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Can nature align? The enigma of Moxos' Lagoons—astronomy and landscape in south-western Amazonia

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Abstract. In this essay we present a tentative archaeoastronomical analysis of the Moxos' Lagoons, a controversial and huge geographical network in the landscape of the Bolivian Amazon. In the late 1990s, a preliminary analysis of the orientation of a comprehensive and statistically significant number of lagoons showed that only human action could explain the peculiarities of their geometry, and especially their orientation according to a main axis aligned to an azimuth of 50° and its complementary angle. Since then, there has been an open debate on how these orientations could have been determined in practice. The absence of distinctive geographical features on the horizon strongly suggests that this peculiar pattern must have an astronomical justification. This short report presents a first approximation to the problem, suggesting that the lagoons could have been deliberately orientated in accordance with certain stellar positions which may have marked selected moments in the local climatic or economic cycle, a fact that could be corroborated by ethnohistoric references. The implications for new ethnographical research in the region are self-evident.

Keywords. Amazonia, Moxos' Lagoons, orientations, Arcturus, Centaurus

1. Introduction

It has been a general belief that Amazonian people did not create complex societies. The current low population density of the river basin and the apparent nonexistence of archaeological ruins of any significance seemed to confirm this fact. According to some scholars, the poverty of Amazonian soils limited food production and made it impossible to maintain urban settlements of any size. However, aerial images and remote sensing have led to the discovery of the remains of complex constructions, which are difficult to explain within the context of a simple hunter-gatherer society. This has been especially important in the area of the flood plains, the 'pampas', within Beni province in the north of Bolivia. Intensive agricultural practices were revealed here in the 1950s following the discovery (by an engineer, Kenneth Lee, who was searching for geological fractures while prospecting for oil) of extensive areas of cultivation-drained fields. These occur precisely in the area of the lagoons and the location of the long-established culture that has given the name to the region under discussion: Llanos de Moxos (Denevan 1966; Iskaenderian 2009). The area concerned is shown in Fig. 1.

During several years of fieldwork, Lee compiled an enormous amount of information and developed an elaborate theory arguing that other features found along Moxos—constructions both undoubtedly and possibly man-made, together with other archaeological remains—actually formed a cluster of structures built in order to colonise the huge flood-plain of the pampas (see Fig. 2). In the 1990s, the second author met Lee in Santa Cruz and they started work together, analysing the different elements of the

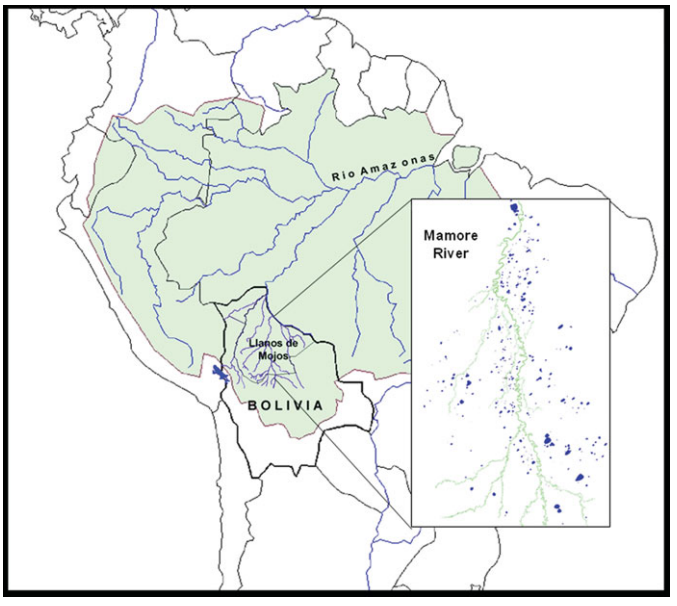

Figure 1. Map of the Amazonian region showing the area occupied by the Llanos de Moxos and the region of the Mamore River basin where most of the lagoons are located.

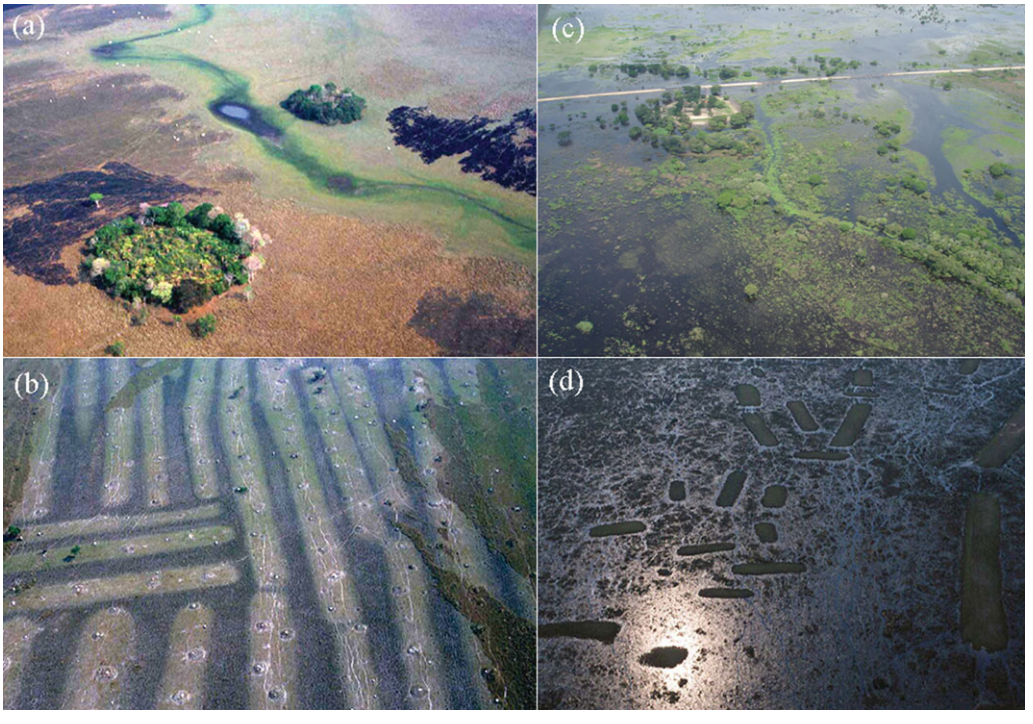

Figure 2. The ancient human landscape in Moxos in the dry (left) and flooding (right) seasons. The upper images show hillocks and the lower images show complete networks of drained fields. Notice how the hillocks and fields remain above the level of the water during the flooding season. Panel (*d*) also illustrates that drained fields do not seem to follow any clear pattern of orientation. Images courtesy of CEAM.

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cluster of structures—lagoons, channels, embankments or 'terraplenes', dams, hillocks or 'lomas', etc.—and studying their abundance and spatial distribution. (A preliminary analysis of the settlement patterns in the region showed that they did not follow any particular trends.) Another objective was to study the environment of Llanos de Moxos throughout history, and to rescue any sustainable productive technologies that might remain applicable today. In 1994 the Centre d' Estudis Amazònics (CEAM) was created in Barcelona with the purpose of supporting this work (Barba 2003; Barba & Miró 2003), including the creation of the 'Estación Piscícola Mausa'.

The most important case study was indeed that of the lagoons (see Fig. 3), whose geometry strongly suggested a possible anthropogenic origin. This was despite the work of George Plafker (1964) and other geologists who considered the lagoons to be natural. In 1995, an agreement between CEAM and the Institut Cartogràfic de Catalunya (ICC) permitted, for the first time, a complete cartographic study of the area though satellite images (see Fig. 4), an inventory of the lagoons, and a structural and design analysis. The first results were presented in the late 1990s (see, e.g., Fig. 5), the main conclusion being that only human action could explain the peculiarities of their geometry and particularly their orientation, with the main axes being aligned at an azimuth of 50° and its complementary angle (Barba *et al.* 1998; Barba & Viñas 2000). The absence of distinctive topographic features on the horizon suggested a possible astronomical justification for such a peculiar pattern. Since then, there has been an open debate.

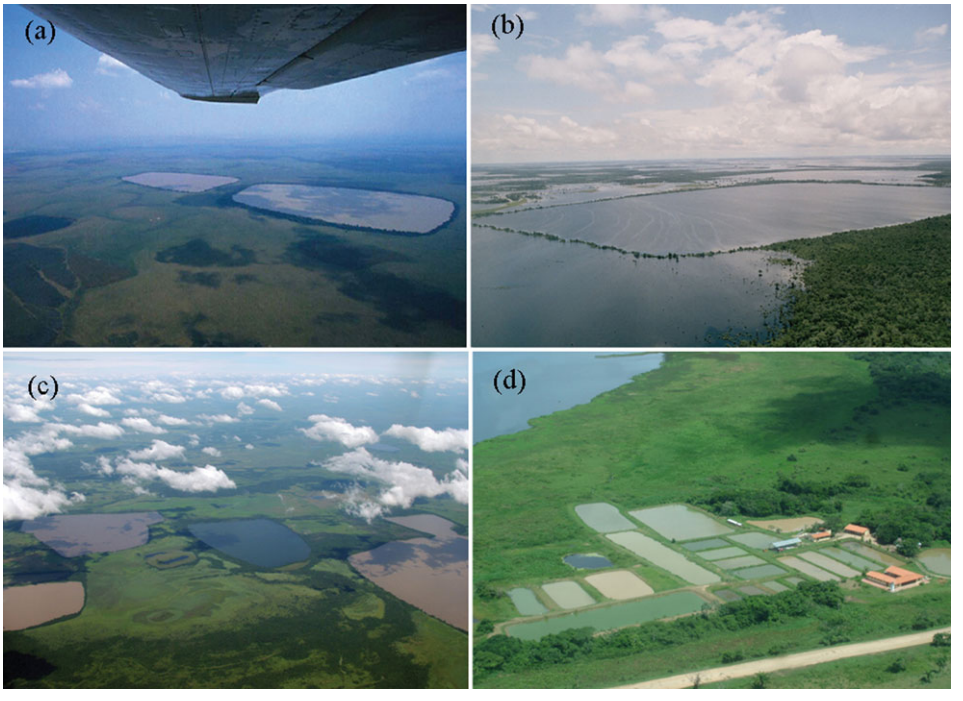

Figure 3. Different aerial images of Moxos lagoons. (*a*) The aligned Montevideo twin lagoons, strongly suggesting human origin. (*b*) A lagoon keeping its form and size during the flooding season. (*c*) Four lagoons in close proximity in different states of preservation. The leftmost and rightmost have resulted from the fusion of lagoons. (*d*) A fish-station ('estación piscícola') close to Laguna Mausa where new fish-farming techniques with autochthonous species have recently been implemented. This demonstrates the capability of the lagoons for modern economic activities. Images courtesy of CEAM.

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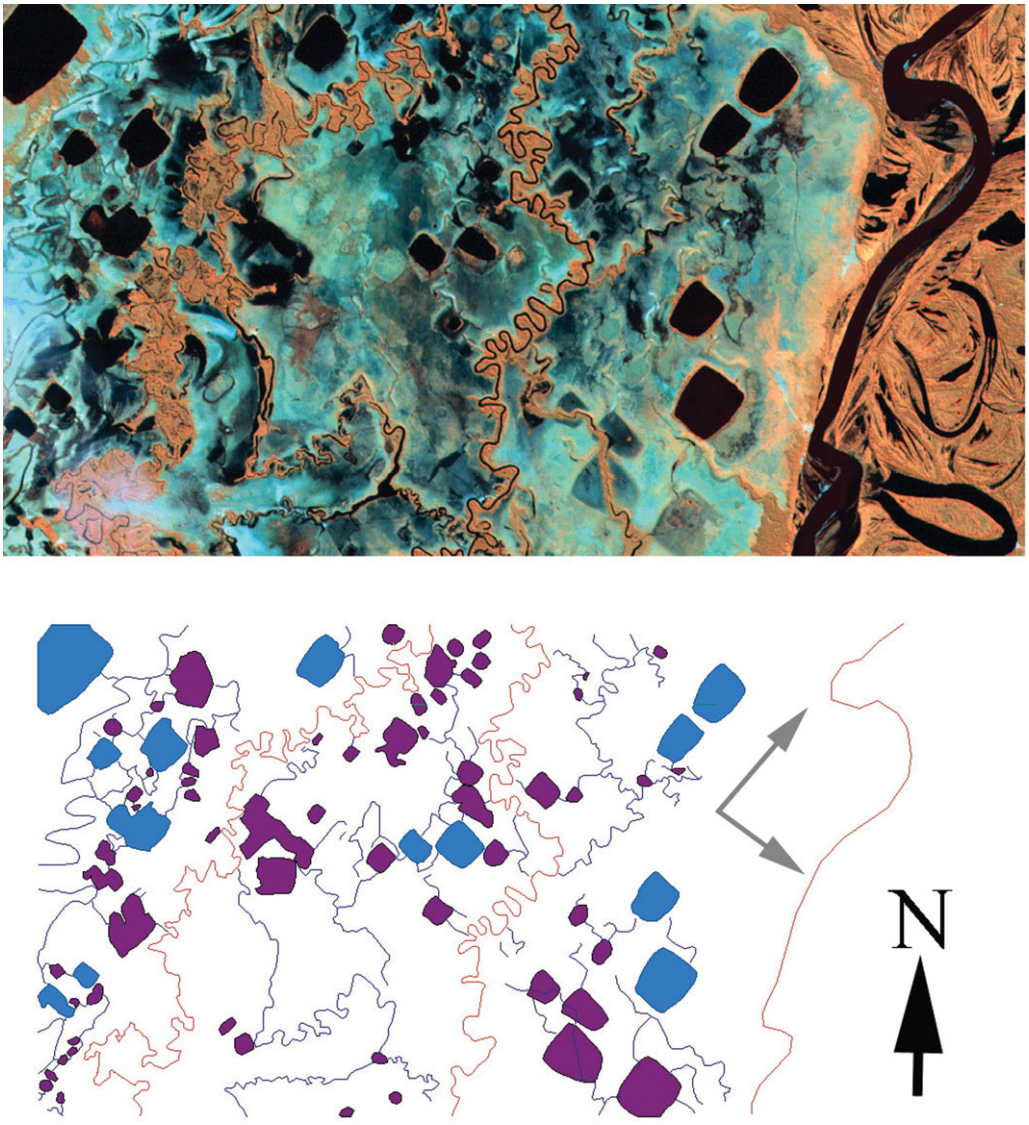

Figure 4. *Upper:* Satellite image of an area rich in lagoons on the left bank of the Mamore River. *Lower:* Schematic plan of the same area, with different tones marking still extant and dry lagoons. The grey arrows indicate the two dominant axes of the lagoons. Images courtesy of ICC and CEAM.

2. Discussion

According to the hypotheses discussed above, Moxos' Lagoons would certainly be the largest archaeological features remaining in Amazonia, possibly even in pre-Columbian America. The region studied covered an area of more than 80,000 km^2 (1170 km^2 occupied by the lagoons only), and would have represented a huge effort to colonise a flood-plain comparable to that of the Egyptian civilization in the lower valley of the Nile, a place where astronomy played a key role in the process (Belmonte 2009). We know little about the society that created the lagoons, presumably to be used as huge fish-farms, and all the related structures; nor do we know the time or the cause of the collapse of a system

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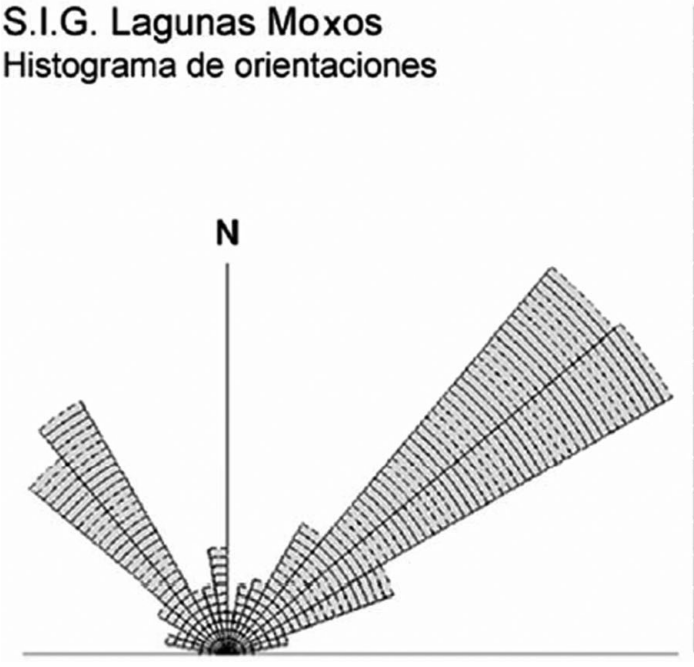

Orientación	Nº lag.	%
- 90 a - 80	3	1
- 80 a - 70	7	2,3
- 70 a - 60	6	2
- 60 a - 50	9	3
- 50 a - 40	29	9,7
- 40 a - 30	33	11
- 30 a - 20	8	2,7
- 20 a - 10	8	2,7
-10 a 0	12	4
Norte		
0 a 10	5	1,7
10 a 20	8	2,7
20 a 30	9	3
30 a 40	17	5,7
40 a 50	57	19
50 a 60	58	19,4
60 a 70	20	6,7
70 a 80	7	2,3
80 a 90	3	1

Figure 5. The original histogram of orientations showing the non-random orientation of the lagoons that forms the basis of the current investigation (from Barba and Viñas 2000).

that had long disappeared by the time the Spanish Jesuits arrived in the 17th century. However, ceramics found in test excavations of certain 'lomas' (Dougherty & Calanda 1984) suggest a date as early as c. 800 B.C. Amazonia may indeed have a long and fascinating history, hitherto ignored.

The present work provides a new archaeoastronomical insight into the construction of the lagoons. Some 370 lagoon axes, and the directions perpendicular to them, have been analysed in an attempt to shed some light on the problem through a multidisciplinary approach. The declination histograms (see Fig. 6) show that neither the orientation of the major or minor axes of the lagoons can be explained by solar or lunar observations. However, the diagrams demonstrate that the lagoons could have been deliberately orientated in accordance with certain stellar positions. It is possible that these marked selected times in the local climatic cycle, given that the rainy season, following several months of severe drought, starts during the month of October. This fact might confirm ethnohistoric records from the late 18th century (see e.g., Eder 1985; Barba 2009). Two alternatives can be analyzed.

If we focus on the major axes of the lagoons, then the main peaks of the histogram could be related to the rising of Arcturus (see Fig. 7). During the first quarter of the first millennium B.C., this star heliacally rose at the end of October. At the present time, we lack information relating this star to any aspect of the culture across Llanos de Moxos. However, the Kobeua tribe of the Brazilian Amazon identify the area of Böotes as a celestial piranha with Arcturus at its tail (Staal 1988). We can speculate, therefore, that the builders of the lagoons might have seen a fish-constellation—perhaps a 'pacu' instead of a piranha—in the same area of the sky. This could well have related to the fishing practices carried out at the lagoons, the heliacal rising of this constellation being seen as a propitiatory phenomenon related to the economic cycle of the region.

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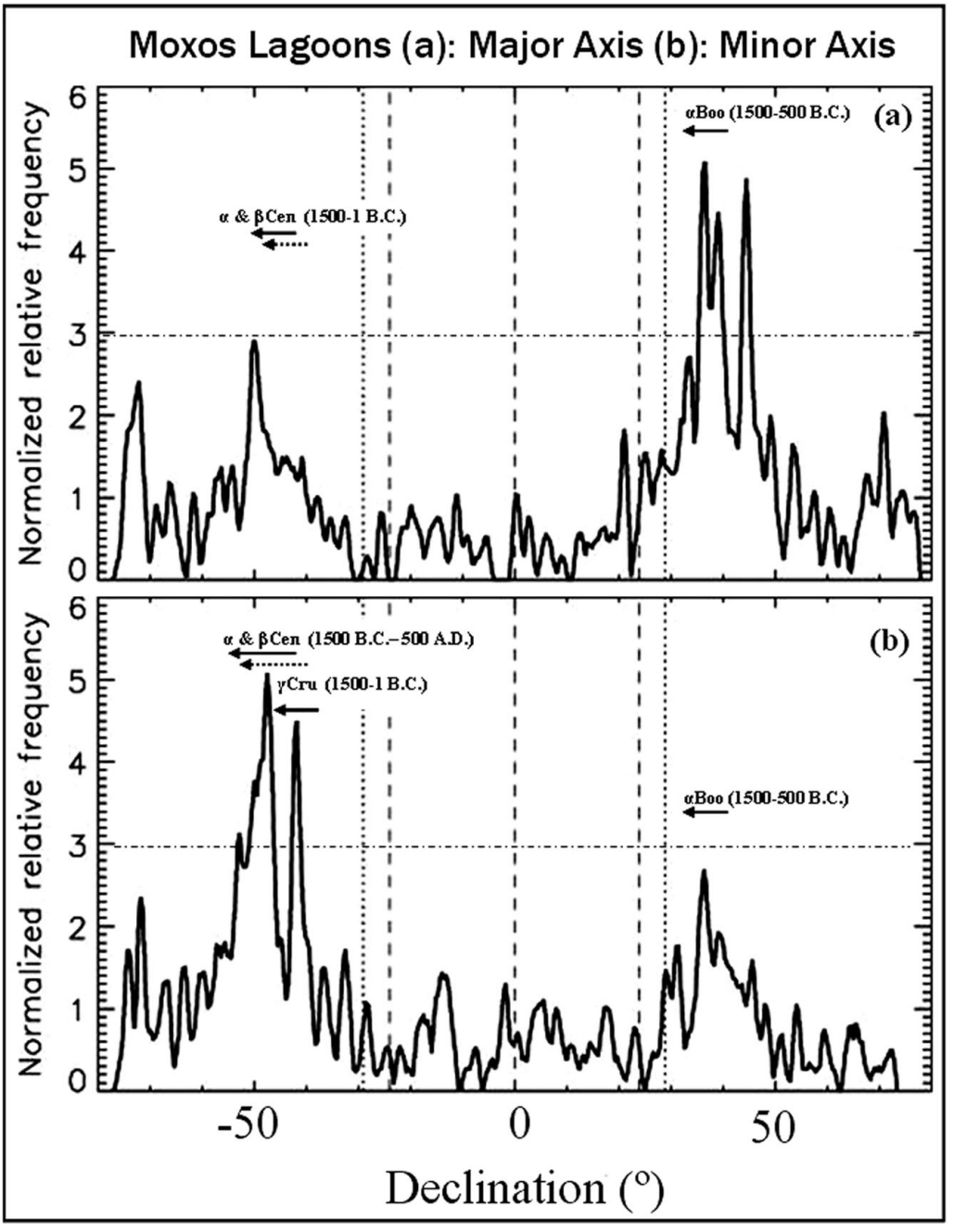

Figure 6. Declination histogram of the orientations of 370 lagoons in Llanos de Moxos: (*a*) orientation of the major axis, (*b*) minor (or dam) axis. There are no significant peaks in the luni-solar range (dashed vertical lines mark the solar solstices and equinoxes; dotted ones mark the lunar extremes). This strongly suggests a stellar explanation for the most significant peaks, i.e. that observations of particular stars were used to orientate the lagoons. The stars of Crux together with Arcturus, Rigil Kent and Hadar are considered the only reasonable candidates. See the text for further discussion.

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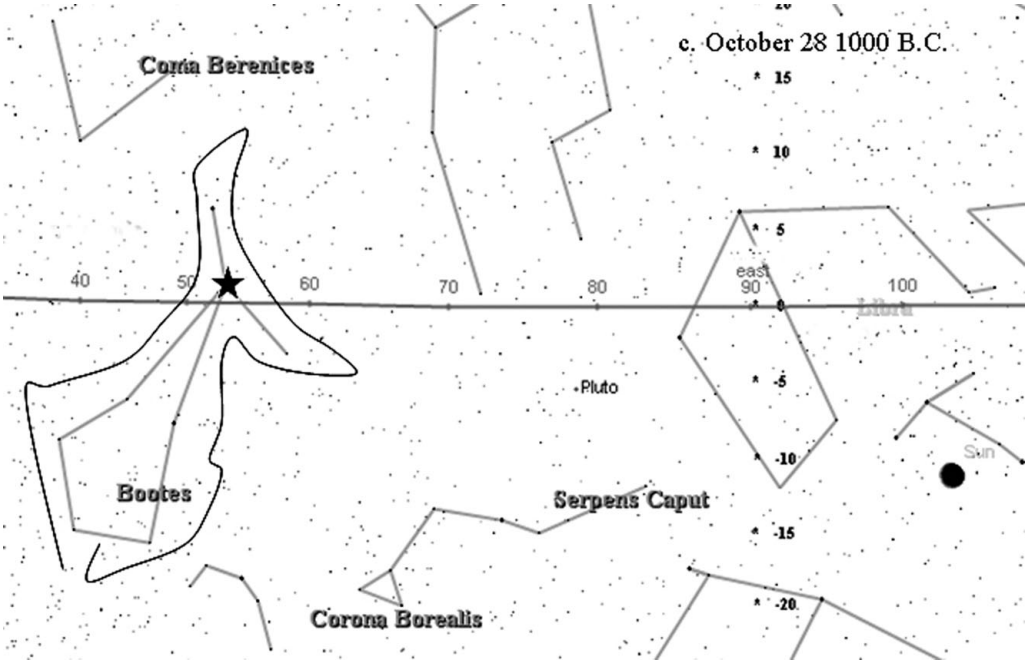

Figure 7. The heliacal rising of Arcturus around October 28, 1000 B.C., following the dominant azimuth of the main axes of Moxos' lagoons. Arcturus may have belonged to a fish-like constellation that rose heliacally at the time when the wet season arrived and the floods started.

If, on the other hand, we consider the minor axes (or actually, the orientation of the dams constraining the lagoons), then the histogram shows that the highest peaks could easily be explained by alignment upon the bright stars of Centaurus and Crux. This grouping of bright stars, especially α and β Centuari, may well have had great symbolic significance in the cosmovision of the ancient Moxeño culture. They were amply recognized by other neighbouring (although not necessarily contemporary) cultures such as the Inca of the highlands (Bauer & Dearborn 1998) and, especially, the Tupi-Guarani of the upper Chaco (Pereira Quiroga 2004), who see the image of a giant ñandu or 'piyu' (the American ostrich) in the same region of the sky (see Fig. 8). Added to this, in the first millennium B.C. α and β Centauri helically rose—and, incidentally, heliacally set as well—at the end of September; this means that these stars could have acted as heralds of the forthcoming rains and flooding.

At the present state of knowledge, we are unable to choose clearly between these two alignment options: Arcturus with Böotes or the bright stars of Centaurus plus Crux. Both offer an interesting and appealing possibility for the astronomical orientation of the very likely man-made lagoons. Indeed, the implications are self-evident for new and extensive ethnoastronomical research in the region, focusing on further investigating local sky-lore and its possible relationship with the lagoons.

Acknowledgements

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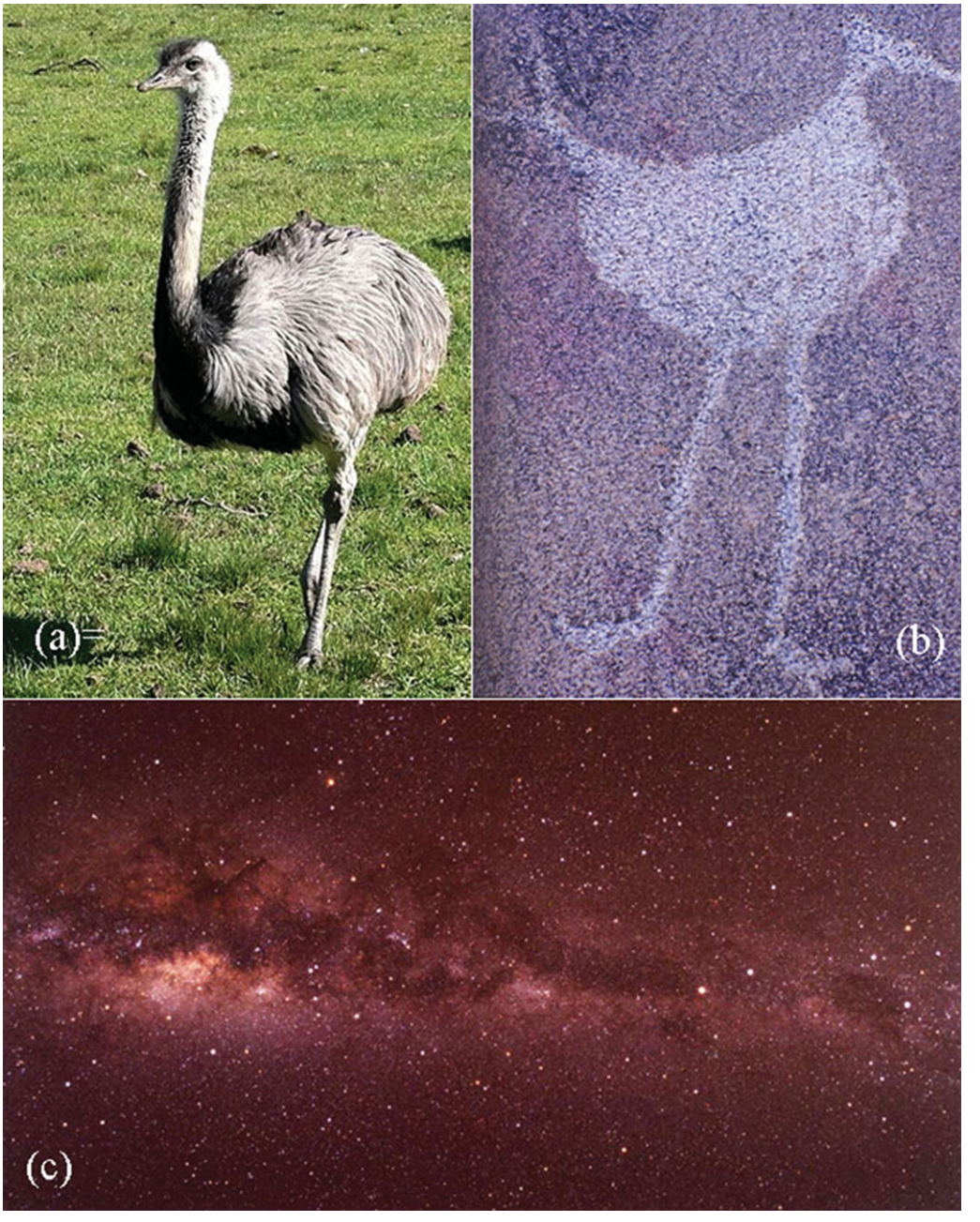

Figure 8. A 'piyu' (*a*) and its local rock-art (*b*) and celestial (*c*) counterparts. The head and neck of this huge constellation might also have been the reference point for the orientation of the lagoons, but its importance has yet be proved for the ancient 'Moxeño' culture. Images courtesy of CEAM (*a*, *b*) and Gonzalo Pereira (*c*).

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