

## DISTRIBUTION, ANTIQUITY AND NICHE OF PRE-COLUMBIAN GUARANI AMAZONIAN HORTICULTURALISTS IN THE MISIONES RAINFOREST, ARGENTINA

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### Resumo

Neste trabalho apresentamos a distribuição do registro arqueológico produzido pelos horticultores amazônicos, englobados dentro da unidade arqueológica Guaraní, na província de Misiones. Se avalia sua distribuição em função das condições ambientais e os processos co-evolutivos ou de construção do nicho ecológico guarani. Os registros dessa unidade são observados em todo território provincial, no entanto, as maiores densidades de vestígios e a identificação de grandes sítios arqueológicos se encontram no estrato ecológico da Selva Paranaense, concentrados especialmente abaixo dos 300 msnm e associados com as áreas mais próximas aos rios Paraná e Uruguai. Esta distribuição parece ser resultado da seleção e consequente modificação de paisagens onde se articulam condições agronômicas estáveis e previsíveis, solos mais aptos para a agricultura de roça e queima, maior densidade e riqueza de fauna, facilidade para o transporte de cargas e para a comunicação fluvial. Esta distribuição populacional também pode ter sido influenciada de maneira concorrente pela presença de outros grupos horticultores que ocuparam a área da Serra Central. O processo de ocupação de Misiones por parte destes grupos parece reproduzir um esquema similar de colonização conduzido em diferentes setores do sudeste da América do Sul por parte desta metapopulação.

**Palavras-chave:** Guaraní, Misiones, colonização, nicho construído, reprodução social

### Abstract

In this paper we present the known distribution of the archaeological record generated by Amazonian horticulturalists, included within the Guaraní archaeological unit, in the province of Misiones, Argentina. Its distribution is evaluated according to the environmental risk conditions and the ecological niche construction. It is observed that, although there are Guaraní materials throughout the provincial territory, the greatest densities of finds and the identification of great archaeological sites from this unit occur in the ecological stratum of the Paranaense jungle below 300 masl, and are associated with the areas closest to the Paraná and Uruguay rivers. This distribution seems to be the result of the selection of landscapes where stable and predictable agronomic conditions are articulated, including soils more suitable for slash and burn agriculture, as well as greater richness, predictability and fauna density, and convenience for cargo transportation and fluvial communication. This population distribution may also have been

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influenced concurrently by the presence of other horticultural groups, who were absolute competitors for the resources to be found in the central highlands and steep slope areas. The colonization process of Misiones by these groups copies a similar pattern carried out by this metapopulation throughout southeastern South America.

**Keywords:** Guaraní, Misiones, colonization, constructed niche, social reproduction

## Resumen

En este trabajo presentamos la distribución conocida del registro arqueológico generado por horticultores amazónicos, englobados dentro de la unidad arqueológica Guaraní, en la provincia de Misiones. Se evalúa su distribución en función de las condiciones ambientales y los procesos coevolutivos o de construcción del nicho ecológico guaraní. En este sentido, se observa que si bien hay registros en todo el territorio provincial, las mayores densidades de hallazgos y la identificación de grandes sitios arqueológicos de esta unidad se producen en el estrato ecológico de la Selva Paranaense, especialmente en su sector más deprimido, por debajo de los 300 msnm, asociados con las áreas más cercanas a los ríos Paraná y Uruguay. Esta distribución parece ser el resultado de la selección y consecuente modificación de paisajes donde se articulan condiciones agronómicas estables y predecibles, suelos más aptos para la agricultura de roza y quema, mayor riqueza, predictibilidad y densidad faunística, facilidad para el transporte de cargas y para la comunicación fluvial. Esta distribución poblacional también pudo haber estado influenciada de manera concurrente por la presencia de otros grupos horticultores que ocuparon el área de la Sierra Central, quienes constituían competidores absolutos por el espacio y por los recursos. El proceso de ocupación de Misiones por parte de estos grupos parece reproducir un esquema similar de colonización llevado a cabo en diferentes sectores del sudeste sudamericano por parte de esta metapoblación.

**Palabras clave:** Guaraní, Misiones, colonización, nicho construido, reproducción social

## Introduction

The Guaraní archaeological unit is widely distributed in the tropical and temperate forests of southeastern South America. It represents a fraction of the physical record of Amazonian horticulturalists grouped within the linguistic Tupi-Guaraní family, which at some as yet unspecified point during the Late Holocene (<3500 years <sup>14</sup>C BP) began to expand, perhaps from southwestern Amazonia towards the south of Brazil, reaching the Río de la Plata River estuary in Argentina and Uruguay a few centuries before the arrival of the Europeans (Brochado, 1984; Chousou-Polydouri *et al.*, 2013; Loponte & Acosta, 2013; Santos *et al.*, 2013).

Misiones province and the adjacent upper Paraná River region in southern Brazil are a pioneering area in the archaeological study of these groups. At the end of the nineteenth century, Ambrosetti (1895) identified the record of this archaeological unit according to different material and behavioral characteristics, assigning them to precolonial populations whose historical descendants correspond to the ethnographic Guaraní. Precisely this material culture, already much modified, had previously been analyzed by this same author in the same region (Ambrosetti, 1894). After his work, the existence of a relatively homogenous record stretching 1800 km in a north-south direction in southeastern South America became clear for archaeological studies. Then, different investigations followed that confirmed and extended the observational basis Ambrosetti's postulates in Brazil, as well as in Argentina. Some of these studies were carried out precisely in Misiones province (Cambas, 1940; Menghin, 1957; Rizzo, 1969; Giesso, 1984; Giesso & Rizzo, 1985; Pujade, 1989, 1992, 1995; Sempé & Caggiano, 1995; Sempé, 1999; Mujica, 2000, 2007; Rizzo & Shimko, 2003). Most of the findings reported by these authors were also made on the margins of the Paraná and Uruguay Rivers, and in fluvial strips adjacent to them. Other

findings by anonymous neighbors from different localities, now deposited in public and private collections, also came mostly from the banks and areas adjacent to these two great fluvial courses.

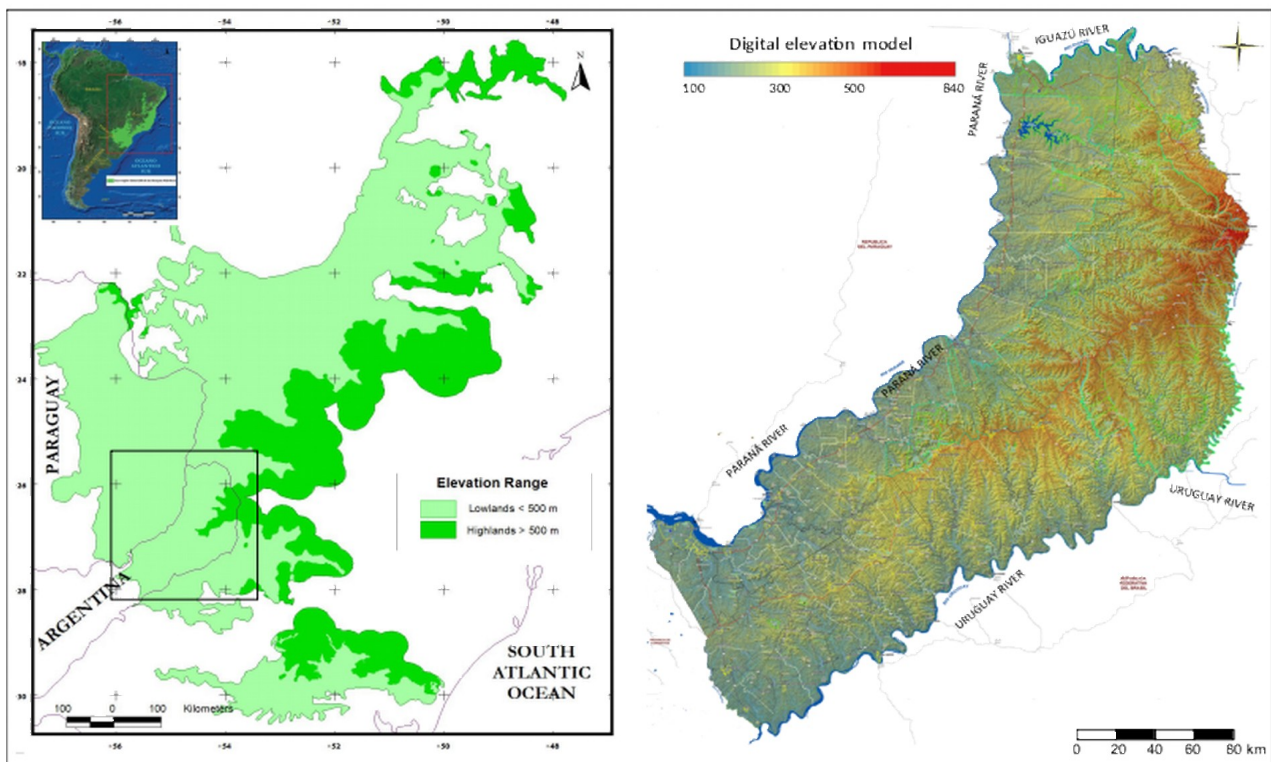
For the past four years, the binational research project *Arqueología del Bosque Atlántico Meridional Sudamericano* (Archeology of the South American South Atlantic Forest) (Loponte & Carbonera, 2013) has begun new research in the south of this ecoregion, developing fieldwork in eastern Paraguay, to the west of Santa Catarina (Brazil) and in Misiones province in Argentina. As a consequence, in this last area, several sites and findings with a certain spatial heterogeneity have been detected. These new investigations, added with the local background, allow us to evaluate, with a degree of uncertainty, the territorial coverage of the Guaraní populations in this territory. It is quite clear that part of this uncertainty is related to the fact that a significant fraction of the province lacks archaeological research and some findings have no exact information regarding origin, generally reported as coming from a locality or municipality, but not from a precise point. There is also a frequent lack of precision as to whether the findings come from a residential/big site, whether the findings are isolated or whether they form part of discontinuous settlements in space, aspects that, on the other hand, are part of the current research agenda of this archaeological unit. Another source of uncertainty when analyzing the territorial coverage of these populations in Misiones is the scarcity of systematic archaeological studies in the Central Sierras area. Nevertheless, the available data that we will use here constitute a first step, thus allowing the beginning this discussion in order to be compared with future investigations.

The distribution of the Guaraní record in Misiones also gives us the opportunity to discuss briefly some aspects of the niche constructed by these groups, since any distribution analysis of living organisms, including humans, requires an understanding of the conditions and reproduction characteristics of the ecological and cultural heritage of each population (Hutchinson, 1957; Brown & Lomolino, 1998; Laland, Boogert & Evans, 2014). We understand by the term 'niche' a volume of  $n$ -dimensions where abiotic and biotic (including cultural) components intersect, including the distribution of resources, inherited capacities for the manipulation of the environment, the social structure, the actions of competitors, etc. Leaving aside the asymmetric perspective where populations passively adapt to an environment (Williams, 1992), the human niche construction theory emphasizes the transformation of selected environments through culture. In this way, the constructed environment is a dynamic source of selective pressures for human evolution (Odling-Smee *et al.*, 2013; Laland, Boogert & Evans, 2014). The transformation of productive landscapes, also seen as ecosystem engineering, tends to be more intense in agricultural societies such as the Guaraní, where many resources were systematically and concurrently manipulated. At the same time, within the analyses of the constructed niche and the human distribution in the landscape, the benefits expected by the population must be considered, as not all environments have equivalent costs for effective colonization. This certainly applies to Misiones province, which presents a heterogeneous environment in several of its components. In this way, the expected pay-offs must also be considered in order to understand any human colonization.

## The environment

Misiones province has a continental tropical-subtropical environment without a dry season. It is located in the ecoregional complex called Atlantic Forest, which encompasses the 15 ecoregions typified by Olson *et al.*, (2001), all of which correspond to different forms of rainforest with precipitation ranging between 2400 and 1700 mm per year (Rodríguez *et al.*, 2005). Its extension in precolonial times covered more than 1.7 million km<sup>2</sup> in the Brazilian states of Ceará and Rio Grande do Norte, the state of Rio Grande do Sul, almost

all of Misiones province and the east of the Republic of Paraguay. In linear terms, it has an approximate length of 1,800 km in a north-south direction, and about 600 km in an east-west direction. Two of its ecoregions are developed in Misiones province. The first corresponds to the Atlantic Forest of the Upper Paraná (also called *Selva Paranaense*) and the second to the Araucarias Forest (Figures 1 and 2). The first is the most representative of the province, as it occupied 80% of its territory before its destruction. This ecoregion is a multi-layered continuous canopy forest of between an average of 10 and 20 meters in height, where the light decreases steadily from the tops of the trees to the ground. After three different layers of trees with successive heights, a stratum of Bambuseae shrub of intermediate height and a fifth stratum composed by mosses, have developed flush with the ground. Crossing these vegetal strata, vines, lianas and epiphytes have developed, forming a closed forest, whereby the amount of light reaching the surface is significantly diminished. This forest has mostly developed below 600 – 500 masl, occupying the plains of the Paraná and Uruguay Rivers, the bottoms of the valleys, and the slopes and peaks of the lower hills. The second ecoregion has developed in the immediate upper levels of the Paranaense Forest. It is located in the central sector and the northeastern quadrant of Misiones province. Here, the upper vegetation stratum (between 20 – 30 m) is dominated by *Araucaria angustifolia* pine forests, which dominate the forests at altitudes above 600 masl, with a shrub stratum where *Ilex paraguariensis* predominates, and another stratum composed of mosses covering the surface. It is a more open environment because of the lower temperatures and greater frequency of frosts (Moscovich *et al.*, 2010).



**Figure 1.** Left: distribution areas of the Atlantic Forest of the Upper Paraná (*Selva Paranaense*) (below 500 masl), and the Humid Forest of Araucarias (above 500 masl) (taken and modified from Di Bitetti *et al.*, 2003). Right: digital elevation model development of the mountain ranges in Misiones province with the division of slopes (taken and modified from Ministerio de Ecología y Recursos Renovables, Misiones province).



**Figure 2.** Above, a view of the Paranaense Forest, near Garuhapé (~200 masl). Below, the Araucarian Forest near San Pedro (~600 masl).

In a small area located in the south of the province below 200 masl, a third ecoregion called *Campos y Malezales* (prairies and undergrowth) has developed, dominated by gentle reliefs with grasslands and some isolated forest formations (Figure 3). Here, the herbaceous communities of *Aristida pallens*, *Andropogon lateralis*, *Elionurus thripesides* and *E. viridulus* predominate according to the topography and soils of each specific micro-environment (Burkart *et al.*, 1999; Rodríguez *et al.*, 2005).

### The landscape of Misiones province

The landscape of Misiones province is made up of three large topographical units. The first unit consists of the summits of the Sierra Central (or Sierra de Misiones) and its slopes, which are mainly developed by the center of the province in a general southwest-northeast direction. The summits range between 850 – 550 masl, and the flanks between 550 – 300 masl. The landscape is made up of hills separated by crags with steep slopes, whose highest cusps and slopes are covered by the Araucaria Forest. In its lower regions, this forest mingles with parts of the Paraná Forest. The soils are shallow, with large amounts of loose rocks on the surface and buried in the ground. Also, bare rock surfaces or ground with little sedimentary cover are frequent. Therefore, the agronomic quality of

this first unit in regional terms is less productive. To this must be added the fact that the removal of the forest cover for agricultural activities (such as slash and burn) means the soil undergoes extreme erosion due to the action of meteoric water flowing down the steep slopes, decreasing its thickness and productive yield (Fernández *et al.*, 2000; Ligier, 2000; Di Bitetti *et al.*, 2003).



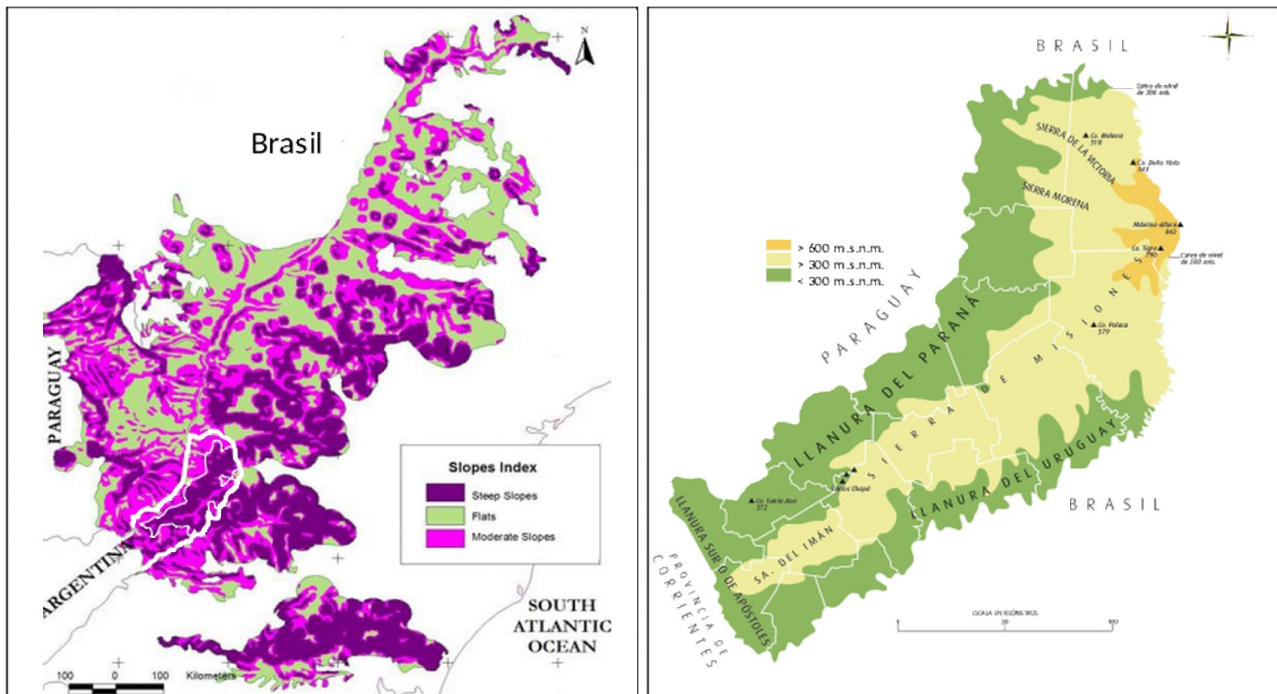
**Figure 3.** A typical landscape from southern Misiones province. Taken from Falguera *et al.* (2015).

Below the flanks of the mountain range, both to the west and to the east, the second topographic unit appears below 300 – 250 masl, making up the plains of the Paraná and Uruguay Rivers, respectively. Both rivers develop in subparallel form, according to two local geological faults. A third plain corresponds to that of the Iguazú River in the north, which is the largest tributary of the Paraná River in the province. The landscape in these fluvial strips tends to be less wavy, with moderate slopes that alternate with vast flat sectors, as they are areas where the sediments that come from the flanks of the hills accumulate. The soil profiles are deeper, more nutrient-rich, more stable and with good drainage, making them more suitable for agriculture (IPEC, 2015; Keller, 2012). In this unit, the Paranaense jungle is most prevalent, especially on the plains of the Paraná and Iguazú Rivers, but today it has been almost totally destroyed by the advance of agriculture. There is an extension of this jungle in the smallest hills of the entire province and along the Uruguay River valley; although this is partially limited due the transverse mountain ranges approaching this last course, especially in the middle sector of the province (see Figures 1 and 4a). For this reason, the Uruguay River is largely enclosed. On the peripheral and neighboring slopes of the Uruguay valley, the Araucaria Forest grows and prevails, extending more towards the northeast of the province as a continuation of the Brazilian Plateau. In the southern reaches of the Uruguay River, the valley widens and allows a further extension of the Paranaense jungle.

Finally, the third topographical unit is located in southern Misiones province, where the sierra forms an undulating landscape, which joins the plains of the Paraná and

Uruguay Rivers, and where the Atlantic Forest ecoregion is joined with the Campos and Malezales ecoregion, which is typical of northeastern Corrientes province (Burkart *et al.*, 1999). This topographic stratum corresponds to an undulating plain, called *Llanura de los Apostoles*, which starts below 200 masl with patches of forest extending from the Paraná and Uruguay Rivers and the southern lowest foothills of the Sierra Central, locally named Sierra del Imán (Figure 4b).

Although the areas with the steepest slopes do not always coincide precisely with the landscapes above 300 masl, the map in Figure 4b shows a rough approximation of its distribution.



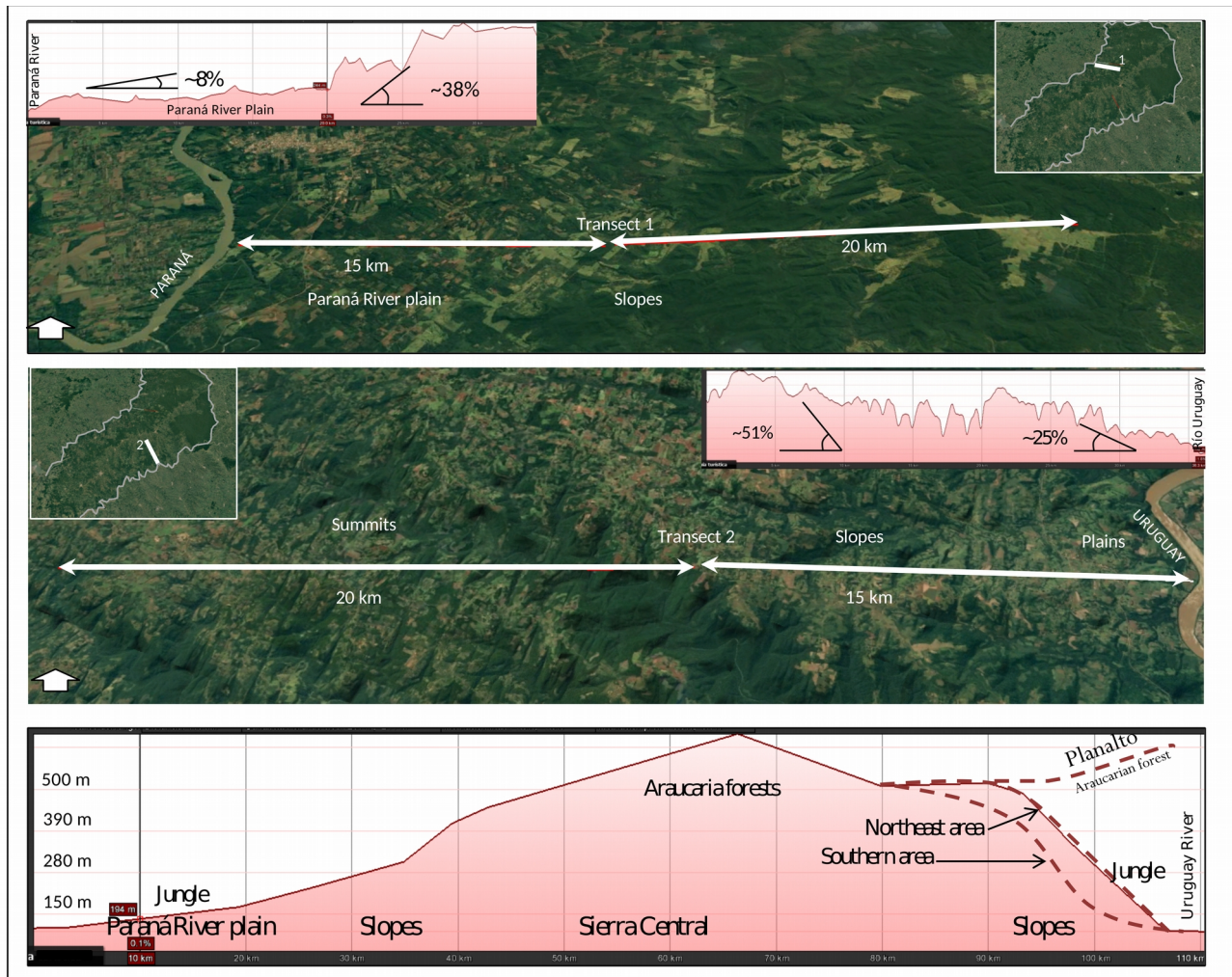
**Figure 4.** On the left, the slope index (taken and modified by Di Bitetti *et al.*, 2003). To the right, a general distribution of the hill ranges and plains of the Paraná and Uruguay Rivers (taken and modified from the Ministry of Ecology, Misiones province, consulted in 2017).

Human pedestrian mobility along the Paraná, Uruguay and Apostles plains is the least resistive. The landscapes tend to be flat and the watercourses allow a fluvial connection using canoes. Towards the interior of the province, the use of navigational devices is substantially hampered by the distorted topography. In this sense, the Paraná plain comprises mild topographic gradients from the Paraná coastline to the hillsides, but then these gradients rise sharply. A transect type of 35 km from the Paraná River ( $26^{\circ} 37' 48.90''$  S,  $54^{\circ} 46' 51.35''$  W -  $26^{\circ} 42' 7.67''$  S,  $54^{\circ} 26' 10.46''$  W, Montecarlo municipality) has along the first 15 km a slope averaging  $\sim 2.6\%$  and a maximum of  $\sim 8\%$ , while along the next 20 km these values rise to  $\sim 8\%$  and  $\sim 38\%$ , respectively. On the Uruguay River plain these distances are drastically shortened; a transect of the same length from the Uruguay River ( $27^{\circ} 25' 19.98''$  S,  $54^{\circ} 26' 33.21''$  W -  $27^{\circ} 7' 28.28''$  S,  $54^{\circ} 35' 6.60''$  W) has an average slope of  $\sim 5.5\%$  and a maximum of  $\sim 25\%$ , with the next 10 km rising to  $\sim 11\%$  and  $\sim 51\%$ , respectively (Figure 5).

### The establishment of the current climatic conditions in Misiones province

It has been postulated that the Atlantic Forest in some areas of its current distribution has had an uninterrupted and stable presence for at least 17000 years, with drier and colder periods such as the late Pleistocene, and peaks of higher humidity and temperature during the middle Holocene (between 7000 and 3500 years BP), at which time some

species from the Amazonian ecosystem moved and colonized this forest. The current climate would have been established definitively  $\sim 4000$  years BP (Pessenda *et al.*, 2009; Buso Junior *et al.*, 2013). The pre-ceramic faunal assemblage of the Tres de Mayo cave, dating from around 3800 years BP, is consistent with this date, as the exploited resources indicate a climate similar to the current one (Loponte & Carbonera, 2015a, 2015b). According to the archaeological data, the Guaraní occupation of Misiones province is after 2000 years BP, and probably even more recent (see below). In any case, the expansion of these groups was well after the establishment of the current climatic conditions.



**Figure 5.** Topographical transects from the Paraná (upper figure) and Uruguay Rivers (intermediate figure), and a schematic latitudinal profile (bottom figure) of the northern and central areas of Misiones province.

### Environmental factors in Misiones province for broad-spectrum economies

The ethnographic and historical Guaraní had a broad-spectrum economy, based on hunting, fishing, cultivation and gathering (Ambrosetti, 1895; Muller, 1935; Metráux, 1946; Schmidl, 1948; Martínez Crovetto, 1968a; Bartolomé, 1978; Chase-Sardi, 1989). Much attention has been paid to the manipulation of plant resources by the contemporaneous Guaraní communities, especially domesticated plants, but historical sources and archaeofaunal analyses have shown that animal proteins were extremely important in their subsistence. Indeed, isotopic analyses carried out on human bones recovered from Guaraní burials indicate that hunting may have taken place even more than plant intake, at least in the southern area of its colonization range (Loponte *et al.*, 2016). We could not find a comprehensive study of the differential distribution of the fauna in Misiones province in



terms of the ecological, altitudinal or topographic differences, but undoubtedly much of its structure is closely linked to this. The most significant correlation in this sense is that which exists between the fish resources of the Iguazú, Paraná and Uruguay Rivers, where the huge supplies of ichthyic resources can be exploited. With regard to the total resources in Misiones province, along the course of the Paraná River 217 species have been detected, representing almost 50% of the local fish population. On the contrary, in the Paraná's tributaries in the territory's interior, this percentage decreases to 14% (62 spp.), composed of small and very small fish. This remarkable fall in the number of available taxa, together with the absence of large and medium-sized species in the Paraná River, may be due to the existence of the topographical slopes and waterfalls of different magnitudes that occur in the streams and rivers descending from the mountains, forming a natural barrier against their dispersal. In the same way, in the tributaries of the Uruguay River only 15 species have been detected (3.4%); this is probably related to the steep slopes close to the Uruguay River. Unfortunately, there are no data on the ichthyofauna of the Upper Uruguay River, but in its adjacent middle course 133 species of fish have been identified, demonstrating a high concentration of resources (López *et al.*, 2002). The contrast in the abundance of fish between the great rivers and the Sierra Central and its slope areas is clearly visible in the mobility of the historical Kaingang groups, who temporarily exploited the mouths of the streams that drain into the Paraná River, and who then returned to the mountains (Ambrosetti, 1897:307). The possibility of exploiting these resources is the main argument behind hierarchizing the productive areas linked to obtaining animal proteins in Misiones, leaving to the interior of the province a totally secondary plane. Moreover, the riverbanks along the Paraná, Iguazú and Uruguay Rivers, and the estuaries of the streams that flow into them, form an ideal environment for mammalian populations with aquatic habits such as the purely ichthyofagous *Pteronura brasiliensis* (a giant otter weighing 22 – 45 kg), and the rodents *Myocastor coypus* (a coypu weighing 5 – 8 kg) and *Hidrochoerus hydrochaeris* (a capybara weighing 40 – 60 kg). All these three taxa are gregarious and spatially predictable, which implies an invaluable source of food, as well as high-quality skins. Furthermore, in the gallery forests along the big rivers in Misiones province it was possible to find *Blastocerus dichotomus* (a marsh deer weighing 90 – 150 kg), the largest South American deer, whose exploitation has been identified at the Guaraní Corpus site (see below). These ungulates probably moved only a few kilometers from the banks of the great rivers to the interior of the adjacent prairies. Although some authors point out that this species is restricted to the southwestern sector of the province, based on contemporary data (Chebez & Casañas, 2000), it is likely that it has spread throughout the Paraná-Iguazú corridor and the Uruguay River valley, connecting the populations of Corrientes province in Argentina with those of southern Brazil.

In addition to all these comparative advantages, the riparian sectors allow the exploitation of the edge effect, and with it, access to all the terrestrial and arboreal species in the Paranaense jungle. All this makes the hierarchy of the riverside areas incomparable with the mountain ranges in terms of fauna resources.

Among the different ethnographic groups in South American rainforests, the use of numerous plants, domesticated, manipulated and wild, has been documented for both food and other purposes (Balick, 1979; Posey, 1985, 1987; Balée, 1989, 2000 among many others). The Guaraní population is no exception. We could not find a full and comprehensive analysis of the variability of edible wild plant distribution in Misiones province, although there are huge amounts of information spread between many reports. Nevertheless, greater diversity is expected in the Paranaense jungle, with five species of edible palm (*Allagoptera campestris*, *Butia yatay*, *Euterpe edulis*, *Acrocomia aculeata* and *Syagrus romanzoffiana*) and other edible species, preferably distributed below 400 masl (Pintaluba & Luaces, 2013; IPEC, 2015). The latter palm was heavily exploited in South

American jungles and along the gallery forest in the Paraná-Uruguay fluvial system during pre-Columbian times (Acosta & Ríos Román, 2013). Indeed, it is a highly valued species by the contemporaneous Guaraní communities who have a traditional lifestyle (Palacios Feltes, 2008; Dujak *et al.*, 2015). In the Sierra Central this palm was also exploited by the Kaingang (Ge linguistic family), but above 500 masl the distribution of *S. romanzoffiana* is limited. Here, the richness of the arboreal stratum decreasing due to the prevalence of *A. angustifolia*, which is associated with *Ilex paraguariensis* bushes. The abundance of araucarias seems to have been substantial before the transformation of the landscape, as their pine nuts were the basis of the historical Kaingang's diet (Ambrosetti, 1897). A loss of richness does not necessarily imply a reduction in the available plant biomass, but rather a reduction in diversity, which is extremely important for the present-day Guaraní populations, and presumably for those of the past. The greater biodiversity of the riparian sectors and lower landscapes reinforces their hierarchy for broad-spectrum economies in general, and for the Guaraní in particular, whose catchment area (called *tekoha*, cf. Zanardini & Bierdermann, 2006) included dozens of plant species for food, medicine, raw materials etc. (Muller, 1935; Martínez Crovetto, 1968a, 1968b; Noelli, 2004; Utermoehl & Gonçalves, 2004; Dujak *et al.*, 2015). While the wild plant component is important, the contemporaneous Guaraní's subsistence depends on cultivated plants, and among them, certain species in particular. In both historical and contemporaneous times the most recurrently mentioned crops are *Zea mays* (maize), *Manihot esculenta* (cassava), *Ipomoea batatas* (sweet potato), *Cucurbita* sp. (pumpkin), *Phaseolus* sp. (beans) and *Arachis hypogaea* (peanut) (Muller, 1935; Metráux, 1946; Schmidl, 1948; Martínez Crovetto, 1968a, 1968b; Bartolomé, 1978; Chase-Sardi, 1989; Schaden, 1974). Several researchers have pointed out that in the contemporary Guaraní communities in Misiones province and nearby areas in the Republic of Paraguay, who maintain a traditional lifestyle and are barely influenced by modern society, the most important cultivated plants are the former three. Nevertheless, in local communities maize stands out (Ambrosetti, 1895; Pochettino, 2007; Crivos *et al.*, 2002; Palacios Feltes, 2008; Dujak *et al.*, 2015). The same situation has been observed in other regions, where this cereal is the most important nutritionally and symbolically among the Guaraní communities (Schaden, 1974; Chamorro 1998; Ladeira, 2001; Ikuta, 2002; Felipim, 2001; Medeiros, 2006). For the development of traditional crops in Misiones province, in principle there do not seem to be any marked differences in relation to the different altitudes or ecological units, but there are some restrictions related to the steepness of the slopes and the agronomic quality of the soils. For example, for the development of *M. esculenta* and *I. batatas*, two central crops in the Guaraní agrosystem, deep soil without rocks is needed so that the subsurface tubers can attain maximum development (Pochettino, 2007; Pochettino, Martínez & Crivos, 2002). For this reason, the tops of the hills and the steep-slope areas are not the most suitable for either. On the contrary, the most appropriate and popular landscape for agriculture is the coastal plains, where the contemporary Guaraní groups have been displaced by economic interests to the mountainous areas, beyond the present agricultural frontier (Keller, 2012). Moreover, the use of stony lateritic soils and basaltic lava beds exposed in the mountains and steep-slope areas mean the fields require more labor for their preparation, including the removal of large rocks. Many of these rocks are immovable due their size. For these reasons, the fields in these disadvantageous areas must be bigger in order to compensate for their lesser quality, thus increasing the effort needed to obtain equivalent yields (Pochettino, 2007). In winter, the fallow land in areas with slopes are heavily eroded by meteoric water (Pochettino, 2005), decreasing the soil layer and its nutrients, which are naturally deposited by the maize, sweet potato and cassava which are harvested (Zent & Zent, 2002). These negative aspects indicate that the fields in Misiones province above

300 masl, in general terms, are the least suitable for any agricultural system in general and for the Guaraní in particular.



*Pteronura brasiliensis*



*Myocastor coypus*



*Hydrochoerus hydrochaeris*



*Blastocercus dichotomus*

**Figure 6.** Typical species of the Paraná, Iguazú and Uruguay Rivers that were targeted as prey by the Guaraní populations (the sources of the images can be found in the references).

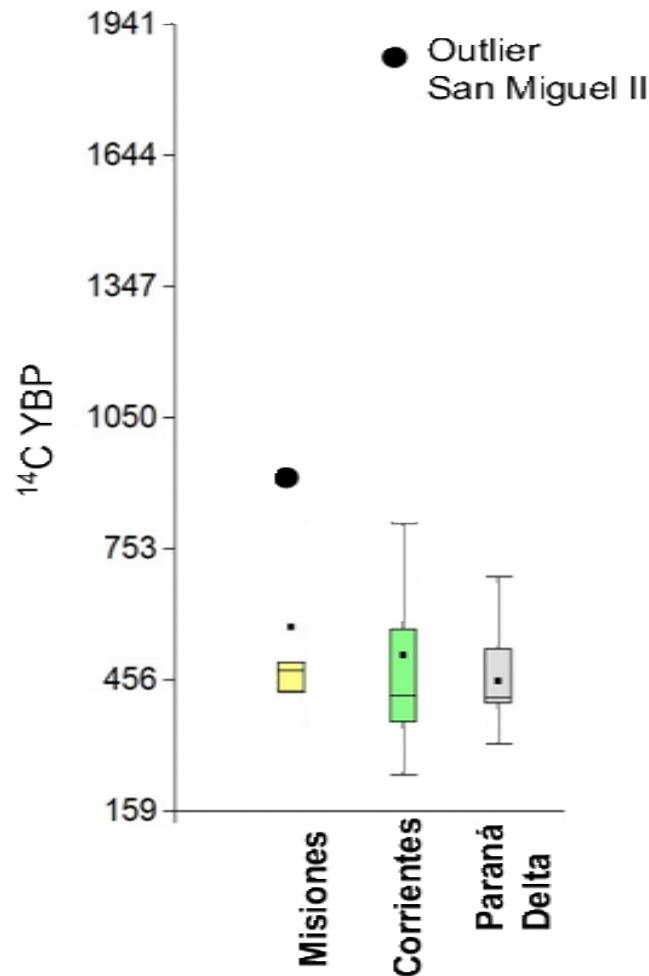
We do not know the importance of each crop for the Guaraní populations in pre-Columbian times. While some variability in time and space is expected, it seems reasonable to consider that maize had a central role, as seen in historical and contemporaneous times. The Guaraní communities in Misiones province cultivate at least 15 races of maize (Cámara Hernández & Miente Alzogaray, 2011), which have a clear genetic link to the traditional maize from the central valleys of Oaxaca (Bracco *et al.*, 2013). According to a hypothesis of McClintock *et al.* (1981), different types of maize were introduced parallel to the Central Andes and northern South America, from where they passed to the Southeast Lowlands, extending along the Atlantic coast, generating a variety associated with the South American Lowlands (Freitas *et al.*, 2003). Other authors postulate that from the Colombia-Venezuela region they would have derived as much to the Central Andean zone as to the South American Lowlands (Vigouroux *et al.*, 2008), thus generating the Tropical Lowland gene pool that has distinctive chromosome features of uncertain origin and age (McClintock *et al.*, 1981). However, the maize varieties detected among the Guaraní from Misiones province point to a genetic divergence regarding the latter group. Paterniani & Goodman (1977) identified the germplasm cultivated by this population as "indigenous landraces," including the most typical and most abundant *Avatí morotí* (yellow corn); the race that is of secondary importance is the *Avatí tupí* (Crystal, white flint) and two popcorns exclusively used by the Guaraní people

named *Avatí pichangá* (with pointed kernels) and *Avatí pichangá ihú* (with round kernels). It is assumed the *Avatí morotí* belongs to an ancient group which was as well adapted for subtropical lowlands (Paterniani & Goodman, 1977) as the Misiones group, especially for an environment of great rivers such as the Paraná and Uruguay valleys. In this sense, it has been observed that the productive performance of maize is related to altitude (Romero Navarro *et al.*, 2017). Although the differences in Misiones province are less than 800 m, it cannot be ruled out that the maize races used by the Guaraní were sensitive to some degree to the altitudinal gradient, thus limiting their productivity in the higher altitude areas of Misiones. It is interesting that different types of maize were identified for other human groups such as the Kaingang or Xavantes, suggesting a cultural and natural selection linked to the different social and natural environments of each population (Paterniani & Goodman, 1977). This scenario of particular races of maize developed and/or cultivated by the Guaraní people, representing local variations with genetic singularity (Bracco *et al.*, 2016), could be related to the specific environments selected by these groups, necessarily adapted to the whole agronomic Guaraní system, such as the flat and deep soils like the ones developed along the great rivers of Misiones province, and similar to those in the vast majority of the landscapes occupied by the Guaraní people<sup>3</sup>. In this way, it is expected that the Guaraní crop system has selected low-lying riverine environments, and deep, stable and rock-free soils for the integrated development of its productive system, which in Misiones province excludes the mountains and their flanks.

### The antiquity of Guaraní occupations in Misiones province

In Misiones province, there are many Guaraní sites from the colonial period and European contact during the 16<sup>th</sup> century. During pre-Columbian times there are two dated assemblages, one immediately prior to contact, corresponding to the Corpus site (Loponte & Carbonera, 2015c) and the second to site 3 in the Panambí area, dating from  $920 \pm 70$  <sup>14</sup>C years BP (Sempé & Caggiano, 1995). The scarcity of data now prevents us from making further progress. We can add that all the southernmost dates that correspond to the Argentinian provinces of Corrientes, Entre Ríos and Buenos Aires (more than 30 dated sites), as well as on the coast of the Republic of Uruguay, are all more recent than site 3 in Panambí (Mujica, 1995a, 1995b; Rodríguez, 1996, 2009; Loponte *et al.*, 2011, Gascué *et al.*, 2016) (Figure 7). There is an anomalous date of  $1860 \pm 50$  <sup>14</sup>C year BP for the San Miguel II site, located in the north of Corrientes province (Mujica, 1995a), which behaves like an outlier very far from the distribution of the available dates. Here, it is not the same as for Misiones province, where the dated Panambí behaves like a soft outlier due to the scarcity of data. On the contrary, in Corrientes province there are numerous data that are fairly coherent with each other, except for precisely San Miguel II. The stratigraphy and contextual framework of this site have never been published in detail, neither have the taphonomic aspects related to the formation processes of this site. The existence of contamination problems was noticed at other Guaraní sites located in the same area (in the north of Corrientes province), where, for example, a date of  $3021 \pm 174$  <sup>14</sup>C years BP was obtained from a Guaraní context (Rodríguez, 1996). Here, the antiquity of the date means it can be quickly discarded, but in the case of San Miguel II, it may not seem to be as dissonant if it is taken as being isolated from the rest. Until further progress is made, this date must be viewed with caution, and it certainly does not seem reliable enough to be used in dispersion models.

3 The gene flow of maize between the different Guaraní groups should have been as intensive during precolonial times as it is today (Madeiros, 2006; Dujak *et al.*, 2015). This behavior contributes to the maintenance and homogenization of their own germplasms among related groups and encourages an intensive evolutionary scenario of the different races of maize throughout the entire region.



**Figure 7.** Distribution of the radiocarbon dates obtained for the Guaraní occupations in northeastern Argentina.

The early dates obtained in southern Brazil, near or adjacent to Misiones province, are not the focus of this work, and will be discussed in a timely manner (Loponte & Carbonera, work in progress). However, we must include a short commentary on the “oldest” site, Fazenda Dona Carlota 2 PR-FI-140 (Chmyz, 1983), located 40 km north of Misiones, on the right bank of the Paraná River<sup>4</sup>. It is quite clear that its position and antiquity are relevant enough to discuss the presence of a Guaraní population in the region, as there was an occupation on the border of Misiones province at least two millennia ago. Fazenda Dona Carlota 2 PR-FI-140 was composed of three circular units grouped together consisting of black soils of anthropogenic origin (“*terra preta*” in Portuguese), which are interpreted as housing units arranged in the form of a triangle. The archaeological record in these circles was very abundant, and outside of them it decreased. This small site is about 40 m long, according to its excavator, and was the product of a short occupation, leaving a very thin and homogeneous archaeological level very close to the surface, where the maximum concentration of materials was no deeper than 18 cm (Chmyz, 1979:44). Notwithstanding all these common characteristics, the two dates obtained are quite different. The first<sup>5</sup> is 1205 ± 75 AD (SI-5027) and the second is 60 ± 75 BC (SI-5028). This diachrony of almost 1300 <sup>14</sup>C years is striking and intriguing, particularly because the housing units are articulated in a geometric pattern suggesting contemporaneity. The recovered assemblages in all these three habitational units are

<sup>4</sup> At the moment it is under the level of the water by the Itaipú dam.

<sup>5</sup> These data appear as they were expressed in the original work of Chmyz (1983).

composed of a homogeneous Guaraní archaeological record integrated within the Ibirajé phase, and regularly dated between 1000 – 1500 AD (Chmyz, 1983:102). In this sense, according to Noelli (2004), Chmyz would not accept the oldest date, as "he argued that the dates failed to agree with stratigraphic parameters for each site" (Noelli, 2004:14). Also, Chmyz pointed out that in one of the stratigraphic sections of this site an Itararé-Taquara ceramic fragment assignable to the Cantú Phase was found (Chmyz, 1979:44). Therefore, Chmyz considers that early date of  $60 \pm 75$  BC does not correspond to the Guaraní occupation context of the site, but to a previous and a different one, and that the most recent data of  $1205 \pm 75$  AD must be considered the only valid ones for the Guaraní context (Chmyz, com. pers. 2017).

### **Brief historical overview of the distribution of the Aboriginal groups in Misiones province**

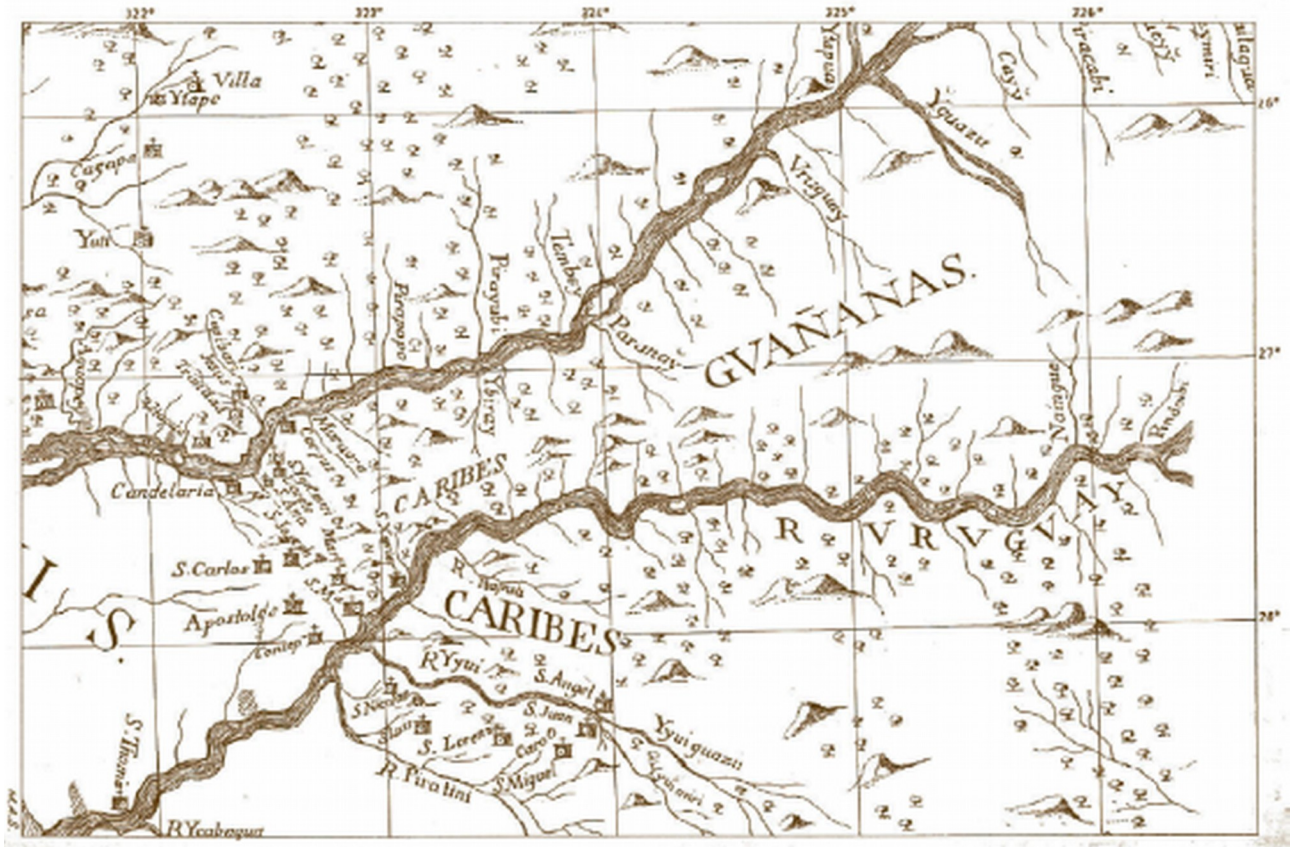
In the year 1542, the Spanish conqueror Alvar Núñez Cabeza de Vaca pointed out the existence of numerous Guaraní groups in the vicinity of the Iguazú Falls, that is, on the coastal plain of the river (Cabeza de Vaca, 1947; Chmys, 1999). A few decades later, during the early part of the seventeenth century, the settlement of Jesuit missions in Misiones province began, which were concentrated in the south of its territory. The missions were installed based on the concurrence of various strategic factors (Páez, 2013), where one of the most important aspects was the pre-existence of a dense indigenous population, which was necessary for two reasons. First as manual labor, and second as an object of evangelization, as Ruiz de Montoya pointed out (see Rebes, 2001). These reductions were inhabited basically by the Guaraní people, and as they were concentrated mainly on the banks of the Paraná and also on the banks and plains near the Uruguay River (Furlong, 1936), we can assume a high density of this population in both areas. There are some references to Guaraní groups that were also displaced from unidentified places to the missions, but mountains are never mentioned. On the contrary, the reductions in the Sierra Central, like San Pedro, were exclusively populated by Kaingang (Rebes, 2001; Manchón, 2005). In this sense, this is clear from the map of Quiroga (1749), where only the Kaingang groups (under the name of "Guayanás" or "Guañaná") could be observed in the central mountain ranges (middle and northern sector of the province). On the contrary, the Guaraní and "Carib" (Guaraníes not reduced) are located on the plains in the south of the province and on the banks of the rivers (Figure 8).

In addition to this spatial separation between the Guaraní and the Kaingang, historical sources reveal another interesting aspect, related to interethnic relations, which are clear references to the existence of a marked state of aggression between them.

*"These two nations were mortal enemies, killing and captivating perpetually each other without any solution"... "These indians [Kaingang] are very warriors, between them and with other neighboring nations mainly with the Guaraní of those who still have many captives (Montoya, 1630, apud Rebes, 2001:80-84; own translation)."*

This small historical panorama points to a state of aggression and spatial segregation between the Guaraní and Kaingang, which probably represents the pre-colonial period to a certain degree. This does not imply that there are no late sites assignable to Taquara on the coasts of the Paraná and Uruguay Rivers. In fact, the funerary mounds associated with this archaeological unit on the coastal strip of the Paraná River near the city of Eldorado yielded ages ranging from  $760 \pm 40$  years  $^{14}\text{C}$  to  $480 \pm 60$  years  $^{14}\text{C}$  (Iriarte *et al.*, 2010), that is, within a chronological range where the Guaraní were already present in the region. The historical distribution we observe should be seen rather as a trend, which seems to be more restrictive for the Guaraní than for the Kaingang, who were distributed throughout the

provincial territory and who should have been partially displaced from the coastal strips by later Guaraní colonization, with a different degree of success. It would not be surprising if parts of this population resisted the Guaraní occupation and remained occupying significant sectors of the plain areas of the great rivers.



**Figure 8.** Detail of the map of José Quiroga (1749)

### **The Guaraní archaeological record in the great rivers of Misiones province**

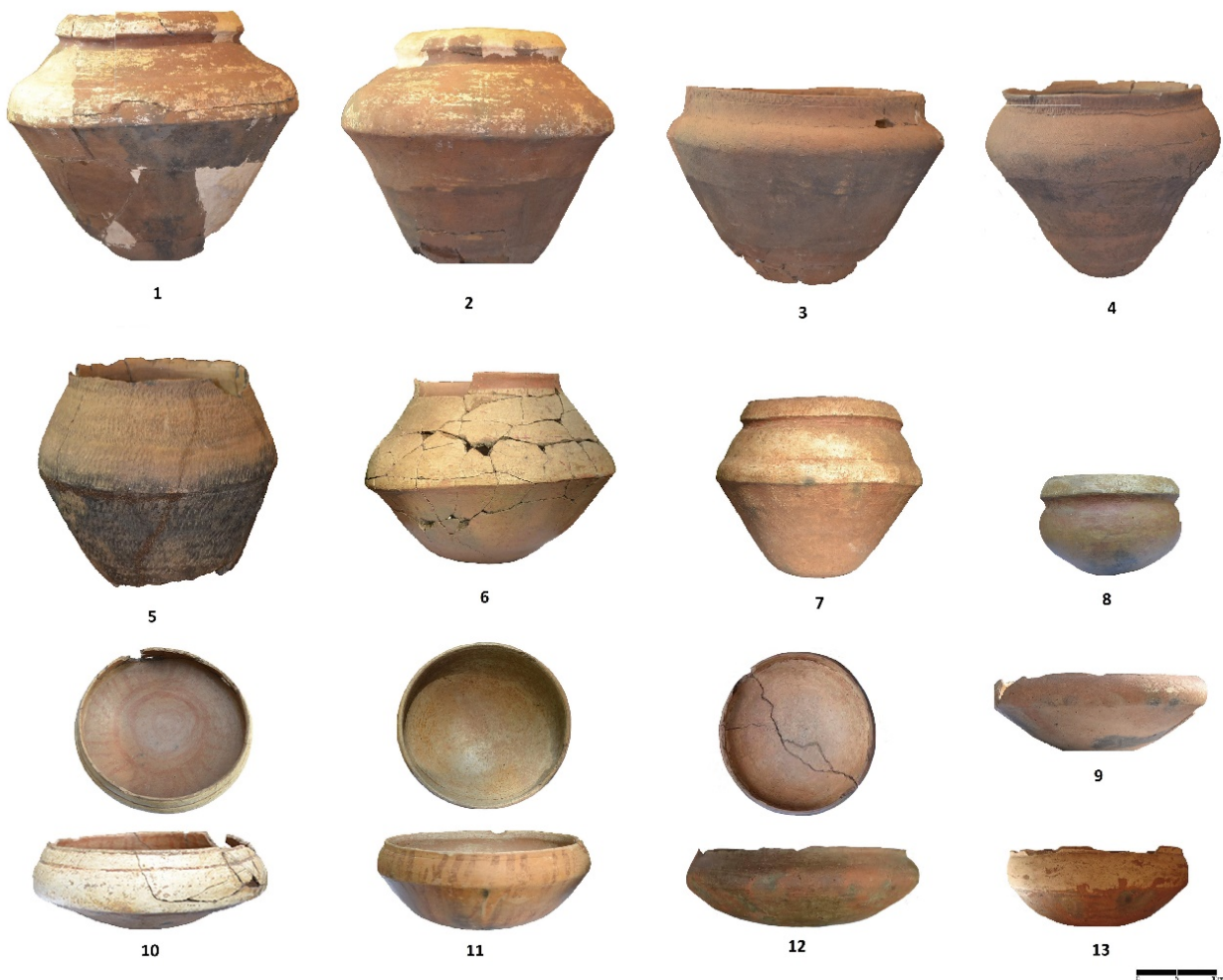
The initial finds of materials classified as Guaraní in Misiones province were made by Ambrosetti (1895). Although this author identified findings in the north of Posadas on the Paraná riverbank (southwest of Misiones), the most abundant record was obtained in adjacent areas of Brazil and Paraguay, also on the riverine plains. Similar to this are the findings reported by Mayntzhusen, which come mainly from Paraguay (in Menghin, 1957). Other findings are reported by this author as coming from the mouth of the Paty-Cuá stream in Paraná (municipality of Eldorado), in San Gotardo and Puerto Rico area (municipalities of Capioví and Puerto Rico) and Caraguatay (municipality of Montecarlo), all adjacent to or near the Paraná River (Menghin, 1957), in the middle section of the province. Further to the southeast, a decade later on the Paraná riverside between the Ñacanguazú and Cuñapirú streams, Rizzo (1969) identified several Guaraní sites arranged in large banks between 7 and 15 m high above the level of the Paraná and its left tributaries, less than 600 m from their riverbanks. As the location data of these sites are generic, we are not able to place them on a map with precision, but all of them are in the southeast between both streams, on the Paraná's fluvial strip (Rizzo, 1969:7). Upstream, in the middle part of Misiones province, this author also identified a site in Colonia Victoria, on a river sand bank (Rizzo, 1969), which is probably the one later excavated and reported by Giesso and Rizzo (see below). Returning to the Montecarlo-Eldorado area, Burna (1983) identified a site in Puerto Laharrague, and another was discovered by Giesso

(1984) located in a cave; both were adjacent to the Paraná River. Other sites were discovered between this locality and the Piray area, near or adjacent to the Paraná River (mentioned in Poujade, 1992). A few km to the north, in Colonia Victoria, the Puerto Victoria site was excavated. This deposit is located on a hill adjacent to the Paraná River (Giesso & Rizzo, 1985; Rizzo & Shimko, 2003), where the owner placed for several years an undetermined quantity of funerary urns. Only 400 m from there, at the Puerto Victoria 2 site, we recovered buried vessels from the post-Hispanic era, in a cemetery probably used since pre-Columbian times (Loponte & Carbonera, work in progress). In contemporary form, numerous informal and journalistic reports of findings of Guaraní pottery are registered in the area between Puerto Victoria and Montecarlo (middle section), always on the Paraná's fluvial strip. The number of finds in the south and middle Paraná River sections is due to the fact that these areas are currently densely populated. In fact, in the municipal museum in the town of Eldorado, between both localities, there are some vessels that were recovered from the surrounding area, although the majority lacks precise data on their specific origin (Figure 9). Some of them contained human remains, thus reinforcing the identification of cemeteries in the area. During the same decade, Poujade (1989, 1992) carried out several field investigations that identified 20 sites distributed throughout the Capital district (Posadas), Candelaria and San Ignacio departments, 200 to 700 m from the Paraná riverbank (in the southwest of the province). This observation coincides with the distance indicated by Rizzo for the location of the Guaraní sites in the vicinity of the Ñacanguazú - Cuñapirú streams, somewhat further to the north. She also verified the existence of seven sites on islands adjacent to the Paraná, along the prospected section. Unfortunately, several have been destroyed by contemporary human activities and some will require a more detailed analysis to determine their allocation, especially those called "lithic workshops." Considering the whole of this record, Poujade points out that by the beginning of the 1990s, "30 or 40" Guaraní sites had been located between "villages and cemeteries" (Poujade, 1992:41), a statement based on the bibliography we have reviewed and on her personal experience, although several of these sites lack a precise location and an adequate description of the contexts. Due to the numerous findings reported in different ways along the coastal strips of the Paraná and Uruguay Rivers, Poujade (1992:68) points out the existence of a continuous record throughout both courses. Already in this century, in the municipality of Puerto Esperanza (in the northeast of Misiones province), Mujica (2007) identified a Guaraní site called MPE-02, which would have one hectare of surface ~5 km from the Paraná riverbank. In the same municipality, a local collector located a second deposit on a lateral sandbank of the Paraná River, from which he obtained a large collection of pottery. We recently excavated the Corpus site<sup>6</sup> (27° 06' 36.0" S, 55° 30' 06.2" W), whose surface has not yet been corroborated, but appears to be extensive, and which is also located on a sandbank in the Paraná River, in the homonymous municipality (southeastern area). This site is residential, where pottery and lithic artifacts were made and used, fauna was consumed and burials were performed (Loponte & Carbonera, 2015a, 2015c).

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6 We have been able to obtain recent information indicating that the investigated area of the Corpus site by Rizzo and Shimko (2003) is quite far from the sector excavated by us, so that it still has to be evaluated if they belong to the same site.





**Figure 9.** Pottery recovered from the Paraná River plain. See annex for further information.

To the east, on the Uruguay River, archaeological investigations are less numerous. Rizzo (1969) pointed out that the Guaraní sites of the Department of Concepción de la Sierra present a grouping pattern similar to that observed on the Paraná River, that is, near or adjacent to the main channel. This author identified two sites with the names "MC.S.-1" and "MS.C.-1", which, according to the map that accompanies the work (Rizzo, 1969:7), are located on the right bank of the Itacaruaré stream, near to its mouth. Sempé & Caggiano (1995) and Sempé (1999) identified six sites near Panambí, four sites in the vicinity of San Javier and one in Puerto Sara. These three areas show an important concentration of sites in the Uruguay valley, immediately adjacent to the coast. There are also references of sites on private properties on the Uruguay River, which will be confirmed in future fieldwork. Even further north, in Moconá Provincial Park on the banks of the Uruguay River, there is a Guaraní cemetery whose material is exposed in the interpretation center of the park, which will be excavated soon. In the same way, in the Municipality of El Soberbio, local residents recently recovered an inhumation in an urn from a cemetery area (Hintz site) over a ravine that joins the Uruguay River.

### **The Guaraní record in the interior of the province**

Until the 1970s, the archaeological record in the Sierra Central and the steep-slope areas was very little known. Several years ago, Mujica (2000) surveyed a small sector of the municipality of San Vicente, located in the Sierra Central. This author identified six sites; three of them were classified as Guaraní. The first corresponds to GSV4/RS (Iwaszinink property), where an undetermined quantity of pottery sherds and a small ax, all

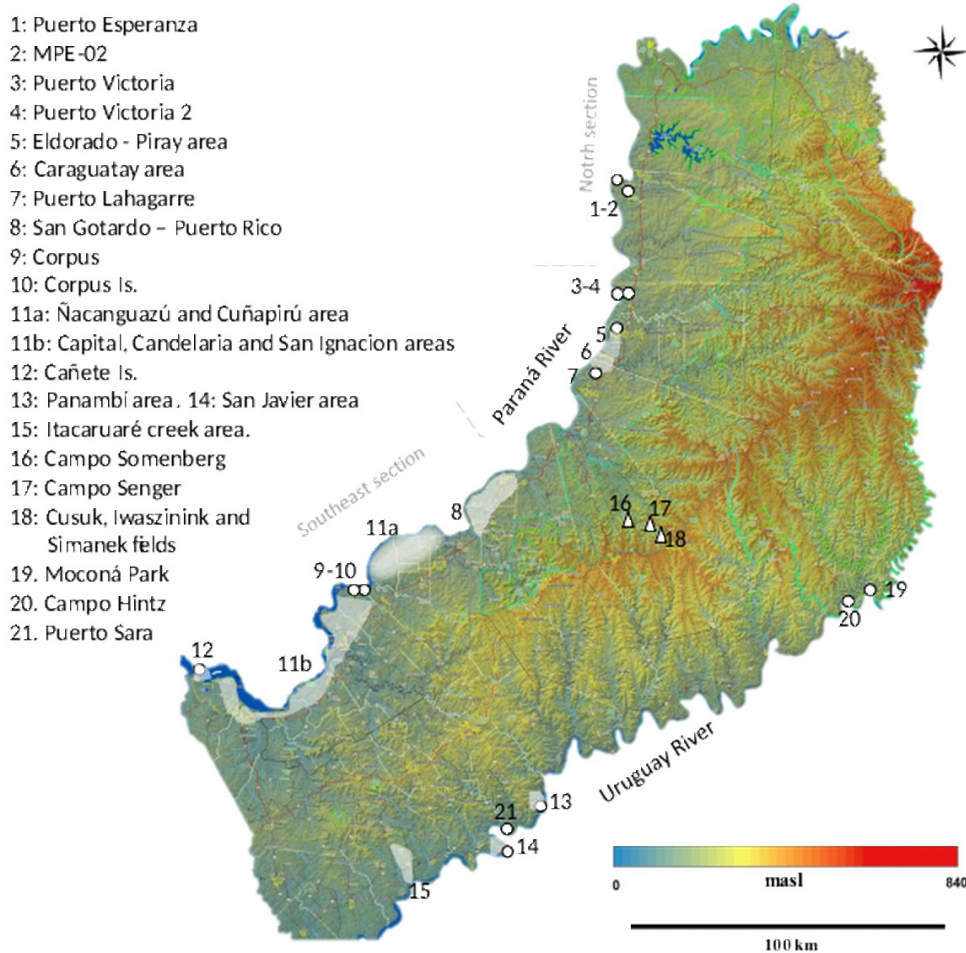
on the surface, were recovered from a cultivated field. Two kilometers away, undetermined quantity of fragments of plain Guaraní pottery were collected at GSV5/RS (Cusuk property), after the field was plowed. Mujica also recovered two small and plain vessels, but their assignment as Guaraní is yet to be confirmed. The third site corresponds to GSV6/RS (Simanek property) located 1000 m from the previous one. Here, a cultivated area was opened, also with a moderate slope, where 37 fragments of Guaraní pottery were recovered, alternately decorated with corrugated, brushed, unguiculated and red-painted sherds with red lines on a white base. Recently, in the same municipality and specifically on the property of Julio Senger (26° 55' 2.9" S, 54° 32' 44.0" W), the owner recovered a Guaraní vessel 51 cm in both rim diameter and height, with a maximum diameter of 58 cm in circumference. The top is brushed and the rest is smooth (figure 10). This vessel was buried in an apparently isolated place, with no other record or bones immediately associated. A few kilometers away, on the property of Carlos Somenberg (26° 52' 16.1" S, 54° 33' 43.8" W), the owner recovered from an adjacent field a Guaraní smooth-walled vessel associated with another one that could not be relocated. These findings are apparently isolated. The dimensions of this container are 34 cm in diameter and 28 cm in height (Figure 10).



**Figure 10.** Vessel A was recovered from the Senger property. Vessel B was found on Somenberg's property. The photographs are provided by the Municipality of San Vicente and digitally adapted by the authors.

We have recently prospected approximately 20 different properties in the San Vicente area, but we have not been able to locate any Guaraní sites. Besides the scarce Guaraní record in these surveyed areas, no reports are known of large cemeteries or significant concentrations of Guaraní materials at other localities in the Sierra Central, at least not like those observed in the valley areas of the Paraná and Uruguay Rivers. Although the San Vicente area is also densely populated, private and public collections lack Guaraní pottery, or they only have a small amount of sherds from this archaeological unit. On the contrary, in the same highland landscapes, Mujica (2000) and local collectors have recovered large quantities of pottery sherds from another archaeological unit commonly called Taquara-Itararé in Brazil and Eldoradense in Argentina. This record is associated with a horticulturalist population of a broad-spectrum economy, chronologically situated during the Late Holocene, whose historical descendants are the Kaingang (Ge linguistic family). Likewise, elongated mortar hands are relatively frequent in these areas,

which have been observed in use by Ambrosetti (1897) among the historical Kaingang of Misiones province.



**Figure 11.** Distribution of the sites and areas with a verified/published Guaraní record in Misiones province

Since the highlands are still little known archaeologically, we cannot yet present the formal gradient values of this differential distribution of the Guaraní and Taquara record. However, given the data we have reviewed, we believe there is substantial evidence to suggest different peaks of density reflecting a heterogeneous use of the Misiones territory by Guaraní groups. The most likely hypothesis is that this population was concentrated on the strips of the Paraná-Iguazú and Uruguay Rivers, and in the adjacent areas below 300 masl. Regarding the most southern sector of the province, within the “Campos y Malezales” ecoregion, it is quite clear that there were Guaraní occupations along the riverbanks of both big rivers, but no archaeological survey is available for the prairies between them. In Figure 11, we have attempted to graph the known distribution of the Guaraní archaeological record on Misiones territory.

### Final remarks

The current archaeological knowledge of Misiones province shows a high concentration of Guaraní archaeological remains on the strips of the Paraná and Uruguay Rivers. This record includes isolated findings, cave and open sites of small and large dimensions, isolated burials that may form part of larger cemeteries, as well as extensive burial areas. All of this suggests a significant Guaraní occupation of the coastal strips that coincides with the historical data. In the hills, the Guaraní record decreases substantially,

but it does not disappear. The meaning of this record is not clear. It could be related to the exchange of goods with the populations of the Sierra Central, who were culturally distinct, sporadic Guaraní occupations or even an initial colonization through a pattern of dispersed settlement. The heterogeneous distribution of the Guaraní record within the province may have been partially influenced by the same heterogeneity of the coverage of the archaeological studies, although the samplings made up to the present time and the compositions of the private and public collections in the mountain range areas show that it may reflect a real one. The historical data are concurrent with this heterogeneous distribution. Therefore, the best hypothesis available to explain this situation is that there was a selection of the areas most suitable for the expansion of the Guaraní constructed niche. The enormous dispersal of these groups, whatever their reasons, seems to have taken place through precise environments that met the specific conditions of the climatic parameters related to lowland and tropical-subtropical rainforests, the good agronomic quality of the soils and the convenience of river connectivity. All these conditions are met on the coastal plains of the Paraná, Iguazú and Uruguay Rivers. Concurrently, these riparian environments are more attractive to a broad-spectrum economy; they possess more diverse resources, and therefore are less risky landscapes. On the other hand, in the Sierra Central there was a pre-existing non-Guaraní horticultural population, with an economy that was also broad-spectrum, that is, they were not complementary but absolute competitors. Part of this same population was probably displaced from the banks of the great rivers towards the mountain ranges during the Guaraní expansion, thus increasing the demographic constraint above 300 masl. This pre-existing and historical social conditioning unleashed a co-evolutionary process between both societies, which were probably not exempt from a high level of conflict, a process which remains practically unknown.

The development of the Guaraní niche implied complex ecosystem engineering and a coevolution with a wide-ranging impact in the rainforests of South America. However, this environmental management was subject to certain limits. Lewontin (1983:280) supposed that "organisms do not adapt to their environments, they construct them out of the bits and pieces of the external world." Ecological niche construction certainly has different constraints. Among them are the cultural and genetic inheritance to modify it as well as the expected pay-off (Fudenberg & Tirole, 1991). These returns included both natural and social components. In the case of the Guaraní population of Misiones province, considering the characteristics of its constructed niche, the highest expected pay-off should be associated with the riverine plains of the Paraná-Iguazú and Uruguay Rivers. After colonizing these landscapes, the pay-off of continuing to the south seems to have been greater than colonizing more costly areas from a social and environmental point of view, such as the Sierra Central. Therefore, the decision-making probably excluded occupying the mountain ranges, and the Guaraní population continued to the south, using the Paraná and Uruguay Rivers until the estuary of the Río de la Plata River was reached, where there is the southernmost limit of its distribution in South America. However, the suboptimal landscape like the Sierra Central could have been used under certain circumstances, with a declining yield up to a certain threshold. The incorporation of these productive spaces with less pay-off may have been encouraged in situations such as demographic pressure, environmental degradation, or social changes. It is reasonable to expect less use of areas progressively further from the great rivers, especially for the latest pre-Columbian period, when the phase of effective colonization by the Guaraní population was already well established, and certainly during the subsequent process of expansion of colonial and national society.

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## References

- ACOSTA, A.; RÍOS ROMÁN, V. 2013. Explotación prehispánica de palmeras por grupos cazadores-recolectores y horticultores del extremo sur de Sudamérica: el caso del humedal del Paraná inferior (Argentina). *Pesquisas, Antropología*, n. 70: 197-216.
- AMBROSETTI, J.B. 1894. Los indios Caingú del Alto Paraná (Misiones). *Boletín del Instituto Geográfico Argentino*, n. 15: 661-744.
- AMBROSETTI, J.B. 1895. Los cementerios prehistóricos del Alto Paraná (Misiones). *Boletín del Instituto Geográfico Argentino*, n. 16: 227-263.
- AMBROSETTI, J.B. 1897. Los indios Kaingángues. *Revista del Jardín Zoológico de Buenos Aires*, n. II: 306-385.
- BARTOLOMÉ, M. 1978. La situación de los Guaraní (Mby'a) de Misiones (Argentina). In: ROA BASTOS, A. (Comp.). *Las Culturas Condenadas*. México D. F.: Ed. Siglo XXI.
- BALÉE, W. 1989. The culture of Amazonian Forests. In: POSEY, D.A.; BALEE, W. (Eds.). *Resource management in Amazonia: indigenous and folk strategies. Advances in Economic Botany*, 7: 1-21. New York Botanical Garden, New York.
- BALÉE, W. 2000. Antiquity of traditional knowledge in Amazonia: The Tupí-Guaraní Family and Time. *Ethnohistory*, v. 47, n. 2.
- BALICK, M.J. 1979. Economic botany of the Guahibo. I. Palmae. *Economic Botany*, 33(4): 361-376.
- BRACCO, M.; LIA, V.V.; POGGIO, L.; HERNÁNDEZ, J.A.C. & GOTTLIEB, A.M. 2013. Caracterización Genética de razas de maíz autóctonas de Misiones, Argentina. *Revista de Ciencia y Tecnología*, n. 20: 52-60.
- BRACCO, M.; CASCALES, J.; HERNÁNDEZ, J.A.C.; POGGIO, L.; GOTTLIEB, A.M. & LIA, V.V. 2016. Dissecting maize diversity in lowland South America: genetic structure and geographic distribution models. *Plant Biology*, n.16: 186. DOI 10.1186/s12870-016-0874-5
- BROCHADO, J.P. 1984. *An ecological model of the spread of pottery and agriculture into Eastern South America*. 1984. 574 f. PhD Thesis (Doctorate in Philosophy and Anthropology) – University of Illinois at Urbana-Champaign, Urbana-Champaign.
- BROWN, J.H. & LOMOLINO, M.V. 1998. *Biogeography*. 2 Ed. Sunderland, Massachusetts: Sinauer Associates, Inc. Publishers.
- BURNA, E.A. 1983. Un paradero guaraní en la zona de Puerto Lahargue (Misiones). *IV Encuentro de Geohistoria Regional*, Resistencia: 87-89.
- BURKART, R.; BÁRBARO, N.; SÁNCHEZ, R. & GÓMEZ, D. 1999. *Ecoregiones de la Argentina*. Administración de Parques Nacionales. Programa de Desarrollo Institucional Ambiental. Secretaría de Recursos Naturales y Desarrollo Sustentable.
- BUSO JUNIOR, A.; PESSENDA, L.C.; OLIVEIRA, P. DE; FONSECA GIANNINI, P.; LISBOA COHEN, M.; VOLKMER-RIBEIRO, C.; BARROS DE OLIVEIRA, S.M.; ROSSETTI, D.; LIMA LORENTE, F.; FILHO, M.; SCHIAVO, J.; BENDASSOLLI, J.A.; FRANÇA, M.; GUIMARÃES, J. & SOUZA SIQUEIRA, G. 2013. Late Pleistocene and Holocene vegetation, climate dynamics, and Amazonian taxa in the Atlantic Forest, Linhares, SE Brazil. *Radiocarbon*, 55(2-3): 1747-1762.
- CAMARA HERNÁNDEZ, J. & MIANTE ALZOGARAY, A.M. 2011. Razas de maíz nativas de Misiones. *Boletín de la Sociedad Argentina de Botánica*, 46(Supl.), 231.
- CAMBAS, A. 1940. Paraderos y enterratorios guaraní. *Boletín de la Junta de Estudios Históricos de Misiones*, II: 8-9, Posadas.

- CRIVOS, M.; MARTINEZ, M.R.; REMORINI, C. & TEVES, L. 2002. Comer y cocinar en una aldea Mbya. In Enciclopedia De Misiones. Available at: <http://www.academica.org/carolina.remorini/46>. Accessed in 2016.
- CHAMORRO, G. 1998. *A espiritualidade Guaraní: Uma teologia ameríndia da palavra*. Serie Teses e Dissertações. Sao Leopoldo: Sinodal.
- CHASE-SARDI, M. 1989. El tekohá, su organización social y los efectos negativos de la deforestación entre los Mbyá-Guaraní. *Suplemento Antropológico*, n. 24(2): 33-41.
- CHEBEZ, J.C. & CASAÑAS, H. 2000. *Áreas claves para la conservación de la biodiversidad de la provincia de Misiones, Argentina*. Fauna Vertebrada. Puerto Iguazú: FVSA-WWF. p.102
- CHMYZ, I. 1979. *Quarto relatório das pesquisas realizadas na área de Itaipu (1978/79)*. Itaipu/IPHAN, Curitiba. 53p.
- CHMYZ, I. 1983. *Sétimo relatório das pesquisas realizadas na área de Itaipu (1981/83)*. Itaipu/IPHAN, Curitiba. 103p.
- CHMYZ, I. 1999. Relatório Técnico sobre a Arqueologia e a Etno-História da Área Do Parque Nacional do Iguazú. Curitiba: Fundação da Universidade Federal do Paraná para o Desenvolvimento da Ciência, da Tecnologia e da Cultura.
- CHOUSOU-POLYDOURI, N. & WAUTERS, V. 2013. Subgrouping in the Tupí-Guaraní family: A Phylogenetic approach. In: *Survey of California and Other Indian Languages. Structure and Contact in Languages of the Americas*, 15: 1-26. Disponível em: <http://escholarship.org/uc/item/8kq4q1t9#page-1>. Acesso em: 25 de jul. 2017.
- DI BITETTI, M.S.; PLACCI, G. & DIETZ, L.A. 2003. *A Biodiversity Vision for the Upper Paraná Atlantic Forest Ecoregion: Designing a Biodiversity Conservation Landscape and Setting Priorities for Conservation Action*. Washington, D.C.: World Wildlife Fund.
- DUJAK, M.; FERRUCCI, M.S.; VERA JIMÉNEZ, M.; PINEDA, J.; CHAPARRO, E. & BRÍTEZ, M. 2015. Registros sobre las especies vegetales alimenticias utilizadas por dos comunidades indígenas Mbyá - Guaraní de la Reserva para Parque Nacional San Rafael, Itapúa – Paraguay. *Steviana*, Vol. 7: 25-47.
- FALGUERA, C.; FAGGI, A.; HOMBERG, V.; BOGAN, S. & BAUNI, V. 2015. La Vegetación de Campo San Juan. In: BAUNI, V.; HOMBERG, M. (Eds.). *Reserva Natural Campo San Juan*. Buenos Aires: Editorial Fundación de Historia Natural Félix de Azara. p. 53-68.
- FELIPIM, A.P. 2001. *O Sistema Agrícola Guaraní Mbyá e seus cultivares de milho: um estudo de caso na aldeia Guaraní da Ilha do Cardoso, município de Cananéia, SP*. 2001. 120f. Dissertação (Mestrado em Ciências) – Universidade de São Paulo, Piracicaba.
- FERNÁNDEZ, R.; LUPI, A.M. & PAHR, N.M. 2000. Land aptitude for forest plantations. Province of Misiones. Informe para Fundación Vida Silvestre Argentina
- FUDENBERG, D. & TIROLE, J. 1991. *Game Theory*. London: MIT Press.
- FURLONG, G. 1936. Cartografía Jesuítica del Río de la Plata. *Publicaciones Del Instituto De Investigaciones Historicas*, n. LXXI, Buenos Aires, Peuser.
- FREITAS, F.O.; BENDEL, G.; ALLABY, R. G. & BROWN, T. A. 2003. DNA from primitive maize landraces and archaeological remains: implications for the domestication of maize and its expansion into South America. *Journal of Archaeological Science*, n. 30: 901-8.
- GASCUE, A.; BORTOLOTTI, N.; LOPONTE, D. & ACOSTA, A. 2016. *Arqueología Guaraní en Uruguay: nuevos datos para El Yacimiento Punta Negra Este*. III Jornadas de Actualización en Arqueología Guaraní, Pelotas. Ms.
- GIESSO, M. 1984. Excavaciones arqueológicas en un sitio guaraní en Gruta. El Dorado, Misiones. *Actualidad Antropológica*, n. 20: 32-33.
- GIESSO, M. & RIZZO, A. 1985. Puerto Victoria, un sitio de tradición tupi-guaraní en el Alto Paraná, Misiones, R. A. Museo Municipal de Eldorado, *Ymaguaré*, n.1: 5-28.
- HUTCHINSON, G.E. 1957. Concluding remarks. *Cold Spring Harbor Symposia on Quantitative Biology*, 22(2): 415-427. doi:10.1101/sqb.1957.022.01.039.
- IKUTA, A.R.Y. 2002. *O Desafio do resgate de práticas fitotécnicas de uma comunidade tradicional indígena Mbyá-Guaraní*. 2002. 300 f. Tese (Doutorado em Fitotecnia) – Universidade Federal do Rio Grande do Sul, Porto Alegre.

- IPEC, Instituto Provincial de Estadísticas y Censos. 2015. *Gran Atlas de Misiones*. Gobierno de La Provincia de Misiones, Ministerio de Estado General y Coordinación de Gabinete. Disponível em: <https://www.ipecmisiones.org/>. Acesso: 27 jul. 2017.
- IRIARTE, J.; MAROZZI, Ó. & GILLAM, C. 2010. Funerary monuments and celebration rituals: Taquara/Itararé enclosure and mound complexes en Eldorado, Misiones, Argentina. *Arqueologia Iberoamericana*, 6: 25-38.
- KELLER, H.A. 2012. El origen y la decadencia de los cultivos Guaraníes, un relato mítico de los Avá Chiripá de Misiones, Argentina. *Bonplandia*, 21(1): 27-44.
- LADEIRA, M. 2001. *Espaço geográfico Guaraní-mbyá: significação, constituição e uso*. 2001. 236 f. Tese (Doutorado em Geografia Humana) – Universidade de São Paulo, São Paulo.
- LALAND, K.N.; BOOGERT, N. & EVANS, C. 2014. Niche construction, innovation and complexity. *Environmental Innovation and Societal Transitions*, 11: 71-86. <http://dx.doi.org/10.1016/j.eist.2013.08.003>
- LEWONTIN, R.C. 1983. Gene, organism and environment. In: BENDALL, D. S. (Ed.). *Evolution from Molecules to Men*. Cambridge: Cambridge University Press, pp. 273-285.
- LIGIER, H.D. 2000. *Caracterización geomorfológica y edáfica de la provincia de Misiones*. Informe para Fundación Vida Silvestre Argentina. Instituto Nacional de Tecnología Agropecuaria (INTA), Corrientes.
- LOPONTE, D.; ACOSTA, A.; CAPPARELLI, I. & PÉREZ, M. 2011. La arqueología guaraní en el extremo meridional de la cuenca del Plata. In: LOPONTE, D.; ACOSTA, A. (Eds.). *Arqueología Tupiguaraní*. Buenos Aires: Instituto Nacional de Antropología y Pensamiento Latinoamericano. p. 111-154.
- LOPONTE, D. & ACOSTA, A. 2013. La construcción del registro arqueológico guaraní en el extremo meridional de su distribución. *Cuadernos del Instituto Nacional de Antropología y Pensamiento Latinoamericano - Series Especiales*, n. 1(4): 193-235.
- LOPONTE, D. & CARBONERA, M. 2013. Arqueologia sem Fronteiras: projeto de cooperação binacional para o estudo arqueológico da província de Misiones (Argentina) e oeste de Santa Catarina (Brasil). *Revista Memorare*, 1: 43-50,
- LOPONTE, D. & CARBONERA, M. 2015a. Arqueología Precolonial de Misiones. In: BAUNI, V.; HOMBERG, M. (Eds.). *Reserva Natural Campo San Juan*. Buenos Aires: Fundación de Historia Natural Félix de Azara, p. 15-38.
- LOPONTE, D. & CARBONERA, M. 2015b The Cave "Tres de Mayo" in the context of the archeology of the subtropical lowlands of southeastern South America. No prelo.
- LOPONTE, D. & CARBONERA, M. 2015c. Arqueología Guaraní en la provincia de Misiones: el sitio arqueológico Corpus. No prelo.
- LOPONTE, D.M.; CARBONERA, M.; CORRIALE, M.J. & ACOSTA, A. 2016. Maize horticulturists and oxygen ecozones in the tropical and subtropical forests of Southeast South America. *Environmental Archaeology Journal of Human Paleoeology*, n. 22: 247-267. <http://dx.doi.org/10.1080/14614103.2016.1211382>.
- LÓPEZ, H.; MORGAN, C. & MONTENEGRO, M. 2002. Ichthyological ecoregions of Argentina. *Probiota Serie Documentos* n° 1, Facultad de Ciencias Naturales y Museo, UNLP. La Plata.
- MANCHÓN, J.F. 2005. *San Francisco de Paula y los Kaingang de las Altas Misiones*. Jardín América: Junta de Estudios Históricos, Sociales y Literarios de Jardín América.
- MARTÍNEZ CROVETTO, R. 1968a. Notas sobre la agricultura de los indios guaraníes de Misiones (República Argentina). *Actas y Memorias 37º Congreso Internacional de Americanistas 1966*. Buenos Aires.
- MARTÍNEZ CROVETTO, R. 1968b. La alimentación entre los indios guaraníes de Misiones. *Etnobiológica*, 4: 1-24.
- MEDEIROS, J.C. de A. 2006. *Reestabelecendo um Tekoá pelos índios Guaraní Mbyá*. Um estudo de caso da aldeia Yakã Porã-Garuva/SC. 2006. 164f. Dissertação (Mestrado em Agroecossistemas) – Universidade Federal de Santa Catarina, Florianópolis.
- MENGHIN, O. 1957. El poblamiento prehistórico de Misiones. *Anales de Arqueología y Etnología*, XII: 19-40.
- MÉTRAUX, A. 1946. The Guaraní. In: STEWARD, J. *Handbook of South American Indians*. Vol. 3. Washington: Smithsonian Institution.

- MCCLINTOCK, B.; KATO, T.A. & BLUMENSCHNEIN, A. 1981. *Chromosome constitution of the Races of maize, its significance in the Interpretation of relationships between races and varieties in the Americas*. Chapingo: Colegio de Postgraduados.
- Ministerio de Ecología de la provincia de Misiones. 2011. Disponible em: <http://ecologia.misiones.gov.ar/ecoweb/index.php/mapas/show/slid-13/scid-8?w=&h=&jsnid=1395810418>. Acceso em: 26 de jul. 2017.
- MOSCOVICH, F.; DUMMEL, C.; PINAZO, M.; KNEBEL, O. & ALCARAZ, R. 2010. Caracterización Fitosociológica de una porción de bosque nativo misionero secundario, con intervención antrópica. *Quebracho*, 18(1-2): 24-36.
- MUJICA, J.I. 1995a. Primeras aproximaciones sobre el uso del espacio abierto en una aldea guaraní prehispanica. *Actas y Memorias del XI Congreso Nacional de Arqueología Argentina*. San Rafael, Argentina, p. 123-141.
- MUJICA, J.I. 1995b. De Corrientes Argentina. Informe de dos sitios arqueológicos guaraní en la provincia. *XX Encuentro de Geohistoria Regional*. Gobernador Virasoro, Argentina, p. 119-127.
- MUJICA, J.I. 2000. *Informe de sitios arqueológicos en el centro de la provincia de Misiones Municipio de San Vicente*. Trabajo presentado en el XX Encuentro de Geohistoria Regional.
- MUJICA, J.I. 2007. *Prospección arqueológica en la cuenca del arroyo Yará-Puerto Esperanza-Misiones-Argentina*. Trabajo presentado en el XXVII Encuentro de Geohistoria Regional.
- MÜLLER, F. 1935 (1989). *Etnografía de los Guaraní del Alto Paraná*. Ed. Societas Verbi Divini, Rosario. 132 pp.
- NOELLI, F.S. 2004. Settlement patterns and environmental changes in human occupation on the left bank of the Paraná river (Paraná State, Brazil). *Revista sobre Arqueología en Internet*, n. 6(1): 1-24.
- ODLING-SMEE, F.J.; ERWIN, D.H.; PALKOVACS, E.P.; FELDMAN, M.W. & LALAND, K.N. 2013. Niche construction theory: a practical guide for ecologists. *The Quarterly Review of Biology*, 88: 3-28.
- OLSON, D.M.; DINERSTEIN E.; WIKRAMANAYAKE, E.D.; BURGESS N.D.; POWELL, G.V.N.; UNDERWOOD, E.C.; D'AMICO, J.A.; STRAND, H.E.; MORRISON, J.C.; LOUCKS, C.J.; ALLNUTT, T.F.; LAMOREUX, J.F.; RICKETTS, T.H.; ITOUA, I.; WETTENGEL, W.W.; KURA, Y.; HEDAO, P. & KASSEM, K. 2001. Terrestrial ecoregions of the world: A new map of life on Earth. *BioScience*, 51(11): 933-938.
- PÁEZ, S.L. 2013. Las Reducciones Jesuíticas-Guaraníes como Antecedente de Organización Espacial en La Región Misionera. *Contribuciones Científicas GAEA*, vol. 25:165-173.
- PALACIOS FELTES, L.M. 2008. Perfil alimentario de la comunidad Mbya guaraní Vijú, Distrito de Tava'i, Departamento de Cazapá. Ph.D. Thesis dissertation. Facultad de Ciencias Agrarias, Universidad Nacional de Asunción.
- PATERNIANI, E. & GOODMAN, M. M. 1977. *Races of Maize in Brazil and Adjacent Areas*. Texcoco: Centro Internacional de Mejoramiento de Maiz y Trigo.
- PESSENDA, L.C.R.; OLIVERA, P.C. de; MOFFATO, M.; MEDEIROS, B.V.; GARCÍA, R.J.; ARAVENA, R.; BENDASSOLI, J. A. & BOULET, R. 2009. The evolution of a tropical rainforest/grassland mosaic in southeastern Brazil since 28.000 14C yr BP based on carbon isotopes and pollen records. *Quaternary Research*, 71: 437-452.
- PINTALUBA, N. & LUACES, P. A. 2013. Caracterización de frutas comestibles de especies nativas de uso popular en el Parque Provincial "Salto Encantado del Valle del Cuñá Pirú – Misiones". *Bonplandia*, n. 22(2): 191-201.
- POCHETTINO, M.L. 2007. La dinámica en la horticultura en comunidades Mbya-Guaraní, Misiones, Argentina. *Etnobiología*, n. 5: 36-50.
- POCHETTINO, M.L.; MARTÍNEZ, M.R. & CRIVOS, M. 2002. Landscape Domestication among two Mbya-Guaraní Communities of the Province of Misiones, Argentina. In: STEPP, J.; WYNDHAM, F.; ZARGER, R. *Ethnobiology and Biocultural Diversity*. Athens: University of Georgia Press, p. 696-704.
- POSEY, A.D. 1985. Indigenous management of tropical forest Ecosystems: The case of the Kayapó indians of the Brazilian Amazon. *Agroforestry Systems*, 3(2): 139-158.
- POSEY, A.D. 1987. Manejo da floresta secundária, capoeiras, campos e cerrados (Kayapó). In: RIBEIRO, B.G. *Suma Etnológica Brasileira*. 2ª ed. Petrópolis, Vozes/Finep, Vol.1: 173-185.



- POUJADE, R.A. 1989. *Relevamiento, rescate e investigación cultural y natural en zona afectada por Yaciretá en Misiones* (R.A.). Posadas: Imprenta del Banco de la Provincia de Misiones.
- POUJADE, R.A. 1992. Poblamiento prehistórico y colonial de la provincia de Misiones. *Revista de Estudios Iberoamericanos*, Vol. XVIII, n.1: 29-69.
- POUJADE, R.A. 1995. Mapa Arqueológico de la provincia de Misiones. Con cartilla explicativa. Ed. Secretaría de Estado de Cultura de Misiones. Yaciretá. Artes Gráficas Zamphirologos S.A. Asunción.
- REBES, M.I.A. de. 2001. *Antonio Ruiz De Montoya: Testemunha De Seu Tempo*. 2001. 400 f. Dissertação (Mestrado em História) – Universidade do Vale Do Rio dos Sinos, São Leopoldo.
- RIZZO, A. 1969. Nuevas investigaciones arqueológicas en la provincia de Misiones. *Antiquitas*, IX: 6-9.
- RIZZO, A. & SHIMKO, S. 2003. La tradición Tupi-guaraní misionera. *Actas del XIII Congreso Nacional de Arqueología Argentina*, p. 115-128.
- RODRÍGUEZ, M.E.; CARDOZO, A.; RUIZ DÍAZ, M. & PRADO, D. E. 2005. Los Bosques Nativos Misioneros: estado actual de su conocimiento y perspectivas. In: ARTURI, M.F.; FRANGI, J.L.; GOYA, J.L. (Eds.). *Ecología y Manejo de los Bosques de Argentina*. CDROM. La Plata: EDULP.
- RODRIGUEZ, J.A. 1996. Investigaciones arqueológicas en Yaciretá (Corrientes - Argentina). *Anales de las Jornadas de Antropología de la Cuenca del Plata*, v. 3. Rosário: Universidad Nacional de Rosário.
- RODRÍGUEZ, J.A. 2009. La ocupación (poblamiento) del norte de Corrientes (Argentina) por la fase de la Tradición Tupiguaraní. In: Meggers, B. (Ed.). *Arqueología interpretativa*. O método quantitativo para o estabelecimento de sequências cerâmicas: estudos de caso. Porto Alegre: UNITINS, p.49-62.
- ROMERO NAVARRO, J.A.; WILCOX, M.; BURGUEÑO, J.; ROMAY, C.; SWARTS, K.; TRACHSEL, S.; PRECIADO, E.; TERRON, A.; DELGADO, H.V.; VIDAL, V.; ORTEGA, A.; BANDA, A.E.; MONTIEL, N.O.; ORTIZ-MONASTERIO, I.; VICENTE, F.S.; ESPINOZA, A.G.; ATLIN, G.; WENZL, P.; HEARNE, S. & BUCKLER, E.S. 2017. A study of allelic diversity underlying flowering-time adaptation in maize landraces. *Nature Genetic*, 49(3): 476-480.
- SANTOS, E.J.M. dos; TAKESHITA, L.Y. C.; MAIA, M.H. & SANTOS, P.D.E. dos. 2013. Evidências genéticas da dispersão Tupi centrada em Rondônia envolvendo patrilocalidade. *Cuadernos del Instituto Nacional de Antropología y Pensamiento Latinoamericano - Series Especiales*, n. 1(4): 137-147
- SCHADEN, E. 1974. *Aspectos Fundamentais da cultura Guaraní*. São Paulo: Difusão Européia do Livro.
- SCHMIDL, U. 1948. *Crónica del Viaje a las Regiones del Plata, Paraguay y Brasil*. Buenos Aires: Editorial Peuser.
- SEMPÉ, M.C. 1999. Excavaciones en Puerto Sara, San Javier. In: MASS, J.L.; SANS, M. (Eds.). *Arqueología y Bioantropología de Tierras Bajas*. Montevideo: Facultad de Humanidades y Ciencias de la Educación/Universidad de la República, p. 173-188.
- SEMPÉ, M.C. & CAGGIANO, M.A. 1995. Las culturas agroalfareras del Alto Uruguay (Misiones, Argentina). *Revista do Museu de Arqueologia e Etnologia*, n.5: 27-38.
- UTERMOEHL, B. & GONÇALVES, P. 2004. Conservação na roça (in situ) da agrobiodiversidade Guaraní. *Revista Brasileira de Agroecologia*, 2(1): 1708-1711.
- VIGOUROUX, Y.; GLAUBITZ, J.C.; MATSUOKA, Y.; GOODMAN, M.M.; SÁNCHEZ, G.J. & DOEBLEY, J. 2008. Population structure and genetic diversity of New World maize races assessed by DNA microsatellites. *American Journal of Botany*, n. 95:1240-1253.
- WILLIAMS, G.C. 1992. Gaia, nature worship, and biocentric fallacies. *The Quarterly Review of Biology*, 67: 479-486.
- ZANARDINI, J.; BIERDERMANN, W. 2006. *Los Indígenas del Paraguay*. 2ª ed. Itaipú Binacional. Asunción. 360 p.
- ZENT, E.L. & ZENT, S. 2002. Impactos ambientales generadores de biodiversidad: conductas ecológicas de los Hotí de la Sierra Maigualidad del Amazonas venezolano. *Interciencia*, 27(1): 9-22.

## Sources of images

Figure 7. Image of *P. brasiliensis* taken and modified from <http://zooinstitutes.com>. Image from *M. coypus* from Marco Mattei ([www.juzaphoto.com](http://www.juzaphoto.com)). Image from *H. hydrochaeris* taken and modified from <http://natuculturaconservacion.blogspot.com.ar>. Image of *B. dichotomus* by authors.

**Annex. Description of the vessels illustrated in Figure 9**

#	Origin	Formal type	Emic type	Finishing techniques	Dimensions
1	Eldorado county	Collared rim pot with carinated body	Cambuchí	Collared rim and upper panel painted in white	Rim diameter: 30 cm. Max.diameter:59 cm. Height: 52 cm
2	Eldorado county	Collared rim pot with carinated body	Cambuchí	Collared rim and upper panel painted with red lines on white base	Rim diameter: 30 cm. Max.diameter:53 cm. Height: 43 cm
3	Eldorado county	Direct rim cooking pot with carinated body	Yapepó	base and upper panel brused and corrugated rim	Rim diameter: 50 cm. Max.diameter:58 cm. Height: 40 cm
4	Eldorado county	Direct rim cooking pot with carinated body	Yapepó	base and upper panel brused with corrugated rim	Rim diameter: 40 cm. Max.diameter:49 cm. Height: 40 cm
5	Eldorado county	Direct rim cooking pot with carinated body	Yapepó	Corrugated	Rim diameter: 28 cm. Max.diameter:47 cm. Height: 30 cm
6	Eldorado county	Collared rim pot with carinated body	Cambuchí	Collared rim painted in red. Upper panel painted with red lines on white base	Rim diameter: 21 cm. Max.diameter:36,5 cm. Height: 27,5 cm
7	Eldorado county. Paraná River bank	Collared rim pot with carinated body	Cambuchí	Collared rim and upper panel painted with red lines on white base	Rim diameter: 21 cm. Max.diameter:31 cm. Height: 24 cm
8	Puerto Victoria 1. Col.Buchinger	Collared rim bowl	Cambuchí Caaguába	Collared rim painted in red on white base. Body with red slip. The interior is covered by a brown slip	Rim diameter: 15,5 cm. Max.diameter: 19,5 cm. Height: 13,5 cm
9	Eldorado county. Paraná River bank	Simple bowl	Cambuchí Caaguába	Interior: red on natural color. Ext: upper panel with red lines on white base	Rim diameter: 28,5 cm. Max.diameter:31,5 cm. Height: 12 cm
10	Puerto Victoria 1. Buchinger coll.	Carinated bowl	Cambuchí Caaguába	Interior: red lines on brown slip. Ext: red lines on white base	Rim diameter: 26,5 cm. Max.diameter:31 cm. Height: 13 cm
11	Puerto Victoria 1. Buchinger coll.	Collared rim carinated bowl	Cambuchí Caaguába	Interior: red lines on white base. Ext: red lines con natural color	Rim diameter: 25,5 cm. Max.diameter:29 cm. Height: 13 cm
12	Puerto Victoria 1. Buchinger coll.	Direct rim carinated bowl	Cambuchí Caaguába	Internal: red and black lines on white base. Ext: natural color	Rim diameter: 23,5 cm. Max.diameter:27 cm. Height: 9,5 cm
13	Porto Esperanza County Paraná River. Gherardi coll.	Collared rim simple bowl	Cambuchí Caaguába	Collared rim and upper panel with red lined on white base	Rim diameter: 28,5 cm. Max.diameter:31,5 cm. Height: 12 cm