Constellations and Time Keeping used by Indigenous Communities in the Northwestern Amazonian Region

Walmir Thomazi Cardoso
Pontifícia Universidade Católica de São Paulo

Abstract:
This article is the result of research conducted from 2005 to 2007 in Brazil's Amazon region. Relying on participant observation and ethnomathematics sources, on practical sky observation activities, and on classical sources about constellations observed in Brazil's Amazon region, a sky mapping project was undertaken with Tukano, Desana and Tuyuka indigenous communities. At the Yupuri School, an astronomical calendar was created that integrates specific environmental and climate events based on descriptions of many constellations from different indigenous communities. This investigation found that in the northwest, Amazonian Indians mark rain periods, drought, planting and harvesting by the set and rise of major constellations. To complement these findings, non-Indian materials were also analyzed mainly from the researchers of the early 20th century who worked in the northwestern state of Amazonas.

Keywords: Cultural astronomy, Indigenous Knowledge, Amazonian Indians, Timekeeping, Indigenous Calendar

Introduction

People around the world have searched for complex correlations between the skies and humankind for as long as we know. The northwestern Amazonian peoples are no different. They learn from each other about the skies as observers and they are strongly encouraged to do so. The situation is not as unusual as some have thought (Aveni 2008; Chamberlain et al. 2005; Kelley and Milone 2011; Selin 2000).

There are more than 23 different languages spoken in the region known as "Dog's Head" in the northwestern part of the Amazonas state in Brazil. (Figure 1) A significant number of these languages are based on a singular trunk language called Tukano, which is also used to refer to the ethnic group among whom we developed our research. Other languages such as Tuyuka and Desana are very similar and correspond to other ethnic groups, which our research also included. These Indians live in the border region where Colombia, Brazil and Venezuela meet. Although they live in different countries, they share many similar cultural features. Languages are only one of the common aspects among them.

During the last quarter months of 2005, I was invited to visit a Tukano tribe by the Instituto Socioambiental (ISA)–a well-known Brazilian non-governmental organization. A group of ISA's anthropologists involved with indigenous issues in this region received a request to call in an astronomer. This demand originated from a group of indigenous teachers concerned with traditional teaching topics at the Yupuri School. This school is one–among other–indigenous differentiated schools in this region. Following educational programs that accommodate indigenous life, traditions and dialogues among Indian and non-Indian knowledges, these institutions have been stimulated by special support from current Brazilian educational government programs. Within this context, anthropologists and indigenous teachers planned a workshop to engage representative members of all communities who speak Tukano variant languages, including the Tuyuka and Desana.

Working in the region over two years, we developed three different but connect-

Figure 1. Dog's Head in northwestern Amazonian region. Detail is focused on the Tiquié River. Source: http://pib.socioambiental.org/en/povo/tukano/1499

ed workshops (Cardoso 2007). In the first one, we hoped to investigate some basic astronomical concepts within Tukano culture; we started by telling them selected myths and stories from our Occidental constellations. We brought to light some myths—such as Orion and the Scorpion, or other stories such as the flying horse Pegasus, Andromeda and her closer relatives, and how they were transformed into constellations—for an avid group of silent students. As they became interested in the mythology, though, there was a sudden movement to tell me some histories of their constellations. They bestowed upon me extended miscellaneous narratives showing me a complex cultural big picture of Amazonia's territory, including the main part of their conceptual natural world framework.

During the second and third workshops we followed similar strategies to describe constellations and we developed together early drafts of circular calendars. In this specific case we suggested, from our research, a dynamic circular calendar inspired by *volvelles* (wheel charts or dynamical circular information tools), extremely popular during the early 20th century but older even than that (Helfand 2002). Not only were the final results of circular dynamical calendars important but also the descriptions of each constellation. Most of them have been described by other researchers, mainly anthropologists and ethnographers from late 19th and early 20th centuries (Koch-Grünberg 1969; Lévi-Strauss 2004a; Brüzzi Alves da Silva 1962). The main ones were remembered by wise elders and senior citizens as well as community leaders, but this knowledge was spread out along a wide zone. Therefore, the workshops were part of a strategy to gather different ethnic leaders and elders together to determine the current state of indigenous astronomical knowledge and its correlation with other conceptions of their natural world (Cardoso 2007).

The corroboration of historical sources through field research conducted in the Yupuri indigenous school allowed us to show that, besides constellations, a group of people inhabiting the Middle Tiquié River region identified correlations between fauna, flora and weather events and astronomical phenomena. In other words, our work during the investigation period became broader than either the study of constellations out of the Greco-Roman matrix or an attempt to set new versions of a calendar.

The calendar itself is not only a tool for reckoning the passage of time but also for showing the complex correlations among star positions and natural phenomena as a whole. The formulation of these new calendars is linked with natural resource management because it is not the case of an astronomical study of measuring time in and of itself. Stars here can be seen as part of a complex landscape made up from nature

and, within indigenous concepts, supernatural elements and phenomena.

From the beginning of our research, several Tukano Indians told us that they recognized significant positions of stars in the sky. They pointed to special locations where a group of stars set together with the sunset (heliacal set). These events are correlated with such natural phenomenon as floods and low river level; times to grow different plants; seeding and harvesting periods; increasing or decreasing amounts of edible fish or other availabilities of sustenance. Therefore, for them an astronomical event is not only what we recognize as celestial phenomenon but also a variable amount of events related to each other in a complex panorama. To grasp part of this intricate puzzle was essential to building the dynamical circular calendar with them.

Methodology

Our work was developed as qualitative research and started by using ethnomathematics references based on Ubiratan D'Ambrosio's (2002) educational conceptions. Beyond their direct application within mathematical education theories, they are also correlated with non-formal mathematical thinking and how they are connected to culture and epistemology (D'Ambrosio 2005). We also worked with some concepts of participatory research, following Thiollent (2008), beginning with our first field research. Currently there are important discussions about methodology within the study of astronomy in cultures (Ruggles 2015). As an interdisciplinary research area, there are different contexts that come from both the social sciences and humanities. The matter of context has shown itself to be an important issue and will be investigated further by the author in a forthcoming paper.

Indigenous leaders and anthropolo-

Figure 2. A Tukano constellation of the Viper, represented during the first workshop in 2005.

gists of the ISA made arrangements to develop one workshop about the astronomy of the upper Rio Negro region late in 2005. They invited me, as an astronomer, and I started to prepare some materials to take with me. I selected sky charts without any labels of our constellations, asterisms, stellar names or lines on them. I brought a telescope and binoculars. Also, I prepared some versions of sky maps with computer programs such as *Stellarium*. The best technique to recognize the main Tukano constellations was the comparison between the natural sky and its simulated projection in different situations. But it was only successful after some sessions of conversation and long talks about our own constellations.

Our first workshop really started when they heard the Occidental myths and narratives of the sky. We told them the stories behind the constellations of the ancient Greeks. We waited and asked for similar topics expecting a similar behavior from them and they answered with narratives of their myths and told us about what they consider to be their most important constellations. We asked about the appearance and the location of each constellation and eventually recognizable asterisms in the sky. Thereafter, they made the first registers of Tukano constellations that I have ever seen. (Figure 2) Only after that did we make our first shared night of sky observations with the presence of the whole community. (Figure 3) Telescope and binoculars were not successfully used in these occasions. Actually they never were! The community was only interested in naked eye sky observation.

The second technique used to identify their constellations was developed with storytellers. We selected some elders and individuals acknowledged to know the configurations of the most important constellations according to what leaders and anthropologists had found. By comparing

Figure 3. Naked-eye sky observation with the community. (Photo by Pieter-Jan Van der Veld)

their descriptions and observing the sky with the same person in different positions and not at the same time, we found the constellations shown in this paper. It is important to emphasize the importance of having more than one meeting with the same storyteller to double-check information, asking him, for example, about the position of one specific constellation in a distinct moment in a different night and site of observation. It was important for this technique, resulting in fewer mistakes.

The third technique was associated with the students' constellation notebooks. During the workshops we requested that the group of students observe the sky during longer periods of time and register them using a notebook with unlined sheets – sketchbooks. I had taught them how to represent the observation site, his/her point of view and the landscape nearby. To reproduce each constellation, we explained a technique to maintain proportions using their own fingers (Cardoso 2007; Ventrudo 2009), and requested that they insert a key, showing each adopted scale.

We compared notebooks from different students in different locations because each student lives in a different tribe far from The Yupuri School. At indigenous schools in this region of Brazil, the students

remain for 15 days in the school staying within that specific community. For the other half of every month they return to their original communities and the cycle starts over again throughout the year. Living according to this schedule, the students could draw constellation sets with all their local nuances. Asking locals elders and relatives within their tribes, they showed us tiny distinctions among their representations. This is important for further investigation because this kind of variation in the descriptions can hide differences in cosmological concepts or eventual changes in environmental conditions. Despite this variability, the big picture of sky descriptions was sustained overall in the documents.

We might assume that the most important natural events are correlated with heliacal settings of constellations, but indigenous elders and storytellers also told us about the importance of specific constellations in positions other than near the horizon—and during sunset or not. Sometimes they talked about events correlated with a constellation rising or even an asterism's movement all night long or during the day. Sometimes they talked about constellations that bring bad things from the eastern side of the sky. While we used this information here, further research will be necessary to delimit better where and when it is really important. It was not possible to investigate it deeply because this kind of knowledge is considered to be part of an extensive personal formation that requires participation in rituals.

The main constellations or main constellation circle appeared in a significant number of observations made by students and it was confirmed by elders and indigenous storytellers (Cardoso 2007, 2012). There is an intentional correlation among those constellations and natural phenomena; constellations are not an end in themselves. Their shape, extension and position become valuable information within an indigenous knowledge system. When a constellation or part of it is setting during sunset, Tukanos expect different, sometimes exclusive, natural events. Floods or low river levels, plants sprouting, flowers blooming, planting or harvesting periods are some of the natural and cultural events related to constellations and recognizable asterisms in a specific sky position relative to the horizon. Most of these events are categorized and ordered by wet and dry periods known as "winter" and "summer" respectively. Tukanos identify short and long intervals of time with rain or the season with heavy clouds to winter, and the sunny season or the season with a low presence of clouds independent of their duration to summer. Cold and hot days within the European-derived ideas of seasons simply do not make sense among the inhabitants of this vast area. A regular day in Amazonian territory is humid and hot without seasonal dependence.

Bringing together the results of these three different investigations, we compared the descriptions with historical narratives and maps (Koch-Grünberg 1969; Lévi-Strauss 2004a; Ribeiro and Kenhiri 1987; Brüzzi Alves da Silva 1962). Since the late 19th and early 20th centuries, ethnographers and researchers have described parts of these complex constellations and daily natural explanatory systems (Cardoso 2007). This knowledge was and still is important to all these communities because it is part of their complex lifestyle becoming, not only a calendar for survival, but also for carrying their spiritual conceptions and cosmology.

The result of our investigation was a group of nine main constellations and asterisms, or a main 'cycle of constellations' as we called them, along with two others

identified in the northern and southern celestial hemisphere respectively (Cardoso 2007).

According to the different tribes/ethnic groups and along different sides of the main river, the cycle could start in different constellations. The Desana group usually start their calendar with the *jararaca*, or the 'viper' constellation, setting on the west horizon. When the head of the viper sets just after sunset (heliacal set) they expect some rainy days or "winter" days – as explained above. This occurs around the second half of November to early December. Sometimes the river level increases rapidly during these days even without excessive rain. In these cases, the heavy rain probably has fallen several days before at the wellspring area far from the observer's position. Usually this event is known as *Aña Duhpoa Poero* – literally, 'the Flood of Jararaca's Head.' In other words, when the viper's head is setting they expect some days of flood or the river level to increase.

A similar event occurs when the venom gland of the viper constellation is setting heliacally, when similar flooding results are expected. Other fluctuations of river levels can be expected in all events described hereafter. Following up with this viper theme, a few times we came across the description of a flood linked with the viper's liver. This was followed by 'the Flood of the Viper's Body – *Aña Ohpu Poero* in Tukano language which is also spoken by the Desana; *Aña Diepa Poero* –Flood of the Viper's Sack of Eggs; and at last *Aña Pihkoro Poero* – the Flood of the Viper's Tail, or more specifically, the Flood of Jararaca's Tail.

As we can see with this description there are cyclical variations of river levels, which are of critical importance because they can vary almost ten meters, or more. Such huge variations can occur in a couple of hours or days. A river in Amazonia is equivalent to a big road; meanwhile little rivers are called *Igarapés* and temporary rivers are known as *Igapós*, which correspond to streets in our cities. But these are not only of concern to humans. Fish change their behavior according to the oscillation of river levels. As important sources of protein to peoples in this region, the presence or the absence of these animals is critical to any kind of action concerned with environment management. If the rivers change, fish change and humans need to know about it so they can change before them. Flowers bloom, new seeds arise, edible insects hatch, animals migrate, etc.; river levels are related to all of these natural phenomena in a cyclical way. Moreover, indigenous people have identified correlations between them and celestial configurations.

As noted above, the Desana begin their calendar with aspects of the viper constellation and recognize divisions such as the head, body, venom, liver, egg sack and the tail. These divisions signify different levels of effects. The constellation that follows the viper is a representation of an armadillo (*Pamõ* in Tukano). To Tukanos the armadillo is the constellation that opens the year or constellation cycle, occurring in early December. Considering the viper as the first constellation, in their calendar the Desana recognize that the Armadillo follows it — as do other ethnic Amazonian groups based on western Tukano languages. While *Aña* (the viper) corresponds to our Occidental constellations of *Scorpius* (the Scorpion), *Sagittarius* and the *Corona Borealis* (Northern Crown), Armadillo has an intriguing division. There is an external part of its body known as *Pamõ Oaduhka*, or 'Armadillo's bone, followed by *Pamõ Duhpoa*, 'Armadillo's head,' *Pamõ Ohpu*, 'Armadillo's body' and *Pamõ Pihkoro*, 'Armadillo's tail.' The sequence follows the same kind of considerations

made to *Aña,* or the rise and fall of the river levels with all consequences previewed. The difference is the length of time for which each constellation sets on the western horizon.

While the viper comprises three of our constellations, Armadillo is part of the Occidental constellation known as *Aquilla* (The Eagle), in its stellar field. An important difference is that we can expect fewer wet periods related to this constellation and among these wet epochs we may find significant dry intervals. The duration of each one correlates to the setting times of each constellation section, but it is not a correlation of cause/effect as we might prematurely suppose. Tukanos are not clear about these relations. Even though, it would be possible, and eventually desirable among us to use it to predict causal correlations, causality is not necessarily present in other conceptions of indigenous natural relations.

After the Armadillo, there is a fish in the Tukano sky known as *Mhuã*, or *jacundá* in Portuguese as it is a well-recognized fish species. The stars that are in this constellation are inside our *Aquarius* (the water bearer pouring water) constellation. *Mhuã* is almost conjoined with another stellar group also in the *Aquarius* region. This one represents a shrimp called *Dahsiu*. Both are connected by a myth that corresponds to their relative positions and orientations in the night sky.

These constellations are not extensive; their associated floods are expected by February. Following these star groups, a huge constellation rises in the northeastern portion of horizon. Slowly, as a big cat, we can see the Jaguar constellation or *Yaí* (literally 'jaguar' in Tukano languages), arising step by step, or portion by portion. The first recognizable part in this constellation is the whiskers. After that observers see its ears and its head. Following these parts observers identify its body, finishing with a curved tail. As noted above for other stellar fields, each part of this constellation is related to a variation in the river level during its heliacal setting. There is a large variation in river level when the jaguar's whiskers are setting just ahead of the Sun (heliacal set). After this relatively short period begins the "Flood of the Jaguar Head" or *Yai Duhpoa Poero* followed by *Yai Ohpu Poero* or the Flood of its Body. This process is complete when the Jaguar's tail (*Yai Pihkoro Poero*) brings another flood or changes river levels again.

The Jaguar asterism is spread over an area of two Occidental constellations, taking up the larger part of *Cassiopeia* and *Perseus*, which sets from the beginning of March until the end of April in these equatorial latitudes. In the other part of the western horizon, our *Pleiades* in *Taurus* is setting. Our *Pleiades* open cluster is called *Ñohkoatero* in Tukano languages, which literally means "star group" or "Star-Thing" (Epps & Olveira 2013). *Ñohkoatero* is actually an important time reckoning icon for many cultures (Aveni 2008; Azevedo et al. 2010; Cardoso 2007, 2012; Epps & Olveira 2013; Hugh-Jones 1979, 1982; Kelley & Milone 2011; Lévi-Strauss 2004a; Riberiro & Kenhíri 1987; Ruggles 2015; Brüzzi Alves da Silva 1962) and along with our Occidental *Hyades* correlates with two other flood episodes at its heliacal set. *Hyades* are identified as a kind of grill or more specifically a fish-smoking grill (Cardoso 2007; Epps & Olveira 2013) known as *Waikasa* (in Tukano) or *Girau de Peixes* (in Portuguese). These two constellations set from April to May.

Almost completing this cycle, Tukanos see an Adze or more precisely an "adze handle" in Orion's belt and making up part of his body. An adze is an important ritual tool and appears in some mythical narratives (Cardoso 2007). Named as

Table 1. List of elements in the main constellation cycle and their periods of heliacal set.

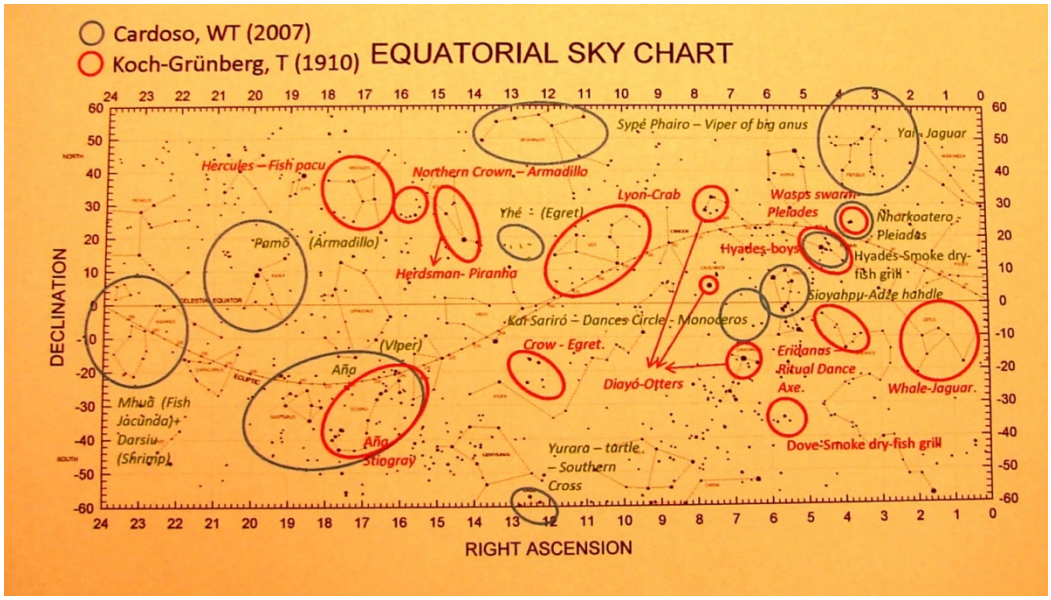
Tukano	English	Occidental Reference	Period of Heliacal Set in Rio Tiquié
Mhuã	Jacundá (fish)	Aquarius & Pisces	early to middle February
Dahsiew	Freshwater shrimp	Aquarius	early to middle February
Yaí	Puma or Jaguar	Cassiopeia & Perseus	first half of March – puma's beard and head second half of March – puma's body mid to end of April – puma's tail
Ñohkoatero	Group of Stars	Pleiades	middle to end of April
Waikhasa	Cooking grill	Hyades	end of April to middle May
Sioyahpu	Adze handle	Orion	middle to end of May
Yhé	Egret	Coma Berenices	August and September
Aña	Jararaca (snake)	Scorpius & Sagittarius	September, October and November
Pamõ	Armadillo	Aquila/ Dolphin	December

Sioyahpu ('adze handle') it follows other constellations into the sunset during the last half of May. Completing the main cycle of constellations, we identified *Yhé* or the Egret. It was described inside the *Coma Berenices* near Leo's region. We are not completely sure about this identification because it diverges from the historically documented descriptions, (Cardoso 2007; Lévi-Strauss 2004) but the storytellers interpreted this area as corresponding to a mythic egret that sets during August and September. Table 1 summarizes some of the information of the main cycle of constellations.

The results of these field investigations and observations with storytellers have been compared with historical sources (Azevedo et al. 2010; Cardoso 2007; Fernandes-Diakuru 2006; Hugh-Jones 1979, 1982; Koch-Grünberg 1969; Lévi-Strauss 1964, 2004a, 2004b, 2008; Brüzzi Alves da Silva 1962). We compared descriptions made by ethnographers such as Theodor Koch-Grünberg (1872-1924), Claude Lévi-Strauss (1908-2009) and by the Priest Alcionílio Brüzzi Alves da Silva (1901-1987) with our own. Koch-Grünberg developed a representational map of the whole sky showing the Occidental constellations and constellations identified by indigenous groups that occupied the same regions. Koch-Grünberg's map was reproduced by Lévi-Strauss in his *Le cru et le cuit* ('*The Raw and the Cooked*') in 1964. We reproduce here a version of that map and some description of the constellations. (Figure 4)

In Lévi-Strauss's considerations of the same stellar field presented here, we find some differences among the constellations. To Koch-Grünberg, part of the Hercules constellation is associated with a fish specimen known in Brazil as *pacu*. Other fish rest inside the Bootes (herdsman) group of stars, but these are the horrifying piranha. Both constellations are on the top-left side of Figure 5, which shows a very small difference in representation between indigenous and Occidental stars. The *Corona Borealis* (Northern Crown) constellation is associated with an armadillo in Koch-Grünberg description. Recall that, in our research, this animal is related with *Aquila's*

Figure 4. Comparison of constellations. Equatorial sky chart (from http://astro4.ast.vill.edu/ast_list.htm) modified by the author.



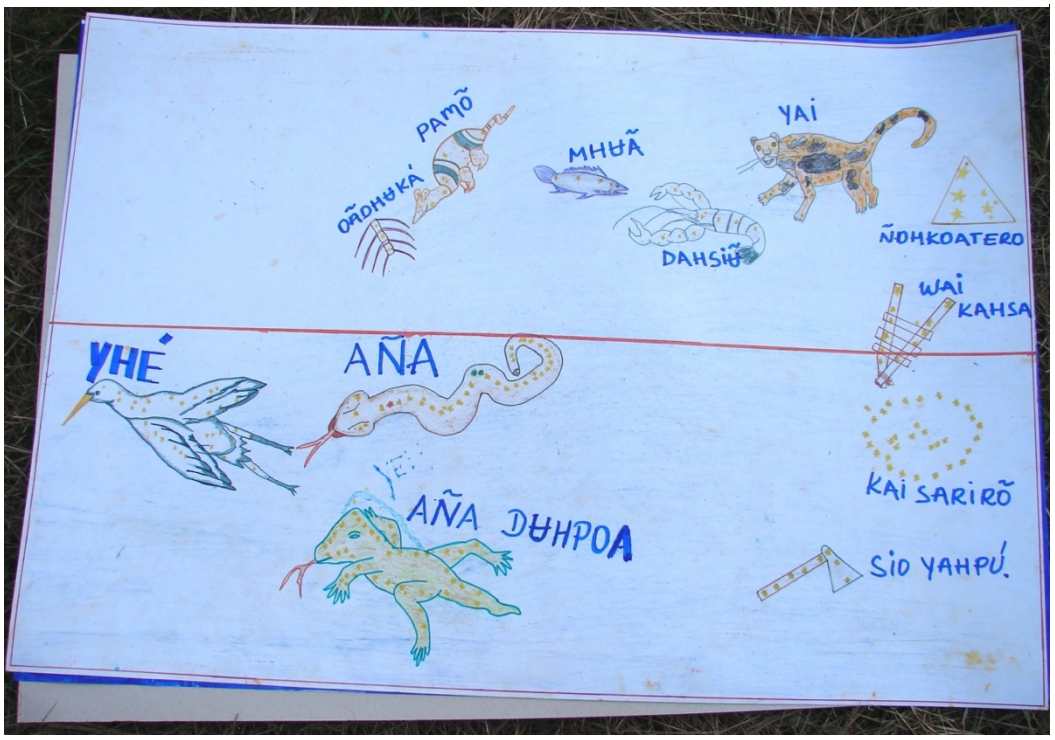
star field. Our occidental *Scorpius* constellation could be seen as "the big snake" (*cobra grande* in Portuguese) a character in a famous Northwestern Amazonian legend.

Our description of the viper constellation is almost coincident with *Scorpius*, with the difference in length involving *Sagittarius*. Another non-coincident description is related to the indigenous constellation known as the Egret. While its star field is related to our *Corvus* (Crow) constellation, in Koch-Grünberg's description, *another* egret's representation could be seen in the *Coma Berenices* area as our survey showed. Following these stars on the north side of the equatorial area, we can see our Leo constellation where Koch-Grünberg described a crab, from his own research. Some of our storytellers said something about a crab in the sky but no one could point to it. Corresponding to similar unidentified stars in our research, but present in Lévi-Strauss's description, there are stars from *Gemini*, *Canis Major* and the *Columba* constellations, along with some other stars from *Orion* in a total of five, that represent an equal number of mythical otters, involved in a robbery of fishes that were set on a smoke-dry fish grill represented here by the dove stars. In this myth, a fisherman extended his fishing net around the Orion stars (between Rigel [α Ori] and Betelgeuse [β Ori]) and was supposedly robbed by some otters. The *Eridanus* constellation represents an axe used in a dance ritual. It is close to our description of an "adze handle" involving a group of Orion's stars. It is not the same constellation but sometimes there is a similar axe constellation described near Orion as we can see in Figure 5.

The *Gemini, Canis Major* and *Columba* constellations are not correlated with Tukano constellation descriptions, but there are legends about otters who robbed fish from a hero. Storytellers say that there are stars that represent those otters, but they were not able to describe their positions.

Lévi-Strauss also refers to *Hyades* and *Pleiades* respectively as "some boys" and a "wasp swarm." These stellar clusters – as

Figure 5. A Tukano stellar chart, including the axe at the lower right. (Photo by the author)



noted above – were identified in our investigation as a grill or, more precisely, a smoke-dry fish-grill, corresponding to *Hyades* and the *Pleiades* as *Ñohkoatero*, or literally a 'group of stars' in Tukano. *Ñohkoa* means star. Although, in a different position a smoke-dry fish grill is present in both descriptions.

Lévi-Strauss identifies, in his final map explanations, the jaguar inside the Occidental *Cetus* constellation, lying near the *Cassiopeia* and *Perseus* stellar fields. Even considering some coincidences, we saw important differences among stellar arrangements and positions between our study and those conducted by Lévi-Strauss and Koch-Grünberg.

Why those differences? We know that parts of Lévi-Strauss's description were made specifically in a different area than ours, which some scholars have previously noted (Hugh-Jones 1979). On the other hand, Koch-Grünberg's research covered a wider part of Amazonian territory and some of the constellations he recorded were also seen by indigenous groups of northwestern Amazonia.

To further examine this issue, we analyzed part of an extended study drawn up by a Salesian priest named Álcionílio Brüzzi Alves da Silva (1903-1988), who worked during the middle of the 20th century. He spent almost 20 years among the Amazonian Indians and was very concerned with ethnographical studies and religious activities (Brüzzi Alves da Silva 1962; Magalhães 1990). Brüzzi Alves da Silva recorded and translated myths, and analyzed a vast amount of materials, primarily during the late 1940's and early 50s. His descriptions (1962) of Tukano constellations can be found within a huge book about this culture *Civilização Indígena do Uaupés* or *The Indigenous Civilization of*

Uaupés. Although it has been critically reviewed, the book is a valuable source for understanding the relationship between a priest and his conception of indigenous life during early 20th century. In it we do find a few pages dedicated to astronomy in a general sense.

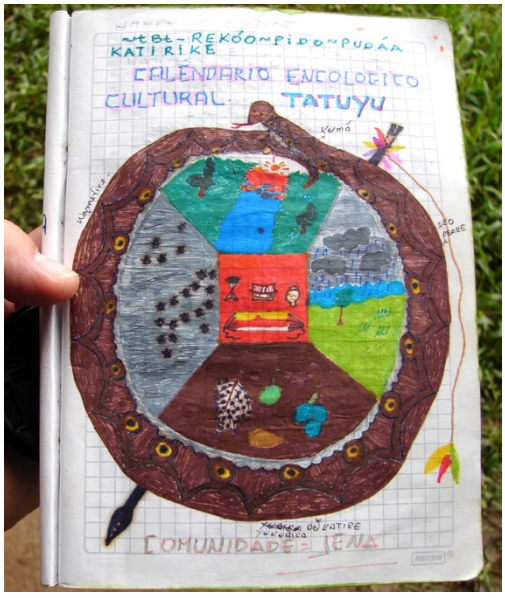
Brüzzi Alves da Silva gathered all constellations told to him by an elder *Piratapuya* indigenous storyteller, in the same sequence we have recovered. *Aña*, our snake, appears also translated as stingray or the planet Venus. The second constellation, *Pamõ* here is also an Armadillo. After that he talks about a "fence for parakeets" called here *Kai Sariró*. (Figure 5) We saw a description of a constellation with the same name, but meaning "circular dance" to the tribe's wise men. The fourth constellation in this list is *Dahsiew*; next was *Yai*'s constellation, followed by *Sioyahpu's* constellation, *Waikhasa* and *Yhé.* Particularly in the case of *Sioyahpu*, even Brüzzi Alves da Silva identified this group of stars as an adze handle, but he did not recognize it as a representation of a ritual tool (Hugh-Jones 1979).

Until this point, the sequence is almost the same as obtained in our research. In the following pages of his book, Brüzzi Alves da Silva displays the indigenous "months" calendar and it is clearly related with the constellations sequence. The 10th month is *Yai Öxséka Poero* (The Flood of the Jaguar's Whiskers) and the 11th month is called (*Ñhorkoatero*'s flood), but it does not match completely with our identified sequence. From here to the end of his list there are many differences. The next constellation is *Dyayó* (otter). I did not describe or identify this constellation because the storytellers did not tell me exactly where it is. They did not know, even though they did tell me about the existence of this constellation (Cardoso 2007). Following the otter, we find a *Böö* (piranha) and only after that *Ñhorkoatero*, presented here as a man — a character from a legend — with his son. There may be some kind of mistake in this case because if it is represented by the Pleiades, one or two characters are not sufficient to cover all six or seven seen stars in this region. Also, in the same work, *Ñhorkoatero* is presented as the "morning star," which is usually related to Venus before sunrise (Brüzzi Alves da Silva 1962).

Other constellations appear here not positioned as we have seen in other descriptions. After *Ñhorkoatero*, Brüzzi Alves da Silva talks about *Aña Pihkoro* (stingray tail); in our research it is the viper's tail. Following *Aña Pihkoro* he mentions the *Kocti-pa's* (scorpion) constellation and only after that, *Kodyérime'sa* (group of [its] eggs) – probably the viper's eggs. We can realize some kind of mistake in this description's arrangement. Three other groups represent the Jaguar's whiskers, the Jacundá fish (our *Mhuã* out of the sequence) and a legendary fawn. Brüzzi Alves da Silva (1962) also shows a diagram with ten of these constellations represented as drawings but he did not relate each star group with particular astronomical areas. As he illustrates in his manuscript (1962:260), some representations are reproduced, probably as they were made by the storyteller or as they have been interpreted by the researcher.

Therefore, our constellations are very similar, in sequence, to those which we have seen in Brüzzi Alves da Silva's work. Some differences can be pointed out in distinct cases, through different astronomical researcher's knowledge bases and the different periods of time. We trust our results compared with Koch-Grünberg, Lévi-Strauss and Brüzzi Alves da Silva, but we recognize that this is still a work in progress. Surely we or other researchers need to follow up on the constellation descriptions and verify our initial results. Some constellations were not described as we

Figure 6. a circular calendar from a Colombian indigenous community



pointed out before (Cardoso 2007).

It is worth qualifying that although Brüzzi Alves da Silva worked in the same region during the 1960's and I worked there from 2005 to 2007, my astronomical knowledge and techniques used to describe constellations are quite different. During the workshops, I worked with elders who knew astronomical traditions and circular calendars. I could work with different storytellers in distinct periods and conditions and I was able to compare these results with student notebooks. The results have revealed coherent correlations among constellations and natural phenomena as reviewed in the next part of this paper.

Results and discussion

Tukano constellations take a central role in their cosmological conception. They conceive an organized world with correlations among star positions and events. When some group of stars or even a constellation rises after sunset, that announces a specific event. When a constellation or part of it is setting along with the sunset or right after it, there is also an associated meaning. In the table above we describe constellations in heliacal settings; further research is required to gather information about rising constellations. Variation in a river level, flourishing, fructification time, fishing best and worst periods, hunting time and specific rituals time, among others natural phenomena are parts of these kinds of associations. Following all these events Tukanos observe lunar phases and give them special names. Lunar phases do not have only four or eight important names for Tukanos as we have in our culture. Each day and shape has a special name.

Tukanos believe that the moon "eats" an animal called *cutia* in Portuguese (*Dasyprocta leporina*) or a Brazilian 'agouti' (in English), so, day after day, during the first half of the month, the Moon keeps eating parts of this agouti until it eats its skin, acquiring its "full" characteristic aspect. After that the Moon stops eating (getting fewer visible portions each day on the second half of the month) until the time to hunt another agouti arrives, at the New Moon phase, starting another cycle. This cycle starts over again and again every month.

All this information has been brought together in a circular calendar. Specifically, we proposed to arrange all of it in dynamical cycles similarly to *volvelles*. These "tools and toys" were very common during 20th century but they are older than this. *Volvelles* or 'wheel charts' were famous as calculus rulers. Using basically two wheels, the first with accurately spaced information and a second concentric wheel with open adjusted windows, questions and answers would be solved with circular movements, framing questions along with answers.

In our specific case, we built a circular dynamic calendar with a common axis. Our last version gave increasing radii to

each circle, so that groups of information or information categories could be related to each other. The first one was built with Tukano constellations, the second with floods or low river levels and average weather conditions, the third with chosen fish species (a hard choice as anyone can guess in the Amazonian basin). The fourth was composed of animals that hunt fish, fruits and food as a whole; the fifth the circle of flourishing and fructifying foods gathered from the chosen plants; the sixth circle is related to rituals known as *dabucuris,* (these rituals are sometimes used to bless food from bad influences in general or to allow its division among families); and the last circle shows lunar phases as explained above.

Each circle moves independently. Mounted in an envelope that has a horizontal line representing the horizon where we can see each constellation setting (heliacal set). In the second circle we can select weather conditions and a river level putting this frame just over the horizon line, the third circle can be positioned near the same line and presents groups of fish that are going up or down the main river, and so on to the other circles.

The main reason for creating this *volvelle* was the possibility of grasping and

Figure 7. Astronomical-environmental calendar constructed in 2007.

Figure 8. A Tukano *Maloca*, or 'Longhouse' from the Tiquié River region (S. José II).

learning astronomical basics in an indigenous school manner. Promoting a comprehensible and friendly representation of a calendar, students could experience the correlation among astronomical and other natural processes and phenomena. This was a result of the collaboration among partners as anthropologists, indigenous community members as elders, women, men and young students inside the school and the researcher himself. There were many others "versions" of the same circular dynamical calendar developed in groups with a smaller number of participants during the workshops (Cardoso 2007).

As noted above, astronomical events have a central importance in cosmological models for western Amazonian indigenous peoples. From common sense ordinary activities to complex rituals, stars, constellations or moon phases — all are somehow related to each other. Tukano communities are rebuilding these rituals and ceremonials houses known as "Malocas." These important communal buildings are also related to indigenous cosmological model. The position (relative to cardinal points) and parts of these buildings (pillars) are representations of elements of the Universe such as positions of stars, constellations and movements, e.g. anaconda and dancers in a ritual (Hugh-Jones 1979; Reichel-Dolmatoff 2008).

In our research we saw the communal relevance of the Maloca. It is not only the ritual site in a community, but also a space used to hold school activities and workshops. There are two doors in a Maloca. One is oriented to the east side (men's door) and another one to the west side (women's side). The projection of the ce-

lestial equatorial line passes over the roof top of this Maloca and joins the two mentioned doors. This tribe lives near the equatorial line (latitude almost 0°). Therefore, both doors are aligned with the East and West cardinal points. Comparing the Tuyuka Maloca door alignment with a measurement of east-west astronomical line we verified a difference of no more than two degrees (Cardoso 2007).

During our last workshop with the students, we considered a Maloca rooftop as a projection of the celestial equator line (Figure 8) and we drew some Tukano sky charts. (Figure 6) The roof top represents the Celestial Equator line while each roof side symbolizes the projection of one celestial hemisphere. This was an example of an exercise performed with students. We recognize the importance and complexity of sky representations and its meaning to the cultures inside this vast region. In addition, it is one didactic strategy to give more significance to a built knowledge as a communicative educational tool.

Final considerations

Constellations and everyday life are intimately connected for indigenous groups who live in a vast area in the northwestern portion of the Amazonian region. This situation provides a substantial amount of investigative possibilities given the diverse ethnicities in the region and a strong correlation among terrestrial and celestial events. New challenges such as: comparing this study to other ethnicities and cultures, developing new strategies to investigate known and unidentified Tukano constellations, applying the same techniques and methodologies in other situations to investigate astronomy in cultures in other human groups — these are just some examples of what could be done with this sort of work.

The central question initiated by our research can be related to methodological issues. Ethnomathematics can be used as a reference to build, on a step-by-step basis, new investigative procedures. Through the use of sketchbooks and astronomical observations we could compare different traditions in constellation descriptions. This kind of register allowed the evaluation of constellation extent, the use of proportions in drawings and representations, sequences of stars and observation periods in different tribes.

The Yupuri School students come from different parts of the community and were also encouraged to ask for information from elderly members in their tribes. But we can follow and apply other methodological procedures to test some of our research answers. For example, participatory research and action research (Thiollent 2008) are some of the new forthcoming methodologies applied in our investigations. Interpretation is a key word in cultural astronomy and methodological procedures, and they are still a work-in-progress in this area.

Time reckoning and tracking star movements are not something unique to these cultures of Rio Negro region. It is a widespread behavior shared by peoples all around the world. But the number and arrangement of stars show that specific sets of constellations, and how they are interconnected among themselves and among the natural environment is unique. We shared a version of the Tukano constellations with one of the most popular known free astronomical software providers. Inside the latest *Stellarium* (www.stellarium.org) version anyone can see the representation lines among stars of each Tukano-described constellation. These are not the definitive Tukano constellations, but a result of our research that might match some historical sources. Thus, the constellation sequences and star

positions correspond with older descriptions.

The dynamical circular calendar was a tool built in an affirmative politics concept to help Tukanos in the organization of their astronomical knowledge within the communal indigenous school. Therefore it is not an exclusive proposal of this research or its researcher. It is built from a shared experienced workshop and a participatory research period. I usually say that it is a result from a "third space." This is not indigenous or non-indigenous exclusive knowledge but a shared space where part of our and their knowledge can build bridges inside an affirmative politics concept. Hence it is part of a research process.

New circular calendars and other kind of representations have been developed since then. Part of the follow up results from an attempt to answer an increasing demand orientated to environmental management pressures. Since late 2005, indigenous environmental management agents ('*agentes indígenas de manejo ambiental*') concentrated their attention on the manipulation of fish diary registers resulting in new calendar versions, showing the dynamicity of this kind of study.

To build calendars as the one presented here, in this study, we needed to understand the importance of each constellation setting and the conceptual mainframe background that supports it. As important as recognizing correct stars and stellar fields that a specific constellation comprises and comparing it with other older descriptions on the same topic is developing a sense of dialogue among cultures. Indigenous science is different from our Occidental science. Basic concepts are different. Our calendar in the past was based on concepts joined with astronomy almost exclusively, but today our environment and our time reckoning apparently has no correlation to it at all. This research leads me to believe that it is time to establish new terms to grasp other ways to bring together time and nature again.

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