Mediterranean Archaeology and Archaeometry, Vol. 16, No 4, (2016), pp. 321-328

10.5281/zenodo.220953

APPLICATION OF CULTURAL ASTRONOMY METHODS TO HIGH SCHOOL BY MEANS OF STUDYING ASTRAL DECORATIONS AND ORIENTATIONS OF GALICIAN *HÓRREOS*

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Received: 26/02/2016
Accepted: 04/04/2016
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ABSTRACT

The specific granaries called *hórreos* are a very characteristic element of the northernmost and wet areas of the Iberian Peninsula, and in particular of the Spanish region called Galicia. They are in fact an outstanding architectural rural element of the Galician popular cultural heritage, with a social prestige surpassing their utility as simple maize granaries.

Braña Rey & Ulla Miguel started in 2013 a multidisciplinary study in cultural astronomy of a sample of hórreos located in the two parishes of Cobres, in the council of Vilaboa (Galicia), on which a significant number of astronomy-related decorative motifs of iconographic importance was found worth studying. As popular constructions of very high social meaning, they still keep their importance as a symbolic and identity referent for the Galician society as a whole. It is, then, crucial to consider the spatial context in relation to their traditional and current uses when it comes to their study and hórreos can be used as a key educational resource for various purposes.

In this regard, the present collaboration deals with an educational project developed to study a sample of hórreos in the parish of Beade (council of Vigo) by a group of 20 students between 15 and 17 years old. No astral motifs were expected to be found in the area, but the sole application of the scientific method to a research project tackled by High School pupils on their own was found most interesting analysing, together with all the educational aspects to be derived from the project development itself.

For this still ongoing work, a summary of preliminary results can be presented for the Beade sample in three main aspects: ethnography, orientations and education. When appropriate, some comparisons with the data previously obtained for the hórreos of Cobres will also be addressed.

KEYWORDS: Cultural astronomy, Hórreos, Staddle stones, Galicia, Astral motifs, Education project.

1. HÓRREOS, STRADDLE STONES OR GRANARIES BY PILLARS

An hórreo is a type of granary. In fact, its name is linked to the latin term *horreum*, (granary) which refers to a storehouse (Rivas Quintas, 1996; Del Llano, 1983; Vidal Rouco, 2001). The practice of building raised granaries in order to store cereals and protect them from humidity or the conditions of the ground has been documented in mid-western Europe dating back to the Iron Age and beginnings of the Bronze Age (García Alonso, 2007), despite the etymological origins being latin.

Hórreos are one of the many popular buildings that satisfy the need for storage of both past and present agricultural societies. Thus, among the different raised granaries around the world we highlight the ones in Mali (Patterson, 2009), Morocco (Caro Baroja, 1971), Great Britain (Quiney, 1995), the Balcan region ones named Cochové (Rachelle, 1990), as well as those in Switzerland (Max Vogt, 1998), Sumatra (Schefold, 2009) or Japan, where they are called Takayuka (Locher, 2010). The shapes of this type of granary also differ across the Iberian Peninsula. However, it is in the Northern part where they appear more abundantly: Asturias (Fernández Ochoa et a., 2013), Cantabria (De la Puente, 2010), Basque Country, Navarra (Caro Baroja, 1971), Portugal, named Espigueiros (Veiga Oliveria, 1994), León and Palencia (Frankowski, 1918) and Galicia (Martínez Rodríguez, 1999).

Galicia is the Spanish region located in the Northwestern area of the Iberian Peninsula, within the so-called "wet" Spain, according to the dominant climate.

Galician hórreos are very popular architectural elements, with an obvious practical purpose as granaries, but with a very high social prestige also. A lot of hórreos decorate the Galician landscape (Carlé counted 35.000 in 1948), but not in all cases keeping their agricultural function.

In this context, Braña Rey & Ulla Miguel (2016), studied a sample of hórreos located in the two parishes of Cobres, in the council of Vilaboa (Galicia), on which a significant number of decorative astral motifs of iconographic importance was found worth studying. In no other region of the Galician territory such astral decorations have been found on hórreos so far. For their general characteristics and social meaning, we believe that hórreos can be used, as well, as a key educational resource (Braña; Iglesias & Sierra, 2012). Therefore, an educational project is now presented, aiming at probing the potential interest of analysing a sample of hórreos (in a separated location) by High School students on their own, from a cultural astronomy and an ethnographic perspective. To quote the scope and context of the project, Section 2 will include a brief summary of characteristics of Galician hórreos and Section 3 of the meaning of their on-roof and on-wall decorations. Section 4 provides a description of the project methodology employed, sample selection criteria and data collection and analysis. Preliminary results obtained so far will be described in Section 5, regarding the three aspects we consider central to our study, that are: ethnography, orientations and education. Section 6 will end up with a summary of conclusions.

2. TYPES AND FUNCTIONS OF GALICIAN HÓRREOS

The Galician hórreo's conditions of use and characteristics have been studied at length, and it has become apparent that it is especially suitable for storing corn. It provides not only a defence against microorganisms and plagues, but also an environment that allows corn to continue to ripen before its consumption (Blas López, 1997; Caamaño Suárez, 2006; Saá et al., 2012).

Each part of an hórreo has a name and a purpose, but basically they are rectangular or squared storerooms elevated over columns, which are called feet, and well ventilated by lateral cracks.

Hórreos receive many names all around Galicia and, also, there are many different types, all of them similar somehow but all of them different as well. They are mainly built in stone or in wood, or in a mixed manner, both with stone and wood.

As an example, in fig. 1 we observe two hórreos supported on stone pillars. These are the base upon which lie the wooden supports or *trabes,* into which fits the rest of the wooden structure. The chamber is crowned by a gable roof with flat tiles.

Figure 1. Two hórreos in a farm in Cobres-Vilaboa, Pontevedra.

With regard to the mixed type hórreo, made of stone and wood, -which can be seen at the back on fig. 1.- it can be observed that the chamber has two differentiated parts: the front and back, called *penales*, and the sides, or *costales*, built of wood and stone.

The stone *penales* are crucial to our work, as in their upper part we find the triangle that supports the gable roof, called *pinche*, where the astral motifs (see Sec.3) previously found during our field work are located (Braña Rey & Ulla Miguel, 2016).

Therefore, the hórreo is a building belonging to the popular architecture, to an architecture without architects, with a shape predominantly adapted to its functionality. Nevertheless, as we will discuss in the following section, its shape is also related to socio-cultural elements, and not only economical.

3. DECORATIONS AND SYMBOLIC MEANINGS

As we said, the main purpose of an hórreo is to dry and store crops in the best possible condition, but they can also have other uses, uses that have evolved with time (Braña Rey & Ulla Miguel, 2016). For the particular task of showing social status and economical power, hórreos count on two important elements: one is size, so that the largest items are always near monasteries, rectoral or nobility houses, or castles or simply belong to the richest families. The other one is decoration: to dry crops, no decoration at all is needed and so, owners have to pay extra for stonecutters to have decorative elements added to their hórreos. This is what Braña Rey & Ulla Miguel (2016) concluded from interviews: ornamental fittings require extra investments, mainly justified for reasons of prestige of the economy of the house to which the hórreo belongs to.

The decorative elements in hórreos can be over the roofs or on the walls. Roof elements are, mainly, crosses, pinnacles and sundials. Crosses and pinnacles are magical protective -- apotropaic-- elements (see below) and sundials, which are obvious astronomical elements, were in use to measure time to about only 60 years ago. (Del Llano, 1983; Castelao, 1998; Martínez Rodríguez, 1999). We do not consider, for a detailed analysis, sundials in the present study.

In fig. 1, a cross and a pinnacle can be seen over the edges of the mixed type hórreo (at the back), and other examples can also be seen in fig. 2. The interpretations of these decorations are grouped into two explanations, but they are not exclusive. The first one argues that the decorations on the hórreo are linked to the religious and ideological sphere, aiming for the protection of corn as food and basic product of the Galician diet (Castelao, 1998; Martínez Rodríguez, 1999; Vidal Rouco, 2011). The second explanation refers us to the expansion of the baroque aesthetic, since the 17th century was also a time of economic expansion for the Galician church (Del Llano, 1983; Bonet Correa, 1984).

As previously said, on the walls of hórreos there can also be decorative elements; either painted or carved ones, both carved on wood and on stone. Stone carvings are mostly simple geometrical holes or cracks to add extra ventilation, but sometimes they can be elaborated motifs such as birds or vegetables.

What we find are decorative figures very common in the Romanesque and Baroque styles, which were widely extended in Galician architecture (Bonet Correa, 1984). Besides, other figures, no less common, have been found as astral forms: moons, stars, circles or hexapetal rosettes (fig.2). These are what we call the "astral motifs" in Galician hórreos (Braña Rey & Ulla Miguel, 2016). Hexapetal rosettes in particular correspond to a well-known solar symbol spread all over Europe after the Bronze Age. They can also be found in Galicia, and not only on hórreos' walls. As we declared at the beginning, is not common finding hexapetal rosettes in hórreos but they are more usual than other astral motifs (Braña Rey & Ulla Miguel, 2016).

The functionality of these figures reinforces what was previously stated. While there are authors who point that they are elements contributing to the protection of the harvest (Romero, 2009; García-Gelabert Pérez, 2011), other authors affirm that they are decoration elements imitating those seen in the most representative buildings, and thus copied in order to depict the power of the house they belong to (Romero, 2009; Muñiz López, 2014). The latter would then be an instance of power representation through analogy of shapes.

Figure 2. Pinches of mixed and stone hórreos with astral motifs.

Along with crosses and pinnacles, astral motifs, which also appear in the hórreos from Asturias (Graña García & López Álvarez, 1983, 1987), reveal a protective significance in their different interpretations (García-Gelabert Pérez, 2011). With regard to the motifs such as rosettes, circles and moons, understood as protective signs, it has been documented

the substitution of naturalistic symbols for religious ones in the hórreos from Asturias, particularly in the 16th and 17th century. A similar phenomenon could have occurred in the Galician hórreos (Muñiz López, 2014).

Finally, out of the Cobres field work done so far, Braña Rey & Ulla Miguel (2016) have been unable to establish if there is a clear relationship between the presence of the astral motifs on hórreos and their cultural meanings or the social practices or uses of the hórreos themselves in their communities.

4. STUDY OF HÓRREOS IN THE *BEADE* PARISH: OUR TWOFOLD OBJECTIVE EDUCATIONAL PROJECT

As a result of carrying out the first ethnoastronomic study of the Galician hórreos in the parishes of Cobres, council of Vilaboa (Pontevedra) (Braña Rey & Ulla Miguel, 2016), we recognized the educational potential of this knowledge. On one hand, it could be of great interest for the knowledge and promotion of the cultural heritage of each community. On the other hand, it could disseminate scientific knowledge from both the astronomical as well as the ethnological points of view.

During 2014, we considered making a trial project with High School pupils and the hórreos in the surroundings of the school. And so we did. To develop this pilot educational project we chose a parish inside the limits of the municipality of Vigo called Beade.

Beade is an inland parish of the council of Vigo, crossed by four rivers and at a considerable height over the city centre and Vigo estuary.

This parish has, as the rest of the metropolitan area of Vigo does, a population grouped into associations and with a parish identity. The duality urban centre-rural parish results in the appreciation of its inhabitants for the benefits of living in an environment associated with nature and tranquillity (González Pérez, et al., 2003). Hence the knowledge and practices of the utilization of the environment and the popular constructions persist.

The project was developed during the school year 2014/2015 with a sample of 20 10th grade students attending the Beade High School. Our idea was twofold: to expand students' skills on inquiry-based learning and to try to draw scientific conclusions on hórreos orientations on this particular geographical spot. The great majority of students attending the High School live in the surrounding parish, inside a relatively rural environment, as explained above. This means many of them have hórreos in their houses, or in their grandparent's, or in their immediate neighbourhood.

The main **educational objectives** of the project were:

- To introduce students to the methodology of scientific research in a particular field.
- To develop the methodology of Project Based Learning, covering curriculum standards of Mathematics (trigonometry), Galician Language and Cultural Heritage (word etymology, traditional Galician rural life, hórreo's uses and typology) and ICT (educational uses of smartphones, spreadsheets and google maps).
- To make the students get involved in the project, as well as the rest of the educational community, so all become aware of the possible relationship of hórreos with ethnoastronomy, at the time they were taking notice of the value of hórreos as both cultural heritage and traditional farming production structure.
- And to obtain field measurements on hórreos' orientations, as well as information on other relevant aspects, suitable for scientific analysis by the pupils themselves.

The project was developed in three **stages**:

1. Introductory phase: students were explained the objectives of the project and the cultural and astronomical methods needed to carry it out. They attended two brief lectures about cultural anthropology and cultural astronomy. Then, in a collaborative group structure, they discussed their own knowledge about hórreos (morphology, uses, location and importance).
2. Designing and developing the fieldwork:
   First they gathered information about the hórreos in Vigo parishes, looking for bibliography and visiting the Council House, where all the hórreos of the city are recorded and localized. In the Beade parish in particular there exist 185 hórreos catalogued by the Council. For all of them general data was collected in inventory sheets where, besides a location map, information on the hórreo's characteristics or uses is included.
   Secondly, they selected some hórreos next to their homes (or maybe in their own family grounds) to visit. The selected sample is thus spread all along the parish. They were asked to look for old-looking hórreos, to ensure an average construction date as old as possible (around one century). We must remember that we are dealing with, at most, 200 year old hórreos and that they are always in the plots near houses, belonging to someone. Also, that the students did the whole field job completely on their own.
   Then, they discussed and selected the important questions to pose the owners, and de-

signed a spreadsheet to gather all the information.

After putting into practice the research methodology, by visiting a nearby hórreo, they did their own fieldwork. Each group visited two hórreos on average. They mainly measured hórreo dimensions (length, wide and height), GPS coordinates, the Azimuth angle for the longitudinal axis and, for some cases, the altitude towards horizon. For the angular measurements they used smartphone applications like Smart Tools Compass or On Protactor. The expected accuracy of these devices is plus/minus 1 degree, granted they are correctly used and not affected by nearby magnetic fields. The experience with the students reveals that the effective error of the angle measurements is bigger than that. More significant than the device accuracy, is the lack of place to lean the device properly levelled.

The Azimuth angle was defined as the angle deviation of one of the *penals* from the North direction. In many hórreos we cannot distinguish between a back and a front side (because they lack of any distinctive element such a door, or a cross), so the Azimuth angle can only be defined between 0º and 180º. A 90º Azimuth will thus imply an East-West orientation for the hórreo longitudinal axis, while a 0º or 180º will both imply the same orientation, North-South, for the longitudinal axis.

3. Summary work phase.
   Each group completed a record card for every hórreo they visited, using Google Docs. The card contained: Hórreo photographs, the recorded architecture, social and astronomical data, and a summary of the owner's interview as well as their own impressions about the work. 15 hórreos were studied this way.

Besides, they created a google map to localize all the visited horreos as well as a common spreadsheet with all the gathered data. A summary of the student's table is presented in Table I.

Table I. Data collected by students in Beade

Latitude, Longitude (N, W)	Removed from original location	Dimensions: length x width x height (cm)	Nr. of feet	Altitude over horizon (º)	Decoration	Azimuth (º)	Apparent declination (º ' ")
42.191652, -8.700779	Yes	494x186x400	6	16	Sundial	154	55 34 19
42.190969, -8.712806	Not	550x200x430	6	21			
42.191680, -8.714430	-	512x190x300	8				
42.197316, -8.730944	Not	500x140x140	6			148	
42.197500, -8.7313	Not	468x153x200	6	16	Sundial	85	14 16 47
42.200992, -8.712204	Not	400x180×300	6		Cross and Spear	106	
42.188343, -8.701702	Not	625x155x245	6	15		21	-29 40 43
42.165811, -8.701476	Yes	752x200x225	6	5		66	-14 06 13
42.201111, -8.709439	-						
42.204475, -8.697167	Yes	350x160x300	4				
42.183683, -8.699407	Not	395x156x333	4				
42.102672, -8.421669	Not	520x140x320	6	11		56	-16 14 35
42.110893, -8.414611	Not	350x250x300	6	12	Pigeons	64	-10 18 44
42.204315, -8.712790	Not	515x148x325	6		Sundial	140	
42.185437, -8.698544	Not	545x180x350	6			34	

5. RESULTS

The complexity and the complementarity of the different areas lead us to present three typologies of results: the descriptive ethnographical data, the data on orientations, and the pedagogical data.

5.1. Ethnographic results

The data obtained in the second stage of educational project was an important resource about heritage protection of Beade's horreos in 1993 (Mateo et al, 1996). The 185 hórreos Council inventory sheets were digitalized (to computer PDF format files) and

the relevant numeric data translated to computer-based compilations. The information they contain was useful to get clear statistics on the materials out of which the hórreos were constructed, their shapes, their actual condition, age, or uses, number of feet, doors, as well as on the overoof decorations, etc. Also, to compare with the field sample information obtained by students.

The results obtained were similar in terms of the typology of the hórreos, the building materials used and the decorations found. As expected, no astral decorative motifs were found by the students but yes a 20% of overoof sundials in their sampling (see Table II), together with many crosses and pinnacles.

Table II. Decoration in hórreos in Beade

Decorations in hórreos	Beade (%) [1993 inventory]	Studens sample (%)
Cross	45,5	40
Pinnacle	38,5	20
Sundial	16,6	20
Others	-	5

The 1993 inventory and the sample collected by the students differ significantly in terms of preservation. That is, 50% of the hórreos listed in the inventory are in good condition, as opposed to a 20% in 1993. In addition, alternative uses are registered, such as woodshed, storage room, and "no longer in use". We perceive such data as a sign of the gradual abandonment of the work in the fields and the transformation of the parish into a metropolitan area of Vigo. The ongoing abandonment of agriculture as the main source of income has led to a diverse variety of uses of the hórreos, and in the specific case of the council of Vilaboa we observe all kinds of transformations to utilize these buildings: dog kennel, barbecue, clothes dryer, garden feature…

5.2. *Orientation results*

The ED50 UTM (X,Y) coordinates provided in the inventory sheets for the Beade hórreos correspond to the leftmost bottom corner of the included area map and not necessarily to the centre position of the inventored hórreo. No Azimuth values can be extracted from them but, with their aid and the usage of GoogleMaps[1], correct Latitude and Longitude values were easily found, for the 15 hórreos in Table I, by the students.

As we can see from Table I, between 20 and 33,33% of hórreos in the students' sample could have been removed, as informed by owners, from their original locations, for various reasons. Taking only into account the 8 ones surely not moved, for which Azimuths were collected for the longitudinal dimension, the mean Azimuth value --on a 0º to 180º basis-- accounts for 81,75º plus minus a standard deviation of 46,80º. With such a few, and so highly scattered, measurements, at most, we very roughly could conclude that an East-West orientation could be preferred for the hórreos locations.

For comparison, for the 245 hórreos of the Cobres parishes (council of Vilaboa) studied by Braña Rey & Ulla Miguel (2016), we get an average Azimuth of 99º but with a plus minus 50º standard deviation, while no clear information exists on the real percentage of them removed from their original locations. A situation which looks quite similar for the hórreos of Beade, that could render the study of orientations from an statistical point of view nearly hopeless, in case enough data could ever be collected for this parish as well.

Declinations in Table I were calculated using Clive Ruggles WEB facility (http://www.cliveruggles.net). As the students recognized, there are great uncertainties in their altitude measurements –only for 5 not removed hórreos-- and, so, the resulting declination values must be taken as very approximate only. As we can see from Table I not any systematic tendency in declinations seems to be found, as it happened for the case of Cobres sample as well (Braña Rey & Ulla Miguel, 2016).

Another obvious question to address, concerns the role played by local winds regarding orientations of hórreos within the landscape: to avoid wetting crops inside when rainy, and to dry them through the lateral cracks when warm. According to Beade neighbours, northern winter winds are humid and, therefore, hórreos must be oriented at least with the wooden door to the South in the studied area. An average Azimuth of 81,75º approximately corresponds to a longitudinal orientation E-W for the sample hórreos, as stated before.

In order to investigate further the question, wind dominant direction time series public data were obtained from the Galician Meteorological Service (Meteogalicia: http://www.meteogalicia.es), from the nearest meteorological station to Beade parish (called Vigo-Campus), for the period May, 2008, to October, 2015. From a first inspection of the data and at a first approximation, two separate dominant average wind regimes could be identified yearly: winds blowing from about 300º NW, for the period April-October, and from about 130º SE, for the period November-March. A more detailed analysis of variables and in situ information is required at this point, to try to clarify the link, if any, among this result, the spread in Azimuths obtained by the stu-

[1]https://www.google.com/maps/d/edit?mid=zHpaXLD9tlZ8.kY8YAMC9qAfQ&usp=sharing

dents and popular meteorological knowledge. The existence of different slopes in the hórreo locations could be an explanation for this spread, as the Beade parish is located on a hillside, with some places in more steppy locations than others.

5.3. Educational results

To measure the educational results of our project we designed and initial qualitative survey, where students were asked to explain what the knew about hórreos: their uses, locations, arquitectural structure and nomenclature. At the end of the project, for each hórreo card they created, they were asked to write down their impressions on the fieldwork and to orally resume their acquired knowledge. After analysing all this material, we could see that:

- In general, they were at first a bit perplexed with the topic, as something it would have never occurred to them. In fact, and although they live literally surrounded by hórreos, they knew almost nothing about them. But, as the project went on and they got familiarized with the methodology and objectives of this particular scientific research, they got more and more involved. They felt proud of their measurements, and of the questions the project arose in their community (friends, family and neighbours) and that now, due to their recently acquired knowledge, they could answer.
- Overall, they appreciated the interesting conversations they all had with the hórreo owners, elderly people in a great percentage.
- They were really motivated by the use of their own smartphones as measure tools.
- They all concluded that the orientation of the hórreos was selected by owners either in ornamentation grounds, or depending on the climatological or orographic conditions of each particular spot.

So, independently of the scientific accuracy of the students' measurements regarding the Azimuth and elevation angles, and the results we could draw from them, we think the educational objectives of our project where widely reached: students participating in the project learned how to scientifically approach to a particular topic; improved their skills in various educational standards of their curriculum (such as trigonometry and anthropology methods, and applications of new technologies); and finally aided to spread in their community the value of their own cultural heritage.

6. CONCLUSIONS

We think that we have found an interesting element of study, which is the presence of astral motifs in Galician hórreos of a particular location (Cobres parishes), not sufficiently studied to date. There are several questions to address, such as: obtaining a precise dating of the most interesting hórreos; to understand the meaning of the motifs (if any); why is there this particular kind of astral motifs and only in this particular area; and to clarify the question of orientations in a better statistical way. We don´t know –but want to know-- on how much Astronomy stonecutters knew and, astronomical orientations for hórreos, if any, are in principle not expected. However, all these questions form part of our ongoing work.

Besides, hórreos are in any case rural heritage elements of great social value, worth studying per se, and with a great educational potential for young scientists-to-be. In this regard, we conclude that our pilot educational project was a great experience for the students, its main objectives being achieved, and we intend to extend it in the following school years, making it a long-term project that would involve all the school and parish community, producing a very valuable ethnoastronomy set of data available for future research.

ACKNOWLEDGEMENTS

We thank among others the Councils of Vilaboa and Vigo, Cobres and Beade Parish Neighbours and IES Beade students: Uxía Rodríguez, Esther Lorenzo, Andrés Graña, Ainhoa Abalde, Alejandro Rodríguez, Miguel Bastos, Brais Domínguez, Gabriel Vila, Anxo Fernández, Israel Fernández, Natalia Martínez, Mario González, Samuel Abalde, Victor López, Daniel Pérez, Paula Oliveira, Antón Ramos, Alejandro Alonso, Jesús Caride, Rocío Cruces. Manuel González helped digitalizing the hórreo inventory sheets.

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