Call to revisit the Mesoamerican Calendars
The count that is called the Real Calendar

André CAUTY

CELIA

… en la cuenta que llaman calendario verdadero cuentan 365 días,
y cada cuatro años contaban 366 días.
Sahagún

Only a detail separates Mayanists and Nahualists. For the first, the Maya calendar contains exactly 18 980[1] **kin** 'days'. For the latter, the Aztec calendar consists of 52 *xihuitl* years whose total in days – determined by the type of the year – is supposed to be the same: 52 x 365. A supposition to be confirmed or invalidated. Showing that the CR of 18 980 days and the Aztec *xiuhtlalpilli* of 52 years are two different types of calendars,[2] this synthesis invites the reader to reconsider the traditional theory according to which the sharing of a mutual calendar is a defining trait in the concept of Mesoamerica (Kirchhoff 1943).

All Mesoamerican calendars seem to be defined by a common structure of a product determined by cycles whose root is the combination of an almanac of divination of 13 x 20 days and a vague year of (18 x 20) + p days.[3] The calendar expressions in fact combined in the Mesoamerican hic et

---

1 GCM (260, 365) is one fifth of the product *tzolkin* x *ha'ab* = 94 900. It is also 949 **uinal** 'months', 73 *tzolkin* or 52 *ha'ab*. Its double, 2 CR, equals 65 cycles of Venus.

2 In spite of a probable common origin and important similarities such as the order of Year Bearer sequencing and that of eponym changes.

3 Mayan *tzolkin* or Aztec *tonalpohualli* of 260 days; Mayan *ha'ab* and Aztec *xihuitl* of 365 or 360 + *p* days, with the question : *p* is it always and everywhere equal or not to 5 ?

nunc are, however, visibly different between the two peoples. Each group of cities followed its own rules for dating events and distinguishing days.

Common to all Mesoamericans, the 'almanac' dates are confirmed[4] from the middle of the VIIth century BC until the colonial period. These are expressions of the form **αX**, where **α** follows a cycle of 13 successive integers, and **X** a cycle immutably ordered of 20 day-glyphs. Or, a cycle which is the product of 260 dates, established with the order: $s(\alpha X) = [s_1(\alpha), s_2(X)]$ where the '**s**' are the 'successor' functions of the cycles being considered. Nearly absent with the Aztecs, the vague year dates are later and are only clearly attested to with the Mayas.[5] These are of the form ***βY***, wherein ***β*** follows the cycle (*0*, *19*) and ***Y*** the ordered cycle of 18 named[6] Months, *veintena*, of 20 days, and of the named complement ***Uayeb***. Thus a set of 365 days/dates for the 365-day year, *ha'ab*, equipped with the order s':

$$s'(\beta Y) = [s_3(\beta), Y] \text{ for each } Y \neq \textit{Uayeb} \text{ et } \beta < 19$$
$$s'(19Y) = [s_3(19), s_4(Y)] = [0, s_4(Y)] \text{for each } Y \neq \textit{Uayeb} \text{ and } \beta = 19$$
$$s'(\beta\ \textit{Uayeb}) = [s_3(\beta), \textit{Uayeb}] \text{ for each } \beta < 4$$
$$s'(4\ \textit{Uayeb}) = [s_3(4), s_4(\textit{Uayeb})] = 0 \text{ Pop}$$

1. The product *tzolkin* x *ha'ab* of the Maya and the cycle of Bearers

The CR[7] Maya is the ordered product *tzolkin* x *ha'ab* whose elements are couples (**αX**, ***βY***). The study of the mathematical properties of the ordered products of ordered cycles has shown (Cauty 2009: 20-30) that the conjunction of three factors,[8] along with the fact that 260 and 365 are multiples of the same

4 The older are anthroponyms (Urcid, Pohl and others).

5 The ***0 Yaxkin*** of the Leyden plaque (15/09/320) is among the first evidences of ***βY*** dates. The latter, from the Post Classic, are in the codex (Dresden and Paris).

6 In colonial Yucatec, for example: ***Y*** covers the following (***Pop, Uo, Zip, Zodz, Tzec, Xul, Yaxkin, Mol, Ch'en, Yax, Zac, Ceh, Mac, Kankin, Muan, Pax, Kayab, Cumku***) that closes the complement ***Uayeb***. To know the date ***βY*** of a day is equivalent to knowing its position *γ* in the *ha'ab*: the cycle of the *ha'ab* dates ordered by **s'** is isomorphic to a group of 365 natural integers fitted with the natural order of integers.

7 Its Mayan name is unknown. But its value of **2.12;13.0.** is established. Mayanists use the expressions: *Calendar Round, Wheel Calendar, Ritual Calendar.*

8 Classic Mayan CR. Let S be that difference which distinguishes, like a signature, the CR from its clones. F1: the rules for formulating the expression composed of dates (*tzolkin*, *ha'ab* and CR), F2: the type of numeration of the numbers in the pairs **αX*βY***, and F3: the relative position (defined for instance by the origin date **4 Ahau *8 Cumku***) of *tzolkin* and *ha'ab* at the moment of starting the CR. To distinguish the **αX*βY*** expressions that belong to the Classic Mayan CR, and not confuse them with an **αX*βY** expression which does not belong to the CR, we can calculate the difference $S(\alpha X \beta Y) = |x - \beta|$ (modulo 5) and compare with the difference S(**4 Ahau**, ***8 Cumku***). In case of a tie, the date (**αX*βY***) belongs to the Classic CR, otherwise it is a starry date that does not belong to the Classic Mayan CR. Let S be that difference which distinguishes, like a signature, the CR from its clones

number,[9] has two important consequences. First, to limit the number of CR dates to 18 980. And to produce, in addition, cyclic events[10] that are resumed by the **theorem**: Whatever the integer ***P***, the almanac date of ***Pth*** day of the vague year is of the form $\alpha\underline{X}_P$, where **α** follows the cycle of 13 integer almanac dates, and where $\underline{X}_P$ follows a class, modulo 5, of four **X** day names. Each day of the 365-day year is thus associated with 13 x 4 = 52 almanac dates who characterize it and succeed one another year after year according to the law: $s(\alpha\underline{X}_P) = s(\alpha)s(\underline{X}_P) = [(\alpha +1), (\underline{X}_P +1)] = [(\alpha +1), (X_P +5)]$. The value $P = 0$ defines the 1st day of the 1st month of the Mayan year, the New Year. Applied to this day, the theorem states, first, that the Mayan New Year is associated with four[11] *tzolkin* $\underline{X}_P$ day names. In other words, the second consequence says that each New Year date $\alpha\underline{X}_P$ distinguishes and defines one and only one *ha'ab* year in the group of 52 years that make up the CR. The system of dates $\alpha\underline{X}_P$ supplied a practical means[12] to distinguish, define and name the years of a CR: by making $\alpha\underline{X}_P$ the eponym for the year.

2. Tonalpohualli, xihuitl and Aztec eponyms

Like all Mesoamericans, the people submitting to the Aztec Triple Alliance used the **αX** dates of the almanac. Public or private, their lives were also organized in cycles of 52 *xihuitl* years, each consisting of 18 *veintena* months of 20 days and a period, ***Nemontemi***.[13] However, the Aztecs have not left written ***βY*** dates prior to the arrival of the Spanish, with the help of the

---

9 Their GCD 5, greatest common divisor.

10 It is the occasion to celebrate, each year among the Maya, the change of Year Bearer; and every 52 years among the Aztecs, the Binding of the years (xiuhtlalpilli) and the New Fire.

11 The entities associated with these 4 names are called the 4 Year Bearers: **Ik**, **Manik**, **Eb** and **Caban** in classic Mayan period.

12 Probably unused in the classic period because the dating methods were particularly redundant. Especially in the use of the solemn public use of stelae and monuments recounting the glory of Mayan cities and leaders in the enameled texts of dates given in the CR system, but also in the Long Count **Σci(Pi)**, in Lunar Series, and other cycles as well. For example: CL **13-baktun 0-katun 0-tun ; 0-uinal 0-kin** and the date CR **4 Ahau *8 Cumku*** from the Stela E of Quiriguá (Guatemala, 771 AD).

13 Except for those who attribute to Mesoamericans the use of a 366-day leap year, sources state that the ***Nemontemi*** contained 5 unlucky days, unnamed, sleeping… In *Historia general de las cosas de Nueva España*, Sahagún gives a list of 18 expressions traditionally accepted as that of the 18 month names although they are "very different from the point of view of their syntactical structure: 'there are gifts of flowers', 'the trees sit up straight', ' little watch', 'skinning people'…" (Launey 2009: personal communication). Sahagún also gives the associated divinities, the name of the period *Nemontemi*, as well as the position (at the period of the months of the Julian calendar. The second *veintena*, ***Tlacaxipehualiztli***, went from March 4 to 23; dedicated to Xipe Totec, it was characterized by the skinning of people. The list is attested to by multiple sources, *modulo* differences: the number of days and the position in the year of the period *Nemontemi*, the month that begins the year and subsequently the numeration of the months. The month ***Quecholli,*** for example, is generally the 14th month, but it is the 13th for Rámirez. In two different texts (manuscript 215 and *Historia antigua de Mexico*) Ixtlilxochitl begins/ends the year in: ***Atlcahualo***/***Nemontemi*** and ***Atemoztli***/ ***Panquetzalztli*** (Roulet 1999).

glyphs of the indigenous pictographic writing. Only certain texts from the colonial period transcribed the detailed Aztec forms for a handful of event dates that were critical for both Worlds into the Latin alphabet;[14] for example "**8 Ehecatl** ***9 Quecholli*** of **1 Acatl**" for Cortez' entry into Mexico City. We thus have only a small body of ***βY*** dates of the type ***9 Quecholli***. To which we may add more vague indications stating, for example, that the twenty monthly ceremonies took place at the beginning, the middle or at the end of the *veintena*. Usually not recorded, the rank within the month remains uncertain when we have it available. The reference ***9 Quecholli*** for example, or the indications first / middle / last day of the month ***Y*** do not allow confirmation that the days corresponding to these dates were, indeed, at the positions ***9***, ***1***, ***10*** and ***20*** of the month ***Y***. Why is this? Because the sources do not say if the Mesoamericans counted their days in the same manner, especially if they began with the same number. However, we are certain that the ways of counting were diverse: the Mayas wrote the numbers from ***0*** to ***19***, the Spanish numbering the days from ***1*** to ***31*** and the Tlapanecs from ***2*** to ***14***. From which are derived two deductions:

1) The CR of 18 980 days distinguished and dated by as many expressions **αX*βY*** is not a tangible reality in the space/time of the Triple Alliance.

2) We can however, from a ***9 Quecholli*** for example, undertake the reconstruction of the dates ***βY*** of a *xihuitl*.[15] Besides the formula of *xihuitl* and its invisible dates,[16] the Aztecs inherited, on one hand, knowledge of the duration (52, in number of years) of the CR and, on the other hand, of the effects of the conventions that structured it and which began the Bearer cycle. This heritage takes into account the representations of successions of *xihuitl* and of *xiuhtlalpilli*[17] and most importantly the habit of distinguishing and noting the years by the ordered succession of their eponyms $\alpha\underline{\mathbf{X}}_{P}$[18] like that of the folio 2r of Mendoza (annexe) going from the year **2 Calli** to the year **13 Acatl** in passing by **2 Acatl** signaled as the year of the celebration of the New fire. Thus, the Aztec date for the day of an event is an expression ($\alpha\mathbf{X}$, $\alpha\underline{\mathbf{X}}_{P}$),

[14] The most sure witness reports concern Cortez' entrance into Mexico City (08/11/1519), the Night of Sorrows when he is driven out, and the destruction of the Temple of Mexico (Tena 1987: ch. IV).

[15] In a more or less credible manner according to the suppositions retained, beginning with that of the number of days attributed to the *xihuitl* (365 or 366?). Or to reconstruct the ***βY*** dates of the 52 years of a *xiuhtlalpilli*, but this with yet more uncertainty.

[16] The ***βY*** dates of type ***9 Quecholli*** that we never see written in indigenous glyphs.

[17] For example, that of the 266 years of the Azoyú Codex and the *xiuhtlalpilli* of the Durán Codex.

[18] $\mathbf{X}_{P}$ are the 4 days, linked to the Bearers among the Mayas. Among the Aztecs, these are the days: **Calli**, **Tochtli**, **Acatl** and **Tecpatl** whose Mayan equivalents are **Akbal**, **Lamat**, **Ben** and **Edznab,** witnessed in the Dresden Codex, but which are neither **Ik**, **Manik**, **Eb** and **Caban** presented in Classical Mayan nor **Kan**, **Muluc**, **Hix** and **Cauac** recorded in the Colonial Period by Landa and the Madrid Codex.

where **αX** is the *tonalpohualli date* of the day of the event and **α**<u>**X**</u>$_{P}$ that of the eponym day of the year in which it occurs. This mode of dating does not result in 18 980 dates as in the case of the Mayan CR, but only 260 x 52 possible different expressions.[19] By its construction, it is ambiguous: 260 dates **αX** are not sufficient to distinguish the 365 days[20] of a *xihuitl*; and 13 520 pairs (**αX**, **α**<u>**X**</u>$_{P}$) are not sufficient to date the days of an Aztec Century of 18 993 days – in *verdadero* (Sahagún) and Julian calendars – or of 18 980 days if one decides to identify it[21] with the Mayan CR.

3. Difficulties and differences

Identifying Mayan and Aztec calendars is a habit[22] whose principal fault is to hide a specific difference: only the Classical Mayas commonly wrote ***βY*** dates of the annual *ha'ab* calendar. When it is noticed,[23] the difference – the inscription of the eponym *vs*. the *ha'ab* date – it is sometimes denied by an interpretation that reduces it to a question of abbreviation or preference.[24] Small cause, big consequence: this stylistic nuance would give, to the Nahuas, 13 520 dates (**αX**, **α**<u>**X**</u>$_{P}$); and to the Mayas, 18 980 dates (**αX**, ***βY***). No, Aztec formulas such as "8 ehécatl of 1 ácatl" and Mayan such as "4 ahau 8 cumku" are not abbreviations denoting the same calendar reality.

These are two types of dates to be analyzed //**8 Ehecatl/1** <u>**Acatl**</u>// and //**4 Ahau/*8 Cumku***//, of very different components. The 1[rst]

19 Not a proper part of the product, though 52 and 260 are divisible by 4 (see the CR), because the law of succession ('linear enumeration', type: 1 January, 2 January, etc.) defined in *tonalpohualli* x *xiuhpohualli* – s(αX, αX$_{P}$) = [s(αX), αX$_{P}$] as long as the *xihuitl* is not passed, otherwise s(αX, αX$_{P}$) = [s(αX), αX$_{P}$+1] – is not the same as that defined in *tzolkin* x *ha'ab* ('diagonal enumeration', type: Monday 1, Tuesday 2, etc.).

20 It is always possible to render the calendar unambiguous by taking an additional cycle, for example, that of the 9 Lords of the Night.

21 Decision leading to the creation of 52 x 105 double dates **αX** to add, in an order to be specified, to the 260 already used in each *xihuitl* year of the Aztec century.

22 "El calendario mesoamericano era el resultado de la combinación entre un ciclo de 365 días, llamado en náhuatl *xiuhpohualli* o "cuenta del año" (*ha'ab* en maya), y otro ciclo de 260 días, llamado en náhuatl *tonalpohualli* o "cuenta de los días" (*tzolkin* in Maya) […] Se requería el transcurso de 18 980 días nominales, equivalentes a un "siglo" de 52 años, para que se agotaran todas las posiciones posibles de un día cualquiera del *tonalpohualli* dentro del *xiuhpohualli*, y viceversa" (Tena 2000: 5).

23 Which it is not always, because the habit of transcribing everything (*tzolkin* date, *ha'ab* date, period, etc.) in the same manner neutralizes and renders invisible many of the differences noted by the scribes.

24 "Tanto los nahuas como los mayas utilizaban una fórmula **abreviada** para los fechamientos, pues ordinariamente no se mencionaban en forma completa todos los elementos que intervenían en una fecha, a saber: el día del *tonalpohualli*, el ordinal del día dentro de la veintena, y el año. Los nahuas **preferían** enunciar sólo el día del *tonalpohualli* y el año; decían, por ejemplo, *8 ehécatl* de *1 ácatl*. Los mayas, en cambio, sólo enunciaban el día del *tzolkín* y el ordinal de la veintena; decían por ejemplo: *4 ahau 8 cumku*" (Tena 2000: 5. AC underlined in bold).

component does not introduce any difference: for both an Aztec and a Maya, it is an $\alpha\mathbf{X}$ almanac date. But the second components are, both in nature and form, different. In Nahuatl: another *tonalpohualli* date $\alpha\underline{\mathbf{X}}_P$, but in Mayan: a *ha'ab* date $\boldsymbol{\beta} \mathit{Y}$. There is no isomorphism.[25] But rather a Type B elder who led the Classical Mayas to write dates ($\alpha\mathbf{X}$, $\boldsymbol{\beta}\mathit{Y}$) and to imply the eponym $\alpha\underline{\mathbf{X}}_P$ and a Type A who, during the Postclassical, led people to write dates ($\alpha\mathbf{X}$, $\alpha\underline{\mathbf{X}}_P$) and to imply the date [$\boldsymbol{\beta}\mathit{Y}$]. The formulas are:

Type A = ($\alpha\mathbf{X}$, $\boldsymbol{\beta}\mathit{Y}$), [$\alpha\underline{\mathbf{X}}_P$] among the Mayas[26]
Type B = ($\alpha\mathbf{X}$, $\alpha\underline{\mathbf{X}}_P$), [$\boldsymbol{\beta}\mathit{Y}$] among the Aztecs.[27]

4. Reflections and conclusions

The non-isomorphism of the Aztec and Mayan calendars possibly has its root in the fact that only the Mayas used the long Count $\boldsymbol{\Sigma c_i(\underline{P}_i)}$ and the CR dates ($\alpha\mathbf{X}\boldsymbol{\beta}\mathit{Y}$) in a joint and immutable manner. This usage led, in effect, to the rigorous synchronous maintenance of the *tzolkin* and *ha'ab* cycles and to never change the number of days of the 365-day year. The real benefit of this rigor was, of course, the possibility of making precise calendar calculations[28] with the help of the Multiplication Tables[29] and the Date Tables that we find so abundantly in the Codex and which served to accomplish the challenges of modular Mayan arithmetic.[30]

Without this rigor and these tools, the scribes would undoubtedly not have been able to simulate the return of eclipses, correct the shortcoming of the Venusian leap year or record the embellished narrative tales of a network

---

[25] In consequence of this non-isomorphism: the contrast between the Mayan facility to find the eponym $\alpha\underline{\mathbf{X}}_P$ from the date $\alpha\mathbf{X}\ \boldsymbol{\beta}\mathit{Y}$ of an event, and the difficulty for a Nahualist to find the date $\boldsymbol{\beta}\mathit{Y}$ from the date ($\alpha\mathbf{X}$, $\alpha\underline{\mathbf{X}}_P$). A Mayan date $\alpha\mathbf{X}\ \boldsymbol{\beta}\mathit{Y}$ defines one and only one day of the CR. The position in the *ha'ab* of the day $\boldsymbol{\beta}\mathit{Y}$ is "$\beta \rightarrow Y$" in spoken protractive numeration. Subsequently, the eponym (*tzolkin* date of the day ***0 Pop***) sought is given by $\alpha\underline{\mathbf{X}}_P = \alpha\mathbf{X} - (\beta \rightarrow Y)$. For example: **7 Eb** is an eponym for the year of **4 Ahau** ***8 Cumku***. Another facilitating factor for the Mayanists is the richness of redundant elements in the calendar expressions.

[26] Whose calendar system imposed the constraint of co-occurrence on the marked components (*tzolkin* date and *ha'ab* date) and implying the redundant eponym.

[27] Whose calendar system imposed writing the eponym $\alpha\underline{\mathbf{X}}_P$ of the year, but no constraint of co-occurrence on the *tonalpohualli* dates (marked) or the *xihuitl* dates (never written).

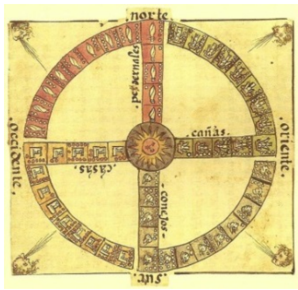
[28] In practice, to one day. The fact that the scribes used all sorts of cycles may be interpreted by saying that they calculated in rings Z/nZ or in classes of appropriate wholes modulo n. Clocks give us a familiar image of this type of calculation which lowers by n any number that reached or surpassed this value, because the hour hand makes additions modulo 12: if it starts from 7 o'clock, for example, and ten hours must be added, it will not mark 17 00 hours, but 5 o'clock.

[29] Containing at times, in the position of intruder, non-multiple numbers serving to correct the calendar deviation in vague years, like that of Venus of the Dresden Codex.

[30] Given 2 dates *x*, *y* (of the Mayan CR to clarity things) and one translation **t** (in whole number of days), solves the 3 equations $\mathbf{t}(x) = y$ *according to whether the unknown is x*, *y* or **t**.

of dates and numbers of distance that celebrated the grandeur of gods, cities, kings... Otherwise stated, it is indeed the rule ROCm (Cauty 2009b:10-12), consequence of the circumstances described above, and cause of the specificities expressed in § 1 by way of the **theorem** which serves as the basis of the possibility of calculating to the day, and which puts it into practice with the constraints of co-ocurrence imposed on couples of the product *tzolkin* x *ha'ab*. It will be further shown that the redundancy brought by the use of the CL[31] acted as a code detecting, even correcting, errors.

For the Aztecs, the product ($\alpha\mathbf{X}$, $\alpha\underline{\mathbf{X}}_P$) of the dates *tonalpohualli* x *xiuhpohualli* is not limited by the factors F_1, F_2 and F_3 because the ***βY*** dates were not or no longer written. Also, in the absence of the Long Count,[32] eventual discrepancies or other calculation errors become difficult not to detect. The Century, *xiuhtlalpilli*, was thus freed from the functional obligations which the ROCm Rule imposed upon the product *tzolkin* x *ha'ab*. Due to this, the cycles $\alpha\mathbf{X}$ and $\alpha\underline{\mathbf{X}}_P$ were like 'free spining gears' in relation to one another. The Almanac had sorted out its 260 $\alpha\mathbf{X}$ dates, but it needed something or someone to increment and count the eponyms $\alpha\underline{\mathbf{X}}_P$ and to maintain the 52-year cycle that no longer rigidly tied to the *xihuitl*.



Colonial or not, the sources do not explain how Mesoamericans without ***βY** dates* went about knowing when to increment the eponym. In principle an Aztec was not obliged to change *xihuitl* like a Maya would change *ha'ab*, that is to say: on the passage from the 365th and last day of the year *n-1* dated ***4 Uayeb*** to the 1rst day of the year *n* dated ***CHUM/0 Pop***.[33] Numerous figures revealing the persistence of the number and of the order of succession of the 52 years of a *xiuhtlalpilli* prove that the tradition of the 365-day year was maintained (Duran Codex).

However, the insistent indication – stating, without proof, that the Natives corrected the vague year, that they possessed a 'real' calendar to

---

31 But also the Distance Numbers, the lunar Series, and other cycles, like that of the Lords of the Night (or patrons of the Underworlds).

32 The 'small' generative capacity of the Aztec written numeration system and its repetitive form are elements unfavorable to the writing of large numbers and the composition of tables of multiples, that partially explains this absence of Aztec Long Counts.

33 Which amounts to changing the manner of counting the days, following the end of the installation of the New Year. Between ***0*** and ***1 Pop*** or between ***1*** and ***2 Pop*** or ***2*** and ***3 Pop*** according to the strategies of enumeration of the ranks ***β*** and the counting of days that we know to have started at ***0***, ***1*** or ***2*** according to the peoples and the periods.

which they added a 366th day every four years – proves two things relative to the Postclassic and Colonial calendar customs. Firstly, that they knew the 365-day year. Secondly, that it seemed to remain in phase with a tropical year of 365.25 days or with a year defined by a whole number of days but of variable length.[34]

The Aztecs could, of course, recognize the changing of seasons or of years. A reasonable hypothesis is thus to suppose that the changing of a year and of the eponym $\alpha\underline{\mathbf{X}}_{p}$ could be decided following the appearance of a designated natural or astronomic sign: the passage of the Sun at the Zenith of a site,[35] a Solstice, a passage at the meridian of *Miec*/*Tianquitzli* (Pléiades), the Bridge of Turtles...

In *Los observatorios subterráneos*,[36] Rubén B. Morante López evaluates the research and the measures taken since the eighties by Aveni and Hartung (1981), Anderson (1981), Broda (1986, 1991) and Tichy (1980, 1992) in the subterranean observatories, notably that of Xochicalco.[37]

The authors record the days upon which rays on light enter into the chamber of the observatory, and the days upon which they do not. The results show that those who conceived the observatories constructed the chimney in such a way as to divide the year in two: one part during which the chamber received the Sun's rays, and a part in which it did not. According to the measurements taken in 1988 – 1992, the first period began on April 30 (once on May 1) and the second on August 13. These dates divide the year into a portion of 105 days and one of 260 days (261 in leap years). The 105 day portion is centered on the Solstice[38] of June 21:

---

34 Consequently, the dates (eponym, n^{th} day of the month, New Year, etc.) do not stray in the seasons like the Mayan ***0 Pop*** should – in spite of the affirmations by Landa who fixed the Mayan New Year on the Christian July 16th, and asserts that the scribes added a 366th day to the year every four years. This type of year more or less elastic is known: it is the festive year (18 x 20 + *p*) or the Catholic liturgical year which has 52 or 53 weeks.

35 In the intertropical zone, the Sun passes twice at the Zenith (before and after the Summer Solstice), and each passage is easily noted by the absence of shadow for objects held vertically (stelae, for example). One may also follow the rising and setting of the Sun in relation to reference points of the horizon or of the city, etc. All of this provides the means to elaborate an annual calendar in phase with the tropical year.

36 On-line: http://www.uv.mx/dgbuv/bd/pyh/1995/2/html/pag/index.htm, the article appeared in 1995 in *La palabra y el hombre.*

37 Are noted (Morante Lopez 2001:48) the subterranean observatories of Teotihuacan (200 AD), Monte Alban (400 AD) or Xochicalco (700 AD).

38 Framed by the 2 passages at the Zenith whose date depends on the latitude of the site.

April 30 + 105 + August 13, August 13 + 260 = April 30,[39] April 30 + 52 = June 21, June 22 + 52 = August 13.

The Aztecs thus disposed of a sort of clock or of calendar giving, live and continuously, the progression of the days and seasons of the tropical year:

	Solstice				
01/V	**21/VI**	**12/VIII**	**13/VIII**		**30/IV**

The interest of the experiment of Xochicalco is to reveal the following points:

Certain Mesoamericans constructed heliographs (markers of rays of light) that gave the beginning and end of two periods. – A lighted period that includes the principal bearings of the tropical year (Summer Solstice and passages at the Zenith) and whose length of 105 days enjoyed undeniable numerological properties. For example: 105 = 5 x 20 + 5 = 2 x 4 x 13 + 1. A period of shadow lasting 260 days equaled the length of the divinatory almanac and catches up with, in four years, the delay of one day that the vague year has on the tropical year. The period of shadow lasts 260 days in a normal year and 261 days[40] in leap years.

Vague Year No. 1		**Vague Year No.2**		**Vague Year No. 3**	
105 days	260 days	105 days	260 days	105 days	260 days

Vague Year No. 4		**Vague Year No. 5**		**Vague Year No. 6**	
105 days	261 days	105 days	260 days	105 days	260 days

Disposing of such a heliograph, the kings and priests have no need of a calendar of the 365-day year, nor even to mark the 365 passing days. Because, in order to know at which point was the tropical year, it was sufficient to go to the observatory to read and interpret what the Sun's rays revealed in this sacred place. And to decide, for example, to increment the Book of Years or to celebrate the New Fire. Without possible error. But in a manner quite distant from the calendar and computational habits of the Classical Mayas.[41]

---

39 August 13 + 261 = April 30, during leap years.

40 Because d(August 13, April 30/May 1) = 260/261 according to whether February counts 28/29 days.

41 At best linked by a cryptomorphism the calendars ($\alpha\mathbf{X}$, $\boldsymbol{\beta Y}$) and ($\alpha\mathbf{X}$, $\alpha\underline{\mathbf{X}}_{\mathbf{P}}$) do not even speak the same language. The 52-year Aztec Century is an adjustable simulation of the solar year, while the Mayan CR is an untouchable arithmetic model made to distinguish and to define each of the 18 980 days of the most typical Mesoamerican temporal cycle. At the price of losing the dates during the seasons and not claiming a 'true calendar.'

During the Postclassic and Colonial period, most of the peoples contented themselves with the dates (**αX**, **α<u>X</u>$_P$**) and to follow in parallel the course of the months of year and the rhythm of the 20 monthly celebrations. In the areas mixed by contact with the Spanish, the Natives had every interest in hiding their attachment to the sacred almanac and to the eponym cycle, largely stigmatized as Satanic works. One way to do so consisted of becoming a user of the vague solar year calendar. *Ha'ab* and *xihuitl* are, indeed, much close to the calendar of the Spaniards, even if they contain 18 months of 20 days instead of 12 months of 30 days on average. The Colonial sources contain Indian calendars that seem to stem from this state of things. These are the annual calendars that respond like the Maya *ha'ab* or the Aztec *xihuitl* to the formula (18 x 20) + 5. But, that differ from it in the manner of writing the 20 dates of a ***Y*** month. At a first analysis, these calendars reveal three types of different situations:

1) The dates of the Mayan months of the Classic Period are of the form ***βY*** and, without going into the details of the representation of ***Uayeb***, we may represent the *ha'ab* calendar by a table of 18/19 columns labeled by the 18 ***Y*** names[42] of the months plus ***Uayeb***, and filled the 360/365 cells of the array by the sequence of the twenty first natural integers which semiotize the twenty numbers ***β*** of the days in the month.[43]

2) For the Mayas of the Postclassic or for the Colonial periods, the months remained unchanged and continued to label the columns of the chart, but the ***β*** positions are no longer written.[44] The monthly columns are, however, filled and learned by the sequence of the 20 **αX** dates of the days of the month, to which the rows α bring a strong character of *trecena*. More precisely, the columns are filled by the dates $\alpha_i\mathbf{X}_j$ where the indexes *i* and *j* vary from 1 to 20, modulo 13 (for the α rows) and modulo 20 (for the **X** names).[45] In the example of the *Calendario de los Indios de Guatemala*, the 20 lines of the days of a month are additionally numbered from 1 to 20 which are said to be the positions of the days in the month. This is

42 The ***Y*** names of the months evidently change with the languages and the periods, but all of the lists contain, with the exception of one translation, the same months in the same order of the type ***Pop***, ***Uo***, etc., ***Cumku***, ***Uayeb.***

43 These 20 rows vary from ***20/0*** (***TI'HA'B/CHUM***) to ***19***.

44 Sometimes doubled by the number ***y*** of its position in the succession of the months of the *ha'ab*. Sometimes translated into Nahuatl or another language, and sometimes doubled by a description in Spanish or Latin. For example, in the *Calendario de los Indios de Guatemala, 1685, Cakchiquel,* http://famsi.org/research/mltdp/ item57 we have: *Mes n° 10 Rucactoεiε.*

45 Reading horizontally, the $\mathbf{X}_j$ are constant, and the α_i in arithmetic progression with a common difference of 7 (modulo 13), so that, in 1 out of 2 columns, they are in the natural order of integers.

evidently a notation made by/for a Spaniard, and not a notation which refers to the β or to the βY dates in the Mayan *ha'ab* of the Classic Period.

3) For the non-Mayas of the Post Classic or Colonial Periods, the months are not identified by their ***Y*** name,[46] but by a scene or a description which seems to vary locally. A bit like the well-known expression *Le temps des cerises* allows a French person to identify the month of June.[47] As in 2), the columns of months are filled with the dates (*tonalpohualli*) of the form $\alpha_i \mathbf{X}_j$.

As shown by the examples of Annexes, it results from 1) and 2) that the Mayan *ha'ab* remained isomorphic to a 365-day year, which amounts to saying that the ROCm rule remained in use. No longer recording the βY dates allowed, however, the tolerance of minor deviations: to change the initial positions of the *tzolkin* and *ha'ab* cycles in relation to one another at the starting moment of the CR. One such deviation reveals itself by a change in the role of the Bearers or the necessity to change the numerical value of the difference S from note 8. But it does not modify the organization of the CR, which remains a calendar of 18 980 dates. In this case, it would be legitimate to reconstruct, from a fragment, the 365 dates of the annual calendar, or the 18 980 of a CR.

In the cases 2) and 3), taking into account the bias introduced by the Colonizer/Colonized contacts, and the imprecision already signaled concerning the eventual length of the *xihuitl* (365? 366? 365.25?), the dating ($\alpha\mathbf{X}$, $\alpha\mathbf{X}_P$) does not, on its own, allow the reconstruction, from a 52-year Aztec Century, of a 18 980-day Calendar Round isomorphic to a Mayan CR cycle.[48] From whence the difficult question of an eventual corrective[49] of the delay of the *ha'ab* or *xihuitl* calendar over the tropical year.

Revisiting the Mesoamerican calendars would consist of crossing a typology of the calendars[50] with a typology of the situations and users.[51]

---

46 Month's sign, or the ***y*** position of the month ***Y*** in the 18-month year.

47 For an example: http://www.lunacommons.org/luna/servlet/view/all/who/Tovar.

48 Marked by 52 $\alpha\underline{\mathbf{X}}_P$ dates in the pages 34-37 of Madrid codex (dates $\underline{\mathbf{X}}_P$ in p. 54-57 of the Dresden).

49 Because correcting the vague year amounts to increasing the duration of a period and redistributing the normal/increased periods. This provokes a substantial delay likely to explain, for example, the diversity of the roles of the Year Bearers or the dates ($\alpha\mathbf{X}$, $[\beta]Y$) of the *Chilam Balam de Tizimin* which contradicts the ROCm of the Classic.

50 On the basis of respect of the ROCm or of the 4 other solutions of equation $|\mathbf{x} - \beta| = \mathrm{S}$ (modulo 5) of the deviations of these rule, we can distinguish, for example: calendars of the type Aztec Century or *calendario verdadero* of 18 993 days (52 *xihuitl* of 365/366 days), calendars of the type CR Mayan Classic of 18 980 days or its four clones, characterized by the roles P_0, P_1, P_2, P_3 and P_4 of the Year. A deviation from the ROCm rule may be provoked by: a change in the variation interval of the rows β, a

This work could cast new light upon the diversity of the roles of the Bearers, eponyms and calendars, and show that the kings of cities with heliography could have, without writing ***βY*** dates, maintain in phase the succession of the *xihuitl* and that of the tropical years. Otherwise stated, here or there, the *Calendario verdadero* may well have had a pre-Hispanic reality. Certainly, different both from the reality of Julian and Gregorian calendars and that of reinterpreted Mesoamerican calendars, in the *mestizo* zones of interaction between the two Worlds, by and for the Colonial and Evangelist institutions of the Europeans.

References

ALVA IXTLILXOCHITL, Fernando de

1977 *Obras Históricas.* Gorman E. O' (ed.), Tomo 2. México: UNAM/Instituto de Investigaciones Históricas.

AVENI, Anthony F.

1981 Tropical Astronomy. *Science* 213.4504: 161-171.

CAUTY, André

2009a Des Porteurs mayas aux éponymes aztèques', on-line publication: http://celia.cnrs.fr/Fr/Pub_Doc.htm#Etudes

2009b Y a-t-il des années surnuméraires mayas ?' on-line publication http://celia.cnrs.fr/Fr/Pub_Doc.htm#Etudes

EDMONSON, Munro S.

2000 Los calendarios de la Conquista. *Arqueología mexicana* VII.41: 40-45.

KIRCHHOFF, Paul

1943 Mesoamérica. Sus Límites Geográficos, Composición Étnica y Caracteres Culturales. *Acta Americana* 1.1: 92-107.

MARCUS, Joyce

2000 Los calendarios. *Arqueología mexicana* VII.41: 12-19.

MORANTE LOPEZ, Ruben B.

2001 Las cámaras astronómicas subterráneas. *Arqueología mexicana* VIII.47: 46-51.

change of synchronization *tzolkin* x *ha'ab*, or a change in the duration of a period (day, month, year, century….) to correct the delay of the vague year over the tropical year.

51 For example: 'experts' (i) Mayan or (ii) Aztec *vs.* 'amateurs' (iii) Mesoamerican, mestizo or Spaniard, of the Post Classic and Colonial Periods, etc.

POHL, Mary E., POPE, Kevin O. & NAGY, Christopher von
2002 Olmec Origins of Mesoamerican Writing. *Science* 6, 298.5600: 1984-1987.

ROULET, Eric
1999 Une page curieuse sur les fêtes aztèques dans un manuscrit du XVIIIe siècle. *Journal de la Société des Américanistes* 85 : 367-373.

TENA, Rafael
1987 *El calendario mexica y la cronografía*. México: Instituto Nacional de Antropología e Historia.
2000 El calendario mesoamericano. *Arqueología mexicana* VII.41: 4-11.

URCID SERRRANO, Javier
2001 *Zapotec hieroglyphic writing*, Studies in Pre-Columbian Art and Archaeology 34, Dumbarton Oaks Research Library and Collection, Washington, D.C.

Abbreviations

The names of days, months, numbers, measurement, and units of time are given in Yucatec (colonial and latin alphabet).
Time units are written in **bold** underlined: **tun**, **kin**
α = integer, ranging from **0** to **13** (inclusive)
β = integer, ranging from ***0*** to ***19*** (inclusive) or from ***1*** to ***20***
X day names are in **Bold** (capital for the first letter): **Ahau**, **Xochitl**
x = position of the day in the cycle of 20 day names (Mayan beginning **Imix**)
$\mathbf{X}_P$ = Porteur (d'année), Year Bearer
Y month names and the period of 5 days are written in ***Bold*** italic (capital for the first letter): ***Pop***, ***Uayeb, Atlcahualo***
y = position in the *ha'ab* (Mayan beginning: ***Pop***)
Mesoamerican figures are transcribed by their corresponding Arabic numerals. Numbers denoting duration are transcribed like **13.0.0;0.0.** where semicolon indicates the passage between **tun** and **uinal** or like **13-baktun 0-katun 0-tun ; 0-uinal 0-kin**
P_i = nodes (count) or periods (units of time measurement)
CL = Compte Long (Long Count)
CR = Calendrier Rituel (Calendar Round)
ROCm = Règle d'Orthodoxie de la Chronologie maya (**4 Ahau *8 Cumku***)
S = $|\mathbf{x} - \beta|$ (modulo 5) is the signature of the days which belong to a same CR.
α**X** * β***Y*** = a starry CR date whose signature is not equal to that of the origin **4 Ahau *8 Cumku.***

ANNEXES

The Mesoamerican year is still a vague solar year composed of 18 months of 20 days, and a remainder of several days. According to the sources, the location, or the historical period, the remainder numbers 5 or 6 days.

There are two main ways to individually determine the days of the year. Like the Classical Mayas, sequencing them by their rank β in the Y period, or like the Aztecs, distinguishing them by their date $\alpha \mathbf{X}$ in the *tonalpohualli*.

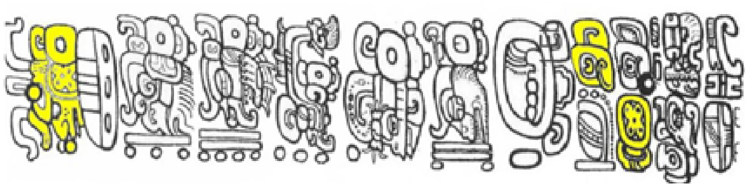
DATES $\alpha \mathbf{X}$ OF THE 20 DAYS OF AN AZTEC MONTH (*TECUILHUITL*, TOVAR CODEX)

4 **Cipactli**	**1 Ozomatli**
5 Ehecatl	**2 Malinalli**
6 Calli	**3 Acatl**
7 Cuetzpalli	**4 Ocelotl**
8 Coatl	**5 Cuauhtli**
9 Miquiztli	**6 Cozcacuauhtli**
10 Mazatl	**7 Olin**
11 Tochtli	**8 Tecpatl**
12 Atl	**9 Quiyahuitl**
13 Itzcuintli	**10 Xochitl**

DATES *βY* OF THE 365 DAYS OF THE 19 PERIODS OF THE MAYAN *HA'AB*

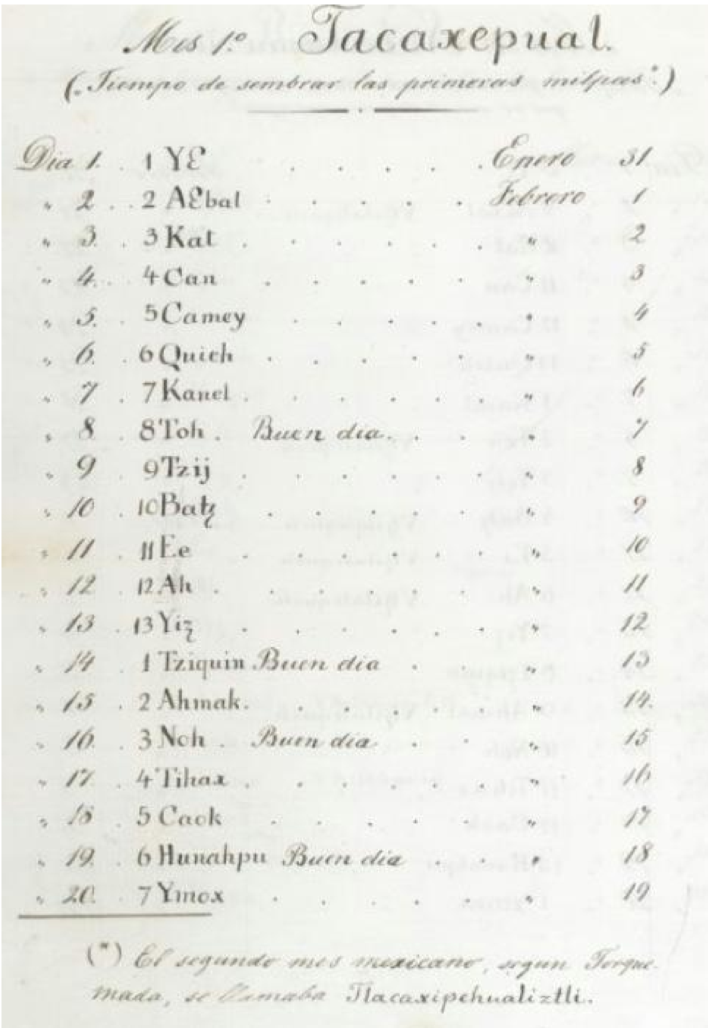
Pop	*Uo*	*Zip*	*Zodz*	*Tzec*	*Xul*	*Yaxkin*	*Mol*	*Ch'en*	*Yax*	*Zac*	*Ceh*	*Mac*	*Kankin*	*Muan*	*Pax*	*Kayab*	*Cumku*	*Uayeb*
0	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
1	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*
2	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*
3	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*
4	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*
5	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	
6	*6*	*6*	*6*	*6*	*6*	*6*	*6*	*6*	*6*	*6*	*6*	*6*	*6*	*6*	*6*	*6*	*6*	
7	*7*	*7*	*7*	*7*	*7*	*7*	*7*	*7*	*7*	*7*	*7*	*7*	*7*	*7*	*7*	*7*	*7*	
8	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	
9	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*9*	
10	*10*	*10*	*10*	*10*	*10*	*10*	*10*	*10*	*10*	*10*	*10*	*10*	*10*	*10*	*10*	*10*	*10*	
11	*11*	*11*	*11*	*11*	*11*	*11*	*11*	*11*	*11*	*11*	*11*	*11*	*11*	*11*	*11*	*11*	*11*	
12	*12*	*12*	*12*	*12*	*12*	*12*	*12*	*12*	*12*	*12*	*12*	*12*	*12*	*12*	*12*	*12*	*12*	
13	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*13*	
14	*14*	*14*	*14*	*14*	*14*	*14*	*14*	*14*	*14*	*14*	*14*	*14*	*14*	*14*	*14*	*14*	*14*	
15	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	
16	*16*	*16*	*16*	*16*	*16*	*16*	*16*	*16*	*16*	*16*	*16*	*16*	*16*	*16*	*16*	*16*	*16*	
17	*17*	*17*	*17*	*17*	*17*	*17*	*17*	*17*	*17*	*17*	*17*	*17*	*17*	*17*	*17*	*17*	*17*	
18	*18*	*18*	*18*	*18*	*18*	*18*	*18*	*18*	*18*	*18*	*18*	*18*	*18*	*18*	*18*	*18*	*18*	
19	*19*	*19*	*19*	*19*	*19*	*19*	*19*	*19*	*19*	*19*	*19*	*19*	*19*	*19*	*19*	*19*	*19*	

***0 Pop*, *1 Pop*, *2 Pop*, etc. *19 Pop*, *0 Uo*, *1 Uo*, etc., *4 Uayeb*.**



8.14.3.1.12.
1 Eb *0 Yaxkin*
(17/09/320)

DATES α**X** OF THE 20 DAYS OF THE 1st MONTH OF THE *HA'AB*
(Calendario de los Cakchiquel)



Mes 1° Tacaxepual.

(Tiempo de sembrar las primeras milpas*)

Dia 1	1 Yɛ		Enero	31
" 2	2 Aɛbal		Febrero	1
" 3	3 Kat		"	2
" 4	4 Can		"	3
" 5	5 Camey		"	4
" 6	6 Quich		"	5
" 7	7 Kanel		"	6
" 8	8 Toh	Buen dia	"	7
" 9	9 Tzij		"	8
" 10	10 Batz		"	9
" 11	11 Ee		"	10
" 12	12 Ah		"	11
" 13	13 Yiz		"	12
" 14	1 Tziquin	Buen dia	"	13
" 15	2 Ahmak		"	14
" 16	3 Noh	Buen dia	"	15
" 17	4 Tihax		"	16
" 18	5 Caok		"	17
" 19	6 Hunahpu	Buen dia	"	18
" 20	7 Ymox		"	19

(*) El segundo mes mexicano, segun Torquemada, se llamaba Tlacaxipehualiztli.

DATES $\alpha\underline{\mathbf{X}}_P$ OF THE 52 YEARS OF THE AZTEC *XIUHTLALPILLI*
(Borbonicus Codex, p. 19/21 and 20/22; $\underline{\mathbf{X}}_P$ = Tochtli, Acatl, Tecpatl, Calli)

DATES $\alpha\underline{\mathbf{X}}_P$ OF THE MENDOZA CODEX

DATES α**X** OF THE 365 DAYS OF THE 19 PERIODS OF THE *HA'AB*

		I	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XI*	*XII*	*XIII*	*XIV*	*XV*	*XVI*	*XVII*	*XVIII*	*XIX*
		Pop	*Uo*	*Zip*	*Zodz*	*Tzec*	*Xul*	*Yaxkin*	*Mol*	*Ch'en*	*Yax*	*Zac*	*Ceh*	*Mac*	*Kankin*	*Muan*	*Pax*	*Kayab*	*Cumku*	*Uayeb*
XX	Ahau	13	7	1	8	2	9	3	10	4	11	5	12	6	13	7	1	8	2	9
I	Imix	1	8	2	9	3	10	4	11	5	12	6	13	7	1	8	2	9	3	10
II	Ik	2	9	3	10	4	11	5	12	6	13	7	1	8	2	9	3	10	4	11
III	Akbal	3	10	4	11	5	12	6	13	7	1	8	2	9	3	10	4	11	5	12
IV	Kan	4	11	5	12	6	13	7	1	8	2	9	3	10	4	11	5	12	6	13
V	Chicchan	5	12	6	13	7	1	8	2	9	3	10	4	11	5	12	6	13	7	
VI	Cimi	6	13	7	1	8	2	9	3	10	4	11	5	12	6	13	7	1	8	
VII	Manik	7	1	8	2	9	3	10	4	11	5	12	6	13	7	1	8	2	9	
VIII	Lamat	8	2	9	3	10	4	11	5	12	6	13	7	1	8	2	9	3	10	
IX	Muluc	9	3	10	4	11	5	12	6	13	7	1	8	2	9	3	10	4	11	
X	Oc	10	4	11	5	12	6	13	7	1	8	2	9	3	10	4	11	5	12	
XI	Chuen	11	5	12	6	13	7	1	8	2	9	3	10	4	11	5	12	6	13	
XII	Eb	12	6	13	7	1	8	2	9	3	10	4	11	5	12	6	13	7	1	
XIII	Ben	13	7	1	8	2	9	3	10	4	11	5	12	6	13	7	1	8	2	
XIV	Hix	1	8	2	9	3	10	4	11	5	12	6	13	7	1	8	2	9	3	
XV	Men	2	9	3	10	4	11	5	12	6	13	7	1	8	2	9	3	10	4	
XVI	Cib	3	10	4	11	5	12	6	13	7	1	8	2	9	3	10	4	11	5	
XVII	Caban	4	11	5	12	6	13	7	1	8	2	9	3	10	4	11	5	12	6	
XVIII	Edznab	5	12	6	13	7	1	8	2	9	3	10	4	11	5	12	6	13	7	
XIX	Cauac	6	13	7	1	8	2	9	3	10	4	11	5	12	6	13	7	1	8	

13 Ahau, 1 Imix, 2 Ik, 3 Akbal, etc. 13 Ben, 1 Hix, etc., 6 Cauac, 7 Ahau, etc., 13 Cimi, etc., etc. 13 Kan.