Journal of Interdisciplinary History, XXXV:2 (Autumn, 2004), 185–224.

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The Missions of Paraguay: The Demography of an Experiment

Not all interactions between colonizers and indigenous populations were destructive. Jesuit fathers greatly influenced the development of greater Paraguay, particularly creating an impact on the Guaraní population of the region. This article assesses the demographic impact, for good and ill, of foreign mission fathers on a local South American population over two centuries.

From the 1640s—when the Jesuit missions of Paraguay achieved territorial stability—to the early 1730s, the Guaraní population, as guided by the Jesuit fathers, increased from 40,000 to more than 140,000. Only a small part of this consistent secular increase was due to a trickle of newly converted arrivals; it was largely offset by the Indios who fled the strict control of the fathers. From 1733 to 1739, however, disaster hit the missions; wars, epidemics, and hunger halved the population. After a period of steady recovery, the population suffered a final crisis before the expulsion of the Jesuits from Spain and its colonial empire in 1767.

The Jesuits' political, social and, economic regime had a profound impact on the Guaraní demographic system. In spite of high mortality and recurrent strikes of epidemics introduced from abroad, early and monogamous unions and a stable social structure allowed high birth and growth rates. Moreover, whenever mortality took a disastrous toll because of epidemics or other exceptional events, the dynamic reproductive system was able to repair the damage.

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The demographic consequences of contact like that between the Jesuits and the Guaraní are often measured on the same scale as those of a natural disaster—say, an earthquake—by the degree of ostensible damage to human resources. But Spanish domination had an effect on the entire demographic system of the Indios—both its proximate and remote factors. In this context, two polar and symmetrical cases are illuminating. In the Greater Antilles, the Taíno population was wiped out in just a few decades after Columbus' landfall. The Conquistadores' confiscation of labor, dislocation of the communities, disruption of families and clans, and subtraction of women from the indigenous reproductive pool placed the thin Taino society on the verge of demographic collapse. The European epidemics that came later finished the job. In the Paraguay region, the missions protected the Indios from the colonists' exploitation and insured them a modicum of stability. Although exposed to the full brunt of European disease, the Guaraní population was able to grow. Nonetheless, a complete understanding of how contact with the Spaniards affected them requires an intensive examination of the structural change suffered by their demographic system.[1]

THE MISSIONS: BIRTH AND CONSOLIDATION Because it had no gold and only a sparse population, the vast region of the Rio de la Plata was not a priority in the Iberian colonization of America. At the time of the initial Spanish *entradas* (conquering expeditions), the large area formed by non-Amazonic southern Brazil, Paraguay, and Uruguay had perhaps a million inhabitants—mainly Tupí and Guaraní tribes—whereas Argentina as a whole had about 900,000. Spanish colonists numbered only a few thousand at the beginning of the seventeenth century. The Jesuits began proselytizing among the Indios in the region of Guayrá in 1587, but not until the creation of the Jesuit province of Paraguay in 1604 did the penetration of the order south of Amazonia gather strength. Although the province was named Paraguay, it included a vast region comprising actual Chile (until 1625), Argentina, Uruguay, Paraguay, and about one-third of Bolivia and Brazil—a total of

1 On Hispaniola, see Livi-Bacci, "Return to Hispaniola: Reassessing a Demographic Catastrophe," *Hispanic American Historical Review,* LXXXIII (2003), 3–51. A good account of Guaraní society is David J. Owens, "A Historical Geography of the Indian Missions in the Jesuit Province of Paraguay," unpub. Ph.D. diss. (University of Kansas, 1977).

about 7 million square kilometers. By and large, the Indios did not object to the Jesuits' presence. As inhabitants of missions, they were able to avoid the hated and feared system of the *encomienda* (amounting to little more than serfdom); they were entrusted directly to the Crown as tributaries but temporarily exempted from the payment of the tribute, as the Ordenanzas de Alfaro, a functionary of the King, confirmed in 1611.

The Jesuits' system consisted of a web of individual reductions (*reducciones),* or missions, each under the strict rule of the fathers, who controlled the Indios' economic, religious, and social life (see figures 1 and 2). The Crown encouraged and supported the missions for the double purpose of protecting the area from Portuguese descending southward from Sao Paulo and defending communications with Upper Peru. Of the ninety-eight missions that the Jesuits administered in the Province of Paraguay until their expulsion (of which the thirty missions in this study were the successful nucleus), most were settled along the primary existing, or planned, routes of communication. The Guaraní thus "reduced" in the missions found protection against the colonists' exploitation, against enslavement by the *bandeirantes paulistas* (members of raiding expeditions from the Sao Paulo region looking for slaves and gold), and against the incursions of other aggressive nomadic tribes. But they lost their traditional modes of life.

Jesuit evangelical activity officially began in 1609, proceeding from Asunción in three directions—northward, in the Itatín, mainly inhabited by seminomadic tribes; eastward in the Guayrá region along the river Parapané; and southward, at the confluence of the rivers Paraguay and Paraná, and later in the Tapé area. But the recurrent incursions of the bandeirantes paulistas destroyed ten of the twelve Guayrá missions and forced the survivors to migrate southward in 1631/32; the Indios of the Itatín reductions were also forced to move southward. In the 1640s, the missions found permanent settlement in the valleys of the Paraná and Uruguay rivers—twenty-two of them at the beginning and eight more created between 1687 and 1707, when some of the original ones became too populous (see Figure 3). The missions were located between 20° and 30° of longitude and 54° and 57° of latitude—altogether about 100,000 square kilometers—but the area was more than twice that size if the *estancias* (ranches) and the fields of *yerba mate* are included. The missions congregated the majority

Fig 1. Jesuit Reductions in South America

Fig 2. Jesuit Guaraní Missions, 1750

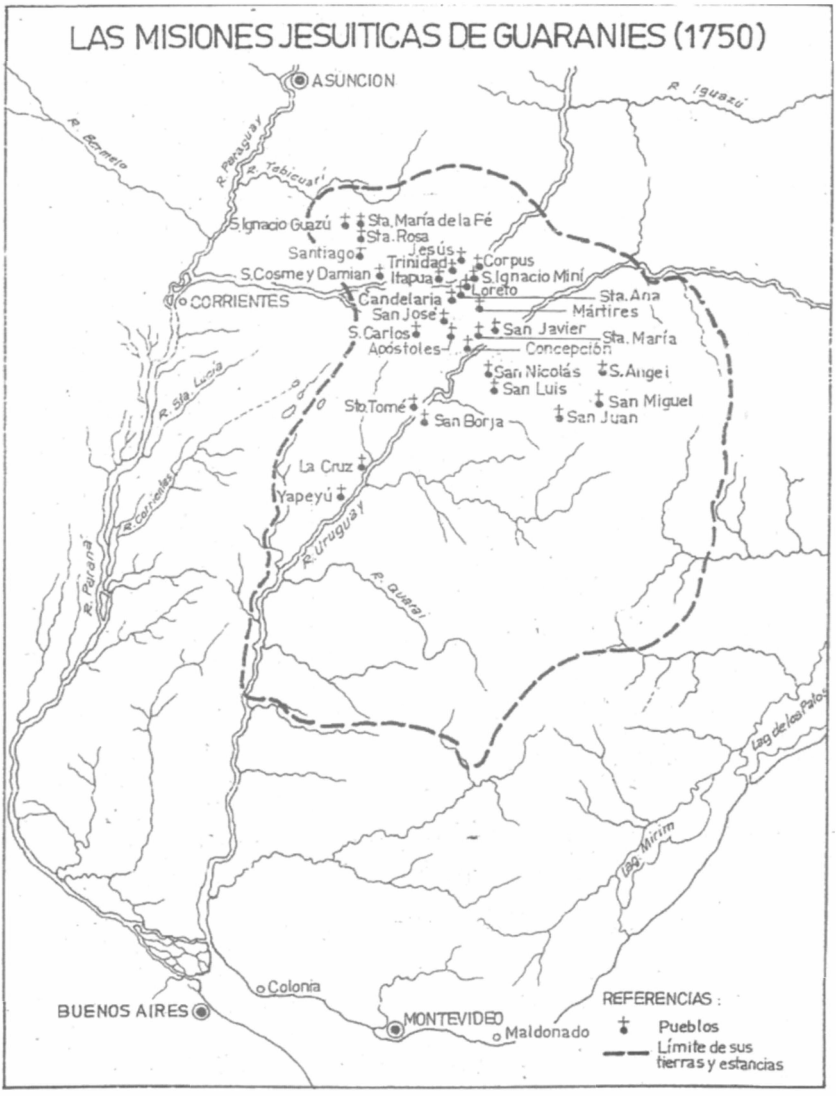
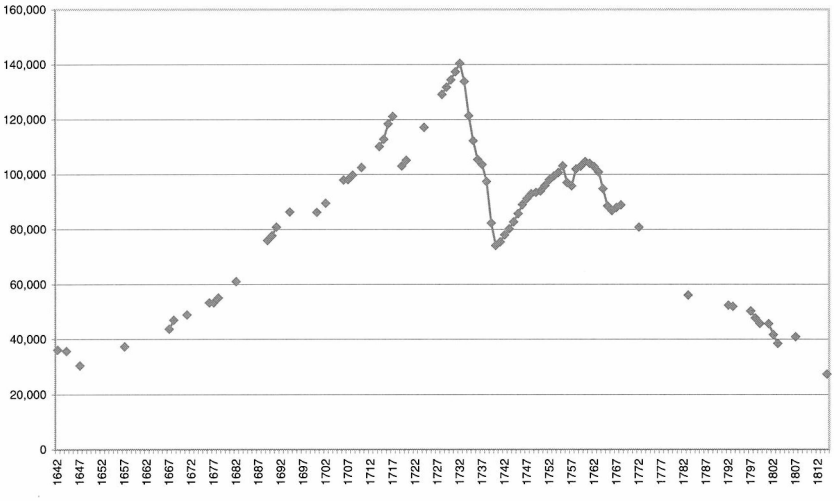


Fig. 3 Population of the Missions, 1642–1815



(54 percent in 1680) of the autochthonous populations of the vast Rio de la Plata province, which included—besides Paraguay and Uruguay—Buenos Aires, Tucumán, and Cuyo.

Each mission was administered by two Jesuit fathers, sometimes assisted by a co-adjutor, under the general authority of a Superior. One of the fathers was also the parish priest and the chief of the community, making the important decisions concerning work and the economy, law enforcement, and the teaching/training of children/adults. Remarkably, the number of fathers who comprised the spiritual and material government of a population that reached 140,000, in a territory larger than England, was never larger than 100.[2]

In 1768, after the departure of the Jesuits, which left the missions under a civil administration, the population numbered about 90,000, after reaching its maximum in 1732 and recovering from the crisis of the 1730s. Once in civil hands, the population de-

2 On contact-population estimates, see William M. Denevan (ed.), *The Native Population of the Americas in 1492* (Madison, 1992), xxxviii. On the geography, see Guillermo Furlong, *Cartografía Jesuítica del Rio de la Plata* (Buenos Aires, 1936), 2v.; Owens, "Historical Geography." A general outline of the history of the Paraguay missions, as well as a detailed and systematic account of their geography, economy, society, and religion, can be found in Furlong, *Misiones y sus pueblos de Guaraníes* (Buenos Aires, 1962). On the missions' share of the entire region's population, see Rafael Carbonell de Masy, *Estrategias de desarrollo rural en los pueblos Guaraníes (1609–1767)* (Barcelona, 1992), 95.

clined rapidly through migration and dispersion to about 40,000 in 1800. The missions' population had been geographically determined by the 1640s, and demographically closed for almost a century. Proselytism and evangelization had either ceased or had acquired a marginal role, and no new groups were incorporated. Emigration was sporadic, although it intensified in periods of stress. Natural growth determined demographic change. Until the emigration and decline of the 1730s, the Guaraní formed a well-identified, stable group that can be easily studied with the traditional tools of demographic analysis.[3]

SETTLEMENT, SOCIAL LIFE, AND DEMOGRAPHY The reduction of the Indios to life in the missions—a process that involved hispanic North and South America under the guidance of different religious orders—brought profound change to the Guaraní way of life. The major material change was the cultivation of maize, manioc, or cotton to supplement traditional nomadic foraging, hunting, and fishing. Farming required them to settle in one place for longer periods and to construct suitable multi-family communal homes. However, the recurring need to find new fields to fertilize with inefficient slash-and-burn techniques also meant that they could never regard their modest villages as completely permanent establishments. The shift from a nomadic life to one in which agriculture and cattle raising became the main source of support, intensified the Guaraní work patterns and conferred precise rhythms on their daily routines.[4]

3 The major demographic studies of the Guaraní, from which many of the data analyzed in this study have been drawn, are Ernesto J. A. Maeder and Alfredo S.C. Bolsi, "La población de las Misiones Guaraníes entre 1702–1767," *Estudios Paraguayos,* 2 (1974), 111–137; *idem,* "Evolución y características de la población Guaraní de las misiones jesuíticas, 1671–1767," *Historiografía,* 2 (1976), 113–150; *idem,* "La población Guaraní de las Misiones Jesuíticas. Evolución y características (1671–1767)," *Cuadernos de Geohistoria Regional,* 4 (1980); "La Población Guaraní de la provincia de Misiones en la epoca post Jesuítica (1768–1810)," *Folia Historica del Nordeste,* LIV (1982), supplement.

4 The organization and society of the missions are described in a number of contemporary works, particularly, José Cardiel, *Las Misiones del Paraguay* (Madrid, 1989; orig. pub. 1913, in Hernández, *Organización social* [see below]); Furlong, *José Cardiel, S.J. y su Carta-Relación* (Buenos Aires, 1953); Pedro F. J. de Charlevoix, *Histoire du Paraguay (translation of Pablo Hernández)* (Madrid, 1913), 5v.; Martin Dobrizhoffer, *Historia de los Abipones* (Resistencia, Spain, 1967, 1968, 1970), 3v.; José M. Peramás, *La República de Platón y los Guaraníes* (Buenos Aires, 1946). Among the modern works, see Alberto Armani, *Città di Dio e Città del Sole* (Roma, 1977); Francesco Barbarani, "Le riduzioni dei Guaraní: un'alternativa al sistema coloniale," in Antonio Sepp (ed.), *Il sacro esperimento del Paraguay* (Verona, 1990); Philip

Geography and lifestyle were significant factors in the Guaraní demographic profile. The thirty missions in the valleys of the Paraná and Uruguay rivers enjoyed a "benign and healthy climate, and although they had both a summer and a winter season, neither one was extreme." Simple cotton clothes were adequate most of the year, and a woolen poncho was adequate protection from the occasional spells of cold weather in June and July. But when the Indios were sent southward in corvées, to a cooler climate, they were vulnerable. A Real Cédula (royal decree) of 1706 forbade sending Indios to *tierras frías;* when exposed to the cold nights in Buenos Aires, with no firewood and inadequate clothing, Indios fell victim to respiratory diseases.[5]

The valleys of the Paraná and the Uruguay form vast extensions of flat or rolling land, with prairies and dense subtropical forests separated by a low sierra, the elevation of which occasionally reaches 500 meters. The location of each mission was decided on the basis of several natural factors, such as the water supply, the suitability of the soil for various crops, the distance from waterways or land routes, and elevation. Sometimes, the first choice proved inadequate, making a costly change of location necessary. The complexity of the missions' economic activities, the need for spacious farmland and for estancias, and the difficulty of governing a crowded village meant that a mission's population normally did not exceed 1,000 families. Sepp gave a detailed description of the process leading to the foundation, in 1697, of the San Juan mission by families from San Miguel, which had surpassed 6,000 inhabitants. Sepp described the criteria followed for selecting the location, for the distribution of land and crops, for the planning of the village, and the construction of communal buildings and family dwellings. After 1690, seven new missions were founded with the population of an equal number of missions that had become too

Caraman, *The Lost Paradise: An Account of the Jesuits in Paraguay, 1607–1768* (London, 1975); Carbonell, *Estrategias;* Furlong, *Misiones;* Pablo Hernández, *Organización social de las doctrinas Guaraníes de la Compañia de Jesus* (Barcelona, 1913), 2v.; Maeder, *Aproximación a las Misiones Guaraníticas* (Buenos Aires, 1996); Magnus Morner, *The Political and Economic Activities of the Jesuits in the la Plata Region* (Stockholm, 1953); Owens, "Historical Geography."

5 For the quotation about climate, see Gonzalo de Doblas, *Memoria sobre Misiones,* in Pedro De Angelis (ed.), *Colección de Obras y Documentos* (Buenos Aires, 1970), 24–25. On vulnerability to cold, see Pablo Pastells, *Historia de la Compañia de Jesus en la Provincia del Paraguay* (Madrid,1933), V, 107, 148.

populous. In 1732—the year of the demographic zenith—only one of the thirty missions exceeded 7,000 inhabitants.[6]

The population of each mission concentrated in the village, with the exception of the families working in the estancias located at a distance from it. Villages, which were planned according to precise rules, had a large rectangular central plaza surrounded by the vast church, the house of the fathers, and other structures (such as the widows' and orphans' house or shops for craftsmen). The Indios' dwellings were rows of single-story buildings—30 to 60 meters long and 10 to 12 meters wide, including the front and back porches—on wide avenues perpendicular to the central square. The distinguishing feature of their layout was the strict separation of each family's living quarters in contrast to the promiscuous arrangements of the clans in earlier times, when the caciques ruled. "The inconveniences of the communal houses must be eliminated . . . each rooster in his corral," wrote Torres in his 1613 *Carta ánua* (annual letter sent to the Jesuit Superior). The fathers gradually imposed, and then sternly enforced, a strictly monogamous family life. On those occasions when the Indios tried to revert to their old communitarian habits—because of overcrowdedness, the founding of a new village, or political commotion—the fathers had to use all of their authority to maintain order.[7]

Each mission had a hospital, at a distance from the village, for those suffering from contagious diseases. The fathers provided rudimentary assistance for the sick, and some of them, particularly those of Italian and middle-European origin, developed a pharmacopoeia of local production. The concentration of Indios in heavily populated villages favored the diffusion of communicable

6 On the location of the missions, see Barbarani, *Organizzazione del territorio e sviluppo urbanistico nelle missioni gesuitiche del Paraguay (1609–1641)*, in Giovanna Rosso Del Brenna (ed.), *La costruzione di un nuovo mondo* (Genova, 1994); Carbonell, *Estrategias,* 301–302; Furlong, *Misiones,* 187. For Sepp's description, see *Sacro esperimento,* 195–216.

7 Each building housed six to twelve families, each with its own living quarters (6 m long by 5 m wide), with two opposite entrances—one leading to the front porch and one leading to the back porch. In the later period of the missions, they were built of stone instead of wood and adobe, without chimneys. On the characteristics of Guaraní dwellings, see Furlong, *Misiones,* 289; Hernández, *Organización social,* I, 102. Quotation of Diego de Torres in J.M. Blanco, *Historia documentada de la vida y gloriosa muerte de los Padres Roque Gonzales de la Cruz, Alonso Rodriguez, y Juan del Castillo de la Compañia de Jesús, Mártires del Caaró y Yjuhi* (Buenos Aires, 1929), 108.

diseases—mainly smallpox, measles, and typhus—with disastrous consequences. The isolation, care, and feeding of the sick had a moderating effect on mortality but could not offset the negative effects of the population density. But the villages had running water and rudimentary sewing systems that undoubtedly helped to make village life more comfortable.[8]

The Guaraní were gifted manual workers, but had little discipline or patience, perhaps because of their seminomadic origin. They were excellent craftsmen, decorators, and musicians—as contemporary witnesses attested—but indifferent farmers. They generally took the full six months of their allotted time to prepare, plant, and harvest their individual plots, though "with the equivalent of four weeks of work they would have harvested enough for a year . . . because the land is exceedingly fertile." The Guaraní often failed to meet subsistence level in spite of the strict supervision, and punishment, of the fathers. The production of the communal fields regularly had to supplement insufficient individual resources. The actual productivity of fields planted with maize was one-fifth their theoretical yield, given the techniques of the time. Taking into account labor in the communal fields—limited to Mondays and Saturdays—the working regime was relatively light.[9]

In normal times—that is, in the absence of war, uprising, and famine—nutrition was adequate in both quantity and quality. Maize, manioc, sweet potatoes, beans, pulses, squash, fruits, sugar, and honey, as well as a consumption of meat and fish several times higher than that of contemporary Mediterranean Europe, constituted a rich and varied diet. Many contemporary witnesses thought that the amount of beef that the Guaraní ate was bad for their health. Cattle was raised on the large estancias under the jurisdiction of the village, but the missions had access to the herds of wild cattle that bred on remote tracts of land (*vaquerias*). In some missions, beef was slaughtered in the morning, and families received 5 to 6 lb. of meat daily; in other missions, the distribution occurred two, three, or four times per week. Carbonell estimated the Guaraní per capita consumption of meat to have been about 82 kg per year (compared with 13 kg in late nineteenth-century Italy) and their per capita caloric budget to have been 2,500 per day in the final phase (not the more prosperous one) of the mis-

8 On the medical knowledge of the fathers, see Armani, *Città di Dio,* 153–155.

9 For quotation, see Cardiel, *Misiones,* 6. On productivity in agriculture, see Carbonell, *Estrategias,* 103.

sions. The caloric estimate, which equals the per capita caloric budget of Brazil c. 1980, is probably low because it does not take into account products like wheat, rice, or eggs.[10]

Mobility and communication depended on an extended system of waterways and land routes connecting the thirty missions with each other as well as with the major centers of the Rio de la Plata region. Thus were the Guaraní able to mitigate their isolation in a vast land with low density (one person per square kilometer). Altamirano wrote in 1684 that although the missions west of Paraná extended for 40 leagues (223 km) from Sant'Ignacio to Corpus (later moved to the eastern side of the river) and were separated by a difficult land route, their residents could communicate in three to four days. The system of roads—centered on Candelaria, the most important mission—allowed horses, as well as carts and coaches drawn by oxen, to reach Corrientes or Asunción. Along the way were many stations (*tambos*) where travelers could rest, eat, and change horses.[11]

The rivers constituted natural and busy waterways. "One Jesuit, writing in 1715, reckoned that there were at least 2,000 canoes from the Reductions in use on the Paraná and almost as many on the Uruguay." Merchant boats coming from Cadiz and navigating upstream could sail to Asunción on the Paraguay or the more distant port of Candelaria on the Paraná, 2,000 km from the estuary.[12]

There were, however, many obstacles to mobility. The Leyes de Indias (laws regulating the rights of both conquerors and Indios), with the continuing support of both civil and religious authorities, prohibited Spaniards, blacks, and mestizos from living in the missions. The Jesuits adhered to these general rules with some local adaptation: The steady stream of travelers and merchants in the *pueblos de abajo* (the lower villages of S. Ignacio Guazú, Santa

10 On consumption of meat and beef, see Dobrizhoffer, *Historia Abipones,* I, 321–325; Sepp, *Sacro esperimento,* 173–174; Cardiel, *Misiones,* 72. Carbonell, *Estrategias,* 106–107, provides estimates of caloric consumption. For a population with the age structure, type of activity, and anthropometric characteristics of the Guaraní, a daily consumption in excess of 2,500 calories was more than adequate. Periods of nutritional stress or outright famine were due more to political disorders than to climatic events.

11 For Altamirano's description, see Pastells, *Historia* (Madrid, 1923), IV, 92. On mobility and its limitations, see Mörner, "The Guaraní Missions and the Segregation Policy of the Spanish Crown," *Archivum Historicum Societatis Iesu* (Rome,1961), XXX; Furlong, *Misiones,* 294; Peramás, *República,* 139.

12 The unnamed Jesuit's quotation appears in Caraman, *Lost Paradise,* 139. On tambos, see Furlong, *Misiones,* 292. On merchant ships, see Dobrizhoffer, *Historia Abipones,* I, 301.

Maria de Fe, Santa Rosa, Santiago, and later San Cosme and Itapúa) on the west side of the Paraná and in Candelaria were allowed to stop at the tambos for three days at most to show and exchange their goods. The other missions between the Paraná and the Uruguay and east of the Uruguay restricted access to all but Guaraní, with some rare exceptions; the exchange of goods with Buenos Aires took place only via the waterways. Hence, the isolation of the missions from the rest of the region was more social than physical. The frequent military and civil corvées of the Indios outside the missions' area, however, permitted ample opportunities for the Guaraní to interact with Spaniards, blacks, and mestizos.

The civil authorities in Asunción and Buenos Aires often requested the aid of Guaraní (given special permission to use firearms by the Crown) to suppress internal rebellions, defend the borders, and launch military expeditions against the Portuguese. Likewise, the Guaraní were often enlisted from the missions to serve in corvées for public works, to transport goods, or construct fortifications.[13]

The General Rules of the Missions of 1689 reveal that the Guaraní were not free to leave the village without the explicit authorization of the fathers. For example, a limited number of singers, musicians, and members of the Cabildo were allowed to accompany the father on a visit to a nearby mission for a specific festival. Any Indio who had resided in a mission for a year had to be returned to it whenever absent without leave. If a husband and wife resided in different missions, the wife had to move to the

13 The colonial authorities of Asunción and Buenos Aires requested the help of the Guaraní for a variety of reasons, both military and civil. In general, the Jesuits complied with the requests in order to maintain good relations with the colonial authorities and safeguard their much-prized autonomy. On occasion, they sent hundreds, or even thousands, of Indios away from their villages for months (and sometime years) at a time. The expeditions to dislodge the Portuguese from Colonia do Sacramento in 1680, 1702–1704, and 1735 involved as many as 4,000 Guaraní; the suppression of the *Comuneros* (insurgent Spanish colonists) uprisings in Asunción, between 1724 and 1729 and between 1732 and 1735, required as many as 12,000 of them. Corvées and other duties outside the mission placed the Indios in direct contact with Spaniards, mestizos, or blacks—much to the Jesuits' chagrin. Not all the Indios returned home; those who did carried the risk of epidemic contagion. Some rough calculations show that in three decades (1700–1709, 1720–1729, and 1730–1739), more than 50 adult Indios of every 1,000, on average, entered corvées every year. Presumably, this considerable loss of manpower had a substantial impact on the villages' economy and society. In the other decades, the effect of the corvées was less significant than that of the absence of young conscripts in those nineteenth-century European nations that had a universal and compulsory military draft. For more discussion, data, and estimates, see Livi-Bacci and Maeder, "Misiones Paraquariae: la demografia di un esperimento," *Popolazione e Storia,* IV (2004, forthcoming).

husband's village. Any Indio arriving in a village had to be sent back to his/her mission of residence or to his/her *pueblo de españoles* of origin. During a visit to Itapúa, the governor found an Indio in the local jail "because he had run away from his village, refusing to live with his wife."[14]

Although the Indios were not able to move as they pleased, the existing documentation makes clear that Indios were not averse to running away for good during periods of hunger, disease, or warfare. The Indios also fled to avoid duties or escape punishments (for, say, killing an ox, neglecting work, or committing "sins of lust"). As Cardiel wrote, "Many Indios run away to the *pueblos de españoles*. Although the proportion is not more than one out of a hundred, from a total of 100,000, the number of those who have fled is 1,000," a slight but not insignificant drain, as confirmed by the data. Fugitives led a vagrant life or were hired as daily hands by colonists.[15]

Certain formal regulations directly affected the demography of the missions. According to Article 20 of the General Rules, "marriages between Indios shall not be celebrated until the groom is 17 and the bride 15, if there are no reasons for the marriage to take place sooner according to the Superior's judgement." Parents arranged marriages for their children when they reached statutory age, subject to the consent of a father, apparently with no exceptions. As Cardiel confirmed, "Everybody gets married. Because of their limited intelligence and their great materialism, they are unable to remain celibate." Sepp mentions minimum ages of sixteen and fourteen; the data confirm the precocity of marriage. Indios from other missions could marry only with the explicit authorization "in scriptis" of the father in the mission of origin (Article 17). But in spite of precepts and rules, the old polygamy refused to die: The caciques of nine reductions claimed the right to have multiple wives in return for their military cooperation. Traditional customs tended to resurface during stressful periods when the fathers lost control of the populace for some reason.[16]

14 For the General Rules of the Missions of 1689, see Paraquariae, 12, folios 168–176, Archivum Romanum Societatis Jesu (arsi), Rome; Hernández, *Organización Social,* I, 592–598. The episode of the jailed Indio is in Pastells, *Historia,* VI (Madrid, 1946),12.

15 On Indios fleeing the missions, see Cardiel, Misiones, *93; Branislava Súsnik and Miguel Chase-Sardi,* Los Indios del Paraguay *(Madrid, 1995), 95–97.*

16 On marriage regulations and practice, see Hernández, *Organización social,* I, 90, 97–98; II, 34–36; Peramás, *República,* 63; Cardiel, *Misiones,* 121; Sepp, *Sacro esperimento,* 124; Furlong, *Misiones,* 288; Súsnik and Chase-Sardi, *Indios,* 96–97.

Other articles stipulated the responsibilities of the fathers. Article 27 mandated that the fathers visit the sick and infirm daily; Article 29 instructed them about how to perform funerals; and Article 31 stated their obligation to keep the parish books (which, unfortunately, have disappeared). These detailed prescriptions and the discipline of the fathers speak well of the quality of the data used in this study.

INCREASE AND DECLINE From the mid-seventeenth century onward—once the missions were established in the valleys of the Paraná and Uruguay rivers—the fathers kept meticulous records of vital statistics. Although none of the parish books that registered births, deaths, and marriages has survived (or has emerged), the yearly population statistics and logs of vital events that the fathers began to compile and consolidate in *planillas,* or prospects, at the end of the seventeenth century for each mission are available. Each mission's planilla lists the total population and the number of families (that is, the total number of married couples); population data are subdivided into *pueri* and *puellae* (boys and girls younger than seven years old), *adolescentes* (from age seven to the age of marriage—fifteen for girls and seventeen for boys), and *viudos* and *viudas* (widowers and widows). The *muchachos* comprised both pueri/puellae and adolescentes. The age separating pueri and puellae from the adolescentes is not entirely certain.[17]

The planillas also included the total number of *bautismos* and *casamientos* (baptisms and marriages)—both celebrated on Saturdays and Sundays—and of *defunciones* (deaths), distinguishing between those of *párvulos* and *adultos*. These data start in 1690, but they have many gaps in years and categories. The series is practically complete from 1728 to 1767. The quality of the data as a whole appears to be good; under the attentive supervision of the Superior, the fathers were precise and accurate. After the expulsion of the Jesuits, when other religious and administrative authorities assumed the responsibility for data collection, the quality and continuity of the records deteriorated. Nonetheless, it is possible to follow the general demographic course of the Guaraní until the beginning of the nineteenth century.

17 On age limits in the planillas, see Pedro A. Vives Azancot, "Entre el esplendor y la decadencia: la población de Misiones (1750–59)," *Revista de Indias,* XXXII (1982), 471–543, 507.

Figure 1 shows the population trends from 1643 to 1812. The population quadrupled during the long phase of growth from 1643 to 1732. The political and military turmoil of the 1730s and two disastrous epidemics almost halved the population by 1739 (from 141,000 to 74,000). In spite of the *guerra de limites* (war of borders, between Spain and Portugal), a twenty-year recovery brought the population to 105,000 in 1760, though a long decline took place thereafter until the dissolution of the communities during the second decade of the nineteenth century. The cycle of expansion was almost exclusively a consequence of natural growth; proselytism was sporadic due to the scarcity of religious personnel and their complete involvement in the administration of the missions. Diaspora was the main reason for the population decline. Table I shows the relatively stable geographical distribution of the thirty missions' population from 1643 to 1802; the population of the Uruguay's basin comprised around 60 percent of the total.[18]

The birth and death rates, rates of natural growth, and net migration outlined in Figure 4 and Table 2 reveal three salient points about Guaraní demography. The first involves the high birth and death rates, their mean values close to 60 per 1,000. The natural "renewal" of the population was extremely rapid. Combined with the small age difference between generations—attributable to the youthful marriages—it had two main consequences, one social and the other epidemiological. Socially, it facilitated the rapid process of religious and cultural change that the Jesuits were eager to promote through the education of children and adolescents and the strict discipline imposed on them. Epidemiologically, it meant

18 Peramás, *República,* 32. On the shortage of religious personnel, see, among others, Pastells, *Historia,* V, 327. The major political and military crises suffered by the missions were the consequences of conflicts between the Crown and the colonists in Asunción (Comuneros)—encomenderos hostile to the Jesuits and eager to make use of the abundant Guaraní manpower reserves. These events culminated in armed conflict in 1724 and 1733–1735, when regular Guaraní forces were involved. The 12,000 Guaraní mustered for military action from 1733 to 1735 amounted to more than one-third of the active male population. The guerra de limites settled the secular border conflict between the Spanish and the Portuguese colonial empires; the new border divided Brazil and the Spanish Rio de la Plata along the river Uruguay. Portugal was to gain seven missions located on the eastern bank of the Uruguay (in today's Brazil) and to lose Colonia do Sacramento (in today's Uruguay), a dangerous enclave in Spanish territory. But when the seven missions refused Portuguese rule, armed conflict followed, culminating in the battle of Caaybaté, in which a joint Hispano-Portuguese force defeated the Guaraní, who left 1,311 dead on the field (Armani, *Città di Dio,* 216).

Table 1 Distribution of the Population of the Thirty Missions by Region, 1643–1644, 1702, 1732, 1767, and 1802

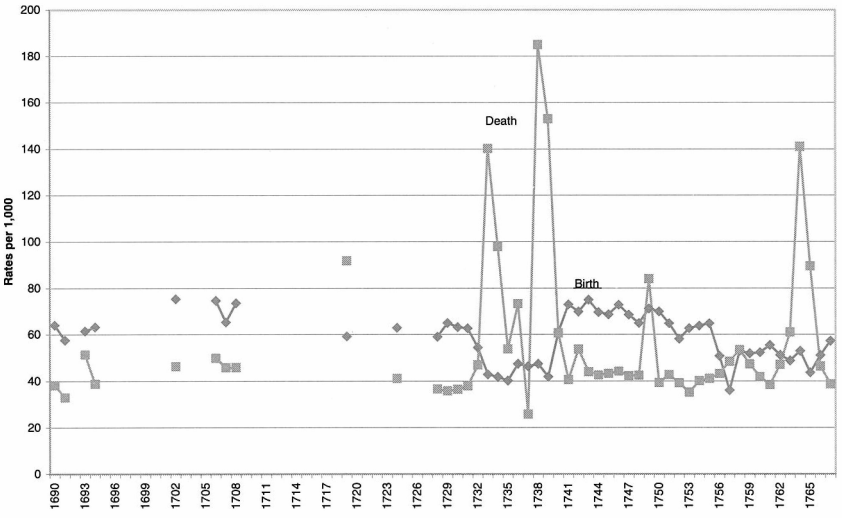
REGION	1643–1644	1702	1732	1767	1802
	POPULATION				
Paraná, west bank	6,903	20,389	33,808	23,297	8,709
Paraná, east bank	5,366	13,145	23,841	17,753	7,174
Uruguay, west bank	23,471	35,721	44,190	27,508	16,050
Uruguay, east bank	0	20,046	39,343	20,306	12,026
Paraná	12,269	33,534	57,649	41,050	15,883
Uruguay	23,471	55,767	83,533	47,814	28,076
Mesopotamia	28,837	48,866	68,031	45,261	23,224
Total	35,740	89,301	141,182	88,864	43,959
	PERCENTAGE DISTRIBUTION				
Paraná, west bank	19.3	22.8	23.9	26.2	19.8
Paraná, east bank	15.0	14.7	16.9	20.0	16.3
Uruguay, west bank	65.7	40.0	31.3	31.0	36.5
Uruguay, east bank	0.0	22.4	27.9	22.9	27.4
Paraná	34.3	37.6	40.8	46.2	36.1
Uruguay	65.7	62.4	59.2	53.8	63.9
Mesopotamia	80.7	54.7	48.2	50.9	52.8
Total	100	100	100	100	100

NOTE From 1643 to 1644, the missions of San Nicolas and San Migel were located on the west bank of the Uruguay and were moved later to the east bank. Corpus was located on the west bank of the Parana and was moved later to the east bank.

that every year, the population received a robust "injection" of new individuals who had not been immunized by a precedent epidemic and were therefore vulnerable to viruses and microbes introduced from the outside.

The second important point is the population's potential for natural growth. That the median value of natural increase was about 2 percent a year from 1690 to 1762 implies that the system was capable of compensating for losses during periods of stress. The ability to rebound after a crisis is a well-known feature of premodern European societies, but it was compromised in many of the contemporary American populations by the checks and impediments to reproduction induced by the social dislocation

Fig. 4 Birth and Death Rates, 1690–1768



brought by colonization. The Guaraní population, however, was free from those checks because the Jesuit policy of precocious, universal, and stable marriages tended to maximize fertility.

The third point concerns the gravity and frequency of mortality crises (see Table 3). In the continuously documented period from 1728 to 1767, the years 1733/34, 1738/39, and 1764/65 suffered mortality rates between 100 and 200 per 1,000 and a significant, although not large, decline of the birth rate. The lesser crises in 1719 (the crisis initiated in 1718, but data are lacking for that year) and 1749 saw death rates between 80 and 100 per 1,000. Ostensibly, the seven-year period from 1733 to 1739 was one long disaster, during which epidemics of smallpox and measles, internal uprising, corvées imposed on the Indios, and hunger resulted in high mortality, a fall in births, and a sustained diaspora from the missions. "In case of famine," wrote Cardiel in 1747, "most of the Indios disperse in the woods and live as barbarians in their primitive gentile conditions." Three-fourths of the decline from 1728 to 1767 was due to net migration and the residual one-fourth to the excess of deaths over births.[19]

19 Furlong, *José Cardiel,* 140.

Table 2 Factors of Population Change, by Period, 1729–1767

PERIOD	BIRTHS	DEATHS	MARRIAGES	TOTAL INCREASE	MIGRATORY INCREASE	NATURAL INCREASE	MEAN PERIOD POPULATION
1729–67	223,378	233,944	58,209	−40,819	−30,253	−10,566	99,526
1729–32	33,301	21,455	6,485	11,704	−142	11,846	137,459
1733–40	37,743	82,207	15,916	−67,480	−23,016	−44,464	99,572
1741–55	91,873	61,077	17,630	30,573	−223	30,794	91,646
1756–67	60,461	69,205	18,178	−15,616	−6,872	−8,744	96,702
	ANNUAL RATES PER THOUSAND						
1729–67	57.5	60.3	15.0	−10.5	−7.8	−2.7	
1729–32	60.6	39.0	11.8	21.3	−0.3	21.5	
1733–40	47.4	103.2	20.0	−84.7	−28.9	−55.8	
1741–55	66.8	44.4	12.8	22.2	−0.2	22.4	
1756–67	52.1	59.6	15.7	−13.5	−5.9	−7.5	

Table 3 Death Rates (per 1,000) in Mission, Years of Crisis

MISSION	1695	1719	1733	1738–39	1749	1764–65
San Ignacio Guazú	271.9	509.6	941.5	43.9	67.5	54.5
Santa Maria de Fe	181.2	52.6	615.9	30.4	38.6	99.1
Santa Rosa de Lima		72	815.5	46.2	28.9	417.8
Santiago	251.9	848.6	58.1	22.1	252.8	94.8
San Cosme	395.1	41.1	122.1	145.3	53.8	71.8
Itapúa	231.1	37	142.4	366.2	118.1	58
Candelaria	312.8	35.6	78.5	530.4	104.9	47.6
Santa Ana	43.7	49.6	228.2	22.3	72	62.1
Loreto	249.2	41.6	162.3	218	44.6	261.4
San Ignacio Miní	135.1	87.6	113.4	89.5	35.3	59.4
Corpus	83.3	37.1	146	48.6	31.9	98.8
Trinidad			95.1	49.1	124.8	68.9
Jesus		14	129.4	42.3	86.9	42.4
San José	94.2	27.7	101.5	692.2	38.8	158.1
San Carlos	288.4		68	178.6	122.9	54.3
Apostoles		20	62.8	871.1	32.1	182.6
Concepcioń		70.3	56.3	272.7	69.3	155.5
Martires		36.6	134	138.2	54	380.6
Santa Maria Mayor	69.3	57	145.3	318.7	99	319.2
San Javier		72.7	125.9	393.9	64.2	79.5
Santo Tomé		50.5	57.2	237.9	70.5	148.1
La Cuz		33.8	198.6	286.3	188.4	123.7
Yapeyú		49.2	136.1	34	86.5	50.1
San Borja		34.4	98.1	51.5	92.6	115.6
San Nicolas		230.9	107.8	275.2	109.9	88.8
San Luis Gonzaga		46.8	166.6	302.6	90.9	109
San Lorenzo		41.4	126.4	250.7	62.1	171.4
San Miguel		26.8	120	23.8	98.1	128.9
San Juan		29.6	100.2	26.7	60.8	77.7
Santo Angel		23.1	68.2	56.4	75.8	103
All missions	197.9	88.3	157.7	169.5	84.7	116.7
Median	231.1	41.5	124.0	141.7	71.3	99.0
	MISSIONS ACCORDING TO MORTALITY LEVEL					
Normal (<50 per 1,000)	1	17	0	11	7	2
High (50 to 100 per 1,000)	3	7	9	3	16	14
Crisis (100 to 250 per 1,000)	4	2	18	5	6	10
Catastrophic (>250 per 1,000)	5	2	3	11	1	4
Number of missions	13	28	30	30	30	30

When the final forty years of the Jesuit administration are subdivided into four sub-periods, interesting variations in natural and migratory changes can be observed: 1728 to 1732 comprised the final period of growth; 1733 to 1739 marked a deep demographic crisis; 1740 to 1755 brought recovery; and 1756 to 1767 brought a return to crisis (because of the border war and the epidemic of 1764/65). In the two periods of expansion, migratory balance was close to zero— −29 per 1,000 in the septennium of crisis (about half the negative natural growth, equal to −56 per 1,000) and −6 per 1,000 during the final twelve years of crisis. Discounting the diasporas' effect on population size during the two periods of crisis, the birth rate (58 per 1,000) would have almost balanced the death rate (60 per 1,000), notwithstanding two wars and four disastrous epidemics.

Only fifteen annual observations exist between 1690 and 1728 (see tables 4 and 5 for vital rates). The mean natural growth for those years was 19 per 1,000, compared with 13 per 1,000 for the thirty-eight year period. But these fifteen years are not a representative sample of the entire period, since two years of general hardship—1695 and 1718—are not included in the data. Natural and total growth probably did not diverge significantly throughout the entire period. The years before 1690, for which vital data have not survived, had a growth rate of 15 per 1,000; proselytism most likely made only a marginal contribution to population growth.

During the period of maturation and consolidation, proselytism was limited and sporadic; immigration into the system must have been negligible. The reports of the fathers continuously lament the scarcity of personnel and ask that new brothers be sent from Europe. In 1712, Jimenez wrote a letter to the king explaining that even though the fathers had been able to convince many "infidels" to "abandon the wilderness," too few were available to convert them. Beside the fathers' lack of time for missionary work, however, the Indios not "reduced" already were too dispersed and remote to bring easily into the fold.[20]

Some of the groups that had been converted eventually returned to their "wild conditions." The Indios of the Tarumá (100 leagues, or 5.57 km, north of the missions) incorporated into the

20 On proselytism and mobility, see Súsnik and Chase-Sardi, *Indios,* 140. Bartolomé Jimenez's letter to the king is in Pastells, *Historia,* V, 327.

Table 4 Death Rates and Expectation of Life, 1690–1767

PERIOD	NUMBER OF YEARS WITH AVAILABLE DATA[a]	DEATH RATE PER 1,000	DEATHS OF PÁRVULOS PER 100 DEATHS
Mean 1690–1767	50, 30, 18	56.8	68.1
Median 1690–1767	50, 30, 18	44.2	68.8
Mean before 1733	15, 5, 2	45.1	69.1
Mean 1733–1767	35, 25, 16	61.4	67.8
Median before 1733	15, 5, 2	41.2	66.2
Median 1733–1767	35, 25, 16	44.3	68.9
Mean 1690–99	4, 1, 0	40.4	73.6
Mean 1700–09	4, 1, 0	47.0	66.2
Mean 1710–19	1, 0, 0	91.9	
Mean 1720–29	3, 2, 2	37.9	70.4
Mean 1730–39	10, 3, 2	85.1	66.0
Mean 1740–49	10, 9, 5	49.8	72.2
Mean 1750–59	10, 9, 5	43.1	69.4
Mean 1760–67	7, 4, 4	63.0	58.0
Median 1690–99	4, 1, 0	38.6	73.6
Median 1700–09	4, 1, 0	46.1	66.2
Median 1710–19	1, 0, 0	91.9	
Median 1720–29	3, 2, 2	36.7	70.4
Median 1730–39	10, 3, 2	63.6	64.9
Median 1740–49	10, 9, 5	43.7	74.0
Median 1750–59	10, 9, 5	42.0	70.6
Median 1760–69	7, 4, 4	46.8	61.0

DEATHS OF PÁRVULOS PER 1,000 PUERI AND PUELLAE	DEATHS OF ADULTS PER 1,000 ADULTS AND ADOLESCENTS	EXPECTATION OF LIFE, E(0)
95.6	30.7	23.3
82.6	21.1	24.5
74.3	21.5	26.0
98.1	32.2	22.2
74.2	22.8	27.1
84.4	19.7	24.3
		27.7
		23.9
		13.2
73.9	18.4	28.9
170.6	57.3	19.7
90.9	21.3	22.8
73.3	18.4	26.2
103.7	53.0	21.4
		28.4
		24.4
		13.2
73.9	18.4	29.6
170.6	57.3	18.5
87.8	17.1	24.7
71.3	18.1	26.6
89.5	33.1	23.9

Table 5 Marriage, Birth, and Fertility Rates, 1690–1767

PERIOD	NUMBER OF YEARS WITH AVAILABLE DATA[a]	MARRIAGE RATE PER 1,000	BIRTH RATE PER 1,000	BIRTHS PER MARRIAGE	BIRTHS PER 100 WOMEN, 15–44 (GFR)	BIRTHS PER 1,000 MARRIED WOMEN (MFR)	TOTAL FERTILITY RATE (TFR)
Mean 1690–1767	50, 49, 51	14.6	59.1	4.29	257.2	260.8	7.7
Median 1690–1767	50, 49, 51	13.3	61.3	4.32	257.1	264.3	7.7
Mean before 1733	15, 14, 16	11.8	64.1	4.81	267.2	277.2	8.0
Mean 1733–1767	35, 35, 35	15.6	56.9	4.10	252.4	253.8	7.6
Median before 1733	15, 14, 16	12.5	63.2	4.71	262.3	270.4	7.9
Median 1733–1767	25, 35, 35	13.9	55.4	4.10	249.7	247.0	7.5
Mean 1690–99	4, 2, 5	7.8	61.6	3.91	245.0	254.3	7.4
Mean 1700–09	4, 5, 5	14.0	72.3	4.97	279.2	295.9	8.4
Mean 1710–19	1, 1, 1	20.3	59.3	2.92	258.4	265.8	7.8
Mean 1720–29	3, 3, 3	11.0	62.3	5.73	280.8	285.1	8.4
Mean 1730–39	10, 10, 10	16.5	48.8	3.30	218.4	231.0	6.6
Mean 1740–49	10, 10, 10	16.7	69.5	4.64	302.7	298.1	9.1
Mean 1750–59	10, 10, 10	11.3	57.6	5.24	259.6	256.9	7.8
Mean 1760–67	7, 7, 7	17.8	51.6	3.22	230.8	232.4	6.9
Median 1690–99	4, 2, 5	7.8	62.4	3.91	249.9	258.9	7.5
Median 1700–09	4, 5, 5	13.5	74.2	4.75	287.4	301.6	8.6
Median 1710–19	1, 1, 1	20.3	59.3	2.92	258.4	265.8	7.8
Median 1720–29	3, 3, 3	10.3	62.9	6.18	282.0	289.7	8.5
Median 1730–39	10, 10, 10	14.5	46.9	2.97	203.1	228.2	6.1
Median 1740–49	10, 10, 10	16.2	69.8	4.42	301.4	296.2	9.0
Median 1750–59	10, 10, 10	11.1	60.4	5.72	270.5	266.2	8.1
Median 1760–69	7, 7, 7	15.7	51.8	3.31	233.7	236.9	7.0

[a]The three numbers in the column refer to the indicators in columns 2, 3, and 6 (first number) in column 3 (second number), and in columns 4 (second number), and in columns 5 and 7 (third number).

mission of S. Maria de Fe defected to the count of "466 in only one day" during the hunger of 1734. A letter from Provincial Manuel Querini to the king, however, reported that they returned to the mission voluntarily ten years later. Insubordination, rather than hunger, was behind the escape of another group of Indios who founded a short-lived village of their own on the banks of the Iberá. But the Guaraní did not just leave the mission on their own accord; they also forced others to enter it. Lozano reported that one group of converted Guaraní went so far as to commit a proseltyzing raid on unbelieving Indios. Spontaneous entries into and exits from the missions' system took place for any number of reasons. Guaraní society was less monolithic and predictable than commonly thought.[21]

CATASTROPHIC MORTALITY AND EPIDEMICS Before the Mission system matured, diseases from Europe had taken a disastrous toll. Eventually, the Guaraní probably acquired—at the price of high mortality—a degree of immunity not dissimilar from that of European populations. Smallpox had devastated the populations in Brazil's coastal settlements between 1562 and 1565 as well as those in the recent settlements of Asunción, Ciudad Real, Villa Rica, and the Guayrá in 1590: "Pestilence took a horrifying toll among the inhabitants of the city [Asunción] and a hundred died daily. After nourishing itself in the city, the epidemic stormed the countryside where the damage was more deadly because of want of the necessary."[22]

The epidemic started in Cartagena in 1588 and traveled down the continent to Magellan's strait. Fragmentary evidence points to local epidemics in the region during the first decades of the seventeenth century; almost all of the missions succumbed to the epidemic of 1634 to 1636 (smallpox, measles, and perhaps scarlet fever or typhus). Another widespread epidemic took hold from 1653 to 1655. Detailed scrutiny of civil and religious documentation (for instance, the cartas ánuas of the missions' Provincials) of-

21 For the vicissitudes of the Tarumá Indios, see Charlevoix, *Histoire du Paraguay,* V, 216; Furlong, *Manuel Querini S.J. y sus "Informes al Rey" 1747–1750* (Buenos Aires, 1969), 113–114; Pastells, *Historia,* V, 689. On the Iberá Indios, see Maeder, "Un pueblo de disertores Guaraníes del Iberá en 1736," *Folia Historica,* 1 (1974); Súsnik and Chase-Sardi, *Indios,* 95. Lozano's observation is quoted in Hernández, *Organización Social,* I, 397–398.

22 For Nicolas del Techo's quotation, see Francisco Guerra, *Epidemiología Americana y Filipina 1492–1898* (Madrid, 1999), 214.

fers a complex picture of the extent and severity of the crises—sometimes identifying diseases by name and sometimes referring to them generically as plague (*peste*).[23]

Doblas, who had a good knowledge of Guaraní society after the expulsion of the Jesuits, observed that "smallpox and measles are the only diseases that cause serious mortality among the Indios, because after years pass without outbreaks, leaving few alive who were exposed to them, the contagion spreads rapidly, and not many are willing to assist the sick, fearing contamination." Doblas mentions the basic elements of epidemiology: the proportion of susceptible versus immune people at the moment of outbreak; the intervals between successive epidemics; and the lethality of the disease. Alvear, a contemporary of Doblas, observed that smallpox killed one person out of four.[24]

The diseases causing epidemics among the Guaraní were not endemic. The population of each village, which rarely surpassed 5,000 inhabitants, and of the villages as a whole, was below the minimum threshold necessary for pathologies like smallpox and measles to sustain themselves. For measles, the minimum threshold is several hundred thousand. Under the threshold, a disease that generates immunity (like smallpox, measles, or scarlet fever) flares up and eventually burns out for lack of vulnerable people. For another epidemic to explode in the same population, an infected person must bring the disease into the community anew.[25]

The Guaraní high birth rate (60 per 1,000 and youthful age structure (almost half the population was made of muchachos and muchachas) ensured that the reintroduction of a disease (even at a short interval from the preceding epidemic) would find a large proportion of people who had not been immunized to it. Five waves of smallpox occurred between 1690 and 1767 (1695, 1718/19, 1733–1739, as well as probably 1749 and 1764/65)—one outbreak every fifteen years on average. At that rate, a re-introduction of smallpox would have placed all children under fifteen at risk

23 For the epidemic of 1588, see Pastells, *Historia* (Madrid, 1912), I, 80. The cartas ánuas were reports written every three years by the missions' Superior to the General of the Jesuits in Rome, regarding various aspects of religious and social life in the missions.

24 Doblas, *Memorias,* 29. Diego de Alvear, *Relación geografica e historica del territorio de las Misiones,* in Pedro De Angelis (ed.), *Colección de Obras y Documentos* (Buenos Aires, 1970), III, 707.

25 On the population threshold for measles, see Roy M. Anderson, "Directly Transmitted Viral and Bacterial Infections of Man," in *idem* (ed.), *The Population Dynamic of Infectious Diseases* (New York, 1982), 1–37.

(about 50 percent of the total population), as well as a share (one-third or so) of those older than that age who had not been infected fifteen years earlier. In this case, two-thirds of the population would have been susceptible. But if the birth rate had been 30 per 1,000 instead of 60, as in many European populations, the proportion of susceptible people would have been lower—more like two-fifths. Even given an equal level of contagion and an equal lethality of the disease (death rate of the infected), general epidemic mortality would have been substantially higher in the Paraquarian case than in the European one.[26]

Evidence shows that general mortality caused by smallpox in a "virgin population" (a population not previously exposed, where everyone is susceptible) was extremely high, between 30 and 50 percent. Mortality was much lower—approximately 10 percent—in the case of measles. But even in a "nonvirgin" population with a young age structure (like the Guaraní), mortality must have been high, though lower than that of a comparable "virgin" population by a factor proportional to the share of the not immune population. In general, the longer a population's interval between two epidemics, the lower is its proportion of immune members and the smaller its difference from a "virgin" population at re-exposure. The difference between the mortality of a virgin and that of a nonvirgin population has three components: (1) the proportion of the immune; (2) the proportion of the infected; and (3) the survival rate of the diseased who, once cured, become immune.

In the Guaraní case, given interepidemic intervals of about fifteen years and the prevailing birth rate and mortality, the first component, the proportion of the immune, must have been in the region of one-third. Regarding the second component, the Guaraní shift from a dispersed, nomadic lifestyle to settlement in densely populated villages must have raised the proportion of those who contracted a disease. In even a seminomadic state, they would have had a better chance of escaping the epicenter of an infection.

The fathers' attempt to minimize contagion by isolating the sick in hospitals separated from the villages might have mitigated the negative effect of high density. Cardiel described the precau-

26 Charles W. Dixon, *Smallpox* (London, 1962). Russell Thornton, Jonathan Warren, and Tim Miller, "Depopulation in the Southeast after 1492," in John W. Verano and Douglas H. Ubelaker (eds.), *Disease and Demography in the Americas* (Washington, D. C., 1991), 187–195.

tions taken during a smallpox epidemic (presumably that of 1738/39): "The nature was such that if one person became ill within a household, everyone eventually did. I ordered a number of huts to be built near the village, and another group—well constructed—farther away. When somebody fell ill, we transported him to one of the nearby huts. If the disease was not smallpox—as we would be able to determine in a few days—we sent him back to his house. But if it was smallpox, we transported him to a more remote hut, burned the hut that had previously hosted him, and constructed a new one in its place." In spite of such precautions, however, the Indios of the missions would have remained far more exposed to contagion than any who were still seminomadic.[27]

So far as the third component is concerned—the proportion of the diseased who survived—we can only speculate. But the cohesive social organization of the missions might well have improved the prospect of survival. Not only did the fathers and their assistants feed and attend those who were afflicted; the victims' family members, who were prevented from abandoning children and partners, had to help as well. Abandonment, which abundant documentation from the sixteenth to the twentieth century proves to have been a common occurrence among the Indios, was a major factor in death during epidemics. With reference to the epidemic of 1635 to 1637, Boróa wrote that many who became ill died because their families fled in terror, leaving them cold, thirsty, and hungry.[28]

Some sparse evidence on the lethality of smallpox is available. In 1612 Arauco (Chile), 153 of the 273 who were infected died (56 percent); in 1614, in three missions of the Guayrá, lethality was much lower (11 percent). In Yapeyú, according to the XIX carta anua, smallpox killed 30 percent of the population. In Santa Maria, about 50 percent of the population fell ill with smallpox or measles (the documentation is unclear), and one-fourth of them died. In 1667, smallpox killed half of the inhabitants of Corpus, and more than a century later (1788), two-thirds of San Borja's population contracted smallpox, one-fourth of them dying from it.[29]

27 Furlong, *José Cardiel,* 188

28 For Diego de Boróa's observation, see Owens, "Historical Geography," 240. For the care of the Indios in the hospitals, see Sepp, *Sacro esperimento,* 179.

29 On mortality in Arauco and in the Guayrá, see P. Leonhardt (ed.), *Cartas Anuas de la Provincia del Paraguay, Chile y Tucumán de la Compañia de Jesus (1615–37)* (Buenos Aires, 1927–

Table 3 reports the death rates of the missions during the years with smallpox epidemics. The death rate in years without social or epidemiological stress—a proxy of which is the median death rate (see Table 2)—was 40 to 45 per 1,000; crisis years can be defined as those in which mortality was above 100 per 1,000. Hence, 1695 was a crisis year for nine out of the thirteen missions of Paraná; according to Burgés, about 16,000 died in Paraná and Uruguay, corresponding to the extraordinary mortality of 200 per 1,000. Crisis hit four out twenty-eight missions in 1719 (1718 was the worse year, but data are lacking), and of the thirty missions existing thereafter, twenty-one suffered a crisis in 1733, sixteen in 1738/39, seven in 1749, and fourteen in 1764/65.[30]

The fathers tried to keep each village isolated, minimizing its contact with other villages and with the external world. But isolation was relative: Rules were broken; communications and trade by river and/or land were easy; and numerous corvées brought the Indios into contact with other tribes and populations. When infection was introduced from outside, it spread from village to village on a contiguous path. The carta ánua of 1661 provides detailed descriptions. In one of them, two infidel Indios were denied entry into Yapeyú (the southernmost mission, on the Uruguay) for fear of contagion. Taking shelter from a storm at a *rancho,* they infected two Indios who were returning to San Tomé. When they reached home, they hid for seven days until discovered by a father, who had been told about "two redfaced Indios," and finally diagnosed them as carrying "the plague [*peste,* or smallpox] that had ravaged the Governatorate and Peru."[31]

Sepp also offered a vivid description: "When the year 1695 was ending, and October, along with springtime, was beginning, a cruel pestilence ravaged Paracuaria, and in a few months, the population of nearly every mission (twenty-four at the time) was infected. . . . The plague was brought by Indios returning from Santa Fe. This city, populated by Spanish merchants, was the first to be hit; than followed Córdoba, Santiago del Estero, and other cities of Paracuaria. At this point, it spread violently among our

1929), I, 215, 452. For mortality in Yapeyú, see Leonhardt, *Cartas Anuas,* II, 709; mortality in Santa Maria, Manuscritos da Coleção De Angelis, *Jesuitas e bandeirantes no Uruguai (1611–1758)* (Rio de Janeiro, 1970), IV, 199–205; mortality in Corpus, Pastells, *Historia,* IV, 56; mortality in San Borja, Maeder and Bolsi, *Población Guaraní,* 75.

30 Burgés statement is quoted in Pastells, *Historia,* V, 52.

31 For the carta ánua of 1661, see Manuscritos, *Jesuitas e bandeirantes,* 204.

missions, wreaking greater havoc with the poor Indios than it did with the rich Spaniards, because the Indio wears just enough clothes to conceal his nakedness but not to defend him from the cold." According to a traveler who had just arrived from Europe, one or more infected passengers from English or Spanish ships were responsible for bringing smallpox to Buenos Aires in 1718.[32]

The continuity and detail of the data permit further conclusions. In 1733, smallpox spread throughout all of the missions, but at other times, certain areas remained untouched. In 1738/39, ten of the thirty missions (almost all of them located in the Paraná valley) escaped the contagion, maintaining a death rate around or below the normal level. In 1749, however, only seven missions had a death rate around or below normal, and only two in 1764/65 (located in Paraná, where the increase of mortality in the other missions was moderate). This pattern is consistent with what normally happens when contagion is re-introduced from the outside to a region where settlements are well connected by land or river—an almost simultaneous explosion of mortality everywhere except in those areas protected by geography, physical/administrative design, or chance.

POPULATION STRUCTURE The data gathered by the Jesuits and published in the annual planillas allow an analysis of the Guaraní population's structure. Muchachos and muchachas were boys and girls younger than seventeen and fifteen years, respectively; pueri and puellae were children younger than seven years; and the adolescentes were girls between seven and fifteen and boys between seven and seventeen. There is evidence, however, that "children" included boys and girls older than seven (see below). The planillas also reported the number of conjugal families (married couples), as well as the number of widowers and widows. Evidently, the wives of runaway and absentee Indios and the women in the *casas de recogidas* (charitable homes for women in need) were recorded as widows; the data count a high number of widows

32 Sepp's description of the 1695 smallpox epidemic is in *Sacro esperimento,* 175. See also Maeder and Bolsi, *Evolución y características,* 127; Pastells, *Historia,* IV, 501; V, 51–55. On the origin of the 1718/19 epidemic, see America Meridionale 2, f. 32, Archivio Congregazione Propaganda Fide, Rome. Africa, via the slave trade, was the main source of smallpox for Brazil and, maybe, for certain areas south of Brazil. See David Alden and Joseph C. Miller, "Out of Africa: The Slave Trade and the Transmission of Smallpox to Brazil, 1560–1831," in Robert I. Rotberg (ed.), *Health and Disease in Human History* (Cambridge, Mass., 2000), 203–230.

(about one of every five adult women) but a relatively small number of widowers (one out of every fifty adult men). The fugitive Guaraní were almost always men (Cardiel's 1 percent of the population) who ended up working as *jornaleros* (workers hired and paid by the day) for the spanish colonists; the women that they left behind were probably counted as widows. Moreover, social norms may have played against widows' remarriage.[33]

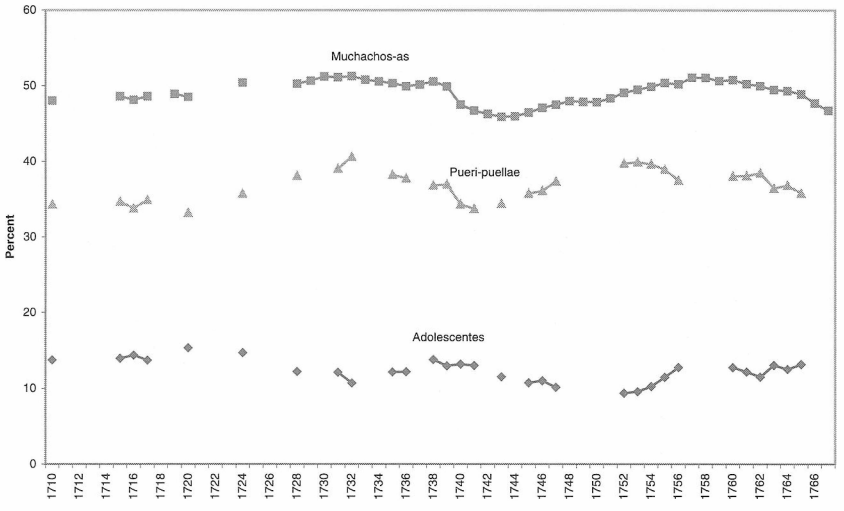
Figure 5 shows the age structure (from 1710 to 1767). The proportion of muchachos and muchachas is relatively stable and close to 50 percent, not surprising for a population with such high renewal, and consistent with that of any stable population that has birth and death rates comparable to those of the Guaraní. Yet, the fact that the proportion of children is low and of adolescentes high (relative to other stable populations with the Guaraní characteristics), suggests that the age limit separating children from adolescentes should be closer to ten years than to seven. The only visible perturbation in the age structure is the depression between the early 1730s and the early 1740s, which is understandable in light of the low birth rate during the disastrous 1730s. The decline of the proportion of the young at the end of the period coincides with the beginning of the crisis that descended on the Guaraní after the expulsion of the Jesuits.

The social structure imposed by the Jesuits was based on the nuclear family of parents and children; widows and orphans lived in communal houses sustained by the community. The fathers promoted the family as the proper setting and institution for reproduction, and they attempted to withdraw the young from their parents' influence well before their precocious age of marriage. Cardiel is explicit on the matter: "When children have reached the age of seven, the Alcaldes inscribe them [the children] in their books, and they join the others [the adolescents] for collective religious and social activities until their marriage. Indeed, if they are left to the care of their parents, they are so devoid of judgment that they grow up like little animals and remain idle all their life."[34]

The number of muchachos and muchachas per family (or per conjugal couple) was between 2 and 2.5; the mean family size between 4 and 4.5. The ratio dropped to its lowest point during the

33 On widows, see Furlong, *José Cardiel,* 142; Caraman, *Lost Paradise,* 135.
34 Furlong, *José Cardiel,* 172.

Fig. 5 Age Structure of the Population, 1710–1767

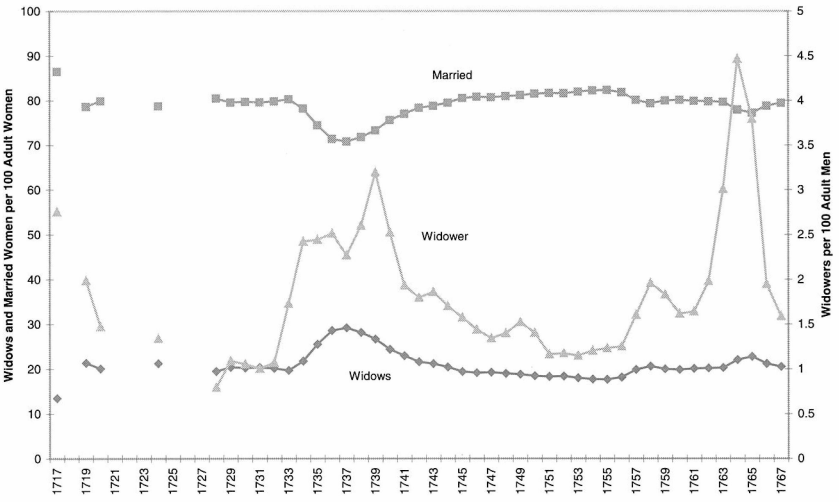


deep crisis of the 1730s; after a recovery, it declined again near the end of the period.

Marital status in the missions becomes evident through the ratios married women/adult women, widows/adult women, and widowers/adult men (Figure 6). Four out of five adult women over the age of fifteen were married—a large proportion (apart from depression in the 1730s) when compared with contemporary European populations. Widowers were few, and the ratio widows/adults remained below 2 percent except during mortality crises (a maximum of 4.5 percent in 1764). On normal demographic terms, the small proportion of widowers is surprising given that boys theoretically married only two years later than girls. But it can be explained by three not mutually exclusive factors: that widowers fled the villages more easily and more frequently than married adults, that men's mortality was higher than women's, and that widowers remarried more frequently than widows. Although differential mortality and differential remarriage may be thought to supply an explanation for the scarcity of widowers, the fact that men, once free from marital obligations, fled the missions, appears to be a more convincing one.

The data of the planillas confirm three fundamental features of the Guaraní demographic system: a young age structure, a high

Fig. 6 Population of the Missions by Marital Status, 1717–1767



birth rate, and a dynamic natural renewal of the population. The relevance of these aspects for epidemiology and acculturation have already been discussed. The Guaraní had early and universal marriage; monogamy and stability were encouraged and enforced, thus maximising fertility. Finally, few males remained in the missions as widowers, perhaps because the system encouraged remarriage (though no documentary evidence to that effect exists) but more likely because widowers fled the strict control of the system.

THE DEMOGRAPHIC SYSTEM AND SURVIVAL Like all poor and uneducated populations, the Guaraní were plagued by a high mortality as a result of hunger, disease, or violence. The Jesuits tried to control the risk factors by organizing the production and distribution of food, isolating and attending the sick during the epidemics, and protecting the Indios from serfdom, enslavement, and brutality. Although their efforts certainly had positive consequences—as impossible as they may be to quantify—they were offset by the crowded conditions in the villages, which reinforced the destructive impact of smallpox, measles, and other communicable diseases. Whenever the social and economic system was under duress, the Indios tended to flee *a los montes* (into the wilderness)

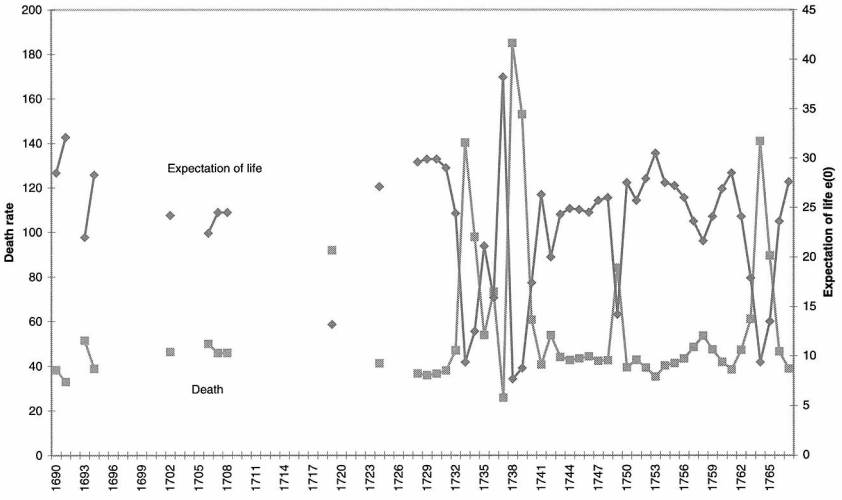
and to revert to the traditional way of life that a long process of adaptation had recommended as more conducive to survival.

The analysis of mortality reveals a pattern of low and precarious survival. Table 4 shows the death rates, the incidence of párvulos (childrens') deaths with respect to the total, the estimates of life expectancy, and the death rates for párvulos and adolescentes/adultos. These two latter ratios are ambiguous, since the age limit of the párvulos is uncertain, although an age close to ten seems coherent with the resulting death rates. To facilitate synthesis and comparisons, Table 4 gives the mean and median value for the entire period (1690 to 1767) and for the periods of expansion (1690 to 1732) and of crisis–recovery–decline (1733 to 1767). It also gives means and medians for each of the eight decades (though the pre-1728 data are sporadic). Figure 7 shows the general trends as well as the fluctuations of the indicators.

The median values of the indicators—which may be thought to represent the levels of mortality and survival in normal years—indicate that death rate and life expectancy were more favorable during the first than during the second period, by three years in each case. The mean life expectancy for the entire period is 23.3 years and the median 24.5—low values that confirm the precariousness of Guaraní survival. In each of the fifty years for which an estimate of $e(0)$ is possible, the level of 30 is surpassed only three times (1691, 1737, and 1753); $e(0)$ falls below 20 eight times. On the four occasions when it falls below 10 (1733, 1738, 1739, and 1764), the death rate was above 150 per 1,000. There were limits to survival even in the most favorable years. In 1737—one of the three years with $e(0)$ above 30—high survival was probably the consequence of the selective effects of the high mortality during the preceding four disastrous years.

The lower threshold of survival is extraordinary. The large proportion of those not immune to epidemic diseases, due to the high birth rate and the concentrated living conditons, meant high rates of infection and mortality. Skilled as the Jesuit fathers were in the medical practice of their time, including access to a varied pharmacopoeia—both local and imported—they probably could do little to stem the tide of mortality in the missions. The extensive medical knowledge accumulated in London, Paris, or Padua presumably had little effect on survival in those cities either. A life expectancy approaching twenty-five years in crisis-free times is

Fig. 7 Death Rate and Expectation of Life, e(0), 1690–1767



not outside the norm for a non-European population like that of the Guaraní in the Paraná and Uruguay valleys. It is also an indication of the likely mortality in pre-contact populations. The "normal" rate of natural growth—close to two percent—was more the consequence of high fertility than moderate mortality.[35]

THE DEMOGRAPHIC SYSTEM: NUPTIALITY AND FERTILITY The evangelization of the Guaraní was based on a radical modification of their rules and customs concerning unions and reproduction. The Jesuits knew that they could not convert adult Guaraní to a "nonbarbarous" way of life immediately. They even consulted Pope Urbano VIII on the matter of how to handle concubinage and polygamy. Their hope was eventually to inure the Guaraní to a monogamous way of life in nuclear and autonomous families through the education and discipline of their children. Under the tutelage of the fathers, boys and girls were separated in all communal activities (schooling, prayer, and work) and ushered into marriage as teenagers. Repression and punishment were used to enforce the rules of marital life, and each family was assigned a rigorously delimited and independent living space, even if still within communal housing. The resulting early, universal, and stable mar-

35 On the Jesuits' pharmacopoiea, see Caraman, *Lost Paradise,* 144–145.

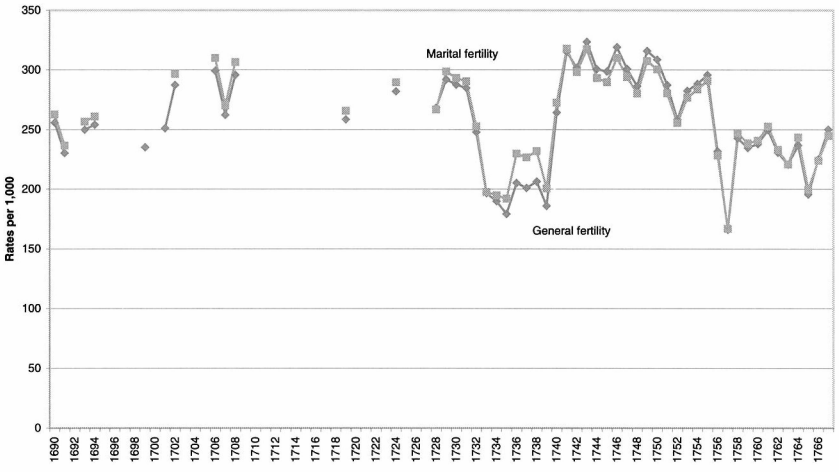
riages among the Guarani resulted in a high birth rate and might have produced a high growth rate if not for epidemic disease and the expulsion of the Jesuits, after which promiscousness and full communal life reemerged.[36]

Table 5 and figures 8 and 9 show the indicators of nuptiality and fertility from 1690 to 1767. We have already noted that four-fifths of adult women were married (Figure 4); if the same kind of ratio could be calculated for women of fertile age, younger than forty-five, the value would be higher (the proportion of widows older than forty-five exceeds that for those younger than forty-five). In practice, almost all adult women younger than forty-five were married. The median value of the marriage rate during the period under study was 13.3 per 1,000 (about double this number for the female population). Hence, each year, about 2.7 percent of the adult Guaraní women wed; assuming that some of them were widows remarrying, this figure is coherent with the presumed weight of a cohort comprised of fifteen-year-old girls in a stable population with the Guaraní characteristics.

High nuptiality and the (relative) stability of marriages imply a high birth rate; the median value in the missions from 1690 to 1767 period was 61 per 1,000, almost double the birth rate of some contemporary European populations. Other measures are the marital fertility rate (MFR, baptisms per 1,000 married women of all ages), the general fertility rate (GFR, baptisms per 1,000 adult women younger than forty-five, based on estimates), the total fertility rate (TFR, calculated as GFR x 30), and the mean number of baptisms per marriage (BMR). All of these indicators are, as is to be expected, in close correlation. They are higher during the period of expansion (1690 to 1732) (5 to 15 percent) than during the period of crisis–recovery–decline (1733 to 1767). Interestingly, the birth rate during the period of crisis–recovery–decline (a median value 8 points below that during the period of expansion) had been more depressed than the death rate had been increased (3 points above that during the period of expansion). That the TFR during the entire period of study was 7.7—significantly higher then the 6.5 estimated for Paraguay by the United Nations for the 1950s, when Paraguayan women were not yet controlling their

36 For the debate about concubinage and polygamy, see Peramás, *República,* 65. On the re-emergence of traditional customs after the Jesuits' expulsion, see Doblas, *Memória,* 33–34.

Fig. 8 General and Marital Fertility, 1690–1767

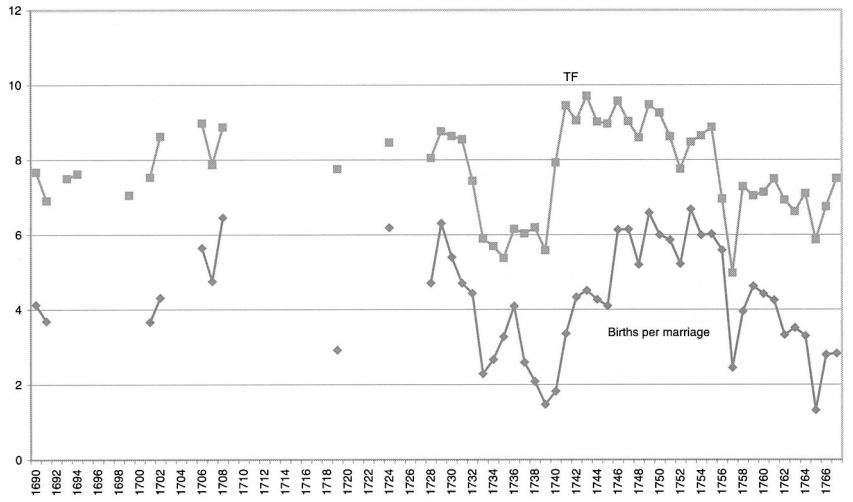


fertility—constitutes indirect proof that reproduction was at extraordinarily high levels during the Jesuit régime. TFR remained only marginally below 6 even during the 1730s, the period of deepest crisis, in spite of the many corvées (as many as 12,000 men mobilized in order to repress the uprising in Asunción), famines, and epidemics, and rebounded to greater than 9 during the 1740s. In a society with high fertility, even the deepest wounds can rapidly heal.[37]

How high was the Guaraní women's fertility? Was it depressed—if compared with natural levels—by such intermediate variables as long breastfeeding and birth intervals, absentee partners, pathologies, or abortion? Literary evidence is contradictory: Dobrizhoffer pointed to the high fecundity of the Indias whereas Alvear thought the contrary. However an indirect test is possible. Under certain hypotheses about the age distribution of married women, an Ig (the ratio between the actual number of births and the number of births that would have occurred given the highest fertility on record—namely, that of the Hutterite women) of approximately 0.8 appears reasonable. This estimate is in the range of average to high when compared with the historical record or with

37 United Nations, *World Population Prospects: The 2000 Revision* (New York, 2001).

Fig. 9 Total Fertility Rates (TFR) and Births per Marriage, 1690–1767



the record of contemporary populations not practicing fertility control.[38]

The departure of the Jesuits in 1768 set in motion a process of decline that might have already begun during the last decade of their rule. In 1768, the missions' population was close to 90,000; in 1800, it fell to 40,000. Epidemic crises ravaged the missions during the 1770s, in 1788, and from 1796 to 1797 as they had during the Jesuit years, but their impact is difficult to assess due to the discontinuity and inferiority of the data. There is some evidence that mortality during years free from epidemics was higher than it had been in the past. For example, the death rate was 55 per 1,000 in the epidemic-free years 1793, 1798, 1799, and 1803, compared with a median of 44 per 1,000 during the Jesuit period. The number of births during those four years remained below that of deaths; traditionally, periods free of stress have a large surplus.

But it was emigration that determined the final decline. Wrote Maeder and Bolsi: "The exploitation suffered at the hands

38 On the fecundity of Guaraní women, see Dobrizhoffer, *Historia Abipones,* I, 107; Alvear, *Relación Geografica,* 595. For modern writers' opinions, see Armani, *Città di Dio,* 149; Furlong, *Misiones,* 289; Owens, "Historical Geography," 143. Assuming that 10 % of married women were older than fifty, and assigning to them a plausible age distribution, Ig in the various decades fell between 0.7 and 0.9, with an average around 0.8.

of the new administrators, poor nutrition, neglect and miseries of all kinds induced the Guaraní to look elsewhere for a better life, free from the constraints of the communitarian system. They emigrated to the areas bordering the periphery of the missions' region." Indeed, the Jesuits—a motivated, able, and dedicated group of administrators and educators—were replaced by an indifferent, if not outright corrupt, administration. The ensuing crisis was social, economic, and demographic. In Maeder and Bolsi's words, "The fundamental missionary action [of the Jesuits] strived to orient the missions' Guaraní toward the formation of an indigenous society that was Christian, kept in isolation and protected from the colonial world. But now the orientation was to integrate them into that same colonial society that was growing all around them, encouraging a continous interaction, individual freedom, trade and mixing, under a contradictory régime in which political and religious power were not united, as before, in the same person." This evolution was probably inevitable, but its consequences were distinctly negative.[39]

Analysis of the Guaraní experience is helpful for understanding the demography of the colonial period. Three major points emerge. The first concerns the epidemiological and demographic consequences of contact. By the time the Jesuit system had reached maturity—approximately the century preceding the expulsion—the Guaraní had already experienced the devastating impact of European diseases for two or three generations. But one or two centuries after the initial contact, smallpox epidemics continued to be disastrous—even though they took place in a nonvirgin population. Mortality rates of 150 or 200 per 1,000 continued to be the rule, largely because the diseases were not endemic and occurred every fifteen years or so in a largely susceptible population with a youthul age structure (50 percent younger than fifteen). A fifteen-year-interval between outbreaks would have found two out of three people without immunity. The density of the missions' populations increased the risk of infection in spite of the fathers' efforts to isolate the sick. The impact of epidemics during the latter part of Jesuit rule was no less devastating than that during the century and a half following it.

39 Maeder and Bolsi, *Población Guaraní post-Jesuítica,* 75–78, analyze demography in the post-Jesuit decades. Maeder's quotation can be found in *idem, Aproximación a las Misiones Guaraníticas* (Buenos Aires, 1996), 117.

The second point is that the Jesuits' emphasis on marriage at an early age maintained the birth rate at the maximum level under normal conditions, generating a large enough surplus of births relative to deaths to compensate for deficits during years of crisis. In contrast with other American populations following contact, in which the negative effect of high mortality from imported diseases combined with the disruption and dislocation of traditional social life and the weakening of the birth rate, the Guaraní managed to come out ahead under the Jesuits. They increased their numbers rapidly for a century and repaired the losses from four epidemics, two wars, and related famines during the last decades before the Jesuits' expulsion.

Third, the Jesuits' isolation of the Guaraní from whites and blacks protected them from the demographic weakening that other autochthonous populations had to endure under white domination. The social stability and economic achievements that the Guaraní enjoyed under the Jesuits led to an increase in their standard of living and had a positive impact on the their demography.

In 1563—two centuries before the expulsion and less than thirty years after the first Spanish settlement—León, the procurador general of the rio de la Plata, wrote to the king that the decline of the autochthonous population was so severe in the Indies that slaves had to be imported from Guinea (West Africa), a remedy that turned out not to be possible at so great a distance. This depletion was a matter of grave concern for colony and motherland alike for two centuries. Yet, no irremediable disasters occurred under Jesuit rule. Germs were a dangerous enemy for all of the New World populations, but human behavior in the Guaraní settlements governed by the Jesuits had a significant effect on survival.[40]

APPENDIX: DATA, ESTIMATES, AND CALCULATIONS

The original planillas containing the data used in this paper have a standard format. Each planilla refers to one year's data for every mission and a recapitulation for the two regions of Paraná and Uruguay. Maeder

40 Antonio de León's letter to the king can be found in Pastells, *Historia,* I, 276.

and Bolsi have analyzed most of the planillas in the Archivo General de la Nación (AGN) in Buenos Aires (see n. 3); new planillas (as well as copies of planillas already known) found in the Archivum Romanum Societatis Jesu (ARSI) in Rome have been used herein to integrate and check the series. The ARSI planillas refer to the years 1691, 1702, 1710, 1724, 1732, 1736, 1739–1741, 1743, 1762, and 1767 (Paraquariae 7, 12, and 13). Francesco Barbarani, of the University of Verona, graciously offered the authors copies of planillas collected in AGN for further research (1715–1717, 1720, 1724, 1728, 1731, 1733, 1735, 1738–1739, 1744–1758, and 1760–1765—AGN IX and AGN Archivo Lamas).

In three cases (for three years), the new planillas supplied missing vital statistics; in other cases (involving nine years), they helped to clarify the distinction between the deaths of párvulos and those of adultos; in most of the cases (involving twenty-six years), the new information concerned the categories of pueri, puellae and adolescentes. Crosschecking the planillas has resulted in the discovery and correction of minor errors. In general, planillas written by different hands and found in such distant locations as Rio de Janeiro, Buenos Aires, and Rome, and those reprinted by contemporary authors, are surprisingly coincident, with few copying errors.

For all years for which such control was possible, we have checked the total population with the sum of different categories that (theoretically) equal that total (doubling the number of families—each family constituted by a conjugal couple—yields the total married population, and adding the number of muchachos/as and the number of viudos/as equals the total population). In only three cases was the discrepancy in excess of 1 per 1,000. Minor gaps in the almost uninterrupted series from 1728 to 1767 have been filled with appropriate estimates. The major gaps were the years 1730, 1734, and 1760 for which data on marriages, births, and deaths were missing. Rates for those years were estimated as equivalent to the average of the (known) rates for adjoining years, multiplied according to the population of the missing year.

The fathers' articulate, strict, and precise administration of the missions and the concentration of the population in villages bode well for the quality of the data. Baptisms have been equated to births. Although normally administered every week, baptisms took place immediately after birth when babies seemed at risk. Some illegitimate births might have escaped registration, but no such documentary evidence exists.

Vital rates were calculated by averaging the population for two consecutive years (in the planillas, the data of stock refer to the end of the year). The calculation of GFR (general fertility rate) entailed an estimate of the number of women aged fifteen to forty-four. In stable populations with characteristics similar to the Guaraní, this age group generally constitutes about four-fifths of the total female population older than fifteen (a figure that equals the sum of the total number of families—one married woman for every family—and of the number of widows). Yearly

fluctuations around this (fairly stable) value have been estimated on the basis of the (known) ratio between the muchachas (younger than fifteen) and the total women older than fifteen. TFR (total fertility rate) has been taken as GFR x 30.

The estimate of e(0), for each year, is the result of combining the death rate (CDR) with the proportion of muchachas (females younger than fifteen, taken as a proxy of the age structure, and relatively unaffected by emigration) and locating the corresponding e(0) value in a stable population. The estimate of e(0) can be done in an alternative but equivalent way, yielding similar results. For each year, a complete age structure is estimated on the basis of the few known parameters (proportion of pueri/puellae, proportion of muchachos/muchachas), and a standard schedule of death rates is chosen, permitting a calculation of the standard number of deaths for each calendar year. Then the ratio of the actual to the standard number of deaths is computed for every year and the ratio used in order to correct the value of e(0) of the standard schedule. Given the paucity of details in the existing data, the two methods produce rather raw estimates.[41]

41 For more details about these estimates, see Livi-Bacci and Maeder, "Misiones Paraquariae."