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The Maya calendar: why 13, 20 and 260?

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Starting from August 13, 3114 BCE, a sort of a mathematical and astronomical measure of time for the Maya was the head of Draco, a constellation in the northern circumpolar sky, which (the head) passed the sky line in 13 days. The other part of the constellation, Draco's neck, passed with respect to the sky line 4 more times of 13 days each. Thus, in one ascension/descension, Draco's head and neck passed the sky line in $5\times13 = 65$ days. A descension was followed by an ascension, then a descension again and an ascension again – to take on the whole $4\times5\times13$ days until 30 April, i.e., $20\times13 = 260$ days. After that, in summer time, due to short nights, Draco was high above the sky line and was not considered relative to it, but the started count continued, to be repeated in another 260 days. Owing to the fact that the constellation is the closest to the Pole of the Ecliptic, its head and neck were always, in the same time of the year, observable for $4\times5\times13 = 260$ days.

Keywords: Calendar; "Measures of time"; "Mathematical time"; "Physical time"; Tzolkin; Haab; Head of Draco; Precessions; Pole of ecliptic; Celestial pole; Five epochs of world history

For a long time the mythological world outlook had been the only way to understand and interpret the reality which surrounded the ancient people. For them, mythical images were not poetic dreams or allegories, but their actual reality.

Restoring mankind's mythological ideas about time seems quite problematic. The mythological world outlook takes its roots in prehistoric times and refers to the infancy of mankind. At that time, with astronomical knowledge accumulating and everyday chronology developing, a unified routine time-reading split up into a uniform mathematical time and a physical time measured by astronomers [1].

For ancient people of various nations, the beginning of the calendar chronology might have meant the time when the social consciousness switched to the mathematical level of time perception, rather than the time of their ancestors' birth. That initiated the mathematical chronology which led to dividing the time continuum into equal intervals, the so-called measures of time.

Analysis of various national mythologies reveals both similar and different measures of time. The day and night measures are the same, being integer units for the other components of the calendar. In other measures of time, however, one can observe discrepancies, which help state the periods of co-existence and temporal differences for some nations. These discrepancies refer both to the day-and-night period

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– as daily hours differ in number and length – and the length of the year, solar or lunar, with various corrections to the length of the tropical year lasting 365.2425 days.

The Europeans display a keen interest in the system of calendars invented by the Maya, a Pre-Columbian Mesoamerican civilization of the Mexican plain, North America. The Maya calendric system keeps astounding scientists by its remarkable accuracy and has no analogues in the Old World.

The Maya calendar dates back to the beginning of the fifth epoch of world history and, according to the Goodman–Martinez–Thompson, or GMT, correlation, its starting point is equivalent to August 13, 3114 BCE in the Gregorian calendar [2–4]. The main distinctive feature of the Maya calendar is a concurrent use of three dating systems: the Long Count, the Haab and the Tzolkin.

The Long Count was used to track longer periods of time and inscribe calendar dates to identify some events in relation to others. The Long Count included such units as a kin (1 day), a winal (20 kins), a tun (18 winals), a katun (20 tuns), a baktun (20 katuns).

The Haab, the Maya civil calendar, represented a 365–366-day annual solar cycle composed of 18 months (winals) of 20 days (kins) each plus 5–6 extra-days at the end of the year. Usual for those times and similar to the European solar calendar, the Haab was used to keep track of the seasons and respect cycles of nature.

The Tzolkin, the Maya divine calendar, gives a 260-day annual cycle composed of 20 weeks of 13 days each. The Tzolkin was used to determine the time of religious and ceremonial events and for divination. The Tzolkin was connected to the Maya cosmogony based on the Maya concept of birth at the beginning of the cycles and death at the end of the cycles in order to be born and die again in the next cycle. The birth and death concepts arose from observing nature, its cycles and phenomena. Smaller cycles made people think of bigger ones; birth and death in a day and night cycle represented birth and death in other cosmic cycles of more than millions and milliards of years.

The Tzolkin and the Haab were united into the Calendar Round where all the dates repeated every 52 Haab's years: $52 \times 365.2425 = 18993$ Haab's days or $73 \times 260 = 18980$ Tzolkin's days (kins) – less than 13 days. Having a mystic attitude towards the end of the cosmic cycles, the Maya expected a doomsday at the completion of each Calendar Round.

The 365-day Haab solar calendar was connected to the 260-day Tzolkin by means of a common time unit called a winal consisting of 20 kins (days), each kin having its own name. In the Tzolkin, however, it was very important to count 20 periods of 13 kins and not 13 winals of 20 kins. At the same time, the order of day names did not change, in other words, after 13 kins a new period began, but the first day of that period was the fourteenth of the 20-day winal. The counting was over when, 260 days later, the first kin called Dragon, its glyph being the head of the dragon, coincided with the first day of the first period.

The Tzolkin counting system cannot be explained by any known measures of time determined by our ancestors on the Eurasian continent. The clue to this system may be hidden in the northern stellar sky of 3114 BCE, when wise Maya were developing their calendar count, having no contact with the Old World.

What were these persistent cycles that the Maya calendar count referred to? What was the Maya measuring unit?

For humankind, the most constant sector of the stellar sky has always been the pole of the ecliptic, which, in the northern stellar sky, is located near the head of Draco. Nowadays the pole of the ecliptic is projected on the point, which is equidistant from all the points of the ecliptic considered as an annual motion of the Sun visible due to the orbital motion of the Earth round the Sun. The motion of the Moon and other planets can be observed close to the ecliptic, too. The pole of the ecliptic is projected on Draco when the Sun is in the present-day part of the Galaxy. The Solar system rotation round the galactic centre takes about 180–200 million years, in other words, 1° rotation takes about 500 thousand years. During the estimated period of history of mankind, that is 5 million years at maximum, the Solar system rotated by an angle of about 10°. Thus, for all that time, terrestrial observers had projected the pole of the ecliptic on the sector close to the head of Draco.

It is worth mentioning that for many nations, such as Indo-European, native Siberian and Southeast Asian peoples, this sector of the stellar sky associated with the symbol of the head of the dragon. Scientific data prove that approximately 20 thousand years ago the Native Americans' ancestors came from Siberia over the Bering Bridge, which used to connect Eurasia with North America. Thus, even in those ancient times, Eurasian nations signed the stellar sky sector close to the pole of the ecliptic with the symbol of the head of the dragon. Besides, it is in those times that the length of the year might have been defined as 360 days plus 5 extra-days, the same way as the solar year was counted on the Eurasian continent. However, having come to America, the Native Americans improved the calendric count by adding the 260-day (kin) Tzolkin.

7200 Tzolkins of 260 kins formed an epoch of world history lasting 1 872 000 kins (days), which equals 5 125.3619 years or, in another way, 5 125 years and 132 days (with amendments in the Gregorian calendar). The Maya believed that each epoch of world history would end in a doomsday. In spite of the expected doomsday, according to the Maya calendar, there are 5 epochs of world history in each big cycle.

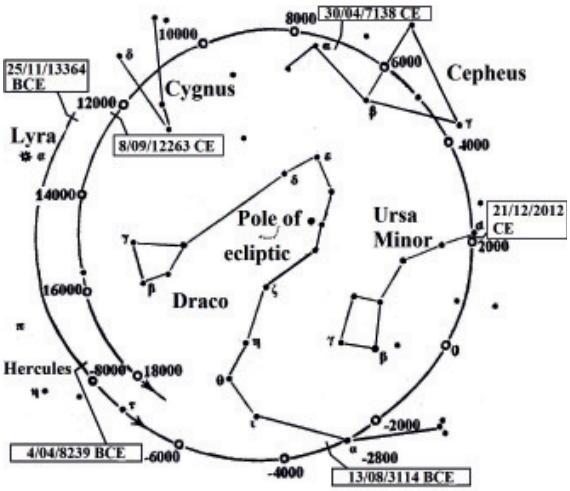


Figure 1 Precession with overlaid starting points of 5 epochs of world history, according to the Maya calendar.

On December 21, 2012 CE the fifth epoch of world history will end and a new cycle of 5 epochs will begin.

Five epochs of world history form a cycle of celestial pole precession lasting about 26 thousand years. On the stellar sky, the celestial pole precession circumscribes a circle with the pole of the ecliptic in the centre, close to the head of Draco (Fig. 1) [5].

The celestial pole changes its location among the stars, while the pole of the ecliptic is observed in the same points all the calendar year round. Therefore, being the most constant sector of the stellar sky, the head of Draco seems suitable to be the calendar starting point. The Maya may be assumed to have lived on the Eurasian continent independently of their ancestors during at least one precession cycle that is 5 epochs of world history, since they must have observed the precession as a recurrent cycle for about 26 thousand years to count 5 epochs of world history.

For the Maya precession cycles to concur with the calendar year dates, the Maya must have counted a big number of precession cycles, because until the concurrence of the dates, in one Maya precession cycle the number of the years is not an integer: $5\,125.3559 \times 5 = 25\,626.7795$ years.

All in all, the Maya calendar totals 41 341 050 000 000 000 000 000 000 000 years. That exceeds the estimated lifetime of the Universe after the Big Bang (13.5–14 milliard years). It does not mean the Maya lived so long ago. The reason is that they did not use fractional numbers in their counting system. In other words, to get integer numbers in counting when the big cycles concur, there should pass as many years as the Maya indicated in their calendar. They added zeros to get 413 410 500 years multiplied by 10 in the twentieth power. Number 20 was the Maya's favourite, as it united two calendar cycles – the Haab and the Tzolkin – by means of the 20-day winal. Besides, this number could have a more ancient origin, being an ancient mathematical "measure of time" associated with the sum of 10 fingers and 10 toes.

The number of 413 410 500 years is approximately equal to the time of two rotation cycles of the Solar system in the Galaxy. This period of time should cover about 16 133.0417... Maya precession cycles lasting approximately $5\,125.3619 \times 5 = 25\,626.8095$ years. 10 in the twentieth power should have given the integer number of the Maya precession cycles.

Each Maya precession cycle consists of 5 epochs of world history. Each epoch counts 13 baktuns (1 872 000 days). Each baktun is made of 20 katuns (144 000 days). Each katun consists of 20 tuns (7200 days). Each tun contains 18 winals of 20 kins (360 days).

So, what is the nature of the initial measuring units in the Tzolkin? What natural stellar sky cycles suggested numbers 13 and 20 to the Maya?

Scientists believe that the names of 20 kins (days) correspond to the sky signs, i.e. constellations and their parts. To clarify the question, we should analyse the circumpolar sector of the northern stellar sky, where, for several millions of years, people have been observing the head of Draco rotating round the celestial pole near the pole of the ecliptic.

The distance from the pole of the ecliptic to the celestial pole changes insignificantly – from 21.5° to 26.5° and back to 21.5° during a period of about 80 thousand years. This is how the angle of inclination of the Earth rotation axis changes with respect to the perpendicular plane of the ecliptic [6]. Thus, the head of Draco is always observed near the celestial pole. However, in the course of time, different stars

and constellations get close to the celestial pole. Therefore circumpolar patterns of the stellar sky differ in different epochs, while the head and the neck of Draco always remain visible in geographical latitudes 21.5° north and higher in the Northern hemisphere.

For the Maya, in this circumpolar pattern the head of Draco, which constitutes 1/5 of the neck of Draco, could have been considered as a measure of time, a specific mathematical and astronomical measuring unit. Discovered by ancient astronomers, the head of Draco became a physical measure of time, the starting point in the Tzolkin having been depicted as the head of the dragon. The sky line might have served as a boundary marker to start measuring and refer to, while estimating the distance to various parts of the head or the neck of Draco in the course of time.

At the beginning of the fifth epoch of world history when the Maya calendar started – August 13, 3114 BCE – Draco's alpha star was in the celestial pole (Fig. 2). On the west, before the sunrise and even before the preceding dawn, the head of Draco was below the sky line, while about 4/5 of its neck remained above the sky line. 13 days later, before the sunrise about 3/5 of the neck remained above the sky line. Thus, 1/5 of the neck falls on every 13 days. After 5 periods of 13 days (65 days), October 17, 3114 BCE, the head and the neck of Draco became invisible on the west to be observed on the east before the sunrise and the preceding dawn. After the next 5 periods of 13 days, December 21, 3114 BCE, Draco became visible on the west after the sunset and dusk. Again, during 5 periods of 13 days, Draco was visible on the west after the sunset and then, during the next 5 periods of 13 days, on the east still after the sunset.

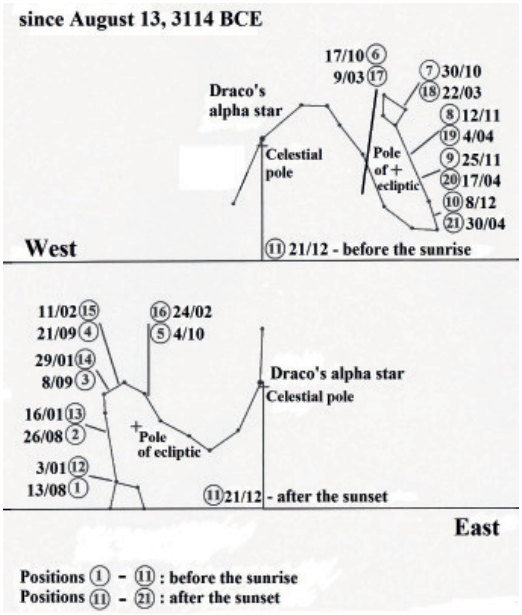


Figure 2 Dated positions of Draco in relation to the sky line in latitudes of Mexico from the starting date of the fifth epoch of world history, August 13, 3114 BCE.

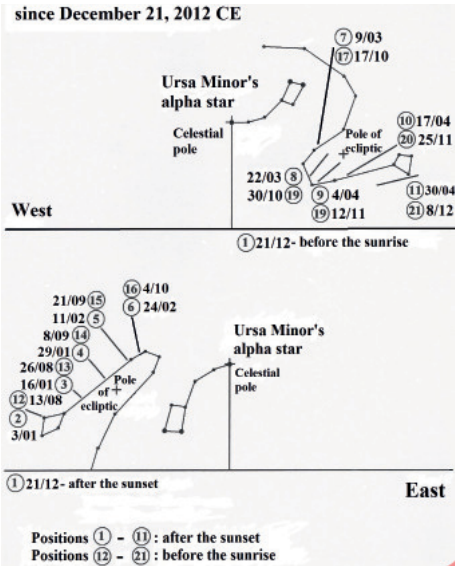


Figure 3 Dated positions of Draco in relation to the sky line in latitudes of Mexico from the starting date of the first epoch of world history, December 21, 2012 CE.

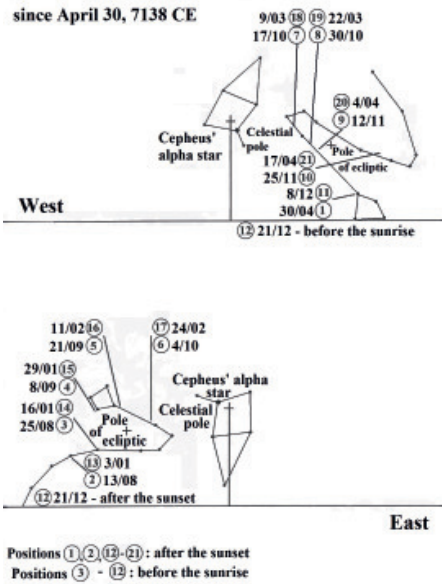


Figure 4 Dated positions of Draco in relation to the sky line in latitudes of Mexico from the starting date of the second epoch of world history, April 30, 7138 CE.

The dates close to December 21 are unique, as in these days the nights are the longest in the year and Draco is visible above the sky line both on the east before the sunrise and on the west after the sunset. This may be a reason why the first epoch of

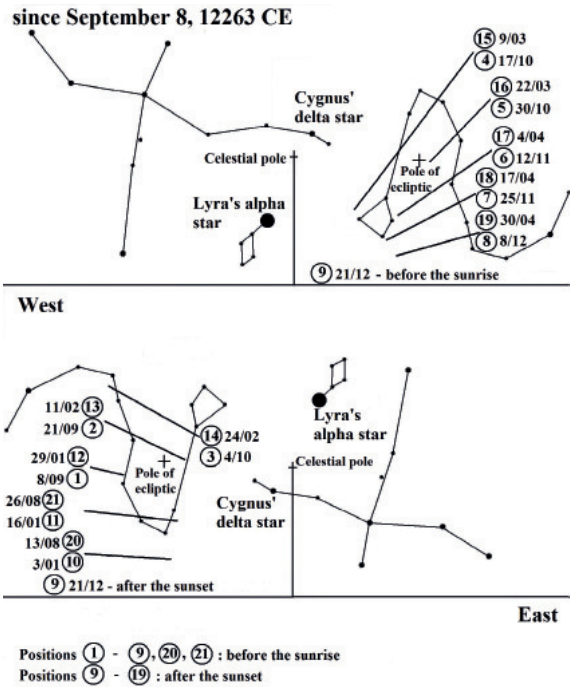


Figure 5 Dated positions of Draco in relation to the sky line in latitudes of Mexico from the starting date of the third epoch of world history, September 8, 12263 CE.

world history begins December 21, the day of winter solstice. For example, nowadays it falls on December 21, 2012 CE.

Therefore the Tzolkin calendric count might have been based on observing the head and the neck of Draco above the sky line during 20 periods of 13 days. On the other days, from April 30 to August 13, nights being shorter in that period of the year, Draco was high above the sky line at night, so its location was not suitable for counting.

The celestial pole is now very close to Ursa Minor's alpha star (Fig. 3). The dates of the Maya calendar, which were expressed in the dates of the modern Gregorian calendar with all leap-year corrections, recur within the periods of each epoch of world history, i.e. they fall on the same time in the cycle of seasons. What changes is the starting date of the epoch of world history.

In our time, the second epoch begins April 30, 7138 CE, Cepheus being close to the celestial pole (Fig. 4).

The third epoch begins September 8, 12263 CE. At that time the wing of Cygnus and Vega – Lyra's alpha star, one of the brightest stars in the northern stellar sky – will be close to the celestial pole.

Before Common Era, the starting date of the third epoch of world history fell on November 25, 13364 BCE (Fig. 5), and at that time the circumpolar pattern was similar. The starting date of the fourth epoch of world history fell on April 4, 8239 BCE. At that time the stars of Hercules were close to the celestial pole (Fig. 6).

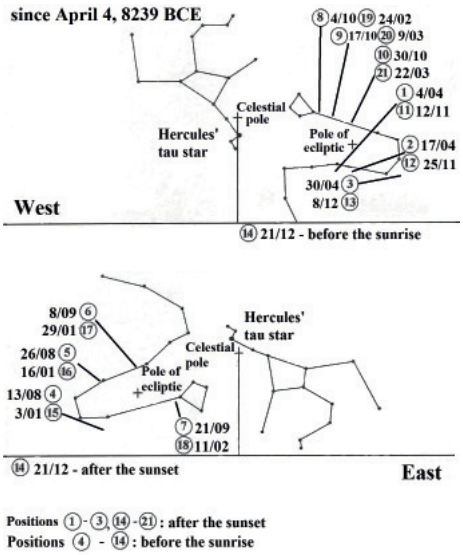


Figure 6 Dated positions of Draco in relation to the sky line in latitudes of Mexico from the starting date of the fourth epoch of world history, April 4, 8239 BCE.

Having analysed from the astronomical standpoint all the five starting dates of the epochs of world history in the Maya precession, we can notice that practically every period starts from the head of Draco; in any case, in 3114 BCE, when they started their calendar counting, the Maya assumed it to always be that way. The symbols of the other 19 days could refer to other constellations, either rising or setting.

The other part of the circumpolar pattern of the northern stellar sky may change drastically, especially in the sector of the celestial pole, since various constellations and stars rise to the celestial pole as a result of the precession. That means that the Maya discovered an astronomical measure of time – the head of Draco – which can practically always be observed in the stellar sky of the Northern hemisphere. This can explain why the Maya calendar turned out to be more precise than other ancient calendars. A successful combination of an astronomical measure of time with a mathematical one generated the Tzolkin calendar counting based on 20, the Maya favourite number. This counting involved 4 periods of observation above the eastern or western sky line, with each period comprising 5 parts of the head and the neck of Draco and each part lasting for 13 days. The Tzolkin is so precise that the starting dates of 13-day periods expressed in the tropical year dates recur in all the epochs of world history in a shifting succession, more precisely, after 130 days, i.e. after 10 periods of 13 days.

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