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Lunar calendar in *rongorongo* texts and rock art of Easter Island

by

Paul HORLEY*

ABSTRACT

This paper analyzes the Mamari lunar calendar using paleographic, astronomical and ethnological data. It confirms that the two last crescents of the calendar correspond to moonless nights. Two small superscript crescents (thought to represent insertion of intercalary nights) have a clear paleographic explanation. Thus, the Mamari calendar consists of 30 nights in full agreement with astronomy and other Polynesian calendars. Studies of Rapa Nui petroglyphs and naked-eye observation of a complete lunation present the evidence for possible relation between delimiter groups of Mamari calendar and sunrise/sunset moon gazing. As full moon is marked with the pictographic sign 152, it was proposed that other explanatory night glyphs may also depict prominent features of moon surface, allowing identification of the current moon phase. Comparison of lunar calendars throughout Polynesia proves that Easter Island calendar has clear Polynesian roots. The variations and shuffling of night names in Rapa Nui calendar suggest that the island was inhabited by a single event, after which it was impossible to reconcile its calendar with those of other Polynesian societies.

KEYWORDS: Easter Island, lunar calendar, *rongorongo*, petroglyphs

RÉSUMÉ

L'analyse le calendrier lunaire Mamari, à partir de données paléographiques, astronomiques et ethnologiques, confirme que les deux derniers croissants de ce calendrier correspondent à des nuits sans lune. Deux petits croissants (précédemment interprétés comme une insertion de nuits intercalaires) ont une explication paléographique claire. Ainsi, le calendrier lunaire Mamari comporte trente nuits, en accord avec l'astronomie et les calendriers des autres îles polynésiennes. L'observation à l'œil nu d'une lunaison complète et l'étude des pétroglyphes de Rapa Nui permettent de proposer une interprétation alternative des groupes délimiteurs, en référence à des observations de lune effectuées au lever ou au coucher du soleil. S'appuyant sur le fait que la pleine lune est représentée dans le texte Mamari par le signe pictographique 152, il est proposé que le reste des glyphes explicatifs nocturnes représentent des caractéristiques de surface de la lune permettant d'identifier la phase lunaire correspondante. La comparaison avec les calendriers lunaires polynésiens prouve clairement que le calendrier de l'île de Pâques et suggère que le peuplement de l'île de Pâques s'est produit en une seule fois, après quoi il n'y avait aucune possibilité de concilier ce calendrier avec ceux des autres sociétés polynésiennes.

MOTS-CLÉS : île de Pâques, calendrier lunaire, *rongorongo*, pétroglyphes

Humans have always been concerned about proper timing of activities to ensure their successful outcome – the crops should be planted at a correct moment to produce the most abundant harvest, hunting will be more efficient during the seasonal appearance of the hunted animals, the construction tasks are easier in a season offering favorable weather conditions, and so on.

Apart from purely practical applications, time reckoning was extremely important for religious and cultural events, marking the dates for ceremonies, holidays and festivals.

As seasonal change is caused by the motion of the Earth in space, it is natural to solve time-tracking problem basing on astronomical observations. The agricultural activities are rela-

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ted to the solar tropical year of 365.242 days (Borkowski, 1991: 127), which can be observed through annual variation of sunrise/sunset azimuth. Easter Islanders had a good knowledge about the motion of the sun, as they constructed ceremonial structures oriented to sunrise/sunset points at equinoxes and solstices, including Ahu Huri A Urenga, Vinapu, Heki'i and Tongariki (Liller, 1993: 11-16).

At the same time, the changes of the moon phases offer efficient time-tracking that do not require marking of a specific point on the horizon. The complete cycle of lunar phases – synodic month or lunation – averages to 29.53 days (Grego, 2005: 52). As lunation does not contain an integer number of days, the lunar calendars usually present a sequence of a “full” month of 30 days followed by a “hollow” month of 29 days, totaling in a bimester of 59 days. The error of this approximation will make up for 24 hours in over 983 days, which can be easily corrected by re-adjusting the calendar by observation. A more complicated problem arises from the fact that the synodic month does not have an integer multiple to make a tropical year, with the latter containing $365.24/29.53 = 12.368$ lunar months. In a three-year course, the remainder will accumulate into 13th lunar month and three extra days, which would require additional corrections to the calendar. One particular solution to the problem was obtained in Ancient Greece, yielding the Metonic cycle of 19 years that will correspond to 235 lunations (Long 1998: 19) with an error of 0.01 days, making a complete day in 1900 years.

There is no information (to the best of my knowledge) on how the ancient Rapanui synchronized lunar and solar cycles. However, it is known for sure that they used lunar calendar and were very keen about the things related to time-accounting, as witnessed by the first missionary to Easter Island, Eugène Eyraud (1866: 124-125):

«Their measure of time is a lunar year. But these memories are fading, so they [islanders] couldn't come to an agreement about the number of the moons [lunar nights]. A remarkable fact! These savages show an extreme interest for everything related to these questions. When I was talking about the months, the sunrise, etc., everybody were coming closer, even the old people, were coming to take their place among the students.»

Further confirmation about the importance of the moon in the ancient culture of Easter Island comes from the “lunar calendar” of *rongorongo* tablet *Mamari* (Barthel, 1958: 242-243; Guy, 1990) and petroglyph panel carved with a sequence of 28 crescents (Lee, 1992: 180). Despite a large number of publications on the subject, the question about lunar observations of Easter Islanders still leave a considerable room for discus-

sion. This paper is devoted to a partial solution of this problem, analyzing the available epigraphic, ethnographic and astronomical data, aiming to reconstruct the ancient Rapa Nui calendar.

The paper uses Barthel's notation for *rongorongo* artifacts and individual signs; glyph tracings are made by the author after the published photographs (Heyerdahl, 1975; van Hoorebeeck, 1979; Ramírez and Huber, 2000; Orliac and Orliac, 1995, 2008).

Ethnographical record of Rapanui calendar

The first ethnographical data on Rapanui lunar calendar was published by Thomson (1891: 546):

«The month is divided into two equal portions, the first beginning with the new moon, and the second with the full moon. The calendar at the time of our visit ran about as follows, the new moon being full on November 26.» (Table 1)

<i>Kokore tahi</i>	Nov 27	<i>Kokore toru</i>	Dec 13
<i>Kokore rua</i>	Nov 28	<i>Kokore hâ</i>	Dec 14
<i>Kokore toru</i>	Nov 29	<i>Kokore rima</i>	Dec 15
<i>Kokore hâ</i>	Nov 30	<i>Tapume</i>	Dec 16
<i>Kokore rima</i>	Dec 1	<i>Matua</i>	Dec 17
<i>Kokore ono</i>	Dec 2	<i>Orongo</i> (LQ)	Dec 18
<i>Maharu</i> (FQ)	Dec 3	<i>Orongo taane</i>	Dec 19
<i>Ohua</i>	Dec 4	<i>Mauri nui</i>	Dec 20
<i>Otua</i>	Dec 5	<i>Mauri Kero</i>	Dec 21
<i>Ohotu</i>	Dec 6	<i>Omutu</i>	Dec 22
<i>Maure</i>	Dec 7	<i>Tueo</i>	Dec 23
<i>Ina-ira</i>	Dec 8	<i>Oata</i>	Dec 24
<i>Ra Kau</i>	Dec 9	<i>Oari</i> (NM)	Dec 25
<i>Omotohi</i> (FM)	Dec 10	<i>Kokore tahi</i>	Dec 26
<i>Kokore tahi</i>	Dec 11	<i>Etc., etc., etc.</i>	
<i>Kokore rua</i>	Dec 12		

TABLE 1. – Thomson's moon calendar

The abbreviations FQ, FM, LQ and NM stands for the first quarter, full moon, last quarter and new moon, respectively. Apart from being the first documentation of lunar nights of Easter Island, Thomson's calendar is considered to have a special value because:

«it appears to have been collected day by day during his stay on Easter Island in 1886.» (Guy, 1990: 135)

The latter statement is slightly misleading for several reasons. First, the *Mohican* expedition stayed at the island from December 18 till “the evening of the last day of the year” (Thomson, 1891: 476), so they could not observe the moon together with the natives on a day-by-day basis for the *whole* period listed in Table 1. Moreover, the schedule of the expedition was extremely tight – in less than two weeks they performed excavations at Vinapu and Orongo, surveyed the whole circumference of the island measuring and

recording 112 ceremonial platforms, gathered a significant ethnographic collection, managed to purchase two *rongorongo* tablets and spent several evenings in a considerable effort to localize and interview Ure Va'e Iko:

«one of the patriarchs of the island [...] [who] [...] have been under instructions in the art of hieroglyphic reading.» (*ibid.*: 514)

Under these circumstances it seems doubtful that the expedition team had a dedicated time for daily moon observations. Most possibly, the question about the calendar surfaced just once during the nights:

«devoted to making notes of the native traditions as translated by Mr. Salmon» (*ibid.*: 477)

and the islanders narrated the *complete* list of the nights with explanations which name correspond to which phase of the moon.

It is instructive to note that Thomson's calendar starts on November 27, when USS *Mohican* was still on her course to Rapa Nui, while for the exact observation diary one would expect the calendar to start on December 18 or 19. It can be objected that Thomson wanted to start the list with a new moon – but the calendar does not begin with a new moon proper, illustrating terminological confusion about the “new moon” term. In the modern astronomy language, the moon is called new when it is in conjunction with the sun and is not visible. However, in many cultures – including Polynesian (e.g., Best 1922a: 29) – the term “new moon” can be used for the first appearance of lunar crescent after the sunset. Most possibly Thomson was told about this, because he treated the “new moon” *Ari* in a modern sense (no moon is visible), starting his calendar with what he thought would be the first crescent – the night *kokore tahi*.

Thomson reports that the new moon occurred on December 25 (when the *Mohican* was anchored at Easter Island) – which would be the day to start the calendar in want to present the whole month starting with the new moon. Despite the expedition left five full days *after* the last date given in the calendar, the corresponding nights are marked as “*etc.*” offering an additional evidence that lunar observations were not carried out after December 26. Therefore, the author is inclined to think that Thomson asked Easter Islanders about their calendar within a week from his arrival, when the new moon did not occurred yet – and that is why he was more disposed to “map” the lunar nights to the preceding month rather than to shift the bulk of the calendar to January. Thus, while it was remarked that:

«Thomson's record of the phases of the moon is not based on a nautical almanac, but on direct observation. This is important, for it means that Thomson's

must be a naïve, first-hand account [...] to be taken at face value» (Guy, 1990: 139)

the question of accuracy of Thomson's calendar remains open, especially because his 1891 report has many other misprints (Horley, 2009b).

The corrected Thomson's calendar was reproduced by Métraux (1940: 50):

«revised in spelling and sequence by Dr. P.H. Buck so as to correspond with other Polynesian systems. [...] The prefix “o” was undoubtedly added before some nights by the Tahitian, Salmon. [...] Thomson's list ends with Tuelo (misspelling for Tiero [*sic*, Tiero]), Oata and Oari, which in other parts of Polynesia are names for the first nights of the moon. [...] By transposing the names Tiero [*sic*], Ari, and Ata, and inserting Hiro, the Easter Island list is brought into conformity with those of New Zealand, Tahiti, Cook Islands, and Tongareva, and the number of named nights is brought up to 30 as required by the lunar month which has 29.5 days.»

Englert's version of the moon calendar (1948: 311-312) includes *Hiro* as a new moon, confirms that *Motohi* corresponds to the full moon and says that *Hua* is the first quarter. Englert's list lacks the *Hotu* and treats *Ari* as an alternative name for *Hiro*, ending up with 28 nights. It was suggested that the unusual shortness of Englert's calendar owes to the fact that:

«his informant gave him the basic, 28-day month without its intercalary nights.» (Guy, 1990: 139)

The supporting evidence for this conclusion seems to appear in the *rongorongo* inscription *Mamari*, discussed in the next section. As Englert mentions both Thomson and Métraux on calendar pages of his book, it seems that his night list was not collected independently but rather based on their publications, which possibly implies that omission of night *Hotu* could have been accidental.

Another native document related to the observations of the moon surfaced during the Norwegian Archaeological Expedition, 1955-56. One page of the manuscript belonging to Esteban Atan (Fig. 1) bears an inscription:

«*He po rae o te mahina he tahi kokore he maro 1936*»
«The first night of the moon is the first *kokore*, June of 1936»

and presents the list of the nights accompanied with schematic drawings of the lunar phases. This list was studied in by Kondratov (1965: 409, 416). The most striking feature of this lunar calendar is significant divergence from the other published versions and overall “shuffling” of night names. While the other sources give the new moon as *Hiro* or *Ari*, Atan's list starts with the first crescent moon in *Kokore* series expanded to seven nights. The names preceding *Rakau*

FIGURE 1. – Moon calendar from Esteban Atan manuscript (image courtesy of the Kon-Tiki Museum)

were forgotten and replaced with invented series of four *Popo* nights. The full moon *Motohi* is followed by *Maure* (which precedes it by two nights in Thomson's calendar) and *Hiro*, heralding a new series of seven [*Te o*] *Hiro* nights replacing the set of five *Kokore* listed by Thomson, Métraux and Englert.

As the Esteban Atan's manuscript was created before the publication of Métraux's monograph in 1940, it may have happened that the detailed knowledge of the moon calendar was already lost, keeping only the "key" nights such as *Motohi* and *Kokore* series. This situation might have improved when Métraux's book reached the island, so that the correct night names were put to use again.

It is important that despite of all its irregularities, Atan's manuscript lists 30 nights in complete accordance with astronomical requirements to accommodate both "full" and "hollow" months. Thus, while the names of many nights were forgotten, the number of nights was remembered correctly. The confirmation of this fact can be found in Juan Haoa manuscript, mentioning that months *Maro* and *Anakena* had 29 days,

while month *Hora iti* had 30 (Kondratov, 1965: 410; Guy, 1992: 121). These results cast additional doubts on Englert's calendar of 28 nights.

Moon calendar of tablet *Mamari*

The repetitive patterns carved on tablet *Mamari* (Fig. 2) were mentioned by Butinov and Knorozov (1957: 10, Table 3.1), but it was Barthel who suggested that left- and right-facing crescents in lines Ca6-9 have different meaning, correctly identifying 30-night moon calendar (1958: 242-243):

«in the passage Ca6-9 [...] a stereotypic expression divides the text into eight sections. Each of these has a number of moon signs, surely including special forms 143 and 152, totaling to 30 occurrences [...] a characteristic number of nights in the synodic period.»

Barthel properly assigned two sets of *kokore* nights, identified glyph 152 with full moon *Motohi* and suggested that two last crescents of the calendar starting line Ca9 correspond to "dark

FIGURE 2. – Photograph of tablet *Mamari* from Alphonse Pinart's archives (image courtesy of Bancroft Library, University of California, Berkeley). Lunar calendar is written in lines Ca6-9.

	Delimiter group	Moon nights
Ca6	I	
Ca6-7	II	
Ca7	III	
Ca7	IV	
Ca7-8	V	
Ca8	VI	
Ca8	VII	
Ca8-9	VIII	
	390.41-378-41-670 - 8.78.711	280-385y-385
		Ca9
		520 - 70
Cb13-14		
	40 - 700	41
Bv2		
	40-41-700	40

FIGURE 3. – Lunar calendar of tablet Mamari. The Roman numerals correspond to the “night groups”. The calendar ends with two crescent signs in line Ca9; the following phrase starting with signs 520-70 also appears in Cb13-14 and Bv2.

moon”, where our natural satellite is invisible being in conjunction with the sun (*ibid.*: 246).

The moon calendar as identified by Barthel is illustrated in Fig. 3. Each lunar night is assigned a number 1-30 starting from the nights corresponding to the first crescent. The delimiter groups marking the division of the calendar into eight parts are denoted with Roman numerals I–VIII. While it is widely accepted that the calendar starts with the first delimiter group, it is far from obvious where it actually ends. Barthel (1958: 244, 246) and Guy (1990: 136) agree that the calendar ends with two crescents (Fig. 3, marked 29 and 30), though the authors interpret these crescents differently. Rjabchikov (1989: 123-124) and the Berthins (2006: 94-95) suggest that two more glyphs 520-70 should be included into the calendar. The author is inclined to think that Barthel’s opinion (1958: 246, footnote 6) was correct, because signs 520-70 enters to the parallel passages shared by the different tablets (Fig. 3, Ca9, Cb14 and Bv2).

Basing on Barthel’s readings of *rongorongo* signs, Krupa made:

«an attempt [...] to interpret [the lunar list of *Mamari*] as a coherent poetical text.» (1971: 8-9)

Krupa’s interpretation was criticized by Guy as:

«not compatible with the calendars gathered by Engler, Thomson, and Métraux, and not compatible with a lunar calendar in general, at least, a functional one.» (1990: 146)

Guy contributed a fundamental paper dedicated to *Mamari* calendar, comparing it with the moon phases during the anchorage of USS *Mohican* at Easter Island, and suggested tentative phonetic values for the glyphs associated with individual nights such as *Hua*, *Atua*, *Maure*, and *Rongo Tane* (Guy, 1990: 143-144). Studying the delimiter groups from tracings published by Barthel, Guy proposed that up/down fish sign 711 in ligature 8.78.711 may be meaningful:

«all three occurrences of [upward] glyph 711 precede the full moon, all four occurrences of [downward] glyph 711x follow it. [...] I see there very strong evidence that 711, either on its own or perhaps only

in combination with the two glyphs to which it is attached [...] expresses the notion of waxing and [vertically flipped] glyph 711x that of waning.» (Guy, 1990: 140-141)

Further analysis of delimiter groups IV and VI resulted in another conclusion:

«glyph 41h, a small version of [crescent] glyph 41, could well refer to the observation that [...] the moon is near its apogee [...] to signal when the apparent diameter of the moon was to be observed (or measured) in order to decide whether intercalary nights were to be use.» (*ibid.*: 140)

This hypothesis offers exciting perspectives to “upgrade” *Mamari* inscription from a simple list of lunar nights into an astronomical canon governing insertion of intercalary nights into the calendar. In this way, one seemingly can explain three peculiarities:

1. Englert’s calendar of 28 nights, which can be treated as a “basic” form of lunar month without intercalary nights;
2. two separately carved crescents in line Ca9, serving as a “repository” of intercalary nights; and
3. two superscript crescents 41h in the delimiter groups IV and VI, presumably related to observation of the apogee moon with its smaller visible diameter.

Fischer’s documentation of the original tablet *Mamari* revealed an unexpected detail:

«It has to be noted that the composite glyph, perhaps v631By.78, has been incised on the tablet edge that begins line RR2a7 [Ca7] in other words, within the ‘calendar’s’ text. Since it is on the edge of the artefact, this glyph appears neither in any photographs of the tablet nor in Barthel’s transcription.» (1997: 418)

The existence of these additional signs was successfully confirmed by study of the original tablet at the Exhibition of 60 objects from Easter Island in Galerie Louise Leiris, Paris, June 3 - July 31, 2008 (Horley, 2009a: 254). The “edge glyphs” perfectly fit the inscription, completing the delimiter group II to the form seen in other delimiters of the calendar. The signs were obviously omitted by a mistake and had to be incised on the edge of the tablet. The evidence for scribal corrections (*ibid.*: 251-255) proves that *rongo-rongo* men paid a serious attention to the accuracy of the texts they produced.

The study of the original artifact revealed that superscript crescents 41h in the delimiter groups IV and VI could be completely explained from a paleographic point of view (Horley, 2009a: 255). The impression is that these crescents

FIGURE 4. – Close-up to Fig. 2 showing superscript crescents 41h in lines: a) Ca7 and b) Ca8 (image courtesy of Bancroft Library, Berkeley). The tracings published by Barthel are given below.

were intentionally carved small despite there was enough space to depict them in full size stems from the tracings published by Barthel, in which the mutual position of the signs was slightly modified to improve the general presentation. The photograph (Fig. 4) clearly shows that these mini-crescents were inscribed into narrow spaces between the signs¹, classifying as inserted glyphs. Moreover, the corresponding crescent sign in the intermediate delimiter group V features abandoned hairline contour of a bird 670, which was re-carved properly nearby (*ibid.*: 253; Fig. 4.b, upside-down contour right above the small crescent in line Ca8). This means that the crescent in delimiter group V was also omitted but, because there was no place to fit it even as a superscript glyph, there was no other option but to discard pre-incised bird and write the sign 41 in full size. Therefore, three delimiter groups in a row – from IV to VI – had to insert an omitted crescent sign, while the remaining groups I-III, VII and VIII feature full-size crescent without any hints about corrections.

Paleographic explanation of small crescents in groups IV and VI influences the hypothesis that tablet *Mamari* contains an astronomical canon for insertion of intercalary nights based on observation of the apogee moon. Wanting to save this hypothesis, one may resort to a possible supporting suggestion considering the hole in the tablet as a kind of sighting device to measure

1. For every line with even number the space above glyph heads is occupied by a preceding line, limiting even more the space available to the scribe.

visible diameter of the moon (Horley, 2009a: 256-257).

From an astronomical point of view, the 28-night lunar month is considerably questionable. While the average length of synodic period is 29.53 days (29^d 12^h 44^m), the shortest/largest duration of a complete lunation is 29.27 (29^d 6^h 35^m) and 29.83 days (29^d 19^h 55^m), respectively (Grego 2005: 52), so that even the shortest synodic month exceeds 29 days. The sidereal period (the time required for the moon to return in the same position with respect of the stars) is 27^d 7^h 43^m long (*ibid.*: 43), but it is much less straightforward to observe. Only anomalistic month averaging to 27^d 13^h 19^m approaches 28 day period (containing 27.55455 days, Steves, 1998: 551). But detection of this period corresponding to the time between two consecutive perigees or apogees of the moon will need careful measurements of its visible diameter on a regular basis. However, these variations are not that pronounced if observed out of full moon phase; please see the difference in size *w* of *Mare Crisium* observed for 3rd and 15th lunar nights, separated approximately by a half of anomalistic month (see Fig. 8).

Therefore, synodic month of 29.53 night is the most favorable for observation, requiring 30 lunar nights to compose a month. On the other hand, if Rapa Nui calendar had a basic lunar cycle of 28 days, it was necessary to insert an intercalary night *each* month, which poses a question whether that night can be actually called "intercalary". On the basis of this evidence, I am inclined to think that omission of the night *Hotu* from Englert's night list was just an occasional mistake, unrelated to any "basic" 28-night month.

Moon-related motifs in Rapa Nui rock art

Among the numerous petroglyphs of Easter Island, there is a lava panel (site 31-44) located in the vicinity of Ahu Ra'ai and featuring "turtles and lines [that] may have some connection with a lunar count; both lines and cupules add up to 28" (Lee, 1992: 180). More details are as follows:

«one great panel has a series of curved lines and cupules in association with three turtle motifs. There are 28 lines, including the edge of the turtle, which gives us a possible hint of an astronomical association» (Lee, 2000: 50)

and:

«[a panel] near Ahu Ra'ai, was called Papa Mahina, or 'moon rock'. According to Georgia Lee, exactly which one is debatable since several papa are scattered around the area and modern Rapanui guides are not

always in agreement [...] Perhaps Papa Mahina was named after the moon because of its round shape; maybe it was a star map showing where the moon moved.» (Liller 1993: 36)

It is important to stress that a similarity between the number of the crescents and the number of nights in synodic month gives us a reason to believe that this panel represents a complete composition with all its details (crescents and turtles) carved within a narrow time window, permitting to analyze this design as a whole. The panel (Fig. 5) should have a preferred viewing direction, possibly with a beholder staying on/behind the turtle tagged "observer" (Fig. 5a). In this case, the crescents of the carving will appear facing left, similar to the crescents denoting lunar nights in tablet *Mamari* (Fig. 2, 3). Importantly, two crescents in the end of the cycle are set within the carapace of the turtle, while two last crescents in *Mamari* calendar appear after the sign group 280-385y-385 (Fig. 3), the first of which also supposedly depicts a turtle. The similar separate depiction of two last moons of the month both in rock art and *rongorongo* is remarkable, strengthening Barthel's suggestion that these crescents correspond to the "moonless" nights (1958: 246).

Analysis of the general composition of the panel 31-44 indicates that two turtles "embracing" the crescents can be tentatively related to the sun. The leftmost crescent is carved behind the "sunset turtle" that swims away; the first moon also appears just after the sunset. At the right side of the panel, the crescents are being followed by swimming in "sunrise turtle", which correspond to last crescents disappearing at dawn. The moon of night 28 can be difficult to spot (Fig. 7b), so it is carved coinciding with the outlines of the carapace (*i.e.*, "touching the sun", Fig. 5a). Two crescents carved within its carapace ("inside the sun") suggest that the ancient Rapanui knew that the absence of the moon is caused by its conjunction with the sun. Maori lore explains this phenomenon in the following way:

«at certain time the moon approaches its elder brother, the sun, and the two move for a period. The moon belittles itself in the presence of its more important elder; its importance (brightness) is lost in the superior magnificence of the sun. After a time the moon leaves the sun behind; then it is said by man 'The moon is again seen'.» (Best, 1922b: 20)

The Polynesian tradition of re-appearance of the first crescent also involves the sun:

«The popular Maori myth [...] is that the stricken moon hides to the waiora Tane, or life-giving waters of Tane [...] She bathes in that fountain of youth, and returns to earth again young and beautiful. This quaint fancy is known as far away as Hawaiian Isles,

FIGURE 5. – Turtle petroglyph site 31-44 near Ahu Ra'ai:

- a) tracings (image courtesy of G. Lee). The numbers designate lunar nights; the turtles “embracing” the crescents can be related to the sun: the first crescent follows the setting sun and the old moon gets “caught up” by the rising sun. The two crescents inside the “sunrise turtle” for the nights when the moon is invisible being in conjunction with the sun;
- b) general view of the panel with “observer turtle” (image courtesy of K. Merritt);
- c) “sunset turtle” (image courtesy of C. Stevenson);
- d) “sunrise turtle” (image courtesy of C. Stevenson). Letters H, F and C marks head, front fins and carapace outline; the arrows inside the carapaces mark directions in which head and fins are oriented. The curved arrow follows the general “flow” of the crescents.

where the clearest proof exists that Tane is the personified form of the sun.» (Best, 1922b: 22)

Fedorova (1978: 18) continues:

«For many Polynesians Tane is the god of light and life; on Hawaiian islands [...] the houses were facing the East in honor of god Tane; on Mangareva he was the symbol of solar heat and fire.»

At first glance, it is tempting to speculate that the turtles of panel 31-44 with their round “sun-disc” carapaces may represent Tane. However, one will rather expect that sea creatures should personify Tangaroa (Fedorova, 1978: 19). This problem can be solved by suggesting that turtles might have been considered as “carriers” of the sun across the sky. The “transporting” role of turtles is known from the legend “Uho and the turtle” (Métreaux, 1940: 372-373). A young girl Uho followed the turtle to arrive to the foreign land, where she married a man called Mahuna-te-raa. Curiously, *mahuna* translates as the “seed” (Fedorova, 1988: 145) and *ra’a* means “sun” (*ibid.*: 168). Nostalgic about her home, Uho sings the song “This country of yours is dark, o Mahuna-te-raa my husband, it is not like our country on the bright side” (Métreaux, 1940:

373), as if hinting that the land she came might be the Underworld where the “seed of the sun” dwells waiting for the dawn. Namely at dawn the turtle carries Uho back to her homeland (*ibid.*). A similar narrative is associated with a petroglyph (Fig. 6a):

«at Omohe [...] large turtles are said to figure in a still-remembered legend concerning a man who left and then returned to the island on the back of a turtle. This man really was a god Makemake in disguise.» (Lee, 1992: 82)

According to Métreaux (1940: 314):

«Makemake [can be considered] the local Easter Island name for the old god Tane»

seemingly corroborating the hypothesis that the sun (as personification of Tane, or Makemake of Rapa Nui) could have been carried by a turtle.

Other rock art motifs are also probably related to the sun and the moon. Two turtles with round carapaces carved inland from Ra’ai (Fig. 6b) follow each other nose-to-tail in East-West direction (Lee, 2000: 48, Fig. 9). Curiously, the leading turtle is associated with a fish hook, which is also the case of “sunset turtle” on panel 31-44 (Fig.

FIGURE 6. – Petroglyphs depicting turtles, the sun and the moon (images courtesy of G. Lee)

- a) large turtle with Makemake eye mask faces from petroglyph panel at Omohe;
- b) two turtles from “paenga factory” inland from Ra’ai, oriented East-West;
- c) the moon and the sun from Ava o Kiri.

FIGURE 7. – Course of the moon in the skies above Easter Island for 30-day lunar month of August 2008: first crescent (night 1) – August 2; full moon (night 15) – August 16. Dark moons (nights 29, 30) for August 31 and September 1 are shown as black circles in bottom right corner. The figures represent a composite computer-generated image visualized with Stellarium. The celestial dome is shown in stereographic projection, in which zenithal moon appears smaller than that close to the horizon. The visible diameter of the moon is increased for the clarity of presentation. Moon observations are intended to be performed at a fixed hour a) after the sunset; b) before the sunrise.

5a). The designs from Ava o Kiri (Fig. 6c) shows the sun (bottom right) situated below wavy lines (the horizon?) with two crescent shapes above. The crescents are carved “horns upward”, just as the young moon is seen from Rapa Nui (Fig. 8a). It is tempting to suggest that the right moon represents the first crescent, while the left one (which is thicker and is depicted at larger distance from the sun) would be the second lunar night.

Resuming the analysis of the panel 31-44, one should address the question of night count. As we have seen, it is quite improbable that the lunar calendar includes only 28 nights; moreover, a remarkable coincidence of this petroglyph panel with *Mamari* inscription (orientation of the crescents and a separate depiction of two last nights inside the turtle) makes one think that both monuments should have the same night count of thirty. It is worth noting that the “observer turtle” faces the middle of the moon series (Fig. 5a), which coincides with a promontory of the panel (Fig. 5b, d). The crescents of waxing moon become pronouncedly rounded for the nights 13 and 14, but for the month of 30 nights the full moon should occur on the 15th night. However, one should note that there is a curved line in front of the “observer turtle”, slightly raised above the other crescents. It is quite probable that this highlighted night should correspond to the full moon (Fig. 5a, 15). This suggestion is seemingly confirmed by the orientation of the panel, with the “observer turtle” facing approximately to the east, towards Poike peninsula (Fig. 5b). As Moon is full when being in opposition to the sun, it will be rising at sunset (Fig. 7a, 15).

Thus, if the turtles of the panel 31-44 are related to the sun, the “observer turtle” looking towards the mark for the 15th lunar night can be interpreted as a depiction of the setting sun “facing” the rise of *Motohi* moon.

Counting back from the crescents carved inside the “sunrise turtle” (nights 29 and 30), one will find that the crescent standing to the right from the full moon mark represents night 17, with no crescent for 16th night documented. However, considerable erosion of panel 31-44 (Fig. 5b and c) and suspiciously wide space between the marks for the 15th and 17th nights (Fig. 5a) makes one think that the crescent for 16th lunar night may be there, escaping documentation due to the bad condition of rock surface.

Observations of the moon

To understand lunar calendar better, it was decided to observe and photograph the moon during a complete lunation (Fig. 8). The extremely favorable meteorological conditions in Lisbon (Portugal) with July and August almost devoid of clouds made these observations possible, resulting in photographic documentation of 25 out of 28 visible lunar phases. The missing phases, low dusk and dawn crescents, were very hard to spot due to the obstructed horizon in urban multi-store environment. The missing phases and images of the new moon were visualized with Stellarium (www.stellarium.org).

The naked-eye observations of the moon were extremely beneficial. It became immediately

FIGURE 8. – Photographic record of the moon during the 30-day lunation of August 2008 (images are taken by the author in Lisbon). The orientation of the moon corresponds to that seen from Easter Island, according to Stellarium. The numbers in the bottom right corner correspond to the moon age; the numbers in upper left corner are dates, prefixed with “A” for August and “S” for September. The images for the nights 1, 27-30 are generated by Stellarium. The Roman numbers I-VIII in the bands refer to *Mamari* calendar groups. The diagram below illustrates the conversion between the days of 00-24 hours and moon nights: moon rising just before the midnight “joins” two neighboring days (*i.e.*, the moon of August 17 is the same as that of August 16, hence August 17 should be skipped); moon setting before the sunrise is distinct from the moon appearing in the same evening (so that September 1 should be counted twice, as new moon before the sunrise and as first crescent after the sunset). The effect of librations is shown in the bottom right corner, comparing distance d of *Mare Crisium* from the edge of the moon. The change in width w of this formation is due to apogee/perigee moon, observed on nights 3 and 15 separated by about a half of anomalistic month.

clear why the majority (eight out of eleven) of “explanatory glyphs” associated to lunar nights in *Mamari* calendar accompany the waxing moon – that is, when the moon is most easily observable in the evening sky. Two of the remaining “explanatory glyphs” are given for the 8th and 9th nights after the *Motohi* phase, when the waning moon appears high in the sky at the sunrise. In other words, the “explanatory glyphs” stand by the moon phases that are comfortably observable under normal life activities and time dedicated to sleeping.

Moreover, twilight observation is beneficial due to a mild visual contrast of the moon. This detail becomes essential closer to the full moon phase, when later at night the moon shine is strong and irritates the eye aimed to study the main lunar features. Twilight moon gazing reveals another useful property – the lunation can be easily di-

vided in half by observing the moon right after the sunset or right before the sunrise. The full moon will emerge just as the sun disappears below the horizon. As Moon moves daily for about 13° (Grego 2005: 52), each night it will rise later, with a retardation from dozens of minutes to about an hour depending on the angle at which the ecliptic intersects the local horizon (*ibid.*, 54). Therefore, one night after the full moon, the moonrise will be delayed in relation to the sunset. This detail will spare the observer from meticulous verification if the moon is still round enough to be called *Motohi*.

Therefore, the first half of the lunation can be conveniently viewed at the dusk (Fig. 7a). In a similar way, starting from the night after the full moon, the rest of the lunation is easy to observe at dawn (Fig. 7b). These observations agree well with Thomson’s comment (1891:

546) that Rapa Nui lunar calendar was bipartite. The delimiters of *Mamari* calendar have two scribal variants of a characteristic group 8.78.711 (Fig. 3), with final fish facing up (with the only exception of the edge glyph of group II) when the moon is waxing and facing down when it is waning (Guy, 1990: 141). In the light of twilight moon gazing hypothesis, one can suggest an alternative interpretation of the ligature 8.78.711, which may mean that the moon rises/sets after the sun, or, perhaps, that the moon follows/precedes it. At the first glance, possible inclusion of the sun into this ligature seems favorable, because sign 8 was read as “sun” by Metoro (see Jaussen list, Robinson, 2002: 228). However, one should take an extra caution with Metoro’s readings (Guy, 1999). On the other hand, if *rongorongo* represent syllabic script, the ligature 8.78.711 could constitute a word related to the motion, with its final fish element possibly adding a visual hint for up/down direction.

It is essential to emphasize that the glyph corresponding to the full moon is purely pictographic, showing woman-in-the-moon (Guy, 1990: 136). This lunar pareidolia is common to the South Seas, with the correct orientation of the picture for moonrise observation (Fig. 9.15). One may ask whether the other “explanatory” glyphs for individual nights may also contain pictographic hints to some characteristic lunar features. Outside of the calendar, these glyphs are expected to behave normally (*i.e.*, to represent syllables if *rongorongo* is syllabic or words if it is logographic).

The idea about “identification tags” for the key phases is attractive. As any astronomic observation, moon watching is heavily dependent on weather. With several cloudy days, it is easy to lose the track of calendar if it is not recorded on a day-by-day basis – for example, moving a stone over an array of cupules. However, such records are vulnerable to vandals, heavy rainfall, etc., so that it would be highly relevant to reconcile the day count at the first possible observation of the moon.

It is worth noting that the division of the month in half is indicative that first crescent and full moon were the most important nights. The apparent lack of interest for the intermediate key phases (such as the first and last quarters, which help to divide a lunation into weeks) was perhaps due to variability of the related periods:

«More confounding [...] is the fluctuation of [...] time between any two successive [key] phases, full moon to last quarter, for example. [...] If these periods were equal, each would span 7.38 days, or one quarter of synodic month. But instead, they vary by [...] plus or minus 19 hours [...] [so that the time between the aforementioned phases changes] from

six to nine calendar days, although most periods are not this extreme.» (Long, 1998: 19)

Therefore, one may hypothesize that the main task of moon-based time-keeping was to know (or to be able to predict) how many nights are left or passed since the full moon. The similar calendar re-synchronization by means of full moon observations was used in the astronomical practices of Maori:

«the fifteenth night is an Ohua [full moon in New Zealand], but in certain months it is the sixteenth night, and sometimes it is the seventeenth night – that is, were the condition of full moon is attained. If the moon does not become full until the seventeenth night, then the fifteenth, sixteenth, and seventeenth nights are all termed Ohua, and then the last three nights of the moon, Orongonui, Maurea, and Mutu, are omitted, because a new moon has appeared.» (Best, 1922b: 30)

The sighting of the first crescent was an important event, which naturally explains the presence of the “explanatory glyphs” associated with two initial lunar nights. For some days since then, there was no need to worry about the full moon, so that the whole *Kokore* series of six nights don’t have any additional glyphs associated. However, as the moon passed the first quarter, the task of phase identification seemingly gained more weight that explains the presence of six “explanatory glyphs” for seven nights including *Motahi*. After that, the astronomer could rest till the last quarter (around which two more “explanatory glyphs” are placed), perhaps implying that at this time the calendar could have been adjusted again upon necessity in preparation for the forthcoming new moon. The final “explanatory glyphs” mark the group of two moonless nights, closing the lunar month.

Figure 9 presents names of lunar seas, mountains and craters; below, we illustrate each night with its descriptive glyph. It is important to comment that libration (slight “rocking” of the moon around its vertical axis due to interplay between its changing orbital and constant rotation speed) may shift the terminator (the boundary between illuminated and dark parts of the lunar surface) for the different lunations. The effect of libration can be seen as variation of the distance *d* of *Mare Crisium* from the border of the moon (Fig. 8, lower right corner, nights 3 and 15). Thus, one should have in mind that, for a given lunation, a phase with the best match of moon features to that of “explanatory glyph” may be shifted for about a day either forward or backward due to the librations.

The descriptive glyph 40.10 for the first night *Ata* perhaps only conveys the notion that the moon is born. The second night *Ari* is associa-

FIGURE 9. – Main seas and craters visible to a naked eye (top panel). Below: tentative identification of the moon features with the “explanatory glyphs” of *Mamari* calendar.

ted with feathered glyph 30. While the presence of barbs on the line could have been intended to denote that moon grew thicker this night, it may be also plausible to associate the shape of glyph 30 with a crescent displaying *Mare Crisium*, which will resemble a characteristic “ear” of the sign. For the observed lunation, this feature becomes visible on the 3rd night (Fig. 9.3). However, due to librations it may appear on the 2nd night as well. The 10th night *Hua* is associated with glyph 74f; it is expected that the similar shape should appear on the left-hand side of the moon, which may be a light oval to the left of *Mare Frigoris* (Fig. 9.10). However, this identification is uncertain. On the other hand, one can also maintain that glyph 74f is hinting on the night’s name as “ideogram for ‘hua’ meaning ‘fruit, to fructify’” (Guy, 1990: 143-144).

The 11th night *Atua* is associated with a “feathered hook” sign 59f standing to the left of the crescent. Similarly, one can see a “hook” on the left side of the moon disc formed by Apennine, Caucasus and Jura mountains contrasting with darker *Ocean Procellarum*. The bottom right appendage (foot?) of the sign will correspond to Kepler crater (visible due to its light-colored halo) appearing partially at the terminator (Fig. 9.11). The crescent sign for the night *Atua* has an irregular appendage to the right; one may tentatively relate it to the characteristic “pointed” look of the right-hand side of the moon, filled by the bright lines spreading from the crater Tycho.

On 12th night crater Kepler appears away from the terminator; it looks like an isolated object now, dispelling the illusion of being a “leg” of the “hook”. For this night, *Maure*, the crescent

2. Guy (1990: 135) suggests that “glyph transcribed 44 by Barthel has been transcribed here as 78 ... [that] resembles it far more than glyph 44”. However, the real shape of this glyph is quite different from both signs 44 and 78 (compare the photo with tracings published by Barthel, Fig. 4.a).

in tablet *Mamari* is appended with a wavy object, identified with Barthel's sign 44. It may serve as a hint for the night name as "a visual pun: a crescent (40A) with a penis (78)², 'ma ure'" (Guy, 1990: 144). However, on this night *Mare Frigoris* with a very similar shape is seen on left side of the moon. One night before it seemed isolated, but on 12th night it looks connected with *Ocean Procellarum*, just as it is carved in ligature 44.40 (Fig. 9.12). The 14th night *Rakau* is depicted as a crescent "embracing" the oval, glyph 143. It may express the notion that the bottom "coast" of *Ocean Procellarum* is not seen yet, so that the moon misses this "closing curve" to be complete. The full moon *Motohi* is associated with a unique sign 152 depicting an oval described around a woman-in-the-moon formed by *Mare Tranquillitatis*/Mare *Serenitatis* (body), *Mare Fecunditatis* (head), *Mare Nectaris* (arm) and *Mare Vaporum*/Sinus *Medii* (foot). The crossed pointed contours at the bottom of the glyph 152 represent *Mare Imbrium* and *Mare Nubium*/Mare *Humorum*, with the latter two looking considerably pointed (Fig. 9.15).

The 23rd night is associated with a ligature 3.40. Remarkably, there is a line of light-colored formations in *Ocean Procellarum* (craters Bulliadus, Kepler and Aristarchus), superficially resembling the "feathered garland" glyph 3 (Fig. 9. 23). The 24th night is preceded with a bird sign 600, which may be "a frigate bird ('taha' in Pascuan) [...] [functioning] as a phonogram for the first syllable of Tane [in Rongo Tane]" (Guy, 1990: 143). As an alternative explanation, one can suggest that the bright/dark areas on the moon may make a semblance of an avian head with *Mare Humorum* being an eye and crater Grimaldi – a nostril (Fig. 9.24). The remaining "explanatory glyphs" 280-385-385 prefixing two last crescents of the calendar are associated

with "dark moon", and hence, cannot be related to any lunar features.

Thus, in addition to Guy's interpretation (1990: 143-144) of the "explanatory glyphs" in *Mamari* calendar, it is possible to propose another hypothesis treating these glyphs as pictographs of characteristic lunar features that helps to identify the current phase of the moon.

Lunar calendars throughout Polynesia

Voicing the concerns about the accuracy of the Thomson's calendar, it is important to compare it (together with the corrected version published by Métraux) against the inscription of the *Mamari* tablet. Associating *Kokore* series with the groups of six and five crescents following the delimiter groups II and V, one will find the following controversy: Thomson's list gives eight nights between *Kokore* series, while the calendar of *Mamari* contains only seven of these (Fig. 3, nights 9-15). Treating *Mamari*'s version as correct genuine Rapanui inscription, one reaches the conclusion that Thomson's list contains a misplaced night. The most suspicious name in this group is *Ina-ira*, which "is a form without equivalent in Polynesia and may be a misprint" (Métraux, 1940: 51). Curiously, "*ina ira*" translates as "not there" (Englert, 1948: 455), suggesting that Thomson's informants may have mentioned a wrong night; to correct the situation, they said that the night was "*ina ira*" – not there – and thus has to be removed. Instead, *Ina-ira* was recorded as a legitimate name.

Further comments by Métraux (1940: 51) say that:

«Thomson's list omits Hiro (2nd night) which was given to me as the name for a new crescent moon [...] Tapume and Matua [also] have no parallel elsewhere.»

FIGURE 10. – Map of Polynesia (background image courtesy of Natural Earth, naturalearthdata.com) showing the islands with analyzed lunar calendars, Table 2

With these comments, one can compare a corrected Rapa Nui calendar (with *Mamari* night groups marked in Roman numerals) with lunar calendars collected from the other Polynesian islands (Table 2). The columns in the table are arranged in accordance with geographical location, listing the places by their approximate increasing distance from Easter Island (Fig. 10).

It is important that the other calendars include 30 nights (with exception of Moriori that lists 31 of these), confirming that *Mamari* inscription contains a complete lunation. Easter Island version of lunar calendar can be successfully aligned with those from the other islands. However, the full moon at Rapa Nui is *Motohi*, which belongs to *Rakau-Motohi* series. On other islands, the full moon occurs in preceding night night group *Hotu-Maure-Marangi*. Thus, Easter Island

Night # E.I.	Easter Island (Métraux 1940)	Mangareva (Williams 1928)	Marquesas (Williams 1928)	Tahiti (Williams 1928)	Mangalia (Best 1922)	Hawai'i (Williams 1928)	Motiori (Williams 1928)	New Zealand (Best 1922)	Night # others
29	Group VIII Tirao	Maema tahi	Tunui	Tirao	iro	Hilo	Owhiro	Whiro	1
30	Maema rua	Tuhava	Tuhava	Hirohiti	Oata	Hoaka	Oere	Tirea	2
1	Maema toru	Tuhaka hoata	Maheama tahi	Hoata	Aniama	Kukahi	Ohehata	Ohoata	3
2	Maema riro	Maheama vaena	Maheama tahi	Hamiana mua	Amiana-akaoti	Kulua	Oua	Oue	4
3	Kore tahi	Maheama vaena	Maheama tahi	Hamiana roto	Tamatea	Kukulu	Okoro	Okoro	5
4	Kokore rua	Maheama haapoo	Maheama tahi	Hamiana muri	Tamatea-akaoti	Kupau	Tamate tufahi	Tamatea	6
5	Kokore toru	Koekoe tufahi	Koekoe tufahi	Oreore mua	Korekore	Ole kahi	Tamatea-alo	Tamatea-alo	7
6	Kokore ha	Koekoe vavena	Koekoe vavena	Oreore muri	Korekore-akaoti	Ole kulua	Tamatea-alo	Tamatea-alo	8
7	Kokore rima	Koekoe haapoo	Koekoe haapoo	Tamatea	Ovahi	Ole kukulu	Tamatea-alo	Tamatea-alo	9
8	Kokore ono	Ai	Ai	Huna	Uha	Ole pau	Tamatea-alo	Tamatea-alo	10
9	Maharu	Omawaru	Omawaru	Ari	Ma'aru	Huna	Hokawatu	Huna	11
10	Hua	Ohua	Ohua	Maharu	Ua	Mohalu	Hua	Hua	12
11	Atua	Oetua	Hua	Hua	Atua	Hua	Mawharu	Mawharu	13
12	Hotu	Ohotu	Atua	Maitu	Otu	Akua	Outua	Atua	14
13	Maure	Omaure	Honu (Hohotu) nui	Hotu	Marangi	Hoku	Ohotu	Ohua	15
14	Rakau	Oturau	Honu ma akau	Mara'i	Oturau	Mahealani	Maure	Turu	16
15	Motohi	Orakau	Tuu	Turutea	Rakau	Kulu	Oturau	Rakau-nui	17
16	Kokore tahi	Omotohi	Aniwa	Raua mua	Rakau-oto	Lau kukahi	Rakau nui	Rakau-matohi	18
17	Kokore rua	Kokore tahi	Akau	Raua roto	Rakau-akaoti	Lau kulua	Rakau motohe	Takirau	19
18	Kokore toru	Kokore toru	Matohi	Raua muri	Korekore	Lau pau	Takirau	Olke	20
19	Kokore ha	Kokore toru	Koekoe tufahi	Oreore mua	Korekore-oto	Ole kukahi	Olke	Korekore	21
20	Kokore rima	Kokore riro	Koekoe vavena	Oreore roto	Korekore-akaoti	Ole kulua	Korekore tufahi	Korekore-turua	22
21	Tapume	Vehi tahi	Koekoe haapoo	Oreore muri	Tangaroa	Ole pau	Korekore turua	Korekore whakapiri*	23
22	Matua	Vehi rua	Takao akau	Taaroa mua	Tangaroa-oto	Kaloa kukahi	Korekore hokopau	Tangaroa-a-mua	24
23	???	Vehi toru	(Takao) atati	Taaroa roto	Tangaroa-akaoti	Kaloa kulua	Tangaro a mua	Tangaroa-a-oro	25
24	Rongo	Vehi riro	Vaka	Taaroa muri	Otane	Kaloa pau	Tangaro a roto	Tangaroa-kiokio	26
25	Rongo Tane	Otane	Vehi	Tane	Rongonui	Kane	Tangaro kiokio	Otane	27
26	Mauri nui	Omouri	Tane	Ronui	Mauri	Lono	Otane	Otane	28
27	Mauri kero	Ononui	Tane	Maori	Omuri	Mau	Otane	Otane	29
28	Mutu	Ononate	Ononui	Mutu	Omuri	Muku	Otane	Mutu	30
29	Tirao	Tunui	Ononate	Mutu	Otiroa	Muku	Otane	Mutu	31
30	Hiro	Tunui	Ononate	Mutu	Otiroa	Muku	Otane	Mutu	32

*Full name: Korekore whakapiri ki nga Tangaroa

TABLE 2. – Comparison of Easter Island lunar calendar with those of other Polynesian islands

calendar appears shifted by about 3 nights relatively to pan-Polynesian version. Of course, one can observe “shuffling” of night order in other calendars as well, but the shifts of the characteristic groups (such as *Kokore* or *Tangaroa*) are far less prominent. I am inclined to explain the observed calendar shift by the isolation of Easter Island. The first settlers most probably had a pan-Polynesian lunar calendar, which became eventually “dephased” during its on-island evolution. The absence of further contacts with the outside world excluded the chances to re-synchronize the calendar with other sources.

Due to the shift, the nights *Tireo* and *Hiro* close the lunation at Easter Island, when on the other islands (Tahiti, Moriori, New Zealand) they open it together with the night *Ata*. The Rapa Nui night *Ari* seems to be out of place, as in other calendars it belongs to *Huna-Ari* group preceding *Maharu-Hua-Atua*. The variations of *Kokore* series are curious: the only other calendar in Table 2 featuring just *Kokore* (*Ole*) series is that from Hawai’i. However, even in this case there are vestiges of some other series, reduced to numbers (*Kukahi*, *Kulua*, *Kukoru*, *Kupau*). The geographically closest calendar from Mangareva in addition to *Kokore* (*Korekore*) has *Mae-ma* group, which is also present for Marquesas, Tahiti and Mangaia as *Maheama*, *Hamiama* and *Amiama*, respectively. Tahitian calendar makes a “bridge” introducing *Tamatea* night, which expands to a full group in Mangaia, Moriori and New Zealand (Table 2).

The grouping of the nights in *Mamari* text highlights an important detail about the structure of the calendar. The nights *Maharu*, *Hua* and *Atua* (group III) appear clustered in all calendars studied despite being “shuffled”. As *Ina-ira* had to be omitted to agree Thomson’s list with night count of *Mamari*, the resulting calendar became one night short. The “missing” night can only appear in the groups VI-VIII and I, because night groups II-V are perfectly adjusted.

Group VI corresponds to *Tangaroa* nights showing up with regional variations (*Takao*, *Taaroa*, *Kalooa*, *Tangaro*) in all calendars studied except for Mangareva and Rapa Nui³. *Tangaroa* group usually has three nights (perfectly agreeing with three crescents in *Mamari*’s group VI). On Marquesas, there are two *Takao* nights, soon followed by *Vehi* night, which on Mangareva makes a group of four nights replacing *Tangaroa*. It is worth noting that both Mangareva and Easter Island with “forgotten” *Tangaroa* nights are located in the same corner of the Polynesian triangle (Fig. 10). The night *Rongo* of Easter Island is paired with night *Rongo Tane*, which, in turn, belongs to *Tane-Rongonui-Mauri* group on other islands, usually consisting of three nights except for Mangareva and Marquesas (2 nights) and Rapa Nui (4 nights). As one can see from Table 2, usually there are *Rongo Nui* and *Mauri*; on Easter Island, *Mauri* splits into *Mauri nui* and *Mauri kero*. The lunar group VII has five crescents, as if suggesting that these should stand

Reconstruction A	Reconstruction B
1 <i>Ata</i>	1 <i>Ari</i>
2 <i>Ari</i>	2 <i>Huna</i>
3-8 <i>Kokore tahi – ono</i>	3-8 <i>Kokore tahi – ono</i>
9-11 <i>Maharu – Atua</i>	9-11 <i>Maharu – Atua</i>
12-15 <i>Hotu – Motohi</i>	12-15 <i>Hotu – Motohi</i>
16-20 <i>Kokore tahi–rima</i>	16-20 <i>Kokore tahi–rima</i>
21 <i>Tapume</i>	21-23 <i>Tapume – Rongo</i>
22 <i>Matua</i>	24-27 <i>Rongo Tane-Mutu</i>
23 ???	28 <i>Tireo</i>
24-28 <i>Rongo – Mutu</i>	29 <i>Hiro</i>
29-30 <i>Tireo – Hiro</i>	30 <i>Ata</i>

TABLE 3. – Tentative reconstruction of Easter Island calendar. Night groups are highlighted as in *Mamari* text.

3. There is a slim chance that the 21st night of Easter Island, *Tapume*, could be an erroneous re-spelling of a quick handwriting for *Ta[n]garoa*.

for two *Rongo* and two *Mauri* nights plus the night *Mutu*, which appears in the calendars from Tahiti to New Zealand. On the basis of this evidence, one can suggest that the missing night, perhaps called in unusual way such as *Vaka* or *Vehi* of Marquesas, should have been inserted to the VI lunar group of *Mamari* calendar, (Table 3, Reconstruction A; the detailed night-by-night list is given in Table 2).

A less structurally coherent but possible reconstruction consists in inclusion of night *Huna* (appearing in every remaining calendar, Table 2) to form *Huna-Ari* group in the beginning of the month (Table 3, Reconstruction B). *Ari* was set before *Huna* to mimic calendars of Mangaeva, Marquesas and Mangaia, while for Tahiti, Moriori and New Zealand this order is reversed. The rest of the calendar proceeds much the same with *Tireo*, *Hiro* and *Ata* being three closing nights, which fits the three-night “shift” of Easter Island calendar. However, in this way the lunar groups of *Mamari* inscription will separate the night *Rongo* from *Rongo-Mauri* series (group VII), also joining *Tireo* night there. The latter issue may be not so crucial, as it also happens in Mangaia calendar ending with *Omutu*, *Otireo* and beginning with *Iro* and *Oata*.

Therefore, Rapa Nui lunar calendar shows strong parallels with other Polynesian calendars, with the main night series clearly marked by the delimiter groups of *Mamari* calendar inscription. The most remarkable structural similarity can be seen between Easter Island and Mangaeva calendars (the same sequence of nights from *Maharu* to *Motohi* with only the inserted night *Oturu*, large *Kokore* series exceeding three nights, “forgotten” *Tangaroa* series and unusual *Orongo-*

Mauri series that do not have three nights as on the other islands).

Crescent arrangements in *rongorongo* texts

If there is a lunar calendar in tablet *Mamari*, could it be that the other *rongorongo* texts also feature more astronomic contents? And, as far as the moon is concerned, could the combinations of crescent signs appearing elsewhere encode parts of lunar calendar or individual nights? These questions are really difficult to answer as long as *rongorongo* remains an undeciphered script.

In his paper Wiczorek (2011) addresses the question of a possible astronomical content on tablet *Keiti*, discussing delimiter groups with two crescents and anthropomorphic signs (Fig. 11, Er1-Er6) following the structural analysis performed by Melka (2008: 161-164). As some of these crescents face to the right and some to the left (as glyphs 40 and 41 in *Mamari* calendar), one can consider this orientation meaningful and potentially containing some information about lunar cycles.

However, the delimiter groups of Er1-Er6 feature a considerable number of minor variations, such as inclusion/exclusion of anthropomorphic signs (that are connected in different ways to the crescents), replacement of closing glyph 24 with round upper part with glyph 28 that have notched upper part in the same line Er1, and pronounced “flipping” of the crescents between left/right orientation. These changes are surprising because nine out of ten occurrences of this gly-

FIGURE 11. – Crescent arrangements and other examples of sign symmetry from different *rongorongo* texts

phic group fall into the neighboring lines Er1-3, so that the carver could have easily consulted the completed passages to ensure textual uniformity. Studying the photo-graphs of the tablet (Horley 2010: 46), one will find that the complete forms of this delimiter group appear in the first half of the line (Fig. 11, Er1₁₋₂, Er2₁₋₂, Er4₁), while the abbreviated forms with omitted anthropomorphic glyphs are carved close to the end of the line (Fig. 11, Er1₃, Er2₃, Er6₁) or belong to the wedged line Er3. These details suggest that the carver abbreviated delimiter group upon approaching the end of the line for space-saving purposes.

On the contrary, all delimiter groups of *Mamari* calendar, also occupying neighboring lines, are always written in full with careful correction of the omitted glyphs, using even the edge of the tablet when it was necessary (Fig. 3). Therefore, it seems that the topic of *Mamari* inscription allowed less liberty to the scribe than that of *Keiti* – or the scribe of *Keiti* was less caring for the details. Also, it is worth noting that orientation of the crescents in *Mamari* calendar serves to distinguish crescents of delimiter groups (sign 41) from those of the calendar text (sign 40). In delimiters of *Keiti*, both glyphs are either mixed (Fig. 11, Er1₁, Er2₁ and Er3₁) or seemingly harmlessly replaced for only left/right facing crescents.

According to Barthel's glyph occurrence tables (1958: 99), sign 40 is considerably more frequent than glyph 41. Scanning the corpus for sign 41 and taking into account parallel passages, it is possible to show that crescent glyph orientation is not always preserved (Fig. 3, Ca9 and Cb13-14; Fig. 11, Pv2 and Qv3, Pr5 and Aa1). The orientation of the clustered crescents (Fig. 11, Bv2, Hv10, Pv11 and Cb13) can be flipped on the whim of the scribe to get the desired symmetric pattern, which may also apply to the delimiter groups of *Keiti*.

Actually, the question about right/left sign orientation is deeper, overlapping with concerns voiced by the Pozdniakovs (2007: 4) for the "instances when anthropomorphic glyphs are rotated [*i.e.* facing] to the left". A preliminary study on this topic was made by Barthel (1958: 159, note 2) for the sign 53, which for different artifacts may predominantly face to the right, to the left, or feature a "mixed" orientation. The orientation of this sign is not always preserved in parallel passages (Fig. 11, Pv2 and Qv3).

Analyzing various sign groups, one becomes inclined to think that symmetric glyph arrangement was considerably appreciated and employed by the *rongorongo* men to improve the visual appearance of their texts. For example,

signs 66 in the parallel passages Bv3 and Hv10 (Fig. 11) alternate their sides in a seemingly free manner, which most probably should not influence the reading of the passage. However, the symmetric arrangement of two glyphs "embracing" head-down sign 95x in line Bv3 or its analogue 559 in line Hv10 improves text composition. Moreover, it could be said that inside "branch" orientation of the sign 66 in the former text allowed to save space (note: glyphs in Fig. 11 are set apart to improve the clarity of the presentation), while the same scheme could not be applied for the line Hv10 because the inner glyph 559 is wider and leave no space to carve the branches looking inside the group. Both glyphs 66 appearing further on in line Hv10 form ligatures 66.61, so that their branches turned left to simplify the carving. Several signs to the right, both signs 66 "embracing" glyph 22f have their branches to the right, which may be caused by preceding sign 207/307 whose hand does not leave much space for left-facing branch of the first glyph 66 in this group (Fig. 11, Hv10, Bv3). The similar side-flipping of sign 66 can be seen in another copy of the same passage appearing in line Bv9.

Another good example illustrating a considerable variation of sign 66 (with its side branches to the right, to the left, to the both sides, or without branches at all) is a structured sequence written in lines Aa1, Hr5, Pr5, Qr5 (Butinov and Knorozov, 1957: 14). Guy made the following conclusion regarding the use of signs 66 in this sequence: "only right [facing] variants of form [with] 1 [branch] occur on tablet P, only left variants on tablet Q. There seems to be no conditioning factor as to when form [with] 1 or 2 [branches] is used" (1985: 382), suggesting that sign orientation here most probably does not have any meaningful role.

Glyph 522 also makes a nice example of asymmetric sign that can be carved with its "proboscis" looking to the right (in the majority of the cases) or to the left. The stable glyphic group 4-522-700-600-59f appearing in seven texts (Bv12, Ev6, Gr2/Kr3, Ma2, Hv12, Ra5) provides a good illustration for interchangeability of left-proboscis (Bv12, Ev6, Ma2⁴, Hv12) and right-proboscis (Gr2, Kr3, Ra5) versions of this glyph (Fig. 11, Ev6 and Ra5). The Large Washington tablet contains the evidence on seemingly non-meaningful side-flipping of proboscis-bearing glyph 520 entering into group 1.520-4.64 repeated twice (Fig. 11, Sa3₁). Further on, one can see symmetric arrangement of glyphs 522 (Fig. 11, Sa3₂). However, not every occurrence of quasi-neigh-

4. Despite the tracings published by Barthel (1958) and Fischer (1997: 503) depict here sign 99 with no proboscis, the digital photography from the Museum für Völkerkunde reveals that actually it is glyph 522 (which perfectly agrees with other parallel passages), with its proboscis turned to the left.

boring signs 522 on this tablet is symmetric (e.g., Fig. 11, Sa6).

Other glyphs also display the similar side-flipping: compare the orientation of glyph 4 in the passages Ev6, Ra5 and its symmetric reduplication 4.3-4.3 in line Cb8 (Fig. 11). The double-head signs 308, 409/410, 609, 770, as well as duplicated glyphs 420, usually have their heads arranged with mirror symmetry (Fig. 11, Aa6). Even highly standardized sign 7, presumably depicting *reimiro*, can be written “back-to-back” (Fig. 11, Da1).

Therefore, it seems plausible to conclude that horizontal flipping of *rongo-rongo* glyphs most probably does not influence their reading/meaning, though, in certain cases, as in *Mamari* calendar, right and left orientation of the crescents helps to avoid visual confusion between the signs belonging to the delimiter group and to the list of the nights proper. With this evidence, the probability that orientation of the crescents appearing in delimiter groups of tablet *Keiti* (Fig. 11, Er1-Er6) is meaningful seems to be quite slim.

Searching more calendar-related contents in the inscriptions, it could be productive to look for the ligatures. However, the corresponding “explanatory glyphs” for the nights 10 and 23, which points out to the similarly-looking compounds 41.74f (Fig. 11, Hv11 and Gv4) and 40.3 (Fig. 11, Gv3). However, the corresponding “explanatory glyphs” for the nights 10 and 23 (Fig. 9) feature the inverse element order (with the crescent being the second). Moreover, as the same compound appears written as a vertical ligature in the both cases involving Barthel’s glyph 42 for a rotated crescent (Fig. 11, Hv11 and Gv3), it becomes doubtful to conclude that these ligatures can be associated with the lunar nights.

Therefore, while it is completely reasonable to expect that Easter Island tablets may contain references to individual lunar nights/month names, it seems that the crescent series appearing in lines Ca6-9 of tablet *Mamari* form the only complete lunar calendar in the survived *rongo-rongo* corpus.

Conclusions

The study of authentic Easter Island documents connected with moon observations (tablet *Mamari*, petroglyph panel 31-44 and Manuscript A) proved that the ancient lunar calendar of Rapa Nui should have consisted of 30 nights, perfectly agreeing with astronomy and other Polynesian calendars. Two last nights of the month correspond to the new moon in conjunction with the sun; these nights are carved separately on tablet *Mamari* and placed wi-

thin a carapace of the turtle (which can be related to the rising sun) in panel 31-44. One of the turtles in the panel is oriented eastwards, facing the mark that can be interpreted as a full moon. Observations of a complete lunation suggested an alternative interpretation for the “explanatory glyphs” of *Mamari* calendar, which may have helped to identify the phase of the moon. The comparative analysis of Easter Island calendar confirmed its undeniable Polynesian origin, highlighting peculiarities indicative for isolated development.

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