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The Reproductive Transition in an Indigenous Population of Northern Argentina

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Latin America has been registering a fast decrease in fertility rates since the mid-twentieth century. This change can be linked to the modernization process these populations have been undergoing. However, research with Latin American indigenous populations, which are undergoing relatively similar lifestyle changes, shows very different trends in fertility. The aim of this study was to analyze fertility patterns in the indigenous Toba community of Cacique Sombrero Negro, which is experiencing a rapid process of economic and social Westernization. Fertility patterns were analyzed between 1981 and 1999, the period for which the most accurate records were found. Results showed an overall increase in fertility rates and changes in the age of peak fertility across time periods. It is hypothesized that the lifestyle transition this population is experiencing leads to better access to resources that, in the absence of contraception, allow for a higher number of offspring. Nevertheless, this higher resource availability would be differential, affecting mostly the fertility of younger mothers.

Introduction

Fertility is the demographic variable with the highest influence on the growth, size, and age structure of a population. Thus, a better understanding of the dynamics underlying changes in fertility in different populations is paramount for building strong theoretical models with greater predictive capacity. Latin America presents an interesting case, given the heterogeneity in its response to the demographic transition. Fertility rates in Latin America have shown a continuous decline since the mid-twentieth century (Economic Commission for Latin America and the Caribbean [ECLAC] 2001; Chackiel 2004). This decline was achieved in a relatively short period of time: fertility rates decreased by 60 percent over a 50-year period (ECLAC-Centro Latinoamericano y Caribeño de Demografia [CELADE] 2004). This demographic change was produced mainly by a reduction in the birth rate of women 20 years and older (Ferrando 2004). As postulated by the demographic

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transition theory, these changes would be driven by modernization processes affecting these populations (Caldwell 1976; Kirk 1996).

Indigenous populations in Latin America represent particularly useful cases for an analysis of demographic transition changes. Studies among indigenous populations in Bolivia (Economic Commission for Latin America and the Caribbean [ECLAC] 2005b), Ecuador (ECLAC 2005a), Panama (ECLAC 2005c), and Paraguay (Melià 1997) have shown, in most cases, a reduction in fertility rates, as expected from the theory. However, different and even increasing rates have also been registered in indigenous populations undergoing modernization in Latin America. For instance, a comparison between the 1992 (Melià 1997) and 2002 (Arce Bordón 2005) censuses in Paraguay shows a decrease in infant mortality—an important fertility determinant (Bongaarts 1978) and life condition indicator—as well as an increase in fertility of the Guaná, Avá Guaraní, Toba Maskoy, and Maká ethnic populations. Similar increments in comparable populations have been registered in the Aché population of Paraguay (Hill and Hurtado 1996) and the Hupd'ah (Machado et al. 2009), Kamaiurá (Pagliaro and Junqueira 2007), and Kaiabi (Pagliaro 2002) populations of Brazil. That is to say, in these communities, modernization is associated with a change in fertility contrary to the one expected from the demographic transition theory.

Argentina is one of the Latin American countries with the most advanced transition process and the one in which the fertility decline started the earliest (Pantelides 1983; ECLAC-CELADE 2004). Between 1895 and 1991, the total fertility rate (TFR) decreased from 7.0 to 2.9. This decline was most likely heavily influenced by the massive waves of European immigrants who arrived in Argentina during that period (Torrado 1999). These immigrants maintained the "modern," lower-fertility reproductive trends of their "developed" countries of origin (mainly Spain and Italy, but also Germany, Austria, and Poland). In the region of the Argentine Chaco (northwestern Argentina), the modernization process influencing the indigenous populations started in the early twentieth century. Being nomadic or seminomadic and having an economy based on hunting, fishing, and harvesting (Arenas 2003), the Chacoan populations practiced a lifestyle that was affected by the restriction of access to large areas of land, by their partial integration into labor and consumer markets, and by the arrival of different missionaries from various Christian denominations (Braunstein and Miller 1999). Throughout the twentieth century, a continuous process of environmental decay and a diminution in labor demand produced migration toward the main urban centers in the country. However, small rural indigenous communities still exist that, despite a sedentary lifestyle, maintain their own subsistence (Valeggia, Lanza, and Córdoba 2005), as well as traditional economic (Gordillo 2006) and cultural (Braunstein and Miller 1999) patterns. The rural Cacique Sombrero Negro Toba population represents one of these communities. Nevertheless, since the late 1980s, the provincial government's grant of 35,000 hectares of land (de la Cruz and Mendoza 1989), the development of different assistance programs, and the increasing number of indigenous men and women working for the provincial and municipal government (Gordillo 2006) have accelerated the sedentarization process of this population. In the last 25 years, this population has undergone a rapid change from a hunting-gathering lifestyle toward an increasing dependency on the market economy, a change that is expected to affect their reproductive behavior. The aim of this study was to estimate and analyze changes in fertility patterns in the Cacique Sombrero Negro Toba population of northern Argentina. Results were then compared with Argentine trends and, finally, some theoretical considerations were examined in order to evaluate possible reasons for the changes in reproductive behavior recorded in this population.

Methods

Ethnohistorical Background

The Toba are one of several indigenous groups that currently live in the Gran Chaco region in northern Argentina. Traditionally, the Toba were nomadic or seminomadic hunter-gatherers with rudimentary agriculture (Arenas 2003; Braunstein and Miller 1999). Historical documents suggest that their first contact with Spanish colonizers occurred around the 1550s, but the Gran Chaco people successfully resisted colonization and "civilization" attempts by the nation-state. It was not actually until the beginning of the twentieth century that major changes in their traditional lifestyle began to occur (Braunstein and Miller 1999). The restrictions on access to large tracts of land, their partial integration into the labor market, and the arrival of missionaries from various Christian denominations have been major determinants in the settlement process of these communities (Gordillo 1994; Gordilla 2002; Braunstein and Miller 1999; Mendoza 2002). Depending on their location, different communities have been exposed to varying degrees of these forces. As a result, Toba settlements can be found in a variety of social and ecological conditions, ranging from a rural, more traditional lifestyle that is relatively foraging-dependent to an urban, sedentary lifestyle that relies on wage labor and store-bought goods for sustenance.

Study Population

This study was conducted in the Toba communities of Cacique Sombrero Negro. The Cacique Sombrero Negro population is organized around five major villages called Vaca Perdida, La Rinconada, Tres Yuchanes, Pozo Ramón, and El Churcal. These villages are located near the midpoint of the Pilcomayo River, toward the northwestern corner of the province of Formosa in northern Argentina (see Figure 1).

The Toba communities of Cacique Sombrero Negro own 35,000 hectares of land, which are considered communal property. The approximately 1,739 inhabitants in this area still rely heavily on traditional forms of economic activity, including hunting and fishing, rudimentary agriculture, and the gathering of seasonal fruits (Gordillo 1994; Mendoza 2002; Arenas 2003). Their first language is the indigenous one (which belongs to the Guaycuruan family), although most men and some women also speak Spanish. Access to Western medical care is limited in these communities, and the use of contraceptives is rare.

Data Sources

We used multiple sources of data. The censuses used in this analysis were obtained by indigenous health workers[11] belonging to the same study population. Table 1 shows the number of people surveyed for each of the communities between 1985 and 2002.

The government of Formosa province developed health systems to integrate indigenous peoples into the larger society. Toward the end of the 1960s, it developed various training programs for Toba nurses and midwives and other indigenous people. The provincial government also established in various communities a local health post where the Toba nurses performed. They helped a doctor who regularly visited the indigenous populations (Bargalló 1992). From our field experience, we found that the Toba nurses also carried out censuses of indigenous communities, registered births and deaths, reported diseases—mainly tuberculosis and Chagas—distributed milk for infants and children, monitored pregnant women periodically, assisted in vaccination campaigns, and warned the doctor in case of emergencies. In brief, the indigenous health workers acted as middlemen between their own indigenous community and the health system developed by the provincial government.

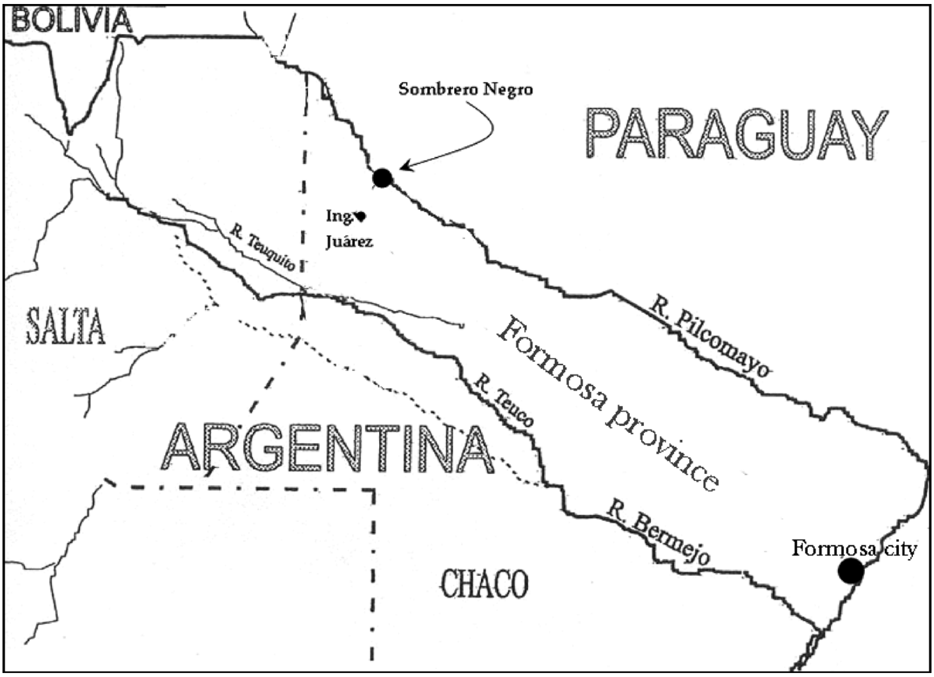

Figure 1. Relative location of the Toba Sombrero Negro of the mid-Pilcomayo River. Adapted from Gordillo (2002).

Table 1
Total number of Toba population recorded in each community of Sombrero Negro

Communities	1985	1993	1995	2002
Vaca Perdida	244	—	236	302
La Rinconada	580	—	—	886
Tres Yuchanes	46	—	89	112
Pozo Ramón	39	75	—	123
El Churcal	172	280	—	316

Source: Local health center (information collected by Toba health workers).

In addition, we obtained birth data from the Civil Registry for the period between 1992 and 2002 and from the local health post for the period between 1999 and 2002, both located in the town of Pozo de Maza.[2] These sources include detailed information about mothers and children, such as name, surname, age, and date of birth. We also conducted reproductive history interviews of women 12 years and older. We attempted to interview all women in the community. The final number of women interviewed was 338, which represented approximately 70 percent of the female population of reproductive age. From

[2]The town of Pozo de Maza is located 11 kilometers south of the village of Vaca Perdida. Its Civil Registry records vital events throughout the area. The local health post provides first aid and health promotion and is staffed by a physician, a nurse, a dentist, and an indigenous health agent, who works as a translator for the indigenous patients.

these interviews, we gathered information about 1,233 births. Recruitment was done in two waves of household visits, conducted one month apart. Toba people make social visits to relatives in other communities quite frequently, which is the main reason why we were not able to collect reproductive histories from all women. We did not expect a selection bias to affect our results.

Data Analysis

Cross-checking among the different sources of demographic data allowed us to overcome some of the difficulties in obtaining accurate information because of language barriers, omission of births and deaths of children, and other missing information. In addition, we used a cross-checking process to eliminate simultaneous reporting of the same birth data in several sources.

We focused our analysis on the 1981–1999 period, and in order to evaluate possible changes in fertility levels and age distribution across time, we organized the data into four time periods: 1981–1984, 1985–1989, 1990–1994, and 1995–1999. For each of these periods, we estimated the age-specific fertility (fx) and the TFR. We analyzed both variables to discover the possible effects of modernization on the reproductive behavior of women at different ages, as well as the total number of children born. Irregularities in age-specific fertility were adjusted using the Brass method for standard age-specific fertility curves (Brass 1974). The standard age-specific fertility curve was chosen considering two parameters. The first parameter (α) was calculated as the difference between the average age of fertility of the observed curve and a selected standard age-specific fertility curve. The second parameter (β) was calculated as the ratio between the log of the observed curve and the selected standard age-specific fertility curve. We chose the standard curves that yielded α values closest to zero and β values closest to 1 (for more information, see Chackiel 1979).

Finally, we estimated the average age of fertility for each period and the percent distribution of age-specific fertility to total fertility of women less than 20 years old, between 20 and 34, and older than 34 years old.

Research Ethics

The research design and data collection for this study used the following process to obtain informed consent. We discussed the research plan with community leaders and then explained the purpose and design of the study during community meetings. As the meetings developed, local health agents translated discussions and agreements into the Toba local languages as necessary. Verbal consent was obtained from all individual participants, with only two people declining to participate because of lack of interest. Reports of study results were presented at a community meeting. The research protocol was reviewed and approved by the University of Pennsylvania Institutional Review Board, protocol #804880.

Results

The TFRs for each of the analyzed periods indicate high fertility values (Table 2). Furthermore, TFR increased with time during the period analyzed here.

Our analysis also points to changes in age-specific fertility curves. During the 1981–1984 period, we find an early fertility peak in the 20–24 age category and a late peak in the 35–44 category (Figure 2a). We smoothed the age-specific fertility curve with the Brass method using the standard age-specific fertility curve for indigenous populations

Table 2
Total fertility rate (TFR), average age of fertility (AAF), and age-specific contribution to total fertility (%)

Years	TFR	AAF (years)	<20	20–34	>34
1981–1984	6.5	27.8	20.4	57.9	21.7
1985–1989	6.2	29.5	17.2	53.9	28.9
1990–1994	6.7	30.6	14.0	53.1	32.9
1995–1999	7.3	29.5	15.7	56.0	28.3

Source: Census, Civil Register, health center, Toba health workers, and interviews with Toba women.

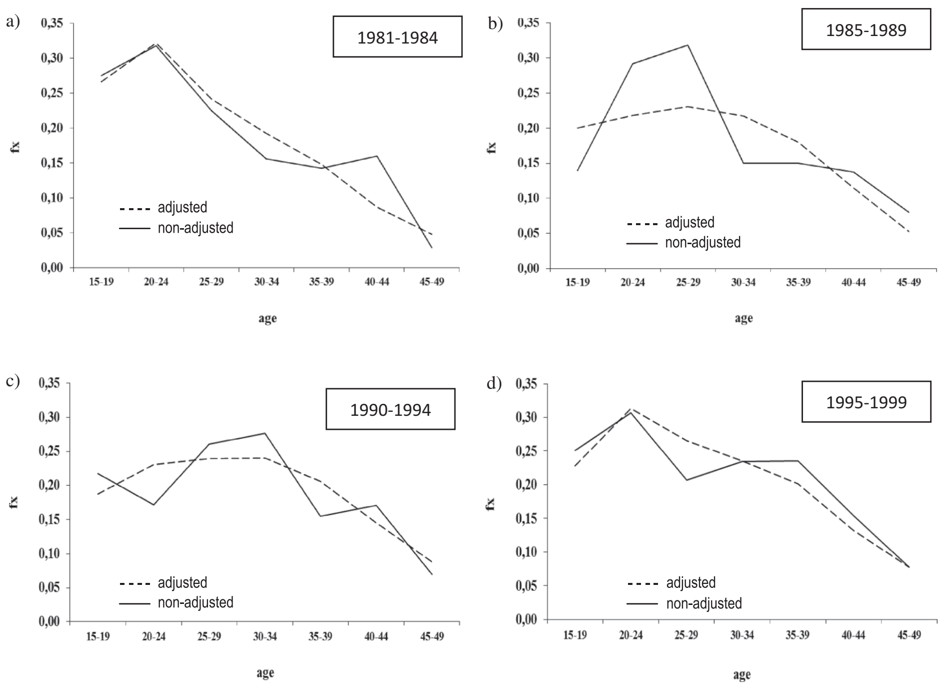

Figure 2. Adjusted (dashed line) and nonadjusted (solid line) age-specific fertility curves of Sombrero Negro from (a) 1981–1984, (b) 1985–1989, (c) 1990–1994, and (d) 1995–1999. Adjustment was performed using the Brass (1974) method.

in Paraguay (Melià 1997). The α value of 0.9169 and β value of –0.1169 were considered acceptable. The smoothing method is shown in Table A1 of the Appendix.

The age-specific fertility curve for the 1985–1989 period shows a peak in the 25–29 years category and a significant reduction in adolescent fertility (Figure 2b). It also shows a decline in fertility in the 30–39 age category. We used the standard age-specific fertility curve belonging to Haiti's age-specific fertility curve for 1950–1955 (ECLAC–CELADE 2004). The values of α and β were –0.2753 and 0.8365, respectively. The details of this method are shown in Table A2 of the Appendix.

For the age-specific fertility curve for the 1990–1994 period (Figure 2c), we obtained a modal age equal to that found for previous years. The analysis showed a decline in adolescent fertility but an increase in the 20–34 age category. We smoothed the shape of the fertility curve of the Toba population using the age-specific fertility curve of Nigeria from 1990 (Federal Office of Statistics, Lagos, and IRD/Macro International 1992). The values of α and β were –0.006 and 0.9817, respectively, which were considered acceptable. The details of this method are shown in Table A3 of the Appendix.

The age-specific fertility curve for the 1995–1999 period showed a younger modal age than that found for previous years. The peak fertility was found between 20 and 24 years old (Figure 2d). With the Brass method, we used a standard-shaped curve belonging to the indigenous populations of Paraguay (Melià 1997). The values of α and β were 0.0952 and 0.8312, respectively (Figure 2c). The details of the procedure performed are outlined in Table A4 of the Appendix.

The average age of fertility and percent distribution of total fertility by broad age groups show large changes in the pattern of Toba fertility (Table 2). Between 1981 and 1999, the average age of fertility increased by about two years. The contribution of women younger than 20 years of age decreased more than 20 percent from their contribution during the 1981–1984 period. However, the participation of women older than 34 years shows an increasing trend (Table 2).

Discussion

Our results indicate that the Toba showed pretransitional values of fertility during the period studied (1981–1999). The demographic dynamics of this indigenous population contrast sharply with the general trends for Argentina and the Gran Chaco region. In fact, the population of the province of Formosa, where the study population is located, experienced a substantial decline in the TFR from 5.01 to 3.4 between 1980 and 2001 (see www.indec.gov.ar).

However, the values obtained in our analysis are similar to the ones found in other Latin American indigenous populations (Hill and Hurtado 1996; Melià 1997; Piñeros-Petersen and Ruiz-Salguero 1998; McSweeney 2002; Pagliaro 2002; McSweeney 2005; Machado, Pagliaro, and Baruzzi 2009; de Souza, Pagliaro, and Santos 2009). Our results are also in line with Campbell and Wood's (1988) analysis of 70 pretransitional populations, which calculated a TFR between four and eight children and an average of 6.1 children. Bentley, Jasieńska, and Goldberg (1993a; 1993b) estimated a hunter-gatherer fertility of 5.4 (SD ± 0.8), somewhat lower than the values obtained for the Toba population, but within the same range.

The Toba age-specific fertility curve shows variation over time. During the 1981–1984 period, there was a fertility peak in the 20–24 age category. Valeggia and Ellison (2003) showed an age-specific fertility curve with a modal age between 20 and 24 years old for a different Toba population in Argentina. A similar shape has been found for indigenous populations like the Xavánte of Brazil (Santos, Flowers, and Coimbra 2005) and in Paraguay (Melià 1997), Ecuador (ECLAC 2005a), and Bolivia (ECLAC 2005b). Nevertheless, the Toba age-specific fertility curve shows a pattern of change between 1985 and 1994 that is at odds with that recorded for Latin America in general and Argentina in particular. The Toba population showed an aging of their age-specific fertility curve, while Latin America showed a younger fertility curve said by some to be due to the increasing use of contraceptive methods among women older than 30 years (Ferrando 2004). In Argentina as a whole, the modal age of childbearing has not changed since 1950, remaining between 25 and 29 years old (ECLAC 2001). However, in the 1995–1999 period, the Toba show an increase in fertility, with a peak in the 20–24 age category, resulting in a younger fertility curve than appears in the two previous periods.

Possible Causes of Fertility Increase

From a political-economic perspective (Goodman and Leatherman 1998), environments determine the availability of resources, which in turn define the reproductive capacity of individuals (Vallin 1994). Hence, changes in lifestyle are predicted to affect human reproductive behavior. The Toba communities of Cacique Sombrero Negro are undergoing social, economic, and cultural transitions that affect their demographic dynamics. Many studies have shown a rise in fertility in sedentarized populations (Roth 1985; Meir 1986; Pennington 2001; Joseph 2004; Sueyoshi and Ohtsuka 2008). Thus, this negative association between fertility and activity levels would indicate a lower trade-off between foraging activities (production) and reproduction (Hill and Kaplan 1988). It is then possible that the change in fertility patterns observed in our study could result from the combination of a transition toward more sedentary lifestyles and an increase in the caloric content of the diet.

Highly sedentary lifestyles require less daily energy expenditure (Popkin 1998). Wage labor and immersion in the market economy have offered the previously isolated Toba communities greater access to purchased food items (Gordillo 2006). Indeed, estimates by Valeggia, Lanza, and Córdoba (2005) have shown that for the study Toba population, approximately 50 percent of food was store-bought and consisted of high-starch items such as wheat flour and cornmeal and processed products such as biscuits, sweets, and sugar. This study also showed that when foraging activities decreased seasonally, daily meals were supplemented with purchased food. Acquiring food from the market is, in general, energetically less demanding than foraging activities. Toba people are usually able to obtain rides on motorized vehicles to the nearby towns to purchase these items. Concurrently, Valeggia and Lanza (2005) showed a relatively high prevalence of overweight and obesity in the study population. Interestingly, it was the families of political leaders (men who have developed strong ties with the nonindigenous sector) who had the higher body mass index values (Valeggia, Burke, and Fernandez-Duque 2010).

In sum, data from previous studies point to a reduction in physical activity levels and an increase in caloric intake, which leads to a positive energy balance (as indicated by high body mass and fat percentage values). In economic terms, this would be similar to having lower production costs and diverting the surplus energy toward energy storage (e.g., increase in body mass) and more reproduction (higher fecundity and fertility; Ellison 2001). Numerous studies of pretransitional populations show a positive relationship between access to resources and fertility (Cain 1985; Cronk 1991; Low and Clarke 1992; Hill and Hurtado 1996; Mace 1996; Borgerhoff Mulder 1998; Borgerhoff Mulder 2000; Clarke and Low 2001). Ours is a perspective grounded in reproductive ecology models that incorporate energy availability and metabolic regulation into explanations of variation in fertility patterns both within and between populations (Ellison 1994; Ellison 2001; Valeggia and Ellison 2002).

Furthermore, sedentary lifestyles would allow greater access to medical care, with an impact on women's fertility. Sexually transmitted infections, particularly chlamydia and gonorrhea, may cause pelvic inflammatory disease that in turn can cause infertility in women (Wood 1994). Harpending (1994) and Pennington (2001) propose that these diseases may be the cause of the low fertility of the !Kung San of Africa. Pennington (2001) argues that the increase in fertility of sedentary indigenous communities could be driven by better access to medical services, which could trigger a lower prevalence of the previously mentioned diseases. Similar considerations regarding an increase in fertility have been made by Pagliaro (2002) regarding the Kaiabi of Brazil.

Another factor that could play a role in an increase in fertility is the abandonment of abortion practices. Traditionally, the practices of abortion and infanticide were not unusual among the indigenous populations of the Gran Chaco (Idoyaga Molina 1999; Vitar 1999; Mendoza 2002). Pregnancies were interrupted and newborns were eliminated when the mother did not have a husband to support her, when consecutive births were too close, or when the child was a twin or had a physical defect. However, pressure from Christian religions and the state has contributed to the disappearance, or at least a substantial decrease, of abortion and infanticidal practices (Vitar 1999). Thus, it is also possible that the high fertility observed is in response to a higher rate of unwanted births.[3]

Changes in reproductive behavior, like the ones observed, could also be associated with an assessment of the reproductive costs determined by the social and ecological conditions of the population (Gelles and Lancaster 1987; Hill and Low 1992; Hill and Hurtado 1996). The human species is peculiar among most mammals in that the father invests substantially in the offspring (Hill and Kaplan 1988; Walker et al. 2002; Kaplan and Lancaster 2003). For instance, estimates by Kaplan and Gurven (2001) from a sample of ten forager populations show that 97 percent of the calories consumed by children were provided by men. Therefore, we can hypothesize that in the past, Toba women without a partner interrupted their pregnancy or practiced infanticide (Daly and Wilson 1987; Hill and Low 1992; Hill and Hurtado 1996). However, this community is currently experiencing dramatic socioeconomic changes (Gordillo 2006), leading to greater access to resources (Valeggia and Lanza 2005; Valeggia, Lanza, and Córdoba 2005; Valeggia, Burke, and Fernandez-Duque 2010). As a result, this situation would mean a decrease in reproductive costs for single Toba mothers and a consequent reduction of both fertility-reduction practices.

Finally, it is possible that the increment in fertility levels is related to a decrease in the interbirth interval. In pretransitional populations, a key factor that determines the reproductive rhythm is the lapse of time from childbirth to the following fertile period (Bongaarts 1978; Wood 1994). However, the return to physiological reproductive capacity depends on the physical condition of the mother before and after pregnancy and breastfeeding (Langsten 1985; Adair and Popkin 1992; Valeggia and Ellison 2003). The Toba study population is undergoing a nutritional transition resulting in the prevalence of obesity and overweight (Valeggia and Lanza 2005). Therefore, it can be hypothesized that Toba women would have a better physical condition that would enable a faster return to postpartum fecundity and a consequent increment in fertility.

Reproductive ecology models, like the ones proposed previously, can provide a useful framework for understanding the demographic impact of modernization from an evolutionary biology perspective. Remarkably, the microeconomic model of fertility developed by Easterlin and colleagues (Easterlin 1975; Easterlin and Crimmins 1985) proposes similar mechanisms for explaining the possible effects of modernization on fertility. According to these models, an upturn in resource availability for parents is associated with a greater demand for larger families, that is, children are considered "goods." This prediction fits well with our results. Current economic and social conditions in the Toba communities of Sombrero Negro have led to an increase in the availability of resources as a result of the

[3] A reduction in infanticide practices would only represent an apparent increase in fecundity, since the results obtained evidence a higher declaration of formerly unwanted children.

coexistence of extractive (foraging) and market economy systems (Gordillo 1994; Gordillo 2006). This model also predicts a rise in the supply of offspring as a result of improvement in the nutritional state of the mother and reductions in pre-reproductive mortality rates. Indeed, results from biodemographic studies in the same Toba population suggest a greater availability of energetic resources to be invested in reproduction (Valeggia and Lanza 2005; Valeggia, Burke, and Fernandez-Duque 2010) and an incipient reduction in infant mortality rates (Lanza and Valeggia forthcoming a; Lanza and Valeggia forthcoming b). It is interesting to elaborate on the compatibility of this microeconomic perspective and the perspective of reproductive ecology. The Easterlin model points to supply factors as the trigger for fertility change and views children as "commodities." The reproductive ecology models also focus on supply factors—in this case, energetic/nutritional factors—and thus can be considered well-fitted complements to the Easterlin model that provide (biological) proximate determinant mechanisms for explaining demographic changes accompanying modernization.

Changes in Fertility Patterns

Our results show important differences in the age-specific fertility curves across time periods. It is important to note that this analysis was based on adjusted curves and that differences in the observed curves could have altered the results. However, we took great effort to select standard age-specific fertility curves that did not change the "nature" of the curve. That is, the modal age remained almost unchanged, so that the adjustments did not modify the age distribution of the fertility curve.

Between 1985 and 1994, the data indicate an aging of the fertility curve. This pattern is due, at least in part, to a decline in fertility in women younger than 25 years old. Subsequent periods of Toba data show a gradual increase in fertility, but without reaching the first-period values. The decline in fertility rates at younger ages is difficult to interpret. This trend in fertility could be determined by changes in divorce ratios. The divorce ratio is an important determinant of female fertility (Davis and Blake 1956; Bongaarts 1978). In hunter-gatherers, divorce mainly occurs in couples with women of younger ages and in couples who have been together for about five years (Fisher 1989; Hill and Low 1992; Blurton Jones et al. 2000). Moreover, researchers argue that resource availability can affect men's reproductive decisions. Low availability of resources would increase the likelihood of mortality among children and therefore the costs of their upbringing. Consequently, men would increase their reproductive success, leaving their wives and producing new offspring with other women (Hill and Low 1992; Blurton Jones et al. 2000). During the late 1980s and early 1990s, Argentina went through a profound economic crisis that may have affected the availability of wage labor opportunities among Toba men. Indeed, Gordillo (1994) observed that during the years of economic crisis, the Toba obtained more food from fishing, hunting, and gathering. Therefore, we hypothesize that the lower availability of resources would increase the divorce ratio at younger ages, reducing the number of children younger Toba women had during the 1985–1994 period.

It is also worth considering the effect of a lower age at first birth on the timing and pace of women's fertility. During adolescence, available metabolic energy is used for body maintenance and growth. A reproductive event during adolescent years diverts energy toward pregnancy and lactation. Therefore, Toba women under 25 years of age would spend more energy in reproduction, which would have a negative effect on maternal energy balance, perhaps extending the postpartum amenorrhea period and, as a result, interbirth intervals. Recently, in a cohort study, Lanza, Burke, and Valeggia (2008) showed a decrease of 4.5 years in age at first birth among the same population during the 1940–1980 period. Meanwhile, in a cross-sectional study, Lanza, Valeggia, and Peláez (2011) showed a decrease of 2.7 years in age at first birth among a Cacique Sombrero Negro population during the 1985–1990 and 2000–2002 periods. In short, it is possible that the decline in fertility for women younger than 25 years of age is in response to a combination of lower access to resources and an earlier age of beginning reproductive life. Both situations would act synergistically and raise the impact on the female body, extending the return time to postpartum ovulation and therefore decreasing the women's fertility.

Finally, the 1995–1999 period showed an increase in fertility at young ages. In these years, Argentina experienced a recovering economy. Hence, it is possible that the Toba would have had an increase in access to purchased food. This would have produced a minor trade-off between reproduction and foraging activities (Hill and Kaplan 1988), a lower divorce ratio (Hill and Low 1992), and a lower effect of reproduction on some of the mothers (Ellison 2001).

Conclusion

Social, economic, cultural, historical, and biological variables have been proposed to determine fertility changes (Kirk 1996). To date, however, a unified theory of fertility remains elusive (Kaplan 1996; Mason 1997; Bock 2002). In this regard, this article considers factors traditionally defined as either "cultural" or "biological" in an integrated way to explain the proximate causes of fertility patterns in an indigenous population in transition.

Research on changes in fertility and mortality in transitioning indigenous populations is scarce. This study contributes data on the demographic dynamics of an insufficiently studied region of South America and encourages the testing of new biocultural hypotheses that can shed light on the variation in responses to modernization.

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Table A1

Smoothing of Toba age-specific fertility curve using Brass's method for the period 1981–1984

Age	fx	F(x)	F(x)/TFR	V(x)	Fer^S	Birth $Acum^S$	$(F(x)/TFR)^S$	$V^s(x)$	V(x)piq	F(x)/TFRpiq	Birth Acumpiq	fxs
15–19	0.28				0.1989							0.27
20–24	0.32	1.3761	0.2106	0.4433	0.3391	0.9945	0.1522	0.6327	0.4633	0.2041	1.3337	0.32
25–29	0.23	2.9671	0.4540	−0.2362	0.2709	2.6898	0.4116	−0.1191	−0.2261	0.4504	2.9433	0.24
30–34	0.16	4.0938	0.6264	−0.7599	0.2140	4.0441	0.6188	−0.7342	−0.7900	0.6352	4.1509	0.19
35–39	0.14	4.8751	0.7460	−1.2275	0.1572	5.1143	0.7826	−1.4060	−1.4060	0.7826	5.1144	0.15
40–44	0.16	5.5894	0.8553	−1.8559	0.0852	5.9004	0.9029	−2.2814	−2.2086	0.8960	5.8551	0.09
45–49	0.03	6.3894	0.9777	−3.7926	0.0417	6.3266	0.9681	−3.4295	−3.2613	0.9624	6.2892	0.05

Notes: We used Paraguay's indigenous age-specific fertility curve for year 1981 (Melià 1997) as the standard curve. For further explanation of the method and references, see Chackiel (1979).

Table A2

Smoothing of Toba age-specific fertility curve using Brass's method for the period 1985–1989

Age	fx	F(x)	F(x)/TFR	V(x)	Fer^S	Birth $Acum^S$	$(F(x)/TFR)^S$	$V^s(x)$	V(x)piq	F(x)/TFRpiq	Birth Acumpiq	fxs
15–19	0.14				0.0775							0.22
20–24	0.30	0.6983	0.1098	0.7927	0.2086	0.3877	0.0610	1.0288	0.5853	0.1660	1.0850	0.24
25–29	0.33	2.1890	0.3441	0.0646	0.2864	1.4308	0.2249	0.4001	0.0594	0.3460	2.2614	0.24
30–34	0.14	3.8254	0.6014	−0.6762	0.2761	2.8625	0.4500	−0.2250	−0.4636	0.5331	3.4839	0.22
35–39	0.14	4.5337	0.7127	−1.0827	0.2188	4.2428	0.6670	−0.9039	−1.0315	0.7002	4.5755	0.18
40–44	0.15	5.2123	0.8194	−1.6135	0.1337	5.3368	0.8390	−1.7396	−1.7307	0.8376	5.4740	0.12
45–49	0.08	5.9594	0.9368	−2.7296	0.0712	6.0053	0.9440	−2.8546	−2.6635	0.9327	6.0950	0.05

Notes: We used Haiti's age-specific fertility curve for years 1950–1955 (ECLAC 2001) as the standard curve. For further explanation of the method and references, see Brass (1974).

Table A3

Smoothing of Toba age-specific fertility curve using Brass's method for the period 1990–1994

Age	fx	F(x)	F(x)/TFR	V(x)	Fer^S	Birth $Acum^S$	$(F(x)/TFR)^S$	$V^s(x)$	V(x)piq	F(x)/TFRpiq	Birth Acumpiq	fxs
15–19	0.24				0.1633							0.17
20–24	0.18	1.1867	0.1700	0.5720	0.3028	0.8165	0.1170	0.7635	0.7435	0.1220	0.8519	0.30
25–29	0.32	2.0939	0.3000	0.1857	0.3107	2.3305	0.3339	0.0926	0.0848	0.3367	2.3503	0.31
30–34	0.29	3.7124	0.5319	−0.4598	0.2518	3.8841	0.5565	−0.5342	−0.5305	0.5553	3.8757	0.25
35–39	0.13	5.1659	0.7401	−1.2007	0.1837	5.1429	0.7368	−1.1860	−1.1705	0.7333	5.1184	0.18
40–44	0.16	5.8285	0.8350	−1.7132	0.1077	6.0615	0.8684	−1.9583	−1.9287	0.8647	6.0358	0.11
45–49	0.07	6.6482	0.9525	−3.0218	0.0760	6.6001	0.9456	−2.8830	−2.8366	0.9431	6.5826	0.07

Notes: We used Nigeria's age-specific fertility curve for the year 1990 as the standard curve (Federal Office of Statistics, Lagos, and IRD/Macro International 1992). For further explanation of the method and references, see Brass (1974).

Table A4
Smoothing of Toba age-specific fertility curve using Brass's method for the period 1995–1999

Age	fx	F(x)	F(x)/TFR	V(x)	Fer^S	Birth $Acum^S$	$(F(x)/TFR)^S$	$V^s(x)$	V(x)piq	F(x)/TFRpiq	Birth Acumpiq	fxs
15–19	0.25				0.2232							0.23
20–24	0.31	1.2563	0.1713	0.5678	0.3805	1.1160	0.1522	0.6327	0.6211	0.1555	1.1405	0.31
25–29	0.21	2.7921	0.3807	−0.0350	0.3040	3.0184	0.4116	−0.1191	−0.0038	0.3693	2.7082	0.27
30–34	0.23	3.8280	0.5220	−0.4306	0.2402	4.5383	0.6188	−0.7342	−0.5151	0.5502	4.0350	0.24
35–39	0.23	4.9987	0.6816	−0.9590	0.1764	5.7393	0.7826	−1.4060	−1.0735	0.7105	5.2104	0.20
40–44	0.15	6.1732	0.8418	−1.7589	0.0957	6.6214	0.9029	−2.2814	−1.8012	0.8478	6.2174	0.13
45–49	0.08	6.9456	0.9471	−2.9123	0.0468	7.0997	0.9681	−3.4295	−2.7555	0.9384	6.8818	0.08

Notes: We used Paraguay's indigenous age-specific fertility curve for year 1981 (Melià 1997) as the standard curve. For further explanation of the method and references, see Brass (1974).