feet point inward toward the centre of a quadripartite cosmogram as they parallel the count of 20 groups of 13, the *tzolkin* or 'sacred round' of 260 days, that circumscribes the figure (Fig. 2)[4] (hereinafter D and M will represent, respectively, the Dresden and Madrid codices).

We know that the contemporary Poptí Maya have long conceived of the measurement of time as a pacing-off of duration 'in feet' (cf. Milbrath 1999, 60, 71). The basic subdivision of their year is 40 days, which they call 'one foot of the year' and which they term *yoc habil*, or *oc*, meaning 'foot, footprint, or track' in the Poptí Mayan language. In *The Book of Chilam Balam of Chumayel* (Roys 1967, 116–17), we learn of the creation of the *uinal* by the first priest:

> 'What shall we say when we see man on the road?' These were the words as they marched along, when there was no man <as yet>. Then they arrived there in the east and began to speak. 'Who has passed here? Here are footprints. Measure it off with your foot.' So spoke the mistress of the world. Then he measured the footstep of our Lord, God, the Father. This was the reason it was called counting off the whole earth, *lahca* (12) Oc. This was the count, after it had been created by <the day> 13 Oc, after his feet were joined evenly, after they had departed there in the east.

Other pages of the codices further underline the Maya fascination with number; for example, M.8 (Fig. 3) depicts piles of dots and bars in an arboreal arrangement borne on the back of a deity. These so-called 'number trees' also appear in the carved inscriptions, for example, among the basement sculptures that line the east side of the courtyard of the Palace Group at

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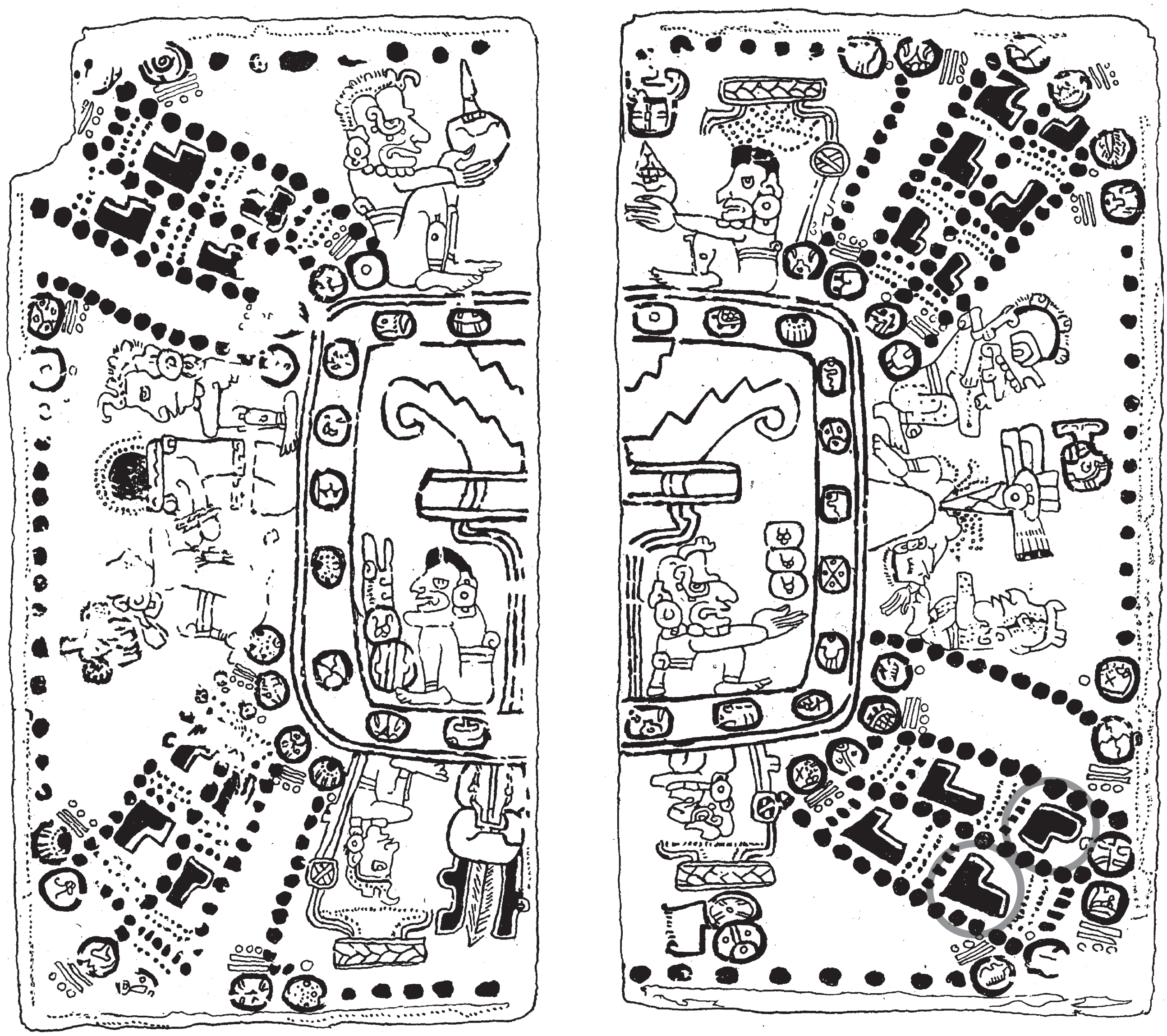

Figure 2. *M.75–6, one of several examples of footprints (circled) representing the passage of time in the codices. (Villacorta and Villacorta 1976). Unless otherwise noted all other figures are derived from this source.*

Palenque. Also, painted Maya ceramics lacking provenience but generally attributed to the Precolumbian Maya, depict scribes gleefully playing with numbers on devices resembling abaci, and writing down dots (ones) and bars (fives) in their codices.

Maya interest in very large numbers is evident in both the codices and the monumental inscriptions. Thus, on D.69, long notations known as the Serpent Numbers (Fig. 4), because the body of a serpent appears to be intertwined about them, translate to millions of years. The inscription on Coba Stela 1 (Fig. 5) begins with a series of nineteen places of thirteen multiples of twenty before it enters the five-place Long Count cycle, which itself exceeds five millennia. The resulting number exceeds the passage of time since our modern Big Bang version of the creation of the universe, 13.7 billion years ago. Possible reasons for writing such long numbers are wanting.

Spurred by a taste for commensuration, the Maya also expressed a penchant for contriving numbers. I define the Maya 'principle of commensuration' as the formulation of long cyclic intervals made up of whole multiples of smaller ones, or, alternatively, the latter via remainderless division into the former. The most celebrated example of a contrived large number obeying this principle is Lounsbury's (1978, 786–7) so-called 'long reckoning'[5] 'super number' of the Maya codices, 9.9.16.0.0, on the introductory page to the

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Figure 3. *M.8, a mountain or tree of numbers is carried on the back of a hunched-over deity.*

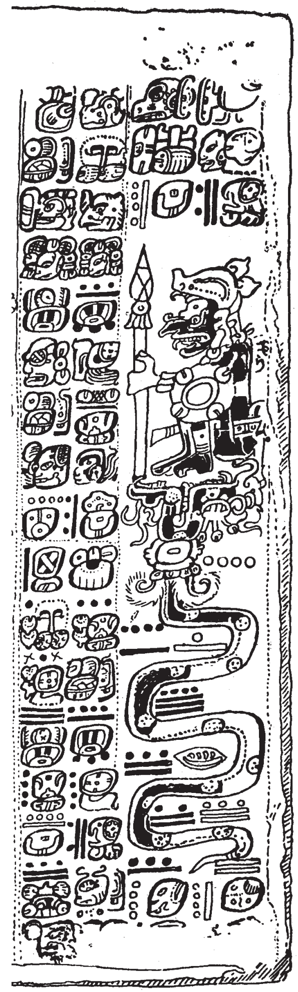

Figure 4. *Ultra-long serpent numbers on D.69 exceed the customary five place Long Count.*

Figure 5. *Coba Stela 1 exhibits a vast number 17 orders above the baktun count. (FAMSI)*

Venus Table, which appears on D.24. This remarkable number turns out to be a whole multiple of a host of important astronomical and ritual time cycles; thus

9.9.16.0.0 1 Ahau 18 Kayab	= 5256 × 260	(*tzolkin*, or 13 × 20 day sacred round)
	= 3744 × 365	(*haab*, or 365-day year)
	= 584 × 2340	(the commensuration of the *tzolkin*, and the number of Lords of the night (9), and possibly the period of Mercury (117 days).
	= 468 × 2920	(five Venus periods)
	= 72 × 18,980	(the calendar round)
	= 36 × 37,960	(the length of the Venus Table in the Dresden Codex (D.24, 46–50))

Note further that

2340 = 9 × 260 = 20 × 117
2920 = 5 × 584
18,980 = 52 × 365 = 73 × 260
37,960 = 65 × 584 = 5 × 13 × 584

(For further details on Maya numerology pertaining to astronomy, see Carlson (1979).)

Often interpreted erroneously to mark a heliacal rising (first pre-dawn appearance) of Venus, the Long Count number 9.9.9.16.0, derived from the long-reckoning interval, is the closest date (by 16 days) that precedes a heliacal rise that also allows for commensuration between the long reckoning number and the aforementioned cycles.[6] The commensuration principle is important when it comes to the interpretation of numbers in the codices, for it emphasizes the constraints that numerical manipulation places upon empirical

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astronomy in Maya calendrics. In a spatial context, this sort of mental outlook can be likened to Aristarchus' geometrical proof of the relative distances of the sun and moon from the earth, wherein the fourth-century BC Greek mathematician and philosopher distorts empirical astronomical data for the sake of creating a geometrically elegant diagram of the solar system (see Aveni 1993, 56–7 for details). Given the tension between the demands of nature and those of number, which will constitute a central theme in the forthcoming sections of this article, one can begin to appreciate the vast amount of skilled mental labour that must have gone into the serious business of Maya time reckoning.

Dates and intervals in the codices

If numbers are the floorboards, then duration is surely the support beam in the framework of the Maya house of time. Dates are reached by intervallic reckoning via so-called 'distance numbers' (DN); for example, in the monumental inscriptions, a portion of the text on the Tablet of the Cross at Palenque reads; 'It was 3 days, 10 uinals, and 13 tuns (since) (Akul-Ah Nab I) was seated' (on) 5 Ahau 3 Tzec…; and later '…(it was) 7 uinals and 5 tuns, 1 katun after K'an Hok Chitam was seated on (date)…'. (Mathews 1991, 152). This is part of a lengthy lineage statement which traces the royal ancestry of the individual who built the temple that houses the inscription. Each phrase is based on a forward movement of time beginning with an event located at the start of the text, to which DNs are added to arrive at later events. The first half of each statement gives the interval in the vigesimally ordered Long Count system (cf. note 2), while the second half states the point in time, or the date, reckoned in a 18,980-day cycle (which commensurates the 260- and 365-day cycles); e.g. 5 Ahau 3 Tzec, from which the next event in the sequence is to be reckoned. This chain-link method of keeping track of events is shared by chronologies of other world cultures, for example in Sumerian time reckoning (see the discussion in Aveni *et al.* 1995; hereinafter AMP I)

In the codices the conventional term 'almanac' has been employed to describe each of the temporal instruments that comprise the pages of these folded-screen, painted-bark documents.[7] Almanacs in our culture are thought of as compilations of useful information, most of it adapted to local space-time. One usually finds a calendar for each month that gives all the holidays one might ever care to know about; there is also astronomical information, such as times of sunrise/sunset, moon-phase tables, and eclipses for the current year, coupled with meteorological information and the schedule of tides for major local harbours. Data concerning weather predictions and positions of the planetary bodies in the signs of the zodiac are also given. Add to all of this, information on season-based food recipes and proverbs and the 'farmer's almanac', updated and altered slightly from year to year, becomes a handy folk/scientific compendium that amuses and instructs us in practical matters and even advises us on personal behaviour.

Maya almanacs also incorporated many of these aspects. An eminent Mayanist of the last generation described the content of the almanacs in the Maya codices as both invocations and divinations that deal with the weather, agriculture, drilling with sticks, disease and medicine, in addition to the fates and ceremonies. Their purpose, in relation to the *tzolkin*, was '… to bring all celestial and human activities into relationship with the sacred almanac by multiplying the span they were interested in until that figure was a multiple of 260' (Thompson 1972, 27). As in the monumental inscriptions, the rhyme and metre are parsed out in durational sequences, with one important distinction: while in the monumental inscriptions the DN represents a means of reaching a specific historical date based in the Long Count, intervals in the codices take on the added role of representing a time span within which events might be anticipated. Such an arrangement accommodates not only phenomena in historical time, such as an eclipse or the scheduling of a rain-bringing ritual, but also a kind of numerological patterning that seems to have fascinated the Maya and with which we will deal with below.[8] This format for representing time stands in stark contrast to our calendar, wherein dates rather than intervals between dates receive emphasis (just look at any wall, desk or computer calendar).[9]

For the benefit of readers less acquainted with the codices, a brief descent into detail concerning how almanacs are structured and how they operate will be necessary before proceeding. Consider the simple almanac that appears on 17c–18c of the Dresden Codex (Fig. 6). This is a 5 × 52-day almanac, each 52-day cycle of which begins on one of the numbered and named *tzolkin* entry and reentry points into the almanac, which are listed in the vertical column at the left. Moving horizontally to the right one can read the DN intervals between the temporal stops or stations in the almanac. These are written in bar (five)-dot (one) notation in black, one to each station or resting point, usually indicated by a picture compartment; thus, 15 (three bars), 33 (written *kal* (20) + 13 (two bars, three dots)), and 4 (four dots). The intervals sum to 52, which reckons the number of days contained in a single row of the almanac. Five such runs, or cycles,

Figure 6. *D.17c–18c, a simple almanac depicting the arrangements of dates (white dot and bar numerals) and intervals in between (black).*

constitute the full 260-day round, after which the last interval in the last line returns the user to the beginning. The coefficients of the 20 *tzolkin* day names, which can range from 1 to 13 for each station in the figures are given in red (6, 13 and 4; these appear as white in the black and white renditions herein). The arrangement of dates and intervals in various almanacs varies considerably. In the present example one proceeds horizontally from left to right, with one red number assigned per station, along with one black interval between them.

Read as a cycle of time, the D.17c–18c almanac begins with the *tzolkin* entry date into the almanac, 4 Ahau, Ahau being the uppermost of the five (out of twenty possible) day names that appear in the vertical column at the extreme left. The omen or rite depicted in each of the stations resembles the imagery on Stela D of Copán. Each station shows a woman carrying some sort of burden on her back; for example in the first station, beginning on 4 Ahau, she carries a death god. To arrive at the second station (6 Men) the user is instructed to add 15 days to 4 Ahau. Then one adds 33 days to get to the third station (13 Lamat); then 4 days to 4 Eb, which begins a second 52-day run through the three stations. As usual, the Men and Lamat signs are not recorded, though they are clearly implied if one follows the ordered sequence of twenty named days.

At this point one proceeds to reuse all of the black intervals, beginning the second passage with 4 Eb (the re-entry date that commences the second cycle) + 15 = 6 (Manik) + 33 = 13 (Ahau) +4 = 4 (Kan); etc.; the second cycle of 52 days, which leads to 4 Kan, thus the third re-entry point. Continuing likewise through the third, fourth and fifth lines of the table, one uses up all five entry dates, having arrived at each of the pictured events five times, finally recycling back to 4 Ahau, where the 5 × 52 = 260-day count had originally commenced. With few variations, the almanacs in the codices operate cyclically as explained above for Dresden 17c–18c. Every one of them could well have been designed to function endlessly and without change.[10]

The glyphs, usually four in number, that appear above the pictures offer clues regarding the meaning of each of the dated stations. Their reading order and general character will not be dealt with here for want of space, except to remark that generally three of them usually give verb, object and subject relating to the picture, while the fourth usually concerns omens and appropriate offerings on the dated occasion. In the present example, however, the verbs are absent. Thus, D.17c, first station: 'death is the burden of the moon goddess — bad winds' (Schele & Grube 1997), or 'dead person' (Vail & Hernandez 2005). Though most almanacs, like D.17c–18c, are linear in structure, with black and red numbers arranged across the page reading from left to right, there are also cross-over almanacs in which the intervallic sequence crosses back and forth between paired pictorials (cf. e.g. D.9c: Fig. 7), or where it directs the flow of time about an image, the numbers appearing in close proximity to particular portions of it (e.g. M.30b (Fig. 8), and the

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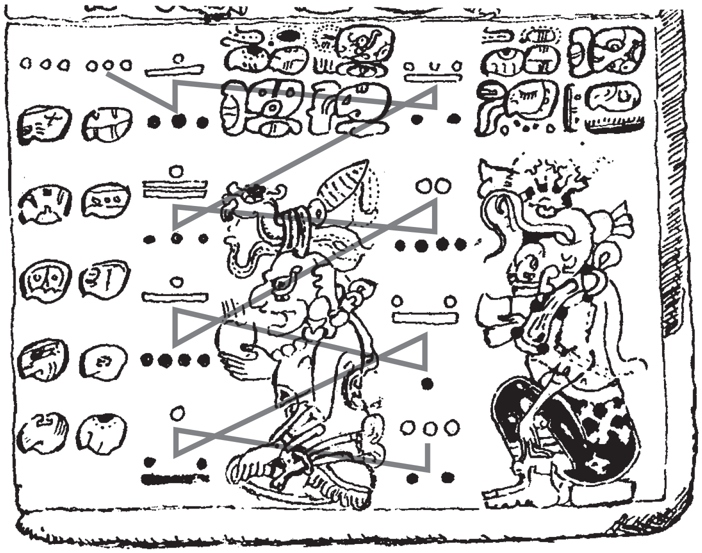

Figure 7. *Unusually structured almanac (D.9c) in which time's numbers follow a cross-over, or zig-zag pattern.*

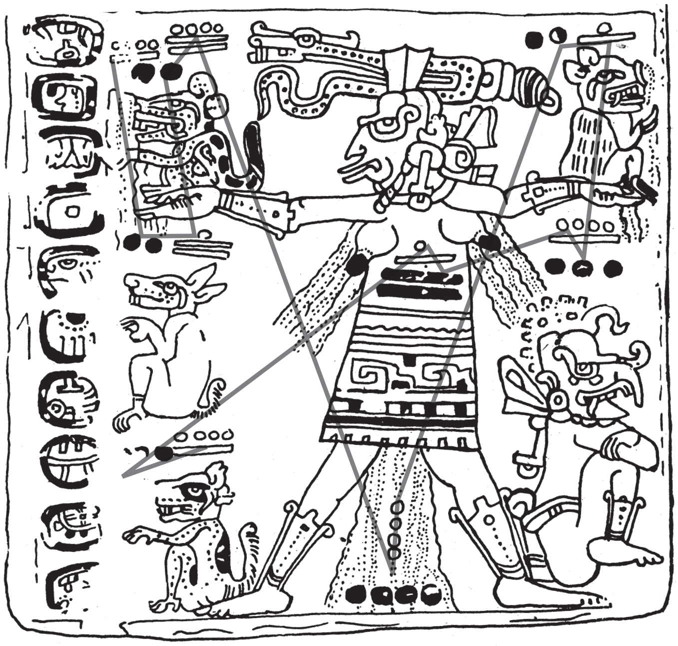

Figure 8. *Unusually structured almanac (M.30b) in which time's numbers move about an image.*

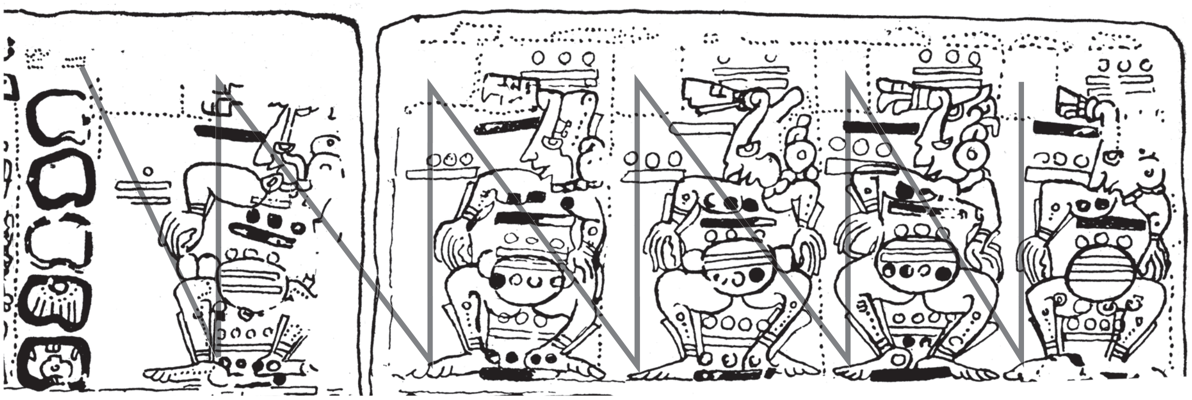

Figure 9. *Unusually structured almanac (M.27a–28a) in which time's numbers pursue a linear course with an embedded vertical structure.*

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Deer-trapping almanacs to be discussed below). In some examples different types of patterning are combined; thus in M.27a–28a (Fig. 9) the number sequence runs upward along the body of each deity occupying a given station before passing linearly on to the next one (see added lines in these figures).

A brief survey of the types of almanacs that make up the Dresden and Madrid Codices is given in Table 1.[11] The table offers a census of different numerical subdivisions of almanacs, the percentage of the total of each kind being given in parentheses. Note the central role of the number 260.

Table 1. *Distribution of almanac types in the codices.*

Length (days)	Dresden	Madrid
10 × 26 = 260	7 (9%)	43 (19%)
5 × 52 = 260	43 (57%)	130 (58%)
4 × 65 ('burner') = 260	14 (19%)	48 (21%)
All Other	(15%)	(2%)
1 × 260	2	1
2 × 260	1	1
3 × 260	1	1
4 × 260	1	0
7 × 260	2	1
9 × 260	1	0
4 × 13 × 65 = 73 × 260	0	1
4 × 91 = 364 (non-260)	1	0
7 × 13 = 91 (non-260)	1	0
54 × 13 = 702 (non-260)	1	0
Total	**75**	**226**

It should be noted that while the Madrid Codex, the lengthier of the two documents, contains a greater number of almanacs, the Dresden exhibits both a greater variety and a larger number of almanacs made up of multiples of 260 days. Moreover, the Dresden Codex also contains the well-known Venus, Mars and Lunar Tables as well as instruments that reckon the seasonal year. However, recent studies reveal that the Madrid is not devoid of information on seasonal and astronomical matters (for details, see Vail & Aveni (2004) and Bricker & Bricker (2011)).

Intervallic patterning

In practically all of the 301 almanacs that make up the two codices, the intervals (black numbers) employed to reach successive dates (red numbers) that mark the stations exhibit at least three basic types of patterned structure related to the manner in which they are arranged to sum to 26, 52 and 65, the number of days that make up one run through most of the tables.[12] These are:

A. Equal intervals of 13 (or 26)

Table 2. *Distribution of almanacs containing equal intervals of 13.*

Length (days)	Dresden	Madrid
2 × 13 = 26	0	1
4 × 13 = 52	5	23
5 × 13 = 65	1	10
2 × 26 = 52	2	8
Total	**8 (13%)**	**42 (19%)**

B. Nearly equal intervals, the last in the intervallic sequence usually being the deviant number

Nineteen such examples (30 per cent of total) appear in the Dresden, 47 (21 per cent) in the Madrid. Herewith a few representative examples:

8-8-8-8-8-8-17 = 65	(D.42c–45c)
10-10-10-10-3-9 = 52	(D.40c–41c)
10-10-10-10-12 = 52	(M.7a, 49c–50c)
6-6-6-6-6-6-6-(4)-6 = 52	(M.98b–99b)
16-16-16-18 = 65	(M.20d–21d)
12-14 = 26	(D.15c)
2-4-3-2-4-2-2-4-2-2-2-4-2-3-2-3-2-3-2-2 = 52	(D.4a–10a)

For further examples of nearly equal intervallic sequences, see AMP I (1995).[13]

C. Alternating intervals that often sum to 20 or 13 (5 per cent in the Dresden; 9 per cent in the Madrid)

Examples include:

12-8-12-8-12 = 52	(D.10a–12a)
6-7-6-7-6-7-6-7 = 52	(M.19a, 53c)
15(11)-15-(11) = 52	(M.108c–109c)
9-4-8-5-9-4-8-5-9-4-8-5-9-4-8-5-9-4-8-5 = 130	(M.73a–74a)
20-19-20-19-20-19-20-19	(M.26c–27c)

Cross-over almanacs, in which the intervallic positions alternate left-right or up-down etc., often display this characteristic.

Interestingly, each of the three categories of intervallic sequences (A, B and C) also appears in the Borgia group of codices from central Mexico, wherein numerical place-holders often replace stations. For example, in addition to several almanacs consisting of multiples of 13 (e.g. 4 × 13, Borgia, or B.22), the nearly equal interval category is reflected in the 7-7-7-7-7-7-5-5 intervallic sequence on B.18–28 and the 8-8-8-8-1-19 sequence in B.57. B.75, which exhibits a 7-6-7-6-7-6-7-6 sequence, offers an example of an almanac with alternating intervals containing sub-intervals that add to 13. Since recent scholarship has established other structural connections between the Maya and central Mexican codices (cf. Vail & Aveni 2004), this should come as no surprise.

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Because details of each of the three categories in the taxonomy of intervallic sequencing mentioned above may yield clues regarding the motives of the daykeeper/scribes to produce such patterns in the almanacs, it becomes important to discuss each category in detail.

One motive for creating *equal intervals* in almanacs is easy to account for. In most of the 4 × 13 cases, the iconography and glyphic text seem to be couched in the framework of the quadripartition of time common in Mesoamerican thought (for examples see Aveni 2001, fig 60, and Fig. 2 this article). Groups of days are doled out equally to each of the four sides of the world (north (up), south (down), east and west). From a calendrical standpoint, if one wished to subdivide equally the most significant period in all of Maya timekeeping, 260, into portions assigned to the principal regions of space, the number 13 would loom as a very prominent interval; that it appears so frequently in the almanacs, therefore, is not unanticipated. A similar rationale can be applied to the 5 × 13-day almanacs, wherein the *centre* is often added as a fifth section of space. Moreover, a black 13 guarantees an endless return to the same coefficient in the *tzolkin* count; thus *1* Ahau +13 = *1* Ben + 13 = *1* Cimi +… . Celebrating rites at constant regular intervals is a common trait in many world religions. Examples of the periodic reenactment of sacred rites practised in our own culture might include attending church on Sunday or synagogue on the Sabbath. Like the 13 that appears as the common factor in each of the aforementioned Maya time divisions, the 7-day cycle punctuates the Western schedule of religious worship.

The equipartition scheme also makes use of each of the 20-day names only once, prior to recycling. The day order regresses by one unit every three positions; thus 1,14,7,20,13,6,19,12,5,18,11,4,17,10,3,16,9,2,15,8,- - - - - , wherein numbers stand for day-name positions.

Related to the almanacs composed of equal numbers of 13 are a fairly large number of cases (55 in the Madrid and 19 in the Dresden) in which sub-intervals can be summed sequentially to make 13. To cite a few simple examples (cf. AMP I for others):

5-8-5-8-5-8-5-8-5-8	(M.110b and elsewhere)
9-4-8-5-9-4-8-5-9-4-8-5-9-4-8-5	(M.27a–28a and elsewhere)
6-7-6-7-6-7-6-7	(M.19a and elsewhere)

Each example returns the user to the same coefficient every *other* interval. Thus, the 9-4-8-5 sequence entering on 13 Chuen (day number 11), modulo 13: 13,9,13,8,13,9,13,8,13,9,13,8…, yields three coefficients, 8, 9 and 13 in an a,b,a,c,a…rhythm. On the other hand there appears to be no pattern in the sequence of day names generated by intervallic sequences, e.g. same example, modulo 20: 20,4,12,17,6,10,18,3,12,16,4,9,18,2,10,15,4,8,16,1,…. . But such a sequence does have the effect of generating repeating day names every *other* 20-day cycle. Thus, if a scribe who utilized 13-day sequences wished a day name to repeat in the *next* 20-day cycle, one way to achieve that end would be to split the interval 13 into a 7-6-7-6- - - - sequence. This is because 7 + 6 + 7 = 20. An 8-5-8-5- - - - split would repeat a day name every *third* 20-day sequence, because 8 + 5 + 8 + 5 + 8 + 5 + 8 + 5 + 8 = 60. Likewise, a 9-4 split yields a repeated day name every fifth, a 10-3 split every seventh, an 11-2 split every ninth, and a 12-1 split every eleventh multiple of twenty. That such a motive of frequent repeatability of day name may have played an influence in intervallic sequencing is supported by the fact that the 7-6 and 8-5 subdivisions of 13 are by far the most common in the codices (cf. AMP I (1995), table 2). Another way to achieve repetition of a day name every *other* 20-day cycle would be to seek a subset that added to 40 days. The 9-4-8-5 sequence offers a way to accomplish this task because 5 + 9 + 4 + 8 +5 + 9 = 40. (Alternatives would be 12-1-12-1 and 8-5-7-6; however these are not found in the codices.) In sum, there are only a few options for a split 13-sequence via sinusoidal repetition to accommodate repeated day names every other cycle.[14]

More complex examples in which longer sequences of sub-intervals add to 13 include:

4-9-4-5-4	(M.83a–84a)
3-2-2-6-2-2-2-7	(D.42–44a)
1-3-4-2-3-11-2	(M.45b)
1-2-5-3-2-11-2	(M.49c)
8-5-4-3-6	(M.79a)
6-4-3-5-8	(M 87a)
7-3-3-13	(D.13c–14c)
1-2-6-4-4-9	(M.46c)

Finally, and at a still more complex level, subsums of 13, or whole multiples thereof, can be arrived at by (a) commencing the tally at a different point (•) in the intervallic sequence, (b) slightly rearranging the sequence, or (c) slightly altering the value of one or more of the intervals; thus

12•7-6-21-6	(D.41b–43b)
9•3-10-2-2	(M.26d–27d)
9•3-10-2-2	(M.26d–27d)
3•13-10	(M.96a)
1-2-2-5-2-4•10	(M.46b)
4-4•6-4-3-3-4-5-4-3-3-3-6 (this resolves to 13-12-13-14)	(M.39c)
7-7•7-6-(8)-5-5-7 (this resolves to 13-13-12-14)	(M.99b–100b)
8-5-9-3-10-3-11-3-8-5	(M.103a)
13-5-8-12-14	(M.82a–83a)

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There are far too many examples of these subtle intervallic permutations and combinations to attribute them to pure coincidence. More likely the daykeeper deliberately altered sequences to arrive at such patterns. In practically all of the aforementioned cases there appears to be no obvious relationship between intervallic structure and either type or content of the almanac (The Deer-trapping almanacs and the Bee-keeping almanacs, to be dealt with below, constitute an exception.) For example, the almost identical sequences (in reverse) in M.79a (8-5-4-3-6) and M.87a (6-4-3-5-8) refer in the former case to a circular almanac consisting of a scorpion deity, while the latter is a linear almanac illustrating episodes of blinding and capture (however, these almanacs do share an Ahau entry date).

Two of the most interesting instruments in the category of nearly equal intervals are D.43b–45b (The Mars Table) and D.51–58 (The Lunar Eclipse Table), both of which have been accorded the status of 'table' to suggest that they are ephemerides designed to reckon specific astronomical events, rather than simply mechanisms for delineating repeatable time cycles, which traditionally has been regarded as the function of an almanac, such as the so-called Moon Goddess Almanac in D.17c–18c discussed above (Thompson 1972). The Brickers' (1992; 2011) studies of astronomy in the codices, however, ask us to rethink the extant definitions of 'table' and 'almanac'. They have demonstrated that many of the so-called almanacs depict seasonal and other astronomical events in real or historical time. The Brickers distinguish between almanacs and tables via the following criteria: almanacs have briefer prefaces or none at all. They consist of one or more columns of day signs and their coefficients cannot be tied directly to an initial series date. It is the presence or absence of dates that can be related unambiguously to the zero point date in the Long Count that distinguishes tables from almanacs.[15] For M.43b–45b and D.51–58, respectively, the intervallic sequences are 19-19-19-21 and 177-177-177-148 - - -, both of which belong to our category B (nearly equal intervals). One pass through the Mars Table tallies one tenth of the Mars synodic period of 780 days, but it is not clear, based on astronomical principles, why the period of 78 (= 19 + 19 + 19 + 21) days should be so subdivided.

The Lunar Table, which served as an eclipse warning table (Bricker & Bricker 1983), separates eclipse stations by intervals consisting of multiples of six lunar synodic months (177 days) followed by a single interval of five lunar months (148 days), then a picture; however, real eclipses do not regularly follow such a pattern. Thus, if an astronomical function for these instruments is accepted, one must allow for the possibility that numerological dictates also may have played a role in constructing them. The same conclusion holds with the layout of D.65b–72b, 73b, the so-called seasonal table, to be discussed below.

One motive for the creation of *nearly equal interval* almanacs could have derived from the inability to equally partition time into units of a prescribed magnitude. For example, 65 cannot be divided into two equal parts; this might account for why the intervals in the almanac on D.9b display near-equal 33 and 32-day intervals. The most nearly equal way of splitting 65 into four parts would be via the intervallic set 16, 16, 16, 17. This could have been the scribe's intention in the almanac on D.29c–30c, as well as that on M.20d–21d. However, this strategy does not readily account for why a calendrical scribe would choose to divide intervals that can easily be equipartitioned, such as 52 days, into unequal periods of 27 and 25, as was done on D.12a. There are occasions in our Western calendar when the simultaneous occurrence of a pair of religious observations results in shifting one of the rites to an adjacent date. For example, when Christmas falls on a Sunday one celebrates it from a civic standpoint the next day, a Monday. This also responds to the contemporary desire to lengthen sacred time (the weekend). Boxing Day in Great Britain and Presidents' Day and Memorial Day in the U.S. offer additional examples of such celebratory postponement. But the 20-number chain of 3±1 that spans six pages of the D.4a–10.a, along with the seven-interval runs 8,7,7,7,7,8,8 and 7,7,7,9,7,8,7 (each totalling 52) that appear in M.23b and M.83c, respectively, are more difficult to explain. Could the problem have consisted of an attempt to divide a 52-unit almanac into seven more or less equal increments?

A host of other bipartite almanacs are made up of very unequal divisions (e.g. 34 and 18, 21 and 31, 10 and 16). Might it be that evenness or oddness of the intervals or avoidance/preference of particular day names played a role in setting up these patterns? If we think carefully, there are examples where a kind of interval-averaging process occurs in timekeeping systems with which we are already familiar. Once again we need only turn to the sequence of the number of days in the months in the Western calendar, a derivative of the Roman reform of the calendar. The sequence handed down to us, which began with March, the month that contained the spring equinox: 31,30,31,30,31,31,30,31,30,31,31,28 (or 29), reflects an attempt to fit the cycle of lunar phases (the synodic month) into the seasonal 365+-day year by adding a day or two to each of the months. The original rhythmic sequence, a pure 31,30,31,30,31,…, was interrupted when Augustus Caesar borrowed a day from the last month in the cycle (February), so that the month named after him, which followed that of his famous martyred predecessor, Julius Caesar, would not be shortchanged. It is not difficult, then, to account for chains of nearly equal intervals in a durational sequence if we invoke some sort of perturbation (in this case a politically motivated one) that alters a pre-existing simpler mechanism, thus throwing off the patterns of more or less equal divisions of time. One wonders whether this also might have accounted for some of the splitting of 13 into sub-intervals discussed above.

The concept of 'equals plus leftovers' exhibited in the 'nearly equal' category also surfaces in other examples of timekeeping around the world; for example, our 12 days of Christmas likely resulted from the uneven fit between a 12-lunar month period (approximately 354 days) and the length of the seasonal year. A second example is the Maya month count, where 'bodysfull', or twenties (the number of fingers and toes), rather than 'moonsfull', serve as the basic temporal unit. The Maya 365-day year consists of 18 months, each of 20 days, with a 5-day month tacked on at the end to round out the count. In like manner the Egyptians chose 12 x 30 + 5.

Another excellent example of nearly equal intervallic sequences appears in a table on pp. 24c–25c of the Madrid Codex. Variants can be found on M.111c (20-20-5-7), 3a–6a (20-20-(6)-(19)), 99d (20-10-10-12), and 22a–23a (10-10-10-10-10-10-5). The sequence 20-20-20-5 would appear to be a logical Maya way to split up a 65-day period in that it mimics in miniature the framework of the Maya month count in the seasonal year. After the Spanish arrived in Yucatan, this way of reckoning so called 'burner periods' was evidently carried over into calendars of the Colonial period, even in the same slightly altered form we find in the pre-Columbian almanacs. Table 3 reproduces the intervals counted between 65-day periods recorded (along with other events of significance) in the listing of days of the year in the post-Conquest *Book of Chilam Balam of Mani* (Craine & Reindorp 1979). We shall return to this table later to raise some questions about the relationship between contemporary and ancient indigenous Maya timekeeping and divination. For the present it is worth pointing out that such a way of partitioning time possesses enormous advantages in the Maya way of thinking: not only does it preserve the convenient 5 and 20 hand- and body-based count from pre-Classic times, but also it is in perfect accord with the habit of quadripartitioning the basic temporal unit of 65.

Table 3. Intervals counted between 'Burner Days' in the *Book of Chilam Balam of Mani.* (After Craine & Reindorp 1979, 20–49, 144–54.)

20 20 5 20 20 20 5 60 5 20 20
25 20 20 20 5 20 40 / 20 20 5 20
20 25 20 20 20 5 19 21 20 5 20
20 20 5 20 20 20 /
20 20 5 20 20 20 5 20 20 20 5
20 20 20 5 20 20 20 5 20 20 20 /

One of the seminal Maya divisions of time consisted of the quartering of the 260-day cycle into 65-day 'burner periods'. On the days marking the last of these periods 'the burner quenches the fire' and a rain inducing ritual is conducted. Thus, Bishop Landa (Tozzer 1941, 162–3) describes a ceremony in which a large fire is lit and hearts of sacrificed animals or *copal* incense in zoomorphic shapes are cast into the fire. The Chacs (rain gods) then pour water from their jugs to extinguish the fire. Several of the post-conquest *Books of Chilam Balam* speak of certain days of the cycle connected with putting out and lighting the fire, proceeding in alternating cardinal directions (Thompson 1950, 99–101). As in the case of year-bearer calculations, because 65 divided by 20 yields a remainder of 5, there can be only four day names in the set of 20 that would be assigned to the lighting and extinguishing of the burner.

As has already been established, the rhythmic quality of *alternating intervallic sequences* may have been devised to set up a pattern of repetition in either the coefficient or day name in the 260-day cycle; thus the sequence 12-8-12-8-12 in the 5 × 52-day table on D.10a–12a, entry 10 Lamat, yields (modulo 20) only Lamat and Ahau day names for the representative stations, thus: 8,20,8,20,8,20,… . The coefficients reached are 3,4,9,(10), and 11, in the following order (mod 13): 10,9,4,3,11,10,9,… . The zig-zag sequence on M.33a: 5-1-5-1-5-1-5-1-5-1-5-1-5-1-5-1-17 = 65, a curious combination of our alternating (C) and nearly equal interval (B) categories also generates (slightly more complex) patterns; thus, entering on 13 Caban (Day 17), the sequences run, modulo 13: 5,6,11,12,4,5,10,11, 3,4,9,19,2,3,8,9,13,… ; and modulo 20: 2,3,8,9,14,15, 20,1,6,7,12,13,18,19,4,5,… .

To sum up the present section, we have established that there are three well-defined patterns of intervallic sequences in the almanacs in the codices: equal intervals, nearly equal intervals with a remainder tacked on at the end, and alternating equal intervals. Practical motives underlying the invention of such patterns include a mandate to set up quadripartite almanacs, the need to install day names that

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repeat at regular intervals, and a general aesthetic desire for rhythmic patterning. The last motive falls under what we might term numerology or 'number mysticism'. Before returning to a more general consideration of attempts to further explain intervallic number patterning in the codices, we next examine, as promised, two specific case-study examples in which content appears to be related to choice of intervallic number. These are the Deer-trapping almanacs, and the Burner almanacs.

Deer-trapping almanacs (Fig. 10)

The almanacs that comprise much of Madrid pages 39, 42, and 44–49 show deer being variously snared. Vail (1997) has connected them with Burner ceremonies and the Maya half-year, and von Nagy (1997) has related them to instruments that deal with subsistence animals in general. But little attention has been devoted to the numerical structure of these almanacs.

Our analysis will be concerned with the 14 almanacs on the aforementioned Madrid pages that exhibit a 10 × 26-day format. These were chosen because, from the point of view of calendrics and numeration, they seem to be structured according to a handful of simple, easily discernible rules. The intervallic sequences proceed in a generally circular course about the image of the snared deer, with the black number count usually beginning at the head of the animal, which is usually the closest portion of its anatomy to the glyphic entry column at the left side of each almanac. Ahau (25 per cent), Caban (11 per cent), and Oc (9 per cent) are the most common entry points into the sequence (Ahau was the day name attached to the start of the Long Count of the present cycle). The almanacs usually contain 6 (6 examples) or 7 (5 examples) stations; three of them consist of 8 and one of 5 stations. The most common intervals, with percentages, are listed in Table 4.

Table 4. *Intervals appearing in Deer-trapping almanacs.*

INT	%
1	12
2	27
3	17
4	15
5	12
6–8	5
9	3
10–13	9
>13	0

Note: There are no sevens.

From the viewpoint of simple gesture as a way of expressing number, it may be significant that 83 per cent of the tabulated intervals can be counted on the fingers of a single hand. When black intervals between 10 and 13 do appear, they are generally ultimate (7 cases out of 15) or penultimate (5 cases) in the sequence; thus the latter belong to our nearly equal interval category (B).

The count generally proceeds clockwise, with black numbers one and two generally positioned at the nose and ears of the animal, where the count usually begins (M.44b (Fig. 10c), 44c, and 48c are the exceptions; in each case a second animal is involved). Sometimes (e.g. M.47b, 48b, and 46c (Fig. 10g)) the two black dots are placed one above each ear, as if to count them. Threes and fours are generally positioned across the back of the animal, while the large numbers are positioned near the hoof, where the count usually ends. In some instances (e.g. M.49a (Fig. 10b), 45b (Fig. 10d), 46b (Fig. 10e), 49b (Fig. 10f), and 46c (Fig. 10g)) there is an iconic playfulness exhibited in the way black numbers, particularly twos, threes and fours are arranged about the rear end of the animal, as if intended to mimic droppings or testes.

Table 5. *So-called scribal errors in Deer-trapping almanacs.*

Should be	Reads	Black/Red	Reference	Figure no.
10	9	B	44b,46b	10c, 10e
10	9	R	45a	not shown
8	9	B	48b	not shown
8	9	R	46c	10g
5	4	B	47b	not shown
5	4	R	47b	not shown
4	3	B	45b	10d
4	3	R	48c	not shown
2	1	R	45a	not shown
6	8	R	48b	not shown
11	10	R	46b	10e
8	7	R	45c	not shown

The number most commonly avoided is 8, and that most stressed is 9 (5 cases).

Whenever an interval clearly does not add correctly to the previous station to give the next one in the text, or when a station arrived at by the addition of an inscribed number is not the same as that in the text, epigraphers often tend to attribute the discrepancy to 'scribal error'. A number of such cases appear in these almanacs; they are listed in Table 5.

Some of the 'errors' in these almanacs are so striking that one must question whether the scribes who committed them were merely ignorant or inattentive copyists. Could it be that what seems incorrect to us may have been perfectly justifiable in the mind of the scribe? Having already suspected that the repetition of certain day numbers was a factor in altering the structure of almanacs, one can find precedence for

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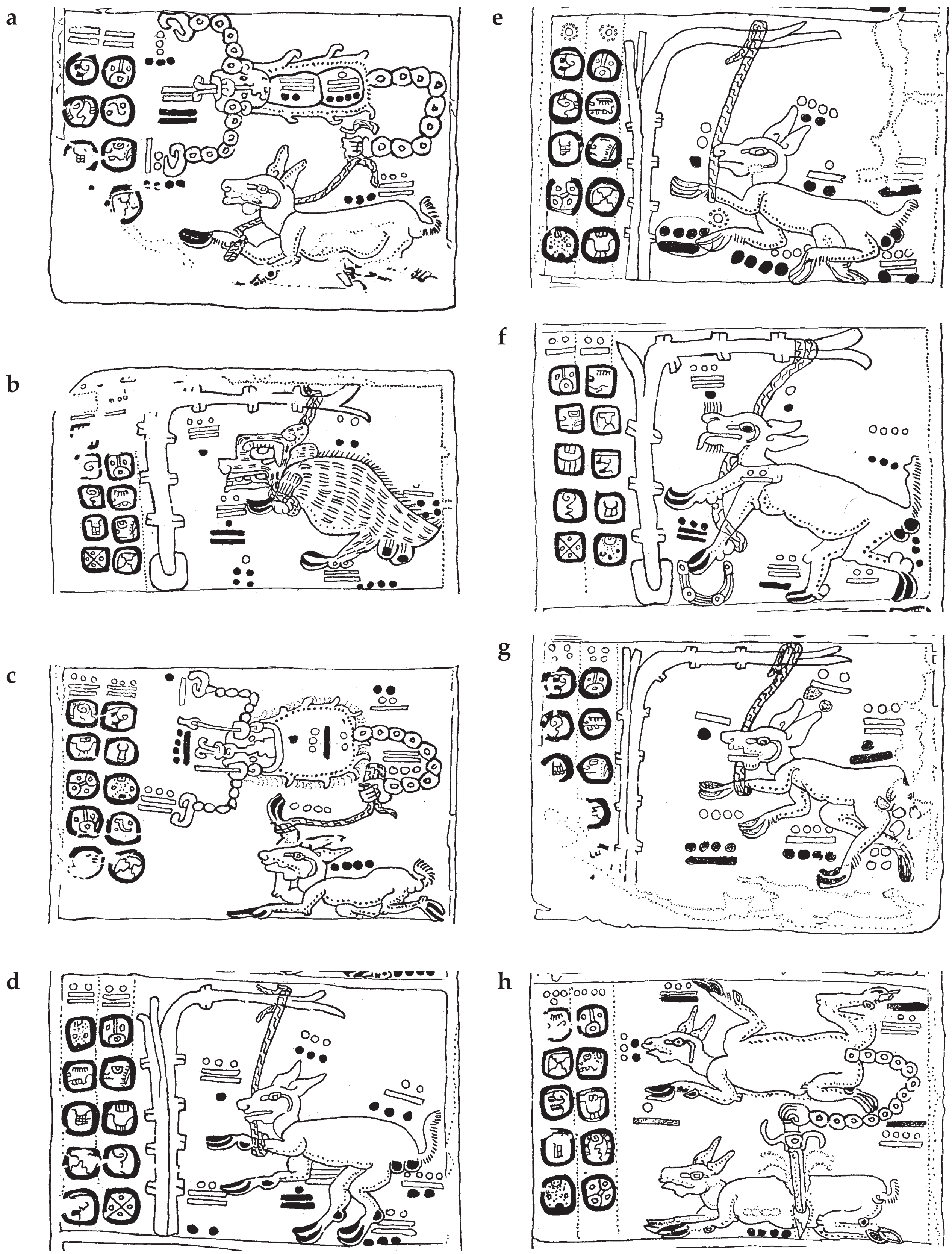

Figure 10. *Selected Deer-trapping almanacs: a) M.44a, b) 49a, c) 44b, d) 45b, e) 46b, f) 49b, g) 46c, h) 39b.*

this sort of behaviour in the ethnographic record. For example, deified days carrying the coefficient nine are regarded as tribal ancestors among the Jacalteca and Cakchiquel Maya, while the Ixil chose a day with the coefficient nine or thirteen to send one's *nagual* (animal spirit) into another person. A Chumayel novice reported that 'On the ninth day and on the thirteenth day: it is to *Bolon-ti-Ku* [the nine lords of the underworld] and *Oxlahun-ti Citbil* [thirteen sky gods] that I count on my beads' (Thompson 1950, 54). Also, nine, or *Bolon*, means 'uncontaminated' (Thompson 1950, 54). Thompson thought it also conveyed the idea of the superlative (Thompson 1950, after Redfield & Villa Rojas 1934). Used in conjunction with certain nouns, the number nine connotes good luck or success; thus, *Ah Bolon Makap* means 'great hunter' (Thompson 1950, 54). Finally, Thompson (1950, 93) cites examples from the monumental inscriptions in which he posits that the number nine was deliberately chosen because of its lucky aspect. He remarked on the recurrence of this number more than any other in Long Count dates on stelae, e.g. the aforementioned 'super number' 9.9.16.0.0 and 9.9.9.9.18 (Uxul, Altar 2), and it is also the most frequently occurring day coefficient on the monuments. Thompson further noted that in the inscriptions 9 avoids Imix, Caban, Kan and Ahau, thus supporting the notion that there may be certain date/number taboos in the divinatory process. A detailed breakdown of the relative occurrence of day names and numbers in the monumental and codical inscriptions is presented in the Appendix of this article.

The role of the lucky/unlucky numbers prompts mention of the interesting case of D.4a–10a, a 20-station almanac referred to above. This 5 × 52-day table consists of the intervallic sequence 2-4-3-2-4-2-2-4-2-2-2-4-2-3-2-3-2-3-2-2. Of the good/ill-fortuned omens that can be read, the interval of 4, mentioned four times in the table, always precedes a good omen, while the interval 2, mentioned twelve times, usually precedes a bad omen.

Lucky and unlucky numbers are ubiquitous in contemporary Maya daykeeping, e.g. in Chocolá (highland) Guatemala (cf. e.g. Weeks *et al.* 2009, esp. app. 1). There practically everyone has something to say about his (her) unlucky numbers and days. According to Weeks *et al.* (table A1.5), the one and eight days emerge as the best, with 8 Batz leading the way. 8 Batz also emerges as the biggest day for church donations.

Returning to the Deer-trapping almanacs, black number sequences, as mentioned earlier, can be regarded as degenerated forms of equal interval almanacs, e.g. 13-13. Inexplicably, however, in 13 out of the 14 examples in the Deer-trapping almanacs, the clustering fits a 12-14 pattern (see Table 6).

Table 6. *Breakdown of intervallic sequences in Deer-trapping almanacs (• indicates where to begin the count).*

5-5-2•5-5-4	M.39b
2-4-2-2-2•5-9	M.44a
1-2•4-4-4•11	M.49a
4•1-2-3-5-1•10	M.44b
1•3-4-2-3•11-2	M.45b
1-2-2-5-2•4-10	M.46b
2-2-8•5-9	M.47b
1-2•3-3-2-4•8-3	M.48b
13-5-1-1-3-3	M.49b (the single exception to 12-14)
1•2-6-4•4-9	M.46c
2•1-3-8•12	M.47c
3-3-4-4•10-2	M.44c
2-3-2-3-2•5-6-3	M.48c
1•2-5-3-2•11-2	M.49c

In one of these cases (M.39b: Fig. 10h) quadripartition seems to have played a role in the selection and positioning of intervals. The four black fives are positioned at the locations of the hooves of a splayed-out animal. The direction of the time count is as follows: 5 (left rear)-5 (left front)-2 (nose)-5 (right front)-5 (right rear), ending on 4 at the bottom of the figure of a second animal pierced by a dagger attached to a scorpion's tail attached to the dorsal portion of the animal.

To summarize this section, the choice of small numbers applied in the Deer-trapping almanacs in the Madrid Codex is non-random. Unanticipated numbers that we might attribute to scribal error were more likely deliberate alterations. Such was the power of pure number that it interfered with the operation of the calendar. But even if the calendrics are rendered non-functional as read, any chronologist would have been able mentally to correct the sequence. Numerical alteration may have been influenced by considerations of good and bad luck. In some instances, as we shall see elsewhere, details in the accompanying iconography may have affected intervallic choices as well.

Linking past and present: the burner almanacs

In addition to relating almanac content to number, the Burner almanacs also provide a connection between ancient and contemporary Maya ritual practice. Landa (Tozzer 1941, 136, n.632 & 162, n.848) tells of a burner ritual in which four rain deities (Chaacs), each assigned a side of space, put out fires after the slash-and-burn agricultural practice. This is one of four associated actions: one *takes* the fire, *begins* the fire, *gives scope to* (or *runs with*) the fire and *puts out* the fire.[16] Landa also tells us that when the fire is lit, 'hearts of sacrificial animals are cast

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into it, priests extinguish the fire with water from their jugs, …'. The ceremonies were conducted, he says, in order to ensure copious rains. 'There were two ceremonies, one in the dry season, the other when rains begin.'[17]

The *Book of Chilam Balam of Mani* refers to several 65-day sequences arranged intervallically 20-20-20-5 (cf. also Table 3); thus

> 3 Chicchan, 'the burner takes the fire,'
> [forward 20 days to]
> 10 Chicchan, 'the burner begins the fire,'
> [forward 20 days to]
> 4 Chicchan, 'the burner gives scope to the fire,'
> [forward 20 days to]
> 11 Chicchan, 'the burner puts out the fire,'
> [forward 5 days to]
> 3 Oc, 'the burner takes the fire.'… .

Burner almanacs in the codices are represented as 4 × 65 = 260-day quadripartite layouts; for example, the one on D.33c–39c (Fig. 11) displays most of the elements of the 20-20-20-5 structure and most of the intervals begin on burner days. Another such almanac appears on D.30b–31b, the quadrants of which begin on burner days (cf. Bricker & Bricker 2011, ch. 6).

Number alterations in the D.33c–39c Burner almanac are evident. This almanac has been dated by the Brickers (1992, 76–8) to AD 1517. It exhibits five rather than (the usual) four intervals: 9-11-20-10-15. According to the Brickers, pictures in the first, third, fourth and fifth intervals refer to the four steps in the ritual cited above. The second picture contains dates that are not part of the usual burner sequence. These are 9 Muluc, Ix, Cauac, Kan (as opposed to Ahau, Chicchan, Oc, Men). The Brickers conclude that, in addition to functioning as a burner almanac, 'a secondary function of the almanacs was to correlate burner stations with the summer solstice and eclipse seasons' (Bricker & Bricker 2011, 78). They cite glyphic and iconographic evidence (in the second and third stations) to support the case. Thus, it may be that an almanac with a more orderly 10-10-20-10-15 intervallic structure was altered in the first two places to accommodate this dual function.

In the realm of contemporary Momostecan daykeeping, B. Tedlock (1983, 62ff.) describes a set of burner rituals in highland Guatemala that offer a motive for the same kind of intervallic patterning we find in the codices. In these rituals, the 'burner' is 'a man or woman who may approach the outdoor community altars in order to burn incense and make offerings to the ancestors or deities'. The novices who undergo the necessary training to enact these rituals are termed 'burdens' during the 65-day period known as the 'washing for work service.' On the day 1 Cawuk the teacher arrives at the shrine named 'In the Water', which is located in a stream at the west end of Momostenango. There he begins the 'back of the path', a general term for the commencement of a set of calendrically timed rituals in which he asks the gods/ancestors for permission to train the novice. Thirteen days later (on the day 1E) he returns to the same place and begins the instruction process with the novice. The process described by Tedlock involves 'instruction in time reckoning, cosmology, observation of the sun, moon, and stars, herbal and shamanic curing, etc.'; then follows an intriguing account of intervallic alternation owing, in part, to a number of factors relating to the geographic environment in which the rites take place:

> Now the rhythm of his visits to the shrines speeds up to 7- and 6-day intervals in order to intercalate or insert the 8-day series (*wajxakibal*) and the #1-day series (*junabal*) that was started first. With the #8-day, 8 Cawuk, there is also a shift of locale to *Ch'uti Sabal*, 'Little Declaration Place', which is a shrine located on a hilltop half a kilometre due west of Paja'. Six days later on 1 Can the teacher returns to the low shrine at Paja'.
>
> This series of 1- and 8-day intervals [see Tedlock, fig. 1] rotates back and forth at 7- and 6-day intervals to produce the following metre: 1 Cawuk + 13 = 1 E + 7 = 8 Cawuk + 6 days = 1 Can + 7 days = 8 E + 6 days = 1 Batź + 7 days = 8 Tijax + 6 = 1 C'at. Expressed in the language of Western music, this 65-day 'back of the path' time period opens with a 13/65 time signature, in which the right-hand figure (65) indicates the unit of measurement (1/65 of the total time period under construction), and the left-hand figure (13) indicates the number of such units in each measure. In this ritual series, however, after only one measure the metre speeds up and alternates back and forth four times from 7/65 to 6/65 through eight measures, thus producing an irregular multimetre. This multimetre resolves itself and achieves an exciting asymmetrical balance through the principle of dialectical complementarity, in which the distinctions (7 and 6) are simultaneously in an alternating relationship to each other — 7, 6, 7, 6, 7, 6, 7, 6 — and in dialectical completion of each other – the original 13 is matched with 7 + 6 = 13, repeated four times. A third type of dialectical complementarity, known as direct opposition, is present in the spatial dimension of the rituals, in the shift from low to high place (Paja'/Ch'uti Sabal); low to high number (1/8); east to west; and wet to dry (Tedlock 1983, 62–3).

This important lengthy quote clearly demonstrates that the set of intervals comprising the 65-day burner period is 13-7-6-7-6-7-6-7-6, a pattern which is present in a host of almanacs in the codices.

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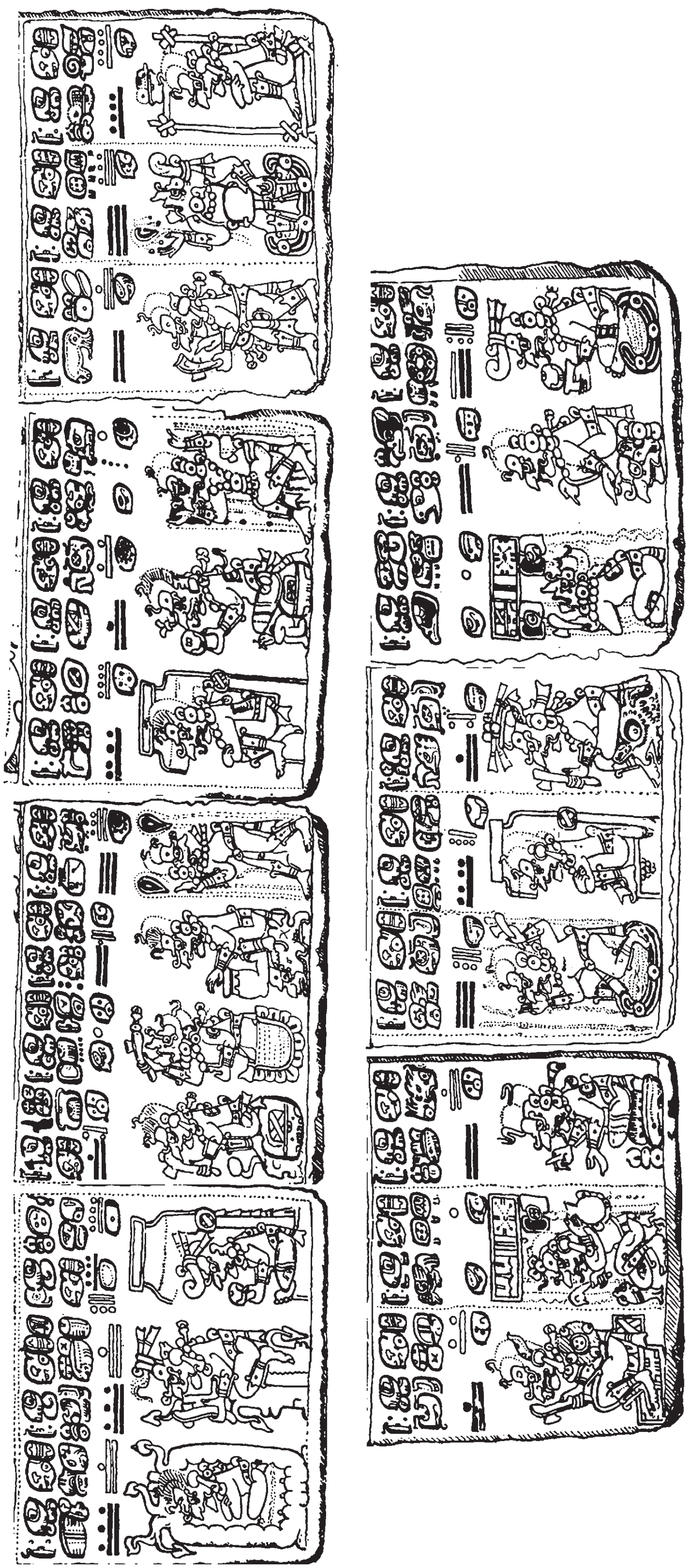

Figure 11. *D.33c–39c, a Burner almanac exhibiting altered intervals.*

Now, once these rites have been concluded and the novice has become a 'burner', he may go on to achieve the status of 'daykeeper' by completing a second 65-day 'back of the path' period known as the 'washing for the mixing pointing'. This begins on the day 1 Quej at the same Paja' shrine and alternates via the same intervallic set 13-7-6-7-6-7-6-7-6; however, the second set falls earlier in the 260-day count than the first. Moreover, the two 65-day periods overlap, so that the first two days of the 'work service' cycle fall on the third-to-last and final days of the 'mixing and pointing' service. Thus, concludes Tedlock, 'the teacher completes the chronologically later 65-day period (work service) first and then waits nearly 250 days to begin the earlier (mixing and pointing) 65-day period' (Tedlock 1983, 64; see Table 7).

The alternation of the day names one and eight in this dualistic wet/dry, high/low, east/west system are obvious; but note also the rhythm in the sequence of day names, thus:

A B A C B D C E D F,

or more figuratively expressed:

A B A C B D C E D F .

Such an arrangement calls to mind other sets of intervals in the *equal intervals* of 13 (category A) almanacs, such as 8,5,8,5…, 9,4,9,4,… etc. One wonders, therefore, whether iconographic/glyphic indicators might be present in these almanacs to support the argument for a sequential, alternating process of setting up intervals in burner rituals. The 4 × 65-day almanacs with such sequences would be the obvious target of such a future investigation.

Tedlock (1983) has further noted that the contemporary double-timed scheduling of mixing-pointing/work service rituals in Momostenango described above is also replicated in scheduled rituals accommodated to the solar year via division into 65 + 65 + 52 days = 182 days (1/2 solar year), repeated twice consecutively (364 days total). She tells us, for example, that in 1976 they overlapped in a 65 + 13 + 65 + 52 days = 195-day schedule; thus: (13 + 7 + 6 + 7 + 6 + 7 + 6 + 7 + 6) + 13 + (7 + 6 + 7 + 6 + 7 + 6 + 7 + 6 + 7 + 6) + 13 + (7 + 6 + 7 + 6 + 7 + 6 + 7 + 6 + 7 + 6) = 195. The point relevant to our study of numerology in the codices is that the intervallic structure was altered from the straightforward 13-13- - - - pattern to a combination of sevens and sixes (and 13) in order to accommodate a solar (i.e. an astronomically based) schedule, which also seems to have been the case in the Burner Almanac on M.33c–39c discussed above.

Table 7. *Sequence for combined Quiché rituals (after Tedlock 1983, figs. 1 & 2).*

Washing for Mixing and Pointing Ritual	Washing for Work Service Ritual
	Begin on 1 Quej (Low) + 13 =
	1 Junajpu (Low) + 7 =
	8 Quej (High) + 6 =
	1 Aj (Low) + 7 =
	8 Junajpu (High) + 6 =
	1 Came (Low) + 7 =
	1 Aj (High) + 6 =
Begin on 1 Cawuk (Low) + 13 =	1 Cawuk (Low) + 7 =
	8 Came (High) + 6 =
1 E (Low) + 7 =	End on 1 E (Low)
8 Cawuk (High) + 6 =	
1 Can (Low) + 7 =	
8 E (High) + 6 =	
1 Tijax (Low) + 7 =	
8 Can (High) + 6 =	
1 Batź (Low) + 7 =	
8 Tijax (High) + 6 =	
End on 1 C'at (Low)	

Having cited an excellent example of intervallic patterning in contemporary ritual that resonates with that in the codices, we return to the general theme of numerical alteration in almanacs. We next visit an interesting set of like-in-kind, or cognate instruments that offer further clues concerning why intervallic patterns in the codices might have been altered.

Cognate almanacs

Cognate almanacs comprise those, either within a given codex or in separate codices, that exhibit similar structure with respect to iconography or calendrical content, or both. The present study concentrates on numerically cognate almanacs in the Dresden and Madrid codices, specifically those that are similar in structure and arrangement with respect to intervallic sequences. In line with earlier work (Aveni 2006 and Aveni *et al.* 1996, hereafter AMP II), the goal of such studies is to discover how almanacs might have been altered from hypothetical earlier versions. My working hypothesis is that the almanacs in the codices, like most almanacs we know of in timekeeping systems in other cultures, were continually being revised and updated to suit contemporary conditions; therefore the extant almanacs in the codices might have descended from earlier, perhaps simpler, versions. The qualifier is added because an 'entropy of time' usually permeates most calendars; that is, complexity often accompanies the process of alteration of basic

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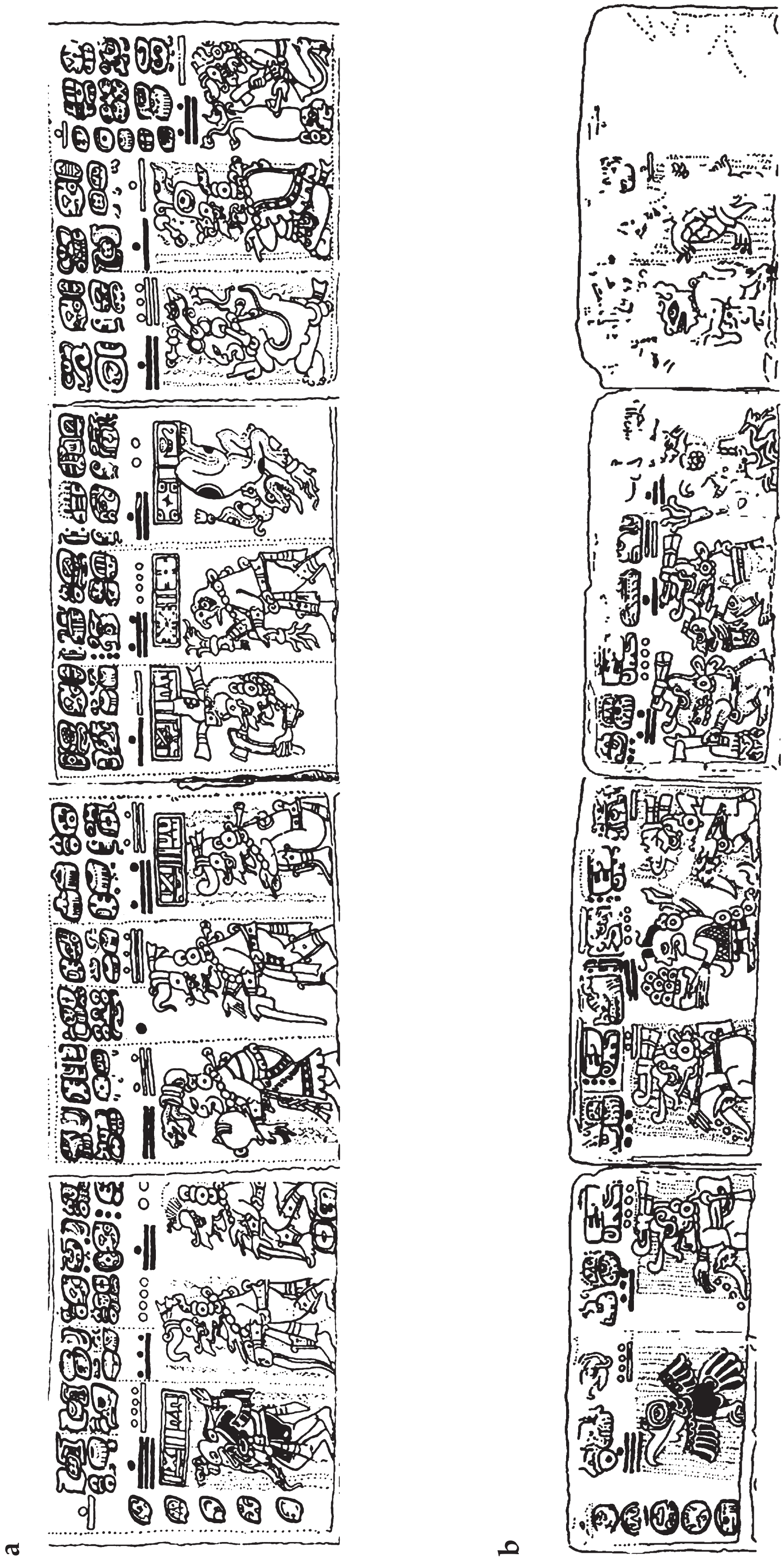

Figure 12. *In cognate almanacs: a) D.38b–41b and b) M.10a–13a showing where intervallic shifts may have been applied to accommodate eclipse phenomena.*

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structural elements, which process can be influenced by astronomical, political, or other exigencies. As mentioned above, our own seasonal calendar of jumbled 30- and 31- (and sometimes 28- or 29-) day months offers one historical example (for a more detailed discussion, see AMP I).

Earlier (Aveni 2006) I identified 15 cognate pairs of almanacs shared by the Dresden and Madrid codices, six of which possessed identical intervallic sequences. In most of the cases the starting date, iconography, and glyphic content of the almanac pairs were similar. Differences in starting date were not correlated with differences in intervallic structure. Those pairs that exhibit slightly different sequences are summarized in Table 8, wherein the intervals can be arranged to indicate clustering sequences that facilitate the recognition of similarities (parentheses have been added to suggest where alterations might have been made).

In about half the cases the Madrid appears to be an expanded version of the Dresden and vice versa. Note that in pairs no. 13 and no. 15 one needs to shift positions as well as combine successive intervals to make the cognates identical. The lengthy linear almanacs in cognate pair no. 11 was the focus of a case study (Aveni 2006) in which intervallic shifting in the later (tenth century AD) Madrid relative to the earlier (late eighth century AD) Dresden version of the almanac may have resulted from a need to accommodate astronomical events, namely a pattern of eclipses that had shifted through time (for details see Aveni 2006, 158–68). In this pair (Fig. 12) the iconography is nearly identical. The third interval in the Madrid (11) loses eight days relative to that (3) in the Dresden cognate; the difference is made up in the penultimate black number (19 *vs* 11). A lunar reference is further implicated if one combines Dresden intervals that accommodate whole and half lunar phase periods, thus:

16 /	8-11-10-1 /	12-6-12 /	11-11-6
(16)	(30)	(30)	(28)
(½)	(1)	(1)	(1) (approx. lunar synodic months).

Such accommodations[18] reinforce the distinction made earlier between distance numbers in the codices as opposed to those in the monuments; namely that the former seem to have been regarded as time *spans* designed, and occasionally altered, to accommodate a variety of phenomena, rather than devices intended to reach a precise historical date, which characterizes the way intervals are employed in the monumental inscriptions.

One way to explore how intervallic sequences might be related to thematic/iconographic contexts would be to assess the content of a set of cognate almanacs found in abundance in the codices. The beekeeping almanacs in the Madrid Codex offer such an opportunity. The Madrid contains 30 such almanacs that refer to stingless bees (*Mellipona beecheii*) (Roubik 1989, 366–70) common in contemporary apiculture in Yucatan). The almanacs display beekeeping rituals and apparatus related thereto (there are no such almanacs in the Dresden). These almanacs also offer an unusual abundance of direct and derivative 13-sequences.

Table 8. *Dresden/Madrid cognates displaying intervallic alteration. (After Aveni 2006, table 6.5.)*

Cognate pair	Source	Intervallic structure
4	D.17c–18c M.93d–94d	15-33-4 (7-8)-(8-13-12)-4
5	D.17b–18b M.94c–95c	11-7-6-16-8-4 (5-5)-7-6-(8-8)-8-4
7	D.40c–41c M.49c–50c	10-10-10-10-(3-9) 10-10-10-10-(12)
9	D.10a–12a M83b	(12-(8))-12-(8-12) 20-[12]-20
11	D.38b–41b M.10a–13a	16-8-11-10-1-[12]-6-12-11-(11-6) 16-8-3-10-1-12-6-12-(19)-(17)
13	D.3a/M.91c	4-(8)-11-15-(14) [4]-22-11-15
15	D.15a M.111c M.96b	34-18 33-19 10-(9-9)-13-11

The beekeeping almanacs are listed in Table 9. With one exception, they cluster in the last pages (103–12) of the codex. About half of them are numerically cognate by virtue of displaying the equal intervals of 13 sequence either directly or via simple derivative, that is, by addition of sub-intervals. These have been placed at the top of Table 9 (cf. the first 20 entries). Interestingly, the non-13 sequence almanacs generally tend to cluster in the middle of the range of Madrid pages 106–8, where the beekeeping almanacs are located. Figure 13 shows their placement in the codex.

Seely (2006) has defined four thematic categories in these almanacs, which I have reduced to three by combining the second and third. The revised categories are (cf. Fig. 14 for select examples):

1. These almanacs picture hovering bees (almanacs 1, 3, 4, 8, 10, 15, 30). They tend to cluster on the left side of the region of the codex that contains the beekeeping almanacs. The stations are highly periodic. Four almanacs display the 13-sequence; three exhibit simple deviations reducible to the 13-sequence via a step or two (Example: Fig. 14a).
2. A second set of almanacs includes some form of a deity or deities along with the hovering bees (almanacs 2, 5, 6, 11, 12, 13, 20, 29). They tend to cluster on the right side of the array of such almanacs. No. 11 shows a morphed bee and deity; four of the six

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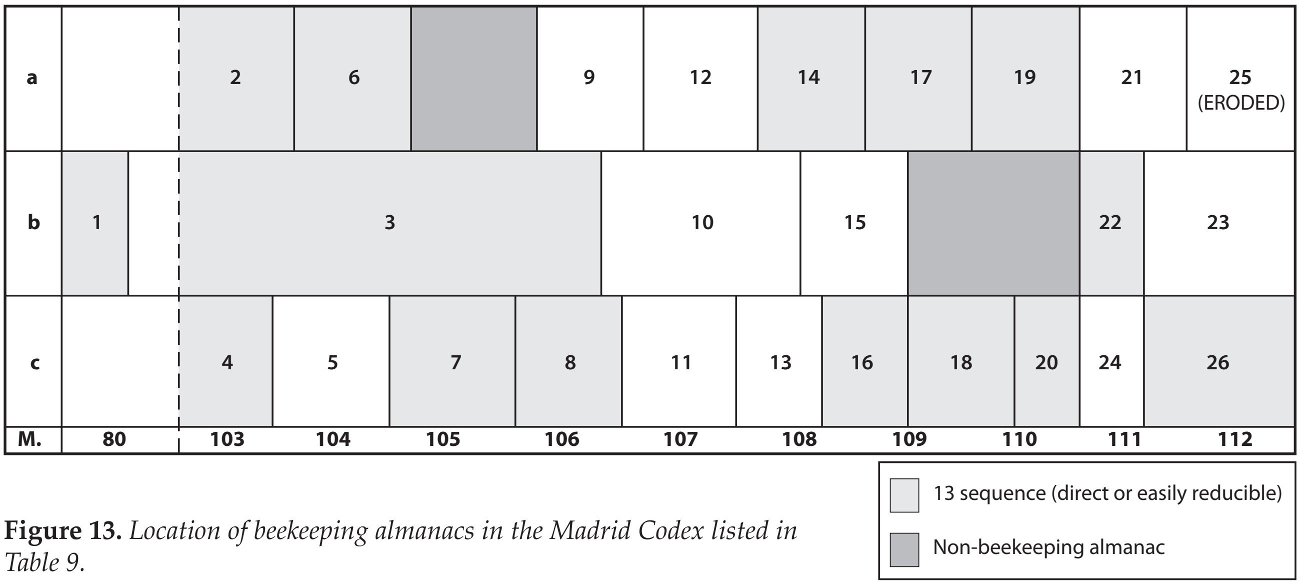

Figure 13. *Location of beekeeping almanacs in the Madrid Codex listed in Table 9.*

are direct 13 sequence; two are slightly deviant. Almanac no. 20 appears to be the single exception (no. 29 is eroded) (Example: Fig. 14b).

3. In this category the focus is not directly on the bees. They are not pictured; but the theme of beekeeping is conveyed via some sort of activity related to beekeeping, e.g. sweeping or moving hives, extracting honey, etc. (7, 9, 16, 17, 18, 19 , 21, 22, 23, 27, 28); they tend to be grouped toward the middle of the array. Intervallically all members of this class, with two exceptions (no. 7, which is a direct 13-sequence, and no. 9, which exhibits the 5-8 alternating pattern) either are not reducible to the 13-sequence or require more than a simple step or two to be converted to that canonic form (Example: Fig. 14c).

Seely further noted that the 13-sequences are generally represented in the first two categories, while the non-13-sequences are found in the third. He concluded that for the 13-sequence derivatives (e.g. 7-6-7-6) from the first two thematic categories, the mathematical steps taken to arrive at a 13-sequence are minimal and clean, usually consisting of only adding pairs (Seely 2006, 21). There are approximately seventy sequences in the entire Madrid that are either direct 13-sequences or simple derivatives of one. These comprise one quarter of the total almanac count. If sequence types were randomly distributed across almanac theme families, only about four of the 20 indicated in Table 9 (i.e. one fifth) would be expected to display intervallic sequences with this numerical attribute; therefore, given that two-thirds share this attribute, it seems highly unlikely that Seely's correlation is due to mere coincidence. Some guiding principle must have been responsible. That intervallic sequences irreducible to the basic 13-sequence dominate a particular iconographic variant of beekeeping almanacs further implies some sort of motive behind the correlation.

A possible explanation for some of the asymmetries that appear in Table 9 may be found in Vail's (1994) analysis of the beekeeping almanacs, which offers another example of linking a contemporary set of rituals with those of the past. Vail was the first to note that many of the almanacs possessed identical *tzolkin* entry dates, the day name Caban, the first syllable *cab* meaning honey, being a frequent choice (10 of 30, or 33 1/3 per cent). Utilizing ethnographic and ethnohistoric sources, Vail developed a model for the almanacs assuming all the dates belonged to a single 260-day cycle, she found that the best fit of the iconography of the almanacs to contemporary beekeeping activity corresponded to rituals conducted in the Maya 20-day months of Tzec and Mol, which in early fifteenth-century Yucatan fell, respectively, in late Oct–Nov and Jan–early Feb in the Gregorian calendar. Landa's (Tozzer 1941, 156–7) extended discussion of the Tzec ritual, which began the cycle, suggests that it was of great importance. The extended rites began with strict fasting in the month of Zotz, which precedes Tzec. Only then could the ceremonies associated with sweeping, offering, etc. take place. Vail's table 3 (1994, 63) gives the order of the rituals by *tzolkin* date. Thus arranged, the almanacs that fall at the earliest stage of the ritual process turn out to be M105c-106c (no. 3 in Table 9), 111b (13), 107c–108c (17), 108c–109c (12), 106b–108b (18), 106a (22), 80b (8), 111b–112b (20), and 104c–105c (10). All but one of these (no. 22) are highly ordered and 13-based.

Based on Vail's model, it is of further interest to note that the intervals between the starting dates of the

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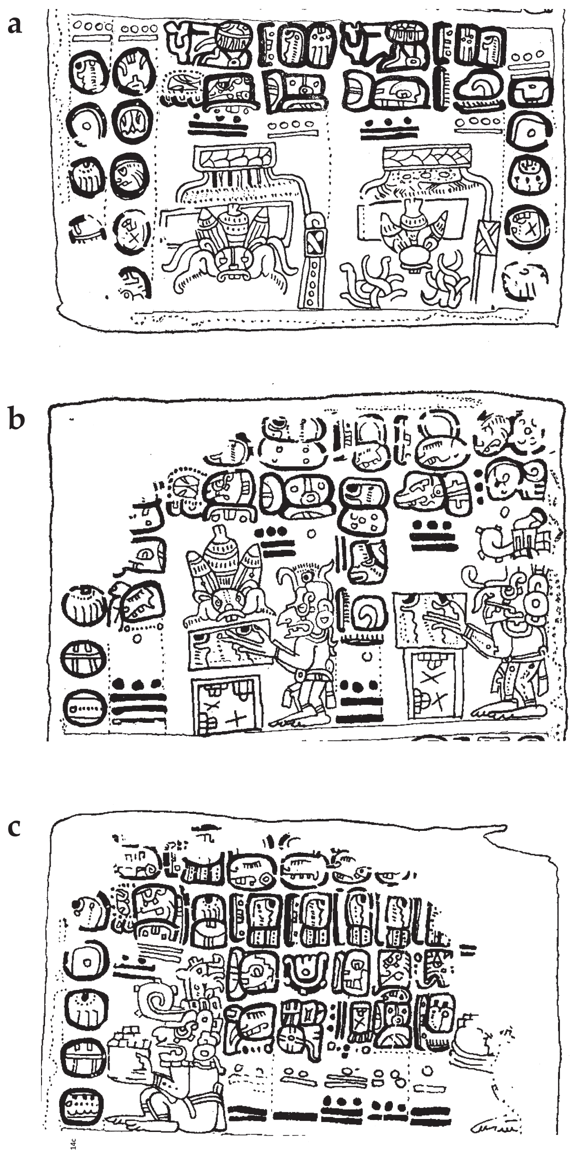

Figure 14. *Beekeeping almanacs: a) Type 1 (M.103c), depicting hovering bees; b) Type 2 (M.104a), with accompanying deities; c) Type 3 (M.107a), showing apparatus and activity connected with beekeeping, in this case a deity holding a honeycomb.*

Table 9. *The 26 beekeeping almanacs in the Madrid Codex. (Intervallic sequences are given, with hypothetical derivatives in parentheses; after Seely 2006 and Vail 1994.)*

No.	Madrid almanac	Entry date	Intervallic sequence	Activity
1	103c	9 Cluen	13-13	Bees, offerings
2	104a	1 Caban	13-13-13-13	Extracting honey
3	105c–106c	9 Caban	13-13-13-13-13	Bees, offerings
4	108a	effaced	13-13-13-13	Bees, offerings
5	109c–110c	13 Ik	13-13-13-13	Bees, deities, birds on heads
6	110a	effaced	13-13-13-13	Bees, flowers, deity
7	110c	6 Caban	13-13-13-13	Deities carrying bees and hives
8	80b	1 Imix	5-8-5-8-5-8-5-8-5-8 (13-13-13-13)	Bees, offerings
9	110b	9 Imix	5-8-5-8-5-8-5-8-5-8 (13-13-13-13)	Deities, incensarios
10	104c–105c	10 Oc	7-6-7-6 (13-13)	Bees, offerings
11	109a	10 Oc	7-6-7-6 (13-13)	Bees deities, offerings
12	108c–109c	9 Oc	17-9-17-9 (26-26; 13-13-13-13)	Extracting honey
13	111b	9 Caban	13-13-39 (13-13-13-13-13)	Deity with serpent scepter
14	112c	1 Caban	26-26-13 (13-13-13-13-13)	Deities with axes
15	103a	6 Chicchan	8-5-9-3-10-3-11-3-8-5 (13-12-13-14-13)	Bees, offerings
16	106c–107c	9 Eb	20-7-6-13-6-13	Deities moving bees/hives
17	107c–108c	9 Caban	20-13-23-9	Deities moving bees/hives
18	106b–108b	3 Caban	7-2-3-4-4-1-(5) (12-14)	Deities, offerings
19	107a	11 Caban	12-10-5-13-8-4 (12-15-13-12)	Deities, honeycomb
20	111b–112b	2 Ik	13-4-11-13-24 (13-15-13-12-12)	Deities, brooms
21	103c–104c	13 Kan	35-10-11-9	Extracting honey
22	106a	10 Caban	7-10-10-10-22-6	Deity with serpent scepter
23	108b–109b	8 Akbal	6-9-8-10-5-13 (?)	Bee deity, scepter, offerings
24	111a	13 Eb	24-11-12-18	Extracting honey
25	111c No.1	13 Ben	20-20-5-7	Deities with broom
26	111c No.2	4 Ahau	33-19	Deities with incensarios
27	105a	1 Caban	11-16-(25)	Deities with offerings
28	109b–110b	10 Ben	29-18- ( )	Deities burying idols
29	112a	effaced	( )	Bees, offerings
30	103b–106b	7 Cib (non-standard almanac)	None	Deities and bees with offerings

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rituals corresponding to the almanac set comprising the early part of the cycle also follow a highly ordered intervallic pattern. Thus,

(105c–106c, 111b, 107c–108c) + *13* days = (108c–109c) + *7* days = (106b–108b) + *20* days = (106a) + *4* days = (80b) + *1* day = (111b–112b) + *8* days (104c–105c) +….;

that is, the intervallic pattern that connects the opening rituals is 13-7-20-4-1-8 = 20-20-13. After the initial 52 (53) days the intervals become totally random: 3-24-8-7-9-36-7-48-1-4-3-16-6-9-12. No consecutive combinations add either to 13, 20, or multiples thereof for the remainder of the 260-day round. Though they do not explain all the nuances of intervallic structuring in the 30 almanac set, these results strongly support Vail's model, which places the highly regulated, fasting portion of the Tzec beekeeping ceremony at the beginning of the cycle. One wonders whether a host of overlapping rituals, such as the pair discussed earlier in the burner almanacs, might have existed.

Having demonstrated the existence of deliberate intervallic alteration in a variety of cognate almanacs, and having opened a few avenues toward understanding practical motives for such numerical manipulation, especially in instances that possess an ethnographic parallel, we turn last to a group of almanacs that exhibit numerical alteration principles that may be attributed less to practical considerations and more to matters verging on what we might regard as purely esoteric numerological concerns.

Mirror almanacs and other esoterica

A seasonal calendar in use in Java in the nineteenth century consisted of the following month lengths (Crawfurd 1867):

41 23 24 24 26 41/ 41 26 25 25 23 41

Counted from the middle, the delineation of the day count in the second half of the year is almost a mirror image of that in the first half (read backward and forward from the '/'). The intervals were determined by the change in the position of the noon-time shadow cast by a vertical gnomon that measured *equal spatial lengths* (rather than equal time intervals) on a dial plate. The resulting 12 months are unequal because the noonday sun advances from day to day up and down the meridian more slowly near the solstices than near the equinoxes. The pivot point in the symmetrical sequence is marked by the day of the passage of the sun through the zenith of the 7°N latitude location of the observer. Dutch anthropologists who later investigated this unusual way of partitioning the year learned that the lengths of the months, so determined, were then adjusted slightly to accommodate agricultural timings related to the rice-planting schedule in the Javanese calendar (Maass 1924).

Examples of this sort of intervallic mirror symmetry are clearly evident in the Maya codices, e.g.''

12-8-12-8-12	(D.10a–12a)
13-26-13	(D.12b)
1-1-3-3-6-6-10-10-6-[6]	(M.85a)
20-[12]-20	(M.83b)
13-[39]-13	(M.84b)
(1-2)-5-3-2-11-2	(M.49c: symmetric about 11)

and the slightly aberrant sequence, read from the interval 6, in D.4b–5b:

4-4-4-3-4-3-4-3-6-3-4-4-3-3

Nitzkin (2002), who continues to pursue both first- and higher-order intervallic differences, refers to alternating patterns of this sort as 'weaves'. He likens them to the Maya idea of 'weaving the mat' (of numbers). He cites imagery in the codices (e.g. birds with intertwined necks) that exhibit this pattern.

Sequences in categories with which we are already familiar also exhibit this mirror-like quality, e.g.:

6-7-6-7-6-7-6-7	(M.19a and other examples of split 13s, such as 5-8, 4-9, etc.)
19-19-19-21	(M.43b–45b, the Mars table)
9-9-9-9-9-7	(D.8c and elsewhere)
12-12-9-10-9	(D.18a–19a, symmetric about 10)
9-9-5-5-5-5-5-(6-3)	(D.20c)
2-10-(8-5)-13-10-2-2	(M.43b, symmetric about the 13s)

In the example of the Javanese calendar, a rational, observationally based motive underlies the mirror-calendar phenomenon. But the Maya symmetries do not appear to be seasonally affected. One wonders whether certain 'rules of number' might have played a role in setting up these curious runs of intervals. The number of such cases seems to be too numerous to be accidental.

One of the most curious cases of number sequencing occurs in D.65–69, the so-called Seasonal Table in the Dresden Codex (Bricker & Bricker 1988). The lower portion of this table (D.65b–69b) includes a 91-day (quarter-year) intervallic sequence, one of two:

9-5-1-10-6-2-11-7-3-12-8-4-13

The 13 entries in the table, which appear *below* as well as above the glyphic captions in the upper portion of the table, exhibit the unusual property that the difference between each number and the one following is a constant (–4 or +9), a fact first pointed out by Förstemann (1906, 236). As a result, coefficients of dates reached by applying each of the intervals (modulo 13) produces a mirror symmetry; thus (beginning with a coefficient of one), we have:

1-10-2-3-13-6-8-6-13-3-2-10-1.[19]

Now, the upper portion of the Seasonal Table (D.65a–69a) exhibits (*below* the glyphic captions) an intervallic sequence that is repeated (above the captions) in the lower portion of the table. The relative placement of the two sequences offers another aspect of mirroring in the codices.[20] This second sequence seems to be partially structured on the constant difference principle (indicated in brackets), except that in this case the difference is –2 (+11); thus:

11-[13-11]-1-[8-6-4-2-13]-6-6-8-2

The differences in this example read:

2-11-3-7-11-11-11-11-6-13-2-7-9

Coefficients thus reached (again beginning with one) are:

1-12-12-10-11-6-12-3-5-5-11-4-12-1.[21]

Could a pristine version of the latter half of the table have become disordered because of the need to accommodate astronomical events? If we locate the Brickers' eclipse/seasonal data in the sequence, it turns out that the key dates neatly bracket precisely that portion of the Table that retains the constant difference rhythm, thus:

ECLIPSE ↓ SOLSTICE ↓ MARS, ECLIPSE ↓ ↓

11 - 13 - 11 - 1 - [8 - 6 - 4 - 2 - 13] - 6 - 6 - 8 - 2

← VARIABLE →← CONSTANT →← VARIABLE →

The difficult question of exactly how the application of these astronomical data, which surely must have perturbed the original rhythmic sequence, might have altered the table to read in its extant form remains open.

Conclusions

This study has established the existence of many well-defined patterns in the intervallic day sequences that comprise a multitude of the 301 almanacs that make up the Dresden and Madrid codices.[22] It also implies that the business of constructing the calendar that prescribed Maya ritual behaviour must have been both complex and rule bound. A multitude of offerings needed to be made to the gods at the proper places and times and the time spans between ritual events needed to be fixed. But did the events determine the intervals or did the intervals fix the events in the almanacs? Or both?

We noted at the outset that the largest percentage of intervals in the almanacs consists of sequences of 13. It seems clear that the combination 13-13-13-13 in 5 × 52-day almanacs emerged as a reflection of the Maya penchant for the directional quadripartition of time, while the 13-13-13-13-13 set in 4 × 65-day almanacs responded to the five-fold or quincunx time/space partitioning, which included the centre.

What of the many almanacs that deviate slightly from the 13-13- - - pattern by splitting or combining 13s? A safe (but certainly not exclusive) assumption to account for intervallic alteration would be that pristine 13-base templates were affected by one or more of the factors summarized below.

1. There was likely a need to *avoid* or *arrive at* a particular day or date (e.g. an interval of 20 returns an almanac user to a given day *name*, an interval of 13 to the same coefficient) or a lucky or unlucky day for planting, burning milpa, fishing, hunting, etc. If almanacs that have been altered to record lucky and unlucky days for religious, civic and other subsistence activities, as indeed the post-conquest and ethnographic sources attest (Thompson 1950, 93–6), then we might expect certain days in the 260-day count either to surface or to be suppressed more than others in the almanacs. When we (AMP I) looked at the distribution of day names for all dates in the *tzolk'in* arrived at via the intervals in each of the almanacs in the Dresden and Madrid codices, we found them to be relatively uniform. On the other hand the distribution of the day names associated with entry dates was decidedly non-uniform.

When we examined the distribution of numbers, specifically the coefficients 1–13 that accompany the day names, we found that in the Dresden the most frequent were 2 and 13, while 4 (the numerical coefficient of the zero day in the Long Count), 1 and 13 dominated the Madrid. In the Dresden, 13 was by far the most common entry number. The most common *entry* coefficients were 13 for the Dresden, and 4 for the Madrid. All three (1, 4 and 13) were frequently paired with Ahau (the name of the day that commenced the Long Count. On the other hand, numbers in the monumental inscriptions display a more random distribution, which supports the view that they were more exclusively concerned with *historical* rather than *ritual* dates. Their scribes, therefore, seem not to have been saddled with the problem of numerological constraints evident in the codices. (For details consult the Appendix.)

In contemporary divination, year-bearers exhibit specific omen-bearing qualities in the year in which they rule and, as we suggested, these may have played a role in intervallic selection. Based on her ethnographic work B. Tedlock writes that Mam Quej [Manik] '… is a wild year-bearer who likes to throw off his cargo, to mount, and also to trample people underfoot'. There are many business losses and many illnesses during a Quej year. Mam E [Eb] '… is quiet, calm, and enduring. An E year is good for business and health. Mam No'j [Caban] … who has a good head, and many thoughts, is a creative year, both for good and for evil'. Finally, Mam Ik' '… is very *bravo*, bringing violent rainstorms or else no rain at all. Many people die from being struck by lightning, from drowning, or else from hunger' (Tedlock 1992, 100). Perhaps such omens favoured the choice of specific year-bearers in the almanacs. Certain days may have gained popularity because of their prescribed outcomes in the past.

If we compare greatest to least frequently occurring numbers in initial and re-entry dates as opposed to stations, we find a drop from 4:1 to 3:1 in the Dresden. In the Madrid, except for the overwhelming occurrence of the coefficient 4, the drop is more like 5:1 to 2:1. Comparably, figures for day names are 6:1 down to an almost even 7:6 in the Dresden and 11:1 down to 6:5 in the Madrid. That is, as one passes from initial entry and re-entry date to station, day-name selection smoothes out more readily than number selection. All of this suggests that intervals do not seem, in general, to have been planned or laid out in such a way as to lead to a preponderance of particular day names, though on some occasions the scribes seem to have been concerned with employing/avoiding certain numbers. This is particularly evident in the Deer-trapping almanacs.

2. A second possible motive for altering intervals might have emerged from the desire to update an earlier version of a calendar to better accommodate real-time events. For example, in the Christian calendar the occurrence of the equinox, coupled with that of the full moon that follows it, fixes Christian Easter holiday precisely: it must be the first Sunday after the first full moon after the equinox. In this case the resulting interval is determined by two celestial events and it can vary between 1 and 37 days after 20 March in our modern calendar. On the contrary, Lent is always 40 days long regardless of when Ash Wednesday falls, the latter being fixed by back calculation from the Paschal date; therefore, the interval fixes the date. At a practical (but still seasonally influenced) level, in the Andean world there are examples of rites celebrated one week later than scheduled because people often say that they are not ready because they have not yet finished tending their crops (Urton 1986). Among the examples dealt with here, the seasonal table (D65a–69a) most clearly reflects the intrusion of celestial events, which follow periods of their own, into what appear to be preconceived base periods in the almanacs.

3. A third motive, perhaps so practical as to escape attention, for intervallic alteration likely derives from the basic need to save space in a manuscript. Such a consideration might involve reducing the number of intervals and stations by combining two or more of the latter. In the U.S. the conflation of Washington's and Lincoln's birthdays into a single President's Day offers an example. Conversely, an almanac could be expanded by subdividing an interval and consequently adding a station. Examples from the Western calendar include tacking on Boxing Day to Christmas in Britain or 'Pascuetta' (little Easter) to Easter Sunday in Italy. The need to save space is clearly evident in the cognate pair D.21b and M.90d–92d (Fig. 15). In the former, three of the four pictures are absent, though the intervallic sequence 7-7-7-5 persists. But there are instances in which pairs of pictures and their content (a single picture/interval) are subdivided. Compare the sequences in the pairs

11 - 7 - 6 - 16 - 8 - 4 (D.17b–18b)
5 - 5 - 7 - 6 - 8 - 8 - 8 - 4 (M.94c–95c)

and

15 - 33 - 4 (D.17c–18c)
7 - 8 - 8 - 13 - 12 - 4 (M.93d–94d)

While we have tended to attribute a chronological direction of development in which almanacs evolve from simple to complex (D. → M.) to these sets, as seems to be the case in most world calendars (cf. the principle of calendrical entropy referred to earlier), we recognize that such an 'evolutionary' approach ought not be regarded as exclusive.[23]

4. Finally there remains, as the ultimate rationale considered here for the determination of intervallic sets, purely esoteric considerations that derive from

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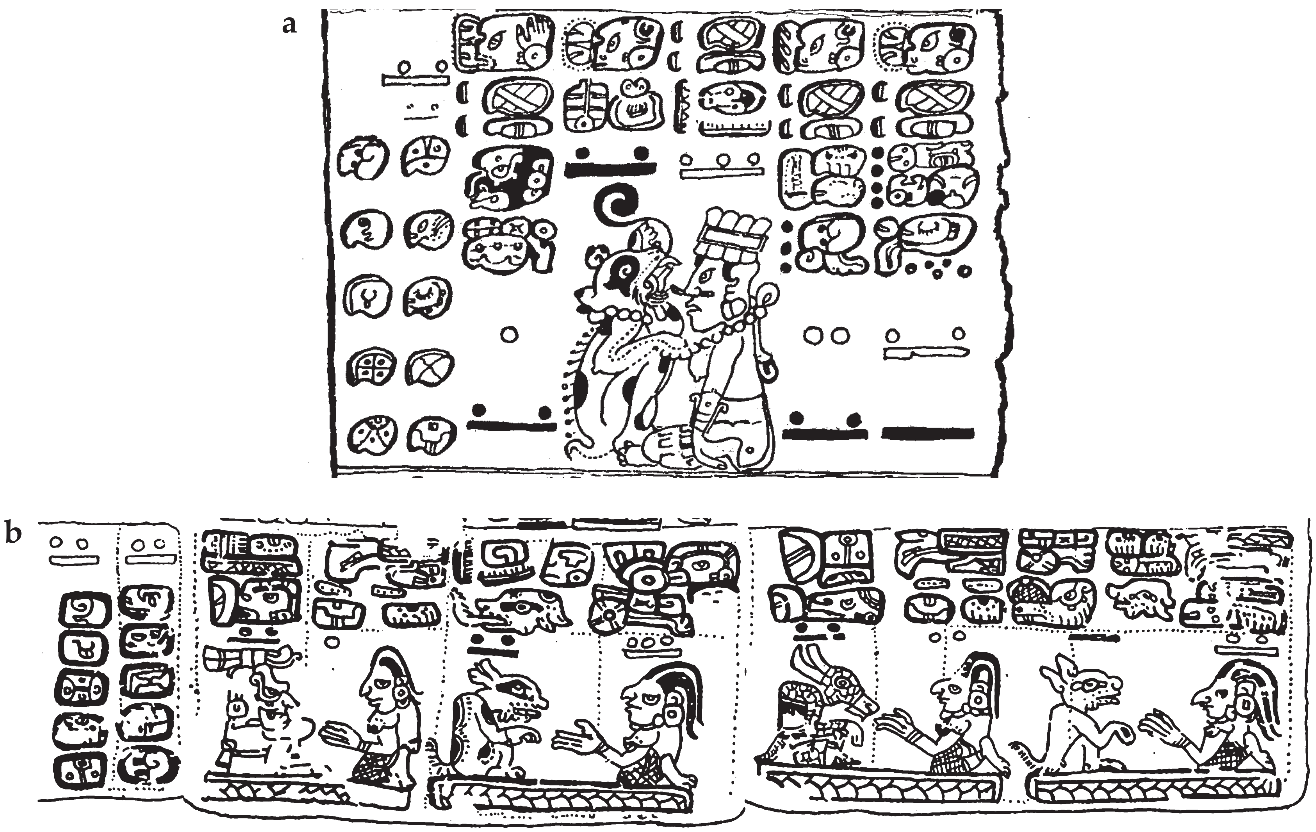

Figure 15. *The almanacs a) D.21b, and b) M.90d–92d. Does the intervallic alteration simply reflect the need to save space?*

so-called 'rules of number', such as the need to create a particular number of stations, other than the most common 2 × 130, 4 × 65, 5 × 52, or 10 × 26, in an almanac. For example, D.4a–10a has 20 stations, while D.29b–30b uses each of the 20 day names exactly once. The latter, a four station 4 × 13 × 5-day almanac, which features the rain deity Chaac, employs the coefficient 3 ahead of each day name (Thompson 1950, 88–93). This motive may overlap with the good luck/bad luck factor mentioned above.

Lounsbury (1978, 804) attributes two different motives to the Maya way of using number. The better-known preoccupation of court arithmetician and astronomer lay in employing large numbers as a way of tying the lives of the rulers to their mythic ancestors of the past, the gods who created the world, and to anniversaries of creation events in the future, when the rulers themselves would become gods. But, Lounsbury notes, there is another type of royal numerology that involves smaller numbers, more like the kind we have been dealing with in the present study, that covers brief intervals and time spans. It is here, he suggests, that we discern numbers being chosen largely because of the nature of *what they are* (Lounsbury 1978, 804) — the same kinds of choices the Pythagorean philosophers made. Interestingly, though Lounsbury first opined that these small numbers were far more interesting, he never studied them.

The constant difference between the intervals and mirror almanacs discussed in the previous section fall into this category. Each serves to express a certain kind of 'aesthetic of number', of which we are able to apprehend but a vestige. Nitzkin's ongoing work, which consists of looking for culturally-based metaphors (e.g. numbers formatted in the various styles of weaving wherein the sequence alternates from right to left) that might underlie the structure of almanacs, may prove useful in this regard.

Commensuration, cycles within cycles, 4- and 5-fold space time, alternation, mirroring — all of these characteristics are reflected in the intervallic structure of Maya almanacs. But the present study has clearly established that the almanacs also are very clearly patterned according to numerological principles which are often obscured by deviations from a prescribed template both for pragmatic and aesthetic reasons. Indeed, the Maya number system is very like their writing system in this regard.[24]

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In the Maya mentality there seems to have been no such concept as pure laws of astronomy *vs* pure laws of divination: the two were intermingled. As a result calendrical and numerological dictates conspired to convolute the time structure of the almanacs in the codices. In a number of instances the semantic values of numbers and day names appear to have been elements involved in the manipulation or corruption of intervallic sequences, thus creating arrays that look complex and unfamiliar to us, but which would have made perfect sense to a Maya chronologist.

Appendix: Frequency of occurrence of numbers 1–13 and (20) day names in the Maya record

The distribution in the percentage of occurrence of the coefficients 1–13 in monumental texts compared with that in the codices is reflected in Table 10. Note that while the number 9 appears most frequently on the monuments there are other numbers (e.g. 5 and 6) that are only slightly less frequent. In the codices the number 9 appears only slightly above the level of randomness in the Dresden and below that level in the Madrid. It is further worth noting that the number 4 occurs with triple the frequency of the mean in the Dresden Codex (indeed it occurs twelve times more frequently than the number 5, seven times more frequently than 6, and six times more frequently than 2). This may owe to its frequent pairing with the day name Ahau. Thus, 4 Ahau dates may have been contrived in the almanacs to match the anniversary of the *tzolkin* date of the start of the present Long Count era. That the same does not hold in the Madrid, where the distribution shows fewer deviations from the mean, may imply less interest on the part of those scribes in prescribing particular number entries. Moreover, the general absence of Long Count dates in the Madrid reflects a lack of interest in the Long Count in that work.

There was also some non-uniformity in the distribution of the 20 name days, especially with regard to entry dates. In the Dresden the day name Ahau is listed far more frequently — two to one over its nearest rival; thus, 25 per cent of the Dresden almanacs open with an Ahau entry, and 12 per cent with an Oc, the second most frequent entry. Random selection would be expected to yield 5 per cent. In the Madrid, the figures are 25 per cent and 8 per cent, respectively. At the other end of the spectrum, least frequently occurring dates of entry are Lamat, Ben, and Chicchan in the Madrid, and Men, Etz'nab, Cimi, Chicchan and Kan in the Dresden; each of these occurs about 1 per cent of the time. A survey of dates on the monuments conducted by Thompson (1950, 90), and incorporated in Table 10, also showed Ahau to be by far the most frequently mentioned of the 20 day names. This is attributable to the fact that so many of them are period ending dates. Imix appears in second place, while Chicchan, Akbal, Oc, Chuen, Men and Cauac were the scarcest. Again, recall that Ahau is the anniversary day name of creation.

Table 10. *Occurrence by percentage of coefficients 1–13 in dates on monuments and in codices.*

Number	Monuments*	Madrid and Dresden Codices	
		Madrid	Dresden
1	8.0	7.1	12.1
2	6.2	11.7	3.7
3	6.9	7.6	6.0
4	7.0	7.1	22.7
5	9.9	8.8	1.9
6	9.9	8.6	3.1
7	9.0	6.4	5.4
8	8.7	7.7	4.7
9	10.7	6.2	9.8
10	4.2	4.3	9.4
11	6.9	8.0	3.9
12	8.7	7.4	5.4
13	4.1	8.9	12.1
Mean	**7.7**	**7.7**	**7.7**

*After Thompson 1950, 91

There seems to be no preference with respect to numerical odd/even-ness, though this matter really requires further study. The most frequently chosen number and day-name combinations in the Dresden are 13 Akbal, Lamat, Ahau, Etz'nab, Manik and Eb, which occur three times more frequently than the least used combinations. In the Madrid 4 Kan, Cib and Ahau are 4:1 choices over a scattering of day names preceded by the coefficient 5. Some of these choices may have been determined by the year bearers (Dresden: Ben, Etz'nab, Akbal, Lamat; Madrid: Cauac, Kan, Muluc, Ix).

Notes

1. There are a few exceptions, e.g. the God C pages in the Paris Codex (15–18).
2. The Long Count cycle operates on a base-20 system. The primary unit of time is a day, or *k'in*. Each number in the notational system represents 20 times the one in the lower place. The third place, the *tun*, or Maya year, is an exception. It is made up of only 18 *uinals*, 20-day Maya months, for a total of 360 days, probably because 360 days is a closer approximation to a solar year than 400 (though the Mayas used the 400 unit when they counted things for trade, such as cacao beans). 20 *tuns* make up a *katun*, and 20 *katuns* make up a *baktun*, or about 400 years. Add these to the number of days since the last cycle began (11 Aug 3114 BC).

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3. Following the numbers, a significant event in the life of the ruler is portrayed on the reverse side, e.g. marriage, accession, or, in the present case, the celebration of a cycle ending alleged to belong to the ruler.
4. Footprints are also evident in D.25c–28c, D.29b, D.35a, D.39a, D.41c, D.65c, M.11c, M.53c, and M.54c.
5. A 'distance number applied to [a] pre-zero base' (Lounsbury 1978, 786) used to calculate the base date of the table, 9.9.9.16.0 1 Ahau 18 Kayab.
6. V. Bricker (p.c. 1/4/10) notes that a similar situation occurs in the Mars Table (D.43b–45b), which begins 78 days after the base date.
7. Only three such pre-Columbian documents, the Dresden, Madrid and Paris codices, have survived the extensive book-burning campaign conducted by the sixteenth-century Hispanic chroniclers (cf. Tozzer 1941).
8. I am indebted to V. Bricker (pers. comm. 1/4/10) for a continuing discussion of the implications of this important distinction.
9. 'Four score and seven years ago…' is a rare exception.
10. Almanacs with events dated precisely and without distance numbers include D.25–28, M.34–37, and pages 19–20 of the Paris Codex.
11. Except for occasional reference, the badly eroded, somewhat aberrant Paris Codex is excluded from the present analysis (cf. Love 1994).
12. But see Vail (2004), who argues that some of the almanacs actually tally 365-day years; however, this point is not relevant to the discussion of number patterning.
13. In AMP I this class was prematurely, and perhaps erroneously, subdivided.
14. I am indebted to Jeffrey Seely (pers. comm. 12/29/09) for pointing out a number of these congruences to me.
15. V. and H. Bricker (pers. comm. 1/26/10).
16. Drawing on Landa, Bowditch (1910, 272) writes that on days Ahau, Chicchan, Oc, Men, on days 2, 7, 12, 17 of the month, a 'burner', respectively, takes on or handles the fire, begins or ignites the fire, gives it scope, and puts out the fire.
17. Cf. also Edmonson (1982, 180) and Long (1923). It was Long who worked out the periodicity and significance of the four ceremonies, Landa apparently having recognized only one. For a detailed account of the burner ceremonies, see Bricker & Bricker (2011, ch. 6).
18. Currently V. Bricker and the author are revisiting this cognate pair with the intention of exploring alternative motives for intervallic alteration.
19. It should be noted that in general any *n*-station almanac, modulo *n*, with a constant difference between all intervals will produce a mirrored pattern of dates. The day names (modulo 20) reached through the application of this sequence of intervals exhibit no recognizable pattern, thus (beginning with one): 1-10-15-16-6-12-14-5-12-15-7-15-19-12-1-6-7-17- - - - .
20. I am indebted to H. Bricker (pers. comm. 12/25/09) for pointing this out.
21. The day names (modulo 20) exhibit no recognizable pattern.
22. Though we have not discussed the heavily effaced Paris Codex, there are two almanacs therein that bear a resemblance to Madrid almanacs. One of them (P.15b–18b) consists of a sequence that partially resembles that in M.10c–11c (cf. AMP II, S30).
23. On the matter of saving space, it might be worthwhile to develop some sort of metric by which to gauge 'degree of crowdedness' in various sections of the codices.
24. This analogy, which I attribute to J. Justeson, has emerged from our extended discussions on the relationship between writing and numeration (e.g. pers. comm. 5/1/09).

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