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New interpretation of the table of eclipses in Dresden Codex: Intercalated numbers as fractions

Abstract

A review to the introductory pages of the Table of Eclipses of the Dresden Codex is made. In particular, the section of three intercalated Maya numbers in columns A, B, C, of page 52a and the list of thirteen 13's (two bars and three points) present in column D of the same page are studied and interpreted as a way to construct the sequence of 69 eclipse prediction numbers for a total period of 11.958 days. Those intercalated numbers (red & Black) in the codex represent big numbers that are multiples of the 11.960-day period. In combination with the draconic month (as studied by Chinese culture (27,2122)), the sequence of 177, 178, 148 days, intervals can be reproduced. The consequent conclusion is that these intercalated numbers could represent numerical fractions.

Keywords: maya numbers, fractional numbers, eclipse prediction, moon's latitude

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In this letter, I am presenting a possible interpretation of the intercalated numbers written in the section of aperture of the Table of Eclipses that are present in the page 52a of Dresden Codex. This new interpretation suggests that Maya Mathematics has made the use of fractions while generating the table for eclipse prediction inscribed in pages 53a to 58a and following from 51b through 58b. Also, a possible procedure to have the sequence of lunations will be discussed.

The Dresden Codex is one of the four original codices attributed to the Maya Culture before the arrival of Spaniards. The other three are: Paris Codex, Madrid Codex and Maya Codex, which was known as the Grolier Codex.[1] It is also, the codex having the greatest number of astronomical features.[2] For example, the Table of Venus, the Table of Mars and the lunar cycles, are some of the most important ones. The Table of Eclipses is the main issue analysed here.

The Dresden Codex is a folded book made of amate paper, covered by a thin layer of stucco in order to give a surface apt for writing. It has been accepted that the writing is in original Mayan hieroglyphic language, and it has 39 leaves, most of them are painted on both sides. The size of each leaf is 20,4 cm height by 9,0 cm wide; the total length of the codex is 3,50 m. Its name comes from the fact that it is conserved at the Saxony State Library in Dresden, Germany.[2]

In Figure 1A, it can be seen the page of interest for this proposal: 52a. There are several columns with hieroglyphic text at the top of it that can be read partially. The maya numbers present in the middle part of the first three columns are count of days as stated by Erik Velazquez in his interpretation. In Figure 1B, a schematic description of the page is given following the analysis made by Bricker. It is of highest interest to look at them and at the 13 13's in the central column. The three intercalated pairs of numbers adjacent to it have been deciphered due to its colours: Red and Black.

As it can be seen in the figure, the six numbers of the three columns are related with the whole extent of the table: the number of days reach multiples of 11.960 (rounding total of 11.958 corresponding to 69 predicted eclipses). I will come back to these numbers ahead. For the moment, the series of 13's has been interpreted as a way to recycle the table but without any mention a possible way to use it: Eric Velasquez says that "As Bricker and Bricker (2011) say, the rest of the sentence is a number of 1.828 days (5.1.8), which serves to update the table and be able to use it in the future, leading to new start dates, the same function that they attribute to the thirteen red numbers 13 located in the lower half of this column" (2016: 74). Other interpretations of this column of 13's refers to a very big number (13 levels meaning an infinite) or as the thirteen levels of the world incorporated in the Maya cosmovision.

(a)

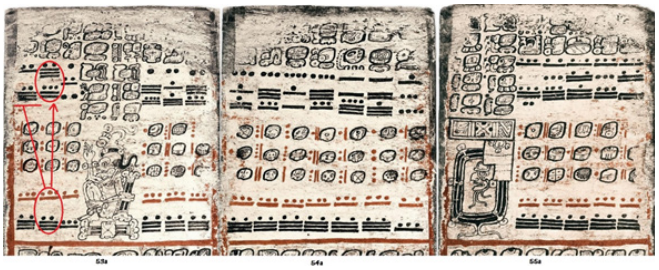
52aA	52aB	52aC	52aD	52aE	52aF
caption	caption	caption	caption	(4) Ahau	(4) Ahau
B R	B R	B R	8 *kin*	8 Cumku	8 Cumku
3 (=4) 8	3 4	1 6	1 *uinal* 5 *tun* =1,828	B R	B R
19 =3× 6	6 =2× 19	18 =1× 12	2 *ta-b(a)* (+)	9 9	9 9
11 (=12) 11,960 2 =5× 11,960	8 11,960 12 =3× 11,960	5 11,960 16 =4× 11,960	13	16 19	16 16
0 0	0 0	0 +1,820 0	13	4 8	4 4
			13	10 (=11) 7	10 11
12 Lamat	12 Lamat	12 Lamat	13	18 8	8 3
1 Akbal	1 Akbal	1 Akbal	13	3 Edznab	12 Lamat
3 Edznab	3 Edznab	3 Edznab	13	7 Lamat	1 Akbal
5 Ben	5 Ben	5 Ben	13		
7 Lamat	7 Lamat	7 Lamat	13		
			13		
			13		
			13		

NOTE: Columns are labelled with upper-case letters, from left to right on each page. The black (*B*) and red (*R*) numbers that are here shown separately are shown alternately (intertwined) within the same column on the Codex page (see fig. 1).

(b)

Figure 1 Contents of page 52a: a) Facsimile of the original codex;[2] b) Section of Table I of the schematic deciphered contents of the page.[7]

From page 53(a) to 58(b) there are a total of 79 columns (69 numeric plus 10 including figures), for my proposal, only the sections of the black number that represents the number of days accumulated from the beginning column of the table and the number corresponding to 177 or 148, which in Mayan notation are written (8.17) and (7.8), respectively, in the lower part of each column (see Figure 2A. In several places, the cumulative total reaches a number that assumes a 178 has been added but in the lower part a 177 is written: the sequence of lapses' days for the occurrence of an eclipse could be, only, 177, 178 or 148[3] as it can be seen in Figure 3B.



Intervalos (días)	Figura	Total (días)
177, 177, 148	53a	502
177, 177, 177, 177*, 177, 177, 177, 177, 177, 148	55a	1,734
177*, 177, 177, 177, 177, 148	56a	1,034
177, 177, 177, 177*, 177, 177, 148	57a	1,211
177, 177, 177*, 177, 177, 177, 177, 177, 177, 148	52b	1,742
177*, 177, 177, 177, 177, 148	53b	1,034
177, 177, 177, 177, 177, 177, 148	54b	1,210
177, 177, 177*, 177, 177, 177, 177, 177, 148	56b	1,565
177, 177*, 177, 177, 177, 177, 148	57b	1,211
177, 177, 177, 177	58b	708

Nota. *en ocasiones se suma 178 aunque el número anotado es 177

(b)

Figure 2 Lapses of days for the occurrence of an eclipse in Dresden Codex: a) Part of the facsimile pages (53a, 54a, 55a),[2] with accumulation in Red; b) sequence of 69 intervals of days.[3]

It can be probed, as I myself do in another paper, that the dates corresponding to the sequence of 177, 178, and 148 days, lapses can be correlated with eclipses observed at somewhere on Earth, not necessarily in the zone of Maya influence.[3,4]

I now ask the critical question about the Table of Eclipses of Dresden Codex: Is there any relation between the information in page 52a, mainly the list of 13's and the multiples of 11.960, and the sequence of intervals of Figure 3B? Any of the many studies have addressed ideas towards this question.[5,6]

In order to give a possible answer to this matter, I will discuss briefly the lunar observations made in ancient China. Christopher Cullen has published a very interesting book, "Heavenly Numbers" (2021), about the astronomy in the early imperial China. I am using the Table of Ying-Yang Sequence shown in Table 1. The contents of the table give us a very important information about what is called the Draconic month: a cycle of 27.212220 days taken by the Moon to make two passages through the same node (intersection of its orbit with the ecliptic).

The column 1 gives the number of days for the Moon being above or below the ecliptic, because the angle between the orbit of the Moon and the ecliptic is about 6 du, which means that the alignment of the three celestial bodies (Earth, Moon and Sun) and, in consequence, the propitious moment for an eclipse (lunar or solar) is of 13 days and a fraction. The corresponding fractions shown in last row of the table are, for a whole cycle 0,13363 and 0,64693. In the real world both fractions change due to several astronomical factors like precession or tidal forces. The reported ones are long term means.

The extension in space of the Moon and Sun makes possible three types of solar eclipses: partial, annular and total.

Table 1 Uranic manifestation system Ying-Yang sequence

1	2	3	4
Day of Ying-Yang sequence	Difference [1/12 du]	Rate of Decrease and Increase [1/12du]	Total Number [1/12 du]
1	-1	17	0
2	-1	16	17
3	-3	15	33
4	-4	12	48
5	-4	8	60
6	-3	4	68
7	-3	1	72
8	4	-2	73
9	4	-6	71
10	3	-10	65
11	2	-13	55
12	1	-15	42
13	1	-16	27
Fractional day [5203/77874 days]		-(16[+306/473])	11

The number thirteen (13 or two bars and three points) becomes relevant to the observation of the latitude of the Moon. Let me show how the 13's and a fraction could work to obtain the sequence of 69 intervals of the table shown in Figure 2B.

The first thing to notice is that summing 13 13's we arrive to 169 days. Then we can assume that column D of page 52a (see Figure 1B) make a base of 169 that need 8 days to arrive to 177 and 9 days to arrive to 178. In Table 2, I show the fractions needed to generate the three lunation cycles for an eclipse, assuming that the fractions are the same for all the periods.

Table 2 Lunations for eclipse observation

Number	13	13	13
Times	13	13	11
Base	169	169	143
Fraction	0.61538	0.69231	0.45455
Total	177	178	148

Table 3 Lunations using fractions from Dresden Codex*

Number	13	13	13
Times	13	13	11
Base	169	169	143
Fraction**	0.6	0.66667	0.28804
Total	176.8	177.67	146.17

*Table of Eclipses page 52a

**Ratio between Black and Red numbers of cols. A, B, C of the same page, respectively

The proper application of this table 3 would allow to reproduce the whole 69 intervals of the sequence; however, if one think about an alternative and nonhomogeneous way to arrive to it, it is possible to assign (observed?) fractions to the sequence. This is why I have look forward to the intercalated numbers in columns A, B, C, of page 52a

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(see Figure 1B). Taking the ratio between Black and Red numbers, we arrive to the following three fractions: 3/5; 2/3; and 0,28804.

My interpretation of these B&R numbers on the Dresden Codex because they are not exact, would imply that in constructing the table, some observational criteria could have been used as it is shown in an alternative reconstruction of the sequence of Table 4.

I can conclude with these words: In one of the introductory pages (52a) of the Table of Eclipses of the Dresden Codex, the list of 13 13's in Column D, can be used coupled to the intercalated B&R numbers of columns A, B, C, representing fractions, to elaborate the sequence of lunations (intervals of 177, 178, 148 days) on the remaining pages of the table.

Table 4 An alternative way to build the intervals sequence

Serie	Acc	
13.600	13.6	
13.600	27.2	
13.600	40.8	
13.600	54.4	
13.600	68.0	
13.600	81.6	
13.600	95.2	
13.600	108.8	
13.667	122.5	
13.600	136.1	
13.667	149.7	
13.600	163.3	
13.667	177.0	177
13.600	190.6	
13.600	204.2	
13.600	217.8	
13.600	231.4	
13.600	245.0	
13.600	258.6	
13.600	272.2	
13.600	285.8	
13.667	299.5	
13.600	313.1	
13.667	326.7	
13.600	340.3	
13.667	354.0	177
13.600	367.6	
13.600	381.2	
13.288	394.5	
13.600	408.1	
13.600	421.7	
13.600	435.3	
13.288	448.6	
13.600	462.2	
13.288	475.5	
13.288	488.8	
13.288	502.0	148
13.600	515.6	
13.600	529.2	
13.600	542.8	
13.600	556.4	
13.600	570.0	
13.600	583.6	
13.600	597.2	
13.600	610.8	
13.600	624.4	
13.600	638.0	
13.600	651.6	
13.667	665.3	
13.667	679.0	177
13.600	692.6	
13.600	706.2	
13.600	719.8	
13.600	733.4	
13.600	747.0	
13.600	760.6	
13.600	774.2	
13.600	787.8	
13.667	801.4	
13.600	815.0	
13.667	828.7	
13.600	842.3	
13.667	856.0	177
13.600	869.6	
13.600	883.2	
13.600	896.8	
13.600	910.4	
13.667	924.0	
13.600	937.6	
13.667	951.3	
13.600	964.9	
13.667	978.6	
13.600	992.2	
13.600	1005.8	
13.667	1019.4	
13.600	1033.0	177
13.667	1046.7	
13.667	1060.4	
13.667	1074.0	
13.667	1087.7	
13.667	1101.4	
13.667	1115.0	
13.667	1128.7	
13.667	1142.4	
13.667	1156.0	
13.667	1169.7	

Serie	Acc	
13.667	1183.4	
13.667	1197.0	
13.667	1210.7	178
13.600	1224.3	
13.667	1238.0	
13.600	1251.6	
13.667	1265.2	
13.600	1278.8	
13.667	1292.5	
13.600	1306.1	
13.600	1319.7	
13.600	1333.3	
13.667	1347.0	
13.667	1360.6	
13.667	1374.3	
13.667	1388.0	177
13.600	1401.6	
13.600	1415.2	
13.600	1428.8	
13.600	1442.4	
13.600	1456.0	
13.600	1469.6	
13.600	1483.2	
13.600	1496.8	
13.600	1510.4	
13.600	1524.0	
13.667	1537.6	
13.667	1551.3	
13.667	1565.0	177
13.600	1578.6	
13.600	1592.2	
13.600	1605.8	
13.600	1619.4	
13.600	1633.0	
13.600	1646.6	
13.600	1660.2	
13.600	1673.8	
13.600	1687.4	
13.667	1701.0	
13.667	1714.7	
13.667	1728.4	
13.667	1742.0	177
13.600	1755.6	
13.600	1769.2	
13.600	1782.8	
13.600	1796.4	

Serie	Acc	
13.600	1810.0	
13.600	1823.6	
13.600	1837.2	
13.600	1850.8	
13.600	1864.4	
13.600	1878.0	
13.667	1891.7	
13.667	1905.4	
13.667	1919.0	177
13.600	1932.6	
13.600	1946.2	
13.600	1959.8	
13.600	1973.4	
13.600	1987.0	
13.600	2000.6	
13.600	2014.2	
13.600	2027.8	
13.600	2041.4	
13.600	2055.0	
13.667	2068.7	
13.667	2082.4	
13.667	2096.0	177
13.288	2109.3	
13.667	2123.0	
13.600	2136.6	
13.600	2150.2	
13.667	2163.9	
13.288	2177.1	
13.288	2190.4	
13.667	2204.1	
13.288	2217.4	
13.288	2230.7	
13.288	2244.0	148
13.600	2257.6	
13.600	2271.2	
13.600	2284.8	
13.600	2298.4	
13.600	2312.0	
13.600	2325.6	
13.600	2339.2	
13.600	2352.8	
13.600	2366.4	
13.600	2380.0	
13.667	2393.6	
13.667	2407.3	

Serie	Acc	
13.667	2421.0	177
13.600	2434.6	
13.600	2448.2	
13.600	2461.8	
13.600	2475.4	
13.600	2489.0	
13.600	2502.6	
13.600	2516.2	
13.600	2529.8	
13.600	2543.4	
13.667	2557.0	
13.600	2570.6	
13.667	2584.3	
13.667	2598.0	177
13.667	2611.6	
13.667	2625.3	
13.667	2639.0	
13.667	2652.6	
13.667	2666.3	
13.667	2680.0	
13.667	2693.6	
13.667	2707.3	
13.667	2721.0	
13.667	2734.6	
13.667	2748.3	
13.667	2762.0	
13.667	2775.6	177.7
13.600	2789.2	
13.667	2802.9	
13.600	2816.5	
13.600	2830.1	
13.667	2843.8	
13.600	2857.4	
13.600	2871.0	
13.667	2884.6	
13.600	2898.2	
13.667	2911.9	

Serie	Acc	
13.667	2925.6	
13.667	2939.2	
13.667	2952.9	177.3
13.600	2966.5	
13.600	2980.1	
13.600	2993.7	
13.600	3007.3	
13.600	3020.9	
13.600	3034.5	
13.600	3048.1	
13.667	3061.8	
13.600	3075.4	
13.600	3089.0	
13.667	3102.6	
13.667	3116.3	
13.667	3130.0	177.1
13.600	3143.6	
13.600	3157.2	
13.288	3170.5	
13.600	3184.1	
13.600	3197.7	
13.288	3210.9	
13.600	3224.5	
13.288	3237.8	
13.600	3251.4	
13.288	3264.7	
13.288	3278.0	148.0

Cd-Dresde	AccDresde
177	177
177	354
148	502
177	679
177	856
177	1033
178	1211
177	1388
177	1565
177	1742
177	1919
177	2096
148	2244

Cd-Dresde	AccDresde
177	2421
177	2598
178	2776
177	2953
177	3130
148	3278
177	3455
177	3632
177	3809
177	3986
178	4164
177	4341
147	4488
177	4665
177	4842
178	5020
177	5197
177	5374
177	5551
177	5728
177	5905
177	6082
148	6230
178	6408
177	6585
177	6762
177	6939
177	7116
148	7264

Cd-Dresde	AccDresde
177	7441
177	7618
177	7795
177	7972
177	8149
177	8326
148	8474
177	8651
177	8828
178	9006
177	9183
177	9360
177	9537
177	9714
177	9891
148	10039
177	10216
178	10394
177	10571
177	10748
177	10925
177	11102
148	11250
177	11427
177	11604
177	11781
177	11958

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It follows to look forward for instructions to be made in order to have the correct sequence. The texts on the top of the columns must be interpreted accordingly.[7,8]

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Conflicts of interests

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