MINOAN FLAT STONE KERNOI
PROBABLY ARE DECODED AS EITHER
LUNAR OR LUNISOLAR OR ONE-YEAR SOLAR CALENDARS

A documented answer

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Abstract: The use of kernoi has been the tantalizing subject among archaeologists since 1901. Archaeologists' conclusions do not converge, as they have suggested that Minoan flat kernoi are either: 1) libation tables, i.e. tables with some produce on their small cups offered to deities or 2) boards for the Minoans to play unspecified games or 3) unspecified board games connected with some ritual procedures; 4) one archaeologist put forward a fourth proposal, that the Mallia kernos is nearly a lunisolar calendar. In this paper the four previous considerations will be commented on. This study deals with the decoding of 73 Minoan flat kernoi and it is based on: a) the detailed observation on the measured characteristics of kernoi, i.e. the number, the size and the distribution of cups on them; b) the use of elementary statistics for the grouping of the above characteristics of kernoi; c) the knowledge of prehistoric Egyptian and Babylonian calendars. The analysis is based on the decoding of 73 kernoi, ten of which are decoded in detail. In the light of the proposed theory, one kernos found in pieces is shown to have been reconstructed incorrectly and a possible new reconstruction proposed.

Keywords: Minoan flat Kernoi, Lunar Calendar, 8-year Lunisolar Calendar, Solar Calendar, Minoan calendars.

1. Introduction

Athenaeus[1] probably having in mind kernoi used in the Eleusinian Mysteries, defined that a kernos[2] (not a Minoan flat kernos) is: "a terracotta vessel with many little bowls stuck on to it. In them there is sage, white poppy heads, wheat, barley, peas (?), vetches (?), pulse, lentils, beans, spelt (?), oats, cakes of compressed fruit, honey, olive oil, wine, milk, and unwashed sheep's wool." Traditionally these artefacts have been labelled kernoi in the archaeological literature. The current definition of kernos is as the above in every bibliographical entry denoting a three dimensions artefact (see Fig. 1). This has nothing to do

Fig. 1.   A terracotta kernos found at Melos matching with Athenaeums' definition; Cycladic period (ca. 2000 BCE).

with the Minoan flat stone kernoi with several small carved cups (< 4cm in diameter and < 1cm in depth) in their perimeter and on their two dimensions' surface (see Figs 4 to 12). Therefore, the need for a new definition of a Minoan flat stone/ceramic kernos is imperative. My proposed definition of those kernoi would be: "A Minoan flat stone/ceramic kernos (from now on will be called just "kernos" or plural

[1] Athenaeus. 3rd ce. A.D: 11478c.
[2] Webster's Dictionary. 1961: kernos.

"kernoi") is an about round or a rectangular stone (or ceramic artefact) on the surface of which many cups are carved in one or more cycles or lines (see Figs 4 to 12). This definition is the outcome of my 5 year- study on kernoi and will be evident from the seventy-three decoded kernoi which are shortly
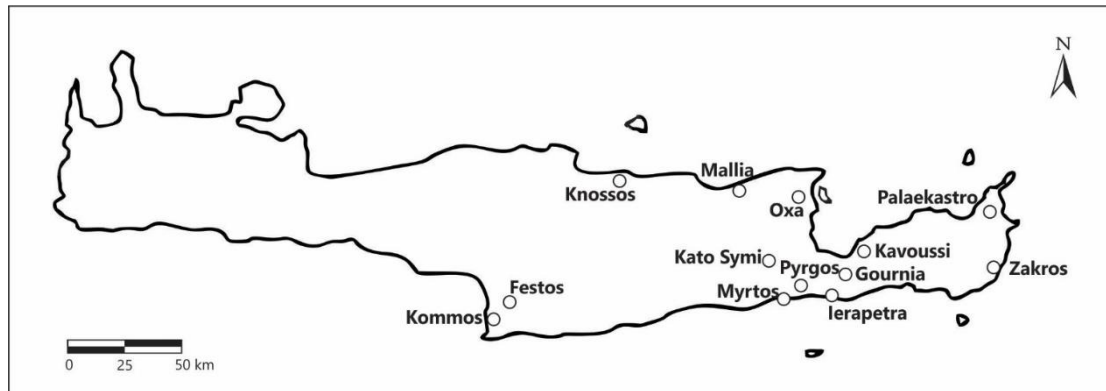

Fig. 2. Map of Crete with sites where 73 kernoi were found and are decoded in Table 1.
The map was created by me.

decoded at the end of the article, Table 1. Nevertheless, ten of those kernoi are fully deciphered in the text as solved exercises. Those ten kernoi have been chosen because they cover a broad wide of cases answering the question 'what were the Minoan flat stone kernoi used for?'

Hillbom[3] collected and measured one hundred and sixty-seven kernoi in his doctoral thesis (but he did not decode them). Those were unearthed in 16 places of Crete (see Fig. 2) by 22 archaeologists from 1901 - 2005. Ninety-four kernoi were broken or badly preserved or they were in theatrical areas, thus, without giving reliable data on their characteristics (number, size and the distribution of their cups). The seventy-three decoded kernoi due to the differences on the above characteristics can be attributed to thirty-three groups, the decoding of which will lead us to a unified proposal on what the kernoi were used for, Table 1. The data of this study have been taken from the publications of the archaeologists responsible for the excavations in question. The marked kernoi of the article are copies of the prototypes and are made by the author.

Some kernoi were/are in "situ" like the famous 'Mallia kernos' (see Fig. 7); some are in the local Museums and a good number are in the Heraklion Museum (= H.M.), like the very important in calendrical meaning kernos from the peak sanctuary of Juktas, H.M., no. 3587, Karetsou[4] (see Fig. 13).

The 167 kernoi of Hillbom' s thesis[3] and the seventy-three briefly decoded in Table 1 covered a period from ca. EM II - LM. Some similar or about similar kernoi (the same software had applied) have been found in Cyprus, in Israel (Gezer), in the Aegean islands of Naxos and Mykonos, in Persia, in central Europe (Germany), in the Frangocatabrian caves (France-Spain borders), in Britain and Ireland, but their simple decoding is outside of the scope of the present article.

1.1. Dimensions of kernoi and the question of pawns found

Sometimes kernoi found broken in pieces and they were usually reconstructed arbitrarily without the application of a documented proposal or theory on the use of them. The number of cups on kernoi varies from 4 to 107 (=100 similar + 7 separated cups) (see Fig. 13). The size of surfaces of the Minoan stone flat kernoi are mainly between ca. 20cm X 55cm (54 %); kernoi with dimensions less than 20cm X 55cm are (12 %): kernoi with dimensions bigger than 20cm X 55cm are (11 %); Minoan kernoi with one

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[3] Hillbom 2005: 139-72; 273-310.   [4] Karetsou 1974: 228-39.

dimension < 20cm or > 55cm and the other dimensions between 20cm and 55cm are (23%). The Minoan flat kernoi are made of local stones, mainly limestone.

Although the types and the dimensions of pawns found nearby to some kernoi look to be of a secondary significance/value they are not. Bright archaeologists, although they proposed that kernoi were either libation tables or boards for playing games or boards for playing games connected with rituals, pay attention to this significant/valuable information and they described, counted and measured the pawns found near kernoi. According to Hillbom' s thesis[3] a great number of pebbles, shells, balls, flat counters (in general called pawns) were found in specific sites where kernoi were unearthed with very many cups, (see H. M. no. 3587 with 100+7 cups of a diam. 1.3-1.7cm), (see Fig. 13), Karetsou[5]. 'There are also many round clays 'pebbles' of various sizes measuring 1-1.5cm in diameter and being the type described by Myres[6] at Petsofas.' Karetsou[4] wrote '… (at the peak sanctuary of Juktas) …were found a lot of ceramic balls;' (author's notation: the lot of ceramic balls are smaller and they fit into the 107(?) bigger cups of kernos H. M. no. 3587, Fig. 13).

1.2. What were the Minoan flat kernoi for?

Usually every newly discovered artefact is compared with some earlier one having some similarities with. The same happened with the Minoan flat stone kernoi. Whittaker[7], Boyed[8], Sir Evans[9] (see Fig. 8), and als. interpreted kernoi as game boards from some similarity with the Egyptian games called "Senet" (an artifact with three by ten cups or painted squares) or "Mehem" (a coiled spiral-like god-snake divided in a great number of squares 100+). Chapouthier[10] and als. considered kernoi as being libation tables, i.e. vessels on cups of which any kind of produce were put and this was poured as a sacrifice in a deity or in an altar. The supporters of this theory having no other explanation for the cups of the two-dimension surface of kernoi considered that the use of the Minoan flat kernoi were the progenitor (although with two dimensions) of the used during the Eleusinian mysteries three dimensions kernoi, according to the definition of Athenaeus[1] (see Fig. 1). H. Van Effenterre[11] pointed out that game of chance may have religious significance without rejecting a religious function of the Mallia Table (see Fig. 7). On the contrary, Herberger[12] tried to interpret the kernos of Mallia Table, as an 8-year cycle period or a clock. He was the only one who proposed that this kernos may have been used as a kind of clock i.e. calendar, but he has not totally proved it, see below.

2. Kernoi interpreted as libation tables

The libation-tables theory, for the use of kernoi as vessels, was introduced by Chapouthier[10], while he was studying the Mallia kernos (see Fig. 7); this theory was later adopted by Demargne[13] (see Fig. 5), Banti & Pernier[14], Pernier[15], Warren[16], Hood[17] and als.

The act of libation is a ritual pouring of a liquid, (as wine, oil etc.) either on the ground or on a victim in a sacrificed to a deity[18]. Consequently, the artifact used in the ritual called libation table. The process was common in many religions in antiquity and continues to be offered in various cultures today.

Hood[17] wrote: "(kernoi) occurred as isolated examples or where no pattern can be discerned… are most easily explained as receptacles for offerings and libations."

Libations[18] were performed in Minoan Crete as can be inferred by the fresco procession in the Minoan Palace, at the procession corridor. It is known that Egyptians (e.g. a libation bowl with the goddess

[5] Karetsou. 2012: 90.
[6] Myres. 1902-3: 379.
[7] Whittaker. 1996: 321-3.
[8] Boyd. 1901: 125-57.
[9] Evans. 1930: 387.
[10] Chapouthier. 1928 : 292-323.
[11] H. Van Effenterre. 1955 :541-8.

[12] Herberger. 1983 : 114-7.
[13] Demargne. 1932 : 60-88.
[14] Banti & Pernier. 1951 : *Festos II*.
[15] Pernier. 1935: *Festos I*.
[16] Warren. 1972: BSA Suppl.7.
[17] Hood. 1995: 101-11.
[18] Britannica Ult. Ed. 2011: libation tables.

Hathor) and Babylonians (e.g. vessels from the Royal Tombs of Ur) used libations to secure gods' favor[18].

2.1. Scientists against the theory of libation tables

The late professor Herberger[12] published an article on the Mallia kernos, which is "in situ" and dating c. 1900-1700 BC (see Fig. 6). He wrote: "…the excavator F. Chapouthier[10], considering its prominent and permanent position, believed that this kernos had a religious significance and by analogy with the clay vessels known as kernoi, he called it a 'Table of Offerings". Herberger[12] continued: "The suggestion (of Chapouthier) that the table has the sole functions of a table of offerings, although consistent with its obviously important location and context, is nevertheless open to certain objections." In brief: 1) kernoi are small to hold offerings for pouring at a shrine or altar; 2) kernoi, if for libations must be movable not 'in situ'; 3) Herberger[12] decoded the Mallia kernos finally as an 8-year lunisolar cycle, not an 8-year lunisolar calendar, see below.

H. Van Effenterre[11] maintained that "the contextual evidence argues against interpreting the stones/kernoi (because kernoi have been found on streets and courts) as having been made primarily for religious use as offering tables."

Herberger[12] argued in his article that the Mallia kernos is either kernos (libation table) or clock (an 8-year cycle). He rejected with arguments the first case and supported the second one. He did not support the idea that the kernos is an 8-year lunisolar calendar, because he did not know (in 1983) the beginning of the Minoan lunisolar calendar, although he knew the other two parameters of characterizing an artefact as a calendar: i.e. 1) the duration of the period, i.e. 99 lunar months (the 3x33 cups/months), and 2) the time unit, i.e. one lunar month, see definition what is a calendar[19]. A calendar is the system by which the beginning, the length, and division of a time period are fixed and by which days and longer divisions of time are arranged in a defined order. Today, paper from the archaeoastronomers Blomberg and als[20] defined the beginning of a Minoan 8-year lunisolar calendar (or of 99 lunar months duration) when the first site of the new moon is seen, after the autumn equinox. Now, it is finally concluded that the Mallia kernos is an 8-year lunisolar calendar (see Fig.7).

It is concluded from Hillbom' s thesis[3] that kernoi unearthed up to 2005 were of three kinds: 1) "in situ", thus the kernoi are immovable and their use as libation tables is rejected; 2) half of 73 of the studied kernoi have surface of 20cm X 55cm and cups with width 1 - 4cm and depth 0.2 - 1.0cm. Therefore, the weight (specific weight of a stone is 1.8-2.2 gr/cm^3), of an average kernos is from 4 - 11 kilos. This weight is heavy for a pilgrim to carry the kernos and the offerings and finally to poor them into the altar or in front of deities. Therefore, it is concluded that kernoi heavier than ca. 4 kilos were used in other (what?) uses than for libations; 3) the dimension of each cup has a volume less than 6cm^3. Those volumes are very small to hold offerings, if they are compared with the picture of the Aghia Triada sarcophagus (H.M. room XIV) where, some pilgrims give to the helping-women of the altar great quantities of wine and/or oil or solid produce for libation or sacrifices as offerings to deities; On the other hand, how many products or fruits can a farmer produce in the same season to put them into a kernos having 30 or 33 or 40 or 51 or 105 or 107 cups? There are not so many agricultural products produced in any season of a solar year in Crete! In addition, since pawns have been found nearby and fitted to the cups of a nearby kernos therefore, probably counting with pawns is involved on those cups. Therefore, the case that kernoi were used as libation tables is questionable.

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[19] Webster's Dictionary. 1961: calendar.   [20]Blomberg and als. 2002: 81-8.

3. Kernoi interpreted as game-boards for playing games

3.1. General comments

It is known that a game is a physical or mental competition contacted according to rules in which the participants play in direct opposition to each other, each side striving to win and to keep the other side from doing so, Webster's Dictionary[21]. Therefore, it is concluded that no rules on a configuration of cups on a kernos mean no game at all.

"Senet" has been the oldest Egyptian board game known to exist worldwide[22]. Sets have been found in burial chambers in Egypt from as far as 3,100 BC. There were made of wood or stone and their dimensions are carved or painted squares (3 cups or squares X 10 cups or squares). The original rules have been lost. The second oldest, game is "The Royal Game" of Ur[22] of the 2,600 years BC. The rules found on a unique clay tablet contained the only direct evidence for the rules of the game[22], this tablet was dated 177 BC. The box of contents of a replica for this game sold at the British Museum includes the rules and the following pieces/ pawns: 1 folding game board; 14 dotted games pieces; 10 pictorial games pieces; 50 coloured 'money' tokens in red, white and blue; 4 special dice. The third oldest is the "Mehem" which may be a race game played on the about 100+ squares carved on a coiled snake[22]. The exact rules are unknown.

3.2. Scientists supporting that kernoi were game boards

Sir Evans[23] in the Queen's Megaron at Knossos unearthed a half broken kernos, (see Fig. 8). He characterized that it was a game, but no rules were given or invented by him on how this 'game' was played. There are three very similar kernoi to it in the Minoan Crete. The main supporters of this theory were/ are van Effenterre[11], Levi[24], Zoes[25], Whittaker[26], Hillbom[3] and als.

Furthermore: Whittaker[26] wrote that Van Effenterre[11] "found supporting evidence for his suggestion that one kernos was board-game in a later Greek inscription made in a rock near the summit of Mount Oxa. The inscription was easily deciphered; it included the word *naumachia* (in Greek: ναυμαχία) and its meaning could reasonably be interpreted as a reference to the later game." This argument is questionable, because: a) the kernos is like the one found by Sir Evans[23] (see Fig. 8); b) it is wandered how that inscription was preserved in the open air in the mountain and finally it was red as *naumachia* (in Greek: ναυμαχία) and at the same time the kernos on the rock was badly damaged from the same weather conditions throughout millions of years! c) The later game of *naumachia* is played on a net of squares by two players each one having two game-boards; one is for distributing the pieces of "his fleet" and the other for keeping track of his shots against his opponent's fleet. Each square is defined by a horizontal and a vertical number. Therefore, Van Effenterre[11] speculation is questionable.

Whittaker[26] argued on the title of her paper, "Minoan Board Games: The Function and Meaning of Stones with depressions/cups (so called kernoi) from Bronze Age Crete", that kernoi were probably games. But she did not give a set of rules on how Minoan board games played on at least one of the 63 well-preserved kernoi, which she presented in her paper.

The same argument suggested by Hillbom[3] who in his doctoral thesis "Minoan games and game boards" did not give any set of rules of any of the 167 well or badly preserved kernoi. Warren[27] and Buchholz[28] also discussed the question of kernoi and both proposed the gaming and the ritual functions

[21] Webster's Dictionary. 1961: game.
[22] Brit. Ult. Ed. 2011: Senet, R. Game of Ur, Mehem.
[23] Evans. 1930: *The Palace of Minos.*
[24] Levi. 1976-88: *Festos e la civilita minoica* I:1-

II:2.
[25] Zoes. 1972b: 274-309.
[26] Whittaker. 2005: 73-85.
[27] Warren. 1984: 307-23.
[28] Buchholz. 1987: 126-84.

of kernoi which are questionable. Warren prefers the kernos as libation table's interpretation.

Scientists who supported that kernoi were game-boards or games connected with rituals have not proposed at least a set of rules for playing a game on any Minoan kernos. Therefore, the case that kernoi are boards for playing games is questionable.

3.3. Archaeologists who refuted this game theory

The archaeologists Chapouthier[10], Demargne[13], Banti-Pernier[14], Pernier[15] and others are against the theory that kernoi were games and they supported that kernoi were libation tables.

Herberger[12] referred that "Sir Evans … offered the hypothesis that the Mallia-table, (see Fig. 7), was merely a table for the diversion of gambling." He inferred that Evans's hypothesis appears the less likely.

Davaras[29], who was then Director of the archaeological Museum in Aghios Nikolaos and Ephor for Eastern Crete, wrote: "It had been assumed (in libation table theory) that in each cup was put a different kind of grain or 'first-fruits' as an offering to the fertility Goddess, but some scholars believe that the Mallia-table was a large gaming board, a rather improbable interpretation unless the game had a religious or magical meaning." Davaras refuted both theories (libation and game theory) without proposing a new one. A written communication with him on the matter failed.

3.4. Additional reasons for rejecting the game theory

A scientist is very difficult to accept (without mathematical proof) that the 63 kernoi presented in the article of Whittaker[26] are board games; because the 63 different board games would need some archaeologist or researcher to invent 63 different rules of playing each game. It is evident that this is theoretically and practically impossible, since it has not been up to now a set of rules on how at least one game was played on one kernos. Therefore, it is concluded that the Minoan kernoi cannot be either board games or board games connected with rituals; but finally, what was the use of the Minoan kernoi for?

4. Kernoi interpreted as calendars

A calendar is a managing time system by which the beginning, the length, and the division of a time period are fixed and by which days and longer divisions of time are arranged in a defined order, Webster's[19]; for instance, our present solar-year calendar begins on 1st January, its length is 365 or 366 days and those days are divided into 12 solar months.

It is generally accepted that civilizations would not have been developed without the use of a lunar or a lunisolar or a one solar- year or a four-solar-year calendar (the last is our present-day calendar). However, despite the great number of scientific articles, books and doctoral theses on the Aegean, Minoan and Mycenaean civilizations, little has been written about their prehistoric calendars. The current opinion is that there were calendars in prehistoric era, but they had been written on perishable materials, thus they may not have been preserved. At the same time there are letters on rocks and in ceramics, e.g. hieroglyphs, linear A & B tablets of prehistoric era. Why prehistoric calendars had to have been written on perishable materials and probably vanished? If they were written on rocks, stones (like the Minoan flat kernoi) or ceramic material then they will have endured throughout the ages. The question remains on what kind of calendars were those civilizations based on? What were the kind of calendars Minoans used? In this paper this question will be answered for the Minoan civilization through the study of its flat stone kernoi.

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[29] Davaras (1976) *Guide to Cretan antiquities.*

[30] Nilsson (1920) 364.

4.1. The use of calendars in ancient cultures and the lunar calendar

It is known the first calendar was the lunar one, Nilsson[30]. A lunar month calendar begins with the first tiny sight of the moon in the sky, its division (time step) is one day, and it lasts 30 or 29 days (duration of the time period). A lunar year calendar begins with the first sight of the moon in the sky; its division (time step) is one lunar month and it ends after 12 lunar months or 354 days (duration of the time period).

There are at least three configurations in some of the 120 prehistoric caves at French-Spain borders of about 15,000-13,500 years BC, some of which Marshack[31] described but not decoded. My decoding of those three as calendars has not been published yet. Nevertheless, the use of a lunar year calendar needed some corrections from time to time, thus hunters and gatherers to anticipate the dates of massive immigrations of wild animals, the dates of fruit-collecting, the dates of celebrating offerings and sacrifices to their Gods, who helped them to their frequently fatal hunting expeditions; later, when human beings lived in permanent establishments another calendar was needed for sowing and reaping the produce and doing the relevant agricultural jobs in time.

The megalithic monument of Stonehenge mainly is a calendar decoded by Hawkins[32]; the monuments of Avebury (Un. Kingdom), Knowth and Dowth (Ireland), the artefacts from: Nebra Disk (Germany), the Ashtoreth Plaque (Gezer-Jerusalem), some of the Frangocatabrian caves (NE Spain and SW France), and some from the Aegean islands (Naxos (undated), Mykonos (4500-4300 BC) and Keros (2800-2300 BC)) have been decoded by the author but their decoding has not been published yet.

The ancient cultures of the Egyptians (ca. 2,500 BC), left us proofs that they used simultaneously a one-solar year calendar, a civil and a lunar year one. Sumerians and Babylonians used a lunar calendar (before 2,400 BC), a solar calendar (2,400-2,100 BC) and a vague 8-year lunisolar calendar (2,100–538 BC; the 538 BC started the Persian occupation), Britannica Ult. Ed.[22]. Earlier from 2,781 or from 2,500 BC Egyptians used a solar year of 365 days (12 solar months X 30 days each +5 celebration days at the end of a solar year) instead of 365.2422 days, Chatley[33].

The one day delay every four solar years of the Egyptian solar calendar was noticed in the 1st century BC. Then, Julius Caesar gave the problem to the Greek mathematician and astronomer Sossigenes[34] (1st ce. BC), who was the Director of the Library of Alexandria to study a solar calendar for the Roman Empire. Sossigenes suggested a four-year solar calendar in which the fourth year lasted 366 instead of 365 days, i.e. the fourth year to be a "leap" year. Julius Caesar accepted the suggestion and this solar calendar has been the calendar for all peoples of the Roman Empire and our own since 45 BC, with a correction of 13 days in 1582 A.D. Was any other four-year solar calendar before that? Yes, it was a Minoan one. The artifact 55cmX95cm was unearthed by Evans in 1901 was reconstructed nearly to perfection by Papadakis and was decoded by the author, Pliakos 2015b.

The Minoan lunar year calendar begins on the first sight of the moon in the sky after the autumn equinox, as archaeoastronomers Bloomberg[20] and als. proved.

The number 12, which is frequently met in the mythologies of ancient people, may signify the 12 lunar months of one lunar year of 354 days (=12 lunar months X 29.5 days/ (lunar month)). A lunar year is shorter by 11 days (=365-354) of a solar one.

4.2. What is a lunisolar calendar?

The leaders of hunters and gatherers moved their tribes from caves to permanent establishments in small or bigger communities. They started to sow their seeds and reap the produce by counting in lunar

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[31] Marshack. 1991: 334-336.
[32] Hawkins. 1965: *Stonehenge Decoded*
[33] Chatley. 1943: 121.
[34] Sossigenes. 1st ce. BC.

months, as they had done before, but the produce was poor and insufficient for feeding the tribes. Their leaders may have understood that the problem was with the lunar year calendar of 354 days; because in three solar years (of 365 days each) the lunar calendar was 3x (365-354=) 33 days behind the seasons. They observed nature and verified that seasons dictated all the agricultural events, but they could not abandon their old and religious calendar with the dates of celebrating their Gods. The lunisolar calendar is the result of the efforts made by the leaders or priests or sky-watchers to find a correspondence between the counting of lunar months (their dates of religious obligations) and to the solar/seasonal year which prevails in nature. Leaders or priests probably by trial and error without abandoning their old lunar calendar tried: 1) a three-year cycle (hypothesis), 2) a five-year cycle (the later Coligny calendar, and maybe evident on a picture in a Minoan fresco) and 3) finally, they found a very good approximation by counting 96 lunar months plus three intercalated 30, 29, 30-day (29, 30, 29-day for the next 96 lunar months period and so on) lunar months, Britannica Ult. Ed.[34a] . The duration of 99 lunar months is 2,923.9376 days; the duration of 8 solar/ seasonal years is 2,921.936 days and the accuracy is about 2 days in 8 solar years. The lunisolar calendar had the advantage that farmers would have good produce by counting 96+3 lunar months in the followed mode: (1st lunar year-l.y.- (=12 lunar months)+ 2nd l.y. (=12 l.ms)+ 3rd l.y. (=12 l.ms +1 intercalated 30-day l.m.)+ 4th l.y. (=12 l.ms) + 5th l.y. (=12 l.ms +1 intercalated 29-day l.m.) + 6th l.y. (=12 l.ms) + 7th l.y. (=12 l.ms) + 8th l.y. (=12 l.ms +1intercalated 30-day l.m.)). Thus, the old lunar calendar will keep in pace with the solar/seasonal one and the farmers will keep their religious obligations/celebration on the old religious lunar dates. The law of intercalation
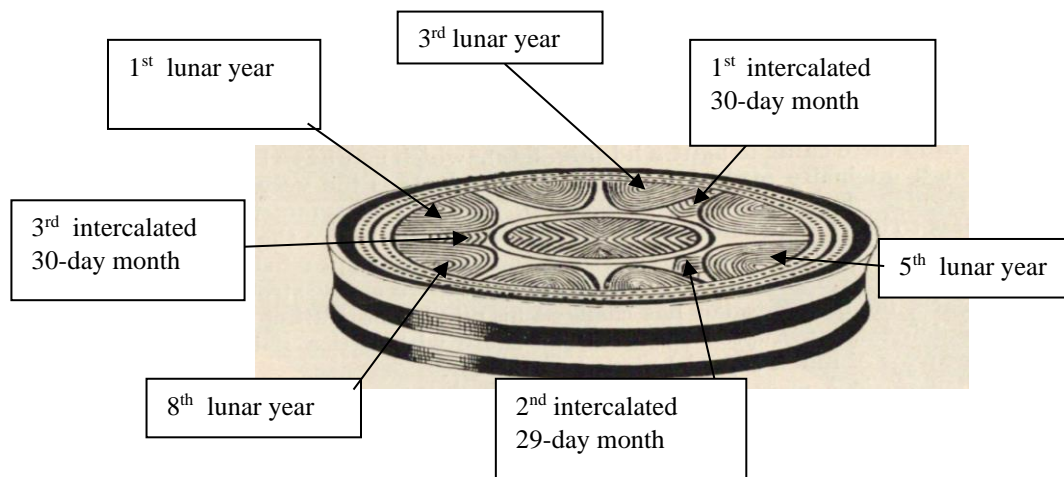

Fig. 3 The cover of the Palaekastro Pyxis probably shows: the big 8 parabolas are the 8 lunar years and the small 3 parabolas are the inserted lunar months at the end of the 3rd, 5th, and 8th lunar years; Bonsaquet; LM III.

at the end of the 3rd, the 5th and the 8th lunar months is pictured on the cover of a Pyxis found in the cemetery at Palaekastro by Bonsaquet[35] (see Fig. 3) but he did not decode it. This law was known to the Minoans from prehistoric times; The pyxis was dated in the LM III era.

Nevertheless, Krupp[36] wrote on the 8-year lunisolar calendar: "So, they (the Greeks) devised a way to bring the moon back in step with the sun (in the 8th or 7th century BC). If a lunar year (12 lunations) is 11-days shorter than a solar year, everybody can recalibrate the lunar calendar by adding an extra month every so often." He continues: "The Greeks, then, tried to broker a marriage between the sun and the

[34a] Britannica Ult. Ed. 2011: Lunisolar Calendar.   [36] Krupp. 1992: 149-53.
[35] Bonsaquet. 1939-1940: 38-59.

moon through an eight-year engagement. They called this eight-year cycle the *octaeteris or MEGA ETOS (ΜΕΓΑ ΕΤΟΣ)*, and they made "leap years" out of the third, fifth, and eight lunar years by inserting one of the three extra lunar months in days [(30, 29, 30)- first 8-eteris-, (29, 30, 29)- second 8-eteris-, (30,29,30)- third 8-eteris, and so on] Britannica Ult. Ed.[34a] at the end of each of those years and in the series of the 8-year lunisolar calendars."

4.3. Lunisolar calendars in Greek Mythology

It is worthwhile mentioning that there are, at least, two ancient Greek myths from which everyone can infer the use of an eight-year lunisolar calendar in the Greek mainland from prehistoric ages.

The first myth is the race of Pelops and Hippodamia (they represented the sun and the moon in the same chariot, i.e. in the same calendar), who contested a race, from Olympia to Poseidon Temple at (Kyras Vrysi 16 km. eastwards of) Corinth, against her father Oenomaus (he represented the old calendar of the 12 lunar months - the 12 heads of the previous 12 suitors-losers, hanging in Oenomaus Palace, before the new suitor Pelops arrives). The race was won by the couple signifying the 8-year lunisolar calendar (or 99 lunar months) had replaced the old lunar calendar. The key to this decoding is that the distance between Olympia and Kyras Vrysi is 990 stadia (=**99**X10).

The second myth is a foot race between Hippomenes - the sun - having three golden apples in his hands given by the goddess Aphrodite, i.e. the three intercalated lunar months - against Atalanta - the moon. The price would be either death for the male or marriage for the insubordinate female. The race started and Hippomenes advanced in the race and whenever Atalanta approached him, he threw a golden apple away; Atalanta stopped to pick up each apple in turn and reached the winning post just behind Hippomenes. The marriage of the sun with the moon took place, i.e. the lunisolar calendar with the three intercalated lunar months (the three apples) was initiated.

The mythological stories are taken from Graves[37]. The general approach to decoding the myths as hidden calendars have been made by the author.

There are testimonies to pre-classical calendars by Greek writers. Dionysius from Halicarnassus[38] (*I 23*), a Greek Historian and Oratorian wrote that the agricultural Pelasgic year started in September (like the Minoans, Blomberg[20] and als. 2002):
'Οι Πελασγοί …εύξαντο…καταθύσειν δεκάτας των προσεγεννησομένων απάντων. Τελεσθείσης δε της ευχής εξελόμενοι καρπών τε και βοσκημάτων το λάχος επέθυσαν τοις θεοίς.'
'Pelasgians …wished …to give one tenth of their produce away. After the end of prayer, each one gave to Gods whatever he had promised (the translation was made by the author).'

The Pelasgians were people who occupied Greece before the 12th century BC and mentioned by Homer[39] (*Od. T 177*), Herodotus[40] (*1. 56,57*). They are said that Pelasgians to have inhabited various areas in Greece, such as Thrace, Argos, Crete, and Chalcidice, Britannica Ult. Ed.[22]. Homer[41] (*Od. 179*) also writes indirectly that an 8-year lunisolar calendar was used by the Minoans.

'Πόλη μεγάλη είναι η Κνωσός της Κρήτης, όπου ο Μίνως, του Δία συνομιλητής βασίλευε για εννέα (9) χρόνια.'
'Knossos is a great city, where Minos, Zeus' interlocutor, reigned for nine years' (the translation by the author).

[37] Graves. 1992: 109, 80k.
[38] Dionysius from Halicarnassus. 1st ce. BC: I 23.
[39] Homer. 9th - 8th ce. BC: Od. T 177.
[40] Herodotus. 5th ce. BC: 1. 56,57.
[41] Homer. 9th - 8th ce. BC: Od. T 179.

It is reminded that prehistoric and ancient people did not start counting from zero, as we do, but from number one. This counting is called "inclusive", Nilsson[30]. Therefore, when Homer wrote 9 years, he meant 8 solar years, when the sun and the moon start a new course of 8 solar years, i.e. the starting of an 8-year lunisolar calendar.

This is verified (today's measures) by the fact that an 8-year solar calendar lasts 2,921.9376 days (=8 solar years X 365.2422 days/s.y.) and this was synchronized in practice with a series of 99 lunar months. The 1st lasted 2,923.9376, the 2nd in the series lasted 2,922.9376 days, the 3rd 2,923.9376, the 4th 2,922.9376 and so on, Britannica Ult. Ed.[34a].

5. What is a solar calendar? When first used?

A Solar cycle is the time it takes the Earth to revolve once around the Sun, i.e. 365.25 or actual 365.2422 days. This solar cycle in order to be a calendar needs the definition of a beginning (e.g. 1st January), the time division (e.g. one solar month) and its duration 365.2422 ca. 365.25 days.

If the 5 (or 5.25) days are subtracted from the 365 (or 365.25) days of a solar cycle then the 360 days can be divided by 20 or 30 or 36 days (probably the days of one solar month), thus the corresponding calendar will have 18, 12 or 10 solar months correspondingly.

The Egyptians started calculating the duration of a solar year as lasting 365 days in 2,781 or 2,500 BC, Chatley[33]. Each solar year was split by the Egyptians into 12 months of 30 days each (3 weeks X 10 days/week), plus 5 celebration days at the end of the solar year which were dedicated to their 5 main gods, Isis, Osiris, Nephthys, Horus and Seth. The Babylonians made the same division of the solar year, but they kept the last 5 days of each of the 5 solar years to be added to the end of the 6th year thus making a 30-day (=5 days/years X 6 years), i.e. a 13th solar month. That happened between 2400 and 2100 BC and later they changed to a vague 8-year lunisolar calendar. Vague means there were no rule of inserting the three intercalated lunar months, Britannica Ult. Ed.[34a].

6. Kernoi as calendar

Herberger[12] tried to decode the Mallia table (Fig.7), from its configuration, as an 8-year cycle, not as an 8-year lunisolar calendar yet. The table of Mallia is a stone artifact "in situ", having 90cm in diameter, 36cm in height (25cm inside the earth), with 33 similar cups and one bigger; Herberger[12] was the first to argue that this kernos functions as an 8-year lunisolar cycle. If he knew when this cycle begins then he would name it an 8-year lunisolar calendar.

The archaeoastronomers Bloomberg[20] and als. proved by observation the existence of a Minoan solar calendar of 365 or 366 days. They wrote, in their fig 4: "The first rays (a beam) of the sun on the equinox strike a shallow bowl (A) built into the floor of the darkest part of the Central Palace Sanctuary at Knossos. A reflection (B) is cast on the western wall and the (corresponding) shadow on the southern wall (in three solar years) touches the tip of the incised double axe (C)." It was easy, the above archaeoastronomers to conclude that every fourth solar year this phenomenon repeated itself but one day later and consequently that the Minoans knew the 365 days (for each of the three solar years) and the 366th day of a leap year, i.e. they knew the four years calendar. Therefore, the use from the Minoans the one-year solar calendar is certain (the proof is in the decoding of Fig.8). There is an artefact picturing the 4-year Minoan solar calendar, Pliakos (2015b).

6.1. Scientists who reject the calendrical theory of kernoi

The old considerations that kernoi are either libation tables or game boards for playing games or game

boards connected with rituals are prevailed without a convincing argument. No scholar made a documented argument against the calendrical proposal/theory on the use of kernoi.

6.2. The basis of the proposed theory

The problem of 'what the Minoan flat kernoi were for' has remained unanswered since 1901. The above three groups of scientists have not presented decisive arguments for their thesis because they approached the answer to the problem only through the qualitative characteristics of kernoi and not through the qualitative and the quantitative (the countable) ones. One's opinion argued against the other's and vice-versa. The three first answers are questionable for the reasons stated above. None scholar on the question of the Minoan flat stone kernoi has seen "out of the box" of archaeology; i.e. to look the problem through its multidiscipline dimensions as the New Archaeology considers. The present paper is based on detailed observation of kernoi, on the analysis of their characteristics (the quantity and the quality of cups) and on the knowledge of prehistoric Egyptian and Babylonian solar calendars.

Two of my relevant papers were presented at Société Europeenne pour l' Astronomie dans la Culture 2013, at the University of Athens, 1-7 September, (in Google: SEAC 2013 *Conference-Book* of abstracts). The abstracts of the two articles were published: a) on p. 95, "Minoan prehistoric solar calendars carved in stones, the riddle of kernoi;" and b) on p. 96, "Comparative study of an Aegean and two Knossian kernoi as lunisolar calendars", Pliakos[42].

A 110 A4-pages book on the calendric decoding of kernoi published in Greek *"ΜΙΝΩΙΚΑ ΗΜΕΡΟΛΟΓΙΑ ΣΕ ΚΕΡΝΟΥΣ (2300-1100 π Χ.)"*, Pliakos[43] and shortly it will be published in English, *"MINOAN CALENDARS ON KERNOI (2300-1100 BC)."*

The journal "*EIRENE*" (2015), of the Czech Academy of Science, published one of my articles by the title: "Minoan Solar Calendars Carved in Stones and the Riddle of Kernoi", Pliakos[44].

7. Detailed examination of the 10 kernoi analyzed and presented here

7.1. Preliminary remarks

The above-mentioned archaeologists Hood[17] and Hillbom[3] allocated each kernos having or not having one central big cup. This division is ineffective because the central cup was used as a depot for holding the pawns for counting, Sir Evans[23], H. Van Effenterre[45]. Some scientists add the central, the similar, the bigger and the separated cups; this operation is against the axiom of addition; because only similar things must be added.

The statistical distribution of similar cups of the Minoan kernoi showed that 28 out of 73 (i.e. 38%) studied here were carved with 12 similar or 12 similar cups + 1 bigger one. Why is that? Because kernoi with 12 similar cups reminded us the 12 lunar months of one lunar year. Kernoi with a configuration of 12 similar cups + 1 bigger one remined us that in the 12 cups the calendar-tender marks with pawns the 1st up to the 12th lunar months of one lunar year and in the +1 bigger cup he marks with pawns both: periodically the 13th lunar month, when needed, and the current lunar year for an 8-year lunisolar calendar. The lunar and the lunisolar calendars prevailed in prehistoric times. Therefore, the author oriented his study on the calendric solution of "what the Minoan flat kernoi were for."

As it was stated earlier the prehistoric calendars were presented here as follows: the one-year lunar (see Figs 4, 5); the 8-year (or 99 lunar months) lunisolar (see Figs 6, 7, 13, 14); the one-solar year in (see Fig. 8) or parts of them (see Figs 3, 8, 9, 10, 11, 12). In a detailed decoding the above 10

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[42] Pliakos (2013) 95-6.   [44] Pliakos (2015b) 221-234.

[43] Pliakos (2015a).   [45] Van Effenterre (1980).

Minoan flat kernoi are decoded. In the appendix, Table 1, the above 10 and the rest 63 well preserved kernoi- calendars are briefly decoded.

7.2. A kernos with 10 cups +1 bigger one

H. Van Effenterre[45] supported that kernoi were board games, but he did not prove how a game was played on a kernos. He excavated at Malia, a kernos with 10 similar cups + 1 bigger dated in MM III – YM I era, ca. 1,700 –1,475 BC (Fig. 4). The 10 similar cups are for counting with pawns the ten days
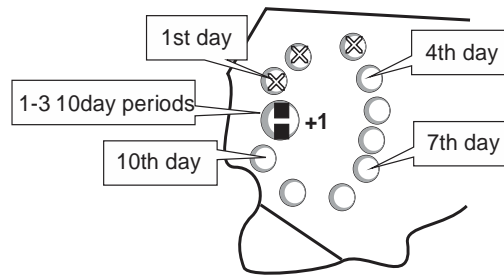

Fig. 4. Kernos with 10 similar cups +1 bigger one; it was unearthed
by H. Van Effenterre, 1980, at Mallia, MM I.

of the one third of one lunar month of 30 or 29 days; in the bigger cup the one or two or three thirds, of a current 10-day periods of a lunar month, are marked with different pawns in the +1 cup.

   Question: What is the date marked in a lunar month calendar on the above kernos on Fig. 4? Answer: The two pawns (the two small black squares) in the bigger cup denote that the current ten-day period is the second one (the first 10 days have passed) of one lunar month and the three pawns (3 x's) in the ten similar cups denote that the current day is the third of a second ten-day period. Therefore, the date marked is the 13th day (=3+10) of a lunar month.

7.3. A kernos with 29 cups + 1 bigger one, and 12 cups + 1 bigger one

Demargne[13] supported that kernoi were libation tables, but he did not prove his thesis in the kernos below. He found this kernos in the open at Chryssolakkos, Malia which was dated in MM I era, ca.
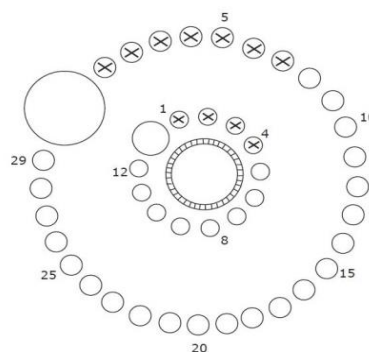

Fig. 5. Kernos with 29 similar cups +1 bigger one (outer cycle) + 12 similar cups +1 bigger one
(inner cycle); it was unearthed by Demargne[13], 1932, at Chryssolakkos, Malia, MM I.

2,100 - 1,900 BC. The kernos had in the outer cycle at least 29 similar + 1 bigger cup and in the inner cycle 12 + 1 bigger cup (see Fig. 5). The 29 similar +1 bigger cups are for counting with pawns (big X's) the 30 or 29 days respectively of one lunar month. The 12 similar +1 bigger cups are for counting with pawns (small x's) the 12 and occasionally the 13 lunar months, when it is needed, i.e. at the end of the 3rd, 5th and 8th lunar years, see below. The central biggest cup of a kernos, when exists, functions as a container for the counting pieces as H. Van Effenterre[45] and Evans[23] suggested.

Question: What is the current date of the lunar year marked on kernos Fig. 5?
Answer: The current day is the seventh of the fourth lunar month of one lunar year.

7.4. A kernos with 48 cups + 3 separated ones

Hillbom[46] supported that kernoi were board games, but he did not prove how a game was played in anyone kernos. He unearthed at Gournia, a kernos with 48 similar cups + 3 separated ones dated in

01 02 03 04 05 06 07 08 09 10 11 12th cup

13 14 15 16 17 18 19 20 21 22 23 24th cup   { I, II, III

25 26 27 28 29 30 31 32 33 34 35 36th cup   separated

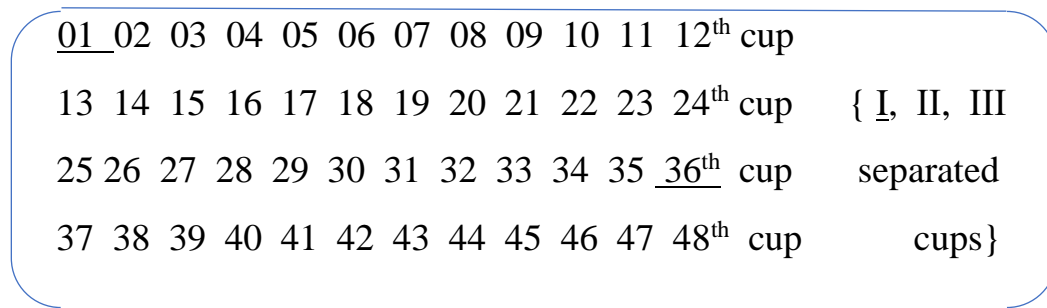37 38 39 40 41 42 43 44 45 46 47 48th cup   cups}

Fig. 6. Kernos with 48 similar cups for counting the 96 lunar months [(1-36, 38-61 and 63-98) = 96 cups = =48 cups X 2 pawns per cup] + 3 separated cups for counting the 37th, the 62nd and the 99th lunar months; it was unearthed by Hillbom, 2005, at Gournia, LM?

the LM? era, (Fig. 6). In the 48 cups by marking two pawns per cup the 96 lunar months are counted. In the three separated cups (for the first time) the three intercalated 30-day, 29-day, 30-day (or for the second time 29-day, 30-day, 29-day) lunar months of an 8-year lunisolar calendar are counted after the end of the 36th (or the 3rd lunar year) -a 30-day lunar month; after the 61st (or the 5th lunar year) -a 29-day lunar month; and after the 98th (or the 8th lunar year) - a 30-day lunar month. It is reminded that the above calendric process of an 8-year lunisolar calendar or the 99 lunar months lasted the first time 2,923.9376 days, the second time 2,922.9376 days, the third 2,923.9376 days and so on. The duration of 8-solar years is 2,921.9376. The deviation of 99 lunar months minus the 8 solar-years is 2 days (2,923.9376 - 2,921.9376) in the first 8-year lunisolar calendar, 1 day in the second (2,922.9376 - 2,921.9376) and 2 days in the third and so on. This is because in the first 8-year lunisolar calendar the intercalated lunar months in the 3rd, 5th and 8th lunar years lasts (30 days, 29, 30), in the second (29 days, 30, 29) and so on Britannica Ult. Ed.[34a]

Question: After the end of the underlined 36th lunar month, what does the calendar-tender count (Fig. 6)? the 37th in the series of the 48 lunar months or the I (the Latin I), the first of the three separated cups on kernos?
Answer: the calendar-tender should put a pawn in the I cup and not in the 37th cup; because the I cup is the first out of three separated cups where the first intercalated 30-day (the second of 29 days and the third 30 days) lunar month will be inserted. It is obvious the calendar on Fig. 6 is an 8-year lunisolar.

[46] Hillbom (2005) 75, 145 (no. 34).

7.5. A kernos with 33 cups +1 bigger one

Chapouthier[10] supported that kernoi were libation tables, but he did not prove his thesis in the kernos below. He unearthed at Mallia, a kernos with 33 similar cups + 1 bigger one dated in MM III – YM I, ca. 1900 – 1520 BC (see Fig. 7). The 33 similar cups are for counting one third of the 99 lunar months of an 8-year lunisolar calendar. The bigger cup is for counting with 1, 2 or 3 pawns the 1st or the 2nd or the 3rd thirds of 99 lunar months. The central biggest cup is a depot for pawns marking the lunar months and for pawns marking the 1st, the 2nd and the 3rd thirds of a 33-lunar months period.
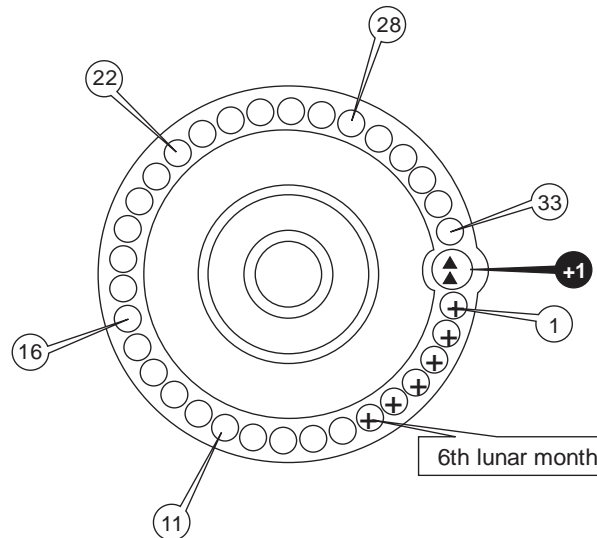

Figure 7. Kernos with 33 similar cups counting the 1/3 of the 99 lunar months + **1** bigger cup counting the 1st or the 2nd or the 3rd third 33-lunar-month period of an 8-year lunisolar calendar; it was unearthed by Chapouthier, 1928, at Mallia; MM III.

Question: What is the current lunar month on kernos Fig. 7?
Answer: The two pawns (two black triangles) in the + 1 bigger cup denote that the current 33 lunar month period is the second one (the first of 33 lunar months have passed) and the six pawns in the (second) 33 similar cups denote that the current lunar month is the sixth in the second 33 lunar-month-cycle. Therefore, the current lunar month is the 39th (=33 passed+6 recently counted).

Herberger[12] tried to prove that the above kernos is a kind of clock or an 8-year cycle; at the beginning he intercalated 3 lunar months after the 33rd, the 66th and the 99th lunar months which corresponded in different seasons of the year and the result was unappropriated for the farmers; Finally, Herberger[12] intercalated one 30-day lunar month at the end of the 36th lunar month, the next 30-day lunar month at the end of the 61st lunar month and the final one 30-day lunar month at the end of the 98th lunar month (or in summary the intercalation was performed at the end of the 3rd, 5th and 8th lunar years). This was appropriate for the farmers because the intercalation was made in the same season of the year; i.e. after the 12th lunar month of a new lunar year; Herberger's idea probably came from the classical Greek lunisolar calendar of the 8th-7th ce. BC. This rule of intercalation is a crystal-clear rule for the farmers and although the farmers count lunar months (religious obligations), this rule keeps closely the counting of lunar months to the solar seasons for the benefit of agricultural produce. On the contrary the Babylonian insertion rule of intercalating the 3 lunar months was vague up to 538 BC, Britannica Ult. Ed.[22].

7.6. A kernos with 5+5 cups and two composite cups of three and two ones

This half-broken kernos was unearthed at the Queen's Megaron, Knossos (Fig. 8) at the beginning of the 20th century by Sir Evans[23] who supported that this kernos was a game board, but he did not propose any set of rules of how the game was played. He dated it in the MM II era, ca. 1,900 – 1,700 BC and he

symmetrically completed the other half. He had missed the opportunity to decode the integrated kernos as a calendar, because he had seen the two diagonally opposite composed 3 and 2 cups (Fig. 8), as consisting of the two double cups and not as one of three and the other of two cups. The joined cups are 5 (=3+2) which remind us the 5 added days at the end of each Egyptian solar year of 365 days (= 12 solar months X 30 days each + 5 days). The precious paper of Blomberg[20] et als. proved that the Minoans knew and used the one-year solar calendar of 365 days (see Fig. 8) the beginning of which was at the next day of the autumn equinox i.e. the 22nd September; this was concluded from the fully enlightened walled ramp at the peak sanctuary of the mountain Juktas, near Knossos, and from the recurrence of a beam of light for three solar years in a special spot of the Central Palace Sanctuary at Knossos every autumn equinox, Blomberg & als[20].
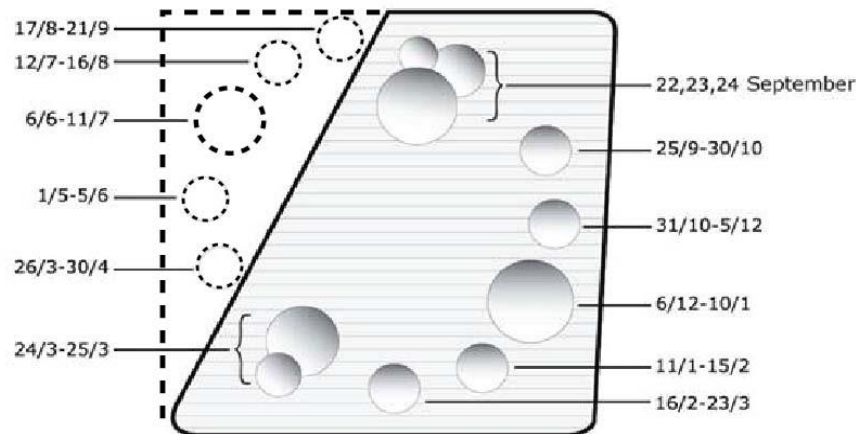

Fig. 8. Kernos with 3 joint cups + 2 similar small +1 bigger + 2 similar small + 2 joint cups + 2 similar small +1 bigger + 2 similar small ones; it was excavated by Sir Evans, 1901, at Queen's Megaron, Knossos; MM II.

If the jointed cups of the 3 and 2 (=5) day-cups are deducted from the 365 days of one solar year, the remainder will be 360 days. If those are divided by 10 cups (=5+5) then the division's quotient will be 36 days per each of the 10 cups (=360/10). The opposite situated composited 3 and 2 cups and the two middle dates of the opposite bigger (on purpose made) cups denote correspondingly the 21st September, the 23rd March, the 22nd December, and the 21st June, i.e. the dates of the autumn and the spring equinox, and the winter and the summer solstices. In conclusion from the above artefact the Minoan priesthood have known, first the Minoan division of a solar year in 365 days (=3 days +5 "solar months" x 36 days each + 2 days + 5 "solar months" x 36 days each) and second the four distinguished solar events of a solar year since 1900-1700 BC. This division of the Minoan solar year is totally different from the Egyptian or the Babylonian one, i.e. the one-year solar calendar in Minoan Crete was indigenous.

Archaeologist Boyd[8] supported that kernoi were board games. She unearthed a kernos at the mountain Kavoussi in the captain's residence, room 1, H.M. 113, an irregularly shaped block; its diameter is 28-29 cm and bears 5 and 5 symmetrically arranged cups, the 3rd and the 8th are bigger, alike (see Fig. 8). The 5+5 cups are divided by a line-diameter signifying the two halves of a year's duration for marking the 5+5 solar months of a Minoan solar calendar. At each end of the diameter are 3 and 2 obtuse angles (difficult to see, Evans[23]) in the place of the 3 and 2 joined cups of the previous Evans' kernos. In the middle of the diameter there are two small parallel lines targeting at the 3rd and the 8th bigger cups at the middle of which the 22nd December and the 21st June can be marked, i.e. the winter and summer solstices. The 21st September and the 23rd March are spotted as the ends of the line-diameter. The cups have diameter 3-4cm and depth 0.4-0.8cm; there, it was found also one pink clay disk with stripes in black of diameter 3.3 cm and thick 0.2 cm matching as pawn to every of the ten cups in the kernos; was it a pawn for counting solar months? Boyd[8] thought this kernos as a board game like a backgammon or roulette, but she did not give any rules how the game was played.

7.7. A kernos with a group of 4 cups and a group of 9 bigger cups

The above 36-day period (=360/10, see 7. 5.) can be named as one Minoan solar month; if this is the case, it must be found a kernos with one group of 6 similar cups and another group of 6 similar or bigger ones (6X6=36 cups/days) or one kernos with one group of 4 similar cups and another group with 9 similar or bigger ones (4X9=36 cups/days). The second case was realized by the founding by Hood[17] of a kernos (Fig. 9) which was unearthed five meters away from the previous half-broken one, the Evans' one (Fig. 8). The connection between those two is evident. One completes the other and both form a one Minoan solar year calendar counting 365 days; i.e. 3 days at the beginning of the solar year + 5 solar month of 36 days each (or twenty 9-day weeks) +2 days in the middle of the year + 5 solar month of 36 days each (or twenty 9-day weeks).

The artifact was dated in the MM era, ca. 2100-1625 BC. Hood[17] supported that this "in situ" kernos 1.20m x1.20m was for offerings and libations which is questionable. Thus, the division
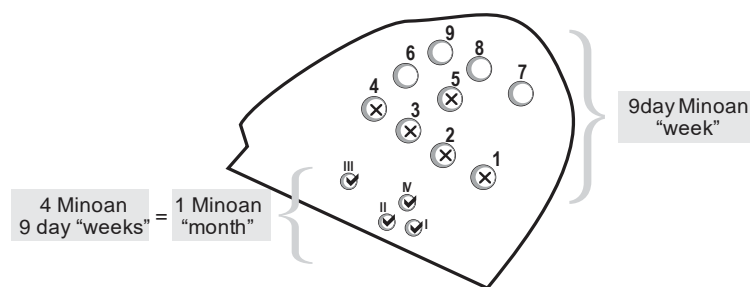

Fig. 9. Kernos with 9 big cups for day-pawns + 4 separated small cups for 9-day week-pawns; it was unearthed by Hood, 1995, at Queen's Megaron, Knossos; MM.

of a 36-day Minoan solar month into 4 Minoan weeks by 9 days each is evident, and it made the 10-month of 36-day each (plus the 3 and 2 intercalated days) Minoan solar calendar more functional.

Question: What is the current date of the Minoan solar month calendar on Fig. 9?
Answer: The current Minoan solar week is the 4th week -4v- (three 9-day weeks have passed) and the current day is the 5th -5x- of the 4th week; thus, the current date of the Minoan solar month is the 32nd day (=3 Minoan weeks X 9-day each + 5 days).

7.8. A kernos with 18 cups or 18+1 cup

Soles[47] supported that kernoi were associated with cemeteries, which is questionable because kernoi were unearthed nearly everywhere. She found at Gournia two kernoi in a street, one outside room Cb 11 and the other outside room Ee 30. The first kernos had 18 cups for counting 36 days (=18 cups X 2 pawns/cup), i.e. one Minoan solar month; the second found at house Aa room 4, G, had 18 cups for marking the 18 days of half a Minoan solar month calendar + 1 bigger cup for marking the first or the second of the 18-day period. Both kernoi dated in MM era.

Question: What is the current date of the Minoan solar month calendar Fig. 10?
Answer: The two black squares on the +1 bigger cup denote that the second 18-day period is running, the first one of the 18 days has passed. The five x's in the 18 similar cups denote that the current day is the 23rd (=18+5) of a Minoan solar month.
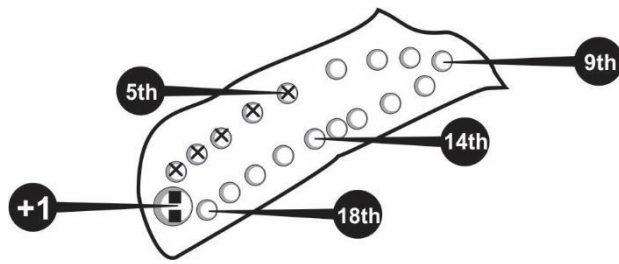
[47]Soles (1979) 149-167.

Figure 10. A kernos with 18 similar cups +1 bigger one;
it was unearthed by Soles, 1979, at Gournia, house Aa, room 4, G; MM.

7.9. A kernos with 9 or 9+1 cups

Whittaker[7] supported that kernoi probably were games, but she did not give any rules on how a game was played. She found two kernoi with 9 similar cups, at Kommos, Phaistos each for marking a 9-day
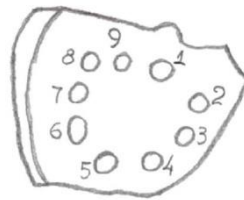

Fig. 11. A kernos with 9 cups; it was unearthed by Whittaker, 1996, at Kommos, Phaistos; MM II.

Minoan solar week; the one, no. 5, fig. 4.53, no. 91 dated in MM II era, ca. 2,000 – 1,700 BC, (Fig. 11); the other, is no. 4, fig. 4.52, (Fig. 12) dated LM? ca. 1,650 – 1,100 BC. She also found a kernos probably with 9 similar cups + 1 separated cup at Kommos, Phaistos (Fig. 11). The kernos had 9 similar cups (the
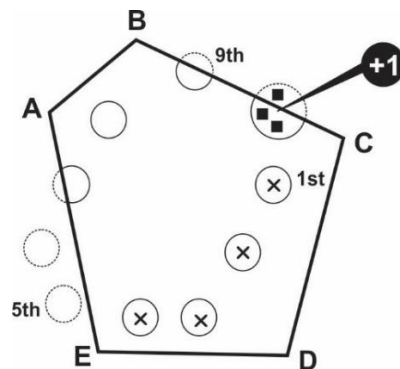

Fig. 12. A kernos with 9 similar +1 cup; it was unearthed by Whittaker, 1996, at Kommos, Phaistos; LM?

5th and 6th probably missed, the 7th and 9th are halves and the +1 bigger cup is half) for counting a 9 days Minoan solar week; in the +1 bigger cup with 1 or 2 or 3 or 4 pawns the current week of a Minoan solar month is denoted; the kernos has not been dated.

Question: What is the current date of the Minoan solar month calendar on Fig. 12? Answer: The three black squares on the +1 bigger cup denote that the third 9-day period is running, (the two 9-days have passed). The four x's in the 9 similar cups denote the fourth day of a week, i.e. the current date is the 22nd day (=18+4) of a Minoan solar month.

7.10. Summary and conclusions of the 10 decoded kernoi

The 10 kernoi are prototypes for the decoding of the 73 rather well-preserved kernoi as they are decoded in Table 1. The 73 kernoi are categorized in 34 groups according to their: 1) similar cups; 2) similar and bigger cups; 3) similar, bigger and separated cups. In brief they cover: a) a lunar month calendar, see Fig. 4 ; b) a lunar year calendar, Fig. 5 ; c) an 8-year (or 99 lunar months) lunisolar calendar, Figs. 6,7 ; d) a one-year Minoan solar calendar of the type 3 days celebration at the beginning of a solar year + 5 Minoan solar months x 36 days each (=180 days) + 2 days celebration at the middle of a solar year + 5 Minoan solar months x 36 days each (=180 days), see Fig. 8 ; e) a one-month Minoan solar calendar of the type 9 bigger x 4 similar cups, see Fig. 9 ; f) a one-month Minoan solar calendar of the type 18 cups x 2 pawns/cup, see Fig. 10 ; g) a 9-day solar week calendar, see Fig. 11; and h) a one-month Minoan solar calendar of the type 9 similar +1 bigger cups, where 1st ,2nd ,3rd or 4th Minoan solar week is marked, see Fig. 12.

8. Wrongly reconstructed kernoi

The reconstruction of badly damaged kernoi according to a proposal/theory is of fundamental importance. A lot of Minoan kernoi were unearthed in bits and pieces and they have been reconstructed arbitrarily, because there is not a general proposal/theory of what Minoan kernoi used for; thus, the responsible archaeologist had no means to base on the guide lines of the reconstruction of a broken kernos. Therefore, it would be very-very difficult for archaeologists to give directions to the reconstructors on how to make up the artifact from its bits and pieces as to how it was in the Minoan times. An example of a wrongly reconstructed Minoan kernos is the artefact in the Heraklion Museum, no. H. M. 3587, (see Fig. 13). It has been unearthed by Karetsou[5], who has excavated at the peak sanctuary of Juktas for some periods since 1974, but she has not decoded it.
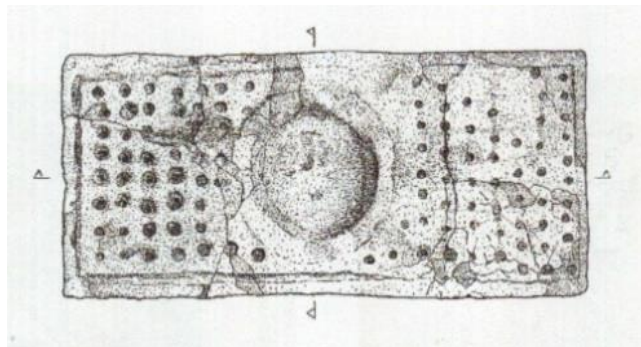

Fig. 13. The kernos M.H. no. 3587 with 45 cups in 6 columns on the left + 55 cups in 7 columns+ 1 big central cup + 7 separated cups around it, unearthed by Karetsou, at Mt. Juktas, Knossos.

If a theory on the Minoan flat stone kernoi had invented, proved and accepted, then archaeologists would have given correct instructions to reconstructors for making up a Minoan kernos as calendar if a corresponding calendrical configuration exists.

Kernos (see Fig. 13) is a slab of 42cm X 18cm X 8cm, unearthed by Karetsou[5], MMII era or 1900 - 1700 BC. On its left side, little damage has been done, there are 45 cups (diam. 2.2-3.3 cm) in six columns. On the left side of the kernos the first 5 columns consist of 8 cups and the sixth one of 5, which makes 45 cups (= 8x5+5) properly arranged. According to the symmetry rule the cups of the right side of kernos should have been arranged in columns of 8 cups and not as the cups they have been (see Fig. 13), i.e. arbitrarily scattered and arbitrarily numbered as 55 (=8+8+7+8+5+9+10); Why two mistakes were made (the columns should be of 8 cups each and the sum should be of 54 cups, see below)? Because only a few scientists, who tackled the problem, knew the prehistoric 8-year lunisolar calendar (or its

duration of 99 lunar months). The number of cups on the right side of the kernos should have been 54 cups (= 99-45). Therefore, the reconstuctor should have arranged the 54 cups in columns of multiple of
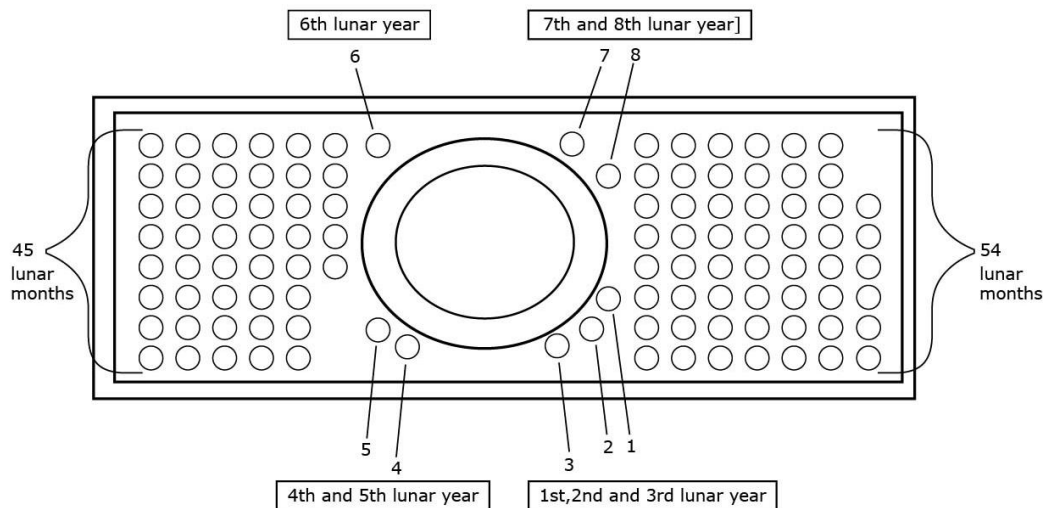

Fig. 14. Kernos with 45 cups (=5 cols. x 8 cups/col. + 5 cups) on the left side and 54 cups (= 6 cols. X 8 cups/col + 6 cups) on the right. Around the central rim the distribution of 8 cups is 3 + 2 + 1 + 2. The kernos was reconstructed according to the proposed/proposal on kernoi by the author.

8 cups plus the rest, i.e. 54 (=8+8+8+8+8+8+6) or 8x6+6, i.e. the symmetrical arrangement of the left side to the right one of kernos H.M. no. 3587. Applying the above proposal/theory that kernoi are lunar or lunisolar or solar calendars or parts of them, the above reconstruction leads to the conclusion that this kernos might have been an 8-year lunisolar calendar.

In the middle of kernos (see Fig. 13) there is a big cup (the earlier mentioned depot) with a diameter of about 9.6cm plus a rim, and about 1.5cm in depth. In the depot were kept the pawns used for marking the 99 lunar months. At the bottom and outside of the rim (Fig. 13), there are 7 cups (= 3 down-right +2 down-left +2 upper- left + 0 upper-right, some of those are badly damaged and therefore, wrongly reconstructed). The 7 cups have not any calendrical justification or connection with the 99 lunar months or the 8-year lunisolar calendar. If the scientist and the reconstuctor knew the previous mentioned calendar of 8 lunar years, then they would make the 7 cups 8 and they would redistribute the 8 cups to a configuration of 3 + 2 + 1 + 2 cups around the rim. The rule of insertion the three lunar months is revealed that they should have made at the end of the 3rd, of the 5th [=(3rd) + 2] and of 8th [=(5th) +1 +2] lunar years. This prehistoric rule of intercalating the three lunar months at the end of the 3rd, the 5th and the 8th lunar years was invented in the Minoan Crete; it is the oldest rule worldwide and it was found by Bonsaquet[35] again on a pyxis, (see Fig. 3). Babylonians made this intercalation arbitrarily up to 538 BCE, Britannica Ult. Ed.[34a].

There are about 15 wrongly reconstructed kernoi which, by the application of the calendric proposal of "what the Minoan flat stone kernoi were", are corrected and decoded briefly in Table 1.

NB. I thank Mrs. Karetsou for giving me the permission to present Fig. 13, from her paper, (2012).

9. Conclusions

The question of what the Minoan kernoi were for, has been tantalizing the old and the new archaeology (multidiscipline science) since the beginning of the 19th century. Famous archaeologists gave three answers that kernoi were: either boards for playing games or board games connecting with rituals or libation tables. None of those prove his argument. Why was that? Maybe, because they did not combine elementary statistics and the knowledge from the prehistoric calendars of Egyptian and Babylonian sources. A fourth archaeologist studied the Mallia table and he (partly) proved that it was used as an 8-year lunisolar cycle, i.e. nearly an 8-year lunisolar calendar.

Having studied for five years 73 Minoan flat kernoi I came up with a new proposal that the Minoan flat stone kernoi were lunar or lunisolar or solar calendars or parts of them, if a corresponding calendric configuration exists.

The 15 wrongly reconstructed kernoi which have a nearly corresponding calendric configuration have been reconstructed again according to the above proposal. All of them are decoded briefly in Table 1.

TABLE I

THE NUMBER, THE SIZES AND THE SEPARATED CUPS ON KERNOI.
Decoded type of calendar; archaeologist found; its location; its citation; dated.

Kernoi according to the number, the sizes and their distribution of cups;	*Decoded type of calendar. Archaeologist found it; its location; its citation; dated.* *(l.ms. = lunar months, l.ys. = lunar years)* *(s.ms. = solar months, s.ys. = solar years)* *(d./ds. =day/days)*
4 similar cups. (3 kernoi) 1st group	1 l.m; 4 phases of the moon, i.e. 7d.+8d.+7d.+6/7d.== =28d. or 29 days, when the moon is in the sky. 1. Boyd, Gournia,1904,38; LM I? 2. Soles, Gournia,1973,7-8; MM. 3. Lebessi & Muhly, Symi,1990, 324, fig. 12; MM III?
4 similar + 1 bigger cups. (2 kernoi) 2nd group	1 l. y; comments as above+ 1 bigger cup, a counter for marking 12 or 13 l.ms. 4. Hillbom, Gournia, 2005,145,32; MM? 5. Whittaker, Kommos, 1996,321-323, no. 3, pl.2. 75; LM IIIA
5 similar cups. (2 kernoi) 3rd group	1 l.m; 5 phases of the moon, i.e. [7d.+8d.+7d.+(6d. or 7d) +(1 or 2) moonless nights ==29 or 30 nights]. 6. Warren, Knossos, 1969a,12; MM III- LM III? 7. Zoes, Vasiliki, 1975,380; EM IIB.
5+5 symmetrical bigger cups with 3 and 2 jointed opposite cups. There are 3 other variations instead of jointed cup. (4 kernoi) 4th group	1 s.y; 3 celebration ds. 22-24 Sept. + 5 s.ms. (180 d.) + 2 celebration ds. 24-25 March + 5 s.ms. (180 d.) =365 days. 8. Evans, Knossos, 1930, PM, 390, fig.261, MM II. 9. Boyd, Kavoussi, 1901, 141-143, fig. 7, LM IIIB? 10. Warren, Knossos, 1984, 321-323; LM III. 11. Van Effenterre, mt. Oxa, 1949, 1036-1038, undated.
Two kernoi found nearby: a) 8 similar cups and b) 40 similar cup + 1 bigger. Both are included in 29th & 31st groups (2 kernoi)	a) 8 l.ys. calendar; b) 8 s.ys. calendar (=40 "weeks" X 9-day/ "week"). The 3 and 2 celebration days counted at the beginning and in the middle of one s.y. in the +1 cup. 12 & 13. H. & M. Van Effenterre, Mallia, 1976,55, pls. VII:2, VII:5; MM IB.

Kernoi according to the number, the sizes and their distribution of cups;	Decoded type of calendar. Archaeologist found it; its location; its citation; dated. (l.ms. = lunar months, l.ys. = lunar years) (s.ms. = solar months, s.ys. = solar years) (d./ds. =day/days)
9 similar cups. (5 kernoi) 5th group	A 9-day solar Minoan "week". 14. Whittaker; Kommos; 1996,321-323; no. 4; pl. 4.52; LM III; 15. no. 5, pl. 4.53; MM I-II; 16. no. 7, pl. 4.54; date not given. 17. No. 2 pl. 4.53; LM I. 18. no.12 pl. 4.56; LM II?
9 similar cups + 1(?) bigger cups (1 kernos) 6th group	Comments as above + 1(?) bigger cup, a counter for marking 1 to 4 "weeks" of a Minoan solar month. 19. Soles, Gournia:1973, 7-8; MM
10 similar cups (capacity: 3 pawns per cup). (3 kernoi) 7th group	One lunar month calendar of 29 or 30 days. 20. Whittaker, Kommos, 1996, 321-323; no. 5; MM I-II. 21. Hillbom, Vasiliki, R, 2005, no. R; EM IIB. 22. Zoes, Vasiliki, M, 1975, pl. IG; EM IIB.
10 similar cups (3 pawns/cup) +1 bigger cup. (1 kernos) 8th group	Comments as above + 1 bigger cup, a counter for marking from 1 to 12/ 13 l.ms. This is a one l.m. calendar of 29 or 30 days. 23. H. Van Effenterre, Mallia, 1980, 321, fig. 438; MM III
11 similar cups. (1 kernos) 9th group	11 days is the difference between solar minus lunar year. It was used to put in pace the one-year lunar to a solar calendar by adding 1-11 pawns (1-11 days) to a lunar year calendar at the end of each l. m, except the 12th l.m. 24. Whittaker, Kommos, 1996, 321-323, no. 6, pl. 4.54; LM ?
12 similar cups or model 3 lines X 4 cups. (7 kernoi) 10th group	1 l.y. calendar; every new moon is marked with a pawn; 25. Warren, Myrtos, 1972, 15, 231, no. 166; EM II. 26. Hillbom, Phaistos, 2005, 161, no. 110; MM I-LM II. 27. 28. 29. Zoes (3 kernoi), Vasiliki, West Court, nos. G, I, P, 1976a, pl. IZ. 30. Hillbom, Vasiliki, 2005, West Court, no. S no. 166; EM IIB. 31. Levi, Festos, 1976-88, I:1, 84, fig. 108, 232u; MM IB.
12 similar cups +1 bigger one. (3 kernoi) 11th group	1 l.ys. calendar +1 cup for the 13th l.m. (when needed). 32. Demargne; Malia; 1932, (inner cycle), 61, pl. III. 33. Whittaker; Kommos;1996, 321-323, no. 13; no dated 34. Zoes; Vassiliki;1975, no. Q, pl. IG; EM IIB

Kernoi according to the number, the sizes and their distribution of cups.	Decoded type of calendar. Archaeologist found it; its location; its citation; dated. (l.ms. = lunar months, l.ys. = lunar years) (s.ms. = solar months, s.ys. = solar years) (d./ds. =day/days)
13 similar +1 separated cups. (2 kernoi) 12th group	Comments as above; one l.y. calendar + 1 separated cup for marking from 1-8 l.ys. for an 8year lunisolar calendar; 35. Zoes; Vasiliki, West Court; no. K; 1975, pl. IG; EM IIB 36. Levi, Festos I, 1935, pl. II; MM II- LM II.
14 similar cups; (2 pawns/cup). (4 kernoi) 13th group	A 28 ds. l. calendar, when the moon is in the sky. 37. Pelon; Mallia; 1970, 146-7, pl. IX:3; MM III – LM I 38. V. Effenterre; Gourn,1955, 544-545, f. 3; MM-LM? 39. Levi, Festos II 1951, 206, fig. 128; MM III – LM I. 40. Levi, Festos, 1952-4, 460-1 fig. 100; MM IB.
15 similar cups; (2 pawns/cup). (2 kernoi) 14th group	1 l. m. calendar; 41. Whittaker; Kommos; 1996, 321-323, no. 9, pl. 4.55; LM I - III. 42. Warren; Myrtos,1972, 231, no. 170 pl.78d; EM II.
15 similar (2 pawns/ cup) +1 bigger cups. (2 kernoi) 15th group	1 l.m. calendar + 1 counter-pawn for marking the 1st or the 2nd half of a l.m. 43. Soles; Gournia; 1979, 154, ill. 1; MM I. 44. Warren; Myrtos; 1972, 231, no. 167: EM II.
c. 27 similar cups. (2 kernoi) 16th group	1-lunar-month calendar, when the moon is in the sky. 45. Hillbom; Mallia; 2005, 157 no. 92. 46. Evans; 1901; NB, n.d.; Knossos; Royal Tomb C; LM II.
28-30 similar cups, no. C. (1 kernos) 17th group	Comments as above; one lunar month calendar. 47. Hood; Vasiliki; 1995, 8, fig. 8; EM II.
28 similar +1 separated cups (1 kernos) 18th group	Comments as above; one l.m. calendar + 1 counter for marking from 1 to 12/13 l.ms. i.e. 1 l.y. calendar. 48. Platon; Zakros; 1972a, 107-108, fig. 102; MM III.

Kernoi according to the number, the sizes and their distribution of cups.	Decoded type of calendar. Archaeologist found it; its location; its publication; dated. (l.ms. = lunar months, l.ys. = lunar years) (s.ms. = solar months, s.ys. = solar years) (d./ds. =day/days)
29 similar cups. (1 kernos) 19th group	One lunar month calendar; 49. Warren; Myrtos; 1972, 231, no. 169, pl.78c; EM II.
2 cycles in the same kernos: 29 similar +1 bigger cups, and 12 similar +1 bigger cups. (1 kernos) 20th group	Comments as 28 +1 above; i.e. 1 l.y. calendar. 50. Demargne; Mallia,1932, 61-63, f. 1; MM I. It has been numbered (see no. 31)
30 (?) similar cups. (3 kernoi) 21st group	One lunar month calendar; 51. Cadogan; Pyrgos, 1978, fig. 5., EM II – MM I. 52. Soles; Gournia, 1973, 7-8, MM. 53. Evans; Knossos, Royal Tomb, A, NB, nd, LM II.
30 similar cups +1 bigger cup. (2 kernoi) 22nd group	one lunar month calendar + 1 counter for marking from 1 to 12 or 13 l.ms. i.e. 1 l.y. calendar. 54. Deonna; Mallia K. Chryss.; 1934, 55, fig. 41:1; MM I. 55. Soles; Mallia; 1992,163, pl. 39b; EM III - MM?
48 similar cups (2 pawns/ cup) + 3 separated cups. (1 kernos) 23rd group	48 X 2 pawns /cup (= 96 l.ms.) + 3 pawns (l.ms) = 99 l.ms. The 99 lunar months of an 8-year lunisolar calendar. 56. Hillbom; Gournia, 2005, 145, no.34; LM I?
33 similar cups (3 pawns/ cup). (2 kernoi) 24th group	33 X 3 pawns/ cup (= 99 l.ms-pawns). That is the 99 l.ms. of an 8-year lunisolar calendar. 57. Warren; Myrtos; 1972, 231, no. 168, pl. 78b; EM II. 58. Hillbom; Knossos, 2005, 148, no. 46; date not given.
33 similar cups (3 pawns per cup) + 8 separated cups. (1 kernos) 25th group	33 cups X 3 pawns/ cup make the 99 l.ms. of an 8-year lunisolar calendar. In the 8 cups the l.ys. are counted plus the inserted 30-day lunar months at the end of 3rd l.y. (36th l.m.), of 5th l.y. (61st l.m.) and of 8th l.y. (98th l.m.) 59. Soles; Gournia; 1979, 154, ill. I; MM I.
33 similar cups (3 pawns/ cup) +1 bigger cup. (2 kernoi) 26th group	99 l.m. lunisolar (=3 x 33) calendar, + 1 counter for 33-l. m. periods. 60. Chapouthier; Mallia; 1928, 292-300; MM IIIB-LM IA. 61. Soles, Gournia. 1991, 48-54, fig. 47, LM I?

Kernoi according to the number, the sizes and their distribution of cups.	Decoded type of calendar. Archaeologist found it; its location; its publication; dated. (l.ms. = lunar months, l.ys. = lunar years) (s.ms. = solar months, s.ys. = solar years) (d./ds =day/days)
99 similar cups + 5 bigger ones. (1 kernos) 27th group	99-lunar-month lunisolar calendar plus 5 cup-counters for counting the days of the 5 phases of the moon. 62. Karetsou; Juktas; 1981, 137-153 & 2012, MM I.
99 similar + 8 separated cups. (1 kernos) 28th group	99-lunar-month lunisolar calendar plus 8 counters for counting the 8- l.ys. 63. Karetsou; Juktas; 1981, 137-153 & 2012, MM I – II.
9 similar cups + 4 separated cups. (1 kernos) 29th group	One s. m. calendar; a 9-day Minoan solar week+ 4 counters for the 4 Minoan (9-day) weeks; 64. Hood, Knossos, 1995, 12, fig. 16-18; MM
40 similar cups + 1 separated one. (3 kernoi) 30th group	One Minoan s.y. calendar; 40 cups X 9-day/ (sol. week) plus + 1 counter for the 3+2 celebration days, see Fig. 7. 65. Chapouthier, Mallia, 1928, 302, fig.9; LM I. 66. Dessenne, Mallia, 1952,293, fig. 90; on date given. 67. H. M. Van Effenterre, Mallia, 1976, 72, pl. VIII, MM IB
20 similar (20 X 9-day/week) + 1 separated cups. (1 kernos) 31st group	One Minoan s. y. calendar. In the separated cup the 3 ds. at the beginning +2 ds. in the middle celebration days. In 20 similar cups the 180 days (=20 cups X 9-day/week) are counted. 68. H.V. Effenterre, Mallia,1955, 544-5, f. 1; MM II-LM I.
18 similar cups + 1 separated one. (1 kernos) 32nd group	A 18-day (=2 X 9-d./week periods) + 1 counter for marking the 1st or the 2nd half periods of one solar month of 36 days. 69. Soles, Gournia, 1979, 154, fig. I; MM I.
18 similar cups (2 pawns/cup). (4 kernoi) 33rd group TO SUM UP: 73 decoded kernoi distributed in 33 different groups	A 36-day (=2X18) one solar month calendar. 70. Van Effenterre, Gournia, 1955, 544-545, fig. 4; LM I? 71. Van Effenterre, Mallia, 1955, 544-545, fig. 2; EM II. 72, & 73. Soles, Gournia, 1973, 7-8, two kernoi, MM.

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