What Equinox?

Juan Antonio Belmonte

1 Introduction: Whose Equinox?

> *… it would probably be helpful if the word 'equinox' were simply eliminated from archaeo-astronomers' vocabulary …* (Clive Ruggles 1997)

It is an honour and a pleasure to be part of this volume. I first met Clive Ruggles in September 1996 during the SEAC Conference in Salamanca, although I already had several references about his extraordinary work and skills through common friends and had read several of his papers. For a rookie archaeoastronomer as I was then, this was like a fan meeting his favourite rock-star. I could not imagine this would be the beginning of a long lasting collaborative effort and, far more important, camaraderie and friendship. Since then, we have always been in close contact. I would like to emphasize two aspects. The first one was the chance to work at his orders during the edition of the Handbook of Archaeoastronomy and Ethnoastronomy (Ruggles, 2015). The second one has been the efforts to promote the IAU and UNESCO 'Astronomy and World Heritage' initiative (Ruggles, 2017; Ruggles & Cotte, 2010), culminating in the process to declare the interior of the island of Gran Canaria as a World Heritage Cultural Landscape (Belmonte et al., 2018); a process where Clive had put all his skills and knowledge, despite his harmful personal situation. This is a fact that greatly honoured him. Finally, we—a huge multidisciplinary team—were successful in July 2019.

Back to 1996, we had just published our first part of the paper on 'equinoctial markers' in Gran Canaria (Esteban, Belmonte, Schlueter, & González, 1996) and were shocked by a preprint where the whole meaning, and even existence, of the equinox within a cultural astronomy study was questioned. The situation was so problematic that Clive thought it would be adequate and indeed useful to ask himself: 'Whose

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equinox?' (Ruggles, 1997). In this work, he established the difference between the true astronomical equinox ($\delta = 0°$), when the sun crosses the celestial equator, the day midway between the two solstices, sunrise at due-East, or the mid-horizon sunrise point between solstice sunrises, among other possible definitions. All of them were near the same point on the horizon where sunrise occurs but could represent quite different concepts in the worldview of the builders under scrutiny.

The concept of equinox (from the Latin 'equal night', meaning the day when the length of the day and night are equivalent) has a precise meaning within the framework of classical spherical astronomy—derived from Greek sources—that underline our Western religious and scientific tradition. From the scientific point of view, the equinox is the instant when the sun, moving along the ecliptic, crosses the celestial equator and has a declination of 0°. The day of the equinox (either spring or autumn) is considered as the day when this fact happens. Alternatively, the preceding sunrise and subsequent sunset (or vice versa when it occurs at night) could be termed the equinoctial sunrise and sunset, respectively.

A culture's understanding of the equinox can be teased out from how they used that concept. For instance, a decade after Clive's question, González-García and Belmonte (2006) asked themselves 'Which equinox?' when the date and concept of the equinox in ancient Rome at the time of the Julian reform had to be taken into account. The Romans apparently favoured the day midway between the solstices instead of the astronomical equinox itself. This could have obvious consequences when interpreting the archaeoastronomical data of the Roman era as we will later demonstrate. As the reader can imagine, from the perspective of a totally different worldview, finding a concept similar to Western equinox would be far from simple, and as Clive argued, and will be proved later on, 'it could make no sense at all' (Ruggles, 1997).

In the following section, a diachronic, geographic approach to different cultural environments somehow related to our Western world, from the hill of Göbekli Tepe to the Christian churches of the Iberian Peninsula, will be performed, seeking for what could have been the exact meaning of equinox and how a people approached it. This will be completed with a few sketches of alien cultures where this concept has also been claimed. Finally, in the conclusion we will concentrate on how reliable the concept of equinox is and if it still deserves to be preserved in cultural astronomy studies, including archaeoastronomy and ethnoastronomy.

2 Discussion: Which Equinox?

Until recent times, the megalithic monuments in Europe were the archaeological remains earning all the credit for any potential astronomical knowledge of the earliest ancestors of humankind. However, a discovery in southeast Anatolia has changed these ideas. There, on a barren isolated hill called Göbekli Tepe, a team of German and Turkish archaeologists (see Schmidt, 2006 for the discovery) have been excavating a cluster of suggestive cyclopean monuments erected with large, megalithic pillars in the form of a T, within a series of dry-stone enclosures. They were built by a completely unknown pre-ceramic, hunter-gatherer society, beginning more than 11,000 years ago. Individual sanctuaries of this series were built presumably one after—and even upon—the other. Each one of them would have remained in use for centuries, perhaps millennia, but was deliberately buried by the progenies of their own constructors for unknown reasons. This is a very peculiar fact that has certainly contributed to their excellent state of preservation despite of their great antiquity. These monuments are mostly ellipsoidal in form and had megalithic accesses mostly open to the S-SE that might define a preferred orientation (Fig. 1). A series of mutually contradictory ideas have been put on the table (see Belmonte, González-García, Rodríguez-Antón, & Shaltout, 2016).

However, what is undeniable is that between the series of monumental structures, there is one on the top of the hill, which has nearly rectangular walls almost perfectly aligned according to the cardinal directions (Fig. 1). This circumstance alone would force us to think that we are faced with a society that had looked at the sky and used it as a guide to find appropriate ways of orientation in space and, almost certainly, also in time. In this context, additional exercises could be performed, analysing the profuse T-pillar decoration where totemic representations of animals are present. These might remind atavistic constellations, such as Leo, Taurus or Scorpius, that can be recognize in the skies of other evolved cultures in the region several centuries later. Besides, one of the pillars of the cardinally orientated hall, which was framing an altar on the eastern side of the structure, has a representation of a lion; and Leo was rising with the vernal equinoctial sun precisely at east in the epoch of construction of this particular shrine (Fig. 1). Are we facing the genesis of the 'equinox' concept? Was this concept born in the plains of Mesopotamia? This is indeed a most interesting point to be discussed but far from the scopes of this essay (see, however, Steele, this volume).

2.1 'Megalithic' Equinoxes

In the line of argument of the previous paragraphs, Clive has consistently argued that: 'it is far from self-evident, then, that any fundamental concept similar to our equinox had any meaning, let alone any importance, to people in prehistory' (Ruggles, 1997). This is an especially sensitive argument when megalithic monuments are considered. It would be farfetched to focus here on the many different occasions that the equinox has been claimed to explain the orientation of certain megalithic monuments in agreement to what has been termed the 'megalithic equinox' (Ruggles, 1999: 54), seldom interpreted as the day midway between the solstices. Hence, we will concentrate in three major examples: the large tumulus of Knowth in Ireland, the dolmen of Viera in Antequera (Spain), and the temples of Mnajdra in Malta. The tumulus is Knowth is a nice example of data overinterpretation. The two main corridor tombs located inside the tumulus are roughly orientated east and west, respectively, and have accordingly been interpreted as equinoctially

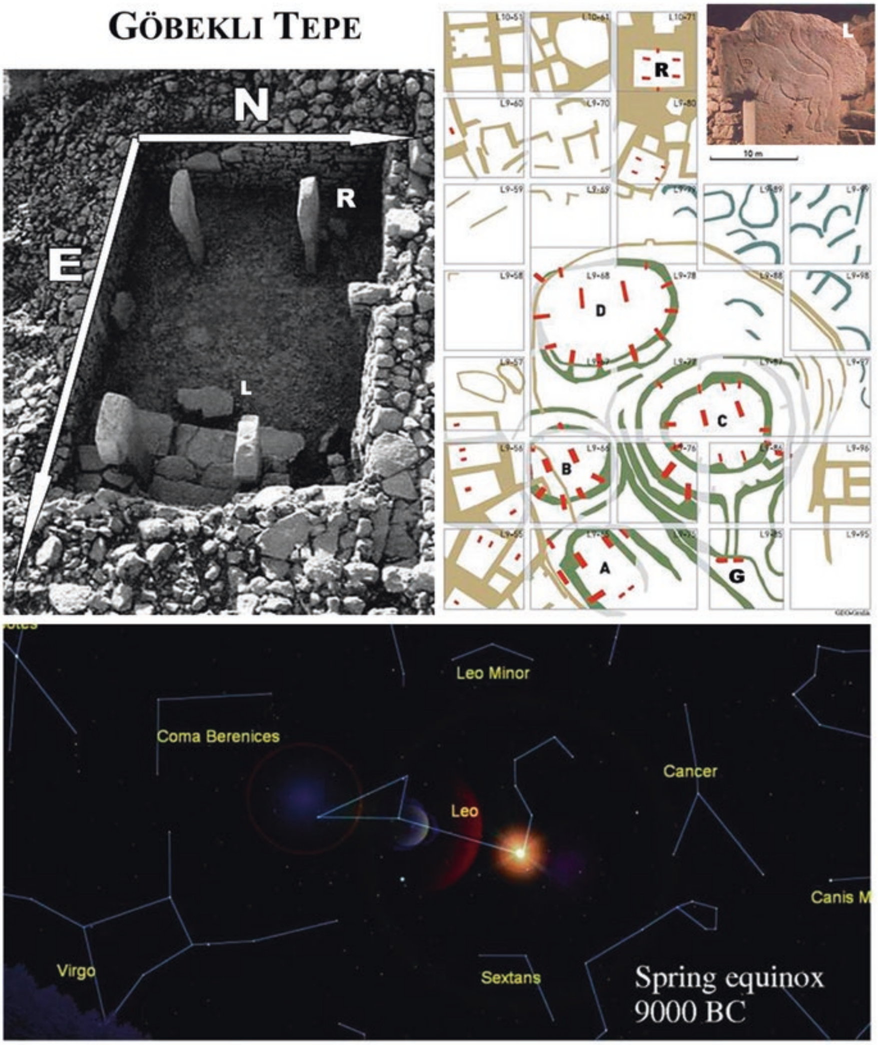

Fig. 1 Composite diagram of Göbekli Tepe. The walls of the rectangular structure (R) built c. 8500 BC in the upper sector of the site are perhaps the first manmade building ever orientated close to the cardinal directions discovered so far. One of the pillars (L) was decorated with an image of a lion. Either by chance or design, the equinoctial sun was easterly rising in conjunction with Leo constellation in that epoch. Adapted from Belmonte et al. (2016)

aligned (Eogan, 1986: 178–179). However, the rough alignment of the corridors and other aspects to be considered has forced a completely different interpretation of the data, discarding any kind of 'equinox' as responsible for the tomb orientations (Ruggles, 1999: 129).

However, there is another interesting case worth discussing. The dolmen of Viera, a megalithic tomb of the mid-third millennium BC integrating the fascinating group of prehistoric tombs in the Antequera Archaeological Park, recently declared as a World Heritage site by UNESCO (Ruiz González et al., 2015), was fist explored by Michael Hoskin in his extensive archaeoastronomical research in the Iberian Peninsula (Hoskin, 2001, and references therein). The initial datum was not very promising (Belmonte & Hoskin, 2002: 77–80) but later observations and, among all, detailed photographic documentation of the dolmen alignment, preparing for the UNESCO candidacy proved otherwise. All in all, Viera was considered, and heartily proposed, as a monument orientated to equinox sunrise. Once more the dichotomy!

Figure 2 beautifully illustrates the problem. The photograph presented there was taken at full-moon the night of the equinox when the declination of our satellite was c. 0°, and hence mimic the exact behaviour of the sun at $\delta \sim 0°$. The alignment seemed perfect. However, the devil is in the details and having a close inspection at the image, a small but still perceptible effect can be ascertained, proving that the photograph was taken slightly off axis (this precision would be impossible at sunrise when strong light and shadow contrasts would preclude such clear perception). If the correct chamber and corridor axis is considered, the moon would have been seen a whole disk diameter to the left of the axis. Actually, the horizon window observable from the chamber would have permitted not only the equinoctial sun light entering the chamber, but also at the day midway between the solstices, and a couple of days before the spring and after the autumn equinoxes.

Fig. 2 ‘Equinoctial’ moonrise on March 21st 2019 on the axis of the dolmen of Viera (Antequera, Spain): The full-moon had a value of the declination of virtually 0°, thus mimicking the behaviour of the sun at the equinox. Photograph by courtesy of Fernando del Pino

Hence, the equinoctial alignment is not as ‘precise’ and we would desire and perhaps different approaches ought to be considered. Could the moon be the relevant celestial object? Anyway, the lighting phenomenon is very suggestive and will certainly keep attracting people to the site every equinox.

Our last singular case is that of the southern megalithic temple of the three present at Mnajdra in Malta. The peculiar orientation of this temple, the only one of the many prehistoric temples in Malta clearly facing sunrise, has often been termed as equinoctial. Michel Hoskin (2001: 30–31) dismissed this possibility as unreliable but it has remained in the literature and the most serious work on the topic has come back with this possibility (Lomsdalen, 2014: 132). Figure 3 shows a model of the three temples at Mnajdra located at the Malta Archaeological Museum in La Valetta, where the light and shadow effect observable at Mnajdra south can be reproduced. Observing this model (and also on direct observations on site), it is easy to notice that the temple gate was designed to allow the light of the sun entering and illuminating different sacred spots inside the shrine from winter solstice to summer solstice and vice versa. Does this mean that the ‘equinoctial’ alignment of the temple is just a chance and was forced by the need to lightening the interior every sunrise throughout the year? The answer is not simple. The most recent data (Lomsdalen, 2014; Fig. 5.16) shows that the temple was aligned to $\delta = 0.7°$. This is far from 0° and hence to the true astronomical equinox, but close enough to the value of the sun declination at the day midway between the solstices (c. 0¾°).

Clive had argued that: ‘re-examination of both the conceptual basis and the actual evidence casts considerable doubt on the idea that any monuments were

Fig. 3 Model of the three megalithic temples of Mnajdra (Malta). Mnajdra I, first to the left, is the youngest of the set, showing the main axis of it oriented towards sunrise at the ‘equinoxes’ (actually to $\delta \sim 0¾°$). Photograph by Margarita Sanz de Lara, courtesy of the National Archaeological Museum of Malta

deliberately aligned upon sunrise or sunset on dates that happen to approximate to the true equinox, because they were conceived as halfway … between the solstices' (Ruggles, 1997). Apparently, Mnajdra South would contradict this statement, unless the orientation of the axis was a mere byproduct of the general design of the temple, as previously discussed (Fig. 3). Consequently, the day midway between the solstices perhaps had more relevance than the one we might expect, or desire.

2.2 Mediterranean Equinoxes

The first buildings which are arguably orientated close to the astronomical equinox, whenever the eastern horizon in nearly flat, are the funerary temples and related structures (e.g., the Sphinx) of the pyramid complexes of Egypt during the Old and Middle Kingdoms (Fig. 4). Various researchers, including the author of this essay (Belmonte, Shaltout, & Fekri, 2009) have thus claimed for equinoctial alignments in ancient Egypt. However, interestingly, this pattern of orientation could simply be interpreted as the byproduct of an actual interest in due-North and the realm of the imperishable stars, rather than sunrise itself. Only later, this transformed, notably with the solar temples of the 5th Dynasty—and perhaps earlier during the reign of Snefru –, into a true solar relationship, whether or not the ancient Egyptians had a knowledge of the astronomical equinox.

Figure 5 illustrates this possibility. The figure presents the declination histograms of a sample of 330 temples of ancient Egypt divided into a global one (panel a) a three series of independent data on temples of the Old and Middle Kingdoms (when pyramid complexes were built), the New Kingdom and the Late Period up to the 26th Dynasty, and finally of Egyptian temples built during and after the Persian conquest up to the Roman period. The statistically significant peak at the equinox, present in the whole sample which made us define a family of equinoctial

Fig. 4 Equinox at Giza in March 2005. Sunrise in front of the Sphinx (**a**) and sunset behind it at the corner of Khaefre Pyramid (**b**) are clear focal points. Photographs: Juan Antonio Belmonte

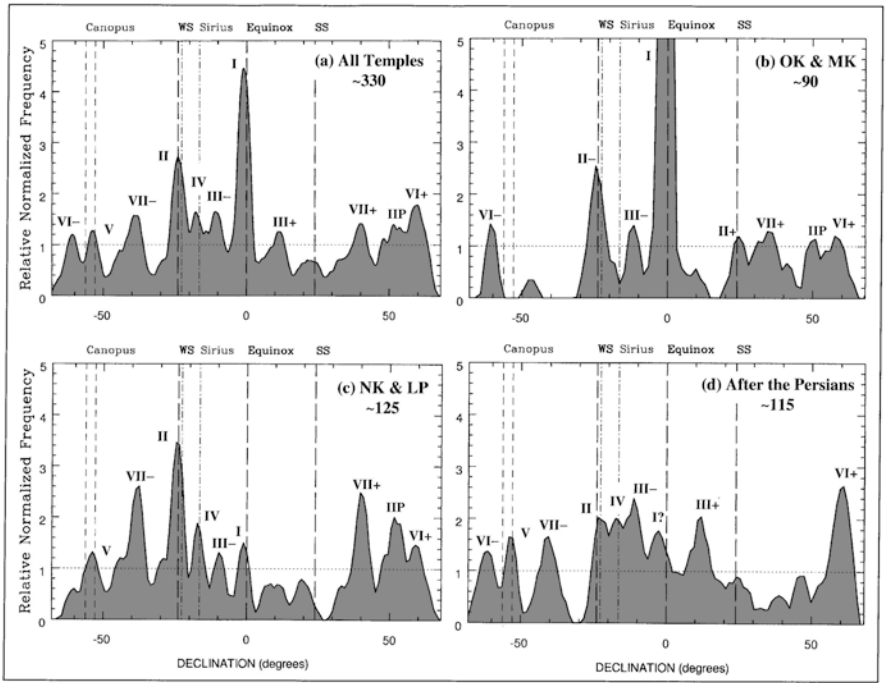

Fig. 5 Declination histograms of the temples of ancient Egypt vs. historical period: (**a**) Complete histogram of a sample of 330 temples showing the seven families of orientation, including family I peak close to 0° declination. (**b**) Temples from the pre-Dynastic period to the end of the Middle Kingdom. (**c**) Temples of the New Kingdom and the Late Period until the Persian conquest. (**c**) Late temples with a dominance of buildings of the Graeco-Roman period. The three series of data plotted in panels (**b**), (**c**) and (**d**) are independent of each other. In panel (**b**), the peak of family I climbs to more than 12 but has been cut to keep the same scale in the different plots. Adapted from Belmonte et al. (2009)

orientations (I) is, however, misleading. This comes from the huge peak related to the orientation of the temples adjoining the pyramids from the 4th to the 12th Dynasties, as clearly demonstrated in Fig. 5, panel b. I am now nearly convinced that this peak, and what it represents, is the results of simple geometry applied to the pyramid complexes, where the pyramid was the first building to be aligned to the north and the realm of immortality. Later on, the shrines associated with the complex, the so-called funerary and valley temples, would be built with an axis perpendicular to the northern one, indeed facing sunrise (solar eschatology was concomitant to the stellar one since the 4th Dynasty), but perhaps facing sunrise at the equinoxes just by chance.

The idea would be reinforced by the fact that, in later epochs, as in the glorious New Kingdom, the ‘equinoctial’ family is hardly significant or, even worse, during the architecturally splendorous Ptolemaic Period, not easily identifiable (Fig. 5, panel d). This was an epoch when the concept of astronomical equinox was already well-known but it seems to be absent from contemporaneous, traditional Egyptian architecture.

Hence, if the true equinox had no relevance in the orientation of monuments of the megalithic phenomenon, neither in those of other western mother cultures, as ancient Egypt was, where should we look for it, if anywhere. The mathematical concept of equinox was fully developed in the Hellenistic world. Instruments like the sundial of Ai Khanoum, from the third Century BC, clearly reflects it (Hannah, 2009: 121), and perhaps even earlier in the first uses of a gnomon attributed to Anaximander in the sixth Century BC (Hannah, 2009: 69). However, as Hannah (2009: 71) argues, the knowledge of the equinox is not reflected at all in Hesiod's *Works and Days* two centuries earlier.

Consequently, it is not surprising to notice that early Greek temples in the Balkan Peninsula and the Aegean islands lack any sort of equinoctial pattern (Bousikas, 2007–2008). This is, for example, the case for the temple of Apollo at Bassae which is orientated north-south instead of east-west as would be expected for a solar deity, among many others studied in Boutsikas' PhD work, under Clive's supervision. This was a sort of unexpected outcome at the land where classical astronomy had been presumably born and developed and the term equinox invented.

However, the situation is different when we moved to the western shores of the Mediterranean Sea. Figure 6 shows two interesting cases of equinoctial orientations, combined with conspicuous topographic landmarks. On the one hand, the temple of Apollo (Temple C) at Selinunte (Sicily) faces a distant peak where the sun sets at the equinoxes ($\delta \sim -0¼°$). Built in the mid-sixth Century BC, it would be one of the first Greek temples with such an orientation (Belmonte & Hoskin, 2002: 204). Why? We do not have the answer but Selinunte was built in an area of Sicily under strong Punic influence and when the city was conquered by the Carthaginians in 409 BC the area was devoted to the cult of the supreme divine couple of Carthage integrated by Ba'al Hammon and Tanit, so Punic influence cannot be discarded. In this sense, other temples of the city, such as the impressive Temple E, also faced the distant topographic landmark but they were clearly not equinoctial (Belmonte & Hoskin, 2002: 205).

Interestingly, on the other hand, this same Punic influence can be ascertained across the sea, in Mactar (Tunisia). In data taken in Africa Proconsularis (Belmonte, Tejera, Perera Betancor, & Marrero, 2007), where Punic, Roman and local (Numidian) traditions intermingled, there is one relevant peak centred at c. 0°. This could be associated with a substantial number of temples devoted to the sun, or deities of solar character, spread throughout the region. This is beautifully illustrated in Fig. 6b, where the equinoctial rising sun can be seen along the axis of the Apollo temple in Mactar. This temple was built upon an early temple dedicated to Ba'al Hammon, the supreme deity of Carthage which was somehow assimilated by the Numidian kings to the Sun. Although the temple orientation is certainly equinoctial, the presence of a notch in the distant horizon, where the sun would have risen a couple of days after the spring equinox (or before the autumn one), and hence at the day midway between the solstices, opens an interesting question.

Fig. 6 Land and skyscape interaction: (**a**) Alignment of Temple C at Selinunte (Sicily) built between 580 and 530 BC, presumably dedicated to Apollo, it was the oldest of the city: sunrise at the 'equinox' was produced over a distant, remarkable topographic landmark ($\delta \sim -0½°$). (**b**) The equinoctial rising sun of March 21st 2002 follows the axis of symmetry of the Sun (Apollo in Roman times) temple in Mactar (Tunisia). The phenomenon is observable close to a notch in a distant mountain which could have been used as a close-equinoctial marker. Photographs by Juan A. Belmonte

Few studies, if any, have been performed in the shores of Levant that can offer a clue of an 'equinoctial' custom perhaps imported from the Middle East (see Steele, this volume). Hittite data shows a preference for near due-east orientations (González García & Belmonte, 2011) and, as we will see later on, Nabataeans played with the concept of equinox (sun entering the 'sign of Aries') and aligned their sacred structures accordingly. However, it is still in the West where some more clues could be ascertained. An example of that are Iberian sanctuaries.

For more than two decades, César Esteban (2016) has been analysing the importance of the equinox in the Iron Age Iberian culture of Mediterranean Spain. He has discovered that more than one third of the explored shrines had equinoctial 'markers'. Some of them are very precise, such as El Amarejo (Fig. 7). However, the vast majority show a remarkable preference for the day midway between the solstices (which he terms the 'temporal midpoint between solstices' and abbreviates as TMPS) when the sun declination is between +0.3° and +1°. Iberian culture developed between the sixth and first centuries BC and most of these 'equinoctial' sanctuaries are dated in that epoch. Esteban (2016) supports a possible Punic-Greek (from western Greeks) inspiration for the use of equinoctial markers in the Iberian ritual, an influence which is also reflected in many other aspects of the culture, such

Fig. 7 Sunrise at the Iberian sanctuary of El Amarejo (September 21st 2004 when the Sun had a declination of 0°9′ (i.e., c. true equinox): The sun climbs the cliff of Montaña Chinar. This would be the most accurate 'equinoctial' marker for Iberian sanctuaries. Adapted from Esteban (2016). Courtesy of César Esteban

as writing. He is possibly right, although the preference for the time midway instead of the astronomical equinox leaves doors open for other possibilities.

A discussion on the equinox in the pre-Hispanic culture of the Canary Islands may follow the same line of argument. Research in Grand Canary has shown that the equinox was an important milestone in the time-keeping system of the ancient Canarians as was reflected in the conquest chronicles and the archaeological record (Esteban, Belmonte, Schlueter, & González, 1996, 1997). Considering the Amazigh ancestry of these populations this may have important connections to the origin of these populations (Belmonte, Perera Betancor, & González-García, 2019). A Roman influence (see below) has been advocated due to the early Roman presence in Proconsular Africa after the defeat of Carthage in 146 BC, although an earlier Punic influence cannot at all be discarded.

The term 'equinox' is clearly used in the chronicles, but it is ignored what this concept meant for the pre-Hispanic society. The work for preparation of the UNESCO candidacy of 'Risco Caído and the sacred Mountains of Gran Canaria Cultural Landscape' as a World Heritage site (Belmonte et al., 2018) did not clarify the situation despite Clive's role as a scientific advisor of the team was fundamental on the discussion. Of the sites within the property, the sanctuary at Roque Bentayga may suggest an astronomical equinox relationship (Fig. 8, see also Esteban et al., 1996), although the day midway between the solstices—other important time-marks of their calendar—cannot be discarded as proven by other sites in the island (Esteban et al., 1997). However, the astronomical phenomenology present at Cave 6 in Risco Caído indicates that the first and last days when sunlight enters the cave though a very peculiar oculus are—with the margin of a day—March 19 and September 25 in

Fig. 8 The *almogarén* (sanctuary) of Roque Bentayga (**a**), a pivotal element for UNESCO's 'Risco Caido and the sacred Mountains of Gran Canaria' Cultural Landscape. At the equinoxes, sunlight crosses an artificial notch and device (**b**), illuminating the large central circular cup-mark of the sanctuary (**c**). At autumn equinox 2018, a member of our team made a libation for the success of the candidacy (**c**). Prof. Ruggles and the author were present at the event. Photographs by Juan A. Belmonte (**b**) and by courtesy of the Gran Canaria Council (**a** and **c**)

the Gregorian calendar, respectively. During autumn and winter months, it is the full-moon which periodically illuminates the interior of Cave 6 (Cuenca Sanabria et al., 2018). This clearly divides the year between two dark and bright halves. All in all, present data does not offer further clues of the actual conception of the term equinox for this ancient society and if they brought it with them in the process of colonization—perhaps under Roman or Punic influence—or if they developed it locally according to environmental needs. The solar hierophany at Mactar (Fig. 6) would support the first possibility.

It is worth noticing that, although the astronomical definition of equinox was certainly known in Rome, it was not applied for the reform of the Republican calendar introduced by Julius Caesar in 46 BC. This was performed to adjust the year and festivities to the seasons, and Caesar certainly carried out his reform with the problem of the equinox in mind. Probably, for the Romans of the end of the Republic, there were varying definitions for equinox, but March 25th was accepted as the canonical date for the vernal equinox by both Caesar and Augustus. Under this consideration, the sense of equinox used probably was the day that marked the middle of the time interval between the winter and summer solstices, i.e., the day midway between the solstices and not the true equinox (González-García & Belmonte, 2006).

In order to check whether those ancient criteria were really present in other spheres of Roman life, and also to reinforce the idea of a likely relationship between Roman city planning and the sky, an analysis of the orientation patterns of Roman cities in general has been performed (Rodríguez-Antón, 2017). This highlights the integration of important dates of the Roman or pre-Roman calendars into urbanism. That is, if beliefs or even political ideology were embodied within city plans. Eastern—aka 'equinoctial'—orientations are not unusual within the Roman world. However, they became standard in the Era of Augustus when they were related (together with those to the winter solstice) to the hagiography of the Princeps (see Espinosa-Espinosa & González-García, 2017).

This is nicely illustrated in Fig. 9, where a comparative between the declination histogram of Augustan vs. non-Augustan cities in the Western Roman Empire is presented (González García, Antón, Quintela, Espinosa, & Belmonte, 2019; Rodríguez-Antón, 2017). There are two clearly significant peaks in the Augustan data of 64 cities mainly from Hispania, Gallia, Africa and Italia: one centred at the winter solstice and another centred close to equinoctial declinations. It is worth emphasizing that Augustus' imperial propaganda put a strong emphasis both in the *Dies Natalis Augusti* at September 23rd in the Julian calendar, which could be considered as a sort of 'equinox', and subsequently on the entering of the sun at the sign of Capricorn at the moment of the winter solstice when he was supposed to be

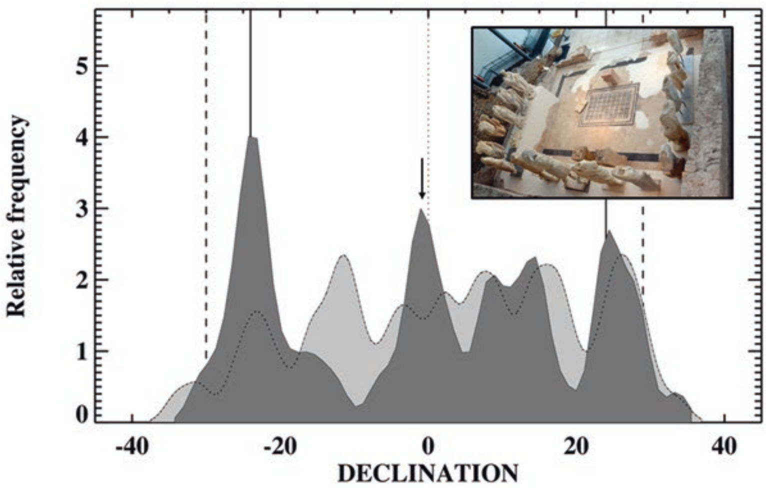

Fig. 9 Declination histogram of Augustan (dark grey) vs. non-Augustan cities located in the Western Roman Empire. Notice the privative 'Augustan' peak (arrow marked) at 'equinoctial' declinations probably related to the anniversary of Augustus in September 23rd. Inset: Sanctuary of Augustus at Narona. Orientated to a $\delta \sim 0¼°$, this is arguably one of the nicest Augustea ever erected in the provinces. Histogram adapted from Rodríguez-Antón (2017) and a photograph by Juan A. Belmonte

conceived (Barton, 1995; González García et al., 2019). Hence temples and cities throughout the empire were orientated accordingly.

Most interesting is the case of the Augusteum at Narona (Fig. 9) since its orientation ($\delta \sim 0½°$) would confirm the possibility that this suggestive monument was built in commemoration of Augustus' 75th birthday, and accordingly aligned (Belmonte, Rodríguez-Antón, & González-García, 2020).

When Christianity ruled over the Roman Empire, the new religion assimilated several concepts of Roman culture. Christmas was assimilated to the birth of the Unconquered Sun in the night from December 24th to 25th and hence, Jesus conception was assumed to be 9 months earlier at the Roman spring equinox at March 25th. This was assimilated as the Feast of the Annunciation. In this sense, church alignments in the Iberian Peninsula followed certain specific rules throughout the early Middle Age. In particular, a vast majority of churches tended to be orientated with the apse facing sunrise on the vernal equinox, taking this as March 25th. This prescription seems to have been followed for almost a 1000 years and can be observed in the shift of the main maximum in the orientation histograms through the different time periods. Such a shift is due to the drift of the Julian calendar in relation to the seasons (González García & Belmonte, 2015). For example, for Mozarabic churches (Fig. 10), the architectural style used in the Christian territories of the Peninsula just before the arrival of Romanesque, the maximum of the declination histogram was at c. 4°, corresponding to March 30th, Gregorian proleptic (or March 25th, 1050 AD, Julian).

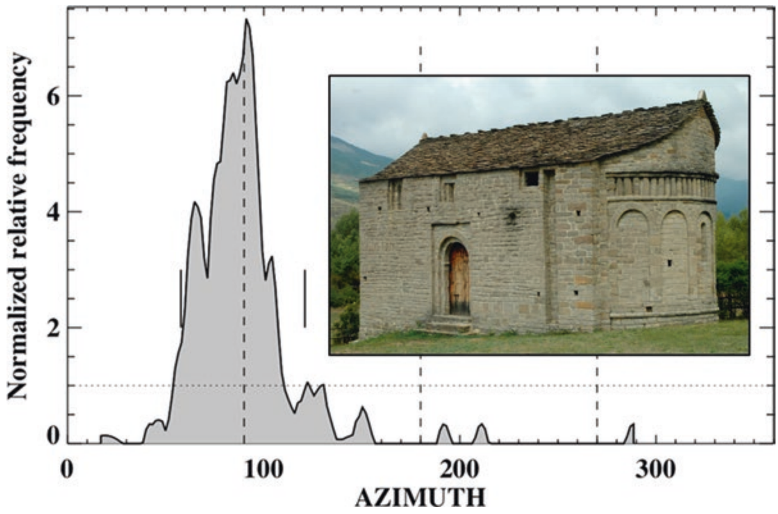

Fig. 10 Azimuth histogram for the orientation of 167 pre-Romanesque churches across the Iberian Peninsula (inset: the Mozarabic church of San Juan de Busa, Huesca). The largest concentration of orientations is towards the eastern half of the horizon with a maximum at due-east. Diagram adapted from González García and Belmonte (2015)

This outcome is quite robust, given the number of churches measured: 167 in total (Fig. 10). Indeed, it would be interesting to test these conclusions thorough investigation of the orientation of the early Romanesque churches in the same geographical area. Further investigation along the *Camino de Santiago* is being carried out in order to analyse whether there was a persistence or a change of the orientation customs of the religious buildings erected in the new style coming from the other side of the Pyrenees. In conclusion, the 'equinox' seems to have many faces.

There is a place in the Mediterranean region where the different possibilities for the term 'equinox' are extraordinarily manifested: the rose city of Petra. Research in the area evidenced the probable role of astronomy in the orientation and design of Nabataean sacred buildings, which mixed with the analysis of ethnohistoric, ethnographic and epigraphic sources, suggested that Nabataean religion, and its related architecture, could have a pilgrimage component. This could be related to major festivals and a well-developed lunisolar calendar. This phenomenon persisted under Roman rule and the adoption of a new—Julian type—calendar for the province of Arabia. Indeed, a concept close to the equinox, or the 'entering of the sun in the sign of Aries', played a major role in the design of these calendars. The Khirbet et Tannur almanac is a nice example of this phenomenology (Belmonte, González García, & Rodríguez-Antón, 2019, and references therein).

Recently, direct observations at various sunsets in March 2018 on days close to the spring equinox have made it possible to verify and somehow qualify earlier outcomes at Petra (Belmonte, González García, Rodríguez-Antón, & Perera Betancor, 2020). For example, on the one hand, the sunset 'equinoctial marker' at the Urn Tomb could justify its conversion into the Cathedral of Petra in the fifth Century AD, since the day midway between the solstices or even March 25th Julian apparently are the dates marked on site, although, on the other hand, the precise equinoctial alignment of the Obelisks in Jabal Madbah at sunrise in the astronomical equinoxes could have been used as a perfect milestone for timekeeping and calendar control.

However, it is at Al Madras where Nabataean ingenuity may be most evident (Fig. 11). The observation of spring and autumn equinox sunsets on top of Jabal Haroun, the highest peak in Petra neighbourhood and probably a very important sacred spot for the supreme Nabataean god Dushara, could have acted as the perfect harbinger of the main pilgrimages and feasts to be celebrated in the lunar months of Nisan and Tishri, as confirmed by later ethnohistoric and even ethnographic sources. Al Madras has usually been considered as a secondary suburb of Petra, but these outcomes suggest it was among the most important sacred sites in the city. The day midway between the solstices could also be considered as an alternative, but a true equinoctial alignment seems a much better candidate (Fig. 11). Al Madras equinoctial phenomenology is indeed paradigmatic. It strongly suggests that people in the Middle East were able to determine the precise moment of the astronomical equinox and use it for architectural and symbolic purposes.

Fig. 11 Above: Spring Equinox (March 21st 2018) sunset behind Haroun's shrine when the sun declination was 23 arc minutes, as observed from Al Madras main high-place. The circle represents the sun at 0° declination when the border of the solar disk would set tangent to the present shrine (arrow). Dashed line indicates the top of the observed solar disk. Solid line indicates the edge of the disk for $\delta = 0°$ while dotted-dashed line indicates the top of the corresponding solar disk. Below: The high place where the image was obtained. This is the apex of the Al Madras sacred area in Petra (Jordan), a sacred site for Dushara. Figure by the author, based on images by courtesy of José Ricardo Belmonte

2.3 Beyond Equinoxes

The situation is not so clear for other cultures around the planet. The equinoxes were probably known in early China (Pankenier, 2018: 47), but the four-part division of the world in the typical of Chinese city planning seems to be more centred in the realm of the Celestial Emperor in the northern skies than in sunrise at due-east or sunset at due-west.

The situation would apparently be different in India, where Surya Puja temples ought to be considered (Malville & Swaminathan, 1996). In these temples, often orientated to the east, the rising sun is expected to illuminate the sancta sanctorum of the temple at certain key moments of the annual festival, perhaps at the 'equinoxes'.

However, a recent analysis of the orientation pattern of more than one hundred Indian temples shows otherwise (Aller & Belmonte, 2015). The sample includes Hindu and Jaina temples, the latter being mostly orientated north. Of Hindu temples, 74 (82%) of them were orientated within the solar range, with a maximum close to due east, a fact apparently supporting 'equinoctial' orientations (Fig. 12).

However, this is misleading when one goes into the details. For example, the substantial temples of the Chola Dynasty are facing 94° in Gongaikondacholapuram but only 74° in Tanjore. This fact is still more remarkable for the wonderful temples of the Chandela Dynasty at Kajuraho (Fig. 12), since they are predominantly orientated

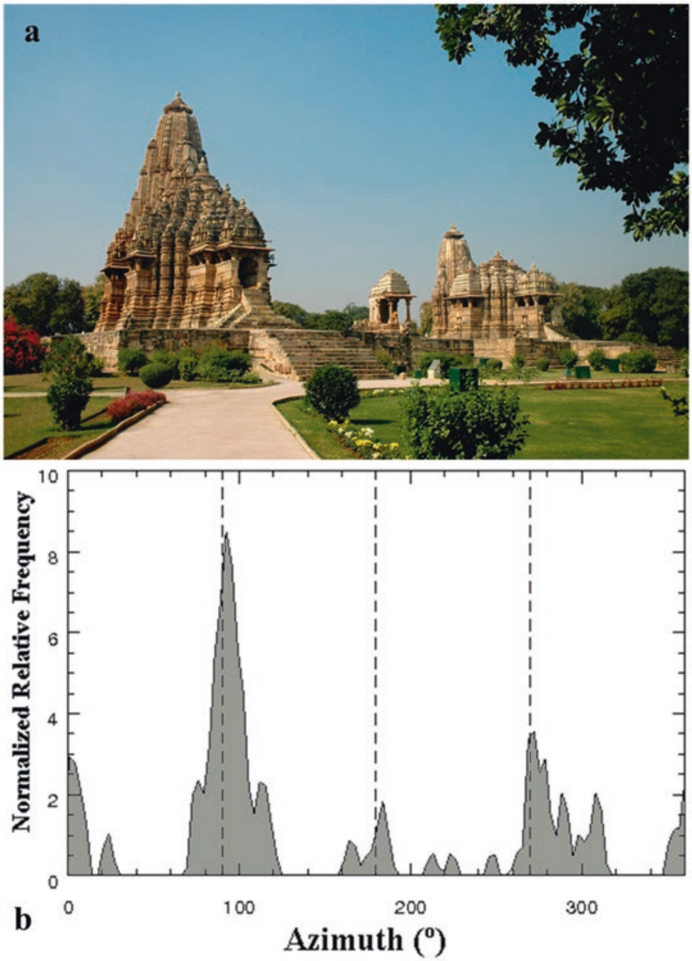

Fig. 12 (**a**) Kandariya Mahaveda and Devi Jagadambi temples in Kajuraho (India; Chandela Dynasty, tenth century AD). These are among the 107 Hindu and Jaina temples measured by the author in November 2007. (**b**) Azimuth histogram of this group, with 74 temples located within the solar range. Notice the peak concentration close to east. Diagram by Juan A. Belmonte

in an interval between 93° and 100°, far from due-east and the equinox. They face a conspicuous chain of mountains in the eastern horizon instead. Actually, only a few shrines of the Hoysala Dynasty in Karnataka, like the Vishnu temples at Somnathpur or the Hoysaleshvara Temple at Halebid are orientated close to due-east (88½° and 91½° respectively) to flat horizons, and hence quite far from any of the different alternatives for 'equinox' discussed in this article for Mediterranean cultures.

Several 'alien' cultures could be explored searching for equinoxes, but I would like to concentrate in only two. The first is the case of Easter Island or Rapa Nui. Liller (2000) proposed that several of the ceremonial platforms or ahu with standing statues or moai of the island were orientated either to the solstices or to the equinoxes, even qualifying them as 'solar observatories'. However, Edwards and Belmonte (2004) performed a new analysis of these sites using data from both archaeo- and ethnoastronomy. Their conclusion was that most of the equinoctial orientations could easily be re-interpreted as orientations to Tautoru (Orion's Belt, Fig. 13) one the most important asterisms of Rapanui mythology, together with Matariki (the Pleiades), and a key instruments for the control of time. Equinoctial solar observatories in Polynesia are at least problematic, if not completely spurious. Clive would certainly agree on this, as his most recent work in Hawai'i demonstrates (Kirch & Ruggles, 2019).

The second case is perhaps the most attractive and shocking. Mesoamerican studies have always contemplated the possibility of equinoctial alignments within the pre-Hispanic cultures of the region (Aveni, 1991: 338) and indeed in their sacred architecture. However, recent statistical approaches to the problem (Šprajc & Sánchez Nava, 2013, and reference therein) have clearly shown that there are patterns of orientation which are closely connected with cultural aspects of various Mesoamerican civilizations, notably with the calendar system. The equinox was not among them!

However, the nicest example of the equinox delusion in Mesoamerica is the 'descent of the serpent' equinoctial phenomenon on the Castillo (the step pyramid of the Feather Serpent) at Chichen Itza in Yucatan (Arochi, 1992). People by the thousands stand today at the site to view the light and shadow effect produced in the eastern stair of the pyramid, as the sun descends on the western sky the day of the equinox (Fig. 14). This phenomenon is today a mass event few people question (but see, e.g., Ruggles & Cotte, 2010: 272).

In astronomy there is an important factor to be taken into account to do correct research: this is the 'selection effect'. This means, not to be selective with the sample of data to be considered, taking into account all possible alternatives. This is exactly what Šprajc and Sánchez Nava (2018) have done when investigating what would happen near sunset at El Castillo several days before and after the equinoxes, when few persons were on site. What they found is astonishing! Figure 14 shows the wonderful light and shadow effect on the eastern stair on April 12th, 2018, 3 weeks after the masses have left the site. On this particular occasion, nine instead of seven light triangles are visible—one for each step of the pyramid. Nine is an important number in Mayan Mythology, seven is not. The reader can get his/her own conclusions. Corollary: do not go to observe a phenomenon like this only when preconceived ideas suggest, check alternatives.

Fig. 13 Edmundo Edwards and Juan A. Belmonte, serving as a reference scale, in front of the seven moai of Ahu A Kivi (Rapa Nui). These are exceptionally facing the sea and possibly orientated towards the helical setting of Tautoru (Orion's Belt) as would have occurred c. 1300 AD. This astronomical event was one of the markers of the New Year starting in the following new moon of the Rapanui calendar. Photographs by courtesy of J. R. Belmonte and M. Sanz de Lara

Fig. 14 Images falsifying the equinox phenomenon at Chichen Itza (Mexico). The upper image was taken the day of spring equinox when masses approach the site to envisage it. However, the phenomenology is far more impressive 3 weeks later in mid-April. Photographs by courtesy of Miguel Ángel Cab Uicab (top), Pedro Sánchez-Nava and Ivan Šprajc

So, we must agree with Šprajc and Sánchez Nava (2018) when they argue that such a popular phenomenon as the equinoctial light and shadow effect at Chichen Itza is certainly not a product of Maya ingenuity, but undoubtedly a concept of western mathematical astronomy projected to the pre-Hispanic past.

3 Conclusions: What Equinox?

It is now time to come back to the sentence opening this article: ‘it would probably be helpful if the word ‘equinox’ were simply eliminated from archaeoastronomers’ vocabulary’ (Ruggles, 1997). Would it be helpful? At the cost of contradicting Clive, my personal answer is yes and no.

Evidence presented in this paper suggests that ‘equinoctial’ alignments are as variegated as definitions of ‘equinox’ we might imagine. It may express the day when the sun rises at due east for the pyramid builders of ancient Egypt. It could mean the day midway between the solstices for the ancient Iberians or the Romans. Although in Augustus’ era it possibly meant the commemoration of his birthday. For early Christians it meant the Feast of the Annunciation. For the ancient inhabitants of Grand Canary and the Nabataeans there are reasonable doubts of what ‘equinox’ would exactly mean.

Indeed, the day midway between the solstices seems to be a very simple and intuitive concept, perhaps with more practical utility than the astronomical equinox. Can we also call it an equinox? The Romans did so. Hence, we could consider it as an open concept, depending on the cultural context we are dealing with. In fact, Hoskin (2001: 18) considers that it is impossible to discriminate the differences between day and night, light and darkness, in the relevant days due to evening and morning twilights. Hence the concept of equinox as ‘equal night’ is ambiguous. My preference would be to keep it with different levels of meaning and understanding. The ‘astronomical equinox’ should be kept only for the day when $\delta = 0°$. However, equinox (without adjectives) could be kept at a cultural level for the day midway between the solstices or a similar date, whenever the term would not be misleading. Statistical significance or textual evidence would be desirable in either case.

Finally, a few examples of other astronomical traditions have been explored. The conclusion is simple. Clive was correct: finding for other cultures a concept similar to western equinox was far from simple and can certainly ‘make no sense at all’ (Ruggles, 1997).

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