# ADAPTIVE RESPONSES TO SCARCITY AMONG

# LACTATING DESERT WOMEN

by

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**ABSTRACT**

Natural selection favors individuals with those adaptive traits that maximize their reproductive success. Effective heat acclimatization in the desert requires conserving body water with a simultaneous reduction in body heat by engaging in adaptive strategic behaviors. The adaptive strategies in response to water and food deprivation that contribute to successful breast milk production among lactating desert women have not been adequately researched. This study compared the rates of energy expenditure between lactating and non lactating desert women in Hidalgo, Mexico, indicating a significantly consistent physiological reduction in the rate of energy expenditure among lactating women as compared to non lactating women. Time allocation data confirmed their exploitation of allomothers with the dominant help being provided by their older female children. The cooling of their bodies prior to breast-feeding, a behavior associated with the "hot breast milk" notion of the hot-cold syndrome, reduces their body heat and ensures maternal relaxation essential to successful breast milk synthesis. The influence of the hormone prolactin during lactation stimulated by increased frequency of breast-feeding, enhances their body water retention, thus improving the cost efficiency of breast milk production for these desert women with limited access to clean water. These adaptive behavioral and physiological strategies that improve infant nutrition and maternal hydration in hot dry climates might prove to be vital to human survival in a future of climatic change and ecological decline.

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**GLOSSARY**

*acocote* – gourd (Lagenaria vulgaris) used by *tlachiqueros* to extract *agua miel* from maguey heart.

*ajo* – garlic

*atole* – thick ground corn gruel with sweetening and other flavors (postpartum mothers drink *atole* for one month during their period of seclusion), e.g. *atole de maíz, atole de mesquite, atole de piñole, atole con masa.*

*ayate* (sacks made from *ixtle* fiber, used for transporting goods, baby carriers, slings or hammocks, bands of *ayate* are used to carry water, wood for fuel, etc.).

*barbacoa* – Otomí *barbacoa* is made by wrapping meat, usually goat or sheep, in maguey leaves and burying it in a bed of coals underground for 2-3 days to cook slowly, creates very tender meat.

*barrio* – neighborhood

*bashqua* – "Merry Christmas" in Otomí language.

*bifstec, puerco, pollo* – beef, pork, chicken respectively raised as cash crops primarily, eat goats only at fiestas or on special occasions (baptisms, weddings, funerals, school graduations).

*bolillos* – soft French-style roll (also called *pan* or *pan dulce*), bought from the back of pickup trucks and eaten instead of tortillas.

*cacahuete* – edible indigenous wild peanuts that grow in the fields (*las milpas).*

*calabazas* – squash, similar to zucchini squash, usually harvested when very small (about 2-3 inches long), but can grow very large if left in the field (the Indians feed the large *calabazas* to their pigs).

*cebollas* – onions.

*comal* – the round flat surface the Indians use to cook tortillas, sometimes just a flat round metal disk balanced on several rocks with fire underneath, others are a large round cylinder about two feet wide and six inches tall with a smoke stack attached (the fire is placed inside the cylinder and the cooking surface is on the top).

*cuartillo* – a measure of corn or maize, used in the marketplace, about a liter in volume.

*cuotas* – costs.

*delegado* – representative of the community members in a political role, intermediary between members and represents them in the county seat affairs.

*faena* – community cargo volunteer labor (obligatory for men between 18 and 65) (usually *delegados* supervise other laborers during community service – successful men were always addressed with the title of "*Don*" before their given name, but no one was addressed with this title in Pañhe or Gandho during my observations, only *Don* Jesus, my mestizo landlord in San Antonio).

*frijoles* – beans

*gatu* –" goodbye" or "*adios"* in Otomí language.

*gusano* – refers to any "grub" or larvae or worm found in Maguey, corn stalks, mesquite trees, put in tequila (beverage made from agave cactus), or stir-fried in scrambled eggs.

*indee* – “Good afternoon” in Otomí language.

*ixtle* - Maguey fiber became important as a cash “crop” as well as *pulque*, supplying the Spaniards, Black slaves, and Indians who migrated to this region in search of wealth and opportunity, the mining industry used bands of *ixtle* to pack bars of silver and gold, and for handling of metal tools.

*junta* – community meeting where decisions are reached politically/socially.

*matate* – stone used to grind corn historically, rarely used by the Otomí today.

*matthuhu* – “My name is” in Otomí language.

*mayordomos* - sponsors of fiestas, primarily responsible for collecting money to pay for the fiestas, this obligatory position was rotated every few years to other families.

*menudo* – soup or stew made with tripe or entrails of goat.

*molé* – hot sauce made for fiestas and special occasions, served with turkey, chicken, or beans.

*nopales* – prickly pear cactus, thorns are scraped off, chopped in small cubes, stir-fried with salsa, served with beans and tortillas.

*organo* – organ pipe cactus, small ones used to build house walls and fences, larger ones are called Saguaro cactus commonly found in northern Mexico and Arizona.

*papas* – potatoes.

*pulque* – fermented beverage made from *agua miel*, honey water or the sap of century plant or Maguey cactus (Otomies drank between three and 15 liters per day until recently when *pulquerías* were outlawed by federal government, Coca Cola and other

sodas (*refresca*) are now consumed more than *pulque* by Otomí women, Otomí men continue to drink several liters of *pulque* on a daily basis).

*quehatzi* – "Good morning" in Otomí language.

*quelites* – "wild greens" in Spanish, belongs to the family of Amaranths, Amaranthus hypochondriacus (pigweed) most common one found in the Valley of *Mezquital* is gathered and eaten steamed or stir-fried like spinach or chard.

*salsa* – spicy sauce made with c*hiles,* tomatoes (*jitomates*), onion (*cebolla*) and garlic (*ajo*).

*social prestige* – indicated by land ownership and size of goat herd*,* not really power as much as respect. These families have greater control over what happens within the village (some were money lenders and owned stores, land, and bigger houses).

*suthi* – heavy or thick *ayate (made from the dregs of the ixtle fiber from Maguey)*, used with tumpline for carrying heavy loads and as a cloak for poor people in cold weather (Pedraza 1978).

*tortillas de maíz o maíz azul* – corn or blue corn tortillas, main staple of their diet.

*tuna de garambullo o nopales* – fruit from cacti.

*verdolagas* – (purslane) nutritious wild green that is gathered and eaten, usually chopped and cooked with scrambled eggs.

*xcpi* – blessed offerings used to "smoke out" evil eye (*mal de ojo*) in infants or young children, usually from *ruda, pirul, romero, manzanilla*, and parasitic plants (mosses) that grow as leafy vegetation in large scrub oak trees.

*xite* – “shite” in Spanish is the pulp leftover after harvesting fiber from the *lechuguilla* plant, historically used for detergent and making nests for chickens (roosting hens). The women studied in this project now use generic *jabon*, a granulated powdered soap similar to Tide that is purchased in the marketplace and used for all cleaning tasks.

*yathama* – “I’m going” in Otomí language.

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## INTRODUCTION

*If a multinational company developed a product that was a nutritionally balanced and delicious food, a wonder drug that prevented and treated disease, cost almost nothing to produce and could be delivered in quantities controlled by the consumers' needs, the very announcement of their find would send their shares rocketing to the top of the stock market. The scientists who developed the product would win prizes and the wealth and influence of everyone involved would increase dramatically. Women have been producing such a miraculous substance – breast milk – since the beginning of human existence.*

- Gabrielle Palmer, *The Politics of Breastfeeding*, London: Pandora Press, 1988.

For millions of years, the only method of feeding a human infant was lactation. When lactation was not possible due to the death or illness of the mother, alloparents or caretakers fed other animals' milk to these infants, or scrounged breast milk from another nursing mother. Lactation remains today as the predominant infant feeding method employed by traditional women (Gaff-Smith 2001, Blaffer Hrdy 1999, King and Ashworth 1991, Kramer 2005, Laukaran 1988, Stuart-Macadam 1995, Piperata 2008, Popkin 1986, Winikoff 1988), however, inadequate research emphasis has been placed on the adaptive responses of lactating desert women who live with insufficient and contaminated water supplies (Bentley 1998).

Clean water is critical for human health and survival, especially for indigenous populations living in water-stressed environments (see Fig. 1) (Myers 2009, Alcamo 2002). However, indigenous populations lack the infrastructure, technology or resources necessary to ameliorate the effects of water shortage (Ibid. 2009). Water scarcity has a disproportionate impact upon women (Ray 2007) who are particularly vulnerable during

Figure I. Otomí child bathing, Pañhe, Hidalgo, 2006.

pregnancy, childbirth and lactation (Folk 1998, Jelliffe 1978). Desert mothers often must drink contaminated water and use this same unsafe water for bathing and feeding their infants. Water shortages force humans to rely on unsafe water, reducing their ability to bathe, wash their clothes or clean their homes, and leading to increasing numbers of humans suffering from infectious disease (WHO 2009).

Hot dry climates stress the human *energy balance* between energy intake and energy expenditure. This requires optimal conservation of body water and cooling efficiency among desert inhabitants to maintain life (Folk 1998). These extreme climatic conditions compound the burden on lactating women, one of the most vulnerable groups facing inadequate water and nutrition (Frisancho 1996, Jelliffe 1978, Rowell 1978). This study focused on the desert population of Otomí Indians in Mexico who struggle every day to survive under conditions of contaminated water shortages in relentless heat and poverty. Since all organisms beneficially adjust to environmental conditions to survive, lactating desert women must biologically and/or culturally adapt to these limited food and water resources.

Medical professionals encourage women to drink sufficient water (~9 cups per day) to maintain their health throughout pregnancy and childbirth (Erschow 1991), and an additional cup of water per day during lactation (Lawrence 1999, Riordan 2005). Interestingly, research studies have verified that breast-fed desert infants do not require additional water (Almroth and Bidinger 1990, Brown 1986, Goldberg 1983), but most Mexican desert mothers continue to offer a few ounces of chamomile tea to their

babies every day during the early neonatal period because, they reported in this study, "it is hot," and the infant is "thirsty." Other studies have revealed an *osmo-regulatory* function of the hormone responsible for breast milk production, prolactin. Prolactin not only regulates the production of breast milk, but simultaneously regulates body water (Horowitz 1980, Horrobin 1971, Leake 1983, Ostrom 1990). During lactation, this hormone retains body water and, as a consequence, while facilitating breast milk synthesis to nourish infants, also enhances the cooling efficiency of lactating desert women. The hormonal actions of prolactin most likely are the evolutionary consequence of the fact that our ancestral mothers suckled their infants on the hot and dry savannah grasslands of Africa.

In 1990, Waterlow suggested that breast-feeding desert women under conditions of resource scarcity meet the biological demands of producing breast milk by conserving energy expenditure, primarily by altering their *rate* of expenditure and, thus, the *cost efficiency* of breast-feeding. Anecdotally, most women agree that a subconscious response to the immediate postpartum challenges of raising an infant is to "pace" oneself in daily subsistence activities, making tradeoff choices among various necessary chores and childcare. Is it possible that this unconscious behavioral response has become fixed in the human female neurological system through millions of years of natural selection? Further research has been recommended to determine the specific adaptive responses of lactating desert women under conditions of food and water deprivation (Bentley 1998).

I embarked upon this project to test the Waterlow energy conservation hypothesis, to discover the adaptive behavioral and physiological strategies these desert women employ while breastfeeding their infants, and to determine the evolutionary *payoff* for this costly reproductive strategy.

Millions of years of hominid evolution have preserved immunological, hormonal, developmental, nutritional and cognitive advantages for the human infant as the result of lactation behavior (Fredrickson 1995). The adaptive strategies that enhance breast-feeding may prove to be an even more powerful selective advantage for the modern industrialized woman who today invests heavily in fewer children. The species-specific nutrition of breast milk improves the current and future health of her child (Micozzi 1995, Stuart-Macadam 1995, Walker 2010) increasing her chances of reproductive success. Long term traditional lactation (on demand, through the night, and for at least one year) provides her and her female infant with future health protection against estrogen-induced cancers (Micozzi 1995, Stini 1978 Walker 2010).

Most importantly, breast-feeding behavior may reduce the potentially devastating economic burden of crushing healthcare costs in a world of overwhelming socioeconomic competition and looming environmental change.

Study Population

During my graduate literature search, I was drawn to the writings of Bernard and Pedraza (1989) concerning the Otomí Indian populations of Hidalgo in the *Valle del Mezquital,* a semi-arid region that is dominated by mesquite trees (see Fig. 2) and

Figure 2. Mesquite tree, near La Mesilla, Hidalgo, Mexico, 2006.

Maguey cactus in hardpan soil, characteristic of this valley, and these mesquite trees provide the origin for its name.

In 1989, Bernard eloquently described the Otomí people, their language, their ancient and recent history, their lifestyle, and social position in Mexican culture. According to Bernard, the Otomí are one of the poorest indigenous populations inhabiting Mexico. The Otomies were driven from the Valley of Mexico by the invading Aztecs prior to the Spanish conquest, and then suffered enslavement and brutal treatment at the hands of the Toltecs, one of the greatest militaristic civilizations of ancient Mexico (Schmal 2004, website). Tula, the center of the Toltec empire was called *Namenhi* by the Otomí, or the "place of many people" (Wolf 1959:112). After the fall of Tula near the end of the 12$^{th}$ century (Wolf 1959:117), partially as a consequence of internal theocratic and militaristic conflicts (Ibid. 1959:122-3), the Otomies escaped into the desert regions to the west of Tula and, in Tecozautla, successfully thwarted repeated attacks from the north by the Chichimecas or "descendants of the dog" (Wolf 1959:119) from behind stone walls that the Otomies had built in 730-740 AD to fortify this city (Ocampo 2008). Centuries later, the Spanish also dominated these people following their conquest of Middle America (Wolf 1959). The Spanish conquest was actually accomplished through the capable assistance of the indigenous peoples who had "suffered grievously" under the cruel domination of the Mexica (Wolf 1959:154-5). Despite centuries of enforced slavery, brutal treatment, and hegemonic control, the Otomies have survived in this harsh desert region. They have maintained their cultural

traditions, defiantly challenging the *mestizo* culture that threatens to engulf them and extinguish the last vestiges of their unique characteristics. The literature credits their survival to their ingenious exploitation of the life-sustaining sap hidden within the Maguey cactus or the *century plant*, hence they are sometimes called the *Maguey People* (Granberg 1970). *Pulque* [1], the fermented beverage obtained from this sap or *agua miel*, has preserved the lives of these desert inhabitants in the face of desperate water scarcity. Today, they remain a stubborn and rebellious, but proud people, clinging to their cultural traditions.

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[1] *Pulque* is a fermented beverage obtained from the sap (called *agua miel* or honey water) of the Maguey cactus or "century plant" that has helped these indigenous peoples to survive for centuries in the desert regions of central Mexico (Parsons and Parsons 1985). The Otomí Indians are credited with discovering the process of making pulque (Ibid. 1985). The Spanish described them as a tribe of half-naked barbarians who were in a chronic state of intoxication by drinking this liquor of the maguey cactus ("The Story of Pulque," http://www.tequilamescal.com/pulque.html, accessed 10/24/2004). To control *pulque* production, native rulers prohibited its use except by the elderly, nursing mothers, and the ruling class during fiestas. In 1953, Hidalgo was one of the largest *pulque* producing states, obtaining 30-50% of their income from this fermented beverage (Ibid. 2004). *Pulque* contains vitamins A, B-complex, C, D and E, protein, minerals, and is a rich source of carbohydrate. This nutrient-rich beverage has been primarily responsible for their survival in this harsh environment since before the fifteenth century. The Maguey produces only one flower stalk in its lifetime. Just before the flower stalk emerges after nearly a decade of plant growth, the cactus produces vast amounts of sap to nourish this flower. The Indian cuts into the cactus removing the base of the flower stalk before it shoots skyward, and creating a cavity for the sap. They place a rock over the cavity to reduce insect activity. The *agua miel* or sap is scooped out of this cavity every day over the following several months, producing hundreds of liters of *agua miel*. The sap is then fermented with mature seed *pulque* (called *Xanaxtli*) *starts* for a week to fourteen days, and then consumed. *Pulque* has a milky, frothy appearance when fermented for just a few days with an alcohol content of about 3%, and is rather bitter in taste. Often raw sugar is added to improve its taste. Since the 1950s, most *pulque* is manufactured commercially in Mexico, similar in taste and quality to vodka but with higher alcohol content. The *indígenas* continue to traditionally produce the original form of *pulque* for private consumption (Parsons and Parsons 1985), despite the government mandate eradicating its local production. For this reason, most Otomies deny drinking *pulque* when questioned.

In 2005, I flew to Querétaro, a two-hour journey by car to the west of Tecozautla. Tecozautla is a community situated in the northwestern section of the *Valle del Mezquital*, the most arid region of this valley. Just outside of Tecozautla in the village of San Antonio, I met with *Don* Jesus Camacho Resendiz, the father of my brother-in-law and the owner of the hacienda that dominates this area. Señor Resendiz had graciously consented to my living in an ancient stone house on his property in San Antonio during this project. Through his influence, I was introduced to a good friend of his, Señor Beltran, an attorney of Otomí origin living in Tecozautla. Together, they were instrumental in obtaining the required local Mexican government permission letters and approval for my research project. Señor Resendiz spent many hours driving me to many of the remote villages surrounding Tecozautla. This journey was sometimes on paved but rut-filled roads, sometimes on cobblestone roads, but often involving the navigation of dirt paths on rocky, hilly, cactus-filled desert terrain, and once across a slow-running stream with a rock-filled riverbed with no evidence of any road. I was captivated by the stark beauty of the desert and intrigued by the ability of humans to survive in this harsh landscape. At first glance there was no evidence of life, but as we meandered up hills, persisting into the more remote areas, bits and pieces of life began to appear. A few times, it was possible to catch a momentary glimpse of a fleeing figure with a mongrel dog, but they would quickly disappear into the desert landscape.

Once, I was thrilled to see a man leading a donkey loaded with two wooden barrels and the required paraphernalia I had only seen before in research journals that is

used to “harvest” the *agua miel* from the Maguey cactus. The man and donkey were picking their way slowly down a mountain path toward home. This scene was reminiscent of photos in a National Geographic magazine. I did not know then, but I was to be privileged to observe many of these remarkable scenes, images of a disappearing life from a past era, during my year of research while living in Mexico. Many of the structures, that were apparently their homes, were nothing more than walls made of organ cactus, sometimes mixed with some rock or concrete block, and some with no roofs. I asked Señor Resendiz what the people living in these houses do when it rains, and he said, “They get wet!”

Over breakfast the following morning, Señor Beltran described the challenges, both historically and present day, for the Otomí people. After several hours chatting over a magnificent breakfast platter of fresh tropical fruit, home-made corn tortillas, *huevos rancheros* and refried beans, I was convinced that this was the destination for my research project.

Later that day, Señor Beltran introduced me to Dra. Olivia Moran, the director of the local medical clinic in Tecozautla, located just off the town square. She graciously indicated her interest in helping me in any way she could to complete this research project. Dra. Moran reported that most of the indigenous women living in the villages surrounding Tecozautla breast-fed their infants for at least two years or longer. She said that they usually delivered their babies in the Indian hospital in Huichapan and were offered prenatal care in the village medical clinics. However, she confided, many were

reticent to adopt the modern medical practices, continuing to practice their traditional customs concerning pregnancy, childbirth, and infant feeding.

The village medical clinics had been built during the Mexican government movement in the 1980s to improve the lives of the *indígenas*. PIVM (*Patrimonio para Indígenas en el Valle del Mezquital*), a government agency established to accomplish this mandate, was managed exclusively by *mestizos*. PIVM built roads, clinics, schools, and connected electricity to many of the Indian villages (Bernard 1989), through the enforced "community labor" (cargo or tributary labor) of the Otomí citizens. In addition, PIVM developed irrigation systems that delivered *agua negra* or black waste water from Mexico City, dramatically increasing the infectious disease rates in the indigenous villages of Hidalgo (Bernard 1989).

After several days in this community, I had fallen in love with the steady rhythm of their life, the slow pace of their existence, and the shy smiles on the faces of their children. I knew I was coming back to study these traditional people. In January of 2006, after packing what we needed into a newly-purchased Ford pick-up truck, and renting my home for the year, my teenage daughter and I headed south toward the border of Mexico. After a few days traveling through Utah, Colorado, then New Mexico and Texas, we crossed the border at Laredo, Texas, or *Nuevo Laredo,* and began our journey into another existence, the world of the Otomies.

# CHAPTER I

## THEORY, OBJECTIVES AND HYPOTHESES

### Theoretical Considerations

The Darwinian mechanism of evolution involves adaptive tactics driven by natural selective forces that alter gene frequencies over multiple generations in natural populations. The most beneficial adaptive variants that demonstrate increased *fitness* to a given environment tend to maximize an individual organism's reproductive success. One of the most costly biological processes of mammalian reproduction (Blaffer Hrdy 1999), lactation evolved long before the major human evolutionary adaptations of bipedalism, an expanded brain, and language acquisition, having a profound impact on the successful evolution of *Homo sapiens*.

Until the end of the nineteenth century, lactation was the primary method of infant feeding throughout the entire history of human evolution, reaching back millions of years. More than 3.5 million years ago, Lucy was undoubtedly breast-feeding her babies, and greater than 6 million years ago, the ancestral hominid Orrorin mothers would have also fed their infants in this same manner. There is every reason to believe that prolonged human lactation was essential to the survival of our *altricial* or developmentally immature infants (McKenna 1993) and to the successful evolution of humankind.

In contrast to the vast span of hominid evolution, in the last few minutes of human history, this infant feeding heritage has been questioned by modern mothers

under the onslaught of modern technological advancements, the *medicalization* of our reproductive choices (Conrad 2007, Micozzi 1995, Stuart-Macadam 1995), Western eroticism of the human breast (Dettwyler 1995) that has promoted the expanding practice of breast implantation, and was very nearly abandoned as a maternal practice in the mid-twentieth century by most of the industrialized world. In the United States, the infant feeding method of choice has rapidly changed from almost exclusive breast-feeding for at least two years in the 1880s to less than half of infants being breast-fed for only six months in the 1990s (Stuart-Macadam 1995, in foreword by Edward Newton, M.D.: ix).

While breast-feeding an infant, the mother must take into account the trade-offs between the costs and benefits of parental investment (Clutton-Brock 1991). As Trivers proposed in 1972, the amount of parental investment varies according to the social and environmental constraints. According to Trivers, the level of parental *fitness* payoffs ultimately depends on three conditions, (1) the relatedness of parent and offspring, (2) the effect of the investment effort on the expected reproductive value of the offspring, as well as present and future offspring, and (3) the effect of the investment on the caregiver's own reproductive value, where both of the latter are affected by ecological variables (Trivers 1972). Despite the physiological and time-allocation costs, breast-feeding provides the infant with short-term immunity to infectious disease through the actions of lactoferrin and immunoglobulin-E, both of which are abundant in human breast milk (Walker 2010), and enhances the infant's long-term health by reducing their

risk for life-threatening diseases such as cancer, diabetes, myocardial infarction, and digestive disorders, while strengthening the health and longevity of the mother and reducing her risk for estrogen-induced cancers (Cunningham 1995, Lawrence 1999, Micozzi 1995, Jelliffe 1978, Riordan 2005, Walker 2010), thus improving the potential survival chances and reproductive value of both mother and infant.

Adopting the conceptual framework of ecology, Steward proposed a theoretical approach to cultural evolution through the analysis of the interaction of culture and the members of that culture to the environmental context of an ecosystem (Steward 1955). Steward's major contribution to evolutionary thought was this ecological dimension that included the key element of human adaptation. The evolutionary paradigm known as the life history theory (Charnov 1993, Stearns 1992) offers further insights into the flexibility of adaptive behavior to maximize reproductive success (Konner 2010). This research project focused on the adaptive responses of desert lactating women that maximize their breast-feeding capabilities in the changing socioeconomic environment of traditional villages in Mexico and the ecological pressures of resource scarcity.

Fluctuations in economic resources, chronically endured by the indigenous Otomí women of rural Mexico, can spell the difference between life and death for their infants, especially during the coldest winter months. Scarcity in a desert environment requires unique behavioral and physical adaptive responses (Frisancho 1996, Rowell 1978, Wenger 2001), especially during pregnancy, childbirth, and lactation. Lactation in hot-dry climates always challenges the fragile human *energy balance* between energy

intake and energy expenditure, requiring optimal conservation of body water and cooling efficiency (Folk 1998, Illingworth 1986). This physical equilibrium is enhanced by the influence of the hormone prolactin, a body water regulator, during lactation (Ho Yuen 1988, Horowitz 1980, Horrobin 1971, Ostrom 1990), especially when the infant is fed "on demand" according to traditional patterns. Because breast-feeding physiologically requires the hormonal actions of prolactin, lactating behavior also sustains maternal body water and enhances cooling efficiency in a hot, dry climate.

As reported in the literature, behavioral and/or cultural adjustments to desert climates include alloparental assistance predominantly by related females (Kramer 2005), dietary or nutritional choices (DeWalt 1983), water intake behavior (Askew 1996), the *compadrazgo* system of reciprocity (Foster 1967), New World traditions that guide behavior known as the *hot-cold syndrome* (Chevalier and Sanchez Bain 2003, Foster 1994, McCullough 1973), and the "pacing" of work to avoid overheating (McCullough 1973). These behavioral adaptations conserve energy and body water, increasing cooling efficiency in hot-dry environments (Frisancho 1996, Folk 1998 Wenger 2001). I hypothesized that these women would probably engage in these behavioral adaptive strategies, especially allomothering by female helpers, the notions surrounding the *hot-cold syndrome,* and "pacing" behavior.

The energy *costs* of lactation are physiologically met with adequate dietary intake and body water, pregnancy fat reserves, and/or a reduction in maternal energy expenditure (Frisancho 1996, Jelliffe 1976, Prentice 1981). The adaptive strategies to

inadequate food intake include maintaining a lower body weight, reducing the *cost* of physical activity, and increasing *metabolic efficiency* to maintain energy balance (Waterlow 1990). The most important factor in determining energy cost is the speed or *rate* of the activity, and testing this phenomenon among traditional women surviving on marginal dietary intake in developing countries has been encouraged (Ibid. 1990). I hypothesized that these lactating desert women would tend to burn calories at a slower *rate*, or use less calories per minute, than nonpregnant nonlactating (NPNL) desert women while performing the same daily activities, thus increasing the *cost efficiency* of producing breast milk.

Human Behavioral Ecology (HBE), a branch of evolutionary ecology, theoretically focuses on behavioral responses to changing socio-ecological conditions. In HBE, the most important elements of the natural selective forces are demographic pressure, environmental changes, and socioeconomic competition (Smith and Winterhalder 2002). The lactating desert women in this study were motivated to breast-feed their infants primarily by traditional custom, but the socioeconomic conditions and the medicalization of reproduction in a changing Mexican culture may eventually erode this motivation.

Using the HBE model, the desert women in this study had a range of behavioral options for infant-feeding that included breast-feeding for many months to several years, infant feeding with animal milk (primarily goat milk), using processed infant formula, a product few women in this population can financially afford (less than 12%),

or eliciting the assistance of another lactating female relative or neighbor as a wet nurse (only two women cited using this choice). Their traditional means of income production relying on labor-intensive artisan crafts is an inefficient mode of income generation, providing a meager income of, at best, 10 pesos a day. The market value of their crafts has steadily declined over the past century (Mayer 2002), thus most of the nonlactating females now enhance their income by working in the *milpas* or fields of others with a daily wage of 100 pesos (~$10.00 US). However, the lactating females rarely worked in the fields until their child was at least two years of age. Only one woman in this study went to work in the fields with her six-month old infant, with the assistance of her niece *allomother*. As a result, these people cannot afford modern infant nutritional products, including infant formula and canned baby foods. As their economic situation improves, and the women increase their contribution to income production, the infant fertility rates most likely will decrease and they will begin to exploit these alternative avenues of infant nutrition (Konner 2010).

Human behavioral ecologists look at risk-sensitive adaptive strategies with an emphasis on the costs and benefits associated with the behavioral decisions under conditions of a given ecological setting in a neo-evolutionism theoretical framework (Smith and Winterhalder 2002, Winterhalder and Kennett 2006). The HBE model includes a “decision set” (range of behavioral options), constraints or assumptions, costs and benefits (value features), and adaptive goals or the evolutionary *payoff* (Ibid. 2002).

Breast-feeding behavior *constraints* among the Otomí women of Hidalgo

included the financial cost of alternative sources for infant nutrition, the caloric value of breast milk production, female work patterns and/or demands by other family members, and physiological constraints such as severe maternal dehydration, malnutrition, or addiction to *pulque,* the fermented beverage made from the sap of the Maguey cactus.

The *costs* of breast-feeding include the energy expended in the production of breast milk, increased maternal food intake, increased energy expended while carrying infants, decreased time for subsistence activities, decreased time for other siblings, and decreased time for social interaction with their peers (Blaffer Hrdy 1999). The *benefits* of breast-feeding include a more rapid and efficient return to the mother's nonpregnant physical state (Lawrence 1999), suppression of female fecundity (Ellison 1995, Konner and Worthman 1980, Lee 1980), improved passive and active immunity in the infant (Lawrence 1999, Micozzi 1995, Stuart-Macadam 1995), reduced incidence of infant illness (Cunningham 1995, Micozzi 1995), optimal infant growth and development (Cunningham 1995), enhanced emotional attachment or bonding between infant and mother (Bowlby 1969, Raphael 1976), and increased protection against future maternal and infant disease (Lawrence 1999, Stuart-Macadam 1995, Riordan 2005).

Efficient reproductive strategies, such as maximizing the *cost efficiency* of breast-feeding through altering the *rate* of energy expenditure (Waterlow 1986 and 1990), would tend to increase their capacity for subsistence activities and lessen exposure to the risks associated with reproduction such as postpartum hemorrhage and another

conception compromising the first infant's chances for survival. The *currency* of cost efficiency may be defined theoretically and measured in terms of "parental success."

Using basic evolutionary principles, I hypothesized that these desert women, despite the immense biological cost to these mothers, would breast-feed their infants because the evolutionary *payoff* included reduced fecundity, decreased infant mortality, and improved infant health, growth and development, thus, improving their chances for reproductive success. As *cooperative breeders*, I hypothesized that their breast-feeding behavior would be assisted by relying on *allomothers* (Blaffer Hrdy 1999) providing respite from childcare duties, assisting in completion of requisite subsistence activities (Kramer 2005), improving their own health, while simultaneously ensuring the survival of their infants.

Time allocation studies were conducted during this research project to measure the percentage of time spent on subsistence activities compared to their parental investment of breast-feeding, infant and child care, to determine the relationship between the *dual-careers* of these mothers (Altmann 1988). According to Cashdan, a female's *fitness* is dependent on her resource-acquiring abilities while simultaneously helping her children to be reproductively successful, requiring physical strength, energy and assertiveness (2008). I hypothesized that these lactating women would spend more time in child care activities, particularly breast-feeding behavior, than subsistence activities, despite the assistance of allomothers, when compared to nonlactating women, while simultaneously procuring sufficient resources for her family's immediate

survival needs, because the parental investment of breast-feeding provides greater evolutionary payoffs in reproductive success.

The primary evolutionary *pay-off* for continuing the tradition of breast-feeding behavior by these desert women is likely to be increased reproductive success, decreased financial cost, and the prestige gained by successfully raising healthier children who mature into contributing members of their community. The older women in this study population reported a history of losing more than half of their children, a situation they had come to expect as a *normal* occurrence in their lives. This was a tremendous physiological cost for these traditional women to pay for a relatively small reproductive payoff. High birth rates and increased infant mortality are often found in traditional peasant [2] societies (Blaffer Hrdy 1999). Their daughters, who are the current participating mothers, have fewer children and experience a much lower incidence of infant mortality while practicing similar parental investment behaviors. The Otomí women of Hidalgo today earn more income as fieldworkers than their mothers did, and are choosing to trade off the quantity of children for quality by investing in the education of fewer children (Ibid. 1999). Perhaps these mothers know that this is the best way for the next generation to escape the impoverished existence of the Mexican peasant. Several factors are influencing the improvement in infant mortality rates

[2] Peasants are defined by Foster as "cultivators of the soil" or farmers who raise domestic animals and live near pre-industrial cities where they participate in the market exchange of goods to obtain those products that they cannot produce at home, such as cigarettes, coffee, and candles (Foster 1967, Wolf 1967).

including access to Western medical treatment, higher daily caloric intake, better houses, increasing education of female children, in addition to their choice to continue the tradition of breast-feeding, enhancing the growth, development, health and immunity of their children.

During semi structured interviews of lactating and nonlactating participants, it was discovered that the cesarean section rate among this population was dramatically increasing with simultaneous tubal ligation procedures being performed without the woman's prior knowledge or consent. This unethical medical practice of tubal ligation without consent is also contributing to a dramatic decrease in birth rates for these two traditional villages.

According to the HBE model, breast-feeding behavior exhibits an evolutionary stable equilibrium of reproductive strategies, minimizing their risks of reproductive failure, and optimizing the evolutionary payoff of reproductive success.

Traditional Breast-Feeding Practices

In 1946, Anderson studied the Otomí indigenous peoples of Hidalgo, and indicated that their indigenous diet of maize, beans, *pulque*, and edible wild plants was apparently adequate, with a mean caloric intake between 1,818 and 1,831 calories for nonpregnant, nonlactating (NPNL) women between the ages of 16 and 50. This study found a mean caloric intake of 2,040 calories for the NPNL women, an increase of approximately 200 calories over 65 years. Anderson found the Otomí to be remarkably healthy, eating a diet that was "relatively high [in] carbohydrate[s], [and] low [in] fat and

protein," despite their poor existence in an "arid and barren" wasteland with limited food choices (Ibid. 1946: 891, 902). He noted that tooth decay was nonexistent, with only a minimal insufficiency of riboflavin in the diet. Despite a reduced caloric intake, many nutrients including calcium, iron, vitamins A and C, and phosphorous were "relatively good" (Anderson 1946: 901). Anderson reported that all babies were breast-fed for "several years" and it was common to have several children being breast-fed at the same time (Ibid. 1946: 887). Anderson did not indicate whether these children were siblings or wet-nursed infants. In the current project, there were two women I encountered in this village who shared with me that they had asked another woman in the past to breast-feed their infant, one because she became ill during lactation and thought that she didn't have "enough milk" and the other because she was a *pulque* drunk and "didn't have any breast milk." These wet-nurses were not relatives, just neighbors who were currently breast-feeding their own infant. Most of the infants in the current project were breast-fed for up to two years and one was being breast-fed at the age of nearly four years; however, three women stopped breast-feeding after 10 months because their infants were sick with cold symptoms, and were following the recommendation of the local physician to wean their infant in order to restore their health. One of the youngest mothers had twin babies. She successfully breast-fed these infants for greater than 10 months. She regrettably admitted to weaning them for financial reasons so that she could return to work as a retail clerk in a small neighborhood *tienda* (store).

The complexity of economic change and agricultural modernization in Mexico since the 1950s has had a dramatic negative impact on their diet (DeWalt 1983) in the form of increasing consumption of processed food with artificial ingredients, especially Coca Cola, resulting in increased rates of diabetes and reduced reproductive success. According to the medical clinic nurses, more than half of these villagers now suffer from diabetes and cardiovascular disease, while in 1946, when Anderson was studying these people, these diseases were nonexistent (Anderson 1946).

Most rural Mexican mothers follow traditional breast-feeding practices (Lipsky 1984, Long-Dunlap 1995); however, how they produce breast milk under conditions of food and water shortage has not been adequately researched. To meet the energy demands of lactation, the adaptive responsive choices of these desert women must include an increased dietary intake, a reduction in energy expenditure, or drawing on their maternal fat reserves. Most of the women studied in this project continued breast-feeding for at least two years, and some for more than five years, despite discouragement by medical clinic personnel of breast-feeding beyond six months. One medical physician was overheard saying to a female patient that after six months, “there is nothing in your breasts but water.” When I questioned this same doctor after the patient left, he indicated that their babies needed food and if he didn’t tell them this, they would keep breast-feeding for too long and their babies would “fail to grow.” The fact that only meager amounts of alternative food sources were available to feed their infants, such as a few tortilla pieces soaked in bean water, did not seem to deter these

medical doctors. A common complaint by women who weaned their infants early in these villages was that their children were very thin and did not "grow well" after weaning. There were some women in Pañhe that were told to stop breast-feeding just because their baby was sick with a cold. Despite these commonly known dire consequences, the mothers usually followed this medical advice.

Objectives

The mammalian behavior of lactation that is essential for infant health and survival (Jelliffe 1978), especially in developing countries, provides optimal nutrition for the extenuated development period of the human infant (Cunningham 1995, McKenna 1993). The effect of food and water scarcity on the production of breast milk among the Otomí Indian women of Tecozautla, Mexico, had not previously been measured. The primary objectives of this project were to determine the degree of food and water scarcity in this desert region, and what effect dietary intake and water consumption has on the capacity of these women to produce sufficient breast milk to meet the nutritional requirements of their infants. More specifically, I set out to:

- document seasonal economic and nutrition fluctuation and/or scarcity. This objective involved conducting semi structured interviews to document economic and resource availability.
- determine the effect of food and water availability on women's energy expenditure. This involved creating daily activity observation worksheets and conducting longitudinal energy expenditure recordings on all participants.

- determine the effect of food and water availability on food consumption patterns. This involved creating 24-hour dietary recall diaries (all women) and direct weight measurement of food for seven days by 10 participating women.
- measure the effect of food and water availability on their anthropometry. This involved a longitudinal measurement and recording of heart rate, body surface temperature, weight, height, mid-arm circumference, percentage of body fat, and the calculation of body surface ratio, BMR, and BMI.
- determine the effect of food and water availability on breast milk production. This involved the longitudinal direct weight measurement of all the nursing infants before and after all breast-feeding sessions during the day to measure breast milk production, and calculate an estimated breast milk production during the night using standard accepted procedures (Arthur 1987).
- observe how "pacing" behavior influences the energy balance of lactating desert women.

Hypotheses

Prior to beginning this research project, I determined to test the following hypotheses, assuming that the Otomí women exclusively breast-fed their infants from birth, that they were in relatively good health, and that they had engaged in similar activity (work) patterns prior to childbirth. I proposed the following six specific hypotheses:

- H1: During lactation, female patterns of activity levels categorized as high energy

expenditure (>4 METS*) by the World Health Organization will occur at a slower rate using less kcal/minute than nonlactating females.

- H2: During lactation, female patterns of activity levels categorized as moderate energy expenditure (2.5-4 METS*) by the World Health Organization will occur at a slower rate using less kcal/minute than nonlactating females.
- H3: During lactation, female patterns of activity levels categorized as low energy expenditure (<2.5 METS*) will occur at a slower rate than nonlactating females.
- H4: Breast milk production will not be affected by food and water availability.
- H5: During lactation, women will transfer the care of their infants to others while they engage in subsistence activities, reducing their total daily energy expenditure.
- H6: During lactation, women will use behavioral pacing strategies to improve the efficiency of their breast milk production.

*METS, or metabolic equivalents, is a concept used to indicate the amount of oxygen or *energy* the body uses during a certain physical activity (e.g., sitting, standing, walking, running). A unit of MET expresses the *ratio* of each individual's metabolic rate while performing a given task *compared to their metabolic rate at rest*. For example, one MET is equivalent to the energy or oxygen used (50 kcal/hour/$m^2$ body surface area) at rest, the resting metabolic rate (RMR), or when the body consumes 3.5 ml of oxygen per kilogram of body weight per minute.

## CHAPTER II

## THE OTOMÍ OF HIDALGO – YESTERDAY AND TODAY

History of the Otomí

According to Winter and Hopkins (1984), the Otomanguean linguistic family, a language dating back to 4500 BC, was spoken by three groups of food foragers, the Zapotec, the Mayan, and the Otomí, who first arrived in the central plateau region of Mexico as early as 7000 B.C. (Ibid. 1984, Melville 1994). The Otomí, the Tepehuanes, Mexicas, and Nahua Indians populated the Central Plateau of Mexico during the archaic period between 7000 and 2000 B.C. (Winter and Hopkins 1984). Originally, the present-day state of Hidalgo was an Otomí Kingdom (Xilotepec), with Chichimecas to the north and Nahuas to the south (Gibson 1964, Schmal 2004). For centuries, these indigenous peoples (see Fig. 3) foraged for wild greens (*verdolagas* or purslane and *quelites* or pigweed) [3] and hunted deer, rabbit, hare, fox, squirrel, opossum, rats, skunk, birds, certain lizards, and insects or grubs, such as the Maguey *gusano* or worm (Bernard and

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[3] *Quelites*, commonly known as pigweed, is a member of the Amaranthus hypochondriacus family of wild edible greens. This plant is a good plant source of vitamins and minerals, including vitamins A, K, B-6, C, B2, folate, and the minerals calcium, iron, magnesium, phosphorous, potassium, zinc, copper and manganese. The plant's stanols (phytochemicals) lower LDL cholesterol, decreasing the risk for heart disease, however, quelites do contain oxalic acid, similar to spinach, inhibiting absorption of calcium and zinc. *Verdolagas* or purslane grows wild throughout the Americas. Purslane is a good plant source of protein, beta carotene, vitamin E, vitamin C, and one of the richest plant sources of the essential omega-3 fatty acid, linked to increased immune function and prevention of heart attacks. It has been used in salads and as a medicinal plant for hundreds of years, especially among traditional peoples. It is thought to have a beneficial effect on the brain and may reduce the incidence of depression, anxiety, bipolar and schizophrenic disorders (Radhakrishnan 1998).

Figure 3. Otomí husband and wife, Pañhe, Hidalgo, 2006.

Pedraza 1989). Coyotes and snakes were considered inedible (Ibid. 1989). By the time the Toltecs established the military city-state of Tula in 980 AD, the Otomí were well established in this region as sedentary subsistence farmers of maize, squash, and beans (Carrasco 1979, Medina and Quezada 1975, Schmal 2004). The Toltecs, or "sun worshipers," seized control from the "moon-worshipping" Otomí (Wolf 1959:122) and dominated this region until 1168 AD when the conquering Mexicas pillaged and destroyed this ancient city center (Wolf 1959: 117). During the pre-conquest period in the 13th century, Hidalgo was conquered by the Mexica and became part of the Aztec Empire (Carrasco 1979, Schmal 2004). Tula, approximately 55 miles north of Mexico City, became a very important part of the Aztec Empire. After the destruction of Tula, the Otomies fled to the west, taking refuge in the mountain caves surrounding the semi-arid plains of Hidalgo (Guerrero 1983, Lastra 2006, Medina and Quezada 1975). Because the Mexicas knew the Otomies were expert farmers, they demanded tributes of the foods they produced (Schmal 2004).

On the northwestern-most edge of Hidalgo in the *Valle del Mezquital*, the Otomies established the village of Tecozautla. Between 730 and 740 AD, the Otomies built a 20 foot high and three mile long stone wall Tecozautla for protection against the invading Chichimecas from the north (www.tecozautla.com.mx/historia.html, retrieved 3/20/2011). After the Spanish gained control of the region in the spring of 1521 AD, Franciscan missionaries began to spread Christianity throughout Mexico. In 1535 AD, a Franciscan missionary, Friar Juan de Sanabria arrived in Tecozautla and established the

first Franciscan convent. This same friar eventually mediated a peaceful compromise between the Otomies and the Chichimecas, and was instrumental in the dismantling of this stone wall surrounding the city (www.tecozautla.com.mx/historia.html, retrieved 3/20/2011). The Spaniard Nicolas Montaño, the overlord of the Jilotepec *encomienda* [4], arrived in 1551 AD, and further subdued Tecozautla with the assistance of Maxorro, an Indian prisoner who was helping the Spaniards in return for gaining his freedom (Ibid. 2011).

Historians agree that there were approximately 20 million Indian peoples living in Mexico during the "early Conquest" period of Spanish domination (c. 1521 AD). Less than 100 years later, the Indian population had drastically dropped to less than one million, most succumbing to a combination of infectious disease spread by the Conquistadores and brutal treatment in the hands of their captors (Batalla 1989, Carrasco 1950, Casasola 1989, Gibson 1964, Wolf 1959). During the Mexican revolution in 1910, the Indian population had grown to 15 million (Carrasco 1975). In 1970, there were approximately 48 million Indians in Mexico with 38% of them younger than 15,

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[4] *Encomiendas* were large tracts of land and indigenous villages gifted by the Conquistadores to wealthy Spanish subjects for their service to the crown pre-dating the era of *haciendas*. These gifted *encomiendas* included the enforced labor or slavery of the indigenous peoples living in these communities to mine the rich mineral resources, such as gold and silver (Wolf 1959). This enforced labor system was modified by the Spanish crown, fearful of a loss of subject loyalty in an environment of expanding colonial wealth. The disintegration of the *encomienda* and its accompanying feudal system resulted in a "benevolent paternalism" associated with the onset of the *hacienda* system (Ibid. 1959). The wealthy mestizo landowners who control *haciendas* are considered a type of "overlord" by the *indígenas* and are still addressed as *don* and *doña* today.

and 50.6% older than 15 (www.inegi.gob.mx, 2004 census). Toward the end of the 20th century, the fertility rate among the Indian populations had dropped from 4.6 per 1000 in 1979 to 2.9 per 1000 in 1993 (Ibid. 2004 census). The Hnahñu or Otomí, the fifth largest group of Indian-speaking populations, remain the poorest Indian group in Mexico (Bernard and Pedraza 1989).

Between 1690 and 1700 AD, the Catholic cathedral (Santiago Apostol is the *patron saint of this cathedral) was built in* the Tecozautla town square (see Fig. 4), and in 1702 AD, the stone *aqueducto de los arcos* (or aqueducts) were built south of the town square (see Fig. 5) to establish an efficient and impressive irrigation system serving the city (www.tecozautla.com.mx/historia.html, retrieved 3/20/2011). Mexico won their independence from Spain in 1821, and in 1824, the Republic of Mexico was established. Hidalgo, including the territory of the Valley of Mezquital, became a state in 1869 (Ramsay 1934).

In 1904, a monumental colonial clock of rose quartz was constructed. The magnificence of this beautiful clock tower still dominates the town square (see Fig. 6). There is a legend that the wealth of Tecozautla was buried in the wall behind the clock tower, and that ghostly *women in white* guarded this *wall of treasures* by night during the construction (www.tecozautla.com.mx/historia.html, retrieved 3/20/2011) of this magnificent stone structure.

Among the most influential figures in Tecozautla history was Sr. Melchor Ocampo Guerrero, a revolutionary who fought to support land reform in the late 19th

Figure 4. Catholic cathedral, Tecozautla, Hidalgo, 2006.

Figure 5. Aquaducts, Tecozautla, Hidalgo, 2006.

Figure 6. Quartz Clock Tower, Tecozautla, Hidalgo, 2006.

century, returning parcels of land to the indigenous populations following the Mexican Revolution (*los ejidos*) [5], and Señor Jose Angeles Ocampo, an influential educator in the early 20th century (Ibid. 2011). My first key informant during this research project was Rosalina "Rosie" Ocampo, an educator who teaches English to the children attending *la primaria* (elementary school), and whose husband counted these heroic men in his ancestry.

Numerous reports of global desertification (McMichael 2004) that threaten human survival, including Australia (Melville 1994), Central America (Melville 1994) and Africa (Glantz 1977), are often the result of human mismanagement of domesticated livestock. Overgrazing by domestic livestock has resulted in the relentless encroachment of unpalatable trees, thorny shrubs, and cacti creating vast regions of semi-arid plains (Melville 1994). As a consequence, these harsh, dry regions are highly susceptible to drought, flooding, and famine challenging the survival of people all over the earth, such as the semi-arid desert plains of the *Valle del Mezquital* (see Fig. 7).

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[5] *Ejidos* are land grants returned to the *indígenas* after the Mexican Revolution from the land that had been originally taken by the Spanish to establish *encomiendas* and later *haciendas*, vast land holdings for the wealthy mestizos. *Ejido* land belongs to the entire community and use of land titles are granted to the individual. Firewood and pasture rights are communally held by the entire community. The *ejido* land plots in Hidalgo have limited access to irrigation water, and without water the peasant farmers cannot cultivate this land. Most peasants cannot afford to pay the cost of running pipelines for irrigation water, reported by residents of Pañhe to be approximately 10,000 pesos (~$1,000 US dollars). As a result, many of these land grants lie unused, and the wealthy landowners resent the policies that removed them in the first place. The wealthy landowners believe that the peasant farmers will never use this land anyway and see these *ejidos* as a waste of valuable land (personal communication with Señor Jesus Resendiz of San Antonio). However, I did see some *ejido* land being cultivated, growing calabaza squash and other vegetables for subsistence and cash crops by a few of the families in Pañhe.

Figure 7. Typical flora of desert surrounding Pañhe, Hidalgo, 2006.

In 1548 AD, the geographical description of the *Valle del Mezquital* was recorded as being a "fertile, densely populated, and complex agricultural mosaic composed of extensive croplands, woodlands, and native grasslands," where "oak and pine forests covered the hills, and springs and streams supplied extensive irrigation systems" (Melville 1994:31). The northwestern portion of the *Valle del Mezquital* (territory that includes modern Tecozautla) was "described as fertile and very productive, with good potential for wheat growing" (Ibid. 1994:158-9). These valleys were once covered with tropical deciduous forest, but after centuries of human intervention, the *Mezquital* is now characterized by "pitiful clusters of unarmed shrubs and grasses cowering in the protective radiuses of the long-armed cacti, out of the reach of animals" (Ibid. 1994:30), sparse vegetation of thorny shrubs, cactus and introduced pirul [6].

Pastoralism, an essential way of life to the Spaniards, was introduced during the Colonial period (see Fig. 8). The Spaniards imported vast numbers of sheep and cattle into central Mexico. The Huichapan Plateau (nearly 1700 $km^2$), bordered on the north by the Moctezuma River and on the south by the Xilotepec Plateau, is home to the *cabacera* (or municipality) of Tecozautla. Sheep and goats are known to destroy their own subsistence base, and most of the regions exploited by sheep-raising during the Colonial period were marred by extensive erosion (Melville 1994), including the

[6] Pirul is a local introduced tree that grows near sources of water. Pirul branches are used by *curanderas* (native healers) to "cure" diseases. The *curandera* sets fire to these dried branches and then waves the smoking branch near the sick individual to drive away the effects of "evil" that are believed to be causing their disease and restores the equilibrium between hot and cold within the individual.

Figure 8. Otomí man with goat herd, Pañhe, Hidalgo, 2006.

Huichapan Plateau. Following several decades of over-exploitation of the sheep and cattle herds and the mismanagement of the ranges, as a result of various converging factors of human intervention and government policies, the once abundant springs disappeared eliminating the irrigation systems. Various xerophytes such as mesquite, maguey and thorny shrubs invaded and eventually dominated this terrain, permanently changing the agricultural potential of this once fertile valley, leaving behind a harsh, arid landscape susceptible to flash flooding and covered with the *tepetate* (hard pan) soil that is characteristic of the *Valle del Mezquital* today (Ibid. 1994).

Driven by a quest for survival in this desert climate, the *indígenas* discovered the life-saving potential of the Maguey cactus, and learned how to harvest *agua miel*. *Agua miel* is the sap that nourishes the flower of the Maguey cactus (or century plant). *Agua miel* when fermented makes *pulque*, a beverage that provides them with sufficient vitamin and protein-rich liquid to survive in the extreme desert heat hence, they are sometimes referred to as the *Maguey People* (Granberg 1970). Many of the Otomí women related that *pulque* increased breast milk production, but once the Mexican government outlawed home-production of *pulque* in the 1950s, most quickly deny consuming *pulque* even while breast-feeding; however, several times I saw them surreptitiously drinking *pulque* despite these claims.

It has long been recognized that one's native language is inextricably connected to social behavior and cultural identity. The Otomí language diverged from the Otomanguean language family during the post-Classic period (c. 1000 AD), probably due

to a combination of isolation and migration while fleeing the Aztecs (Winter and Hopkins 1984). In 1969, Manrique reported a population of some 300,000 speakers of the Otomí language in the Central Plateau region of Mexico. In 2000, there were a total of 114,043 speakers of the Otomí language in the state of Hidalgo (Lastra 2006), however, the 2005 census in Tecozautla reported only 1,646 speakers of the Otomí language living in this municipality, and only 22 percent of the 95,057 Otomí *indígenas* residing in the state of Hidalgo were monolingual speakers of their original dialect (www.inegi.gob.mx, census of 2005).

For many years, the Mexican educational policies directed "hispanification" of indigenous children, teaching them to speak Spanish. During the 1990s, the Mexican government made a reversal in educational policies in regard to indigenous and linguistic rights, prompted by the 1996 adoption of the "Universal Declaration of Linguistic Rights" (Pellicer 2006). Certain Mexican government agencies were created and charged with promoting and protecting indigenous communities and their languages. These agencies included the National Commission for the Development of Indigenous Peoples (Comisión Naciónal para el Desarrollo de los Pueblos Indígenas or CDI) and the National Institute of Indigenous Languages (Instituto Naciónal de Lenguas Indígenas or INALI) (Ibid. 2006). However, these national policies may have been introduced too late for most of these children, and have yet to influence the villages of Pañhe and Gandho near Tecozuatla where the children are being taught exclusively in Spanish. Most Otomies believe that speaking their native language is associated with

being and remaining poor (Bernard 1989). The participating women (ages 18-43) in this project were bilingual, speaking both Spanish and Otomí, and interpreting for their monolingual Otomí-speaking parents (older than 50 years). However, the children younger than 15 years of age in Pañhe and Gandho no longer understand or speak Otomí. Spanish is their only language, and much of their traditions, customs, and culture have now been forgotten by these village children.

The *mestizos* (descendants of Spanish and Indian mixed blood) of Mexico view the Otomí as one of the most inferior nomadic populations (Bernard 1989). This negative perception dates back to their conquest by the Mexica Indians during the establishment of the Aztec empire. Their name comes from the Nahuatl word, *Otomitl* meaning *wanderer* (Lanks 1977). However, the Spanish term *la otomía* is a noun that means *barbaric acts, savagery, villainy, vulgarity,* and *merciless atrocity* (Ramsay 1934, Bernard 1989). The Mexican federal government, administered by mestizos, still regards the Otomí Indian with contempt, believing them to be a lazy, rebellious and trouble-making people (Bernard 1989), and this distrust was mutually evident during this project. One Otomí woman in Tecozautla disparagingly remarked to me that the mestizos "always lie to us" and take advantage of the Otomí in business transactions, while the mestizo landowner of the hacienda where I resided during this project refused to allow an Otomí woman to walk on his grass when she came to visit me. These traditional people call themselves the *Hnahñu*, literally meaning to "speak well," a term they prefer to *los Otomies*.

As a result of historical forces over several centuries of time, the Otomí has been forced into a lifestyle of further marginalization in the northwestern and central semi-arid desert region of the state of Hidalgo. The mountain caves where they survived historically can still be seen while driving through many of the roads of Hidalgo. One of these caves has been converted into a religious shrine along the road to Huichapan (see Fig. 9). Some members of the Pañhe community still live in these mountain caves and a few remember sleeping in these caves as children (see Fig. 10). One grandmother told me she had lived in the mountain caves as a child, with no clothes or shoes, until she was ten years old. She slept on a rough maize sack laid on the dirt, sharing one blanket at night with three others, her grandmother and two aunts. The winters were the hardest, she said, when one blanket was not enough to keep the cold away. It was just too cold to sleep. In the winter months, the desert regions are very cold at night, at times reaching temperatures below freezing. The hardy constitution of this people is most likely responsible for their survival for well over two thousand years under these harsh social and environmental conditions.

This same grandmother told me that she knew her father was married to other women, a practice that was discouraged during the Colonial Period with the arrival of Catholic priests and their teachings (Carrasco 1975), but she did not know how many. He was not around very much when she was young. She knew her mother, but didn't see her much. Instead, she was raised by her grandmother and her aunt. She still remembers how hard it was to stay alive with very little to eat and only *pulque* to drink.

Fig. 9. Mountain cave shrine, Hidalgo, 2006.

Figure 10. Mountain caves near Pañhe, Hidalgo, 2006.

As a child her stomach "always hurt," because she was so hungry. Most of the women in this study told me a similar story, that their stomachs were "always hurting" as children making it very difficult for them to "concentrate" in school. Until 20 years ago, two or three tortillas, a handful of beans, *pulque* and some gathered wild greens composed their total daily diet, according to many participants.

Her grandmother never taught this woman about menstruation, pregnancy, childbirth, or lactation, she just learned through experience. She and her husband had 13 children and lost four of their children to starvation and to pneumonia.

As a young mother, she ground corn into flour for *masa* (corn dough) and made tortillas *por mano* or by hand. Today the women take their soaked maize or *nixtamal* [7] to the mill to grind into *masa* each morning, and then carry the *masa* back home in small plastic buckets. They no longer make tortillas by hand, but use a tortilla press to make their tortillas.

Pañhe is very different now, she said. When this grandmother was young, she

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[7] *Nixtamal* is a mixture of water, corn and calcium oxide or lime (*cal*) that has been cooked until the corn skin begins to separate from the kernel when squeezed between the fingers (tender). This mixture is then ground into *masa*, the corn dough used to make tortillas, either by hand on a *matate*, a flat wedge, loaf-shaped rectangular lava stone with a lava stone roller, or the cooked *nixtamal* is carried in a small plastic bucket to a grinding mill (*molina*) where it is ground into *masa* for about 1-2 pesos per bucket and carried back home in this same plastic bucket. A kilo or *quartillo* of tortillas (about 20 tortillas) costs 7-10 pesos to buy from a *tortillería* (a shop that sells hand-made tortillas), while these women can make about 4-6 *quartillos* of tortillas from one bucket of masa for just 2 pesos, according to one of my participants. However, she did not count the cost in human labor for growing, preparing, storing, and cooking the corn, which involves hours of hard labor, or the time in human labor to prepare the tortillas. The practice of grinding the *nixtamal* by hand is rare today, however, I did find one family in Gandho that still had a *matate* stone, and the grandmother showed me how she used it many years ago.

said there were no schools, no medical clinics, no hospitals, no doctors, and no vegetables or fruits in the market. She said they ate *quelites* (pigweed)*, verdolagas* (purslane)*, nopales* (prickly pear cactus)*, tuna* (fruit of the prickly pear cactus)*, flor de sabila* (cactus flower)*, flor de garambullo* (cactus flower)*,* and *fruta de garambullo* (cactus fruit). She never saw carrots, peas, *calabazas* (squash), potatoes, or the other vegetables that are now common in the markets. They lived on *pulque* and tortillas, sometimes beans (if they made enough money making baskets), and sometimes meat if her husband had some luck in hunting. There was no sugar, no sweets, no chocolate, no cookies, nothing but beans, corn, and tortillas in the market.

This same grandmother said that the weather in Pañhe is also very different now, hotter and dryer than when she was a young child. She said that they used to be able to rely on the rain to grow their corn. She thought it was sad that the younger generation no longer eat the indigenous plants, but instead buy vegetables in the markets with money, which is hard to earn. She said that most of her grandchildren don't like *verdolagas* or *quelites*, so they no longer eat them. She learned how to make baskets when she was very young from her grandmother, and has survived making baskets her entire life.

An elderly Otomí couple in Gandho described their life as one of "back-breaking endless toil" (see Fig. 11). This couple had lived in a house built by his great grandfather since the 1930s. For most of their lives they lived on *frijoles* (beans), *verdolagas* (purslane), *quelites* (pigweed), lentils, rice, *nopales* (prickly pear cactus), and tortillas *de*

Figure 11. Elderly Otomí couple, Gandho, Hidalgo, 2006.

*maiz* (corn). Neither went to school because there was no school in the 1930s. They worked the fields together, planting and harvesting green tomatoes, alfalfa for their animals, maize and green beans. They used a bull to pull the plow in those days. Today they use horses. The man said his father taught him how to "train" the bull by tying its head into the fork of a tree and leaving it there all day, twisting and pushing, trying to get free, until it was very tired and thirsty. When they placed the yoke on the bull, the bull would then push forward again to try and get free, thus pulling the plow through the earth. His wife, with her baby wrapped in a *rebozo* (shawl) on her back, followed in her husband's footsteps, dropping the corn seed into the freshly thrown furrows created by his plow and bull. The woman confided that her parents had many acres of land when she was young, but her parents were "killed by her uncle because he wanted their land."

When asked to describe how they met, the woman told me that her future husband was working in Morales as a young man and came to visit his parents in Gandho. He met her in the streets and asked if she "wanted to go to his house?" The family all laughed at this story because, according to their daughter, this was in reality a proposal for marriage. They told me that they lived together until they had their first baby and then they "got married." They said it was different now, because today they get married before having babies. This man claimed that there were five other girls who wanted to marry him, but he said he wanted "only her." The Otomí apparently practiced polygamous marriage for centuries, however, during the Colonial period the Catholic

Church discouraged this practice. Some of the women I interviewed in Pañhe know their husbands do have other wives today, but they seemed to be in denial, and told me that their husbands were “busy working in other places,” and that they “came home *a veces”* (sometimes).

This elderly Gandho couple had 12 children, three of whom died because of “sickness,” one child from measles at one month old, another from whooping cough at 10 months old, and one from pneumonia at 15 days old. Two others died from drinking too much *pulque*, and one died in a car accident at the age of 19 after immigrating to the United States for work. He had only been in the United States for two months when this happened to him. The father said that he still has a "pain in his heart" for all of his lost children.

The woman described her daily activities beginning at 4:00 a.m. when she would wake up to grind the *nixtamal* using a *matate* stone to grind the *masa* (tortilla corn dough). She would make “enough tortillas for everyone,” that included her husband, her eight brothers-in-law, and all her children. She made four *quartillos* of tortillas every morning (approximately 80 tortillas). The woman told me that she had boys first, and they did not help her, only her girls helped her. After childbirth, she said she went back to work immediately because there was “no one to help her.” There was no water near their house when they were first raising their children. The woman walked more than half an hour to a *manantiel* (natural spring) with a *cantaro* (large clay jar of 2-3 liters) that she carried on her back, using a *macatal* (a band of *ixtle* or a woven fiber called

ayate [8] made from the maguey cactus) over her forehead (see Fig. 12), and then walked for the half an hour back again. Because water was so difficult to obtain, they usually drank *pulque* to quench their thirst.

History of the Otomí Diet

In 1946, the Otomí were found to have an adequate diet by Dr. Anderson, existing on maize tortillas, beans, *chile* peppers, small amounts of onion, garlic, and tomatoes, wild greens (*quelites, verdolagas, mallow, lengua de vaca, nopales, garambullo, endivia*), some wild rabbit, insects, grubs, and *pulque* (see Figs. 13 and 14). Most ate only two meals a day, the main meal being consumed in the mid-afternoon. The evening meal was small and consisted of leftovers. According to Anderson, he had "not seen a poorer region in the course of [his] rather extensive travels in Mexico" (1946: 885). He reported nearly 60 percent of the children were no longer living (Anderson 1946). In the present study, most of the women older than 50 years of age reported similar infant and child mortality rates in their lives, however, the younger generation of women (ages 18-43) who participated in this project no longer suffered

[8] *Ayate* refers to rectangular pieces of fabric made from the woven ixtle fiber from the Maguey cactus. These pieces were used primarily as headbands to carry heavy loads, however, these women called any size of ixtle fiber material an *ayate*, including the large square (about 3x3 feet) that is used as a sling-type of cradle that is hung from the limb of a tree, with the baby comfortably lulled to sleep by gentle breezes, because of the loose weave of the fabric that easily allows air flow, while being rocked by the mother or an alloparent. The Otomí Indians still used *ayates* for carrying purposes, such as wood and other types of fuel, as well as any large bundles of harvested plants or fodder for their animals, however, they no longer weave them to sell in the markets, but use them strictly for personal purposes.

Figure 12. Ayate or ixtle fiber, used as tumpline, Gandho, 2006.

Figure 13. Otomí child eating garambullo fruit, Pañhe, 2006.

Figure 14. Otomí infant eating tortillas, Pañhe, 2006.

from this high rate of infant mortality, primarily due to improved lifestyle conditions and increased female education. The primary causes of death among the Otomies in the 1940s were pneumonia (or other respiratory illnesses), and intestinal disorders such as diarrhea or dysentery (Ibid. 1946).

Despite the extreme poverty and minimal dietary intake, Anderson concluded that the Otomies were consuming large amounts of gathered plants that provided them with sufficient quantities of vitamins and minerals, as well as adequate protein, high carbohydrate content and low fat intake, with a significant quantity of *pulque* being consumed even by the babies, averaging nearly 15% of their total dietary intake. He noted no protein deficiencies, anemia or iron deficiencies, even among the lactating and pregnant women (Anderson 1946). The only nutrient found to be "definitely inadequate" was riboflavin (vitamin B-2) with clinical signs of tongue inflammation being noted.

Anderson concluded that because of the complete lack of sugar in their diet, combined with an adequate intake of most vitamins and minerals, these people were remarkably healthy and had excellent teeth with no evidence of hypertension. He did not recommend any changes in food intake until something "really better" could be offered. He did note their small stature by American standards, however, he felt that it would be impossible to separate their growth status from a physiological adaptation to the desert (Anderson 1946). In the current study, the dietary intake of the Otomies in Pañhe and Gandho hasn't dramatically changed in the last half century.

The food dishes that Tecozautla is noted for in the tourist publications are red *chile* sauce with chicken (*mole rojo con pollo*), barbecued sheep (*barbacoa*), *quelites* and *verdolagas* (Aranda 2000); however, the peasants living in these villages only eat the first two dishes on very special occasions, such as baptisms, primary school graduations, weddings, or funerals and religious fiestas.

On the hacienda where I resided during this study, the mestizo owner's family hosted barbecues at least every other month for many family members and friends (usually 150-200 people), slaughtering a sheep and roasting the carcass in an underground pit for two to three days wrapped in maguey leaves (*barbacoa*). This slaughter would take place early in the morning. Unfortunately for me, it occurred just in front of the gate to my house compound, and was timed to occur just as I left the house in the early morning hours. This was so distressing to me that I asked them if they could let me know ahead of time so that I might leave a little earlier on these mornings to avoid this grizzly sight as I embarked on my day's activities.

Despite this unpleasant prequel to preparation, the sheep meat or *barbacoa* was very tender and had an exquisite taste. Unlike the mestizos, the *indígenas* usually made *menudo* (stew prepared from the intestines) from the slaughtered sheep for their fiestas. However, the mestizos never ate *verdolagas* (purslane) or *quelites* (pigweed), two of the main greens consumed by the Indians. Mallow, another wild edible green, was abundant on the hacienda property, and the wife of this family, was always showing me these plants in her garden, indicating that they were the customary food for the

*indígenas*, but not for the mestizo. In contrast, the mestizos served *barbacoa*, broiled or roasted chicken with mole, enchiladas, burritos, salads with head lettuce and tomatoes, fruits, and refried beans with mountains of tortillas and very fancy desserts and cakes, along with vast amounts of beer and tequila, to complete their table on these special occasions. Her kitchen was always stocked with lots of *chiles*, fruits and vegetables.

The Otomí of Hidalgo Today

There are three groups of Indian populations in Hidalgo, the Otomí, Tepehauno, and Huasteco, however, the Indian population in the Valley of Mezquital is primarily of Otomí origin (Casasola 1989). The Otomí indigenous peoples have lived for centuries in this harsh desert environment subsisting primarily on maize and maguey cactus cultivation (Manrique 1969), maintaining much of their traditional lifestyle despite being surrounded by the rapidly changing world of the *mestizo* (Spanish and Indian mixed origin). The indigenous population in Mexico is about 16.3% of the total population and greater than 40% of these people are illiterate. The Otomies account for about 5% of the total indigenous population (www.inegi.gob.mx, 2005 census). The Otomies who live in the Valley of Mezquital are the most completely abandoned, with scarce water, and land that is infertile (see Fig. 15) (Casasola 1989). Until the 1970s, they lived on the fiber of the Maguey cactus (*ixtle*), and were experts in weaving, making shawls and ropes from *ixtle*, spinning this fiber while walking using a *malacate* (stick or spindle whorl with a small clay disc) (Lanks 1977). Once the demand for *ayate* was replaced by

Figure 15. Otomí child making mud “pies”, La Mesa *barrio* of Pañhe, Hidalgo, 2006.

commercially produced textiles in the markets during the mid-20th century, they adapted to creating other artisan crafts for income production. The peasant farmers who live in Pañhe today are known for their expertise in weaving baskets from the indigenous Carrizo reeds and making obsidian figurines. They are still expert farmers, however, there is relatively little fertile land for them to plant. They do not move to another region, despite the harsh conditions and scarce resources, because they say the best *pulque* is in Hidalgo (Casasola 1989).

I met one elderly Otomí woman in her eighties who had never married (see Fig. 16). She was living on the property of another family, behind their latrine among their chickens and pigs in a rough stone one-room dwelling with a small doorway where she slept each night. In front of her house was a small cleared area covered with a Carrizo reed lean-to "roof" that was supported by two rickety tree limbs, under which she spent her days sitting on the rock-filled hard earth weaving her *canastas* (baskets).

She told me she had lived most of her life out in the desert with no shelter from the elements, wearing few clothes and no shoes. Only recently, her uncle had died leaving her his small house. "My first house," she beamed, "where I can finish my life and die." She spoke only Otomí, and one of the other participating women translated her story into Spanish so that I could understand and record her story. This old woman taught me most of the Otomí words I learned in this difficult language (see Glossary).

Most of the women in these two villages were housewives who made baskets for an income, some worked in the fields because they were too poor and needed more

Figure 16. Elderly Otomí woman in front of her “first” home, Pañhe, Hidalgo, 2006.

money, others made glass figurines from obsidian, almost all worked very hard, especially in Pañhe. A few women in Gandho didn't work very hard because they had husbands who made more money working in Mexico City or in the United States, and there was no one watching them like a mother-in-law (*suegra*). Most did live with their mothers-in-law and some were treated like slaves, working very hard all day long supervised by the ever-present, watchful eye of their *suegra*. For many of these women, however, they seemed to be friendly with their *suegra*, and had formed a mutually supportive and caring relationship.

All of these women looked well-fed and most seemed happy, even in living conditions of devastating and oppressive poverty. Many of their homes were relatively neat and tidy, despite the overwhelming dust and the constant annoying presence of flies. Their school children looked bathed, cleanly dressed in freshly washed and pressed uniforms, with braided hair (they used lime juice to make the children's hair shine) interwoven with white and red ribbons. They were attentive and devoted mothers for the most part. I only met a few women who seemed to be unconcerned about the appearance of their children. The rest were loving mothers who spent much time cleaning their homes and their children. Sometimes this was difficult because they had to walk great distances for water when the water and utilities were cut off by the administrators in Tecozautla. Only on rare occasions did I see them standing and talking with relatives or friends for more than a few minutes. For the most part, they seemed to be always working, always busy, with tired, but cheerful faces (see Fig. 17).

Figure 17. Otomí woman making Carrizo reed baskets, Pañhe, Hidalgo, 2006.

Most of these women were dominated by men who regularly abused them (see Fig. 18). Many reported beatings by the men in their lives on a regular basis. During interviews, it became apparent that the women believed that all men throughout the world abuse their wives and daughters, so they tolerate this behavior, perhaps because the dominant male might be seen as a good potential mate to increase their chances for reproductive success (Blaffer Hrdy 1999).

The only women who did not participate in this study were those whose husbands had refused to allow their participation. Many of the *indígenas* believed that my motivation was to "steal their babies," perhaps a practice having historical basis in reality. While one of the participating women helped other women who couldn't read to obtain their DIF[9] money one morning, I was taking photos of her children playing in the Tecozautla town square. Unknown to me, other watching women told the police I was planning to "steal her children." The police talked with the children and their mother to verify this claim. Since this was not the truth, I was never approached. Only later did the woman tell me about this incident. Despite my repeated assurances throughout the months of this project that I was not interested in their children, and would most certainly not take their babies away from them, some of these men stubbornly refused to allow their wives to participate. Among the Otomí people, the man's decision is final,

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[9] DIF checks were a government welfare system called *Los Oportunidades* to benefit the *indígenas*. These DIF payments (~ 150 pesos or $15.00 every three months) were dependent upon attendance at medical clinic meetings, school attendance and academic performance of their children.

Figure 18. Otomí father and husband, Pañhe, Hidalgo, 2006.

and the woman could not and would not disobey. It was obvious that these women were frightened of their husbands and fathers and never questioned their decisions.

The Setting

Nestled in the *Valle del Mezquital*, about 114 miles northeast of Mexico City, the rural agricultural municipality of Tecozautla lies in the most arid northwestern corner of the state of Hidalgo (see Fig. 19), and is home to 31,609 people of *mestizo* and *Otomí* Indian origin (www.inegi.gob.mx, 2005 census).

The name Tecozautla is derived from the *Nahuatl* root words, *tetl* (stone), *cozauqui* (yellow or ochre), *tla* (place of). In Spanish this means a "place where there is an abundance of yellow stone" (www.tecozautla.com.mx/historia.html, retrieved 3/20/2011). Tecozautla, a rural agricultural community characterized by a short wet and a long dry season (Walsh 1981), has become an attractive tourist destination, famous for *balnearios* (natural hot springs) and the abundant production of avocados, citrus fruits, pomegranates and figs.

Established as an Otomí village in approximately 1200 AD, Tecozautla became a city in 1969 and was declared a *município* or county seat in 1993 (http://www.houstonculture.org/mexico/hidalgo.html, retrieved 4/11/2011). Today, this *município* or *cabacera* is surrounded by several indigenous *pueblos* or villages, including *Gandho, Pañhe, San Antonio, La Esquina, Bomanxotha, El Doranhi,* and *La Mesilla,* that are situated on communal *ejido* land with limited access to electricity, irrigation or groundwater.

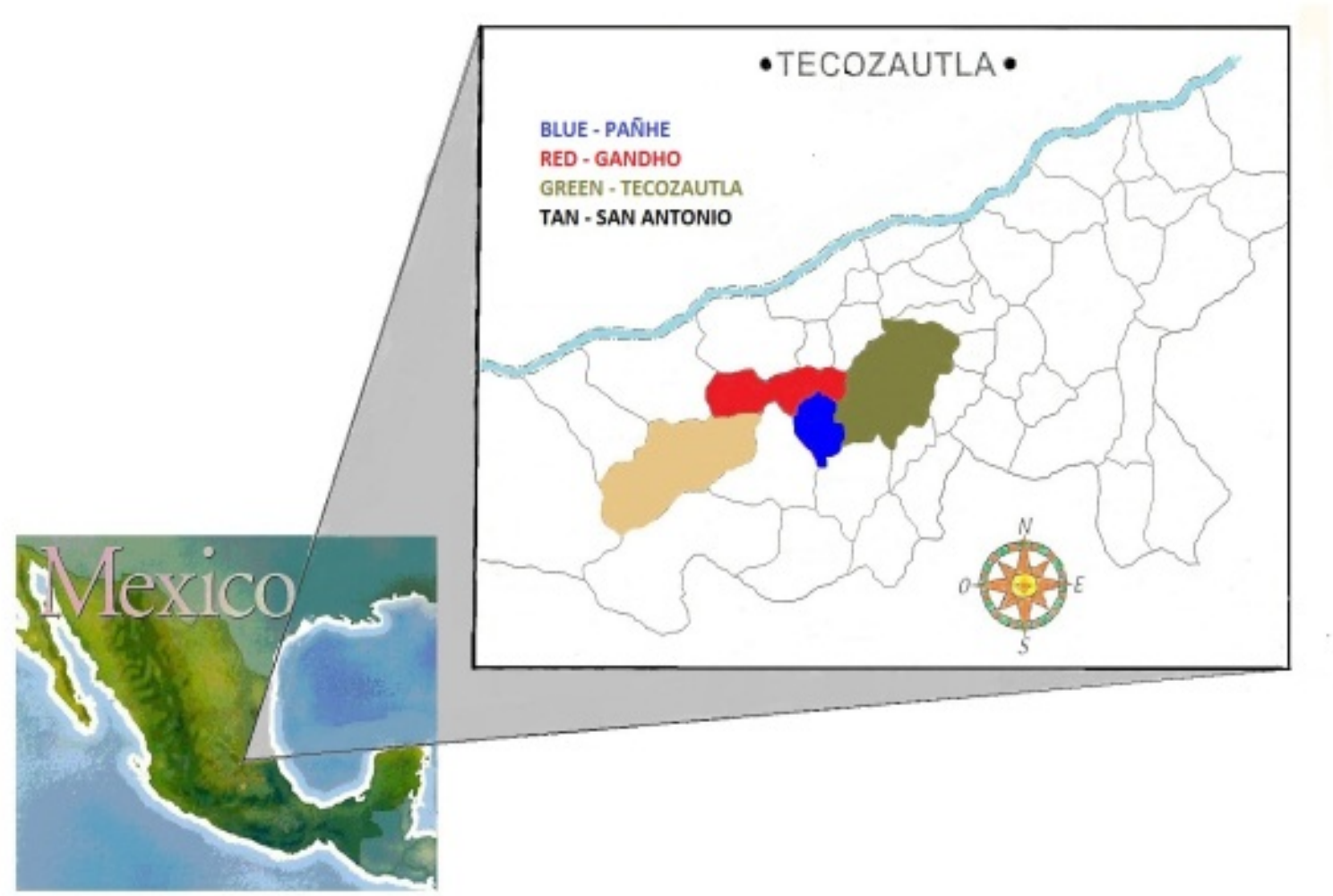


Figure 19. Map of Tecozautla municipality with location in Mexico; Map of Mexico, copyright Googlemaps 2011.

The *Valle del Mezquital* is named for the overwhelming number of mesquite trees growing in this semi-arid region (Bernard 1969, Manrique 1969, Melville 1994). The vegetation in the desert regions surrounding Tecozautla is primarily thorny shrubs, maguey cactus, acacia trees, scrub oak, and introduced *pirul* trees (see Fig. 20). The Pañhe *curanderas*[10] (native curers) use various indigenous plants for healing such as *cedron* (cedar)*, peregil* (parsley)*, ruda,* and *pirul* (see Appendix, Figs. 118-124). The fauna of this region includes armadillo, hawk, chameleon, squirrel, hare, viper snakes, opossum, coyote, vultures, insects, scorpions, and spiders, in addition to the few remaining rabbit and deer (Pedraza 1978).

Pachuca, the capital of Hidalgo with a population of nearly 276,000, is southeast of Tecozautla (www.tecozautla.com.mx/historia.html, retrieved 3/20/2011). The Sierra Madre Oriental mountain range, a natural barrier to rainfall, lies to the northeast. The state of Queretaro is to the west and Ixmiquilpan, with a population of 74,000 and considered the center or *heart* of Otomí territory, is approximately 26 miles to the east of Tecozautla (Ibid. 2011).

The plains of Hidalgo are characterized as a semi desert steppe, rising to

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[10] C*uranderas* or native healers (curers) were highly respected in Hidalgo, and sometimes feared by the *indígenas*. They use indigenous plants to heal infants from mal de ojo and los aires, as well as diseases among adults. One of the women who lived in Pañhe had a recently-built healing "temple" behind her house that was not visible from the road. She and her mother-in-law, and several aunts were all native *curanderas* who made their living performing "native healings" twice a week. This temple had been built in 1993 by the inscription on the wall, and was called "*Hermanos Espíritual"* (spiritual brothers) with the words "triangulo de amor" (love triangle) written on the inside front wall.

Figure 20. Organ cactus, mesquite trees and Maguey cactus in Hidalgo, 2006.

approximately 1,700 meters above sea level with sparse rainfall (30-38 centimeters per year) with an average annual temperature of 18 degrees C. In January and February, temperatures can drop to as low as 2 degrees C at night (recorded in November 2006), and during May and continuing through the hottest summer months until September, temperatures may climb to 30 degrees C (www.tecozautla.com.mx/historia.html, retrieved 3/20/2011).

This region is also home to the most western edge of the Monarch butterfly annual migratory destination each spring, providing a mesmerizing panorama of thousands of these delicate creatures, twirling and floating high above among the graceful boughs of the towering acacia trees on the hacienda in San Antonio, less than a mile west of Pañhe (personal experience of co-investigator).

Tecozautla

The community of Tecozautla is characterized by very narrow paved streets leading into the town square, filled with numerous potholes, and high stone walls that surrounded well-built masonry and stucco homes. On the road leading to Tecozautla (see Fig. 21) there is a modestly gracious hotel just to the east of the entrance to Pañhe. There is another resort to the south on the main entrance road to Pañhe that is also owned by *mestizos*. As one enters Tecozautla on the main road, there are several auto garages and many *tiendas* or stores selling food, furniture, clothes, shoes, household goods, stationary, as well as pharmacies, internet cafes, butcher shops, and ice cream parlors along the way.


Figure 21. Entrance to Tecozautla surrounded with scrub oak trees , Hidalgo, 2006.

Dra. Olivia Moran's medical clinic is about a block east of the main square and several beauty parlors are within a few blocks of the main square. There is a bank and a telegraph office on the main square inside the government building, where the peasant women line up every three months to collect their DIF (*oportunidades*) government checks, and another bank down the first road to the north near one of the beauty parlors. The post office is on the east side of the main square next to several other clothing and food shops. Dominating the peace and beauty of this town square is the Catholic cathedral and the monumental clock tower of rose quartz built in 1904.

Once every week on Thursday, the town square is magically transformed in the space of a few hours into a thriving, bustling open-air marketplace (see Fig. 22), filled with hundreds of stalls! The vendors sell everything from fresh produce, corn, beans, grains, and nuts, to clothing, household utensils, jewelry, farm equipment, auto accessories, audio equipment, and small televisions. It is like seeing a gigantic Wal-Mart created overnight, and then about 6:00 p.m. that evening, the vendors pack up their wares and booths into pickup trucks, vans, and various other modes of transportation and move on to the next community. Once again, the peace and tranquility returns for another six days.

The architecture in Tecozautla is primarily Spanish with open courtyards and fountains behind the entry walls, with evidence in some areas of modest wealth. There was one particular compound with a three-story house rising high above the trees. One of my key informants, Rosie Ocampo, told me that this house belonged to the man or

Figure 22. The abundance of Thursday's market in Tecozautla, Hidalgo, 2006.

*coyote* who helped the workers to cross the border illegally into the United States. They pay him about 10,000 pesos (~$1,000 US dollars) each time so he will help them get to the border, risking their lives for a chance to earn enough money to build a house and feed their children. Many never return. I was always being stopped by peasant women asking if I could "find their husband." Some would say about their husband, "He left several years ago, and it is so hard to raise six children alone, can you help me?" I couldn't get them to understand that it was virtually impossible to find one man among all the millions living north of the border. What I did not want to tell them was that their husband might be dead, or he might have married another woman in the United States and, thus, would never come back.

Villages of Pañhe and Gandho

About five miles west of the town square, the *Otomí pueblos* (villages) of Pañhe (see Fig. 23) and Gandho are located to the north and south of the main road leading into Tecozautla. The Otomí Indians who reside in these villages are one of the most marginalized sectors of the Mexican population, with greater than 40% of those older than 15 years of age being illiterate. These villages are situated in a dry desert landscape characterized by sparse vegetation, with volcanic rock embedded in *tepetate* (hardpan soil) interspersed between thorny vegetation, Maguey cactus and mesquite trees.

Pañhe, on the south side of the road (see Fig. 24), has a population of 1,821 people, more than two thirds of which are of indigenous descent. There are 959 females and 862 males (www.inegi.gob.mx, 2005 census). Some of the older villagers still speak

Figure 23. Footpath meandering through Pañhe, Hidalgo, 2006.


Figure 24. Aerial map of Pañhe village, copyright Googlemaps 2011.

only Otomí, however, all children now speak only Spanish after attending school for at least three years. The women participants studied in this project spoke Spanish and Otomí and interpreted when necessary for their parents.

Traveling from Tecozautla, the first entrance to Pañhe is a cobblestone road with a large *mestizo*-owned chicken ranch [11] near the main road. A *mecánico* (auto repair garage) and a *pharmacía* (pharmacy) are on the corner of the main road, and a Coca-Cola stand that was erected during my study time in 2006, a few hundred feet up the road into Pañhe. Until about 20 years ago, the *Otomies* drank *pulque* to quench their thirst. The wealthy landowners who hire *peónes* (peasant farm laborers) to work their fields began "giving" them Coca Cola to drink on their morning breaks. Now, the *Otomies* are "hooked" and this Coca Cola stand seemed to be a thriving business.

About half a mile from the main road, there is a *papelería* (stationary store) owned by one of the *delegados* (political leaders) of Pañhe. The second cobblestone entrance road to Pañhe is the main entrance. There is a *mestizo*-owned resort on the left about half a block from the main road to Tecozautla. About a half a mile further on

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[11] This chicken ranch was owned and operated by Señor Jesus Camacho Resendiz, the owner of the *hacienda* where I lived during this research study. He sold his chickens to Pilgrim's Pride brand in the U.S. The Pilgrim's Pride Corporation provided Señor Resendiz with "special" feed and hormones that made the chickens grow "very fast." They were shipped away in 12x12 inch crates on semi-trucks, four to five chickens in each crate, after only 45 days of growth for slaughter. I visited this chicken ranch on several occasions. It was very dirty with thousands of little chickens milling around inside the metal and concrete buildings. These chickens were never allowed outside. The Resendiz family members cautioned me to always wash my hands immediately and thoroughly after being inside the ranch buildings, using hand sterilizing gel if water was not easily accessible. They told me that they used very dangerous pesticides and chemicals to raise these chickens.

is a fork in the road, the left road leading to the elementary school about a mile away, and a medical clinic on the right, with the village Catholic church just beyond. The fork to the right leads to other family compounds and to a riverbed area filled with Carrizo reeds. Further down this road, there is a corn grinding mill (*el molino*) on the right with a small snack shop next to it. The *molino*, the stationary shop, a house window for ice treats for children, and an indigenous temple of native healing that is behind one house compound were the only business enterprises in Pañhe.

At the westernmost end of the village, there is a third entrance that is really just a small foot path, leading up into the foothills towards the mountain caves where some members of the community still reside. The general atmosphere of Pañhe is one of seclusion and poverty. There are several *barrios* or neighborhoods in Pañhe including *Los Pinos, Colonia, Gardenia, Centro 1* and *Centro 2, Maguani*, and *San Miguel*. The *ejido* land of the Pañhe villagers was located on the north side of the main road leading toward Tecozautla just across from *La Mesa*. *La Mesa* is a *barrio* (neighborhood) of Pañhe that is on top of a mesa overlooking the rest of the village.

Gandho, on the north side of the road from Tecozautla (see Fig. 25), has a population of 2,049 people, 1,078 females and 971 males (www.inegi.gob.mx, 2005 census). The main entrance was a well-paved wide road lined with tall trees leading into the town center with many small shops along the way. Gandho seemed to have a better socioeconomic status, in comparison to Pañhe, with paved roads and five drilled water wells. Many of the houses were made of well-built masonry and stucco with terraces

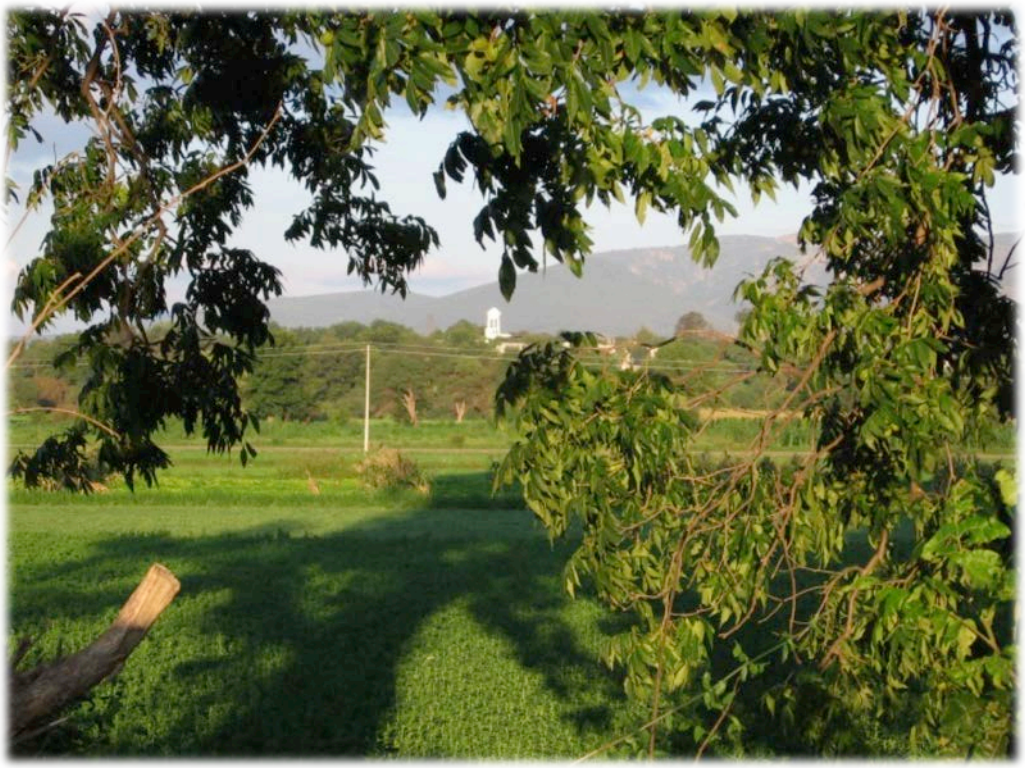

Figure 25. The green fields of Gandho, Hidalgo, 2006.

and porches. There were several shops selling fruits and vegetables, tortillas, clothing, shoes, meat, auto accessories, and some building materials along the main road into town, with a large medical clinic compound across the street from a large elementary school near the town center. Further down this main road to the left was a large Catholic cathedral. There were many fields of maize, *calabaza* squash and strawberries, with much more evidence of accessibility to water. There were more trees, more gardens, and some very well-built homes. In the outlying areas of this village, there were some poorer quality masonry block homes such as were observed in Pañhe, with no fencing or protection. But there were less dogs overall, and the village seemed to have more economic and social stability. Gandho has numerous mestizo-owned agricultural fields that stretched for many miles in all directions.

One family that I studied in Gandho lived on the edge of one of these estates (see Fig. 26). They described seeing helicopters landing on the rooftop of the mansion that was built about a mile away from their "home." This family was one of the poorest in Gandho with only one room in their house, one bed with no sheets or blankets, no other furniture and no indoor cooking facilities or plumbing. There was such a contrast between the lives of these two families living side by side, one an unseen wealthy mestizo family with sheep meandering in the shade of the massive trees lining the dirt path leading to the humble circumstances of this impoverished Otomí family.

This Otomí family had two dogs that were the best fed of any I had seen in Gandho, so they obviously cared for their pets. They also had several chickens, but not

Figure 26. Grandmother and infant from impoverished family, Gandho, 2006.

much else. The parents displayed the typical signs of *pulque* alcoholism with physical evidence of an extremely harsh existence.

Production in Tecozautla, Hidalgo

The state of Hidalgo, one of the smallest states in Mexico with approximately 8,000 square miles of territory, is named for the leader of Mexico's quest for independence from Spain, Miguel Hidalgo y Costilla. Miguel Hidalgo was executed in 1811 by a firing squad for his role in their struggle for independence (Tuck 2008). A statue in his honor is situated at the entrance to Huichapan, a few miles south of Tecozautla.

Hidalgo is known as Mexico's largest producer of alfalfa and maguey cactus, however, this state is primarily noted for its mining industry, including obsidian, zinc and lead, with decreased supplies of gold and silver due to the intensive exploitation of these metals by the Spaniards during the 16$^{th}$ and 17$^{th}$ centuries (Schmal 2004).

Some of the villagers (*artesanias*) in Pañhe make figurines from the abundant obsidian in Hidalgo to sell in the markets as a source of income, however, most of the participating women in Pañhe and Gandho made baskets (*tejederas de canastas*) and most of the men were peasant *agricultóres* or farmers (see Fig. 27). According to INEGI, *Censos Economicos* in 2004, the average income in the state of Hidalgo was nearly 65,000 pesos (~$6,500 US), however, the *delegado* of Pañhe reported an average income for his village as being less than 5,000 pesos for basket-makers and about 10,000 pesos for farmers (~$500 to $1,000 US).

Figure 27. Otomí husband and wife cultivating family garden, Pañhe, Hidalgo, 2006.

There are nearly 12,000 hectares of cultivated fields surrounding Tecozautla, producing alfalfa, corn (maize), calabaza squash, tomatoes, beans, and many varieties of tropical fruit including avocadoes, limes, lemons, oranges, pomegranates, and figs (www.INEGI.gob.mx 2005). According to the Hidalgo state 2005 census, there were 6,421 hectares of corn, 2,517 hectares of beans, 743 hectares of calabaza squash, and 300 hectares of green tomatoes.

In 1999, there were nearly two million chickens, 8,516 cattle, approximately 8,000 sheep, about 7,500 goats, about 7,500 pigs, and almost 2,400 turkeys in Hidalgo (www.inegi.gob.mx, 1999 census). The villagers studied in this project primarily raise goats, pigs, chickens, and sheep, in addition to growing corn, beans and squash in family gardens. Most worked as field hands for wealthy landowners, in addition to making baskets and obsidian figurines. Approximately 1,000 of these agricultural hectares are cultivated *por mano* (hand-cultivated) by *las indígenas* (the indigenous peoples). The indigenous fields are protected by ancient religious symbols that protect the fields from the "gaze of strangers" and help to ensure a productive crop during the growing season (Nolasco Armas 1966).

## Village Subsistence and Production

The Otomí people of Hidalgo are known as one of the largest producers of maguey cactus and *pulque,* the fermented beverage derived from agua miel (honey water) or sap of the century plant or Maguey cactus. The indigenous villages are bursting with creativity. Some of the village artists (*artesanias*) of Pañhe make figurines

from obsidian to sell in the markets as a source of income, however, most of the participating women, and some of the men, in Pañhe and Gandho make beautiful baskets (*canastas*).

Some families plant cash crops on their *ejido* land, but most adult men seasonally migrate to Mexico City and elsewhere for employment as migrant farm workers and in construction. There were only a few families in Pañhe that planted crops on their *ejido* land because they told me it cost 10,000 pesos (~$1,000 US) to connect the irrigation pipes to water their land, a vast sum of money for these peasants and, thus, an impossible venture for the poor. Most of the families cannot afford the seed, fertilizers, pesticides, or water rights, nor do they own a horse and plow (some pay for a man to prepare the soil with his horse and plow), so they rent out their *ejido* land for about 500 pesos each year instead.

Some families grow corn, beans, *chiles*, squash, green tomatoes, tomatoes and squash in small garden plots. One man asked me if I could bring him some seeds for jalapeno *chile* peppers from the United States when I return, because the American variety is so much bigger than the small *chiles* grown in Mexico. The *chiles* I observed growing there were only about an inch in length, very hot and very tiny. A few families plant these same crops on their *ejido* land, if they have access to irrigation, as well as some cash crops such as green tomatoes or calabazas to sell in the markets (see Fig. 28).

Both the men and the women work in *las milpas* (the fields) as agricultural laborers, but the agricultural duties are allocated by gender. The men did all the field

preparation and most of the planting. The women do most of the weeding and harvesting (see Fig. 29), but the men carried the harvested produce from the fields to the trucks. During harvesting, most members of the extended family work together. They exchange agricultural services by offering food or future assistance in exchange for preparation, planting or harvesting tasks to other nonrelatives, especially when the extended family is small in size. The fields are protected by symbolic objects to ensure a bountiful harvest (see Fig. 30). After the corn is harvested from the family gardens, they return from the fields, sort the corn in the family compound and store the corn cobs on their concrete rooftops.

One family in Pañhe is the primary supplier of *pulque* to the village. They harvest the *agua miel* from the Maguey cactus planted on their family owned fields and ferment the *pulque* for several days before selling it to the villagers. This activity provides sufficient income to survive without working in the fields. This family also made baskets, in addition to raising several varieties of domesticated animals, including sheep, goats, pigs, chickens, and turkeys.

The Otomí women of Pañhe and Gandho are hard-working peasant artisans, making beautiful Carrizo reed baskets (*tejederas de canastas*) for which they are known throughout the region, spending most of their daytime hours weaving. Others make glass figurines from obsidian, some of them work in the fields and make baskets, while a few are clerks in stores or work in the “houses of others” as maids. One of the women I studied worked as an auto mechanic alongside her husband who was also a mechanic.

Figure 28. Crates of calabazas, Pañhe, 2006.


Figure 29. Otomí women harvesting corn, Pañhe, 2006.

Figure 30. Otomí field protection symbols, Pañhe, 2006.

The husband of another woman built and repaired roads for the Mexican government in the countryside. Many nonlactating women herd animals during the day (see Fig. 31).

The women were paid about two or three pesos for each basket, depending on the size of the basket (see Fig. 32). Most could only make eight baskets a day, working for at least 10 hours to earn between 16 pesos and 20 pesos (~$1.50-2.00 US). The women were totally dependent on a male mestizo "agent" who drove through the village in a pick-up truck every week to collect the baskets and sell them in Mexico City in the markets there. They knew he was selling these baskets for 50 to 100 pesos each, so he was making a large profit. The women said that if they complained, he would never come back and they would starve to death. Their emic perceptions of male dominance continued to control their lives, making it almost impossible for them to see or make alternative choices. The men and women were both paid 100 pesos per day (~$10.00) to work in *las milpas* (fields). One family (*delegado* of Pañhe) who owned the village stationary store, planted a family garden and worked as a farm laborer, claimed that they made one of the higher incomes in this village, about 10,000 pesos each year (~$1,000 US).

According to the Otomí division of labor, child care, food preparation and cooking including making tortillas, washing dishes, washing clothes, sweeping, cleaning houses, food shopping, planting, weeding, harvesting and animal herding were the domain of women, while house construction, repair and maintenance, preparing fields, planting crops, heavy lifting, and gathering fuel were the domain of men. However,

Figure 31. Otomí woman with baby goat, Pañhe, 2006.

Figure 32. Otomí woman making Carrizo reed basket, Pañhe, 2006.

some men neglected this task, so often the women resorted to gathering their own fuel.

Fetching water, gathering fuel, and animal herding are tasks that are usually done by children, but girls worked much harder and at much younger ages than boys. Several women told me that, as children, if they neglected to carry home the five gallon container of water after school, they went to bed hungry that night. One participating woman remembered being beaten with Carrizo reeds as a small child for failing to return quickly enough with the bucket of *masa* dough in the early pre-dawn hours so that her mother could make tortillas for the family.

Cargo labor is also required of all adults in the villages, especially when the government begins a project (Ennis-Macmillan 2006). The women and girls must sweep the streets (see Fig. 33) and keep the ditches free of garbage and debris or their families will be punished by cutting off their utilities and water. The teenage boys sometimes work by loading crates of harvested food on to trucks, making about 10% of an adult wage, not nearly enough to compensate for their consumption and support by their parents (Kramer 2005).

Preparing Tortillas

No one really knows how long the Mesoamerican peoples have eaten corn *tortillas* (see Fig. 34), however, there is evidence for domestic use of maize among the Aztecs as far back as 10,000 B.C. (Mangelsdorf, MacNeish, and Willey 1960). The women prefer tortillas *azules* (blue corn tortillas) grown in the family gardens, but toward the end of the season in the late summer when they have run out of blue corn (see Fig. 35),

Figure 33. Girl sweeping streets as cargo labor, Pañhe, 2006.

Figure 34. Fresh corn tortillas, Pañhe, Hidalgo, 2006.

they turn to buying yellow corn in the markets until the Indian blue corn is harvested once more.

After removing the kernels of corn from the cob using a bundle of empty corn cobs that are bound together with wire (see Fig. 36), the women prepare the *nixtamal* by cooking the corn with *cal* (calcium hydroxide or lime powder) in a metal cauldron over a low fire until the outer husk of the kernel separates easily from the inside germ between thumb and forefinger. The women reported that the corn was ready when it "sounded different in the metal bucket while stirring." This depended on the length of time on the fire and the heat of the fire. Early in the morning, they carried this bucket of *nixtamal* to the grinding mill, and returned home with the bucket of *masa* dough, ready to make tortillas. This ritual behavior was repeated every other morning by every Otomi woman in the both villages.

Each woman uses different fuel for her fire preparation under her *comal* (cooking surface), including corn stalks and corn husks, dried corn cobs, aged manure, mesquite branches and other woody shrubbery gathered near their houses. While observing one woman make her tortillas, she told me that her husband had failed to bring sufficient fuel for the fire this morning, so she was using moldy cornstalks and aged manure for her fire. The smoke produced from this fire was definitely intense.

I discovered that every woman's tortillas tasted unique. Some women attributed this phenomenon to the different fuels and the fact that the "ashes get into the *masa* dough."

Figure 35. Blue Indian corn, Pañhe, Hidalgo, 2006.

Figure 36. Otomí woman separating corn kernels from cobs, Pañhe, 2006.

The majority of the women prepare tortillas outside the house (only two prepared tortillas inside), some under make-shift Carrizo reed lean-to's or over-hangings or concrete block enclosures (see Fig. 37), but most make tortillas directly in the hot sun. One woman prepared her tortillas on her rooftop in the sun and open air. Once the fire is started (see Fig. 38) and sufficiently hot, the women take a small ball of *masa* dough in their hands and quickly fashion these balls of dough into flattened round circles by hand (see Fig. 39) or in a tortilla press between plastic sheets made from used plastic sandwich bags, and cook the tortilla on a *comal* (cooking surface made of metal or clay) sprinkled with a little *cal* (calcium hydroxide or lime powder) to prevent sticking. The length of cooking time is estimated by how easily the tortilla pulls away from the *comal* when touched with the fingertips. Sometimes they add a little water to the *masa* dough to maintain correct consistency. After breakfast, the women sometimes begin to make the *nixtamal* for the following day, however, most only made tortillas every other day.

As one of the participating women made tortillas in the early morning, she told me that her mother had taught her how to make tortillas by hand (*por mano*) when she was seven years old. Now she uses a tortilla press. She explained that it was cheaper to make tortillas despite it being very hard work. The price of tortillas in the *tortillerías* (tortilla stores) ranges between six and seven pesos per "kilo" (kilogram). There are approximately 20 tortillas in one kilo. Most families eat two kilos of tortillas every day at a potential cost of 12 to 14 pesos each day. The women pay three to four pesos for a

Figure 37. Otomí woman preparing tortillas, Pañhe, 2006.

Figure 38. Otomí woman preparing fire for tortillas, Pañhe, 2006.

Figure 39. Making tortillas from *masa* dough, Pañhe, 2006.

*cuartillo* (see Glossary) of corn in the marketplace, enough corn to make three or four kilos of tortillas (60 to 80 tortillas) and one peso more for grinding the corn. They believe this saves the family about seven pesos every day or about 50 pesos per week.

Unfortunately, many children are now begging their mothers for *pan* (bread) or sweet rolls that are sold from the back of a pick-up truck to replace the traditional staple of tortillas, a food that has sustained these traditional people for thousands of years.

Domestic Animals

All of the participating families had many domesticated animals, including dogs (see Fig. 41). Most of the families raised pigs and goats (see Fig. 40), some had sheep, one had cattle, and all of them had chickens. Their animals were raised in enclosures often only a few feet from where they lived, bathed, ate and slept. The chickens roamed freely throughout their houses and compounds. The pigs (see Fig. 42) and sheep were raised primarily to sell to mestizos.

The goats were inherited after marriage and indicated prestige or status within the village, depending on the size of the herd. The goats or sheep were only slaughtered for very special occasions (e.g., fiestas, school graduations, marriages, or funerals) to be eaten as *barbacoa* (wrapped in maguey leaves and roasted underground for several days). The chickens were raised for meat and their eggs were gathered daily, however, they told me they would usually sell the eggs to the mestizos so they could afford other food for their children.

Figure 40. Domestic goats, Pañhe, 2006.

Figure 41. Domestic dog, Pañhe, 2006.

Figure 42. Domestic pig, Pañhe, 2006.

Most of the families in Pañhe had dogs for protection, some were vicious, and all deserved respect (see Fig. 43). Many dogs also roamed the streets of Pañhe looking like "walking skeletons" suffering from semi starvation, disease and/or multiple injuries sustained when hit by passing cars and trucks. Many drivers actually tried to hit the dogs because they saw them as pests. According to other researchers, the Otomies used to eat their dogs (Lanks 1977, Ramsay 1934), but when asked about dog meat as a food source in Pañhe or Gandho, these peasants could not remember ever eating their dogs. Cats were rare and were only seen in two family compounds in Pañhe. Most of the villagers treated their animals with affection and appreciated the protection they gave, however, the scarcity of resources for humans meant that sometimes their animals suffered from lack of food (see Fig. 44).

Women's Daily Schedule

The women made tortillas every other morning (see Fig. 45), preparing their nixtamal (cooked corn and *cal* or lime powder) in the afternoon, retiring for bed early, and leaving the nixtamal in the bucket until morning. Awakening at about 4:30 a.m. they carried their bucket of nixtamal to the Molina (grinding mill) and waited for their masa (corn dough). Then, they carried their plastic buckets of masa dough back through the early morning mist to begin making tortillas. Every other day, one could see this early morning ritual of women scurrying down dirt paths toward home, rushing to prepare tortillas and the lunchtime meal for the fieldworkers. A fire was lit, and then the masa

Figure 43. Family dogs efficiently guarded their compounds, Pañhe, 2006.

Figure 44. With scarce resources in the desert, many animals starve to death, Pañhe, 2006.

Figure 45. Otomí lactating woman preparing tortillas, Pañhe, Hidalgo, 2006.

was prepared into individual tortillas, cooked for a few minutes on each side until golden brown, and added to the stack of prepared tortillas in an embroidered cloth inside a basket for the day's comida (food). The women would then eat a small piece of bread or a tortilla and a cup or two of chamomile tea or sweetened coffee.

The women working in *las milpas* would head for the fields of wealthy landowners in the back of pick-up trucks usually about 7:30 a.m. (see Fig. 46). After working for more than four hours, the workers stopped for a 10 minute mid-morning break. During this break they were usually given Coca Cola by the landowner supposedly to increase their work capacity, but this practice has contributed to a generalized craving for this beverage. They stop working about 2:00 p.m. for lunch and a *siesta* under the shade of trees on the edges of the fields for about an hour. Then they would go back to work until evening, when the pick-up trucks would take them back to their villages for their supper and sleep for the night.

The women fieldworkers would return to their homes at night, eat a few leftovers from their lunch meal, and spend the next few hours making baskets or embroidering tortilla cloths to sell in the markets to supplement their income, often not retiring for the night until well after midnight.

The women working at home, making baskets or glass figurines during the daytime hours, were usually those that were breast-feeding their infants. These women would complete house cleaning chores first, sweeping the dirt out of their houses and then sweeping the garbage away with the dirt in front of their houses (see Fig. 48),

Figure 46. Nonlactating Otomí women working in calabaza fields, Pañhe, 2006.

watering their “gardens” (pots of flowers lined up on concrete block walls near the house), made beds, cleaned toilets and fed their animals for a couple of hours, between breast-feeding sessions, and then they would begin making their baskets or figurines. They also prepared food for the lunch meal, made tortillas every other day, served meals to their husbands and children, washed dishes and/or washed clothes, bathed their children (see Fig. 47), and then returned to making baskets or figurines and caring for their animals in between breast-feeding and other child care until nightfall when their families would eat a supper of leftovers from the mid-day meal before retiring to sleep for the night.

Those women with children who were attending the *kinder* or pre-school also walked their children to and from school, in the early morning and mid-afternoon. The older children walked to and from *la primaria* (elementary school) with friends or siblings. When the children returned home from school, many would tend their breast-feeding infant younger sibling while their mother worked at making baskets or prepared supper. The female children were especially attentive in caring for their younger brothers and sisters, spending many hours entertaining them, feeding them, and keeping them out of harm’s way. These children had few toys, but many times I observed the children playing with home-made objects, pebbles, stones, corn cobs and other natural objects found in their environment, and sometimes old worn-out plastic toys, lining them up for hours and creating rivers and bridges over which to maneuver these play “trucks” (see Fig. 49).

Figure 47. Lactating mother washing infant, Pañhe, 2006.

Figure 48. Lactating Otomí mother sweeping house and yard, Pañhe, 2006.

Figure 49. Otomí child playing with corncob “trucks.”

Current Indigenous Diet

The subsistence peasant diet today consists of tortillas *de maiz* (corn), *frijoles* (beans), *verdolagas* and *quelites* (gathered wild greens), tomatoes, onions, *chiles*, squash, and *pulque* (fermented beverage made from the sap of the Maguey cactus) (see Fig. 50). Most villagers continue to grow maize (corn), beans, *chile* peppers and green tomatoes (*jitomates*) in their family gardens. In addition to the dietary staples of corn tortillas, beans, *chile* peppers, onions, garlic, and green tomatoes, they gathered wild greens and plants (especially *quelites* or pigweed, *verdolagas* or purslane, *nopales* or prickly pear cactus, *tuna* or the fruit of the prickly pear cactus, *espinaca* or wild spinach, acelga or wild chard, *flor de garambullo*, a cactus flower, *gusanos* or corn worms, *hongo de maiz* or corn smut, flor de sabilla, flor de calabaza or squash flowers, and flor de palma or palm flowers to supplement their dietary intake. The participants told me that they no longer gather or eat *lengua de vaca* or *berros* (an iron-rich plant), indigenous greens that were especially good eaten with beans and known as being very nutritious. One *delegado* explained that many years ago, the mestizos in larger communities diverted much of the water away from Pañhe to irrigate their cash crop fields. With the abundant application of pesticides, the introduction of hybrid crops that absorb soil nutrients and replace indigenous plants, and deplete groundwater, these nutritious greens have virtually disappeared from the surrounding countryside. He believed this was why the *lengua de vaca* and *berros* were gone. One afternoon, one of the women showed me some peanut plants (*cacahuetes* – see glossary) growing wild on the edge of

Figure 50. Young Otomí child eating menudo at a fiesta, Pañhe, Hidalgo, 2006.

the field. She told me that the villagers used to eat these nuts all the time, but now they don't see them as often, and have virtually lost this source of gathered protein. One of the other women had found some nuts she called *garbanzas* (not chickpeas, looked something like a pumpkin seed) while gathering the day before with her daughters, and she was roasting this "treat" on the *comal* surface next to the tortillas for her children's lunch.

Many women made *sopa* (soup) with thin pasta and salsa, and to this soup they sometimes added wild greens or other vegetables to supplement the tortillas and beans at the mid-afternoon meal (see Fig. 51). Some of the additions to their diet included calabaza squash (summer squash), chayote, chicken, and sliced roast beef (*bifstec*), eggs, bread or *pan*[12], coffee, tea, milk, beer, and most notably, Coca Cola. All the women admitted to drinking beer and Coca Cola, in addition to juices, some milk and water. Most of the men continue to drink vast quantities of *pulque* especially after they returned from *las milpas* (the fields), however, the women and children drink more Coca Cola or *refresca* (other sodas) than *pulque*. Once I watched a toddler of about fourteen months drinking Coca Cola from a bottle as she meandered around outside her

[12] A small pick-up truck comes through the villages every other day selling white bread to the women. This bread is either a white roll, or a form of sweet bread, similar to a breakfast pastry. This is becoming more popular, and the children now want this bread instead of the corn tortillas. This practice will inevitably lead to increased tooth decay, diabetes, as well as other nutrition related diseases. The women pay about 5 pesos for each piece of bread, much higher than the cost to make home-made corn tortillas, which is about 2 pesos for 20 tortillas. This is having an economic impact on these families, and is only one of the motivating forces behind the increasing levels of migratory employment engaged in by the men and women of these villages.

Figure 51. Otomí lactating woman making *sopa* for lunch, Pañhe, 2006.

house.

Consequently, the Gandho medical clinic nurses confirmed that approximately half of the indigenous population in these villages now suffers from diabetes, a disorder unheard of among this people until recently. According to the clinic nurses, hypertension and heart disease are becoming more common as causes of death, and they are beginning to report concerns about dental caries for the first time. One of the participating women while visiting my home early one morning observed my daughter using an electric toothbrush. She asked me where she might find one of these toothbrushes because she was so concerned about her own daughter's teeth. This is a relatively new phenomenon, since these people have never used toothbrushes before now and have not been plagued with dental caries until recently (Anderson 1946).

Two or three of the participating families with a little more income consumed some packaged foods, such as sliced ham, fried pork rind, powdered milk beverages, and processed cereals that are available in the local *tiendas* (grocery stores). However, the majority of the participating women and their families continue to eat a diet remarkably unchanged over the past six decades. They still eat primarily only two meals a day, some only one meal a day, with leftovers consumed for the evening meal, and usually only one cup of chamomile tea and a tortilla or a piece of bread (*pan*) in the morning to sustain them for more than six hours of hard work in *las milpas* (the fields) before their mid-day meal is eaten.

All these women remember being very hungry as children. When one of the

participating women was nine years old, she remembers passing out one day because she was so hungry. She wanted to help her parents, but she lacked the energy to work. Her family never had enough food when she was a little child. Another woman described hearing her baby brother cry for three days because her father had not come back from working with the money to buy food. Her mother had nothing to feed the baby. This woman remembered wanting to help her baby brother, but not knowing what to do for him, she covered her ears and curled up in a corner of the house to wait for her father's return.

These women believe that if a person shares all they can with other people, that others will always help them when they are in need. They practice generalized reciprocity and depend on each other to survive. Some say that they ask for credit in the stores when there is no money, others say they work harder at making baskets for money, and still others report that they go out in the fields and spend more time gathering wild foods when there is not enough money for food for their children.

## Reproduction and Infant Care

### *Childbirth*

Since about 1993, the Otomí women have delivered their babies in hospital, most in the Indian Hospital in Huichapan, but a few have delivered at specialty hospitals in Queretaro because of "at risk" delivery circumstances such as prematurity or a breech presentation (see Fig. 52). All receive prenatal care from the doctor at the local village

Figure 52. Otomí three-month old infant sleeping with mother, Pañhe, Hidalgo, 2006.

medical clinic.

In past generations, women had delivered their babies at home with a *partera* (midwife) in attendance. Until the 1990s, the grandmothers' description of childbirth involved other female members of the family assisting the woman who delivered her baby in a squatting position while supported from behind by another female family member, with the mother holding an *ixtle* (maguey fiber) rope looped over a rafter inside the house or a tree limb just outside the house, similar to childbirth described in the Yucatan (Jordan 1980). The midwife placed the infant in a *rebozo* (shawl) immediately after birth, and the infant was held by the mother or grandmother while the midwife buried the umbilical cord and placenta under the "hearth" of the home or the area where tortillas were cooked. The infant was breast-fed immediately upon delivery, and the mother and infant remained in seclusion for forty days to avoid *los aires* (cold air) and *mal de ojo* (evil eye or gaze of a stranger), both conditions that they believed caused *punzadas* (vomiting and diarrhea) and, in extreme cases, could kill their infant. They refer to this practice of seclusion as *respuesto despues de parto.* The last reported childbirth attended by a *partera* or midwife in Pañhe was about 12 years ago.

Since the death of this last *partera*, all the women now attend the local medical clinic for prenatal care and deliver their babies at the Indian Hospital in Huichapan. Forty four percent of the women studied in these villages underwent cesarean sections in this hospital. In addition, the doctors perform tubal ligations (73% of the cesarean deliveries in this study) while the women are anesthetized without prior permission, telling the

woman later that they already had “too many children.” Four women cried for the children they had wanted to have while sharing this information with me. One of the women in this study had an infant with cerebral palsy that she attributed to a “bad cesarean delivery.”

The nurses in the Gandho clinic shared their concern with me over the increasing numbers of cesarean births. They indicated that there was definitely an economic component to this trend in childbirth among the indigenous women. The cost of a vaginal delivery was about 6,000 pesos (~$600 US), while the cost of a cesarean delivery was about 16,000 pesos ~($1,600 US). Upon their arrival at the hospital in labor, the participating women were asked how many male relatives were in their extended family and then the total combined income of the entire family was calculated. After ascertaining their ability to collect sufficient money for delivery, they would admit the woman. Then within minutes of being admitted to the labor ward and without a vaginal exam, the doctor would tell them that their infant was “too big to deliver” vaginally and recommend a cesarean section birth. According to the participating women, the birth weights of their babies averaged 2960 grams or 5.9 pounds, smaller than the average American baby and certainly not warranting a cesarean section delivery for too large of an infant. The newborn infant was never released to the mother or the family unless the entire hospital bill was paid prior to discharge.

Three women were concerned about their children because they were so small. I observed a few children as old as eight years old who weighed less than 20 pounds.

These children's "failure to thrive" was possibly linked to malnutrition in response to early weaning. The clinic physicians urged these women to cease breast-feeding when their babies were only six months old.

Lactation

Lactation has been practiced by the Otomí women for centuries of time, but the younger generation who were the participating women in this study is beginning to change their reproductive behaviors. These women all expressed their intention to breast-feed their babies after delivery for at least two years (see Fig. 53); however, Western medical practices are interfering with these traditions. These women were advised by the clinic physician to stop breast-feeding if their infant was sick with a cold. When I asked one woman about what worries her about producing breast milk, she said she never worried before, but now the doctors in the clinic "make her worry" that she may not have enough milk. This medical advice can lead to the "insufficient milk" syndrome that is prevalent in the industrialized world (Gussler 1980). Others were told by the clinic physician that there was only "water" in their breasts after six months, contributing to a recent trend among these villagers in earlier cessation of breast-feeding. This same physician recommended feeding their infants only solid food after six months with no breast milk. A few of these women have begun to follow this medical advice.

Only a small number of these indigenous women could afford to purchase infant formula (about 15%), but four women sacrificed food for their other children and other

Figure 53. Otomí woman breast-feeding her infant, Pañhe, 2006.

household purchases so they could buy formula to feed their infant as directed by the doctors in the hospital. One participating woman delivered her infant prematurely in the government hospital in Queretaro. Her three month old infant appeared normal when I first met her, with an average weight and length for these babies. She told me that she was instructed by the physicians in the hospital to feed her infant formula every day, as well as breast milk, for the first four months in order to help the infant to "gain enough weight." The practice of supplementation with formula always reduces the quantity of breast milk of the mother, and it is very difficult to ever "catch up" and provide complete infant nutrition from breast milk (Lawrence 1999, Riordan 2005). During this project, this mother continued supplementing her infant with formula because she never had been able to produce enough breast milk. She produced only six ounces of milk the day I followed her. She had to give her baby at least five bottles of formula every day because she said she did not have enough milk to "satisfy" her baby.

One lactating woman worked in the fields with her five-month old nursing infant, with the assistance of her niece who cared for the infant while the mother worked a few hundred yards away, weeding the *calabazas* (see Fig. 54). One young mother had twins. She successfully breast-fed them for more than 10 months, producing a daily amount of more than 40 ounces of milk while I was studying her. She finally did stop breast-feeding only because she had to return to work as a clerk in a nearby store in response to financial deprivation.

All the women practiced *respuesto despues de parto* (40-day period of seclusion

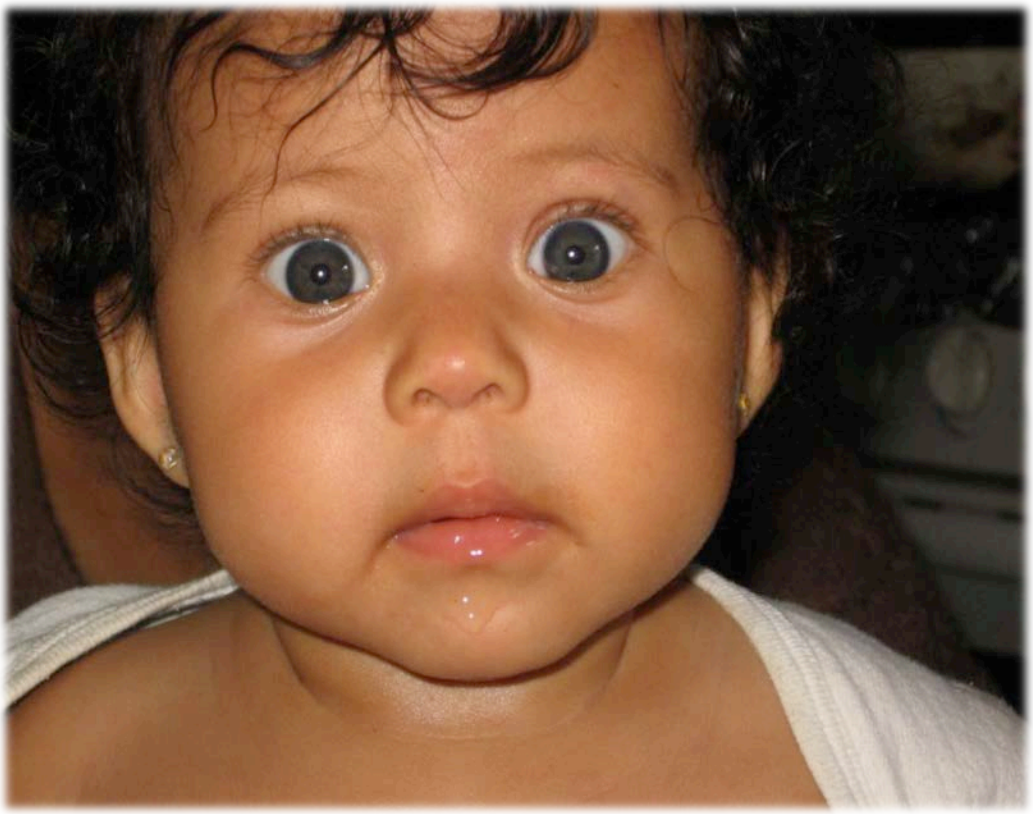

Figure 54. Five-month old breast-fed Otomí infant, Pañhe, 2006.

after childbirth); however, none of them participated in the baño de hierbas (herbal bath) at the end of this period of seclusion, a traditional custom that has fallen out of favor. Many reacted to my mention of this behavior with revulsion. Indigenous women associate customs such as peasant clothing, Indian languages, and traditional reproductive practices with devastating poverty and a lack of education, so when it is possible they abandon these practices. Exclusive breast-feeding for at least six months was nearly universal, and most breast-fed for at least another six to 12 months after the addition of solid foods. A few women continued breast-feeding for several years. One participating woman was still breastfeeding her child after five years. The Otomí women lactate for extended periods of time, most indicating no return of menses for at least six months, some as long as 10 months. This generation breast-feeds with less frequency than their mothers. Their mothers reported that their menses did not return sometimes for several years following childbirth, contributing to more effective lactational amenorrhea. The grandmothers reported frequency of breast-feeding every half an hour, while the participating women in this study follow the Western medical recommendation for breast-feeding frequencies every two hours (Lawrence 1999).

There were 101 children among the participants with an average birth spacing of three years (see Figs. 55 and 56). One woman had one teenage child, eight were having their first baby, five women had children spaced more than eight years apart, and one woman had two children who were 12 years apart.

An average breast-feeding session was approximately 10 to 12 minutes. All the

Figure 55. Thirteen-month old breast-fed Otomí infant, Pañhe, 2006.

Figure 56. Nine-month old breast-fed Otomí infant, Pañhe, 2006.

women slept in the same bed with their babies at night, and breast-fed "on demand" during the night hours. In the winter months, the mothers indicated that it was necessary to sleep with the infant so that their bodies can keep them warm during the cold night hours. All the women reported a belief in *brujas* (witches) having the ability to kill infants. Three older women reported that their infants died in the night because a *bruja* came and sucked the life from them, finding the baby blue and still in the morning.

During the seclusion after childbirth, the women drink atole con masa (thick corn drink) and bean water to promote breast milk production. They eat tortillas, beans and soup, but no fruits or vegetables for at least two weeks following childbirth. The women place an *ojo de venado* (deer's eye, small red-beaded bracelet with amulet) on the baby's wrist at birth to protect the infant from *mal de ojo* (evil eye) and *los aires* (bad or cold air).

One young child of about three years of age was still wearing an *ojo de venado* around his neck because the mother said he was "sick all the time" and was very "small for his age." She hoped this amulet would continue to protect him until he grew stronger and bigger.

*Ayates* or slings made from *ixtle* fiber are used to rock their infants to sleep hung from limbs of trees (see Fig. 57) near where they are making baskets, or on the edge of fields when working in *las milpas*. While working in the fields, female children or siblings or older grandmothers watch the babies, rocking them if they stir, and alerting the mother if they wake and are hungry. The babies are always carried in *rebozos* or shawls

Figure 57. Mother rocking infant in an *ayate* sling, Pañhe, 2006.

that are wrapped over the shoulder, around the infant, and then tied around the mother's waist.

When asked what foods helped in producing enough breast milk, most women agreed that foods such as vegetables, rice, soup, milk, fruits, *pulque* (contains vitamins A, B, C and E, protein, fats, and is a rich source of carbohydrate; see footnotes for more information) and meat in addition to *atole con masa* and beans were beneficial, but very few had access to all these foods during the first few weeks postpartum or even throughout the lactation period. Only three of the women in this study reported purchasing vegetables, fruits, meat, and milk in the markets on a regular basis. The women made soup from salsa and pasta, and they gathered wild greens, nuts, and cactus fruit. Most would not admit to drinking *pulque*. However, I observed many drinking *pulque* on other occasions, especially during fiestas, and it was likely that they did indeed consume this Maguey cactus fermented beverage, especially immediately postpartum and throughout lactation.

Several give their infants a few ounces of chamomile tea every day, especially during the first three to four months of life, because it was "very hot" and the baby was "thirsty." They also used chamomile or *Manzanilla* tea or *hierbabuena* (mint) tea for colic symptoms, and some used this same chamomile tea to cleanse a baby's eyes. When asked what causes breast-fed infants to get sick, most said cold weather (*los aires*), the "gaze of a stranger" or *mal de ojo,* bad food, and a few said dirty hands and dirty nipples (see Fig. 58). Evidence of teachings at the medical clinic meetings are often

Figure 58. Ten-month old Otomí breast-fed infant sick with respiratory infection, Pañhe, 2006.

observed among the younger women. The grandmothers never mentioned any connection between dirt or germs and illness.

When asked about problems that women experience while breast-feeding, the women believe that problems usually occur when women go to work in the fields. The lactating women won't return to *el campo* (the country) to work until the baby is at least two years old. Three women in this study continued to work in the fields with their nursing infants, with the assistance of allomothers who watch the infants while they slept in *ayates* under nearby trees. They believe that when women work in the fields while lactating that some get "angry" because they "lose time" while breast-feeding. If they are "angry" then their milk can harm their babies similar to the harmful effect of "hot milk." They also say that they "can't work as hard" in the fields when they are breast-feeding. When women must work in the fields with a breast-feeding infant to get enough money to feed their other children, they are pitied by the other lactating women. The breast-feeding mothers do work in their family gardens at times, however, weeding while carrying their babies in a *rebozo* (shawl).

During lactation they tell me that they "need to get their chores done so they have more time to care for and breast-feed the baby." As a result, they seem to focus on completing a given task more efficiently (they say "work faster") so they can turn their attention to their infant's needs. The lactating mothers also report that they often feel "frustrated, guilty, and tired" at the end of the day because they "can't get everything done" and always feel as if they should have finished more tasks each day.

*Alloparental Care*

As observed in other cultures, most mothers rely on others to assist them in caring for their children (see Fig. 59), including older siblings, mothers, other female relatives, and mothers-in-law all assist with child care (Blaffer Hrdy 1999, Kramer 2005, Piperata and Dufour 2007). While visiting one woman who said that her older son helped care for her baby, however, I observed that this child spent more time teasing, rather than tending, his baby brother, at times becoming quite physically rough with the baby before the mother intervened. I never observed the older brother "caring" for his younger brother.

A participating woman who was harvesting her corn the day I was following her, placed her baby in an *ayate* sling hung from the limb of a tree. Her 10-year old daughter stayed near the sleeping baby while she was herding the family's goats, alerting her mother when the baby awoke. Another woman who did work in *las milpas* (fields) while breast-feeding also placed her baby in an *ayate* sling hung from a tree limb. Her young niece spent the day staying close to the infant, rocking the infant in the *ayate*, and alerting the mother when the baby was crying with hunger (see Fig. 60).

One mother-in-law (*suegra*) would only allow her daughter-in-law to come to her baby when he was hungry, and then only to breast-feed him, and immediately forced her to return to her work. The mother-in-law and her older daughters would play with the baby, hold him, comfort him, and entertain him when he wasn't hungry. These older women acted as if the baby was their baby, and the biological mother was a

Figure 59. Young girl caring for her younger brother, Pañhe, 2006.

Figure 60. Teenage girl watching breast-fed nephew in *ayate* while mother works in fields, Pañhe, 2006.

servant who was merely the source of food for this baby. There were five participating women living with or near their *suegra* (mother-in-law) who regularly contacted their migrant working husbands by phone (absent from the home for extended periods) reporting their wives' daily activities. These women seemed to have more anxiety and depression than the other women. This living arrangement appeared to create a great deal of stress for these women, similar to the findings by Voland and Beise (2002) of increased stillbirths and neonatal mortality associated with the increased stress of constant surveillance by a mother-in-law.

Infant Weaning

The participating women began offering solid food after six months of exclusive breast-feeding (see Fig. 61), while, the grandmothers reported waiting until the infant was between eight and 10 months old before offering solid foods. This change in weaning age is possibly connected to the arrival of medical clinics in the villages and the required weekly meetings with the purpose of "educating" these women in Western medical practices.

Weaning foods were *atole* (thick cooked corn gruel), small pieces of tortilla soaked in bean water, bananas, guavas and apples. Some women chewed the tortilla before offering it to their infant. The women scraped the outer surface of these fruits with a spoon and fed these small bits of scrapings to the infant. *Atole con masa* (thick corn gruel cooked with *masa*) was given to weaning infants, as well as vegetable soups with carrots, squash, and chayote when they were older. One mother, after making the


Figure 61. Mother feeding “scraped” apple to six-month old infant, Pañhe, 2006.

family's tortillas, made a couple of thicker and smaller tortillas for her 10 month old infant because it was softer for her to eat and easier to hold. These thicker tortillas are similar to teething biscuits given to older infants in developed nations. Two mothers were observed giving their babies a packaged cereal (Aveeno) sold for adults in the local *tiendas*. None of the women admitted to offering *chiles* or salsa to their babies, but, I did observe infants being given salsa by their siblings. Anecdotally, it has been reported that the Mexican babies are given *chiles* as a teething food, but I never observed this custom.

In one house, I observed a seven year old girl feeding her baby sister of about 10 months some Jello that she had just purchased at a village store down the road (see Fig. 62). This baby was chronically ill with respiratory infections – I never saw this infant without caked mucous around her nose. These commercially-packaged foods are a recent introduction in the village stores and are now eaten by the children as treats. The children also buy frozen juice Popsicle treats in the summer months from a local family business. These processed, packaged, commercially-marketed foods are slowly making their way into the indigenous village life.

Government Services

The political organization of Tecozautla is led by an elected *presidente* assisted by a secretary, a mayor of Tecozautla with little authority, and several directors and judges over such public concerns as police protection, water, utilities, and education, who report directly to the *presidente* through his secretary. There are 44 *delegados*

Figure 62. Young girl feeding Jello to her 10-month old baby sister, Pañhe, 2006.

governing the surrounding 62 villages. The *delegados* have political responsibility to the members of the villages and act as mediators between the village members and the county seat in Tecozautla. Because the villages are located on communal *ejido* property, the *delegados* are responsible for maintaining peace and order and assisting in the demarcation of family compounds and garden plots. During this project, the *presidente* of Tecozautla was Francisco Endonio Juarez, from whom I obtained official approval for this study.

According to the 2005 Hidalgo state census, of the 62 villages registered in the *munícipio* (municipal or county seat) of Tecozautla, only 18 have telephone connection and 26 have post offices and telegraph communication. Public transportation via minibuses or vans that seat a maximum of eight people connects the villages with the town square of Tecozautla. Paved walks, sewer systems, public parking, and street lights, in addition to indoor plumbing and electricity, are found in Tecozautla.

The Health clinics in the towns surrounding Tecozautla are managed by the Secretaria de Salubridad y Asistencia (SSA or Secretary of Health and Assistance) and the Mexican Institute of Social Security (IMSS). The primary medical services offered are outpatient office visits, vaccinations and childbirth. The health clinics in these villages were built by PIVM (*Patrimonio Indígenas de Valle del Mezquital*) in the 1980s with enforced indigenous *cargo* labor.

The local medical clinic in Pañhe had one physician and one nurse, while the Gandho clinic had two physicians and four nurses. Built in the 1990s, these clinics held

regular “meetings” to inform the women about Western medical practices and provided outpatient services and prenatal care to the women and children of these villages.

They had limited access to electricity and piped water (see Fig. 63) in the villages of Pañhe and Gandho, but there were no telephones or sewer systems. Their only source of potable drinking water in Pañhe was from one well in the western section of the village. This water ran through small ¾ inch pipes that stuck out of the ground with a faucet attached. This pipe was located some distance from each house and the water ran for a few hours every other day.

Makeshift “kitchens” were set up near this piped water to facilitate washing dishes and other cleaning chores (see Fig. 64). Pañhe had requested a government permit to drill another well for more than 12 years; however, the officials in Tecozautla informed me that they had been “studying the problem” since 1993, and still hadn’t determined if another well was necessary. Gandho, the indigenous village on the other side of the main road, had five wells with a similar population size and an improved standard of living when compared to Pañhe.

Water Resources

According to the 2005 Hidalgo state census, the primary water sources for this county are natural springs (*manantiales*), wells (*pozos*), and the tributaries, *Rio San Francisco*, *Rio Panuca,* and *Rio Tecozautla* flowing from the *Rio Moctezuma*, named for the famous Aztec emperor and notable as the northern political border of Hidalgo, that empties into the Gulf of Mexico. These tributaries of *Rio Moctezuma* carry black

Figure 63. Piped water with Otomí child, Pañhe, 2006.

Figure 64. Otomí woman washing dishes in outside “kitchen,” Pañhe, 2006.

wastewater from Mexico City for irrigation in these villages. There are more than eight hundred bodies of surface water surrounding this community. These are primarily natural hot springs noted for their medicinal qualities that were used in the past by the indigenous populations of this valley for healing.

During this project, the Pañhe villagers reported dramatically reduced groundwater from when they were children that they attributed to the creation of numerous *balnearios* (spas). These *balnearios* attract tourists from all over the world, generating considerable income for the *mestizo* population living in Tecozautla, however, these spas have drained the limited water resources sufficiently to cause the disappearance of many edible indigenous plants, such *as lengua de vaca* (see Appendix) and *berros*. There are two *balnearios* quite close to the villages of Pañhe and Gandho, however, the indigenous peoples were not welcome and most could not afford the entrance fees.

The peasants who live in the villages surrounding Tecozautla depend on the black wastewater irrigation from the *Rio de San Juan*, one of the tributaries from the *Rio Moctezuma* to the north of the *Valle del Mezquital.* However, the great grandfather of Señor Jesus Camacho Resendiz, Jesus Camacho Uribe, built a dam (*presa*) on the *Rio de San Juan* during the 18$^{th}$ century. Thus, the lion's share of the water is diverted to the Resendiz hacienda in San Antonio about a mile from Pañhe on the other side of the main road into Tecozautla.

In Pañhe, the *agua negra* (black water) waste water from Mexico City empties

into the irrigation ditches that run alongside the dirt paths near the family compounds. This contaminated water is used for bathing, washing their clothes, washing their children (see Fig. 65), and sometimes cleaning their food. To save time, many simply bathe with their clothes on while sitting in these ditches before the water is cut off. This ditch water is accessible sporadically at best, and if one family doesn't pay their utility bill, then the water is cut off to the entire community until the bill is paid. No one knows who owes the utility bill, so the people just suffer in silence (Ennis-McMillan 2006). During these weeks of water scarcity, the women must walk many miles to find water for washing clothes and bathing babies, and then carry water back home using *ayates* (maguey fiber cloth bands) and ceramic water jars (see Fig. 66) or plastic water containers.

Gandho has five wells with accessible water every day to most homes, and there are many homes in Gandho with water accessible inside the houses. For this reason, several homes in Gandho had kitchens and bathrooms inside the house with running water, while in Pañhe, their bathrooms were makeshift "latrines" or outhouses with a hole in the ground under the toilet. There were only two homes that I visited in Pañhe with a bathroom located inside the house, and one was an unfinished, bare concrete room without connected facilities to water.

Despite the introduction of irrigation and other agricultural developments in the mid-20$^{th}$ century that has been done, more for the mestizo population than the indigenous people, DeWalt reported that many of the government programs instituted

Figure 65. Otomí mother bathing child in “black water” irrigation ditch, Pañhe, 2006.

Figure 66. Otomí ceramic water vessel for fetching water, Pañhe, 2006.

to “improve” the lives of these Indian peasants through communal cattle or chicken ranching enterprises resulted in failure (1983). The ghost-like vestiges of many of these government structures now dot the landscape of Hidalgo, serving as a stark reminder of the gross inadequacies of these government programs during the past 50 years. While driving through the back roads of Hidalgo, failed government projects are evident everywhere along the byways -- empty shells that once held chicken ranches and other deteriorating farming structures that have long-since been abandoned by the frustrated *indígenas*.

Housing and Household Furnishings

According to the Mexican National census of 2005, there are 7,602 private homes in the combined Mestizo and Indian population of Tecozautla municipality with an average of four people living in each one (www.inegi.gob.mx, census of 2005). The home on the hacienda where I was living was built of stucco with a Spanish tile roof and beautiful Spanish tiles throughout the home. The village indigenous shelters or housing used to be constructed from organ cactus walls and maguey leaf or Carrizo reed roofs from the environment; however, today, most have built concrete block homes with laminated (asbestos) tile roofs, with dirt or concrete floors (see Fig. 67). Their “gardens” consist of a few flower pots near the house (see Fig. 68) and their houses are surrounded by dirt, which they sweep every morning to clear the garbage and clean the hardpan soil front yard. Some have fences made from materials ranging from organ

cactus to barbed wire with family compounds. Some had concrete floors, while others had only dirt floors. A few had flat concrete roofs, but most roofs were made of laminate roofing material (corrugated metal pieces with asbestos lining about 2x3 feet in size), maguey cactus leaves, or Carrizo reeds, while some had no roofs at all. Many houses had no doors or windows, just openings in the concrete block walls covered with cloth "drapes." Most had "latrines" that were built of concrete blocks outside the house, similar to an outhouse (see Fig. 69). The toilet inside had no seat, and there was no connection to a public disposal system, so there was no flushing. These latrines were cleaned daily by the women. There were three or four bigger houses that were in the process of being built with two stories and better masonry construction. These houses were owned by the men who had crossed the border to the United States for work. They would send money home to buy the materials required for these houses, but the money was never enough, the progress slow, and they were all unfinished.

The furnishings inside the houses were sparse and simple in nature, a wooden table with benches or a few chairs, one or two beds with sheets sometimes, but few blankets, and sometimes a hot plate inside to cook food (see Fig. 70), however, almost everyone prepared tortillas outside with fires fueled with mesquite, corn stalks, dried goat manure or other woody shrubs gathered from the surrounding desert. Many had blenders for making salsa in addition to a hotplate, both of which required electricity. Only a few had refrigerators or stoves with ovens (see Fig. 71), but few used these larger appliances because they couldn't afford the electric bills. The stoves were rarely used,

Figure 67. Typical Otomí house, Pañhe, 2006.

Figure 68. Otomí flower-pot “garden.”

Figure 69. Otomí latrine or outside bathroom, Pañhe, 2006.

Figure 70. Typical Otomí stovetop on wooden table, Pañhe, 2006.

Figure 71. Typical Otomí kitchen appliances, Pañhe, 2006.

but the oven was never used because they never bake anything. The tradition of a "birthday cake" is just beginning to reach the *mestizos* in Tecozautla. The *mestizo* families buy birthday cakes at the *pastelería* (pastry shops); however, this is a cost most of these villagers cannot afford. Instead, the oven was used as a shelf for the storage of dishes.

Some had radios and a few had irons, stereo systems, and very small black and white televisions, and one or two families had wardrobe chests for clothing. The families who had these features also had husbands that migrated to the United States for employment, sending money home to purchase these items, and improving their standard of living.

One of the best houses in Pañhe, the *delegado's* home was constructed of concrete block and brick walls with concrete floors and roof. There was a sliding glass door entrance into the stationary store that was attached to the house. There was one bedroom with two beds, a kitchen inside the house with running water in a sink, and a dining area. This family owned a medium-sized television (large for Pañhe), a stove, and a stereo system. There was a wooden chest in the kitchen area for storing dishes (only one other family had this type of furniture in Pañhe). This house was constructed by the *delegado* after working for two years in Ohio as a landscaper and sending his wages home to save to construct this house. He returned to Mexico because he said he missed his family too much to remain in the United States. He now works as a peasant farmworker and his wife tends their stationary store. They report an annual income of

approximately 10,000 pesos (~$1,000 dollars US), higher than most families in Pañhe.

There were several sheep in a pen about 15 feet from her back doorway, with only a curtain covering, so the house was always filled with flies, a common finding in this village.

On the main cobblestone roads, many compounds had metal or mason block fences and locking gates, with several "houses" or households inside each of the family compounds, always guarded by the family dog. The paths leading off the main road were dirt paths, but both of the "main" roads leading into Pañhe were cobblestone.

These cobblestone roads had been laid by hand by the men and women of Pañhe in 1998 at the direction of the mestizo government authorities. The indigenous populations are required to participate in community work, called *cargo* labor, building and repairing when it is needed (Ennis-McMillan 2006). Since the 1970s, the *Patrimonio Indigena del Valle del Mezquital* or PIVM has built *primarias* (elementary schools) and medical clinics, improved roads, and dug wells and irrigation canals, all facilitated by the *cargo* labor of the *indígenas* in the villages. The men and women said they were forced to go into the hills to collect the stones for these roads and carried them back, one or two at a time in their *ayates* (Maguey fiber cloths) or *rebozos*, and then placed the stones by hand to complete the cobblestone roads leading into their villages. The people told me they worked very hard for more than 10 years to complete these two roads. Traveling down these cobblestone roads in a vehicle was extremely bumpy, even at very slow speeds, but the natives say these roads are a definite improvement on the

previous dusty paths and there is less mud during the rainy "monsoon" season in late summer and early fall.

Social Systems

The Otomí Indians live in nuclear families and most practice monogamy, patrilocal residence, a bilateral descent system, and participate in the *mayordomo* system for the obligatory fiestas (see Fig. 72). The villagers had *madrinas* and *padrinos* (godparents) who were active in a child's school graduation, baptisms, and weddings; however, when asked about financial or resource assistance from their *padrinos*, the women said they were "too ashamed" to ever ask for help from them. The women told me that they would much prefer to ask for help from their immediate or extended family members if they were in need of life's necessities. Most just worked harder, gathered more food, or asked for credit from the local *tiendas* when they were hungry.

The Otomí men are known to be silent, aggressive, violent and often brutal fathers and husbands, a reputation that was reinforced by the laissez faire response by the women when they were asked about physical abuse. "Women and children are always beaten, *verdad*?" they would say to me, believing that this is a common practice among all people. Otomí children do not question adult behavior or instruction, and politeness, patience, and respect for their elders is characteristically obvious when observing the children's interactions with adults.

The Otomí people practice generalized reciprocity, always sharing what they have with others so that "when they are in need, others will help them." These villagers

Figure 72. Typical Otomí nuclear family with father, lactating mother with breast-fed infant daughter, and two sons, Pañhe, Hidalgo, 2006.

have a central lifestyle motif of donation, giving to one another so that all survive. Foster saw these people as having little control over their life conditions, and characterized them as "old-fashioned" in their ideas, customs, furnishings and social organization (Foster 1967). But, every family contributes 100 pesos to the *mayordomo* when he comes to their doorway, contributing their support for the annual fiestas. If they are very poor, they save this money carefully all year, sometimes going without food or clothing, to be prepared for this annual donation. The women also contribute their time, money, and food to annual festivities associated with the schools. I observed a planning meeting for the "*kinder*" (the village pre-school) school graduation party. All the women were required to bring prepared food to celebrate the end of the school year. They were also required to pay for their children's school picture mounted on wood (100 pesos) and another 25 pesos for party decorations. Some of the women said they could not afford to pay money in addition to the required food, so other women immediately offered to pay greater amounts for those who could not afford it, and the ones without enough money would exchange service hours for their lack of money. The village women seemed to usually work together without question, and those who were generous gained prestige within the community. One lactating woman with more education (nine years) and rumored to have more money from her migrant working husband, donated liberally to school and other village functions. She was the only woman in Pañhe who owned a small car. She was usually found to be taking charge in many village meetings, especially at the medical clinic. She was listened to with respect

and cooperation by the other women, who nodded in consent to her verbal opinions. When I held the group discussion for the women, she insisted on holding the meeting at her house, and organized most of the arrangements for refreshments, issuing invitations and following up on attendance. The women knew she could read government documents and the papers given them in the medical clinic, and she interpreted the political information for other women. Many told me she is an “important woman” in the village.

Traditional women have a lifestyle characterized by mutual assistance, improving their chances for reproductive success. The scientific literature emphasizes the role of alloparenting in successful breast-feeding and infant survival (Blaffer Hrdy 1999, Kramer 2005). The women who live near their mothers and had older children, especially female older children, were more likely to receive quality and quantity alloparenting assistance in caring for their infants (see Fig. 73). One woman reported that she had no help from her oldest sons. Until her first daughter was born, she had no help because only her daughters would help her with chores while raising her subsequent children.

The majority of these women (92%) live in compounds dominated by the mother-in-law. For these women, the assistance offered by their mothers-in-law in caring for the infant was infrequent, while others found more willing help from other female relatives or even more “readily available,” unrelated women (Kramer 2005). When the mothers-in-law did assist these women, it was primarily to dominate the grandchild’s time and sometimes led to the enforced “slavery” of the biological mother.

Figure 73. Older sister playing with her younger brother, Pañhe, 2006.

One of the women I followed spent her entire day running from one to another task, stopping only when her *suegra* (mother-in-law) told her that her infant was hungry and required breast-feeding. She was only allowed to breast-feed her infant, and then immediately return to work, while the *suegra* and her daughters burped the baby and spent time playing with, and comforting, the child. This lactating mother was killing the chickens, doing all the food preparation, including making tortillas, all the washing and laundry, cleaning, bathing the other children, beating the harvested beans, and serving her *suegra* and her sisters-in-law their food and drinks, while they sat laughing and talking, and playing with her baby throughout the afternoon.

Education

According to the 2005 Hidalgo state census, there were 111 schools in the *município* of Tecozautla, 47 of these were preschools, 50 were *primarias* (elementary) schools, 13 were *secundarias* (high school) schools, and one was a bachelor degree school (community college). Of the 50 *primarias* (elementary) schools, only 13 are indigenous *primarias* with a total of 96 recorded graduates. There are no indigenous *secundarias* (high school) schools. The indigenous children do not attend school with mestizo children. The average number of years of education for members of the entire *município* of Tecozautla is 5.8 years; however, among the group of women I studied in the villages of Pañhe and Gandho (n=51), the average number of years of education was 6.5 years, most likely skewed because some of the nonlactating participating women had attended more than 13 years of education.

Fiestas

Fiestas are an extremely important sociocultural component of the Mexican culture (Carrasco 1967, Dow 1986, Ennis-McMillan 2006, Fournier-Garcia 2003, Guerrero 2003). The most important fiesta in Tecozautla is the Fiesta de *Fruta* celebrated in July each summer. This fiesta was established in 1934 by Juan Resendiz, who was then the president of Tecozautla. President Resendiz declared that since the town was *owned* by Santiago Apostol, the patron saint of the cathedral in Tecozautla, this religious fiesta was to be held in Santiago's honor and to celebrate the abundant fruit harvest of the mestizo population (Schmal 2004).

In Pañhe, the spiritual fiesta celebrating Easter was in April. This fiesta was celebrated with parades and then the men, disguised by masks (see Fig. 74), tossed hundreds of baskets (the major product of this community) from the rooftop of the cathedral to those waiting below. The baskets, if caught, were free to the catcher, not unlike the beads thrown during "Mardi Gras" in New Orleans. There is an unusual ritual performed during this fiesta. Several chickens were hung by their feet from an overhead wire, and the men on the backs of donkeys would ride toward this line of chickens, and the first man to pull off the most chicken heads would win the prize of free *pulque*. These rituals are one of the reasons these people are seen as barbaric by the mestizo populations of Mexico.

Following several days of food preparation, at fiestas (parties) for baptisms, school graduations, weddings, and confirmations, relatives and friends gather in the

family compound to enjoy sumptuous foods such as *pollo con molé* (chicken with hot *chile* sauce), *barbacoa* (barbecued sheep or goat), mounds of tortillas and beans and vast quantities of *pulque,* beer, and sodas.

These people are very visual in their belief systems. Two women had permanent displays of Christian objects on small tables in their homes. Prior to the fiesta for Easter in April, the villagers create archways with palm branches to welcome the patron saint of the village. The image of the patron saint is carried in the parade as the fiesta begins, and after a few days, the patron saint is carried to the next village (see Fig. 75), accompanied by fireworks before and after the fiesta that welcome this saint and bid him farewell. Just before Easter, the village had a small parade that was a re-enactment of Jesus Christ carrying his cross to his death surrounded by village "roman soldiers" (see Fig. 76). The villagers also prepare special Christmas scenes in December inside the family compounds, each day adding more to the entourage, with eventually a total replication of the scene of Bethlehem, with many tiny people and animals, the Holy Family, many ornaments, stars, and miniature houses, all surrounded by miniature lights.

Religion and Belief Systems

The religion in Tecozautla is reported to be 92% catholic; however, the villagers practice a form of "nahuatized Christianity" (Klor de Alva 1993) rather than the traditional Roman Catholic religion (see Fig. 77). The residents of Pañhe and Gandho rarely attended mass in the Tecozautla Catholic cathedral, only on special occasions

Figure 74. Men in masks at Easter fiesta, Pañhe, 2006.

Figure 75. Easter fiesta parade, Pañhe, 2006.

Figure 76. Easter re-enactment of Christ and Roman soldiers, Pañhe, 2006.

such as baptisms, weddings, or funerals, and then they only went to the cathedral to speak with the priest to request the sprinkling of "holy water" on household items for special healing rituals. The village Catholic cathedral was attended during fiesta celebrations rather than for weekly communion or mass. In November, the women showed me an indigenous temple that was being built on the south side of the village (see Fig. 78). They told me that this temple would facilitate their offerings to *los espíritus* (spirits in water, land, and trees) and to celebrate their indigenous rituals such as the Day of the Dead (see Fig. 79).

The Otomies practice a shamanistic belief system embedded within their desert ecology. According to their indigenous beliefs, a *nahual* is a person with an ascribed status, based on the day of their birth, who can turn himself into a dog, a coyote, a turkey, a donkey, a jaguar or a puma for good or evil purposes. *Nahuals* can also "shape shift" from *brujas* (witches) into bats and suck blood from babies during the night. A mother of one of the women participants in Pañhe told me that one of her babies died because "a *bruja* came in the night and sucked her blood, and in the morning, she was cold and blue." According to Aztec mythology, the god Tezcatlipoca was the protector of *nahual*, his *tonal* (spirit essence) was the jaguar, and this god governed the distribution of all wealth (Kaplan 1956). *Nahuals* or *curanderas* (native healers) are always hired to remove curses, such as *mal de ojo* (evil eye) in an infant, in addition to healing other childhood and adult sicknesses such as *susto*.

The Otomí believe that illness among children is caused by *los aires* or *mal de*

Figure 77. Catholic church, Pañhe, 2006.

Figure 78. Otomí man working on native church, Pañhe, 2006.

Figure 79. Otomí native church, Pañhe, 2006.

*ojo* (see Figs. 80 and 81). The native healers are tolerated, feared and respected. The members of the community always know who is a *nahual* (Kaplan 1956). One of the women studied in Pañhe had a mother who was known as was one of the village's most experienced *brujas* or *curanderas* (see Fig. 83). When I asked her what plants she used for healing, she quickly ran out of the house, and came back within a few minutes with some gathered plants, such as *cedron* (cedar), *peregil* (parsley), *flor de perrito, pirul*, *hierbabuena* (mint), *altamisa*, and *ruda* (see Appendix, figs. 118-124). She told me that she uses these herbs in healing rituals. The *pirul* and *ruda* are set on fire and the smoke is waved over the sick individual inside a house. The others are consumed as tea, or dried and the powdered compounds used as a poultice. One grandmother put a small piece of *pirul* inside the sock of her grandchild before setting off, with the child in a *rebozo* (shawl) on her back, to another relative's house. She believed this would protect the infant from *los aires* while they walked (see Fig. 82).

One woman had a "temple of native healing" recently built behind her house and hidden from the view of casual passers-by. Every other day, several *curanderas* performed trance-like behaviors in this temple in various healing rituals, using kerosene-lit circles of fire, eggs, numerous plants, massage, as well as songs, prayers, crosses, affirmation speeches, and other Christian images.

Another woman had a small wooden cross next to her front door on the wall, which has a piece of horse tail wrapped around it. She also has a palm branch with several pieces of palm intricately braided hanging next to this cross. There is also a small

Figure 80. Ojo de venado protects infants

Figure 81. Ojo de venado on neck of sick three year old.

Figure 82. Piece of pirul in baby's sock

Figure 83. Native *curandera* (healer) or *bruja* (witch), Otomí grandmother, Pañhe, 2006.

necklace or rosary hanging from the same nail as the cross. She explained that these objects protect the house and her family (see Fig. 84). I asked her why these objects were not on all the other houses in Pañhe, and she said it was because “they do not believe” in the Otomí customs.

When her uncle fell sick, she went to all her relatives’ houses and collected wooden religious objects with painted crosses and several facial images beneath. She explained that these images were her ancestors, and they were needed as part of a display on her kitchen table to begin the healing ritual because her uncle was very sick and it would take power from all these sources to get him better. In addition, some of the collected objects were taken to the Catholic cathedral in Tecozautla to receive a blessing with “holy water” from the priest. The display remained in her kitchen for several weeks while the healing ritual continued. Candles were lit, the family fasted and prayed, using pirul, ruda, and other herbal remedies to accomplish the healing of this family member (see Fig. 85).

They all report being Catholic when asked about their religious beliefs, but in practice they use a synergistic blend of traditional Indian beliefs and Catholicism. They believe that native curers or *curanderas* are more capable of healing *susto* or an infant that is suffering from *mal de ojo* (evil eye) and all use the *ojo de venado* (deer’s eye) that protects their infants from this disorder.

The Otomí have a strong belief in the spirits that inhabit everything in their environment, the mountains, the caves, the water, the trees, the air, the moon and the

Figure 84. House protection cross with horse-hair, Pañhe, 2006.

Figure 85. Ritual “healing display,” Pañhe, 2006.

sun. The capillas where they leave offerings to these *espíritus* (spirits) to maintain life in their children and prosper in their families are found everywhere (see Fig. 86). Some are near bridges (water spirits), some are in family compounds and are used in the celebration of the Day of the Dead, and others are found in the fields (mountain or land spirits) or open desert lands for protection of the corn and other crops as well as the people as they travel to and from work as *agricultóres* and the children while they fetch the *masa* from the village *molino*.

At the request of one particular family, I spent an entire day observing the elaborate preparations that precede the Day of the Dead by one Otomí family, the Tzidejhe family. They were the only family in Pañhe with a strong Otomí name and they strictly adhered to most of the traditional customs of the ancient *indígenas*. The grandmother (the wife's mother) in this family was a well-respected *curandera* (native healer) and was feared as a *bruja* (witch) by many of the villagers. The food preparation by the women goes on for many days, but special candles and ornamental decorations are prepared the day before. In this family, the father made these candles and ornaments with his children watching closely, bringing various items and helping him when they were asked (see Fig. 88). The entire compound is strewn with yellow flowers to welcome the ancestral spirits (see Fig. 87). The men, women and children in this family spent the entire night awake sitting inside their temple (the only family in Pañhe that had built a traditional Otomí religious edifice for this Day of the Dead ceremony and for funerals), waiting for the spirits to visit and eat the prepared food. The father told

Figure 86. Otomí capilla for offerings to *espíritus* near organ cactus fence.

Figure 87. Traditional yellow *flor de palma* adorning fences, *Dia de Muertes*.

Figure 88. Family preparing candles for *Dia de Muertes,* Pañhe, 2006.

me that if they failed to prepare this food, the spirits would eat their children. Of course the children really believed this to be true, a notion that would have given most children cause for serious nightmares. In the morning, the "leftover" food was consumed for several days by the family accompanied again by vast quantities of *pulque*.

The Hot Cold Syndrome

In 1967, George Foster described peasants in the rural Mexican setting as "cultivators of the soil" that live in a "symbiotic spatial-temporal relationship" with the Mexican national urban centers. Foster's definition of a "peasant" was structural and relational rather than occupational. In 1978, Foster described the cultural belief system observed in rural Mexico known as the "hot-cold syndrome" as similar to the Greek humoral system, promoting a continuing controversy over the origin of this belief system in the literature. Foster reported that this system of opposition guides their choices for treatment and healing (see Fig. 89) (Foster 1978, Foster 1994).

In The Hot and Cold: Ills of Humans and Maize in Native Mexico, Chevalier and Sanchez Bain published a response to this description of the "hot-cold syndrome" (Chevalier and Sanchez Bain 2003). They clearly differentiate the Greek humoral theory of blood (hot/moist), phlegm (cold/moist), yellow bile (hot/dry), and black bile (cold/dry), from the Latin American humoral theory, as described by Foster, of hot (fire), cold (air), wet (water), and dry (earth). The Latin American *humoral* approach to the hot and cold belief system is most often practiced by the mestizo populations or those of European descent in Latin America.

Figure 89. Mesquite trees (cool) in contrast to the heat of the green fields, Pañhe, 2006.

According to Chevalier and Sanchez Bain, there are no humors in the hot-cold syndrome practiced by the Indian populations of Latin America, only the traits of *heat* and *cold*. To the Mexican *indígena*, the normal healthy body cycles from hot to cold, with a daily alteration and movement from hot to cold conditions that varies with activity, such as sleeping (cold condition), working (hot condition), or eating (hot condition). The *indígenas* believe that this *moving* hot-cold process is essential for growth, reproduction and the maintenance of health (Chevalier and Sanchez Bain 2003).

The Mexican peasants believe that disease is caused by the disruption of these hot-cold cycles, not unlike the definition of disease by the Ayurvedic physician, Dr. Deepak Chopra, as a deviation from the spontaneous expression of nature's intelligence. Normal health is thought of as a moving balanced entity within the structure of life cycles and growth (Chevalier and Sanchez Bain 2003). Chevalier describes the *heat* of aging and death as *feeding* the cycle of life. Men and women as they mature gather strength and heat to reproduce seed (corn and/or children) and sustain life (Ibid. 2003). Chevalier's model is based in the heliotropic law that healthy bodies have warm blood, a feature of the pre-Hispanic belief that life is movement and growth in the sun (see Fig. 90), the solar-driven process of life and death (Ibid. 2003). The *campesino* works in the *milpas* (fields) in the hot sun and experiences heat. The health risk is not the loss of balance but rather the threat of cold when the body experiences this necessary "phase" of heat. The "pacing rule" that regulates salt intake and excessive work in the heat prevents heat cramps and heat stroke while walking to the fields and performing their

Figure 90. Otomí girl with pomegranate, “life is movement and growth in the sun,” Pañhe, 2006.

work (McCullough 1973). The “cold exposure rule” that requires a man to rest outside the house until the “hot winds” of the *milpas* evaporate, allows the body to return to a normal level of heat before entering the house and prevents respiratory illness. The major components of the Nahua hot-cold syndrome are balance, cyclic movement and heliotropic growth (Ibid. 2003). This hot-cold equilibrium facilitates the cycles of reproduction (moving equilibrium) and the solar-driven process of growth and death. There is an order in the *space* seen in the desert, the *milpas*, the water holes, and the body. There is an order in the *time* seen in pregnancy, birth, lactation, aging and dying. Nahua space and time influence humans, maize and all life (Ibid. 2003). The notion of thermal balance interacts with dynamic cyclic shifts and heliotropic growth to sustain all life. The children come alive by sucking fluids from the brains of their parents who dry up and burn themselves out to bring children into existence (see Fig. 91) (Ibid. 2003). The ritual of burying the placenta and umbilical cord in the corner of the house where the sun rises at dawn reinforces the child’s connection to home and land that must never be cut if life is to be sustained (Ibid. 2003).

Breast milk is regarded as sacred food, and must never be given to infants when too hot or they will fall sick with diarrhea and vomiting. The practice of the “hot breast milk rule” of waiting for 10 to 15 minutes after working in the sun (see Fig. 92) or after sweating while preparing tortillas, often even expressing some “hot milk” or using cool water compresses to reduce the heat in their breasts before beginning to breast-feed their infant, in reality, allows the mother time to relax and focus on her infant. One

Figure 91. Otomí lactating infant with green bean, parents “dry up and burn themselves out” to give life to their children, Pañhe, 2006.

Figure 92. Otomí lactating woman working in the heat of the sun collecting *quelites* for her pigs, Gandho, 2006.

mother told me that she always waits at least 20 minutes after making tortillas before breast-feeding to be sure that her breast milk is not “too hot” for the baby. This prevents the baby from getting sick with diarrhea or respiratory illness, and in extreme cases, the infant’s death. This behavior contributes to a feeling of maternal relaxation, essential for the oxytocin-induced “milk let-down” reflex that is associated with successful lactation (Ueda 1994). This adaptive behavioral strategy was universally practiced by the women studied in this project.

## CHAPTER III

## LITERATURE REVIEW AND METHODOLOGY

### Brief Literature Review

#### Lactation History and Traditions

Individuals who adopt life strategies that maximize their reproductive success will be favored through natural selection. Maternal investment in an infant's struggle to survive is essential to this process. Breast-feeding has long been endorsed by the medical and scientific community as the infant feeding method of choice, maximizing nutritional and developmental benefits for the human infant (Lawrence 1999, Riordan 2009, Short 1984, Stuart-Macadam 1995, UNICEF-WHO 2009). The ideal method of infant feeding for the *slow-growing and long-living* human species (Cunningham 1995, McKenna 1993), lactation is endorsed and recommended by numerous professional organizations as the best nutrition for at least the first year of human life, including the World Health Organization (WHO, 2002), American Academy of Pediatrics (Gartner, 1997, AAP 2009), American Academy of Family Physicians (AAFP, 2003), American Dietetic Association (ADA, 2001), Institute of Medicine (IOM, 1991), Life Sciences Research Organization (LSRO, 1998), U.S. Department of Health and Human Services (HHS/OWH, 2000), and the Canadian Pediatric Society (1998).

When studying the morbidity and mortality of infants, it is essential to consider the effects of breast-feeding practices (Fildes 1995). Differing beliefs in the potential

harm of colostrum, duration of exclusive breast-feeding, and the cultural context of weaning behaviors have all effected the health of breast-fed infants (Sellen 2001, Stuart-Macadam 1995). Historically, in the absence of infant formulas, the "availability of breast milk" and the longer a child was nursed, the more likely they were to survive (Blaffer Hrdy 1999). Wet-nursing, the social custom of employing a lactating woman of a lower class to nourish the biological mother's infant, released the mother to pursue other activities (Ibid. 1999). This widespread practice of wet-nursing, safeguarded by the Code of Laws of Hammurabi in Babylon more than 3,000 years ago, became unfashionable in the mid-18$^{th}$ century (Fildes 1995). The "return to nature" concept found in the writings of Rousseau and others promoted this social trend of breast-feeding, and many mothers returned to breast-feeding their infants. Eventually, wet-nursing became a prestigious "fad" among European royalty and "bourgeois" mothers, socially relegating the practice of breast-feeding to a level of poverty and peasantry (Fildes 1995, Blaffer Hrdy 1999, Van Esterik 1995). Toward the end of the 19$^{th}$ century, rural mothers continued to breast-feed their infants, urbanized working mothers rapidly shifted to supplementing breast milk with alternative infant nourishment and weaning their infants earlier (Fildes 1995).

In recent human history, changes in female employment, women's liberation efforts, and concerns with HIV infection, have promoted controversial discussions on the risks and benefits of human breast-feeding behavior (Cunningham 1995). For more than 50 years, a public debate over infant feeding methods has ensued, known as the

infant formula controversy (Filer 1991, Van Esterik 1995). The International Baby Food Action Network (IBFAN), in addition to other groups such as INFACT (Infant Formula Action Coalition) in the United States and Canada, continue to promote breast-feeding and implement the WHO-UNICEF code for marketing breast milk substitutes throughout the world (Filer 1991, Van Esterik 1995, UNICEF-WHO 2009) in response to the marketing strategies of the multinational corporate producers of infant foods.

Breast-feeding has been shown through scientific research to improve the health of both the mother and her infant, enhancing maternal metabolic function (Stuart-Macadam 1995, Lawrence 1999), providing short and long-term immunity for the infant against intestinal and respiratory infections and numerous adult diseases (Goldman 1993, Goldman 1998), such as diabetes type II, inflammatory bowel disease, and breast cancer (Le-Hueron-Luron 2010, Micozzi 1995, Walker 2010), protection against serious brain damage in the infant (Walker 2004), evidence for increasing infant cognition (Stuart-Macadam 1995), lengthening of birth spacing to reduce infant mortality (Ellison 1995, Konner and Shostak 1987, Konner and Worthman 1980), decreasing the incidence of SIDS (sudden infant death syndrome) (McKenna 1993), decreasing the incidence of obesity in adolescence (Le-Hueron-Luron 2010) and strengthening the mother-infant relationship (Riordan 2005, Stuart-Macadam 1995, Walker 2004).

Despite the overwhelming scientific evidence for the advantages associated with breast-feeding for a minimum of two years (AAP 2009), most infants in developed nations are fed milk substitutes after six months of age. The duration of breast-feeding

among traditional populations can last up to four years or longer (Dettwyler 1995). This behavioral strategy, though biologically costly to the mother, improves their infant's chance for survival, especially among traditional peoples whose infants and children are commonly exposed to high risk disease factors from contaminated water.

The biological process of breast-feeding is profoundly influenced by cultural beliefs in infant health and nutrition, and the mother/infant relationship (Stuart-Macadam 1995, Dettwyler 1995). Despite a history of successful lactation, many of the traditional populations in developing countries have now altered their cultural beliefs and corresponding breast-feeding behaviors in response to encroaching industrialization and the *medicalization* of reproduction. Prestige is often accorded to behaviors associated with industrialized nations, including the reproductive choices of infant feeding, associating the technological advances of infant formula with wealth and the practice of breast-feeding with poverty (Acosta-Johnson 1980). The "insufficient milk" syndrome is seen as the major reason given for early cessation of lactation among women in most developing countries (Perez-Escamilla 1993, Greiner 1981, Gussler 1980), a cultural notion based in changes in breast-feeding frequency and duration combined with the practice of using formula combined with breast milk. When formula is used to supplement breast-feeding, this always results in a reduction in breast milk production (Lawrence 1999). In particular, many urban Mexican women in the Sonoran Desert region, who have delivered in hospitals with easy access to infant formula, believe they have "insufficient milk" (Perez-Escamilla 1993).

European hegemonic colonization in underdeveloped nations has resulted in the adoption of Western practices including the medicalization of childbirth and infant feeding practices (Quandt 1998, Scrimshaw 1997). Multinational corporations have had a profound impact on these traditional peoples, particularly infant formula manufacturers, and the cumulative effects of globalization (Greiner 1981). “In the 1880's, more than 95% of infants in the United States were breastfed, [while] in the 1990's, only about half of all infants are breastfed” (Stuart-Macadam 1995: *ix*). The World Health Organization indicates that exclusive breast-feeding through six months of age is still not the preferred method of infant feeding worldwide with an average global exclusive breast-feeding rate of only 36% (World Health Organization Statistical Information System, Web. WHO 2011, retrieved 2/4/2011).

The “Healthy People 2010” Report called for an increase in breast-feeding rates to 75% initiation with at least 50% continuing to breast-feed their infants after six months (Healthy People 2010 Report, 2010, www.cdc.gov, retrieved 2/4/2011). During recent years in the United States, the projected breast-feeding initiation rate of 75% had been reached by 2007; however, breast-feeding rates at six and 12 months remain low, at 43% and 22.4%, respectively. According to the CDC, the hospital practices and policies found in hospitals that interfere with breast-feeding remain common. One in four American babies is supplemented with formula within two days of birth (www.cdc.com, retrieved 2/4/2011). Exclusive breast-feeding rates through six months in the United States is only 13.3%, and among socioeconomically disadvantaged groups this rate is

even lower, especially among African Americans, with rates of exclusive breast-feeding through six months at only 8.2% (Ibid. 2011).

Despite the numerous advantages to breast-feeding practices, not the least of which are the nutritional, immunological, and developmental benefits to the human infant, few research studies have focused on the strategies employed by nursing mothers in different ecological settings (Piperata and DuFour 2007). Cultural beliefs and practices concerning breast-feeding in various ecological settings worldwide include a belief that breast milk is "water" instead of nourishment, thus, thin millet gruel is given to the infant from birth (Richards 1939), and the notion that mother's milk falling on children's genitals will cause the infant to die (Smith 1954). Others believe that if a mother becomes pregnant again before the infant is two years old, that her breast milk will be spoiled and will hurt the first baby (Ibid. 1954). Some societies exploit animal milks, such as the Somali pastoralists who are only nursed by their mother for one year and, thereafter, the children suckle from goats or camels (Puccioni 1936). The Tiv babies are often suckled by allomothers, while the Maasai women breast-feed their infants for only one month while they are identified as a fetus rather than as a baby. The infants are then fed cow's milk in later months once identified as a child (Spencer 1988). The Ugandan mothers supplement their babies with solid foods such as banana, orange juice, soup, and cornmeal porridge beginning between two and six months of age (Ainsworth 1967). Ainsworth also noted that Ugandan mothers who reported having insufficient milk also expressed a dislike for the practice of lactation (Ibid. 1967).

Ainsworth reported that Ugandan infants fed on a schedule were passive, accepting the breast when offered, while infants fed on-demand were eager to initiating suckling with no evidence of fussing, in direct contrast to her observation of American babies (Ibid. 1967). The Otomí mothers believe that breast milk is sacred and has a "hot" condition and, as a result, they don't suckle their infants immediately after working in the heat of the sun, but rather they cool their breasts down with cold water and wait in the shade until their milk is "cooler" before nursing to prevent illness in their infants.

Lactation in the Desert

Human adaptation refers to either temporary or permanent adjustments. These adaptations are physiological, structural, behavioral and/or cultural, and are aimed at improving the individual's functional performance (Frisancho 1996, Rowell 1978). Developmental adaptation or acclimatization refers to traits acquired during the lifetime of the individual due to complex stressors, while acclimation refers to a single induced-stress response (Ibid. 1996). One type of stress that induces both acclimation and acclimatization is the extreme heat of desert environments.

Deserts are characterized by high daytime air temperatures (32-52$^{o}$ C), low humidity (less than 10%), intense solar radiation, little precipitation, little vegetation, and marked day to night variation in temperatures exceeding 50 degrees (Adolph 1947, Frisancho 1996:54, Hiernaux 1982, Klausen 1967, Rowell 1978, Wenger 2001). In general, acclimation to "work in heat stress" among women produces a reduced heart rate, reduced rectal and skin temperatures, "the onset of sweating at a lower skin

temperature, and an increased sweating capacity" (Frisancho 1996:56-57, Wenger 2001). By increasing the surface area of the human body, thermoregulatory mechanisms function more efficiently (Benzinger 1977). As a consequence, the indigenous desert populations who seem to tolerate heat stress more efficiently are tall and lean, or short and light short trunks and relatively longer extremities (Frisancho 1996). Individuals living in desert climates maintain higher radiation and convective heat loss capabilities and have decreased sweat rates (Ibid. 1996, Adolph 1947). The anthropometric measurements of adapted desert men have been quite extensively recorded, (Frisancho 1996) however, accurate anthropometric measurements of adapted desert women have not been obtained.

There have been several studies conducted on the fluid requirements and adaptation of desert mammals such as the goat during lactation (Lee 1972, Maltz 1980, Olsson 1982), which illustrate the environmental stressors of desert regions that is further compromised by the strain (or heavy workload) of lactation (Weiner 1981). The adaptive capacity of certain large desert mammals (camels) to retain surplus water in their rumen or fore-stomach under limited water conditions is well known in the literature (Lee 1972). The suggested physiological mechanism that allows the desert goat to successfully lactate is attributed to the retention of intracellular body water (Hossaini-Hilali 1994) through reduced urinary and fecal excretion of water. Maltz reported, however, that milk production was not reduced until 48 hours following the last drinking episode and that, despite a rapid weight loss that coincided with this period

of decreased production of milk, the desert goat has a remarkable ability to rehydrate rapidly and regain full milk production (Ibid. 1994, Olsson 1982). The suggested physiological mechanism that allows the desert goat to successfully lactate is attributed to the retention of intracellular water (Hossaini-Hilali 1994) through reduced urinary and fecal excretion of water, a condition seen in humans that often results in dark colored urine, or urinary concentration, and can lead to constipation. These physiological mechanisms, allowing the desert goat to lactate efficiently in water-stressed environments, may or may not be the same in human lactating females. Lacking a rumen or fore-stomach to store excess water, humans must rely on drinking behavior to remain hydrated in the desert.

There have been numerous studies on the nutritional requirements of pregnancy and lactation (FNB 1993, Lonnerdal 1986, Prentice 1989), and some studies on the fluid requirements during pregnancy and lactation among nondesert women (Dusdieker 1990, Erschow 1991, Illingworth 1953, Stumbo 1985); however, there still remains a scarcity of research concerning human lactation strategies among desert lactating women in a water-stressed environment (Bentley 1998). The few studies undertaken to assess the fluid requirements of lactation among nondesert women in developed countries have used methods that may have been inconclusive, such as forced fluids or hyper-hydration (Dusdieker 1990, Erschow 1991). The participants were asked to drink large quantities of water twice daily, mid-morning and mid-afternoon, that ultimately led to a reduction in their breast milk production, not unlike the findings among desert

goats (Hossaini-Hilali 1994). However, the mechanisms that allow the desert animals to successfully produce milk have not been studied or discovered, as yet, among human desert females.

It has been suggested that the dilution of mammalian milk, or a maternal increase in body water content, may be a physiological adaptive mechanism providing increased water to the infant under conditions of hydration stress (Yagil 1986), but Hossaini-Hilali disagrees (1994). Some researchers discourage forced fluid intake by lactating females, but instead suggest that drinking behavior should be left up to the discretion of the individual woman's thirst threshold (Stumbo 1985). Humans exposed to extreme stressors, such as the extreme heat experienced in a desert climate can succumb to "involuntary dehydration" (Greenleaf 1992). Drinking behavior does not always accompany a sensation of thirst, suggesting there may be a sociocultural component to drinking behavior in desert climates such as the hot/cold syndrome that reduces life-threatening heat casualties in a desert environment (McCullough 1973). The !Kung San who live in the Kalahari Desert drink one to two cups of water and then wait two or three hours before drinking again, because they believe drinking small amounts more often leads to dehydration (Polly Wiessner, personal communication, 2011).

## Biology of Lactation

Cross-culturally, lactating females have the ability to produce between 750 milliliters per day (singletons) to 2,500 milliliters per day (multiples) of breast milk

(Riordan 2005, Short 1984). In general, fluid intake for nonlactating female and male individuals can vary from 600 to 6,000 milliliters per day (Frisancho 1996, Bentley 1998), depending on their activity levels and the ecological setting. The recommended adult water intake under nondesert environmental conditions is one milliliter per calorie of energy expenditure (Lawrence 1999). The average energy expenditure for breast milk production in nondesert environments is 640 k-calories per day during the first six months of lactation which is reduced to 510 k-calories per day during the next six months (USDA government statistics, 2002). It is recommended, therefore, that lactating women in nondesert climates consume an additional 500-600 milliliters per day of fluids, or between two and two and a-half cups of water obtained from food and/or water (USDA government statistics, 2002). Because of the scarcity of research concerning the water requirements of lactating desert women, there are no accurate estimates of recommended water intake among these people. It has been estimated that some of the energy expenditure required for lactation is derived from maternal body fat stores, facilitating postpartum weight loss and preserving a positive maternal energy balance. Piperata reported that lactating traditional women in the tropical setting of the Brazilian Amazon drew on their maternal body fat stores during the course of lactation, showing significant weight reduction in the pelvic region (2007).

The differences observed in the osmoregulatory functions of thirst and the release of vasopressin, the hormone responsible for regulating body water content among nonlactating human subjects under environmental conditions of extreme heat,

suggest that genetic factors may explain observed phenotypic variations (Davison 1988). In the lactating female, oxytocin and vasopressin are released into the portal circulation of the posterior pituitary gland, which seem to have similar functions. Interestingly, vasopressin is found in abundance in human breast milk, protecting the newborn breast-fed infant from dehydration during the immediate postpartum minimal weight loss (Marchini and Stock 1997). Oxytocin, the hormone that regulates uterine contractions in childbirth and stimulates the "let-down" response in lactation, is the only hormone that contributes to the feeling of thirst experienced by lactating females during suckling (James 1995, Leake 1983, Ueda 1994). The thirst response is a sensory component of a homeostatic osmoregulation system that functions to maintain body fluid balance (James 1995, Nagy, 1992, Zerbe 1991). Improper positioning of the infant results in poor nipple stimulus which can hinder the release of oxytocin (James 1995, Ueda 1994), decreasing the sensation of thirst until after the state of dehydration has already been established (Askew 1996).

The anterior pituitary gland releases the hormone prolactin in response to suckling during lactation, which regulates the amount of milk produced (Imagawa 1994, Nagy 1992), and simultaneously reduces the loss of body water (Horowitz 1980, Horrobin 1971). Since the major adaptive component that improves human survival under conditions of extreme heat is the cooling efficiency that preserves body water content (Frisancho 1996, Wenger 2001), the behavior of lactation, through the action of prolactin, reduces loss of body water and increases their cooling efficiency. Lactation,

therefore, is a life-sustaining behavioral strategy for the desert mother, as well as for her infant.

The human mammary gland's primary function is to synthesize and secrete milk essential for the nourishment of the human infant. The endocrine regulation of human mammary gland development is unclear; however, there is no doubt that it is an extremely complex system of organogenesis, and that the breast is one of the most complex endocrine target organs (Lawrence 1999), initially involving the hormonal actions of progesterone and estrogen during puberty. The mammary gland consists of an epithelial nipple and a branching secretory ductal and alveoli system, having 15-20 ducts terminating at the skin surface through the nipple. There is a layer of contractile myoepithelial cells surrounding these alveolar sacs. During lactation these myoepithelial cells, stimulated by suckling, release the hormone oxytocin that regulates the milk ejection or "let-down" response. Increased estrogen secretion, during puberty and again during the first gestation, contributes to alveolar cell differentiation resulting in the subsequent responses to prolactin and glucocorticoids by these cells to produce mature human milk (Imagawa 1994). Psychological relaxation is essential for the release of oxytocin to produce an adequate milk ejection and thirst response in the mother (Ueda 1994).

The human reproductive cycle begins with conception and culminates in lactation. During the entire cycle of human reproduction of gestation or intrauterine fetal growth and development, childbirth, and finally lactation, the human female is

providing nourishment for this new life. Lactation involves two stages, lactogenesis and lactation.

During lactogenesis, colostrum is secreted immediately after childbirth. Colostrum is especially high in antibodies, conveying passive immunity to the infant. Colostrum is also rich in hormones, which "potentially affect [the infant's] subsequent growth and development," and the development of the infant's gastrointestinal tract through the establishment of beneficial digestive flora (Tucker 1994).

The secretion of prolactin by the anterior pituitary gland into the bloodstream is the primary hormone responsible for the maintenance of lactation or mature milk production (Ho Yuen 1988, Leake 1983, Ostrom 1990, Tennekoon 1994, Tucker 1994). The secretory hormonal activity for human milk production is determined by the stimulation of infant suckling, which increases the secretion of several hormones, including prolactin, that are required for mature milk production. Thus, the suckling infant determines the mother's lactation performance (Frisancho 1996, Ueda 1994).

The mammary gland retains prolactin receptors for a long time after the reduction of serum concentrations of prolactin, perhaps explaining why the "leaking" of breast milk can continue long after weaning (personal experience of author). Frequent suckling, observed among traditional peoples, favors maintenance of high levels of serum prolactin, which is directly related to increased milk production (Nagy 1992, Prentice, 1986, Tucker 1994). It has been hypothesized that higher levels of serum prolactin may also be responsible for ovarian inhibition, or increased birth-spacing, in

the lactating female (Konner 1976, Ellison 1995). This pattern of increased suckling frequency has been shown to produce adequate breast milk, in that their babies are well hydrated (Almroth 1990, Brown 1996). It has also been shown that the action of the hormone prolactin influences renal retention of water (Horowitz 1980, Horrobin 1971), contributing to total body water content and cooling efficiency among lactating females in desert environments.

Lactation, Water and Diet

Lactating women are physiologically functioning under the stress of extreme production or a heavy workload (Weiner 1980). The increased energy demands occurring during lactation is met by increasing energy intake (dietary/fluid intake), utilizing body fat stores, or lowering energy expenditures. Weiner indicated in 1980 that there was no research on the required intake of water by individuals during heavy workloads in desert climates or the effect of dehydration under these circumstances. The few studies which have observed the water requirements of human lactating females concluded that rather large variations in water intake had little or no effect on milk production, and that human lactation seems to have a surprising tolerance to water restriction (Prentice 1989). Prentice found a direct correlation between plasma osmolality and breast milk osmolality during conditions of dehydration, with a remarkable degree of adaptation to reduced water intake with no marked changes in the normal physiology of 10 lactating Gambian women (Prentice 1989). Lonnerdal proposed a possible connection between the amount of milk produced and

dehydration; however, most studies find very little variation in human milk production, even in the severely malnourished individual, with breast milk supplied to the offspring sometimes at the expense of maternal tissue damage (Prentice 1984).

Human milk is composed of about 4% fat, less than 1% protein, approximately 7% carbohydrate in the form of lactose and much less than 0.5% of minerals, including sodium, potassium, calcium, magnesium and phosphorous, providing the energy of 60 to 75 kilocalories per 100 milliliters of milk (Jenness 1979). It appears that race, age, and parity have little effect on the composition of human milk (Ibid. 1979). Cross-cultural investigations into the correlation between maternal diet and human milk composition reveal few differences, such as higher levels of omega-3 and omega-6 essential fatty acid concentrations in the breast milk of women in China with traditional high fish dietary consumption as compared to Western women (Boersma 1991, Jensen 1992, Wu 2010).

Lactation in Mexico

Class distinctions in Mexico determine infant feeding traditions, since breast-feeding is often associated with poverty and a lack of education (Acosta-Johnson 1980, Villalpando 1992). The duration of breast-feeding among traditional populations varies between two and six years (Dettwyler 1995) and the frequency is driven by their infant's demand for nourishment (Cunningham 1995). Lactation as a physiological and cultural strategy, though costly to the mother, improves their infant's chance of surviving to reproductive age (Blaffer Hrdy 1999). The cultural definitions of appropriate maternal

roles and attitudes, female workloads, diet, restrictions on sexual information, and an absence of the father because of migrant work practices in traditional Mexican villages have contributed to the patterns of social organization that have encouraged universal breast-feeding within the indigenous populations (Acosta-Johnson 1980).

In the southwestern United States, a study of Hispanic women in San Antonio, Texas indicated a trend toward a medicalization of the human reproductive process for these recent immigrants, reporting changes in prenatal care, childbirth, and lactation from those of their Mexican grandmothers. Their breast-feeding rates were less than 40% initiation and only 3% continuing after six months (Kay 1980). Infant feeding patterns throughout rural Mexico indicate breast-feeding rates of 86% initiation, dropping to approximately 40% after three months, among the lowest rates in developing countries. Disturbingly, these rates are even lower in the urban populations of Mexico (Perez-Escamilla 1993). This trend is connected to a belief that breast-feeding behavior is associated with a lifestyle of poverty.

In developing countries, early cessation of lactation is associated with higher socioeconomic status, urban residence, increased maternal education, use of oral contraceptives, and maternal employment outside the home (Perez-Escamilla 1993). Patterns of successful lactation in urban Mexico were associated with the appearance of early breast milk arrival, maternal intention to breast-feed, planned duration of breast-feeding, and hospital birth rooming-in practices (Perez-Escamilla and Dewey 1992). The cessation of lactation was primarily associated with insufficient or not enough milk, a

prevalent complaint throughout the Western world and, more recently, in developing countries (Greiner 1981, Gussler 1980, Perez-Escamilla 1993).

According to Kay's research among the Mexican and Chicanas of Texas, babies were delivered in the Sonoran desert of Mexico by midwives until the 1950's. With the events surrounding World War II, Mexican childbirth beliefs came to be seen as superstition and were forgotten. With the advent of hospital births, the art of breast-feeding babies was abandoned. The herbal teas used for infant colic and infections were replaced with physician-prescribed infant formulas. Among the Chicanas, these established traditions concerning women's mutual help or alloparental assistance (blood and marital relatives who support childbirth and lactation) and folklore (*Albaca* or *Ocimum basilicum* tea for lactation, A*lcanfor* or *Cinnamomum camphora* for mastitis, and chamomile or *Manzanilla* for colic) are showing signs of being revitalized (Kay 1980).

Postpartum maternal diet among rural traditional Mexicans includes chamomile tea (*Manzanilla*), toasted tortillas and *atole* (thick spiced corn gruel) for two days, then advancing to chicken soup. Food taboos immediately postpartum included vegetables and fruits (too acid and cold), and pork, *chile* and tomatoes (believe to be harmful to breast milk) and are avoided for the 40 days of seclusion (Kay 1980). Most women went to their mother's home for the period of time referred to as "seclusion," and the new mother was not allowed to sweep, sew or do any heavy work until a bath (*baño de hierbas*) was taken after 40 days. During this time, the mother and her infant remained

with head and body covered to avoid coldness (*los aires*), which was believed to be dangerous after childbirth, and might cause *punzadas* leading to blindness, mastitis (caused by eating cold or sour things), or "coldness," that might create maternal frigidity or infertility (Ibid. 1980).

Acosta-Johnson et al., studied the Mexican migrants in Houston, Texas, and found similar traditions. Support for indigenous lactating mothers depends entirely on cultural definitions of appropriate maternal roles and attitudes. According to Acosta-Johnson's research, the Western hospital personnel in Houston, Texas, convinced these migrant Mexican women that breast- feeding was associated with hippie-like behavior, caused cancer, and would increase their already strained workload. Breast milk, they said, was bad for their babies, that it was not really milk, and it was indecent to expose their breasts to their families. In addition, the hospital personnel told them that they could not produce enough milk to feed their babies adequately (Acosta-Johnson 1980). The administration of birth control pills, diet medications, tranquilizers, and a routine injection of Deladumone after delivery (a medication that inhibits breast milk supply), in addition to the cultural notions mentioned above, all contributed to these Mexican migrant women's inability to successfully breast-feed their infants (Ibid. 1980).

Breast milk in their breasts was naturally expected, observed and experienced (Acosta-Johnson 1980) by all women delivering in rural Mexico; however, the social support that provided emotional security to the mother during lactation was no longer seen among these migrant Mexican women living in Houston (Ibid. 1980). These migrant

Mexicans reported feeling sorry for the rural women in Mexico, associating the requirement of breast-feeding with poverty (Ibid. 1980). The migrant Mexican women who now reside in Houston regarded infant formula (Similac) as superior food for their babies. The prestige value or preference of infant food ranged from the most valued infant food being Similac infant formula, next was pasteurized cow's milk, then Koolaid (fruit punch), herbal teas, rice water, burro milk, with the least valued food being human breast milk (Ibid. 1980).

According to Acosta-Johnson, the emotional stress of violating traditional taboos and their efforts to modernize childbirth and infant feeding was apparent (Ibid. 1980) as these women tearfully remembered the social support networks of their grandmothers in Mexico that sustained their ancient cultural beliefs of the 40-day seclusion after childbirth and reinforced their breast-feeding behaviors (Acosta-Johnson 1980). They felt that violating the 40-day seclusion period was the most serious detriment to successful lactation (Ibid 1980). Among babies born in rural Mexico, 92% were breast-fed, while less than 40% of the Mexican migrant babies were breast-fed. She reported in her study that breast-fed babies tended to sleep in the same bed with mother and father, while formula-fed infants slept separately (Ibid. 1980), increasing the risk for, and incidence of, SIDS (sudden infant death syndrome) (McKenna 1993). Breast-feeding continues well into the second year of the infant's life in traditional Mexico, supplemented with herbal teas beginning at childbirth (Acosta-Johnson 1980).

## Methodology

### Research Design

During the preliminary phase of this project, key informants were located and recruited, worksheets and questionnaires for semi structured interviews were written, interview protocols were translated and tested, and a purposive sample of women were chosen. In the second phase, initial anthropometric and personal data were recorded, and semi structured interviews and group discussions were conducted. In the third phase, the women were followed for 24 hours, obtaining anthropometric and energy expenditure data, dietary and water intake data, and breast milk production data using direct weight measurement of infants before and after breast-feeding sessions.

### Choosing Key Informants

Upon arrival in Tecozautla, I was introduced to a school teacher by Sr. Beltrán, the Otomí attorney I had met in 2005. This school teacher taught English to children in the primary school off the town square in Tecozautla. Her name was Rosalia Ocampo. Rosie was eager to assist in this project, hoping to improve her English skills, and became my first key informant. Rosie knew many of the *delegados* in the surrounding villages, and had connections to numerous medical clinic personnel through her travels in teaching English throughout the valley. In addition, Rosie had a past student, Aida Rojo Resendiz, who was now a school teacher in two local secondary schools, one in Tecozautla and the other near Gandho. Aida became my second key informant. These

two informants came from very different social categories with diverse religious backgrounds (one Catholic, the other a Jehovah's Witness), one was middle-aged with two teenage daughters, and the other was young and newly married without children. They both had markedly different experiences and backgrounds that allowed me to compare their lactation behavioral assessment against each other. I had several in-depth interviews with each of these key informants during the first weeks of living in Tecozautla, in addition to several months of friendly chats over breakfasts, lunches, and in the villages and fields. Both of these women became my lifelong friends.

Sample Selection

The requisite approval and permission letters from the *presidente* of Tecozautla, and the *delegados* of several surrounding villages were facilitated and obtained through Rosie's social connections. With Rosie's assistance, I learned that regular bimonthly meetings were held in the clinics that required the attendance of all child-bearing age women. If they did not attend, their meager government DIF funding was terminated. These meetings were intended to disseminate biomedical information to the community of female *indígenas* concerning the diagnoses and Western medical treatment of various prevailing health conditions in this region. This information was designed to replace the traditional folk remedies practiced by native curers or *curanderas* and by midwives or *parteras*.

After sharing the context of my research project and obtaining the approval of the medical clinic personnel in Pañhe and Gandho, I was permitted to introduce myself

and the project to the women in attendance. Many women showed an interest in participating and, within a few weeks, I was able to collect a long list of enthusiastic volunteers, both lactating and nonpregnant, no lactating (NPNL) women, from these indigenous villages.

I selected a purposive sample of Otomí women (n=55), 28 were lactating with established breast milk production (infants older than two weeks in February, 2006) and 27 were nonpregnant, nonlactating (NPNL) Otomí women residing in the villages of Pañhe and Gandho. Although choosing a purposive sample can mean generalization from the study is impossible, this sample did enable me to choose women that maximized variation on the independent variables of maternal parity and age, infant age, number in each household, access to land and *agua potable* or irrigation water, and socioeconomic level (Bernard 2002).

Initial appointments for semi structured interviews with each woman were made at these meetings, obtaining their names, addresses, and the approximate "directions" to their homes. Most women just said they lived in "*los pinos*," or "*el centro*" or another neighborhood in the village, without further directions. This made finding them a real challenge but, thankfully, my key informants knew the paths and byways of these villages very well, facilitating relatively easy discovery of their humble homes.

Preliminary Research Activities

In the following days, I refined the semi structured interview questionnaire and translated this questionnaire into Spanish, with the assistance of my first key informant,

Rosie Ocampo, during several in-depth conversations with her to verify that the Spanish words used in the questionnaire would obtain accurate information from, and be clearly understood by, the Otomí women. All the participating Otomí women in this study had learned Spanish in school. However, all were bilingual, speaking Otomí and Spanish. They acted as translators for their mothers, the older generation of Otomí-speaking women in these villages, facilitating collection of multigenerational ethnographic data. Several worksheets were then designed, transcribed and translated into Spanish to facilitate ethnographic data collection, including a *Participant Demographic Information* worksheet to record the personal information for each participating woman, a *Socioeconomic Status* form adapted from DeWalt's socioeconomic measurement method (DeWalt 1983), a *Breast Milk Production* worksheet, a *Daily Diet and Fluid Intake* worksheet (Quandt 1987), *a Daily Behavior and Activities* worksheet, a *24-hour Recall Food Diary* worksheet (Graham 2003), and a *Guttman ladder scale* (Bernard 1995) to rank their reasons for choosing to breast-feed (see Appendix for samples of worksheets).

Data Collection

At the time of the initial appointment, each participating woman was given a participant number and an IRB-approved Informed Consent sheet in Spanish, which was signed and dated by each participant. The signed informed consent sheets and all collected data were placed in a completed folder and then stored in a locked file box, for which I had the only key. Each woman was paid 50 pesos (~$5.00 US or half a day's

wages) for her participation to compensate for any loss of work.

*Anthropometric Data*

At the medical clinic, preliminary weight and height were obtained, and an appointment was made for a semi structured interview. The anthropometric data was again measured and recorded on the *Participant Demographic Information* worksheet at the time of this first appointment. The anthropometric data included:

- Participant's **initial weight** in kilograms and **height** in centimeters from the medical clinic scale.
- Participant's **weight** in kilograms using a Salter scale and **height** in centimeters using a medical ruler on the concrete wall of her house.
- Infant's **weight** using a Medela "Baby Weigh" scale and total **length** estimate using a medical tape on a table, from crown of head to base of heel, keeping foot at right angles.
- Participant's **body fat percentage** using the Salter scale combined with a digital body fat analyzer and weight scale, model 9310, with a weight capacity of 150 kilograms with 100 gram graduations. [The technology of this scale relies on the differential conductivity of fat and muscle cells and, using a system known as bio-electrical impedance analysis (BIA), a minute electrical impulse passes through the body to determine a resistance reading of body fat cells. This reading is then processed by the Salter digital scale using the user's age, weight,

sex and height that was pre-programmed into the scale before weighing to calculate their body fat percentage. The instructions with the Salter scale indicated a preference for normal hydration, rather than weighing during a period of excessive perspiration, or just after a bath, or after drinking excessive amounts of water. These instructions were carefully adhered to in this study, weighing the women early in the morning before drinking and before they went to work in the fields.]

- Participant's **mid-arm circumference** using a medical tape in inches and centimeters. The MAC and scale-measured body fat percentage were then used to manually estimate and compare body fat percentage values (Jackson and Pollack 1985, Jelliffe and Jelliffe 1989, Weiner 1969).
- Participant's **urine specific gravity** was obtained using a Biokwitech uritest-10 dipstick kit, supplied by the nurse at the Pañhe Medical Clinic.
- Participant's **body temperature** measured using medical thermometer placed under the arm for five minutes.
- Participant's **pulse rate** taken on radial pulse at wrist, counting beats for 10 seconds while monitoring second hand on my wrist watch and multiplying by six.

Based upon the WHO Technical Report Series #854, *Physical Status: The Use and Interpretation of Anthropometry* 1995, and Frisancho's *Anthropometric Standards for the Assessment of Growth and Nutritional Status* (1990) the **body mass index** (weight in kilograms/height in meters$^2$), **basal metabolic rate** (0.8 x weight in kilograms), and **body**

**surface ratio** (weight in kilograms/height in meters)/(weight in kilograms/height in meters$^2$) were calculated for each participating woman.

*Ethnographic Data*

The woman's participant number and a demographic assessment that included the woman's birthdate and birthplace, migration history, ethnic origin, parental and sibling history, marital status, household size and composition including the birthdate and birthplace of her breast-feeding infant, the other children's birthdates, occupation and education of the woman and her spouse, religion, fertility and illness history, and any remarkable physical traits (Weiner and Lourie 1969) were entered on the *Participant Demographic Information* worksheet.

The semi structured interviews were conducted and recorded using a Sony IC recorder (IC-ST25 stereo). These interviews typically lasted three to four hours and covered the following five areas of interest: demographic assessment, lactation and infant nutrition, women's work, intra household food distribution, and food production behavior.

Various questions were also asked concerning women's work patterns in the community, migration for employment by their husbands, notions of "pacing" behavior while working and while lactating, beliefs about appropriate work during lactation, what chores were considered exclusively men's domain, and what chores were considered exclusively women's domain, how they cope with scarcity, their perceptions of responsibility and loss, and their fears and stressors in their daily lives. Questions were

asked about food sharing behaviors, their responses to scarcity (e.g., who they trust to help them under conditions of scarcity), what items are ever exchanged, how they are exchanged, and their reliance on the *compadrazgo* system. To obtain information concerning intra household food distribution, each woman was asked who prepares and distributes the food and what person is served first at meals. Some questions were designed to discover whether food gathering behaviors are influenced by food and water scarcity including altering foraging behaviors under conditions of plant disappearance.

A biographical history was obtained of the participant's gestation, childbirth, and lactation experience with the current breast-fed infant and with her other children. Infant weaning foods, weaning timing, perceptions of mothering and self-reported confidence in their mothering skills were elicited during the conversation.

After discussing the advantages of breast-feeding with my key informants and other participating women, I designed a ladder scale to determine the self-reported ranking of various reasons or advantages to breast-feeding (Bernard 1995). The nine reasons used for their choice to breast-feed included:

1. The benefits of breast-feeding to the health of the mother and/or the infant (*salud de bebe* or baby's health), (*proteccion por madre* or maternal immunity), (*proteccion por bebe* or baby's immunity).
2. The benefits of breast milk to the growth and development of the infant (*criar mejor* or infant grows better), (*mas inteligente* or baby is more intelligent), (*criar*

*mas rapido* or baby grows faster).

3. Breast-feeding is a custom or traditional behavior (*costumbre*).
4. Choosing to breast-feed for convenience and/or economic reasons (*facil* or easier, *barato* or cheaper).

These nine reasons were printed on small laminated cards, and the woman was asked to place these cards on the laminated ladder scale from the least to the most important reason to breast-feed their infant and the results were recorded on the *Reasons to Breastfeed* worksheet (see Appendix), grouping the reasons into the four categories, health/immunity, growth/development, custom, and ease/economics to facilitate scoring and statistical analysis.

In September of 2006, an evening group discussion meeting was held for several hours at the home of one of the participating women. Several participating women, along with their mothers or mothers-in-law from Pañhe and Gandho discussed different issues concerning their feelings, beliefs, joys and fears about reproductive behavioral choices in response to water and food availability. The posed questions were designed to elicit further ethnographic data on behavioral practices and beliefs concerning pregnancy, childbirth, lactation, weaning and infant nutrition. The specific aim of these questions was to understand their past behaviors and the differences between these practices and those offered in the clinics and hospitals today, what they thought about these changes, and what behaviors they still practice despite pressure from Western medicine. Some examples of these questions were:

- Where did you deliver your babies? Were there problems? If so, what kind of problems? What did you do? Where do you deliver now? Who helped you then, and who helps now?
- When you knew you were in labor, and delivery was near, what did you do many years ago? What do you do now?
- Are there herbs or plants that help a woman to deliver faster or better? Have these plants disappeared? Are they still used today?
- How does a *reposo despues de parto* (period of seclusion following birth) or *baño de hierbas* help mothers and babies?
- Are there changes in childbirth practices now? If so, what do you think about these changes?
- Breast milk is hot. What does this mean? When the mother works hard in the sun, what does she need to do before breast-feeding? Why?
- Do women breast-feed their babies the same today? What has changed?
- At what age should a baby be first given solid foods?
- What are the best first foods to feed a baby?
- What did you first feed your babies many years ago? Are there some foods given to babies or children now that were not here many years ago?
- Do mothers need help caring for their children? Who should or does help?

This group included women who had already participated individually and, in addition, there were several older grandmothers and teenage girls in attendance. I was

able to obtain a much broader context of historical reproductive tactics in comparison to the current behavioral responses to changing environmental conditions.

*Energy Expenditure Data*

At the end of the semi structured interview session, a second appointment was made to initiate a 24-hour *follow* or continuous observation while wearing the Sensewear $Pro_2$ armband [13]. During the second appointment, each participating woman was weighed a third time. To estimate the woman's level of hydration, a urine specific

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[13] Sensewear Pro2 armbands are an efficient method for measuring energy expenditure in the field. The Sensewear monitoring technology has been tested over the past 10 years and compared to other methods of measuring energy expenditure, including doubly-labeled water, and has been found to be compatible to DLW as an efficient and accurate method of measuring EE in field situations (Fruin 2003, Fruin 2004, Johannsen 2010, King 2005, Malavolti 2007, McClain 2005, Welk 2007). The following is an informational release, by Body Media, Inc., on the latest technology used in the Sensewear Pro2 armband that was used in the current research study: *In 2003, Bodymedia released a new version of the armband that has some significant improvements including a replaceable AAA battery and a USB connector. The sensor set remained essentially the same: heat-flux, skin-temperature, near body temperature, galvanic skin response sensors, and a two-axis accelerometer.* The *armband sample(s) data at 32-hertz and records compressed channels of data in the armband's memory. The SenseWear® Pro2 has memory for approximately two weeks of wear. The channels recorded are a carefully chosen set of features that capture both basic statistics of the data streams (e.g. averages, variances) as well as more complex features (e.g. peaks, steps). These channels are stored on the armband and are then sent to a PC via either a USB cable or using a proprietary wireless protocol. On the computer, activity detection and lifestyle algorithms are executed on the incoming data, producing estimates of each lifestyle algorithm (e.g. energy expenditure, sleep, etc.) for each minute of time. The algorithms in Body Media's software utilize the physiologic signals from all the sensors to first detect the wearer's context and then apply an appropriate formula to estimate energy expenditure from the sensor values. Body Media's algorithms analyze activities into their fundamental components. For each fundamental component, a different equation is then used to predict the energy expenditure. For the SenseWear® Pro2, the algorithms accurately classify many activities automatically and user selection of an appropriate algorithm is no longer required.* (Andre D. et al., "The Development of the SenseWear Armband, a Revolutionary Energy Assessment Device to Assess Physical Activity and Lifestyle," 2006, Bodymedia, Inc.)

gravity test was obtained from her morning urine using a Biokwitech uritest-10 dipstick kit provided by the Pañhe medical clinic nurse.

Urine specific gravity is a test that measures the ratio of the density of urine to the density of water (U/W ratio), and is based on the release of protons from a poly-acid in the presence of cations in the urine. The released protons change the chem-strip indicator's bromthymol blue color to blue-green to yellow measuring hydration status. Each woman was asked to urinate for five seconds and then place the chem-strip in the urinary stream. The chem-strip was then handed directly to me, and I waited 45 seconds, according to the kit instructions, before reading the level. Nearly all of these women revealed levels indicating dehydration (levels > 1.020 indicate dehydration, and most participating women had levels of 1.030); however, some studies suggest that the dipstick method of specific gravity assessment may be unreliable (Stumpfle 2003).

After entering her name, age, weight, height, and handedness into the armband using a USB port connection to my laptop computer, the Sensewear $Pro_2$ armband (SWA) monitoring device was placed on the participant's right upper arm to measure her energy expenditure per minute as she proceeded with her daily activities. The SWA armband was to be worn continually for 24 hours. Each woman was instructed to avoid getting water or other liquids on the armband, and not to bathe or shower until the armband was removed the following day. While wearing the monitor, the woman was continuously observed by the researcher for a period of approximately twelve hours recording all activities, behavior, work patterns, and category of work level as defined by

WHO (1985). This data was recorded on the *Daily Behavior and Activities* worksheet.

The SWA monitoring device was chosen for this project because of its accuracy and ease in assessing energy expenditure in free-living individuals in a field setting. Numerous scientific techniques have been developed to measure energy expenditure including the metabolic cart analysis method using indirect calorimetry (measures the oxygen and carbon dioxide one inhales and exhales, thus indirectly calculating calories burned during a given time period); however, these carts vary between 5-10% in accuracy on repeated measures, and are not suitable for monitoring outside the laboratory because of bulk and size (Andre et al., 2010). Full room chambers that measure oxygen consumption are extremely accurate but are large, expensive, and unsuited for free-living experimentation. Douglas bags are another accepted technique, but these devices are awkward and have the same limitations as the metabolic cart (Ibid. 2010). The double-labeled water (DLW) stable isotope method is considered the "gold standard" by the industry for measuring total energy expenditure of free-living individuals for long-term energy expenditure over weeks of time, not minute to minute as the SWA measures. However, DLW is also very expensive, and has about a 5% error rate over a two week period of time (Ibid. 2010). There are numerous small user-friendly products such as pedometers, accelerometers, and heart rate monitors that have limited scientific research use since they rely on single modalities to calculate total energy expenditure with limited accuracy. The SWA was developed as a wearable body monitor that uses multiple sensors and sophisticated computerized algorithms to obtain

accurate data outside the clinical laboratory setting with minimal interference.

After the SWA monitor was placed on her arm, the monitor calculated her body mass index (BMI) and her total energy expenditure per minute based upon the pre-programmed personal information, and the algorithmic context of the various activities (e.g. walking, running, sleeping, etc.) she engaged in while wearing the SWA armband.

The SWA monitor has greater than two weeks of memory, 10 days of battery power, 3.6MHz of on-board processing, and 2.4 GHz wireless body-LAN connectivity. The monitor powers on automatically with skin contact and takes 32 measurements per second, including galvanic skin response, skin temperature, heat flux (amount of heat leaving body), and step counter from numerous sensors on the inside of the band with a 2-axis accelerometer that measures movement forward and backward, as well as prone and upright positions.

The SWA armband was also capable of being "marked" by the woman pushing a button when she began and ended a breast-feeding session, helping to verify the number and duration of breast-feeding sessions during the night. The SWA computer-generated reports also indicated when the band was on or off the woman's body at any time during the 24 hours.

Numerous validation and comparison studies have been scientifically performed by sports medicine researchers (Bernsten 2008, Cole 2004, Fruin 2003 and 2004, King 2005, McClain 2005, Wadsworth 2005, Welk 2007) indicating that the SWA monitor provides "precise and accurate estimates of energy expenditure in healthy subjects,"

(Malavolti et al., 2007), and "accurately measures daily energy expenditure in comparison with DLW for measuring daily EE [energy expenditure] in free-living adults." (St-Onge et al., 2007). At the end of 24 hours, the armband was removed and the data were entered into the InnerView research software and saved in Excel data files via a USB port connection to my laptop computer, prior to being erased in preparation for being worn by the next participating woman. These data were then evaluated, analyzed, and kilocalories per minute were calculated by the software for each MET level and entered into an Excel data file prior to statistical analysis.

*Food and Water Consumption Data*

During this second appointment, each woman was asked to recall all the food and beverages she had consumed during the past 24 hours. The *24-hour Recall Food Diary* worksheets (modified version of dietary survey, Weiner and Lourie 1969) were used to record this estimate of their daily food and water intake based upon the woman's memory of what she had consumed in the last 24 hours. The food intake was then coded for the estimated amount of food eaten in grams, the food group (grains, vegetables, fruits, dairy, etc.), the meal or time of day at which the food was eaten or beverage was consumed, and the total food and water consumption calculated for the day.

Ten women were randomly selected to measure their dietary food intake for seven days using direct weight measurement to improve the accuracy of the energy (dietary) intake assessment (Graham 2003, Quandt 1987). These 10 women were given

seven *Daily Dietary Intake* worksheets instead of the 24-hour recall diaries, with careful instructions as to how to complete these worksheets, recording all their food and beverages consumed over seven days. These 10 women were also provided with a stainless steel Salter electronic kitchen scale, model 1004 (www.salterhousewares.com), with auto shut-off and auto-zero capacities. This scale has a precision strain gauge weight sensing system that is extremely user-friendly. The scale was pre-set by the researcher to measure in kilograms to facilitate ease in calculating kcal/gram of food consumption.

After placing an empty bowl or empty glass provided by the researcher on the scale, the scale was turned on by pushing a small button. The food to be eaten was placed in the bowl, or the beverage to be consumed was poured into the glass to reveal an accurate weight of each food item or beverage consumed minus the container. Instructions for use of this food scale were carefully given to these 10 women, including how to wipe clean the surface of the scale between each food being weighed, and how to rinse out the provided plastic bowl and plastic 16 ounce drink container between each use. The researcher weighed all their food and beverages for the first day during the 24-hour follow, assisting the woman to learn how to utilize this scale for the following six days of direct weight measurement. The kitchen scale and the daily diet intake sheets were collected at the end of one week. Their total food and beverage intake was then calculated prior to statistical analysis.

All dietary intake consumption was calculated in kilocalories per 100 grams of

food using a nutritional value table of Mexican food, *Valor Nutritivo de los Alimentos Mexicanos: Tablas de Uso Practico*, published by Hernandez in 1974. To facilitate ease of calculation, some common foods were calculated using the USDA National Database, (http://www.ars.usda.gov/SP2UserFiles/Place/123545001/Data/SR22/nutrlist/sr22a208.pdf, retrieved 6/10/2010).

*Breast Milk Production Data*

Lactation performance is quite difficult to assess in the field without interfering with the breast-feeding process (Subcommittee on Diet, Physical Activity, and Pregnancy Outcome, 1992), but a reliable estimation of 24-hour breast milk production was determined, using the technique described by Arthur, by weighing the infants with a digital Medela "BabyWeigh" infant scale with a 24-pound capacity and ±0.2 ounce accuracy, before and after all breast-feeding sessions while the mother was awake, or for at least 10 daytime hours, subtracting the weight of the infant's clothing and/or diaper from the final weight (Arthur 1987).

The number of breast-feeding sessions at night was estimated using the SenseWear Pro Armband monitor for the number and duration of breast-feeding sessions as marked by the mother. The mother was questioned early in the morning to verify the number of sessions that had occurred during the night. The amount of breast milk consumed during each of the night BF sessions was estimated by calculating the ounces of breast milk consumed per minute during each daytime BF sessions, and this number of ounces was then divided by the total number of sessions for an estimate of

ounces consumed per minute in each night BF session (# ounces BM/# min/total # of sessions). Each woman was carefully instructed in how to use the Medela scale to weigh their infants during evening hours if awake, how to save and weigh the wet diapers, and how to record the data during the night, if awake, on provided sheets of paper.

Summary of Methodology

The ethnographic, medical, clinical, and anthropometric data for this project was collected over the course of one year, between January 2006 and January 2007, recorded on worksheets and detailed variable descriptions were entered into a codebook. Field notes on each participant were completed at the end of every day.

This research design had several strengths. Ethnographic observations provided data with high internal validity with regard to how maternal energy responses are altered by resource deprivation (Waterlow 1990). Continuous monitoring and quantitative measurements of lactating and nonlactating women allowed me to document the interrelationship of resource scarcity, energy expenditure rates, and lactation by measuring food intake, work activity patterns, rates of energy expenditure, and breast milk production. The *24-hour Recall Food Dairies* used in combination with direct weight measurement of food for seven days improved the accuracy of dietary intake (Quandt 1987). Individual interviews provided a greater depth of perception of maternal behavior. Finally, the use of quantitative and ethnographic forms of data collection allowed me to check the results of each method against the other, facilitating identification of data collecting problems.

# CHAPTER IV

# RESULTS

## Participants

At the beginning of this project, I determined to choose a sample of at least 25 lactating women and 25 nonpregnant, nonlactating (NPNL) women to study the physiological and behavioral adaptive responses by these lactating desert women to their environment. As I completed this study, I had obtained a sample of 29 lactating women, however, one woman quit after four hours and I was unable to obtain complete data on her. By the time of the second appointment for the 24-hour follow when energy expenditure, dietary intake, and breast milk production data was obtained, three of the lactating women were no longer lactating. Two reported that their doctor had advised them to stop breast-feeding their infants because their babies were sick with "la grippe" (a cold), and the third woman had stopped breast-feeding since her child was nearly three years old and her "milk had gone," so these participants were added to the nonlactating group. This left the lactating group with a total of 25 participants (n=25). The three lactating women who were no longer lactating were added to the NPNL group, making a total of 26 NPNL participants (n=26) (see Fig. 93).

The women ranged in age from 17 to 36, with 28% younger than 25 years, the NPNL women ranged in age from 18 to 43, while the majority of the NPNL women

(57.7%) were between 31 and 35 years old (see Fig. 94). Thirty-two percent of the lactating women had five years of elementary education and 32% had eight years of secondary (high school), while 40% of the nonlactating women had only six years of primary (elementary) education; however, 7.6% of the NPNL women had between 10 and 13 years of education, unlike the lactating women who had no education past nine years (see Fig. 95).

Twelve percent of the lactating women were housewives only and did not contribute to the household income. Twenty four percent of the lactating women were housewives who made baskets, another 24% of the lactating housewives made baskets and worked in the fields, while 50% of the nonlactating women housewives contributed to household income by working in the fields and making baskets (see Fig. 96).

The lactating women had fewer children overall than the nonlactating women. Many NPNL women had completed their families, some without their consent via tubal ligation surgical procedures. Fifty percent of the NPNL women had only two children, and one had five children. Twelve percent of the lactating women had one child, while 7.7% of the nonlactating women had one child, and one 18 year old NPNL woman had one child (see Fig. 97).

The number of siblings for all participating women reflects the cultural, economic, and reproductive behavior changes mentioned earlier. More than 52% of the women had between seven and fifteen siblings (see Fig. 98), while most of the families today have no more than five children. In addition, there are an increasing number of

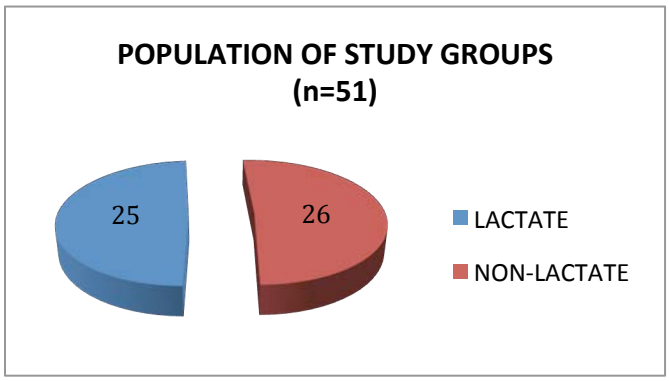



Figure 93. Population of Study Groups

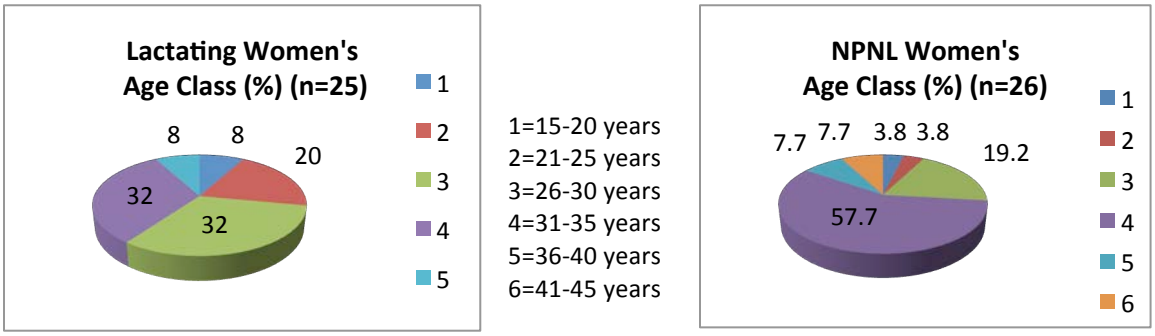



Figure 94. Comparison of age categories for lactating and NPNL women's groups.

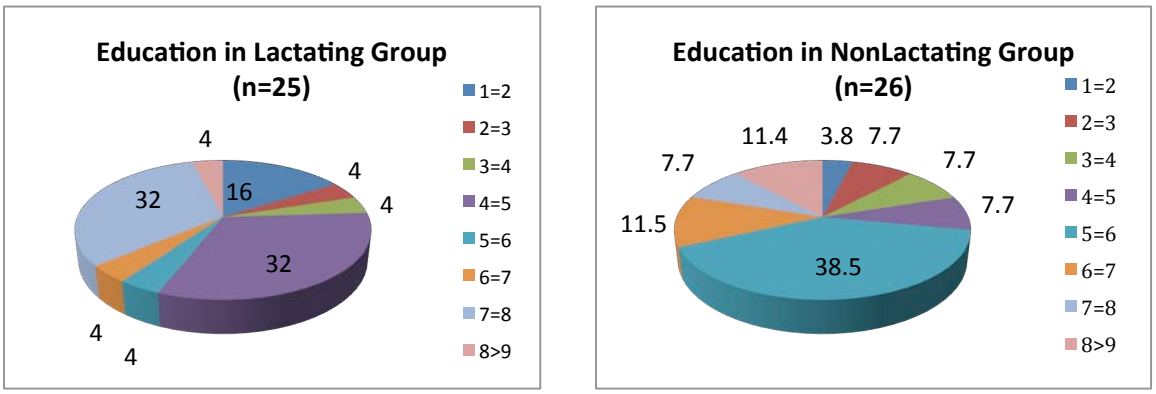



Figure 95. Comparison of education between lactating and NPNL women's groups.

1=HOUSEWIFE ONLY
2=HOUSE, BASKETS
3=HOUSE, BASKETS, FIELDS
4=HOUSE, SHOPKEEPER
5=HOUSE, FIELDS
6=HOUSE, FIGURES
7=HOUSE, FIGURES, BASKETS
8=OTHER

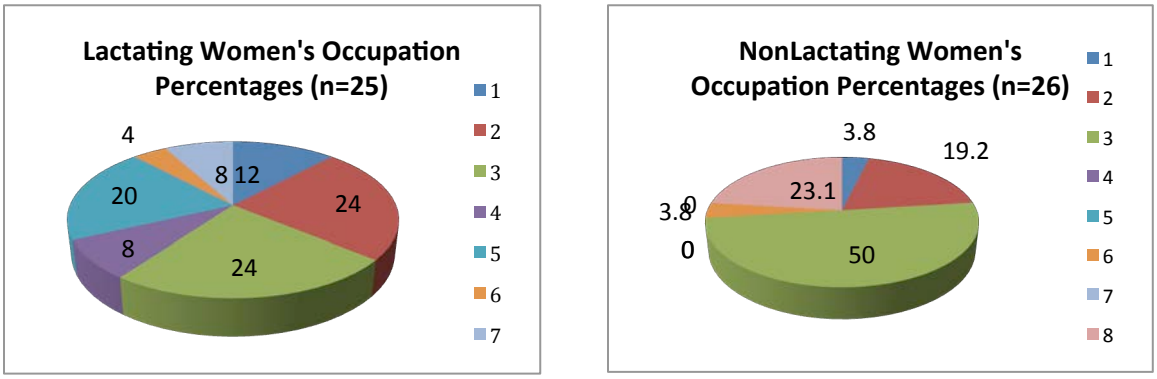



Figure 96. Comparison of occupation between lactating and NPNL women's groups.

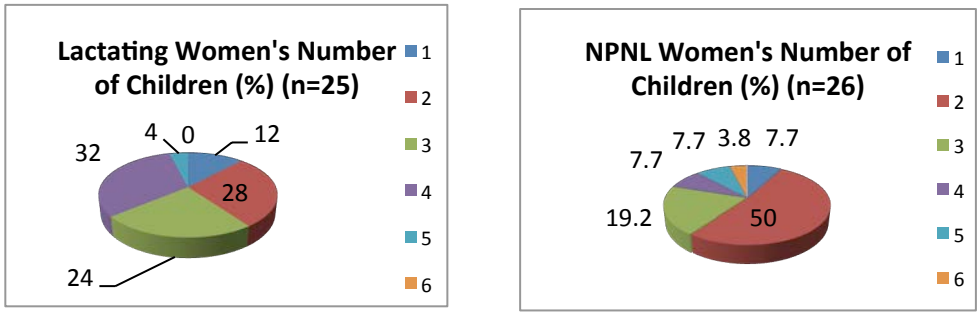



Figure 97. Comparison of children between lactating and NPNL women's groups.

These women who are being intentionally sterilized via tubal ligation by the local hospital physicians during caesarean section childbirth procedures without the woman's permission. This practice has reduced the number of children being born to these traditional women.

Ninety percent of the nonlactating group was categorized as very poor, or poor, with only 10% in the middle or less poor class, while there are 40% of the lactating women in the less poor, middle class. This trend reflects the growing number of younger men who migrate to other areas including the United States for employment, earning higher wages that help to pay for better houses, more food and more possessions for their families (see Fig. 99). This reflects the changing lower income levels from the relatively older nonlactating women's group. While women are breast-feeding younger infants, some husbands tend to temporarily take local employment for less money, thus offering more reproductive support to their wives until their infant is older, but the majority of husbands quickly look for better employment at great distances from home (see Fig. 100).

Anthropometry

Table I summarizes the anthropometric characteristics of the participating women from both indigenous villages. Overall, the lactating women were a little younger and slightly heavier than the nonlactating women, perhaps facilitating maternal fat exploitation to improve breast milk production. However, their height, pulse rate, and body surface ratios were virtually the same in both groups, perhaps reflecting

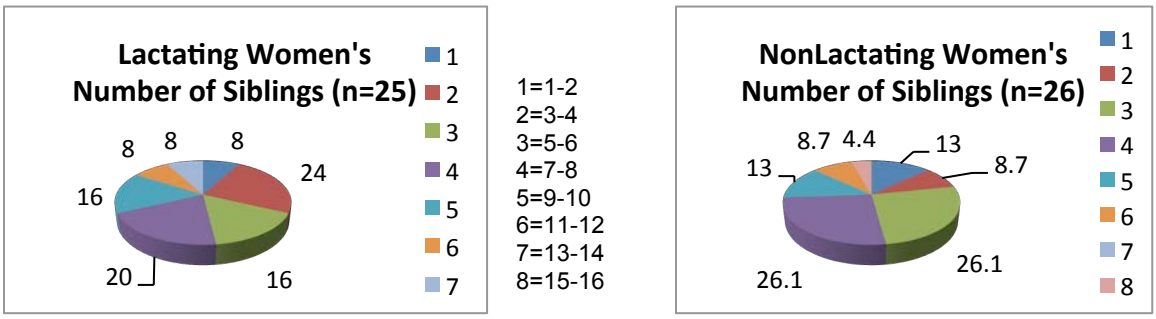



Figure 98. Comparison of siblings between lactating and NPNL women's groups.

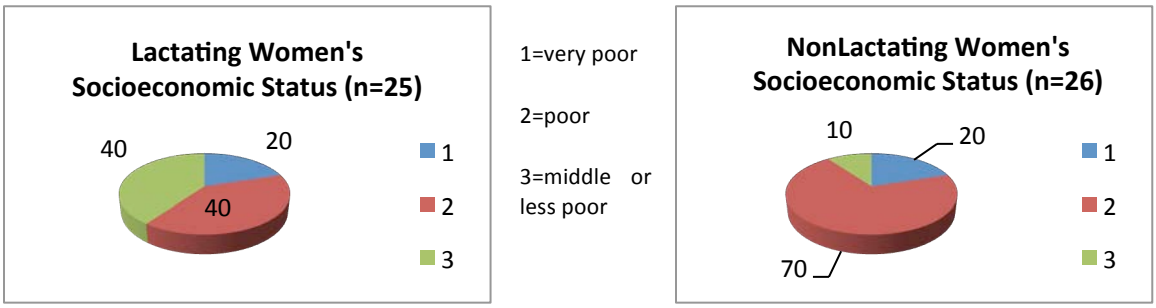



Figure 99. Comparison of socioeconomic status between lactating and NPNL women's groups.

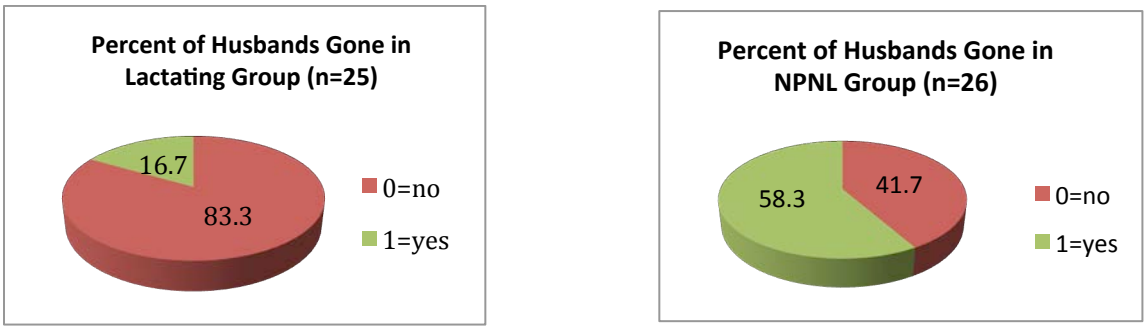



Figure 100. Comparison of percentage of husbands absent from residence for employment between the lactating and NPNL women's groups.

TABLE I. Anthropometric measurements of lactating women (n=25) and NPNL women (n=26)

| Variable | L Women (Mean) | S.D. | NPNL Women (Mean) | S.D. | t-score | *p* value |
|---|---|---|---|---|---|---|
| age | 28.40 | 5.25 | 31.37 | 5.18 | 2.055 | 0.045 |
| weight (kg) | 60.50 | 12.89 | 59.68 | 9.07 | -0.19 | 0.85 |
| height (cm) | 149.24 | 4.89 | 149.13 | 3.91 | -0.018 | 0.986 |
| BMI | 27.04 | 4.75 | 26.85 | 4.04 | -0.083 | 0.934 |
| BMR | 48.44 | 10.21 | 47.92 | 7.29 | -0.138 | 0.891 |
| Body Fat % | 31.51 | 4.93 | 31.96 | 4.11 | 0.414 | 0.680 |
| Pulse | 66.76 | 7.91 | 66.93 | 7.68 | -0.014 | 0.989 |
| RATIO | 1.50 | 0.06 | 1.50 | 0.04 | 0.293 | 0.771 |
| Urine SPG | 1.03 | 0.04 | 1.03 | 0.01 | | |
| Temperature (C) | 36.45 | 1.48 | 36.49 | 0.79 | 0.043 | 0.966 |
| BMPROD | 21.58 | 14.18 | 0.00 | 0.00 | | |

*DEFINITIONS: BMI=body mass index, BMR=basal metabolic rate, RATIO=ratio of surface area to body mass index, Urine Specific Gravity, normal range=1.002-1.030 using URITEST 10 BKT by Biokwitech, BM production=ounces of breast milk produced in 24 hours.*

*Source: Weiner and Lourie 1969, Frisancho 1996, used standard protocols for calculating BMI, BMR, and RATIO*

biological adaptive responses to living in the desert heat. Desert populations usually have reduced heart rates and lower skin temperatures when compared with nondesert people that maximize their cooling efficiency (Frisancho 1996). These women exhibited a relatively slow pulse rate of 66.76 $\pm$ 7.91 and 66.93 $\pm$ 7.68 beats per minute and a lower skin temperature of 36.45 $\pm$ 1.48 and 36.49 $\pm$ 0.79 C (97.7 F) among the lactating and nonlactating groups respectively, and a mass to body surface ratio of 1.5 that is

comparable to other groups that are successfully acclimated to desert environments (Ibid. 1996).

Overall, the women from these villages were very short with an average stature of 149.15 ± 4.81 cm, or less than five feet tall. The average weight for the lactating women (n=25) was 60.23 ± 12.69 kilograms or 132.8 ± 28 pounds with an average BMI value (BMI=26.95 ± 4.68), commensurate with adequate nutrition in what is considered the borderline overweight category when compared with American standards (BMI values between 19 and 25 are considered normal weight). It is relevant to note that body fat is an insulator that increases heat strain on the individual's cooling efficiency (Frisancho 1996, Wenger 2001). Their average weight and BMI values in combination with an average body fat percentage of 31.46 ± 4.84 percent may be the result of an increased caloric intake from earlier generations (Anderson 1946), and if this trend toward heavier bodies continues, this population may have to resort to cultural adaptive strategies, such as the artificial environments that are associated with modernization.

The urine specific gravity test, using a dipstick test kit, indicates that all participating women, both lactating and nonlactating were in a state of moderate dehydration with a mean of 1.030 ± 0.01-0.04 (> 1.020=moderate dehydration). While this test is not considered to be totally reliable by the scientific community (Stumpfle and Drury 2003), it certainly reflects the ethnographic observation in this study of comparatively minimal fluid intake by the lactating women (average of about 46 ounces, or less than six cups of liquid per day). Other desert creatures do retain body water as

an adaptive response to desert heat and scarce water, and this test result may be indicative of another adaptive response by these women to their desert life. The urinary concentration results may reflect their ability to retain body water to increase their cooling efficiency and improve breast milk synthesis. American medical professionals recommend that lactating women consume at least eleven cups of water per day to produce sufficient breast milk. The results of this project suggest that drinking behavior may not have as much to do with successful breast milk production as has been recommended by Western medicine.

## Behavioral Strategies

The behavioral strategies used to facilitate breast milk synthesis included behaviors associated with the hot-cold syndrome such as "pacing" of their work patterns and the "hot breast milk" notion, as well as the assistance of allomothers or helpers who contribute to maternal energy conservation, enhanced nourishment and physical well-being, and assists them in leading longer lives (Hrdy 2009, Kramer 2005).

### Pacing Strategies

The women described "pacing" tactics such as working faster or *more efficiently,* prioritizing their time so that they have adequate time to breast-feed and care for their infant (see Fig. 101). If the lactating women are working in the fields, they said that they must work faster to complete the weeding of a row of plants, especially when they know their baby is about to wake up, completing their work before stopping to breast-

Figure 101. Otomí lactating woman working more efficiently as a “pacing strategy,” Pañhe, 2006.

feed their infant. Speeding up work increases their time allocation efficiency, allowing them to get their work done *and* care for their child. They all reported walking and moving faster, and working more rapidly when they are lactating. Despite these tactics, many lactating women expressed frustration at their inability to complete more tasks accompanied by a feeling of total exhaustion at the end of every day.

The Hot-Cold Syndrome Strategies

Lactating women strictly adhered to the guiding principles associated with the "hot breast milk" notion. Pregnancy and breast-feeding are considered "hot" conditions. If this heat is allowed to accumulate it can create "hot milk" that is harmful to their babies. These women believe that if they do not cool themselves down, washing their breasts with cool water or extracting some of the "hot" milk, after working in the sun or making tortillas, that this "hot" breast milk can cause their baby to become ill with diarrhea, vomiting, and stomach pain. In addition, they believe that breast-feeding women must restrain themselves from "fits of anger" because their "sacred" milk can turn "watery" and become hot to the point of harming their child (Chevalier and Sanchez Bain 2003). The "hot milk" may even cause the death of their baby in extreme cases (Ibid. 2003). This strategy essentially provides time for the mother to relax prior to breast-feeding, enhancing the hormonal response of oxytocin that triggers the breast milk "let-down" reflex and improves her ability to efficiently breast-feed.

Alloparental Assistance

Social networking was a large contributing component to their efficient breast-feeding. The women were often assisted by their children (both male and female), their mothers, other female relatives, and by their *suegras* (mothers-in-law) in caring for their children. Sixty-eight percent of the lactating women (n=17) were observed using *allomothers* while being followed for 24-hours. The majority of help was provided by their female children (64%), with their mothers being the next highest category of helpers (22%). Their mothers-in-law accounted for only 6% of assistance, the smallest category of alloparental care (see Fig. 102). Of the 72% of lactating women who were living with their mother-in-law, two were treated as "slaves" in their own household with limited access to their own infant. Only one woman lived in the same house with her mother-in-law, the rest lived an increased distance from their mother-in-law (50-100 feet away) and had a relationship of relative harmony with their *suegra*, forming a bond of respectful mutual reliance and improving their chances of survival. Those women who were living nearer to their mothers or who had older female children seemed to have the most emotional support and physical assistance (see Fig. 103).

Physiological Strategies

The physiological strategies employed by these lactating women included increasing their dietary intake, exploiting pregnancy fat reserves, decreasing their rate of energy expenditure and increasing their metabolic efficiency.

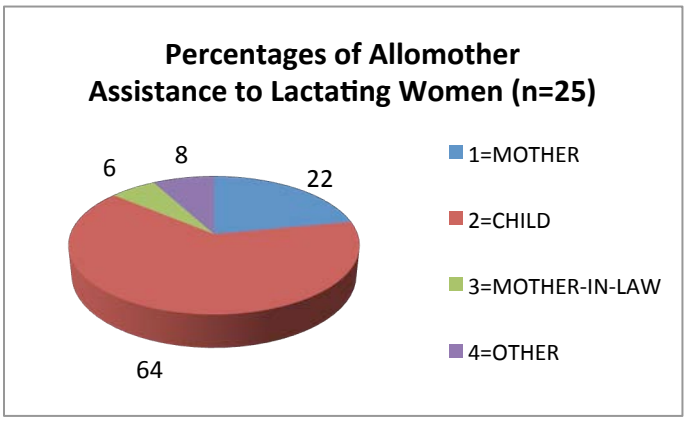



Figure 102. Percentages of differential allomother assistance provided to lactating Otomí women.

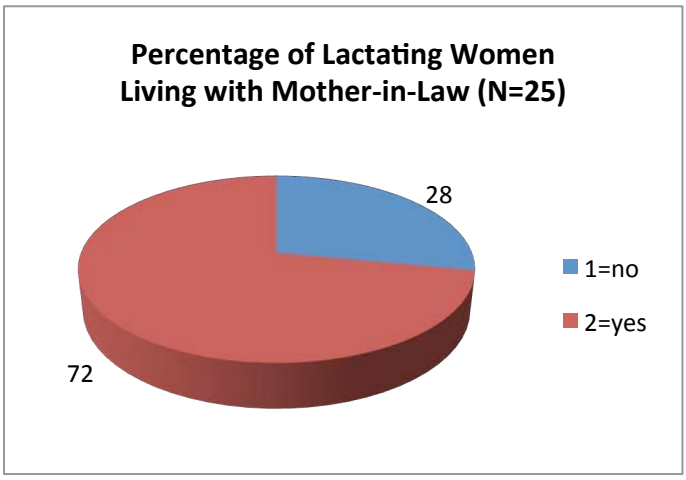



Figure 103. Percentage of lactating Otomí women living with mother-in-law in same compound.

The balance of energy refers to a state of physical equilibrium between energy intake and energy expenditure or energy output that contributes to a homeostatic state of balance within the human body. Table II provides the means, standard deviations, t-scores and *p* values for the energy intake and energy expenditure rates between the lactating and nonlactating groups of women.

TABLE II. Energy Data for lactating (n=25) women compared to NPNL (n=26) women

| Variable | Lactating Women (Mean) | S.D. | NLNP Women (Mean) | S.D. | t score | *p* value |
|---|---|---|---|---|---|---|
| Dietary Intake | 2337.73 | 742.60 | 2039.72 | 747.59 | -1.481 | 0.145 |
| Water Intake | 46.08 | 16.59 | 48.76 | 25.19 | 0.46 | 0.647 |
| Total EE | 1571.36 | 379.94 | 1805.19 | 435.06 | 1.797 | 0.078 |
| EE *Rate* | | | | | | |
| MET-1 | 1.06 | 0.12 | 1.09 | 0.11 | 0.862 | 0.392 |
| MET-2 | 2.00 | 0.41 | 2.04 | 0.32 | 0.12 | 0.905 |
| MET-3 | 3.01 | 0.65 | 3.05 | 0.46 | 0.007 | 0.994 |
| MET-4 | 4.02 | 0.84 | 4.06 | 0.62 | -0.106 | 0.916 |
| MET-5 | 5.03 | 1.06 | 5.08 | 0.75 | -0.087 | 0.931 |
| MET-6 | 5.93 | 1.30 | 6.12 | 0.94 | 0.294 | 0.770 |

*Dietary Intake=calories eaten in 24 hours, Water Intake=ounces of water consumed in 24 hours, BMPROD=ounces of breast milk produced in 24 hours, Energy Output=calories expended per minute at given MET* level, Total Energy=total calories expended in 24 hours.*

**MET=metabolic equivalent, ratio of amount of oxygen used by an individual to perform a given task as compared to their resting metabolic rate, e.g. MET-1=calories expended per minute while sleeping.*

*Sources: Dietary direct weight technique and 24 hour recall (Graham 2003, Quandt 1987, Weiner and Lourie 1969); Breast Milk data collection technique (Arthur 1987); Sensewear Pro2 armband manufactured by BodyMedia and Innerview Software 6.1 used for energy output data evaluation.*

Dietary Intake and Water Consumption

The dietary intake of the Otomí women is composed of about 75% carbohydrates, 10% protein, and 15% fats. Blue corn tortillas is their staple food and provides the majority of their energy consumption, followed by beans, salsa (tomatoes, onions, garlic, and *chiles*), wild greens, potatoes, pasta, with some fruits and eggs, and coffee or tea sweetened with sugar. When in season, they eat the flowers and fruit of the abundant forms of cacti that grow near their homes. Coca Cola and other sodas are replacing water and *pulque*, and some occasionally eat *bifstec* (thinly sliced roast beef) and sliced ham. Sweet bread (*pan dulce*) is beginning to replace some of their tortilla consumption. The local village *tiendas* (stores) sell the *bifstec* and sliced ham, hence sandwiches using this white bread are becoming more prevalent.

The average daily caloric intake for both groups of women (n=51) was 2189.59 $\pm$ 757.51 calories, approximately 300 calories greater than the dietary intake reported by Anderson in 1946 among these same people. The higher consumption of sugars and fats in the form of Coca Cola, granulated sugar, other sodas, more meat and eggs are the major contributors to this increase in their caloric intake. Increased fat and sugar intake will eventually lead to adverse health consequences. The Gandho medical clinic nurses reported increased incidence of diabetes (approximately 48% of the women in Gandho), as well as dental caries, both associated with increased fat and sugar intake in the scientific literature.

The average dietary intake for lactating women was higher *(*2377.10 $\pm$ 734.95)

and the total daily energy expenditure was lower (1571.36 ± 379.14) than the nonlactating women, indicating that the lactating women were in positive energy balance with an additional 337.4 calories per day, while the nonlactating women had a lower daily dietary intake *(*2039.72 ± 747.59) and higher daily energy expenditure (1805.19 ± 435.06) than the lactating women. Positive energy balance contributes to the efficient production of breast milk with recommendations in the U.S. to consume an additional 500 calories per day (Lawrence 1999).

The average consumption of liquids including water by the lactating group of females was 46.08 ± 16.59 ounces or 5.8 ± 2.1 cups while the average intake of liquids including water by the nonlactating group was 48.76 ± 25.19 ounces or 6.1 ± 3.1 cups. Their water intake behavior was motivated *only* by thirst, and the nonlactating women, working in *las milpas* and, with reported increased incidence of thirst, consumed a little more water. As reported in other studies, there was no significant correlation between breast milk production and dietary intake or water consumption.

Energy Expenditure or Output

The lactating women expended a mean total of 1571.36 ± 379.94 calories per day, 251 calories to produce breast milk, and 342 calories to make tortillas. The nonlactating women expended a mean total of 1805.19 ± 435.06 calories and 328 calories to make tortillas.

The primary focus of this project was the adaptive responses by lactating women to an environment of resource scarcity involving the physiological strategy associated

with the reduction of energy expenditure, specifically the *rates* of energy expenditure per minute. According to Waterlow, the *rate* or speed at which energy is expended is the most important factor in determining energy *cost* (Waterlow 1990). These women showed a significant difference in the *rate* of energy they expended, or calories they used per minute while performing their daily chores, thus increasing the *cost efficiency* of their breast milk production. These women even showed a difference in the calories they used per minute while sleeping.

Preliminary statistical analyses to measure the difference between the mean EE *rates,* or calories expended per minute, at any given MET level by lactating women in comparison to NPNL women were not statistically significant. However, after adjusting the lactating group to include only the women who were breast-feeding infants younger than 10 months of age (n=20) and, thus, providing most of their infant's nourishment through breast milk, there was a significant difference between the *rates* of energy expended (calories expended per minute) between the two groups of women as reported in Table III. At MET level one (sleeping), the mean for lactating women was 1.035 calories per minute (cpm), compared to 1.0923 for NPNL women. At MET level two (light work and walking), the mean for lactating women was 1.915 cpm compared to 2.039 for NPNL women. At MET level three (moderate work and fast walking), the mean for lactating women was 2.875 cpm compared to 3.046 for NPNL women. At MET level four (heavier work and jogging), the mean for lactating women was 3.85 cpm compared to 4.058 for NPNL women. At MET level five (heavy work and lifting heavy

loads), the mean for lactating women was 4.815 cpm compared to 5.081 for NPNL women. At MET level six, the mean for lactating women was 5.721 cpm compared to 6.12 for NPNL women. This reflects an increasing level of difference between energy expenditure with increased levels of work (see Fig. 104).

Additionally, the difference in the *rate* of expenditure per minute between the groups of women increased as the MET levels increased, with a difference of 0.067 calories between MET level one and MET level two increasing to a difference of 0.108 calories between MET level five and MET level six. The women who had begun to feed their infants more solid food and reduced the number of breast-feeding sessions per day, or when the amount of breast milk production was reduced, their energy expenditure rates had returned to those of NPNL women (see Fig. 104).

A one-way ANOVA (analysis of variance) was performed to measure the significance of the difference between the means of the *rates* of energy expenditure by lactating women with infants younger than 10 months (n=20) and those of NPNL women while performing activities at all levels of work effort (MET or metabolic equivalents) as hypothesized in H1-H3. The differences between their energy expenditure rates at MET level two (e.g., sitting), MET level three (e.g., light work), MET level four (e.g., moderate work), MET level five (e.g., heavy work or herding animals), and MET level six (e.g., intense strenuous work, pushing or pulling heavy loads) were all significant with F=4.206 (MET-2), F=4.223 (MET-3), F=3.595 (MET-4), F=4.261 (MET-5) and F=3.197 (MET-6) respectively, at $p < 0.05$ as indicated in Table III. Thus, the null

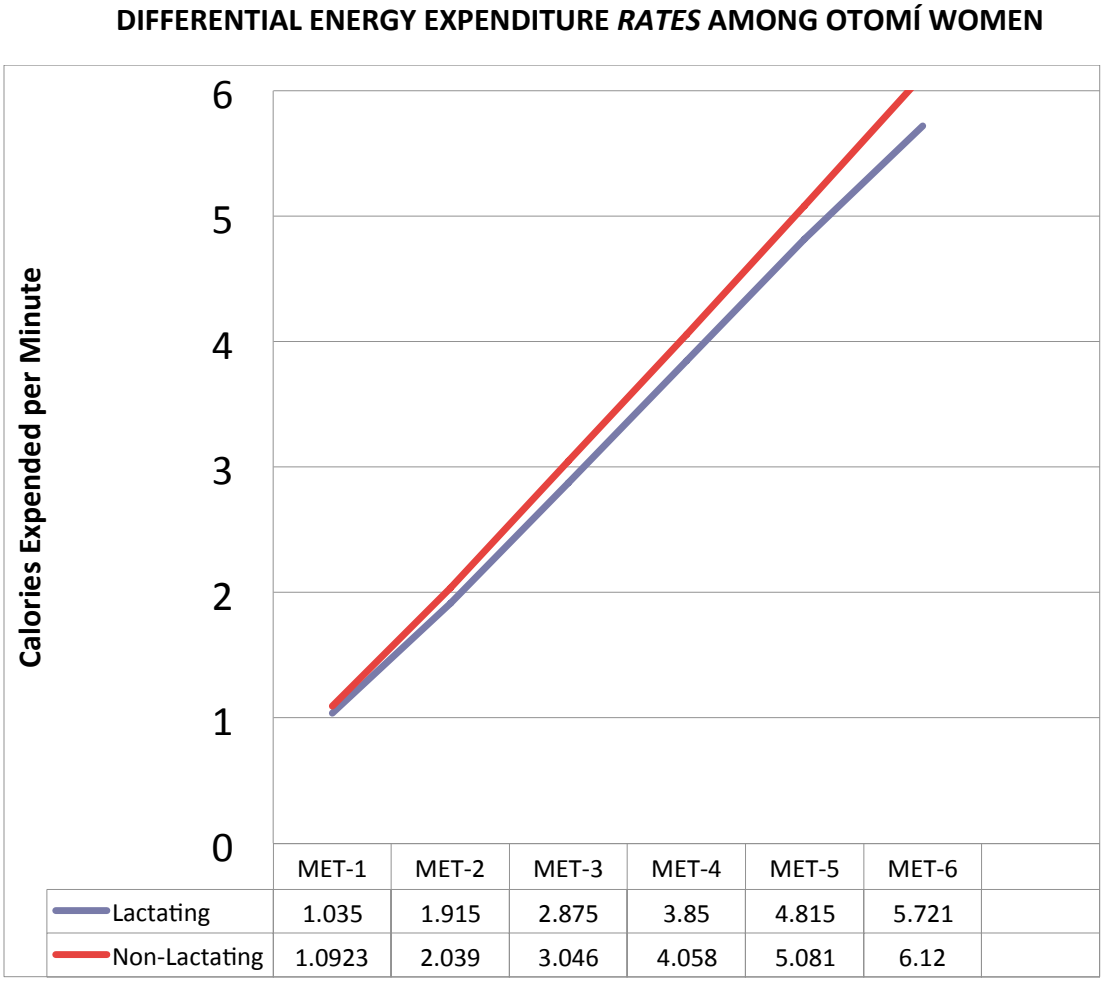



Figure 104. Differential *rates* of expenditure in lactating (n=20) and NPNL women (n=26)

TABLE III. One-way ANOVA between L (n=20) and NPNL (n=26) women comparing MET levels one through six

| MET LEVELS | Sum of Squares *between groups* | df | Mean Square | F | Significance |
|---|---|---|---|---|---|
| MET level one | .246 | 28 | 1.641E-02 | 2.048 | .101 |
| MET level two | 3.629 | 28 | .242 | 5.206 | .002* |
| MET level three | 8.536 | 28 | .569 | 4.223 | .006* |
| MET level four | 14.070 | 28 | .938 | 3.595 | .013* |
| MET level five | 22.980 | 28 | 1.532 | 4.261 | .006* |
| MET level six | 30.720 | 26 | 2.048 | 3.197 | .029* |

**Significance = p < 0.05*

*MET= metabolic equivalents, or the amount of oxygen the body uses during a certain physical activity. A unit of MET expresses the ratio of an individual's metabolic rate while performing a given task compared to their metabolic rate at rest. One MET is equivalent to the energy or oxygen used (50 kcal/hour/m2 body surface area), or resting metabolic rate, or 3.5 ml of oxygen per kilogram of body weight per minute.*

hypothesis can be rejected. Only the difference between their energy expenditure rates at MET level one (while sleeping) was not significant with F=2.048, p=0.101.

Twenty-four hour recordings of energy expenditure per minute while performing various tasks of a lactating and a nonlactating woman were obtained. Graphs were generated by the InnerView 5.1 software, manufactured by BodyMedia, Inc., and used in this study to analyze the energy expenditure of these women while they worked. The recordings illustrate their skin temperature, total amount of time participating in moderate activity, energy expenditure in calories during moderate activity, the total energy expenditure in calories, the total number of steps taken, hours spent lying down,

total hours of sleep, and their sleep efficiency throughout the 24-hour period. The red line indicates skin temperature, the green line indicates the steps being taken (step counter), and the white line indicates energy expenditure (see Figs. 105 and 106). According to the Innerview 5.1 software, sedentary activity levels include MET levels of 0 to < 3, moderate activity levels include MET levels of 3 to < 6, vigorous activity include MET levels of 6 to < 9, and very vigorous activity include MET levels $\geq$ 9.

The sleep efficiency differences in these graphs reflect the fact that the lactating women sleep with their nursing infants, and the breast-feeding sessions during the night hours are recorded with short periods of arousal by the lactating woman, while the nonpregnant, nonlactating women show a steady sleep pattern throughout the night. Note the difference in the patterns of their work in total energy expenditure, 2118 and 2527 calories for the lactating and nonlactating women respectively, the number of hours in moderate physical activity, three hours versus nearly five hours for the lactating and nonlactating women, respectively, and total calories expended during moderate activity, 504 and 1058 calories for the lactating and nonlactating women, respectively. The lactating woman took more steps during the day (13,599 compared to 11,007 for the NPNL woman), worked more efficiently in a continuous pattern, while the nonlactating woman took less steps but was working harder (expending more calories per minute) with short bursts of energy expenditure in the vigorous activity level (maximum region) and expending more total energy throughout the day (see Figs. 105 and 106).

*red line=skin temperature; green line=energy expenditure (calories used); white line=steps taken*


Figure 105. Graphic recording of lactating Otomí woman, July 26-27, 2006.

*red line=skin temperature; green line=energy expenditure (calories used); white line=steps taken*

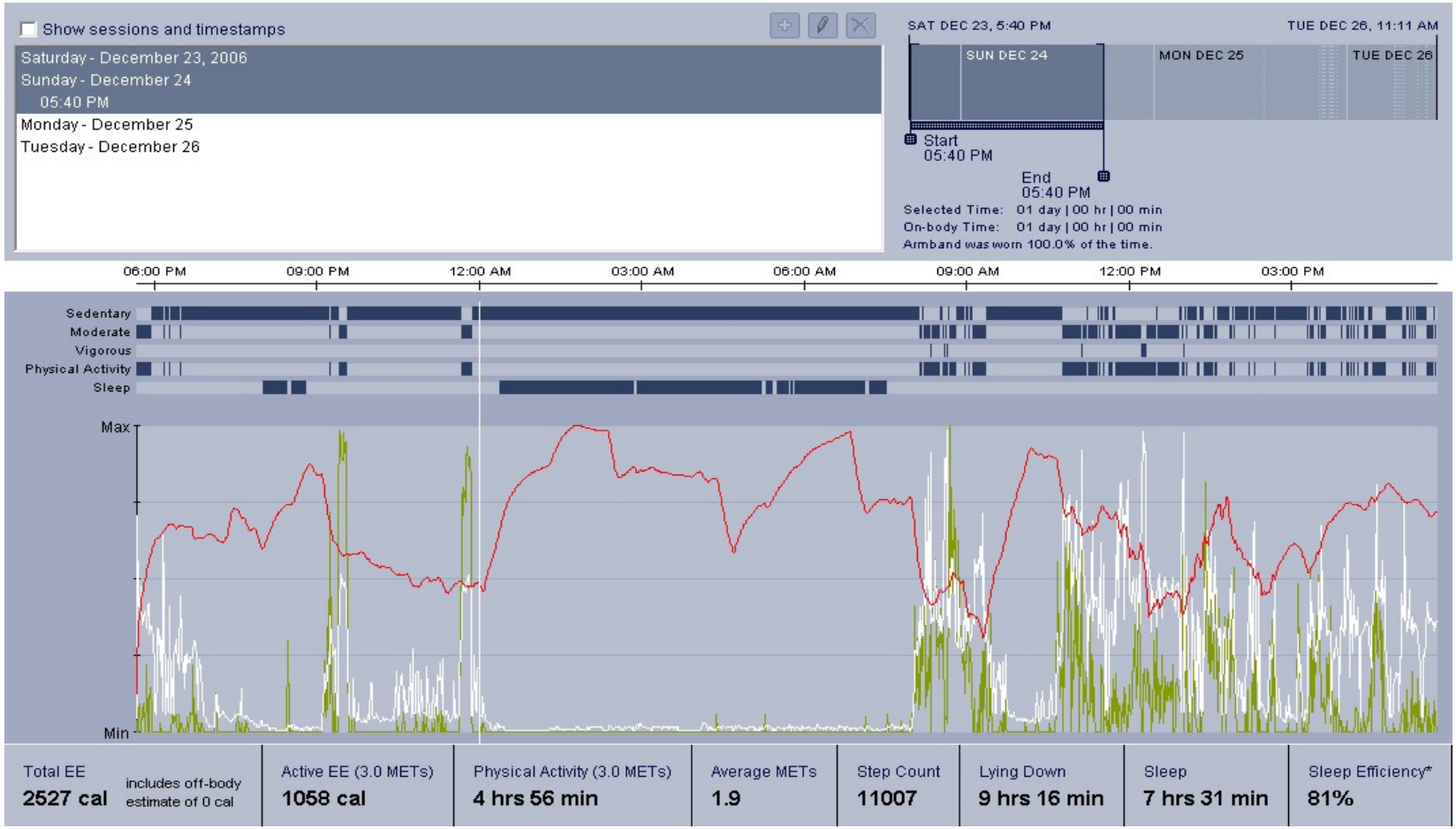



Figure 106. Graphic recording of NPNL Otomí woman, December 23-24, 2006.

Time Allocation and Energy Expenditure

In this study, the lactating women spent more time in child care and breast-feeding (35.01 ± 8.05%), and less time in subsistence activities (34.48 ± 21.08%), such as food preparation, basket-making, housework, animal care and gardening (see Fig. 107) than the nonlactating women who averaged 4.17 ± 4.28% of their time in child care and 48.62 ± 20.26% of their time in the subsistence activities including fieldwork, making tortillas, gathering food and fuel, basket-making, herding animals, and housework (see Fig. 108). The lactating women spent more time breast-feeding their babies (17%), not surprisingly, than in other forms of child care (8%), while 21% of their time was allocated to subsistence activities, including 14% of their time cooking tortillas, 40% of their time resting and sleeping, essential for successful breast milk production, and for other activities such as building social interrelationships. The lactating women did not herd animals to the fields, but they did feed and clean the animals in their family compounds. The lactating women made baskets during the day, while the nonlactating women who worked in the fields during the day usually made baskets in the night hours between 6:00 p.m. and 2:00 a.m. The major difference was when they retired to sleep for the night, as indicated in the energy expenditure graphic recordings (see Figs. 105 and 106).

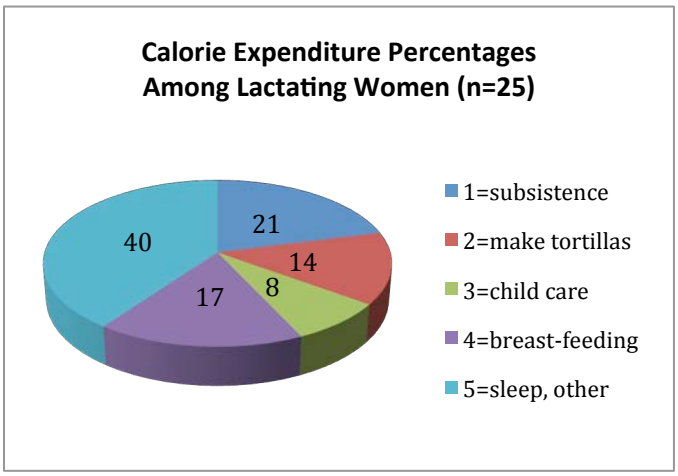



Figure 107. Calorie expenditures by lactating Otomí women in various daily activities.

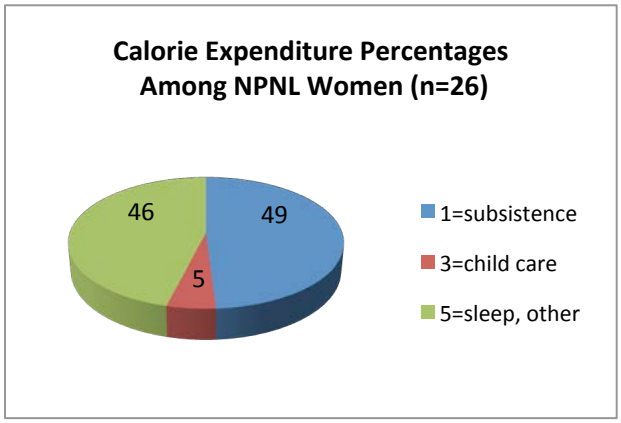



Figure 108. Calorie expenditures by NPNL Otomí women In various daily activities.

Breast Milk Production

The lactating women who were breast-feeding infants younger than 10 months old and not supplementing with bottle feeding (n=20), were expending an average of 251 calories per day to produce an average of 23 ounces of breast milk (or about 11 calories to produce one ounce of breast milk). The Otomí lactating women in this study were expending an average of 2.4 ± 1.5 calories per minute while breast-feeding, higher than previously reported for Mayan women with an average of 1.5-1.9 calories per minute while engaged in "child care" (Kramer 2005: 195). However, these were *estimates* of energy expenditure while engaged in child care (not clear if this includes breast-feeding) and were based upon studies of European women performing household chores (energy expenditures taken from Durnin and Passmore 1967: 47). During the breast-feeding sessions of the Otomí lactating women in this study, there was a wide diversity of calories expended per minute during lactation, as low as 1.0 calories per minute (night feedings) to as high as 7.3 calories per minute during the day time hours.

Despite their minimal liquid intake, these lactating desert women (n=25) were producing adequate quantities of breast milk (mean BM production=21.6 ± 14.2 ounces) (see Fig. 109). The stomachs of most babies have a maximum holding capacity of six ounces, and the recommended consumption for breast-fed infants is eight feedings per day of approximately three to four ounces per feeding, or 18 to 24 ounces of breast milk per day (Lawrence 1999, Riordan 2005). The average cross-cultural amount of breast

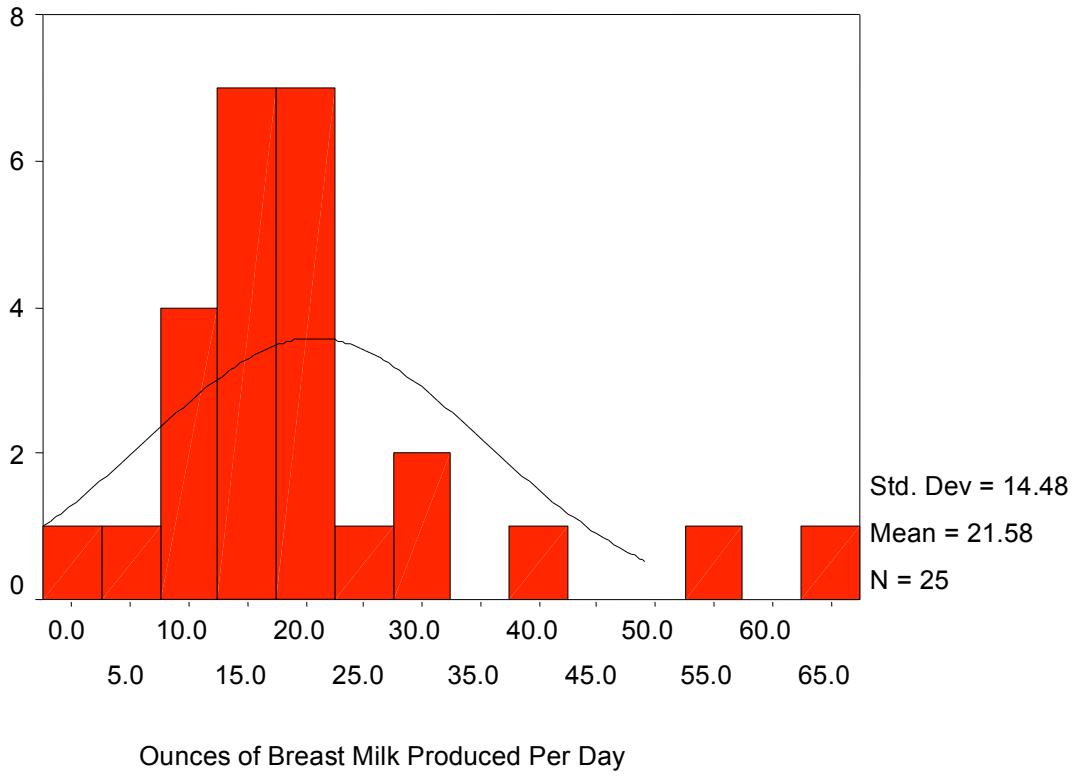



Figure 109. Daily breast milk production by Otomí lactating women.

Milk produced for singletons is 25.4 ounces per day (Riordan 2005, Short 1984), and these lactating women (n=25) were producing an average of 22 ounces of breast milk per day. The exclusively lactating Otomí women (n=20) breast-fed their infants between 10 and 14 times per day. It is relevant to note that seven of these women were supplementing their infants with infant formula in response to medical advice, resulting in reduced amounts of breast milk production by these individuals. This may have skewed the results of average breast milk production among the entire group. The women with exclusively breast-fed infants younger than 10 months without infant formula supplements (n=15) had an average breast milk production of nearly 25 ounces per day (24.9 ounces), compatible with the average breast milk production reported in the literature.

Summary of Results

This project was undertaken to study the adaptive responses to scarcity among lactating desert women, specifically looking at the physiological and behavioral strategies they employ to maximize their ability to produce breast milk in a desert environment. The results of this study indicate that exclusively breast-feeding desert women engage in the physiological strategy of energy expenditure conservation by reducing their *rates* of energy expenditure in calories per minute. In addition, the desert adaptive traits such as reduced metabolic rates, decreased core body temperatures with reduced sweat thresholds, and retained body water in combination with the diuretic actions of the hormone prolactin are all physiological mechanisms that were present in

this population and are known to contribute to the cost efficiency of breast-feeding in a desert environment.

Their behavioral strategies included “pacing” their work habits by working more efficiently at their chores to increase the time they can devote to breast-feeding and infant care, in addition to the “hot breast milk” notion associated with taking time to cool down prior to breast-feeding. This behavior contributes to maternal relaxation and emotional calmness, essential to the oxytocin-stimulated breast milk “letdown” reflex and probably contributes the most to their successful breast-milk production. Another important behavioral strategy involved the assistance of allomothers or helpers, especially the lactating women’s female children, their mothers, and other female relatives. Alloparental assistance conserves maternal energy, increases infant and maternal physical well-being and nutritional status, and improves the mother’s chances for leading a longer life (Hrdy 2009, Kramer 2005), as well as the ultimate evolutionary payoff, their infant’s healthy survival.

# CHAPTER V

# DISCUSSION

For more than 200 million years, the mammalian behavior of suckling their offspring has contributed to the successful evolution of Homo sapiens. Despite the reproductive cost of lactation, breast milk, a species-specific human infant food, provides optimum physical growth and development, health, and immunity to short and long-term disease in the human infant. Women's reproductive behavior has had a profound impact on the course of human evolution, and yet there has been minimal research emphasis on the adaptive strategies employed by traditional lactating women in response to hot dry climates with scarce food and water resources. The current challenges of lactating mothers are further compounded by the increasing likelihood of blue water scarcity related to climatic swings, global warming, and human activities (Hoekstra and Mekonnen 2011: 34).

Successful acclimatization to desert climates requires behavioral, physiological, and genetic responses, the most important being heat evaporation or sweating (Frisancho 1996, Rowell 1978), and the most immediate being heat avoidance behavior (Low 1990). The *hot-cold syndrome*, a traditional belief system governing behavior among Mesoamerican peoples, defines and guides their emic perceptions of health, illness, medical treatment, and food choices (Chevalier and Sanchez Bain 2003, Foster 1994). The hot-cold syndrome includes notions such as the "water-salt" rule that

diminishes the “cold” effect of water, the “cold exposure” rule, resting outside house until the “hot winds” evaporate to reduce respiratory illnesses, and the “pacing” rule to avoid overexertion and heat stroke (McCullough 1973), and the “hot breast-milk rule” that was observed among these lactating women. Human mothers have been responding to the struggle to reproduce successfully for centuries of time by exploiting related and nonrelated helpers, allowing them to conserve energy, strength, and more efficiently feed their babies, while maintaining and extending their own lives.

Nutritional intake, maternal fat reserves, and/or reduced energy expenditure (Frisancho 1996, Jelliffe 1976, Lawrence 1999) provide the biological energy required to produce breast milk. Studies of lactating women in developing countries show an *increase* in daily energy expenditure under conditions of chronic energy intake deficits (Butte 1997, Kigutha 1995 Lawrence 1989, Panter-Brick 1993, Roberts 1982, Schutz 1980), particularly during the planting season (Paul 1979, Tenets 2003). An increase of 500 calories per day in nutrient intake is recommended to produce about 800 milliliters per day (or about 27 ounces per day) of breast milk (Dewey 1997, Stini 1978); however, food supplements offered to lactating women in developing nations had no effect on milk volume and little effect on milk composition (Subcommittee 1992). In addition, water consumption patterns, as noted in other research (Prentice 1984), had little effect on milk volume in this study.

In view of these findings, when I set out to study lactating women among the Otomí populations of Hidalgo, Mexico, I was interested in pursuing the following

questions. How do lactating traditional women in desert climates produce sufficient breast milk to nourish their infants? What behavioral and physiological strategies minimize the impact of scarce food and water, conserve maternal energy, improve the cost efficiency of breast milk synthesis, and ultimately contribute to successful lactation among these traditional desert women?

## Interpretation of Results

### Physiological strategies

The Otomí lactating women, in general, had an adequate dietary intake of more than 2,300 calories per day with a minimal liquid intake, motivated by thirst rather than cultural beliefs, of less than six cups per day. Their dietary and liquid intake had no significant effect on their breast milk production, confirming the previous scientific findings of the same relationship (Subcommittee 1992). Prior scientific studies have confirmed the exploitation of maternal fat reserves during lactation evidenced by site-specific weight loss to partially meet the energy demands of producing breast milk (Lawrence 1999, Piperata and DuFour 2007). Studies on *total* daily energy expenditure during lactation have found no measurable difference between lactating and nonlactating women (Barbosa 1997, Butte 1997). It has been suggested, however, that desert women have strategically adapted metabolically to lactation energy requirements by altering their *rates* of energy expenditure, or calories expended per minute (Waterlow 1986 and 1990).

According to Waterlow, the most important factor in determining energy cost is the speed or *rate* of calorie expenditure during a given activity. The Otomí lactating women who were exclusively breast-feeding infants younger than 10 months significantly reduced the amount of energy they expended per minute while performing their daily activities, thus increasing the cost efficiency of their breast milk synthesis. This finding confirms the Waterlow hypothesis of metabolic adaptation to water scarcity in the desert heat by reducing *rates* of energy during exclusive lactation among this population of traditional desert women.

The adaptive genotypic traits of desert populations improve their cooling efficiency (Hortsman 1982, Morimoto 1967), retain body water and salt (Jeunemaitre 1992, Kenney 1963, Oliver 1981), and metabolically alter energy expenditure rates (Waterlow 1986). Hormonal regulation of body water during lactation (Askew 1995, Folk 1998, Nagy 1992) reduces urinary output resulting in increased urinary concentrations (Folk 1998, Yagil 1986). This reserved bodily fluid contributes to more efficient breast milk production among desert women. The maintenance of lower core body temperatures in smaller bodies with lower basal metabolic rates, and reduced sweat rates that minimize body water loss (Frye and Kamon 1983), efficient salt and water retention (increased blood volumes), and reduced pulse rates (high cardiac output) are all physiological traits associated with efficient developmental desert adaptation (Frisancho 1996, Folk 1998, Rowell 1978, Schreider 1964, Wenger 2001). These same traits also contribute to successful lactation among desert women. The lactating women

in Hidalgo exhibited anthropometric evidence for these physiological adaptations in response to desert life. The evidence for urinary concentrations compatible with moderate dehydration, known to be associated with the heat adaptation of reduced sweat rates and reduced sodium content in their sweat (Frisancho 1996, Jeunemaitre 1992, Oliver 1981, Rowell 1978, Wenger 2001), that is present in the indigenous lactating women of Hidalgo, probably contributed to enhancing their cooling efficiency and retention of body water. Thus, despite their low levels of daily water intake, the metabolic efficiency of these desert women facilitated mobilization of their retained body water and nutrients to efficiently synthesize their breast milk (Illingsworth 1986).

*Anthropometric Data*

The Otomí women participating in this project exhibited anthropometric evidence for water retention with increased urinary concentration, low pulse rates, low basal metabolic rates, and an observed evidence for reduced sweating, all of which are adaptive physiological strategies to living in a desert environment. These physiological adaptive strategies contribute to more efficient breast milk production.

The etiology of “stunted” growth rate among many indigenous populations has been debated for several years in the scientific literature (Butte 1992, Dagan 1983, Hernandez-Beltran 1996) and despite the tendency to conclude that the small body size found among desert populations is totally the result of inadequate protein as children, it has been suggested by Frisancho that smaller bodies with a larger body surface area in relationship to body weight increases cooling efficiency and, thus, their small stature

may be an evolutionary adaptation rather than the result of inadequate protein (Anderson 1946, Frisancho 1996).

The propensity to encourage over-nutrition with high protein intake during infancy (by formula-feeding) to enhance rapid growth of muscles and bones has been linked in scientific studies to childhood and adolescent obesity (Stini 1978:31-39) and an increased risk for cancer later in life (Micozzi 1995:375). The Western opinions expressed in the literature that traditional desert people require more protein may be associated with cultural beliefs concerning appropriate nutrition in the industrialized nations. Americans consume an average of 43 kilograms or about 95 pounds of bovine meat per capita per year, about 4.5 times the average per capita global beef consumption (Mekonnen and Hoekstra 2011:30) and are suffering from epidemic levels of cardiovascular disease and diabetes. The populations in underdeveloped nations obtain the majority of their protein intake from plants, a combination of beans or legumes and whole grains (Wardlaw and Smith 2009), and have a much lower incidence of nutrition-related diseases. The Otomí women consumed most of their protein from tortillas and beans during this study, however, meat and eggs are steadily increasing in their dietary intake patterns, most likely influenced by global marketing and the increasing amount of income from male migratory wage-labor. In 1946, while consuming a traditional diet, there was no evidence of diabetes, heart disease or dental caries among these traditional people (Anderson 1946). Sadly, this study provided evidence for significant alterations in dietary consumption with a simultaneous increase

in the incidence of nutrition-related diseases such as diabetes, hypertension, and dental caries among the traditional Otomí population of Gandho and Pañhe, Hidalgo.

*Energy Intake*

The average dietary calorie consumption among this population has increased nearly 300 calories per day since Anderson reported on the nutritional intake of this same population in 1946, from an average of approximately 1900 calories per day to an average of about 2300 calories per day. This caloric increase is reflected in a number of changes in their dietary consumption, particularly drinking Coca Cola and other sodas, eating processed meats, eating more refined bread products rather than hand-made whole grain corn tortillas, in addition to the fairly recent practice of adding sugar to their drinks and foods. These changes in dietary practices are contributing to greater caloric consumption and the majority of these calories contain minimal nutritional density. As a consequence, these women are now succumbing to modern disorders associated with industrial nations such as diabetes, heart disease, and tooth caries (Gandho, Hidalgo clinic nurses, personal communication, 2006). However, in general, these women eat a variety of wild greens, one of which is the richest source of omega-3 essential fatty acids in the plant kingdom (purslane), a combination of whole grains (corn tortillas) and beans that provide a high quality complete protein. As observed by Anderson in 1946, overall this population seemed to have an adequate diet with sufficient protein and a moderate amount of fats and sugars.

Because of the diversity of human body size and activities throughout the world,

Shetty and Weisell suggest that nutrient requirements should be calculated based upon body mass index (2002 and 2002), thus we should proceed with caution when interpreting the caloric intake of this population. According to American nutrient recommendations for their body mass index and the level of their activity, the lactating Otomí women apparently have an inadequate diet and, according to U.S. government recommendations, should probably consume an additional 200 calories per day, or 2500 calories per day for optimal health throughout lactation (United States Department of Agriculture, http://www.choosemyplate.gov/mypyramidmoms/index.html).

The water consumption of the lactating women in this study was lower than that of the nonlactating women, probably related to the tendency to drink only in response to thirst among this population. This apparently adaptive tactic involves hormone-induced water retention that can lead to increased body size *and*, simultaneously, more efficient breast milk production. The nonlactating women are drinking water in response to working in the fields in extreme heat, a work stress that produces a greater thirst response than that of the lactating women, who are influenced by the milk-regulating hormone prolactin and are working in the house caring for children or making baskets under shade in their housing compounds. Despite a minimal water consumption of less than six cups per day, their breast milk production was adequate (mean=20.77 $\pm$ 14.48 ounces) with babies who were observed to have an average of five wet diapers during daytime hours, appeared to be healthy and to be growing within the 50$^{th}$ percentile (Mexican growth charts). Lactation allows women through the actions of prolactin to

retain body water. When the motivation to drink is regulated by thirst instead of cultural beliefs, and lactating desert women are retaining water, they will drink less water than the nonlactating women.

The Otomí desert women in this study almost universally exhibited levels of urine specific gravity indicating a state of moderate dehydration. While being followed for 24 hours, the women were observed to urinate between three and four times during the day, but the quantity of urine was not measured. However, none of the women showed physical evidence of dehydration, such as dizziness or confusion or other symptoms associated with heat exhaustion, cracked lips, excessively dry skin, an inability to urinate, or a feeling of excessive thirst. These levels of urine specific gravity perhaps indicate the adaptive biological capability of desert women to retain intracellular water that reduces urinary excretion of water, and redirects water and nutrients to metabolically improve the cost efficiency of breast milk synthesis.

*Energy Expenditure*

The lactating women who were exclusively breast-feeding infants younger than 10 months of age showed a significant reduction in the number of calories they expended per minute at MET levels two through six when compared with the nonlactating group of women. The exclusively breast-feeding women used fewer calories per minute even while sleeping at MET level one, however, this difference was not significant. The differences in the two groups with regard to total energy expenditure indicate that, unlike the nonlactating women who were working

sporadically at MET levels as high as 15, the lactating women were never working at greater than nine metabolic equivalents (METS).

The lactating women were expending an average of 2.4 calories per minute while breast-feeding, with a range from 1.0 calorie per minute (during night hours) to 7.3 calories per minute. In 2005, Kramer reported caloric expenditure of 1.5 calories for child care activities (Kramer 2005:195, data taken from Durnin and Passmore 1967:47), an *estimation* of caloric expenditure rate based upon indirect calorimetric measurements among relatively sedentary European housewives. There was no separate category for breast-feeding in her data (Kramer 2005). The current research enhances our knowledge of field measurements of energy expenditure on active traditional women, with real-time results measured in the field using a computerized monitoring device designed for real-time field observation with the least interference and compatible with DLW, the gold standard of the industry. The measurements in Table III indicate higher, and probably more accurate, energy expenditure *rates* for active lactating traditional women.

While observing these women for 24 hours, it was apparent that the majority of these women were hard-working peasants. But two lactating women whose husbands were absent from the home engaged in migrant farm work and who lived alone without supervision from another adult female, spent many hours “resting” and watching the relatively new phenomenon of television, perhaps a reflection of the altered lifestyle that is to come in these villages with the advent of modernization.

Most of the lactating women did not go to the fields to work (only three participating woman went to the fields with nursing infants), while all the nonlactating women worked in the fields every day, gathering food and fuel, planting, weeding, hoeing, harvesting, and herding animals as well as making baskets. The children of lactating women did most of the animal herding for their mothers, in addition to fetching much of the water and fuel for the household. The lactating mothers did not intend to return to the fields until their babies were at least two years of age. Instead, the lactating women spent a great deal of time making baskets or figurines, cleaning their house, making tortillas, working in family gardens with their infants on their backs in *rebozos*, and preparing food for their families in addition to breast-feeding and other caring for their children.

The primary difference in their work habits was the observed behavior among the lactating women of "pacing" themselves, focusing all their attention on getting a given task done as efficiently as possible with less distraction so that they could quickly return to meet the needs of their nursing infants and other children.

*Breast Milk Production*

The group of lactating desert women in this study produced an average of 21 ounces of breast milk per day, slightly fewer ounces than observed in previous cross-cultural studies (Riordan 2005, Lawrence 1999). However, the exclusively lactating Otomí women, with infants younger than 10 months of age, produced approximately 25 ounces of breast milk, compatible with cross-cultural average breast milk production,

using slightly more than 250 calories each day. Medical research recommends an increased nutritional intake of 500 calories to produce approximately 27 ounces of milk but these women were able to produce a similar quantity of breast milk using half the amount of recommended calories. The lactating group consumed an average of 300 calories more per day than their nonlactating peers, adequate to partially meet the energy requirements of breast-feeding. In addition, the lactating Otomí women reduce their *rates* of energy expenditure, providing an excess of energy reserves for the production of breast milk, allowing them to efficiently synthesize breast milk on a lower calorie intake and a much lower liquid intake. This physiological strategy reflects the genotypic adaptations to a desert environment that include lower heart rates, lower core body temperatures and lower sweat thresholds. Increased urinary concentrations and high prolactin concentrations as the result of more frequent breast-feeding sessions (10-14 per day) increase body water retention and improve the metabolic efficiency of breast milk production. These physiological strategies complement their behavioral strategies that contribute to maternal energy conservation and relaxation, improve maternal hormonal function and metabolism, and have a combined profound influence on the cost efficiency of the lactation process among desert women.

Their higher body mass index most likely is linked to relatively recent changes in their dietary intake since their weights have increased since the nutritional research of 1946 (Anderson 1946). Increased saturated fats and proteins found in commercially-processed foods are being increasingly distributed in the global markets and finding

their way into the local village *tiendas*. This is a pattern that has been noted among other Amerindian indigenous populations, including the Inuit of Canada, the Australian aborigines, and the Native Americans in the United States, causing increased rates of obesity, dental caries, diabetes, and cardiovascular disease and death among these peoples (Bramley 2004, Ring 2003). Despite the maternal physical risks, the outcome of increased insulating body fat is also contributing to more efficient synthesis of breast milk and healthier babies, with evidence for declining infant mortality rates among the indigenous people of Mexico. Hence, as Konner indicates, when survival and reproduction no longer support each other, reproductive success prevails (2010).

## Behavioral Strategies

The behavioral strategies of pacing themselves, exploiting alloparental assistance, and the "hot breast milk rule" that were observed among the Otomí lactating women all contributed to successful breast-feeding behavior, conserving energy, facilitating maternal relaxation, reducing maternal stress, improving hormonal function, and enhancing the metabolic efficiency of breast milk synthesis.

### *Alloparental Assistance*

There is every reason to believe that alloparenting has been associated with efficient maternal reproductive strategies for at least thousands of years. Exploiting readily available helpers has provided respite to the lactating mother throughout history, conserving energy and improving maternal health, as well as contributing to the

survival of both mother and offspring. The lactating women in Hidalgo rely heavily on the capable assistance of their older female children and their mothers, to a lesser extent on other related females such as sisters, aunts, or cousins, and even less on mothers-in-law, substantiating Haldane's notion of kin altruism (1955).

The relationship between the lactating women and their mothers-in-law was predominantly characterized as one of "restrained respect," sometimes leading to increased levels of anxiety and depression in the breast-feeding women under this continuum of constant surveillance, especially if their husband was absent for extended periods of time for migratory wage-labor employment. One woman with obviously high emotional stress levels was treated as a virtual slave in her mother-in-law's household with extremely limited access to her own infant. This participating mother lived in the same house as her mother-in-law that was built by her husband with higher wages from America. She told me that her mother-in-law reported to her son (the woman's husband) in the United States concerning her daily activities on a regular basis. The stress associated with this common practice of daily reports to distant sons was alleviated for some by living *near* the mother-in-law, rather than residing under the same roof. This slight increase of distance increased their privacy and seemed to decrease the emotional stress levels for many of these women.

*The Hot-Cold Syndrome*

The Otomí women who participated in this project practiced an adaptive strategy associated with the "hot-cold syndrome" traditional belief system concerning

the *hotness* of breast milk. This most important strategic behavior was described as the "hot breast milk" rule. After working outside in the sun, or after working at high energy tasks with resultant profuse sweating, the women cooled off inside the house or under the shade of a tree, sometimes washing their breasts with cool water, before breast-feeding to avoid the risk of illness or death in their infants. This behavior ultimately facilitates maternal relaxation that is required for the hormonally-induced breast milk "let-down" reflex, an essential component of efficient breast milk synthesis.

The lactating women always focused on the immediate task at hand in order to more efficiently complete their work and return to caring for their child as soon as possible. They described this strategy as "working faster," but upon observation while being followed for 24 hours, a more accurate description of their behavior was that they placed more emphasis on the immediate chore without allowing distractions, thus accomplishing their work *more efficiently*. This behavioral tactic associated with heat avoidance and a lower sweat threshold, retains body water, improves cooling efficiency, reduces maternal stress, and conserves maternal energy facilitating more efficient breast milk production.

## Conclusions

The lactating Otomí women living in Hidalgo partially met the energy demands of lactation by reducing the calories they expended per minute, conserving sufficient energy to produce adequate breast milk. They also conserved maternal energy through the social support of allomothers and practicing "pacing" behavior. The "hot breast

milk" traditional rule of behavior enhanced maternal relaxation, ensuring the milk "let-down" reflex that is an essential component of efficient breast milk production. The genetic adaptations to heat exhibited by the anthropometric data of the lactating women greatly facilitated the physiological strategies, reducing body heat, hormonally increasing water retention, and metabolically providing the nutrients to efficiently synthesize breast milk under the environmental conditions of inadequate water. Consistent with other research studies, dietary and water intake had no significant impact on breast milk production among this lactating group of Otomí women.

The Otomí lactating women responded to the environmental conditions of desert heat and water shortage with behavioral and physiological tactics that improved the cost efficiency of their breast-feeding behavior. By reducing their *rates* of energy expenditure, drinking less water with evidence of increased urinary concentrations and efficient metabolic use of body water, maintaining lower body core temperatures and reduced sweat rates, and breast-feeding in the traditional manner "on demand" that enhanced the prolactin-induced hormonal regulation of their body water, these lactating desert women increased the metabolic efficiency of their breast milk production.

As cooperative breeders, the adaptive behavioral strategy of exploiting related and nonrelated allomothers further conserved their energy and increased their well-being. Pacing themselves by concentrating on a given task to complete their work more efficiently allowed these women to avoid overexertion and reduce their energy

expenditure. The traditional rule associated with the notion of "hot breast milk" afforded these women the time to relax prior to initiating breast-feeding. Maternal relaxation and a calm state of being are essential to the hormonally-induced "milk let-down" reflex that stimulates efficient breast milk synthesis (Ueda 1994).

The socio-ecological conditions in Mexico are being influenced by the process of modernization and the medicalization of reproduction. The modernization process is beginning to alter behavior within these traditional villages. With increased income, the convenience of formula feeding infants will become more appealing to these women and their infant feeding methods may change. As a result, many of the reproductive physiological strategies these women currently exploit will be lost, except as scientific knowledge, in the rapidly advancing transition from a traditional subsistence economy in the coming years. However, their behavioral strategies will take longer to disappear and some of them, especially alloparenting strategies associated with cooperative breeding, will not vanish but perhaps alter in configuration, implementation, and perception as the modern world invades their peaceful and secluded existence.

Recommendations for Further Research

Research into reproductive behavior is of scientific and public health importance. The data obtained in this study contributes to international recommendations for promoting and improving breast-feeding practices and the accuracy of nutritional requirements for successful lactation. This is the first study to examine the effect of energy expenditure *rates* on breast milk production efficiency among lactating desert

women, and further define the costs and benefits of these strategic adaptations under conditions of water shortages. The Waterlow model for reduced *rates* of energy expenditure in lactating desert women was verified in this research project, expanding our knowledge and understanding of human energy balance and the adaptive potentials of lactating women and enhancing the data from prior energy expenditure studies. This study replicated well-accepted research methods and, using the latest activity monitoring device with computerized technology (Jakicic 2004, King 2004), may facilitate future research to establish the validity of these findings. This study was limited by the small number of participating women. Therefore, it is recommended that future research should be completed on larger samples of desert lactating populations to further validate these results and expand our understanding of the strategic response of altered *rates* of energy expenditure among lactating desert women. In the onslaught of changing socio-ecological conditions, much of this knowledge will be lost to science if anthropologists do not record the mechanisms that allow the human female to synthesize breast milk in a cost efficient manner.

In recent years, scientific research has offered increased enlightenment concerning the nutritional, immunological, and developmental benefits of human breast milk. Women are emerging from millions of years of subservience, navigating the shifting sands of changing gender roles, and assuming a more participatory role in their own destinies. Despite advances in knowledge concerning lactation, many women are being constrained by socioeconomic pressures to opt for maternal survival over

reproductive success, and succumbing to false advertising encouraging an end to this ancient method of infant feeding. An expanded understanding of the evolutionary legacy of breast-feeding, particularly with regard to female adaptive responses to resource scarcity in a world challenged by climatic changes, economic uncertainty, and ecological decline (Myers 2009, Woodbridge 2004) will help women throughout the world to make more enlightened decisions when feeding the next generation of children.

**APPENDIX**

## PARTICIPANT DEMOGRAPHIC INFORMATION

### INFORMACION DE LA MADRE

3/31/06 8-11 a.m.

| | | | |
|---|---|---|---|
| participant no. 06-010-L | weight/peso de madre 81.2 kg | % body fat 38.1% | ethnicity Spanish + Otomi |
| name/nombre [illegible] | height/talla de madre 155 cm | oral temperature 36.9 C | lactando? si ✓ no ___ |
| address/direccion Boyaj across from store<br>physical traits? ___ | smoke/fuma? si ___ no ✓<br>illnesses? none | triceps skin fold (20 mm) 30.1%<br>mid arm (MAC circumference 29cm. 11¼" | # children/hijos 3, 2 girls, 1 boy<br># siblings 2, 1 brother, 1 sister healthy |
| age of mother 23<br># pregnancies 4 | alcohol o pulque? si ___ no ✓<br>household size 5 | heart rate 63 10x6<br>BMI ___<br>CED ___ | # generations in Hidalgo all<br>religion Catholic |
| DOB/fecha de nacimiento 16 Sept 1982 | handedness ✓R | S/BM ratio ___<br>BMR ___ | household comp 2♂ + children |
| ocupacion? housewife | educacion? 9 yrs. | nacio? Huachapan | salud? ✓ |

### SPOUSE/INFORMACION DE ESPOSO

| | |
|---|---|
| name/nombre Jose Luis Hernandez Colin | educacion? anos? 9 years |
| DOB/fecha de nacimiento 28 May, 1972 | cuidad de nacio Huachapan |
| age/edad de esposo 33 | ocupacion? agriculture |

### CHILDREN/INFORMACION DE HIJOS

| | |
|---|---|
| name/nombre (BF baby) Itzel | nino o nina? nina |
| DOB/fecha de nacimiento 20 Feb. 2006 | weight/height? 4344 g / 54 cm. |
| age/edad de hijo 46 days >1 mo. | amamantarlo? ✓ |
| name/nombre Luis Eduardo (9), Ana Karen (5), Itzel (1 mo.) | nino o nina? |
| DOB/fecha de nacimiento ___ | educacion? ___ |
| age/edad de hijo ___ | amamantarlo? only for 1 month had diarrhea, intolerant to BM |

Figure 110. Demographic Information worksheet sample.

custom = 3

Participant no. 06-003-L
Participant name Alma Cruz

Yo voy a leer algunas razones para amamantar a tu bebe. Cuando yo termine, voy a leer otravez y entonces ordena de la más importante a la menos importante cada una de estas razones en la escalera:

1 Debe amamantarlo a tu bebé porque es una costumbre.

4 La leche materna es mejor por la salud de su bebe.

8 Un bebé se cría más rápido con la leche materna.

7 Un bebé se cría mejor con la leche materna.

9 La leche materna le da a tu bebe protección para enfermedades cuando es chiquito.

___ ~~La leche materna le da a tu bebe protección para enfermedades cuando es mas grande~~.

3 Un bebé será más inteligente con la leche materna.

___ ~~La leche materna es la mejor comida para los bebés~~.

___ ~~Cuando amamantarlo a tu bebé, quieres más a tu bebé~~.

6 Amamantar a tu bebe es más fácil.

5 Amamantar a tu bebé es barato por que no es necesario para comprar la leche.

2 Amamantar a tu bebé le da a la madre protección para el cáncer de pecho y otras enfermedades.


Figure 111. Reasons for Breast-Feeding worksheet and methodological tools.

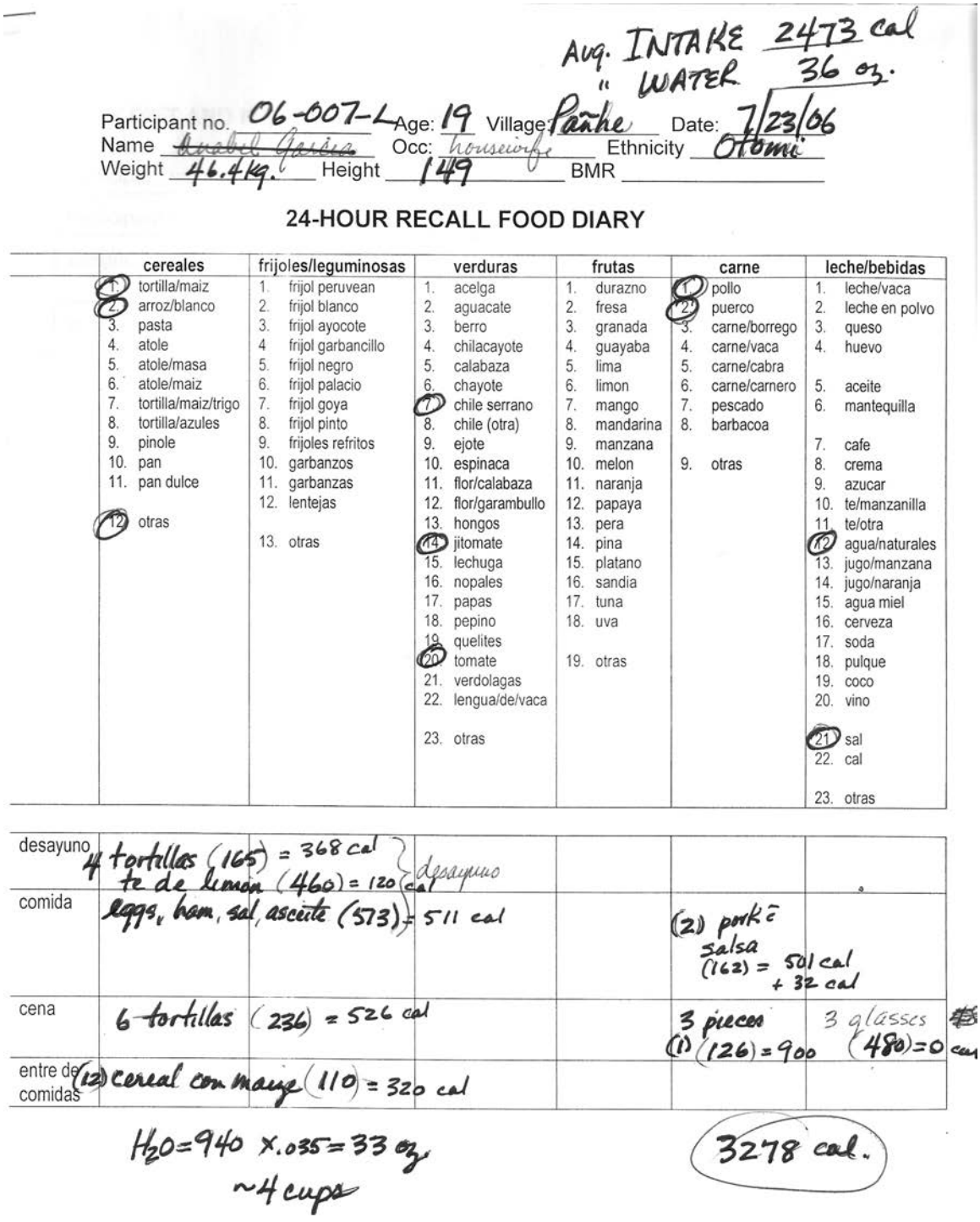
| LEVEL OF SOCIOECONOMIC STATUS | | | | |
|---|---|---|---|---|
| **ITEM** | **1** | **2** | **3** | **4** |
| HOUSE TYPE | WOOD/CARRIZO | STONE/CARRIZO | CONCRETE/CARRIZO ROOF | CONCRETE/CONC ROOF ✓ |
| # OF ROOMS | ONE | TWO | THREE | FOUR |
| # OF WINDOWS | NONE | ONE | TWO | THREE |
| # OF DOORS | ONE | TWO | THREE | FOUR |
| KITCHEN | NONE | OUTSIDE | OUTSIDE BUILDING W/ROOF | INSIDE |
| BATHROOM | NONE | OUTSIDE/CARRIZO ROOF | OUTSIDE/CONCRETE BLDG W/ROOF | INSIDE HOUSE |
| ELECTRICITY | NO | YES | YES W/LIGHT BULBS | YES W/FIXTURES ✓ |
| TELEVISION | NO | YES – SMALL | YES – LARGE ✓ | YES – LG W/CABLE |
| STEREO | NO | YES ✓ | | |
| STOVE | NO | YES | YES W/OVEN | |
| TRUCK OR CAR | NO ✓ | YES, OLD CAR | YES, OLD TRUCK | YES, NEW TRUCK |
| WASH MACHINE | NO ✓ | YES, OLD | YES, BETTER | YES, NEW |
| REFRIGERATOR | NO | YES, OLD ✓ | | YES, NEW |
| BLENDER | NO | YES, OLD ✓ | | YES, NEW |
| COMPUTER | NO ✓ | YES, OLD | YES, NEW | YES W/ INTERNET |
| IRON | NO | YES, OLD | YES, NEW | YES W/ BOARD |
| WATER ACCESS | NO | YES, NO HOSE | YES W/ HOSE ✓ | YES W/ TANK |
| TOTAL POINTS | 3 | 6 | 6 | 8 |
| SES LEVEL | | | | |

Participant No. 06-008-NL

Participant Name Marta Gomez Clay

23

Figure 112. Socioeconomic Status worksheet sample.



Avg. INTAKE 2473 cal
" WATER 36 oz.

Participant no. 06-007-L Age: 19 Village: Pañhe Date: 7/23/06
Name Anabel Garcia Occ: housework Ethnicity Otomi
Weight 46.4kg. Height 149 BMR

## 24-HOUR RECALL FOOD DIARY

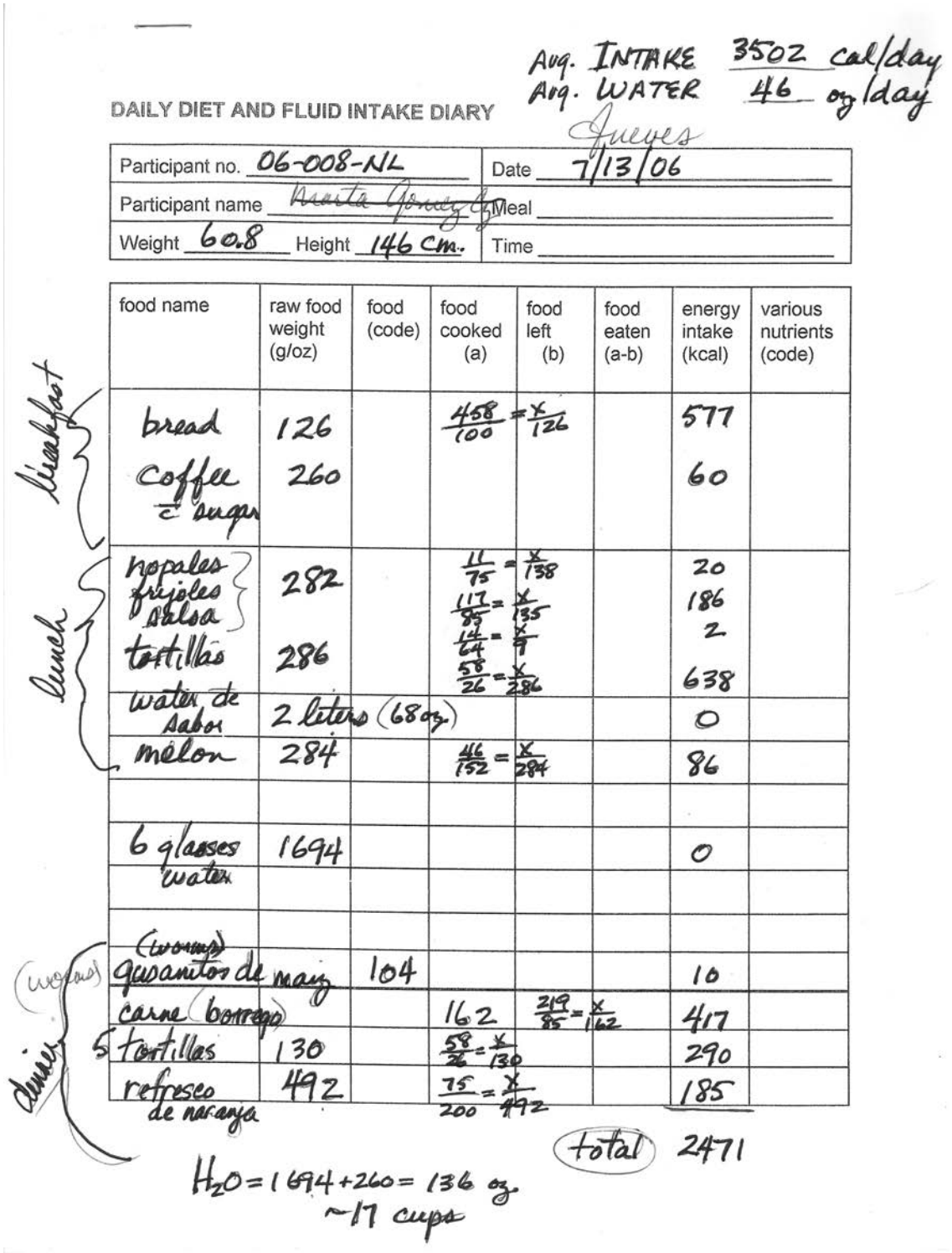
| | cereales | frijoles/leguminosas | verduras | frutas | carne | leche/bebidas |
|---|---|---|---|---|---|---|
| | (1) tortilla/maiz | 1. frijol peruvean | 1. acelga | 1. durazno | (1) pollo | 1. leche/vaca |
| | (2) arroz/blanco | 2. frijol blanco | 2. aguacate | 2. fresa | (2) puerco | 2. leche en polvo |
| | 3. pasta | 3. frijol ayocote | 3. berro | 3. granada | 3. carne/borrego | 3. queso |
| | 4. atole | 4 frijol garbancillo | 4. chilacayote | 4. guayaba | 4. carne/vaca | 4. huevo |
| | 5. atole/masa | 5. frijol negro | 5. calabaza | 5. lima | 5. carne/cabra | |
| | 6. atole/maiz | 6. frijol palacio | 6. chayote | 6. limon | 6. carne/carnero | 5. aceite |
| | 7. tortilla/maiz/trigo | 7. frijol goya | (7) chile serrano | 7. mango | 7. pescado | 6. mantequilla |
| | 8. tortilla/azules | 8. frijol pinto | 8. chile (otra) | 8. mandarina | 8. barbacoa | |
| | 9. pinole | 9. frijoles refritos | 9. ejote | 9. manzana | | 7. cafe |
| | 10. pan | 10. garbanzos | 10. espinaca | 10. melon | 9. otras | 8. crema |
| | 11. pan dulce | 11. garbanzas | 11. flor/calabaza | 11. naranja | | 9. azucar |
| | | 12. lentejas | 12. flor/garambullo | 12. papaya | | 10. te/manzanilla |
| | (12) otras | | 13. hongos | 13. pera | | 11. te/otra |
| | | 13. otras | (14) jitomate | 14. pina | | (12) agua/naturales |
| | | | 15. lechuga | 15. platano | | 13. jugo/manzana |
| | | | 16. nopales | 16. sandia | | 14. jugo/naranja |
| | | | 17. papas | 17. tuna | | 15. agua miel |
| | | | 18. pepino | 18. uva | | 16. cerveza |
| | | | 19. quelites | | | 17. soda |
| | | | (20) tomate | 19. otras | | 18. pulque |
| | | | 21. verdolagas | | | 19. coco |
| | | | 22. lengua/de/vaca | | | 20. vino |
| | | | 23. otras | | | (21) sal |
| | | | | | | 22. cal |
| | | | | | | 23. otras |

| | | | | | | |
|---|---|---|---|---|---|---|
| desayuno | 4 tortillas (165) = 368 cal<br>te de limon (460) = 120 cal | | desayuno | | | |
| comida | eggs, ham, sal, aceite (573) = 511 cal | | | | (2) pork ē salsa (162) = 501 cal + 32 cal | |
| cena | 6 tortillas (236) = 526 cal | | | | 3 pieces (1) (126) = 900 | 3 glasses (480) = 0 cal |
| entre de comidas | (12) cereal con maiz (110) = 320 cal | | | | | |

$H_2O$=940 x.035=33 oz
~4 cups

3278 cal.

Figure 113. 24-hour Recall Food Diary worksheet sample.



Avg. INTAKE 3502 cal/day
Avg. WATER 46 oz/day

DAILY DIET AND FLUID INTAKE DIARY

Jueves

Participant no. 06-008-NL | Date 7/13/06
Participant name Beata Gomez G. | Meal
Weight 60.8 Height 146 cm. | Time

| food name | raw food weight (g/oz) | food (code) | food cooked (a) | food left (b) | food eaten (a-b) | energy intake (kcal) | various nutrients (code) |
|---|---|---|---|---|---|---|---|
| breakfast: bread | 126 | | 458/100 = X/126 | | | 577 | |
| coffee c sugar | 260 | | | | | 60 | |
| lunch: nopales | 282 | | 11/75 = X/138 | | | 20 | |
| frijoles | | | 117/85 = X/135 | | | 186 | |
| salsa | | | 14/64 = X/9 | | | 2 | |
| tortillas | 286 | | 58/26 = X/286 | | | 638 | |
| water de sabor | 2 liters (68oz) | | | | | 0 | |
| melon | 284 | | 46/152 = X/284 | | | 86 | |
| | | | | | | | |
| 6 glasses water | 1694 | | | | | 0 | |
| | | | | | | | |
| | | | | | | | |
| dinner: (worms) gusanitos de maiz | | 104 | | | | 10 | |
| carne (borrego) | | | 162 | 219/85 = X/162 | | 417 | |
| 5 tortillas | 130 | | 58/26 = X/130 | | | 290 | |
| refresco de naranja | 492 | | 75/200 = X/492 | | | 185 | |
| | | | | | total | 2471 | |

$H_2O = 1694 + 260 = 136$ oz.
~17 cups

Figure 114. Daily Diet and Fluid Intake Diary worksheet sample, used for seven-day direct weight measurement method.

| FOOD/ BUDGET INFORMATION | | | | |
|---|---|---|---|---|
| **ITEM** | **1** | **2** | **3** | **4** |
| FAMILY INCOME (FAMILY SIZE 4) | LESS THAN 5,000 PESOS / YEAR | 5-10,000 PESOS/ YEAR | 10-15,000 PESOS/ YEAR | MORE THAN 15,000 PESOS/YR ✓ |
| FOOD BUDGET | < 100 PESOS/WK | 1-200 PESOS/ WK | 3-500 PESOS/ WK | > 500 PESOS/ WK ✓ |
| MAIZ (type _____) | 1 CUARTILLO | 2 CUARTILLOS | 3 CUARTILLOS ✓ | > 3 CUARTILLOS |
| BEANS | 1 CUARTILLO ✓ | 2 CUARTILLOS | 3 CUARTILLOS | > 3 CUARTILLOS |
| HITOMATES | < 1 KILOGRAM | 1-2 KILOGRAMS | 2-3 KILOGRAMS ✓ | > 3 KILOGRAMS |
| ONIONS | < 1 KILOGRAM ✓ | 1-2 KILOGRAMS | 2-3 KILOGRAMS | > 3 KILOGRAMS |
| CHILES (TYPE Serrano) | < 1 KILOGRAM ✓ | 1-2 KILOGRAMS | 2-3 KILOGRAMS | > 3 KILOGRAMS |
| GARLIC (ajo) | 1 head ✓ | 2 heads | 3 heads | 4 heads or more |
| PASTA (SOPA) | 1 PKG | 2 PKGS ✓ | 3 PKGS | 4 PKGS or more |
| VERDURAS PARA SOPA | 1 PKG ✓ | 2 PKGS | 3 PKGS | 4 PKGS or more |
| OIL | YES ✓ | NO | QUANTITY ½ botte | |
| SUGAR | YES ✓ | NO | QUANTITY 1 Kilo | |
| FRUITS (type Banana guave, FRUITS (manzana | < 1 KILOGRAM ✓ | 1 KILOGRAM | > 1 KILOGRAM | |
| VEGETABLES (type Calabaza, ejote, carrots VEGETABLES (__) | < 1 KILOGRAM | 1 KILOGRAM ✓ | > 1 KILOGRAM ✓ | |
| COCA COLA | 1 liter | 2 liters | 3 liters | 4 liters |
| COFFEE | YES | NO ✓ | | |
| MEAT (type Bistec Pollo, pork) | YES ✓ | NO | QUANTITY ½ kg. 1 kg. | |
| OTHER FOOD | TYPE | QUANTITY | | |
| TOTAL MONEY SPENT FOR FOOD | | | | |

Participant No. 06-007-L Date of week 7/16-7/23/06
Participant Name Anabel Garcia

Figure 115. Food Budget worksheet sample.

## BREASTMILK PRODUCTION RECORD SHEET

| | |
|---|---|
| Participant no. 06-037-L | SLDFOOD (yes/no) _____ gm |
| Participant name Reynalda Gomez | Daily tea (yes/no) _____ oz |
| Infant age 3 months | Growth percentile _____ % |
| Weight (g) first interview 6750 g. | Length (cm) first interview 62 cm. |
| Weight (g) in summer 6750g. | Length (cm) in summer 62 cm. |
| Weight (g) in winter _____ | Length (cm) in winter _____ |

| | TIME OF DAY | WEIGHT BEFORE in grams (a) | WEIGHT AFTER in grams (b) | WEIGHT OF WET DIAPER (g) (c) | BREASTMILK CONSUMED (g) (b-a-c) |
|---|---|---|---|---|---|
| 10' | 4:30-4:40 | 6895 | 6980 | | 85 |
| (15' ea) 15' | 10:15-10:30 | 6985 | 7070 | | 85 |
| 5x noche 7' | 8:25-8:32 | 6870 | 6940 | | 70 |
| 15' | 9:45-10:00 | 6835 | 6980 | | 145 |
| 14' | 1:20-1:34 | 6940 | 6920 | | -20 |
| 10' | 4:48-4:58 | 6785 | 6820 | | 35 |
| | | | | | |
| | | | 5x night | = | + 448.8 gm |
| | | | | | 848.83 gm |
| | | | | | |
| | | | | | |

848.83 x .035 = 29.71 oz.

Figure 116. Breast milk Production Record worksheet sample, page 1.

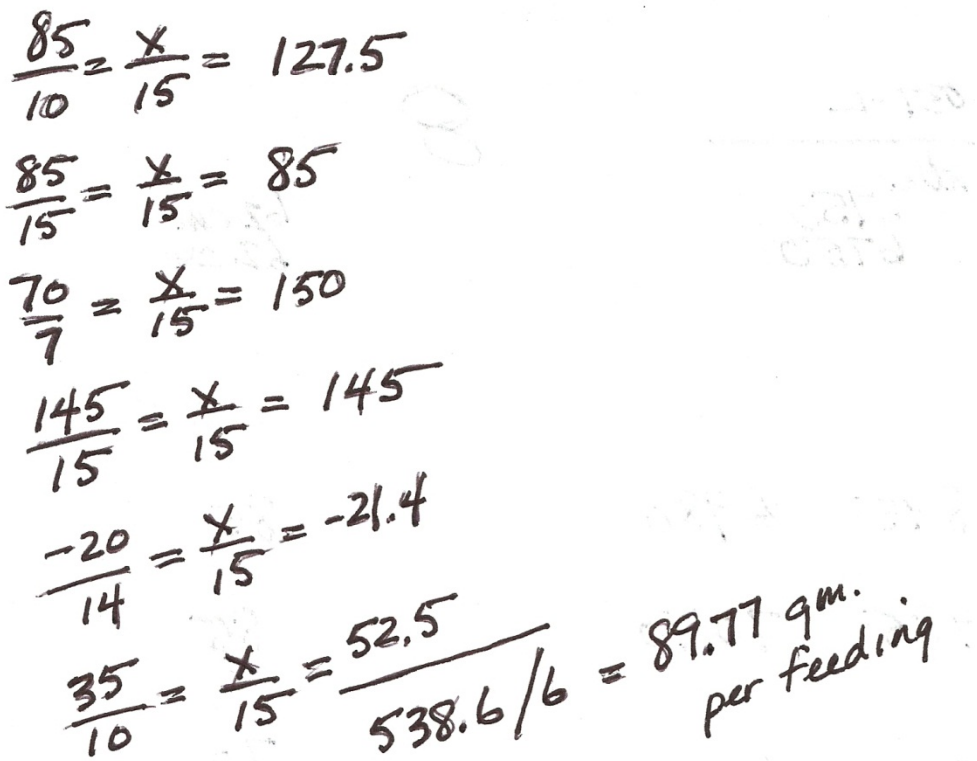



Figure 117. Breast milk Production Record worksheet sample, with calculations for night feedings, page 2.

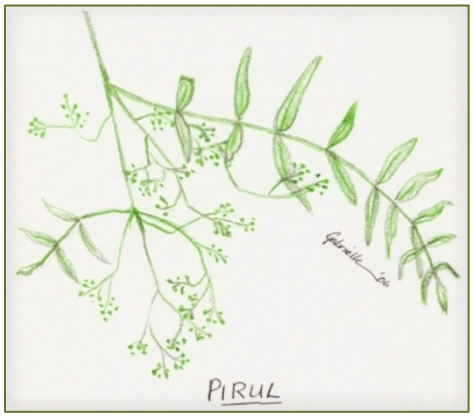



Figure 118. Illustration of *pirul*, 2006.


Figure 119. Illustration of *flor de perrito*, 2006.


Figure 120. Illustration of *hierbabuena*, 2006.


Figure 121. Illustration of *altamisa*, 2006.

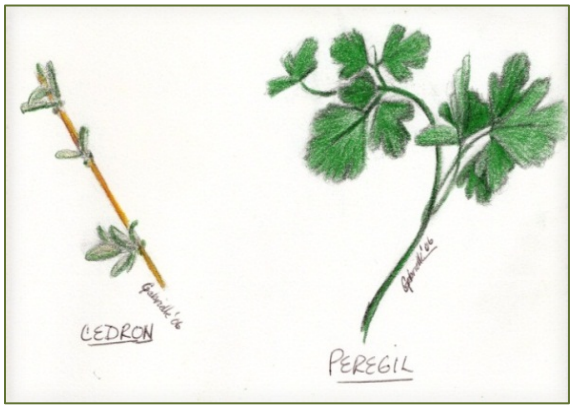



Figure 122. Illustration of *cedron* and *peregil*, 2006.


Figure 123. Illustration of ruda, 2006.


Figure 124. Illustration of *lengua de vaca*, 2006.

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