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# Age Appropriate Wisdom? Ethnobiological Knowledge Ontogeny in Pastoralist Mexican Choyeros

Eric Schniter
*Chapman University*, schniter@chapman.edu

Shane J. Macfarlan
*University of Utah*

Juan J. Garcia
*University of Utah*

Gorgonio Ruiz-Campos
*Universidad Autónoma de Baja California*

Diego Guevara Beltran
*University of Arizona*

*See next page for additional authors*

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## Authors

Eric Schniter, Shane J. Macfarlan, Juan J. Garcia, Gorgonio Ruiz-Campos, Diego Guevara Beltran, Brenda B. Bowen, and Jory C. Lerbak

# Age Appropriate Wisdom?

## Ethnobiological Knowledge Ontogeny in Pastoralist Mexican Choyeros

Eric Schniter[1*], Shane J. Macfarlan[2,3,4], Juan J. Garcia[5], Gorgonio Ruiz-Campos[6], Diego Guevara Beltran[7], Brenda B. Bowen[4,8], Jory C. Lerback[8]

[1]Economic Science Institute, Chapman University, Orange, California, USA
[2]Department of Anthropology, University of Utah, Salt Lake City, Utah, USA
[3]Center for Latin American Studies, University of Utah, Salt Lake City, Utah, USA
[4]Global Change and Sustainability Center, University of Utah, Salt Lake City, Utah, USA
[5]Department of Education, Culture, & Society, University of Utah, Salt Lake City, Utah, USA
[6]Departamento de Biología, Universidad Autónoma de Baja California, Ensenada, Baja California, México
[7]Department of Psychology, University of Arizona, Tucson, Arizona, USA
[8]Department of Geology & Geophysics, University of Utah, Salt Lake City, Utah, USA

*Corresponding author: Eric Schniter, eschniter@gmail.com (email), 714-628-7272 (telephone). ORCID: https://orcid.org/0000-0002-2381-3616

## Abstract

We investigate whether age profiles of ethnobiological knowledge development are consistent with predictions derived from life history theory about the timing of productivity and reproduction. Life history models predict complementary knowledge profiles developing across the lifespan for women and men as they experience changes in embodied capital and the needs of dependent offspring. We evaluate these predictions using an ethnobiological knowledge assessment tool developed for an off-grid pastoralist population, known as *Choyeros*, from Baja California Sur, Mexico. Our results indicate that while individuals acquire knowledge of most dangerous items and edible resources by early adulthood, knowledge of plants and animals relevant to the age and sex divided labor domains and ecologies (e.g., women's house gardens, men's herding activities in the wilderness) continues to develop into middle adulthood but to different degrees and at different rates for men and women. As the demands of offspring accumulate for parents with age, reproductive aged adults continue to develop their knowledge to meet their children's needs. After controlling for vision, post-reproductive adults' show the greatest ethnobiological knowledge. These findings extend our understanding of the evolved human life history by illustrating how changes in embodied capital and the needs of dependent offspring predict the development of men's and women's ethnobiological knowledge across the lifespan.

*Keywords:* Traditional ecological knowledge; ethnobiological knowledge; learning; embodied capital; life history theory; Baja California Sur, México

# Introduction

Life history models predict knowledge profiles developing across the lifespan as organisms learn, grow, reproduce, invest (e.g. nutritionally, educationally) in dependent offspring, and senesce. Debates in anthropology have centered on alternative interpretations of what shapes these age-specific knowledge profiles should take across the lifespan. One view, inspired by general life-history models applied to primate foraging (e.g., Schuppli et al., 2012) suggests that effort allocated to productivity (which includes investments in acquiring knowledge) should increase up until physical maturation and plateau for the remainder of the life course (e.g. see discussion in Kramer & Ellison, 2010). This “wise adults” view suggests that the wisdom of younger adults should be equally developed as that of older adults. A different view, held widely among social scientists is that vocabulary and worldly knowledge, which relies on experience, (what Cattell (1963) called "crystallized intelligence") continues to accumulate past the age of physical maturation, resulting in “wisdom of elders” (Berlin, 1992; Gurven et al., 2017; Koster et al., 2016). Heterogeneity in aging and the experience of stochastic shocks (e.g. injury, illness) contribute to unequal abilities among elders to develop this wisdom, challenging the universality of wise elders claim. Previous studies have reported peak ages for ethnobiological knowledge through a wide range of adult ages: around 30-80 years of age for Mayangna and Miskito forager-horticulturalists of Nicaragua (Koster et al., 2016), around 30-40 years for Djerma farmers, and 40-50 years for Peulh herdsman of Nigeria (Ayantunde et al., 2008).[1]

The embodied capital perspective (Kaplan, 1996) considers (from a biological fitness maximization perspective) how individuals and their parents optimally invest in growing and maintaining the body’s physical capital (e.g. bones, muscles, neurons) and functional capital (e.g. strength and coordination, skill, knowledge). According to embodied capital theory, extreme investments in cognitive capital have led to a human life history pattern of complementary “age appropriate” knowledge profiles developing across the lifespan for women and men as they experience changes in their stocks of embodied capital and demand of their dependent offspring (Del Giudice et al., 2016). This perspective predicts that levels of productivity and childrearing increase through reproductive parent ages when offspring provisioning demands (for both calories and knowledge/experience) are growing (peaking approximately 35-45 years of age), and should remain high until impacted by senescence (e.g. of physical mobility, visual, and hearing systems). We use “age appropriate” to refer to the nuanced view that an older

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[1] Others also report ethnobiological knowledge variation at different ages and across generations (Hewlett et al., 2011; Kline et al., 2013; Ohmagari & Berkes, 1997; Schniter et al., 2015; Zarger & Stepp, 2004; Zent, 2001).

adults' ability to demonstrate knowledge is constrained by their particular abilities (e.g. to see, to move about, to remember), and that there is increasing heterogeneity in these abilities with age.

To gauge ethnobiological knowledge, we evaluate responses to a set of images showing culturally salient plants and animals that we presented to Mexican *Choyeros,* an off-grid arid land pastoralist population whose livelihood has been closely tethered to arid land springs and open rangelands of the Sierra de la Giganta mountains of Baja California Sur for more than 300 years (Cariño Olvera, 2014; Koster et al., 2019). From an evolved life history strategy perspective, we predict how age-appropriate complementary knowledge profiles develop across the lifespan for *Choyero* men and women as they experience changes in embodied capital and the needs of dependent offspring. We report age profiles of *Choyero* ethnobiological knowledge development that are consistent with predictions derived from life history theory. This paper sheds new light on the distribution of ethnobiological knowledge maintained by a relatively isolated and small-scale subsistence society.

## Hypotheses and predictions

We test predictions based on our overarching hypothesis that the time-path of ethnobiological knowledge development corresponds with functional "life goals" and embodied capital constraints specific to each of three stages of the human life course. In the *pre-reproductive life stage* the goals are to: (1) acquire basic skills and knowledge (e.g., ability to recognize and name edible and dangerous plants and animals) to support one's self; and (2) attract and secure a mate, which often involves demonstrating basic competence consistent with the first goal. The goals of the *reproductive life stage* are to (3) reproduce, optimally developing and using skills and knowledge to support reproduction, such that (4) offspring are successfully raised to be able to accomplish pre-reproductive and reproductive goals 1, 2, 3, and 4 (this entails transferring both material resources and *knowledge* to dependents). After reproduction ceases with menopause, additional years of life are needed for the last-born offspring to fully achieve goals 1, 2, 3, and 4. During transition to the *post-reproductive life stage,* adults (5) continue making contributions towards fulfilling kin's goals 1, 2, 3, and 4, despite (and in compensation for limitations related to) age-related senescence. Below we derive several predictions concerning ethnobiological knowledge development across the life course.

**Pre-reproductive life stage.** The pre-reproductive life stage includes gestation, infancy, childhood, adolescence, and ends at first reproduction. During this period, young adults are generally protected, remain relatively free of responsibilities that require great exertion or risk, and are supported by the surplus food production and knowledge provided by older adults (Kaplan, 1994; Kaplan et al., 2000; Lee, 2013; Lee & Kramer, 2002). Social learning of conceptual elements and procedures needed for survival in a subsistence society is well underway during childhood (Hewlett et al., 2011; Kline et al., 2013; Ruddle & Chesterfield, 1977; Stieglitz et al., 2013).

Cross- culturally people name and classify plants and animals - a key to rapid and effective learning (Atran, 1990; Berlin, 1992; Mithen, 2006). What is even more striking is the ease with which some of this knowledge is acquired at young ages – human minds appear to be pre- tuned for acquiring and processing information about certain classes of animals and plants relevant to adaptive challenges in early life stages throughout our evolutionary past (Atran, 1990; Barrett et al., 2016). Below we consider the reasons and evidence for preferential knowledge of plants and animals that are potentially dangerous and/or food.

It is important for youngsters to prioritize acquiring information about dangerous plants and animals without experiencing morbid and mortal hazards first-hand. It appears that children are born with an innate understanding of what distinguishes living from inanimate things and begin learning about plants and animals at the youngest ages (Atran, 1990; Barrett & Behne, 2005; Carey & Spelke, 1994; Keil, 1987, 1994). Infants in the first and second year of life selectively identify plants over artifacts as food sources, but also show a greater reluctance manipulating plants due to the dangers they can pose (Wertz & Wynn, 2014a, 2014b). As an alternative to direct hands-on exploration, infants prefer to learn about plants indirectly by watching or receiving cues from adults (Elsner & Wertz, 2019; Oña et al., 2019). Likewise, cross-cultural evidence shows that children show preferential attention to, learning of, and ability to remember culturally transmitted information about dangerous animals (Barrett & Broesch, 2012).

Over the course of evolutionary history, it was also likely important for youngsters to identify plants and animals as natural sources of food or as competitors for food, the latter of which could present danger (Barrett, 2005; Brantingham, 1998). Though dangerous hazards prevent child foraging opportunities in many ecologies, some children as young as young as 3-5 years of age forage with other children or while accompanying their mothers on foraging trips providing rich opportunities to gain important information about plant and animal dangers (Bird & Bird, 2002; Crittenden et al., 2009; Hewlett, 2017). Brown (1985) has suggested that, given the hazards of agricultural crop and livestock failures, an interest in wild plant and animals that are potential food sources may have been crucial to the survival of small-scale agriculture groups. Others have noted that edible plants and animals are more salient than non-edible things in the minds of horticultural people (e.g., Berlin, 1992; Malinowski, 1925).

During the pre-reproductive life stage ethnobiological knowledge is transmitted via specific social vectors. Vertical transmission of important knowledge and subsistence skills during childhood often comes from same-sex parental figures (Borgerhoff Mulder et al., 2019; Garfield et al., 2016; Reyes-García et al., 2009; Schniter et al., 2015). This vertical transmission pattern promotes information stability over generations, even in the face of sociopolitical, economic, and environmental change (Hewlett & Cavalli-Sforza, 1986; Ohmagari & Berkes, 1997; Zarger & Stepp, 2004). The necessary strength and size needed for coping with dangers, independent performance, and dedicated practice of difficult and physically demanding skills are often undeveloped until after the adolescent growth spurt (Bogin & Smith, 1996), when adult stature is nearly attained and most subsistence skills are finally mastered (e.g., Cain, 1977; Draper, 1976; Ruddle & Chesterfield, 1977). As learning-by-doing continues during adolescence and early adulthood, people often have greater opportunities to work and play alongside peers, learn horizontally from peers, and socialize beyond the nuclear family (Gallois et al., 2017; Hewlett & Cavalli-Sforza, 1986; Reyes-García et al., 2016). Oblique transmission (from older relatives other than parents), often same-sex, is reported to be a dominant mode of ethnobotanical knowledge learning and subsistence skill development after early childhood (Garfield et al., 2016; Reyes-García et al., 2009; Schniter, 2009; Setalaphruk & Price, 2007). A pattern of knowledge acquisitions that includes delays due to physical strength development and due to delayed social opportunities for learning suggests the possibility of continued knowledge development into adulthood (consistent with wisdom of elders and embodied capital model predictions).

*Prediction 1. Knowledge of plants and animals will develop monotonically in the pre-reproductive life stage and children will develop more knowledge of plants and animals that are potentially food and/or dangerous*.

**Reproductive life stage.** The reproductive life stage for females is defined by fertility, spanning from the onset of reproduction to its cessation prior to menopause. During the reproductive stage, a primary goal is maintaining sufficient food production, education, and care to meet the waxing and waning demands of a family of dependents accumulated under a fertility schedule. The embodied capital model proposes that parental and grandparental childcare and support allow children the learning and on-the-job training opportunities in areas of food production, craft production, and childrearing (Kaplan, 1996). Parental costs of provisioning and caring for young are offset by offspring's increasing surplus returns over the long reproductive and post-reproductive lifespan (Kaplan et al., 2000; Robson & Kaplan, 2003).

Maintaining proximity to helpful kin may be important because one's ability to be economically self-sufficient and fully support dependents is often achieved later than sexual maturity (Hill & Hurtado, 2009; Howell, 2010; R. D. Lee, 2013; Marlowe, 2007; Walker et al., 2013). Delayed productivity and downward resource flows among adults means parenting and grand parenting roles will often blend together towards the end of this stage, with adults possibly contributing support to two generations of dependents prior to cessation of the reproductive stage.

During fertile adult years, as the number and net caloric demands of dependents increase within a family, parents and grandparents are faced with greater provisioning and caregiving demands. Children's daily caloric net consumption requirements almost double between early childhood and teenage years (Institute of Medicine, 2002).

When the net caloric demand of dependents is at its highest, adults who rely on subsistence skills produce the greatest amount of food of their life (Gurven & Walker, 2006). During these times of high productivity, adults will also be actively engaged with relevant knowledge. Others have proposed that ethnobiological knowledge appears to develop as a function of time allocated to related tasks (Guest, 2002; Koster et al., 2016; Reyes-García et al., 2013). In general, we expect that performance with knowledge skills related to subsistence (like plant and animal identification and naming) is most needed, most practiced, and thus at highest levels around the time of greatest offspring demand.

With a focus on labor substitution within the household, Bock (2002a, 2002b) suggested that family members make optimal contributions to fitness given their strength and knowledge as a function of age, and differences in energetics of reproduction. From this a sexual division of labor is expected where men and women invest in household and childrearing contributions that complement one another. Over the course of human evolution and across cultures today, starting in early childhood, females typically move through smaller home ranges while males range over significantly larger areas (Gaulin & Hoffman, 1988). In subsistence societies we see evidence of a clear sexual division of labor that affects men's and women's activities in and experience of the environment (Gurven et al., 2012; Kaplan et al., 2009). Plants may be differentially distributed (e.g. near human habitation vs. in the wilderness) and encountered differently by men and women who range across and frequent different environments.[2] Sex differences in men's and women's activities in their respective economic domains could affect reproductive aged adults' exposure to and knowledge of the plants.

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[2] Like plants, animals may also be differentially distributed across environments (e.g. human inhabited vs uninhabited), but potentially less so due to their mobility and movements across environments.

*Prediction 2. Ethnobiological knowledge should continue to develop into reproductive adulthood as parents continue to meet their offspring's burgeoning needs*

*Prediction 3. During the reproductive life stage, ethnobiological plant knowledge relevant to gender associated domains develops to different degrees and at different rates for women and men.*

**Post-reproductive life stage.** The post-fertility period that we call the "post-reproductive life stage" is mostly an extension of the reproductive career. Physical strength that contributes to productive subsistence work is highest earlier in adulthood and declines into later adulthood, a human aging process referred to as sarcopenia (Rosenberg, 1997; Walker et al., 2002; Walker & Hill, 2003). By the seventh decade of life when one's children are all economically self-sufficient, caloric production among subsistence people declines (Amoss & Harrell, 1981; Gurven et al., 2012; Gurven & Kaplan, 2006; Walker & Hill, 2003), food transfers to kin declines (Hooper, 2011; Kaplan et al., 2000), and functional disability increases (Kaplan et al., 2010; Stieglitz et al., 2015). Despite their functional deficits, older adults are often capable of transferring important information to and helping younger kin (Burke & Mackay, 1997; Schniter, 2014). Delayed productivity, extending beyond peak ages of offspring dependency, is consistent with both embodied capital model and grandmother hypothesis (Hawkes, 2003; Hawkes et al., 1989) expectations. While the grandmother hypothesis is a one-sex model of life history evolution that focuses on selection for older females who are grandmothers, the embodied capital model is a two-sex model that predicts both sexes will make important complementary post-reproductive contributions to fitness. For example, by sharing their late life wisdom with close kin.

Late life wisdom is also consistent with a cognitive reserve hypothesis arguing that encephalization of brain tissue, particularly in the cerebral cortex, which is specialized in the storage, retrieval, and processing of experiences, represents an increased investment in the capacity to transfer important information (Parker & McKinney, 2012). Returns from accumulated "cognitive capital", for example via transfers of ethnobiological knowledge (e.g. via applied and communicated knowledge and experience), may show stability with advancing adult age or even increase until the final decade of life (Park et al., 2002; Salthouse, 1993; Schaie, 1994). Thus, conceptual and procedural learning may continue in the post-reproductive life stage, producing wise elders decades after the expected age of peak transfers needed to meet dependents' needs.

Specific physical and cognitive abilities (e.g., strength, hearing, seeing) may decline with age and negatively impact older adults' ability to develop or recall knowledge stored in memory. Overall memory performance is traditionally understood in terms of the concerted functioning of three stages – encoding, storage, and retrieval (Craik & Rose, 2012). The encoding and storage of plant and animal information tends to take place at early ages when people are first exposed to information about them. Retrieval of stored information based on stimulus prompt (e.g. recognizing a seen item which triggers the retrieval of its name) is improved with practice, a process sometimes called "rehearsal" but also consistent with practice and "general use models" predicting knowledge. Age related decrements in ability to correctly name recognized items may reflect inefficiencies of retrieval operations involved in memory but may also reflect age-related changes in activity and experience that affect how older adults interact with memory prompts in their environment. Age-related physical and cognitive declines affect older adults' interaction with the stimulus that facilitates memory.

Finally, visual acuity directly affects how carefully one can recognize encountered items. Recognition affects rehearsal and recall ability. If people are not seeing well, they might not be recognizing things as clearly as when they saw better and therefore have less reason to recall and rehearse their memories (e.g. details and names). Perceptual deterioration reduces recall of specific detail from the encoded record, leading to degraded memory (Craik & Rose, 2012; Schneider & Pichora-Fuller, 2000).

As heterogeneity in physical (Maddox & Clark, 1992; Nelson & Dannefer, 1992) and mental abilities (Ardila, 2007; Christensen et al., 1999) increases at later ages, it reinforces greater specialization in the post-reproductive life stage, with older adults increasingly focusing on skills best suited to their abilities and contribution opportunities. Heterogeneous patterns of aging suggest that while a "wisdom of elders" pattern may not emerge for most or on average, the highest levels of knowledge demonstrated among adults may be differentially represented by a few wise individuals in their post-reproductive years.

*Prediction 4. The highest level of ethnobiological knowledge will be observed among a subset of adults in their post-reproductive years.*

*Prediction 5. Knowledge in gender associated economic domains among post-reproductive adults is explained by visual acuity variation and the different male and female activity patterns in their gender associated economic domains.*

## Methods

Below we present information about our study sample, their biogeographical setting, way of life, and ethnobiological knowledge breadth. We also describe research we conducted that contributed to our knowledge about our sample including their fertility schedules, family budgets, and ethnobiological knowledge.

## Study sample and ecology

Our study was conducted across four ranching communities (Santa Maria de Toris, San Pedro de la Presa, La Higuera, and La Soledad) in the southern Sierra de La Giganta mountain range within the municipality of La Paz, Baja California Sur, México (see Figure 1).

<Insert Figure 1 about here>

**Choyeros.** Approximately 4000 people known as *Choyeros* currently occupy the Sierra de La Giganta (hereafter "*Giganta*") mountain range of Baja California Sur, one of the least populated areas in one of the least inhabited states in Mexico (Comisión Nacional de Areas Naturales Protegidas, 2020). *Choyeros* refer to themselves by this name which roughly means people of the local cholla cactus (*Cylindropuntia cholla*) desert. With the *Giganta* covering approximately 7,400 square kilometers (Leon de La Luz et al. 2008), Choyero population density is about 1 person per 2 square kilometers. These *Choyeros* reside on working ranches distributed over the many drainages found throughout the *Giganta* and most are descended through consanguineal and/or affinal ties from the original Euro-American families who colonized the region over the last 300 years (Koster et al., 2019; Macfarlan et al., 2020). *Choyeros* share culture history with other ranching populations found throughout the peninsula and have been referred to as *rancheros*, *Californios*, or *Oasiana-Rancheros* in the academic literature (Crosby, 2015; Cariño Olvera, 2014).

**Biogeographical setting.** Biogeographically, the *Giganta* is characterized as Sonoran Desert (Shreve & Wiggins, 1964) with sacrocaulescent scrubland vegetation. It has a hot arid climate with most of its rainfall generated by tropical storms and hurricanes occurring during the late summer and early fall (August-October) (INEGI, 2016). The *Giganta* is Baja California Sur's largest mountain range, spanning approximately 150 km along a NW-SE axis (León De La Luz & Coria Benet, 2018). The mountain range is situated in a geological complex known as the Comondú Formation, which is composed of clastic sandstones, volcanic rock, and conglomerates. Although the range is situated more closely to the Gulf of California along its precipitous eastern escarpment, the majority of its surface slopes towards the Magdalena plain in the west, producing a number of intermittent-stream drainages that terminate at the Pacific Ocean. It is along these drainages that a variety of perennial wetlands emerge, either as perched water tables, springs or hanging gardens (Maya et al., 1997; Ruiz-Campos et al., 2014). These wetlands are species rich and diverse (León De La Luz & Domínguez Cadena, 2006; Riemann & Ezcurra, 2005; Ruiz-Campos et al., 2002). The wetlands act as waypoints for resident and migratory species (Erickson et al., 2008; Rodríguez-Estrella, 2005), provide forage and pasture for livestock, and have been making human life possible in this harsh and unforgiving landscape for at least the last 4000 years (Henrickson, 2014; Macfarlan & Henrickson, 2010).

**Cultural adaptation to arid land pastoralism in the Giganta.** *Choyeros* have accommodated the *Giganta*'s hot arid climate and sparse rainfall over the last three centuries by culturally adapting to the perennial springs scattered along mountain drainages (Cariño Olvera, 2001; CONANP, 2014). Any spring able to water a suitable home site creates potential for a *Choyero* ranch. The population maintains many of the productive traditions that were first brought to the region during the Jesuit mission era by the colonists, such as leather working, metal smithing, heritage crop production, and ranching (de Grenade & Nabhan, 2013a, 2013b; Nabhan et al., 2010). Historically and still today, *Choyeros* remain relatively isolated from the larger Mexican society: they are outside the reach of market places, paved roads, mail service, electrical grid, cell-phone networks, potable water systems, sewage, and waste disposal systems (Cariño Olvera, 2001; CONANP, 2014; Crosby, 2015).

The primary subsistence mode is goat and cattle ranching, with an emphasis on meat and cheese production for export by roaming merchants to local and regional markets. The average ranch has four or more people, mostly related as kin extended across multi-generational families. Households may also maintain sheep, pigs, turkeys, chickens, and rabbits for domestic consumption, as well as horses, donkeys, and mules for transportation. Households supplement their diet through the governmental sponsored food program CONASUPO, as well as with food purchased from urban markets found in Las Pocitas, Ciudad Constitución, and La Paz. Near their homes, most ranches maintain *huertas* and/or *jardines*. Huertas are typically tended by adult male and female family members and provide edible foods for the household, as well as feed for domestic livestock (e.g. alfalfa, sorghum). Beyond their collaboration in the *huertas*, *Choyeros* have sex divided labor domains and ecologies that affect the genders' differential exposure to plants (encounters of which vary by ecology). *Jardines* are most often tended by female heads of household and serve important household functions such as providing shade, decorative flowers, culinary herbs, and medicine (e.g. for herbal infusion into teas). When not tending to livestock near the ranch, men are most often tending to livestock in the *campo* or the open-range desert wilderness of the *Giganta*. While *Choyero* children can assist parents with household chores, they do not engage in substantial ranch work outside of the house.

Because they are places where fertile soils and fresh water come together, both *huertas* and *jardines* serve as attractive oases for a variety of plant and animal species. Many *huertas* that were quite important for ranch-level subsistence throughout Baja California's mountains a few generations ago are now less productive, as ranchers have increasingly focused on milk, cheese, and meat production for sale to the market (Cariño Olvera, 2001; Crosby, 2015; de Grenade & Nabhan, 2013a). Aside from market sales and occasional itinerant wage labor, *Choyeros* remain relatively unintegrated into the larger market economy and subsist on yearly incomes that lie below the poverty line (CONAPO, 2010). According to government statistics, *Choyero* ranches are classified as "*muy bajo*" - the indicator of being in Mexico's lowest (poorest and most underdeveloped) socio-economic stratum (SEDESOL, 2010).

Open range lands like those used by *Choyeros* are distinguished by their rugged landscapes and the vast distances traversed, due to the far-reaching mobility of livestock (Huntsinger, 2016). Cattle and goats often travel long distances (>10 miles a day) between elevations, to water and food, and away from harsh weather or to avoid predators. Cattle and goats are able to make use of a wide variety of rangeland plants of low nutritional quality and that may present dangers to other animals and humans. Because food and water are scarce in the arid ranges of the *Giganta*, the ability for livestock to find scarce resources is key to the rancher's success. The movement of livestock is also sometimes under the control of the herder (who depends on wayfinding knowledge to traverse the vast landscape), such as when rounded up and brought back to an enclosure or when moved to greener pasture after a rain. As such, pastoralists who depend on livestock in harsh environments have developed culturally specific subsistence traditions and bodies of knowledge that allow them to both support and control the grazing and reproduction of livestock in otherwise unproductive landscapes (Fernandez-Gimenez & Febre, 2006). For example, *Choyeros* make use of horses, donkeys, and mules that facilitate human travel over these ranges whether ridden or loaded with packs, and herding dogs - that when well-trained can effectively herd livestock without the guidance or instructions of human herders. *Choyeros* have a keen sense of when and where resources can be found the landscape, and when hazards need to be avoided (e.g. high predation rates by coyote and mountain lions during the dry season, flood and storm risks during the summer monsoonal season). Currently, no information exists concerning *Choyero* ecological knowledge variation.

***Choyero* ethnobiological knowledge and school education.** To meet the challenges of becoming competent off-grid ranchers in the Giganta, *Choyeros* acquire, develop, maintain, and transmit a rich body of knowledge about the local ecology associated with springs, gardens, and wild rangeland. This includes knowledge over 1) predators (e.g. coyotes, pumas), 2) vectors for infectious disease (e.g. racoons, skunks), 3) venomous animals (e.g. rattlesnakes, scorpions), 4) poisonous and dangerous plants (e.g., arrowpoison plant, cacti), 5) wild and domesticated plants and animals eaten by humans or livestock and 6) plants and animals for construction, shade, cooking fuel, medicine, ritual, and artisanal crafts. *Choyero* knowledge may also be supplemented by or complemented by education and social exposure gained with schooling.

Educational achievement has been on the rise for the last several decades (INEGI, 2004). Nevertheless, due to economic hardship, costs of transportation and school supplies prevent some *Choyeros* from maximal exposure to education. Families who wish their children to pursue a formal education must send them to public schools for primary, middle-school and high school education. Due to the challenge of transporting children from remote ranches to schoolhouses on a daily basis, a unique feature of the educational system in Baja California Sur is the placement of schools, cafeterias, dormitories, teachers, and social welfare officers in rural locations through the *Coordinación Estatal de Albergues Escolares.* Most children attending school are brought to the school for five days and four overnights a week and then return home every weekend. The *albergues escolares* program established rural schools in La Soledad in 1969 and in Santa Maria de Toris in 1980.

Local history and culture of Baja California Sur is neglected in the school curriculum, which is taught by non-local teachers and features the history and culture of mainland Mexico. Knowledge about the local ecology and about subsistence skills is also not gained directly from a school education. As such, like many of the ranching cultures of Baja California Sur, *Choyeros* are expected to acquire most of their ethnobiological education informally in the social and work contexts of ranch life. This kind of practical ranching knowledge is typically learned from same-sex peers and adults (Cariño Olvera, 2001; Crosby, 2015).

While ethnobiological information is not taught in the schools, there are reasons that educational achievement and ethnobiological knowledge might be related. One possibility is that formal education and experience of nature and subsistence activities are mutually exclusive opportunities for children, such that those who choose to develop their knowledge through scholastic studies do so at the expense of developing their ethnobiological knowledge (Nabhan & St Antoine, 1993; Zent, 2001). However, a mix of both kinds of learning should be possible for *Choyero* children because formal education is coming from non-*Choyeros* in a schoolhouse setting, while ethnobiological education is likely coming from a combination of older kin at home on the ranch and near aged peers (who may be encountered at school). As adolescents and young adults, *Choyeros* might also learn ethnobiological information from *Choyeros* living on other ranches, especially neighbors nearby whom they might see more often. As such, a positive correlation between school education and ethnobiological knowledge may exist if more capable individuals self-select into both achieving more years of education and acquiring more ethnobiological knowledge from others.

### Choyero demographics and fertility

Based on community censuses, we implemented interviews and demographic surveys with 143 heads of household from across 70 ranches in four communities across five field seasons (2014-2018). We used information from these interviews and surveys to determine characteristics of *Choyero* demographics, fertility schedules, and childrearing demands on parents.

**Fertility schedules.** Based on a sample of 46 women across 4 communities (born between 1930 and 2000), the mean female age of first reproduction among *Choyeros* is 22.6 (SD 5). On average, *Choyero* men become fathers by the age of 27 (the average husband is 4.4 (SD 7) years older than his wife). The average fertility schedule of a *Choyero* man is tied to that of his wife, with an interbirth interval (IBI) of 3.9 years and a total fertility rate (TFR) of 3.7 surviving offspring. As such, *Choyero* fertility schedules extend roughly from age 16 to about age 46. See Table 1 for additional details about *Choyero* fertility.

<Insert Table 1 about here>

**Childrearing demands on parents.** We estimated the parent ages at which dependent offspring impose peak dependency (for food and essential information) on parents based on a cumulative model of relative costs from generalizable features of human nutritional demand schedules across the pre-reproductive life stage (per Institute of Medicine, 2002) and estimated fertility schedules based on the Choyero IBIs and TFR reported in Table 1. According to this model, the average *Choyero* mother aged 40-45 (and her husband of expected age 44.4-49.4) is at peak dependency of 3.7 expected offspring younger than age 20 (two of them adolescents and one a very young adult).

Among *Choyeros*, offspring that remain at natal ranches maintain net dependency (consuming more than they produce) until they marry and start living more independently - typically after age 20. *Choyero* last-borns will often remain dependent until their mother is in her sixties. Young *Choyero* parents tend to live in close proximity to and are affiliated with older kin from whom they receive support (Crosby, 2015)

Consistent with the estimates above for parent ages at peak offspring dependency, our sampling at the household level from across 70 ranches indicates that the number of co-resident dependent offspring (around an average of 2) relying on a head of household is greatest for heads of household in the 35-45 year-old age range (see Figure 2). The number of dependent offspring observed for heads of households of a given age is always less than the number of expected offspring because a large proportion of our sample included adults with no coresident dependents.

<Insert Figure 2 about here>

## Choyero ethnobotanical lexicon

In 2015, two authors (SJM & JJG) asked 46 heads of households from 28 ranches (n-males=29; n-females=17; Mean Age=52 years) within one community (Santa Maria de Toris) to free-list plants and animals they associated with *Giganta* spring ecosystems to develop an initial lexicon for discussing ecosystem knowledge. This free-list task identified an initial set of  218 animals and 201 plants. Following the free-list task, the researchers, along with a focus group of 10 adults (seven males, three females; Mean Age=43 years; Min/Max Age=21/74 years) from four ranches, linked the emic plant and animal terms with the Linnaean classification system (i.e. Family, genus, and species) using photos and descriptions from botanical and faunal field guides (i.e., Grismer, 2002; Howell & Webb, 1995; Kays & Wilson, 2009; León De La Luz & Coria Benet, 2018; Rebman et al., 2012; Rodd et al., 2007; Wiggins, 1980). Furthermore, this focus group clarified that certain plants and animals were referred to by multiple emic terms. Based on this information, we obtained from this focus group, using a process of consensus, the term that was most likely to be used amongst the ranching community. We noted and consolidated these terms. Occasionally, a plant description could not be linked to a field guidebook photo. As such, we asked the focus group to find examples of the plant for us to photograph. These photos were then sent to botanical experts at the Red Butte Garden at the University of Utah, the San Diego Natural History Museum, and from the Departamento de Biología at the Universidad Autónoma de Baja California, who assisted with linking the photo to its associated Linnaean classification. Three plant species could not be reconciled, resulting in a final set of 162 plant and 125 animal species. Of these 287 species, 72 plants and 50 animals were included in our ethnobiological assessment task (described below).

## Plant and animal categorizations

In May 2016, two key informants (1 male and 1 female) suggested to two authors (SJM and JJG) that the consolidated list of 162 plants mentioned above could be categorized according to where the plants are found: *jardines*, *huertas*, or in the *campo*. Using a process of consensus, the two key informants provided their assessments (45 *jardin* plants; 18 *huerta* plants; 99 *campo* plants).

In June 2018, four authors (SJM, ES, JJG, and DGB) employed surveys about plant and animal uses with heads of households from 38 ranches from three communities (Santa Maria de Toris, La Higuera, & San Pedro de La Presa), as part of our larger project on *Choyero* ethnobiological knowledge. In these surveys we asked participants to enumerate plants and animals which conform to a number of use categories, two of which we report on here ("human plant comestibles"(food), "dangerous plants and animals"(danger)). For our purposes, a plant item was considered "food" if a single respondent identified it as such and provided its preparation for consumption. Respondents provided 210 unique plant concepts, 60 of which were identified as human food. We then linked these reports of food uses to our initial plant database. Of the 87 plants shown in our ethnobiological assessment task (described below), 27 were categorized as "food" (see Appendix A). Of the 50 animals shown in the ethnobiological assessment task, we also categorized five (i.e., three species of birds, a jack rabbit, and a fish) as "food", based on reports and evidence that these were eaten. Among a subset of these ranches (n-ranches=3) we also asked participants to enumerate dangerous plants and animals. Respondents provided examples of 10 dangerous plants and 5 dangerous animals along with common reasons for their danger: poisonous sap, sharp thorns, dangerous and potentially disease transmitting bite. Based on these dangerous features we categorized 28 items as dangerous: 7 cacti, 7 shrubs and trees with thorns or toxicity, 14 predatory or disease transmitting animals (see Appendix A).

## Ethnobiological knowledge assessment task

In 2017 and 2018, seventy-one individuals (33 females and 38 males) aged 5 to 86 years old from 40 ranches across three communities (Santa Maria de Toris: n = 55; La Higuera: n = 5; and La Soledad: n = 11) were presented an ethnobiological knowledge assessment task (see Table 2 for sample characteristics). As a first step of the task, individuals took a vision acuity test using "tumbling E" eye charts presented on a laptop computer, a robust and easy to use diagnostic tool that is practical for populations with innumerate or analphabetic participants (Messina & Evans, 2006). From this test we derived a visual acuity score (ranging from 1 to 11). A higher score indicates better visual acuity. Visual acuity across the sample was 10.6 on average (SD=0.77, min=6 max=11) on the 1-11 scale (Table 2). The ethnobiological knowledge assessment task presented a sequence of 137 slides on a laptop computer featuring images of 87 plants and 50 animals (Appendix A). The set of plants and animals used in our ethnobiological knowledge assessment task was informed by the ethnobiological research methods described above and selected based on the availability of clear and representative photographs.

<Insert Table 2 about here>

The order of items presented was varied with about half of participants seeing items in reversed order. Assessments of ethnobiological knowledge were conducted in Spanish in the privacy of individual homes and occurred as part of a larger set of household interviews regarding ranching demography and lifestyles. These household interviews additionally informed us of individuals' educational achievement, their ranch affiliation, and community membership. For each of 137 plant and animal images presented in sequence, the researcher (ES) asked the participant whether they recognize the item in the image. If the participant answered affirmatively, the researcher asked the follow-up question about what the item is called. Responses were recorded and coded "correctly named" if matching any of the locally appropriate culturally correct names used for species identification (see Macfarlan et al., 2020).

**Analytic models**

Our analytic models are performed using STATA/IC 16.1 (Rabe-Hesketh & Skrondal, 2012). We investigate ethnobiological knowledge with two-stage logistic regression models. In the first stage of these models we predict an individual's ability to recognize $R_i$ a plant or animal item shown to them ($R_i$ $e$quals 1 if item $i$ is recognized and zero otherwise). In the second stage, we predict an individual's ability to correctly name $C_i$ a recognized plant or animal item ($C_i$ $e$quals 1 if item $i$ is named correctly and zero otherwise).

Multiple individuals may reside at the same ranch, so we nest the outcome variable at both the level of the individual and the ranch. As such, we employ multi-level logistic regressions, whereby we use an exchangeable variance-covariance structure at the level of the individual and ranch. Furthermore, we employ robust standard errors for all fixed effects in all models. We assess 6 classes of models of ethnobiological knowledge: 1) a model that examines knowledge across all life stages; 2) a model that examines knowledge of food and or dangerous items (relative to all other investigated items) across all life stages; 3) a model that exams sex differences in knowledge of *jardin* plants only; 4) a model that exams sex differences in knowledge of *campo* plants only; 5) a model of sex differences in *jardin* plant knowledge for post-reproductive adults only; 6) a model of sex differences in *campo* plant knowledge for post-reproductive adults only. For the age ranges of *pre-reproductive* (< 23 years), *reproductive* (23 to 45 years), and *post-reproductive* (> 45 years) life stages demarcated in or bounding the models, we used the observations of *Choyero* life stage tendencies detailed in the **Fertility schedules** subsection above.

Where appropriate for each class of model, we specify the results of the following co-variates: age (in years), age squared, sex (1=male, 0=female), visual acuity or *vision* (scored 1 to 11), educational achievement or *education* (in years), and whether the item is potential food and/or danger or not (1=food or danger; 0=Other). All models presented in this study can be replicated using the associated STATA DO and Data files provided as electronic supplementary materials.

## Results

Original data of this study are available at Mendeley Data (Schniter et al., 2020). Although the scope of our research is to understand how factors associated with specific life stage moments affect ethnobiological knowledge, we first consider the variables generated by our ethnobiological knowledge assessment task. Across all ages, most participants recognized the majority of plant ($M$ = 71.0%) and animal ($M$ = 85.9%) items presented, but fewer were able to correctly name those plant ($M$ = 42.6%) and animal ($M$ = 59.0%) items according to local nomenclature. 63.54% of all recognized items were correctly named.

By life stage, we see that pre-reproductive individuals (3 females and 4 males) correctly named an average of 30.8% species, reproductive adults (11 females and 15 males) correctly named an average of 52.7% species, and post-reproductive adults (19 females and 19 males) correctly named an average of 49.0% species. Appendix B presents additional details about ethnobiological knowledge among the full sample, males, and females in each of the three life stages studied (i.e. pre-reproductive, reproductive, and post-reproductive). Below we begin with a review of our results across all life stages. We then follow with attention to how ethnobiological knowledge develops across the age ranges associated with *pre-reproductive*, *reproductive*, and *post-reproductive* life stages.

### What explains knowledge across all life stages?

We fit a two-stage model of ethnobiological knowledge across all life stages. This allows our results to be compared to previous work on the topic (e.g., Koster et al., 2016) and portrays the overall development of knowledge across the life course within our sample. We find that reported recognition of plant and animal species takes a quadratic, concave shape over the life course (Age: Odds Ratio = 1.1; $p < .001$; Age Squared: Odds Ratio = 0.99; $p < .001$) and that better visual acuity is associated with improved ability to recognize (Odds Ratio = 1.50; $p <$

.001) (Table 3 Model (1)). Educational achievement has no effect on recognition (Odds Ratio = 1.02; $p = .41$) and the difference between males' and females' recognition is not significant (Odds Ratio = 1.17; $p = .19$) (Table 3 Model (1)). We find that the ability to correctly name recognized species takes a quadratic, concave shape over the life course (Age: Odds Ratio = 1.1; $p < .001$; Age Squared: Odds Ratio = 0.99; $p < .001$) and that better visual acuity is associated with improved ability to correctly name (Odds Ratio = 1.20; $p = .032$) (Table 3 Model (1), Figure 3). Educational achievement has no effect on correct naming (Odds Ratio = 1.00; $p = .87$) and males correctly name recognized species more than females (Odds Ratio = 1.20; $p = .03$) (Table 3 Model (1)).

<Insert Table 3 about here>

<Insert Figure 3 about here>

## What explains ethnobiological knowledge in the pre-reproductive life stage?

To evaluate whether the rates of ethnobiological knowledge development in pre-reproductive individuals are continuously increasing yet different for species that are potentially dangerous and food (compared to those that are not), we employ a two stage model of ethnobiological knowledge across all life stages. Despite predicted effects in our models, we observed no variation in vision for participants in the pre-reproductive life stage. We find that recognition of plant and animal species continuously increases during the pre-reproductive life stage (Age: Odds Ratio = 1.11; $p < .001$; Age Squared: Odds Ratio =0.99; $p < .001$) and that recognition of dangerous and/or food species increases at more than twice the rate than for non-dangerous and non-food species (Odds Ratio = 2.05, $p < .001$) (Table 3 Model (2)).

We also find that the ability to correctly name recognized species continuously increases during the pre-reproductive life stage (Age: Odds Ratio = 1.11; $p < .001$; Age Squared: Odds Ratio =0.99; $p < .001$) and that correct naming of dangerous and/or food species increases by 80 percent compared to non-dangerous and non-food species (Odds Ratio = 1.80, $p < .001$) (Table 3 Model (2), Figure 4). On average, knowledge of dangerous and/or food species is greater during the pre-reproductive life stage, with 42.65% of these species correctly named compared to the 20.78% of other species. While rates of this knowledge acquisition change across the lifespan, the greater knowledge of food and dangerous species than for other species studied is evident across all life stages (Appendix B, Figure 4).

<Insert Figure 4 about here>

## What explains ethnobiological knowledge in the reproductive life stage?

Results of our estimated family budgets suggest that parents face growing offspring needs at least until the end of the reproductive lifestage when offspring demands may be highest, and that those demands fade but can continue for decades after, stretching into parents' post-reproductive years. To evaluate whether the rates of ethnobiological knowledge development in reproductive adults are continuously increasing as parents continue to meet their offspring's burgeoning needs, we first focus on trends in the reproductive lifestage revealed by our models of ethnobiological knowledge development across the lifespan (Table 3 Models (1) and (2)). Despite predicted effects in our models, we observed no variation in vision for participants in the reproductive life stage. These models both reveal that correct naming of plant and animal species continuously increases with younger adult ages such that the highest levels of correctly named species occur at the end of the reproductive life stage (Figures 3 and 4), when offspring demands are highest.

During the reproductive life stage, females correctly name 61.4% of *jardin* plants compared to males who correctly name 44.6%, while males correctly name 49.4% of *campo* plants compared to females who correctly name 36.0% (Appendix B). To assess the role of age and gender on *jardin* and *campo* plant knowledge in the reproductive lifespan we use two multi-level two-stage logistic regression models. For brevity, we report only results of the second stage of these models (3) and (4) in text, concerning the ability to correctly name recognized *jardin* plants and *campo* plants, respectively (see Table 4 for complete model results). Our first model shows that males correctly name substantially fewer *jardin* plants than females do (Odds Ratio = 0.55; *p* < .001) (Table 4, Model (3)). Our second model shows that males correctly name more *campo* plants than females do (Odds Ratio = 1.5; < .001) (Table 4, Model (4)). These models show that, overall and relative to their opposite gender, being a reproductive aged female improves the probability of knowing plants associated with house gardens by 45%, while being a reproductive aged male improves the probability of knowing plants associated with herding activities by 50% (Figures 5 and 6).

<Insert Table 4 about here>

<Insert Figures 5 and 6 about here>

### What explains ethnobiological knowledge in the post-reproductive life stage?

Post-reproductive adults are most representative of the top decile of ethnobiological knowledge in our sample, occupying seven out of eight of the highest ranks for recognizing and correctly naming plants and animals. The ages of these most expert adults in the top decile ranged from 46 to 63 with a mean age of 53. On average, post-reproductive adults correctly name 49.0% of plants and animals, while reproductive adults correctly name 52.7% (Appendix B).

During the post-reproductive life stage, females correctly name 50.0% of *jardin* plants compared to males who correctly name 35.4%, while males correctly name 44.3% of *campo* plants compared to females who correctly name 35.5% (Appendix B). Compared to earlier lifestages in our sample that have no variation in visual acuity, post reproductive adults show the greatest variation in visual acuity (min=6, max=11).

To evaluate whether the rates of ethnobiological knowledge in post-reproductive adults are predicted by visual acuity, age, sex, and gender-associated economic domains, we employ a pair of multi-level two-stage logistic regression models that consider only adults in the post-reproductive lifespan (Table 5 Models (5) and (6)). These models examine male and female knowledge of *jardin* and *campo* plants. For brevity, we report only results of the second stage of these models (5) and (6) in text, concerning male and female abilities to correctly name recognized *jardin* plants and *campo* plants (see Table 5 for complete model results).

We find that sex (Odds Ratio = 0.53; *p* = .001) is a significant predictor of correctly naming *jardin* plants, even after controlling for age (Odds Ratio = 0.96; *p* = .01) and visual acuity (Odds Ratio = 1.46; *p* = .023), with post-reproductive females able to name more house garden plants than post-reproductive males (Table 5 Model (5)). Among post-reproductive adults, we do not find an effect of sex (Odds Ratio = 1.27; *p* = .09) on correctly naming *campo* plants, after controlling for age (Odds Ratio = 0.97; *p* = .01) and visual acuity (Odds Ratio = 1.38; *p* = .01) (Table 5 Model (6)). While the average proportion of *campo* plants correctly named by women does not change between reproductive and post-reproductive life stages, the portion of *campo* plants correctly named by males declines, with post-reproductive aged adults naming 10.3% fewer *campo* plants than younger reproductive aged adults (calculated from life stage proportions reported in Appendix B).

<Insert Table 5 about here>

## Discussion

We investigated whether age profiles of *Choyero* ethnobiological knowledge development are consistent with predictions derived from life history theory about the timing of productivity and reproduction. We see evidence of age-appropriate complementary knowledge profiles developing for *Choyero* men and women as they experience changes in embodied capital and needs of dependent offspring. We find that while individuals acquire knowledge of most dangerous items and edible resources by early adulthood, knowledge of plants and animals relevant to the age and sex divided labor domains and ecologies (e.g., women's house gardens, men's herding activities in the wilderness) develops into middle adulthood but to different degrees and at different rates for women and men. Across our models, we see peak predicted ethnobiological knowledge for men and women aged 5-60, near the ages at which parents experience the greatest demand from dependent offspring, bearing support for a "wisdom of adults" view of ethnobiological knowledge development.

A widespread "wisdom of elders" view has been that highest levels of ethnobiological knowledge should be found among post-reproductive older adults generally (Koster et al., 2016). When we consider the top decile of most knowledge *Choyeros* sampled, we find that almost all of these experts are post-reproductive aged adults ranging in age from 46 to 63 – bearing support for a nuanced "wisdom of elders" view of ethnobiological knowledge development. On the other hand, average rates of recognition and correct naming for reproductive adults are higher than for post-reproductive adults, challenging a "wisdom of elders" view. Our study resolves this apparent paradox by showing the effects of vision on ethnobiological knowledge, and the possible effects of reduced activity by males in the *campo* on their knowledge of *campo* plants (contributing to ethnobiological knowledge). The effects of sensory acuity (vision and hearing) on intelligence among older adults are large; after controlling for age and hearing, Lindenberger and Baltes (1994) found that vision accounts for 43% of the variance in intelligence among a sample of older adults. Additional cognitive and physiological measures affecting men and women's activities in their economic domains might explain additional variance in ethnobiological knowledge and should be considered for future research on older adult knowledge. If individuals are unable (e.g. due to vision limitations and perhaps other limitations like difficulty hearing or immobility) to effectively recognize and talk about specific plant or animal examples being referred to with a visual examples, they are severely incapacitated in their ability to reliably transmit knowledge about those things. While these age-associated limitations may prevent many older adults from reliably transmitting ethnobiological knowledge, a small subset of older adults appear to be differentially advantaged with better abilities to function as ethnobiological experts. Experts can be of great cultural value and of great value with conservation efforts, as we discuss below.

Conservation biologists (e.g., León de la Luz & Domínguez Cadena, 2006; Riemann & Ezcurra, 2005; Rodríguez-Estrella, 2005) and non-governmental agencies (e.g. World Wildlife Fund) have implicated rancher lifestyles as primary vectors for *Giganta* ecosystem decline, suggesting ignorance of the local ecology, but those conclusions are typically drawn from non-representative samples in areas of relatively high population densities or vehicular traffic that tend to be more depleted of biodiversity. Elsewhere, in natural protected areas of Baja California Sur, conservation biologists have suggested that local ranchers' environmental traditional knowledge is of value for developing conservation, sustainable use, and local economic development policies (Pío-León et al., 2017). Our own partnerships leveraging local *Choyeros* ethnobiological has led to novel findings regarding species range extensions (MacFarlan et al., 2019). Our research shows that, as a group, *Choyero* ranchers embody a great distributed body of ethnobiological knowledge: they generated for us a vast inventory of 287 known plants and animals and provided detail about various names used to refer to those species and species traits and uses that are important to their way of life. While there is substantial variability in ecological knowledge among *Choyero* ranchers, most are knowledgeable of most items in our ethnobiological knowledge assessment tool by adulthood – meaning they have, at minimum, the necessary visual recognition ability (to trigger memory of having seen the plant or animal item before) and semantic memory (to recall the appropriate lexicon by which people refer to the item specifically) to indicate knowledge of the species. Furthermore, a few experts are highly knowledgeable of almost all items in our tool's set. In aggregate, our ethnobiological lexicon results, species classification results, and the analytic results of models predicting knowledge of species included in the ethnobiological knowledge assessment task are important evidence of the rich ethnobiological knowledge that *Choyeros* maintain. As primary stakeholders whose economic and cultural livelihoods have been tethered to arid land springs over the last 300 years, it is possible that *Choyero* knowledge and social institutions either support or can be leveraged to improve the goal of long-term *Giganta* ecosystem sustainability. For example, their detailed understanding of the biota and its natural occurrence can facilitate cost-effective biological inventory programs seeking to identifying species presence-absence, abundance, distributions, range extensions, or introductions (Berkes et al., 2000).

That reproductively and post-reproductively aged *Choyero* women and men maintain separate but complementary ethnobiological knowledge fits both the literature on the evolution of the sexual division of labor in humans generally (e.g. Gurven et al., 2012; Macfarlan, 2016), as well as the human ecology of the *Giganta*, specifically. In the *Giganta*, ranches are typically established in valley bottoms on level ground near springs. Because springs and flat terrain occur in a sporadic fashion throughout this region, ranches can be separated by large distances from one another. This has caused households to become highly independent (Crosby 2015). In response, women and men have developed distinct divisions of labor and associated knowledge to support autarkic household functioning. Although this produces strongly gendered economic domains, there is a complementarity to gender dynamics within *Choyero* communities, whereby people explicitly recognize the value of each gender's role in household economics. Among *Choyeros*, men's greater knowledge of *campo* plants compliments women's greater knowledge of *jardin* plants during the reproductive life stage, and while women retain their relative advantage in *jardin* knowledge into post-reproductive years, men lose a relative advantage in *campo* knowledge – possibly associated with declining exposure to species in the campo with advancing post-reproductive years.

## Limitations and future prospects

We discuss limitations to our study method and results. Our methods to capture a portrait of ethnobiological knowledge development across the life course are based on cross-sectional sample design, rather than longitudinal study. Cross-sectional sample design may not correctly reveal the path of knowledge development if secular changes might differentially affect the life stage cohorts (e.g. educational opportunity has improved since at least 1980). We controlled for possible effects of educational achievement on ethnobiological knowledge across our full sample and found no effect. Our analyses also reveal that substantial differences in ethnobiological knowledge exists at the ranch level, however ranches have also changed over the past century. Future research on pastoralist ethnobiological knowledge should carefully investigate whether ranch-level differences may be associated with economic differentiation between households, distance from neighbors, and different family histories in the *Giganta*.

Our set of items presented for visual identification may not provide the most appropriate representations of the actual items and may not be adequately characterizing the breadth of species knowledge essential for ranching. The color photographs we presented of items were assembled from images opportunistically gathered from a variety of personal and publicly available plant photo archives. An alternative approach for visual identification is to present participants controlled transects or a collection of specimens (both of which present practical challenges for permitting, and for controlling quality and reliable stability of over time) (e.g., see Begossi, 1996; Zarger & Stepp, 2004). Visual identification and naming tasks are commonly used methods for investigating knowledge but there are others (some of which we also used) that reveal dimensions of ethnobiological knowledge including questionnaire (pile sort, multiple choice, free-listing), semi-structured interview, and observation (Reyes-García et al., 2007). Missing from this report on *Choyero* ethnobiology is related knowledge about insects, fungi, and knowledge about agriculture, animal husbandry, weather, hydrology (e.g. of local springs), and geology.

Last, interpretation of survey results from older adult respondents as evidence of their ethnobiological "knowledge" necessitates careful consideration of the difficulty in lexical access that many older adults experience, which may be distinct from their ability to see and recognize, recall familiarity with, and produce knowledge of the species example (Craik, 1998; Grady & Craik, 2000). Word-finding failures increase with age (Burke et al., 1991), and almost all elderly people experience increased difficulty in retrieving proper names for recognized things (Cohen & Burke, 1993). While we rely on knowledge revealed by participants in response to questions on our survey, we have no measure of how people view one another's contributions or expertise. We also have no independent measure of subsistence ability to directly correlate with knowledge as others did (Koster et al., 2016; Reyes-García et al., 2007; Schniter et al., 2018). While we fall short of providing a comprehensive measure of ethnobiological knowledge based on a full range of complimentary methods, we leverage a mix of ethnobiological research methods that contributed to a detailed study of the ability to name recognized plants and animals across the lifecourse. From this study we can draw several conclusions about characteristics of the evolved human life history.

## Conclusion

This research represents an important contribution to the literature on ethnobiological knowledge among a small-scale subsistence population, since pastoralism (practiced by *Choyeros*) is the subsistence mode least represented in this literature (Reyes-García et al., 2007). Furthermore, the research highlights the ethnobiological knowledge of an understudied culture that is feared to be in rapid decline (Crosby 2015). With this research we also provide a new test of the embodied capital model hypothesis that the life course of ethnobiological knowledge development is shaped by the changing risks, capabilities, and wisdom of individuals with age and experience (Del Giudice et al., 2016), and the changing needs of the family budget (Bock, 2002a, 2002b; Crittenden et al., 2013; Gurven & Kaplan, 2006; Schniter et al., 2015). As adults become grandparents and advance through their post-reproductive years, a number of physical and sensory declines reduce the profitability of various types of economic activities. In response to these declines, older adults are expected to shift their efforts towards low-strength yet knowledge-intensive service niches (Schniter et al., 2018). The knowledge required to know what plants and animals look like (to recognize them) and what recognized plants and animals are called (according to culturally correct names) bears characteristics making it optimal for continued development over the life course: these forms of knowledge require extensive learning and facilitate communication for teaching about features of the local ecology, supporting the childrearing, subsistence goals, and conservation efforts distributed within and between multi-generational familial groups.

## Declarations

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Conflicts of interest/Competing interests: We have no conflicts of interest to declare.

Availability of data and material (data transparency): Raw data for this study is available at *Mendeley Data* https://doi.org/10.17632/hgd8zdyf2c.1

Ethics approval: All procedures were in accordance with the ethical standards of the Declaration of Helsinki and the University of Utah Human Research Ethics Committee (approval number IRB 00083096)

Consent to participate: Informed consent was obtained from all adult individuals included in this study. Both child assent and parental permission were obtained for all child participants included in this study.

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Table 1. *Choyero* reproductive demographics.

| | N | Mean (SD) | Median | Min, Max |
|---|---|---|---|---|
| Age at first birth (years) among women | 53 | 22.6 (5) | 22 | 15, 42 |
| IBI* between offspring 1 & 2 (days) | 43 | 1335(761) | 1190 | 224/2985 |
| IBI between offspring 2 & 3 (days) | 33 | 1565(1108) | 1307 | 244/4204 |
| IBI between offspring 3 & 4 (days) | 19 | 1719(1688) | 896 | 367/6768 |
| IBI between offspring 4 & 5 (days) | 7 | 864(728) | 661 | 314/2466 |
| IBI between offspring 5 & 6 (days) | 6 | 1530(1736) | 649 | 377/4822 |
| IBI between offspring 6+ (days) | 4 | 809(538) | 656 | 342/1586 |
| IBI All (days) | 112 | 1430(1125) | 1044 | 224/6768 |
| Total fertility rate among women[1] | 27 | 3.7(2) | 3 | 1/9 |

[*] IBI: Interbirth intervals.

[1] Total fertility was based on our sample of women who were older than 45 years.

Table 2. *Choyero* ethnobiological knowledge sample characteristics for full sample (all), females, and males.

| | N | Mean (SD) | Median | Min, Max |
|---|---|---|---|---|
| **Full sample** | **71** | | | |
| Age | 71 | 46.6 (17.73) | 48 | 5, 86 |
| Visual acuity | 71 | 10.6 (0.77) | 11 | 6, 11 |
| Educational achievement (years) | 71 | 5.0 (3.71) | 6 | 0, 12 |
| **Females** | 33 | | | |
| Age | 33 | 47.3 (18.33) | 49 | 5, 79 |
| Visual acuity | 33 | 10.5 (0.97) | 11 | 6, 11 |
| Educational achievement (years) | 33 | 4.6 (3.39) | 6 | 0, 10 |
| **Males** | 38 | | | |
| Age | 38 | 45.8 (17.42) | 45.5 | 16, 86 |
| Visual acuity | 38 | 10.7 (0.53) | 11 | 9, 11 |
| Educational achievement (years) | 38 | 5.3 (3.98) | 6 | 0, 12 |

Table 3. Two stage multi-level logit regression model coefficients associated with *Choyero* ethnobiological knowledge.

| | Model | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **(1)** | | | | **(2)** | | | |
| | B (RSE) [1] | OR (RSE)[2] | *z* | *p* | B (RSE) [1] | OR (RSE)[2] | *z* | *p* |
| **DV: Recognized**[3,4] | | | | | | | | |
| Age (years) | 0.097(0.02) | 1.10(0.02) | 4.9 | <.001 | 0.100(0.02) | 1.11(0.02) | 4.9 | <.001 |
| Age Squared (years) | -0.001(0.0002) | 0.99(0.0002) | -4.3 | <.001 | -0.001(0.0002) | 0.99(0.0002) | -4.7 | <.001 |
| Visual Acuity | 0.410(0.11) | 1.50(0.17) | 3.7 | <.001 | 0.460(0.12) | 1.59(0.2) | 3.9 | <.001 |
| Education (years) | 0.023(0.028) | 1.02(0.03) | 0.8 | .41 | | | | |
| Sex Male (=1) | 0.160(0.12) | 1.17(0.14) | 1.3 | .19 | | | | |
| Food or Danger (=1) | | | | | 0.720(0.05) | 2.05(0.1) | 13.6 | <.001 |
| Constant | -5.400(1.4) | 0.005(0.006) | -4.0 | <.001 | -6.100(1.5) | 0.01(0.003) | -4.1 | <.001 |
| **DV: Named**[5,6] | | | | | | | | |
| Age (years) | .0930(0.016) | 1.10(0.02) | 5.9 | <.001 | 0.097(0.01) | 1.11(0.02) | 7.1 | <.001 |
| Age Squared (years) | -0.001(0.00019) | 0.99(0.0002) | -4.9 | <.001 | -0.001(0.0001) | 0.99(0.0001) | -6.5 | <.001 |
| Visual Acuity | 0.150(0.07) | 1.20(0.08) | 2.1 | .032 | 0.190(0.06) | 1.20(0.07) | 3.1 | .002 |
| Education (years) | 0.003(0.018) | 1.00(0.02) | 0.2 | .87 | | | | |
| Sex Male (=1) | 0.160(0.07) | 1.20(0.08) | 2.2 | .03 | | | | |
| Food or Danger (=1) | | | | | 0.580(0.05) | 1.80(0.09) | 11.7 | <.001 |
| Constant | -3.190(0.089) | 0.04(0.04) | -3.6 | <.001 | -3.900(0.8) | 0.02(0.02) | -4.7 | <.001 |

[1] OR(RSE): Odds Ratio (Robust Standard Errors); [2] B(RSE): Unstandardized coefficient (Robust Standard Errors)

[3] Model 1 Wald $X^2$ = 46.6; n observations = 9,727; n ranches = 40; N individuals = 71; $p$ < .0001; Random effects estimates of estimated standard deviation in the intercept on the logit scale (and its standard error) include Ranch= 0.09(0.09) and Ego = 0.4(0.2)

[4] Model 2 Wald $X^2$ = 266.4; n observations = 9,727; n ranches = 40; N individuals = 71; $p$ < .0001; Random effects estimates of estimated standard deviation in the intercept on the logit scale (and its standard error) include Ranch = 0.01(0.01) and Ego = 0.4(0.2)

[5] Model 1 Wald $X^2$ = 113.1; n observations = 7,435; n ranches = 40; N individuals = 71; $p$ < .0001; Random effects estimates of estimated standard deviation in the intercept on the logit scale (and its standard error) include Ranch = 0.03(0.03) and Ego = 0.8(0.3)

[6] Model 2 Wald $X^2$ = 181.7; n observations = 7,435; n ranches = 40; N individuals = 71; $p$ < .0001; Random effects estimates of estimated standard deviation in the intercept on the logit scale (and its standard error) include Ranch = 0.05(0.03) and Ego = 0.8(0.3)

Table 4. Two stage multi-level logit regression model coefficients associated with *Choyero* ethnobiological plant knowledge.

| | Model | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **(3 Jardin Plants)** | | | | **(4 Campo Plants)** | | | |
| | B (RSE) [1] | OR (RSE)[2] | *z* | *p* | B (RSE) [1] | OR (RSE)[2] | *z* | *p* |
| **DV: Recognized**[3,4] | | | | | | | | |
| Age (years) | 0.09 (0.02) | 1.09(0.03) | 3.6 | <.001 | 0.09(0.02) | 1.1(0.02) | 4.2 | <.001 |
| Age Squared (years) | -0.001(0.0003) | 0.99(0.0003) | -3.5 | <.001 | -0.001(0.0002) | 0.99(0.0002) | -3.9 | <.001 |
| Visual Acuity | 0.410(0.11) | 1.74(0.3) | 3.7 | <.001 | 0.5(0.1) | 1.6(0.02) | 3.7 | <.001 |
| Sex Male (=1) | -0.6 (0.20) | 0.55(0.09) | -3.7 | <.001 | 0.3 (0.2) | 1.4(0.2) | 2.1 | .04 |
| Constant | -6.2 (1.8) | 0.002(0.004) | -3.4 | .001 | -6.4(1.6) | 0.002(0.003) | -3.9 | <.001 |
| **DV: Named**[5,6] | | | | | | | | |
| Age (years) | .1(0.03) | 1.13(0.03) | 4.7 | <.001 | 0.1(0.02) | 1.11(0.02) | 5.5 | <.001 |
| Age Squared (years) | -0.001(0.0003) | 0.99(0.0003) | -4.6 | <.001 | -0.001(0.0002) | 0.99(0.0002) | -4.7 | <.001 |
| Visual Acuity | 0.3(0.1) | 1.37(0.2) | 2.9 | .004 | 0.2(0.1) | 1.2(0.1) | 4.2 | .08 |
| Sex Male (=1) | -0.6(0.1) | 0.55(0.07) | -4.4 | <.001 | 0.4(0.1) | 1.5(0.1) | 4.2 | <.001 |
| Constant | -5.1(1.5) | 0.006(0.009) | -3.5 | <.001 | -4.2(1.2) | 0.02(0.02) | -3.5 | <.001 |

[1] OR(RSE): Odds Ratio (Robust Standard Errors); [2] B(RSE): Unstandardized coefficient (Robust Standard Errors)

[3] Model 3 Wald $X^2 = 30.1$; n observations = 2,556; n ranches = 40; N individuals = 71; $p < .0001$; Random effects estimates of estimated standard deviation in the intercept on the logit scale (and its standard error) include Ranch= 0.2(0.09) and Ego = 0.3(0.1)

[4] Model 4 Wald $X^2 = 31.7$; n observations = 3,7673; n ranches = 40; N individuals = 71; $p < .0001$; Random effects estimates of estimated standard deviation in the intercept on the logit scale (and its standard error) include Ranch = 0.05(0.01) and Ego = 0.5(0.2)

[5] Model 3 Wald $X^2 = 31.1$; n observations = 1,893; n ranches = 40; N individuals = 71; $p < .0001$; Random effects estimates of estimated standard deviation in the intercept on the logit scale (and its standard error) include Ranch = 0.1(0.06) and Ego = 0.1(0.06)

[6] Model 4 Wald $X^2 = 78.5$; n observations = 2,575; n ranches = 40; N individuals = 71; $p < .0001$; Random effects estimates of estimated standard deviation in the intercept on the logit scale (and its standard error) include Ranch = 7.84e-32(5.47e-31) and Ego = 0.2(0.06)

Table 5. Two stage multi-level logit regression model coefficients associated with *Choyero* post-reproductive ethnobiological plant knowledge.

| | Model | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **(5 Jardin Plants)** | | | | **(6 Campo Plants)** | | | |
| | B (RSE) [1] | OR (RSE)[2] | *z* | *p* | B (RSE) [1] | OR (RSE)[2] | *z* | *p* |
| **DV: Recognized**[3,4] | | | | | | | | |
| Age (years) | -0.03 (0.02) | 0.97(0.01) | -2.2 | .027 | -0.03 (0.01) | 0.97(0.01) | -2.2 | .03 |
| Visual Acuity | 0.6(0.2) | 1.8(0.3) | 3.5 | <.001 | 0.5(0.1) | 1.69(0.2) | 3.7 | <.001 |
| Sex Male (=1) | -0.7 (0.3) | 0.48(0.1) | -2.5 | .012 | 0.2 (0.3) | 1.21(0.3) | 0.7 | .048 |
| Constant | -2.5 (1.7) | 0.08(0.1) | -1.5 | .15 | -2.8 (1.6) | 0.068(0.1) | -1.8 | .08 |
| **DV: Named**[5,6] | | | | | | | | |
| Age (years) | -0.04 (0.01) | 0.96(0.01) | -2.6 | .01 | -0.03 (0.01) | 0.97(0.01) | -2.6 | .01 |
| Visual Acuity | 0.4(0.2) | 1.46(0.2) | 2.3 | .023 | 0.3(0.1) | 1.38(0.2) | 2.5 | .01 |
| Sex Male (=1) | -0.6 (0.3) | 0.53(0.1) | -2.4 | .015 | 0.2 (0.1) | 1.27(0.2) | 1.7 | .09 |
| Constant | -1.0 (1.4) | 0.4(0.5) | -0.7 | .47 | -1.4 (1.0) | 0.26(0.3) | -1.3 | .19 |

[1] OR(RSE): Odds Ratio (Robust Standard Errors); [2] B(RSE): Unstandardized coefficient (Robust Standard Errors)

[3] Model 5 Wald $X^2$ = 18.1; n observations = 1,368; n ranches = 26; N individuals = 38; $p$ = .0004; Random effects estimates of estimated standard deviation in the intercept on the logit scale (and its standard error) include Ranch= 0.17(0.1) and Ego = 0.4(0.1)

[4] Model 6 Wald $X^2$ = 19.4; n observations = 2014; n ranches = 26; N individuals = 38; $p$ = .0002; Random effects estimates of estimated standard deviation in the intercept on the logit scale (and its standard error) include Ranch = 0.1(0.01) and Ego = 0.5(0.2)

[5] Model 5 Wald $X^2$ = 12.2; n observations = 972; n ranches = 26; N individuals = 38; $p$ = .00067; Random effects estimates of estimated standard deviation in the intercept on the logit scale (and its standard error) include Ranch = 0.3(0.3) and Ego = 0.2(0.3)

[6] Model 6 Wald $X^2$ = 18.5; n observations = 1348; n ranches = 26; N individuals = 38; $p$ = .0003; Random effects estimates of estimated standard deviation in the intercept on the logit scale (and its standard error) include Ranch = 0.2(0.09) and Ego = 0.03(0.05)

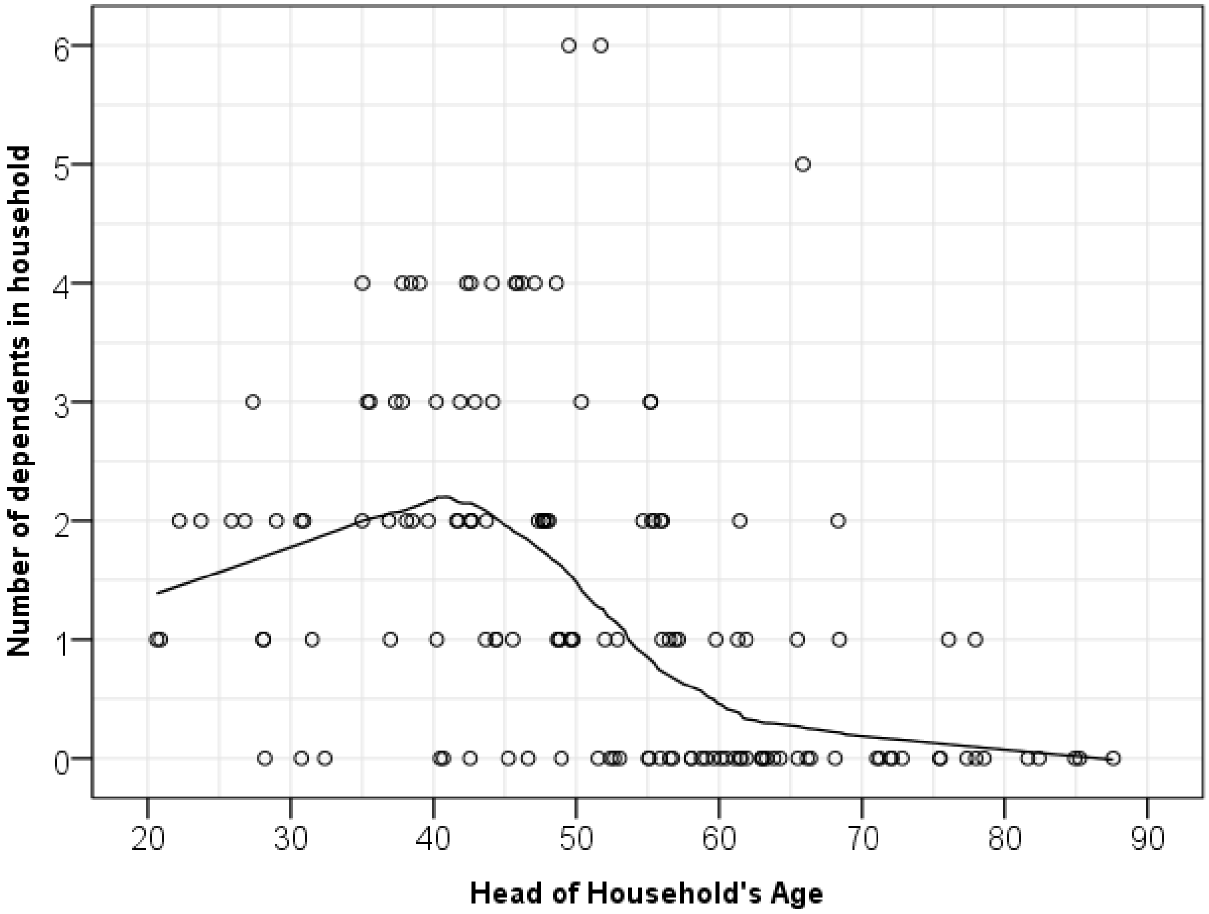
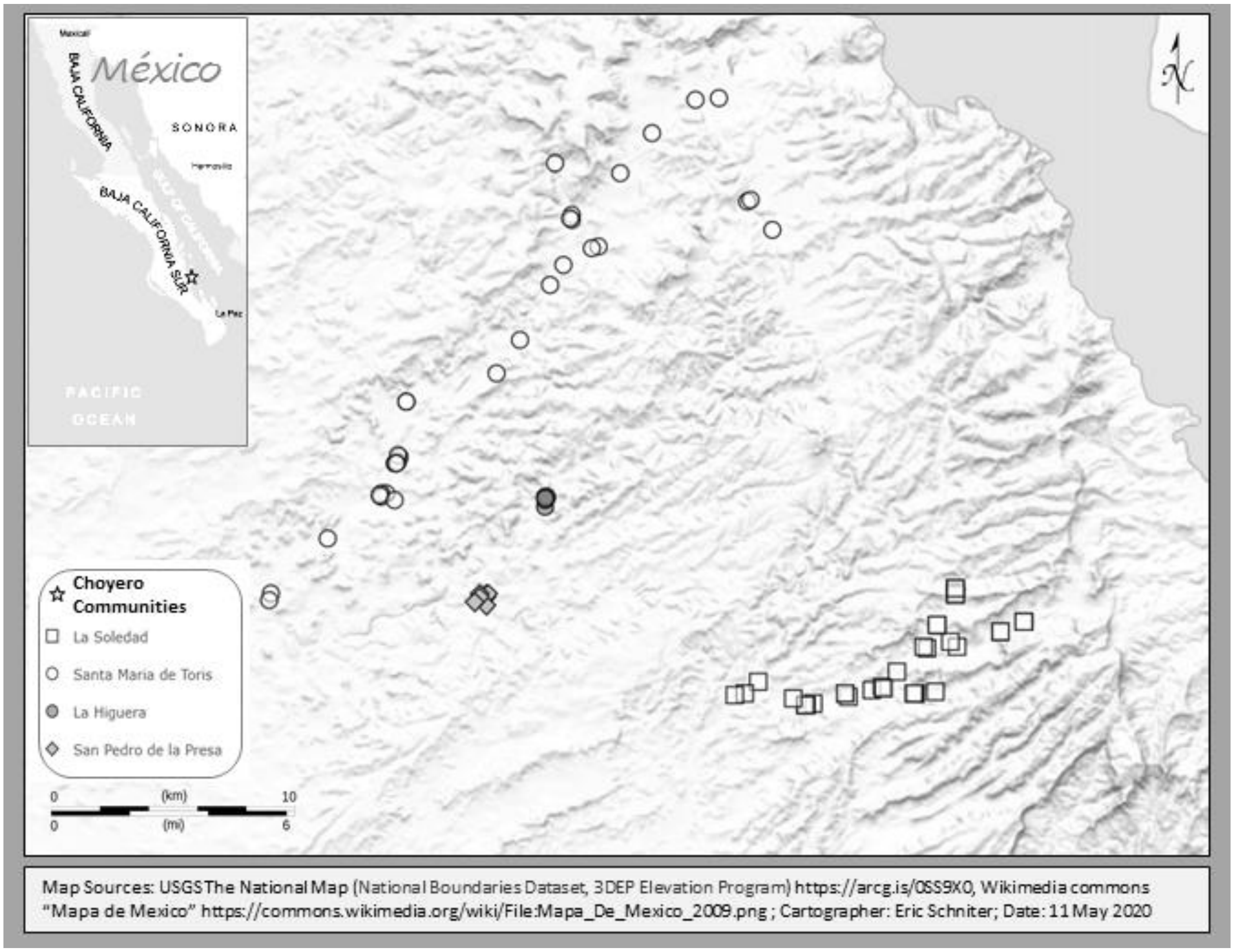


**Figure 1.** Loess smooth lines (50% fit) showing number of dependent offspring for each *Choyero* head of household (n = 143).



Map Sources: USGS The National Map (National Boundaries Dataset, 3DEP Elevation Program) https://arcg.is/0SS9X0, Wikimedia commons "Mapa de Mexico" https://commons.wikimedia.org/wiki/File:Mapa_De_Mexico_2009.png ; Cartographer: Eric Schniter; Date: 11 May 2020

**Figure 2.** *Choyero* ranches and communities in the southern Sierra de La Giganta of Baja California Sur, México

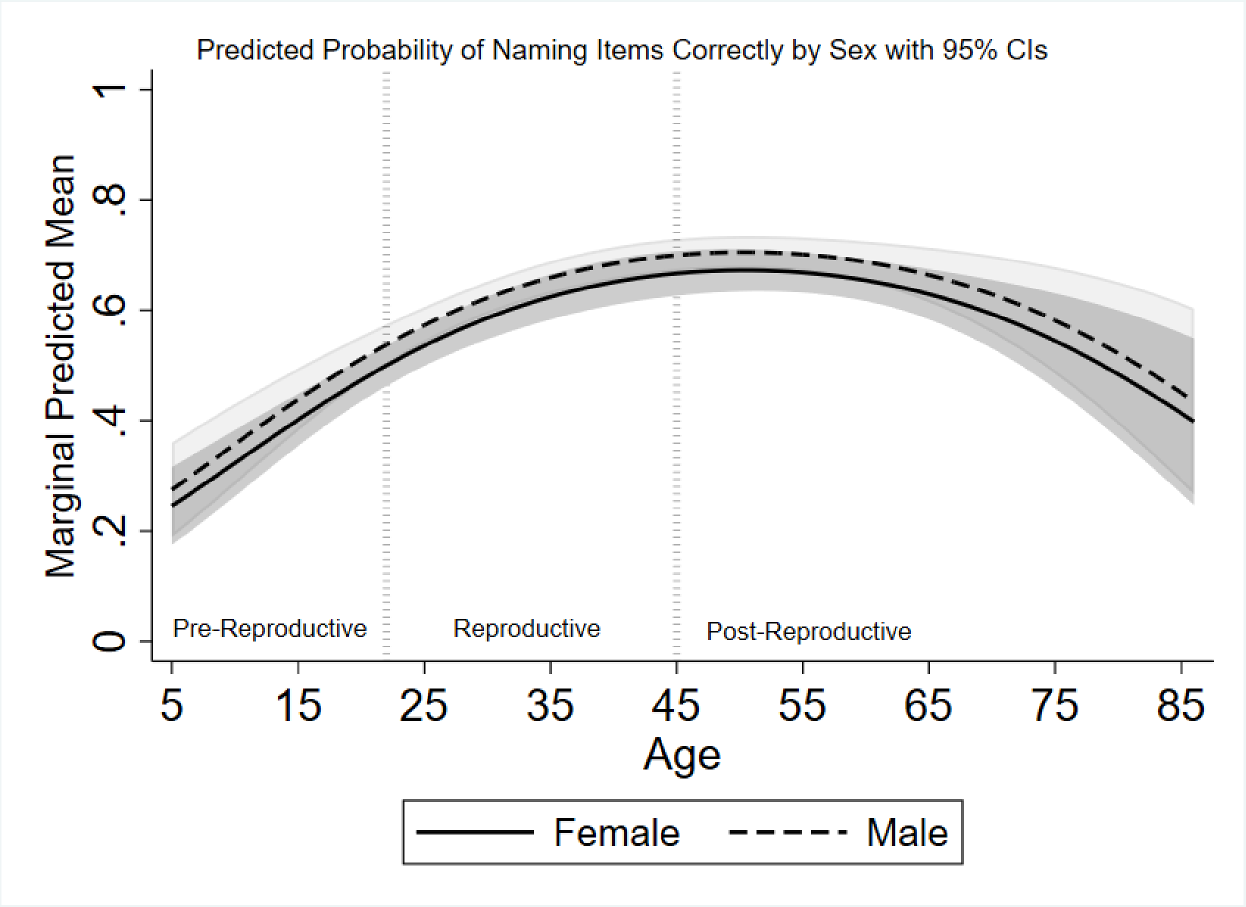


**Figure 3.** The predicted *Choyero* ability to correctly name plant and animal species is extracted from the regression model and plotted as a function of age, age square, sex, visual acuity, and education, with random effects for data nested at the level of ranches and individuals.

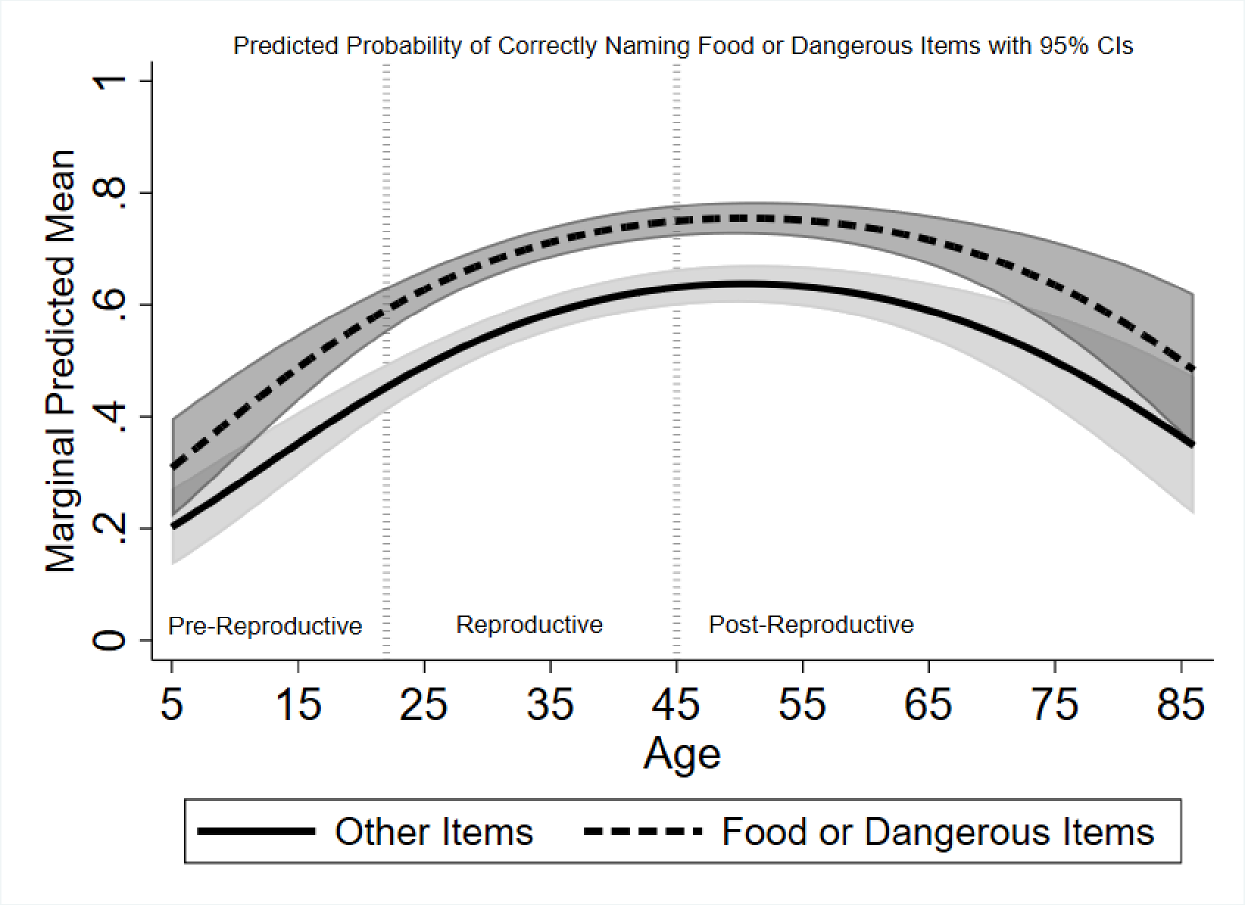


**Figure 4.** The predicted *Choyero* ability to correctly name plant and animal species is extracted from the regression model and plotted as a function of age, age square, visual acuity, and whether or not the species were potentially food and/or dangerous, with random effects for data nested at the level of ranches and individuals.

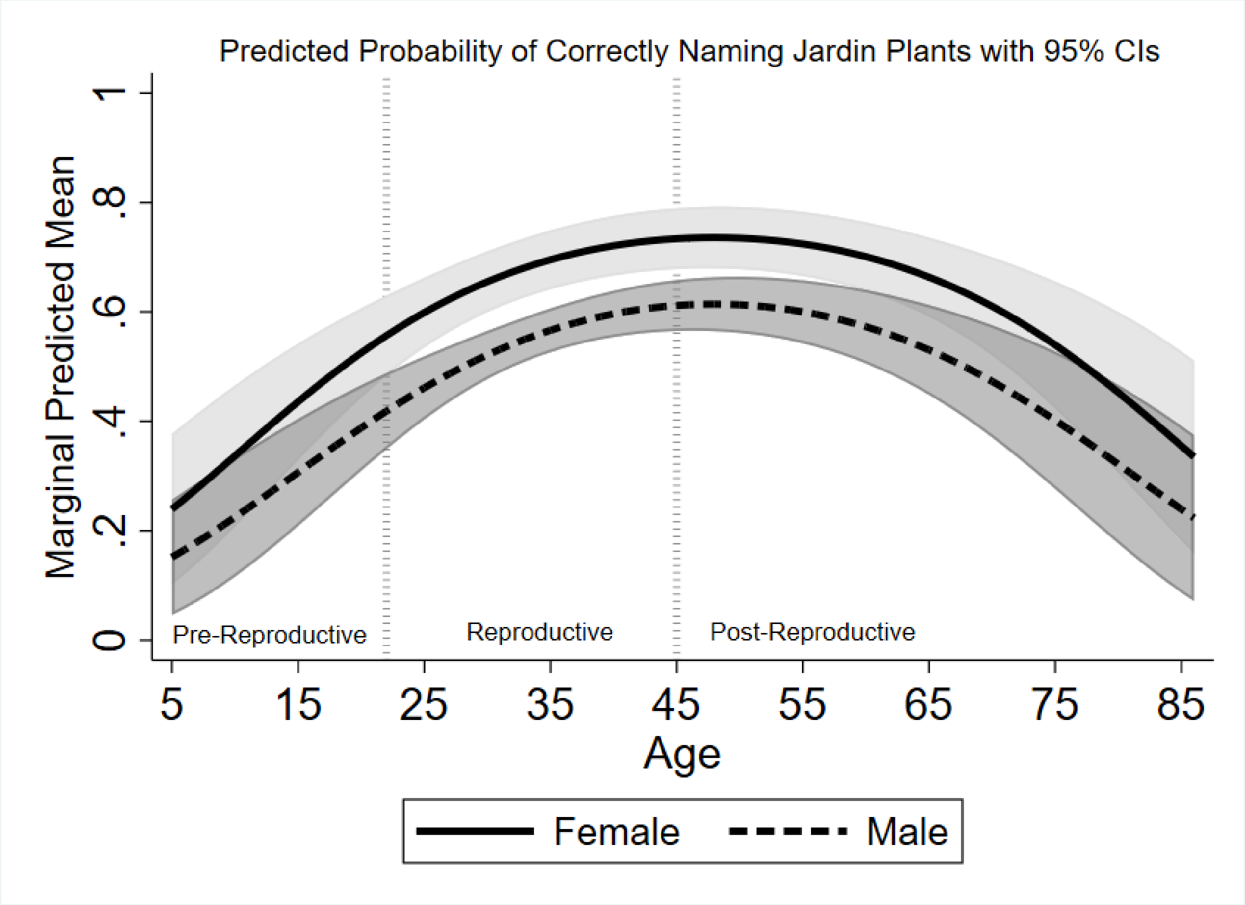


**Figure 5.** The predicted *Choyero* ability to correctly name house garden (*jardin*) plants is extracted from the regression model and plotted as a function of age, age square, sex, and visual acuity, with random effects for data nested at the level of ranches and individuals.

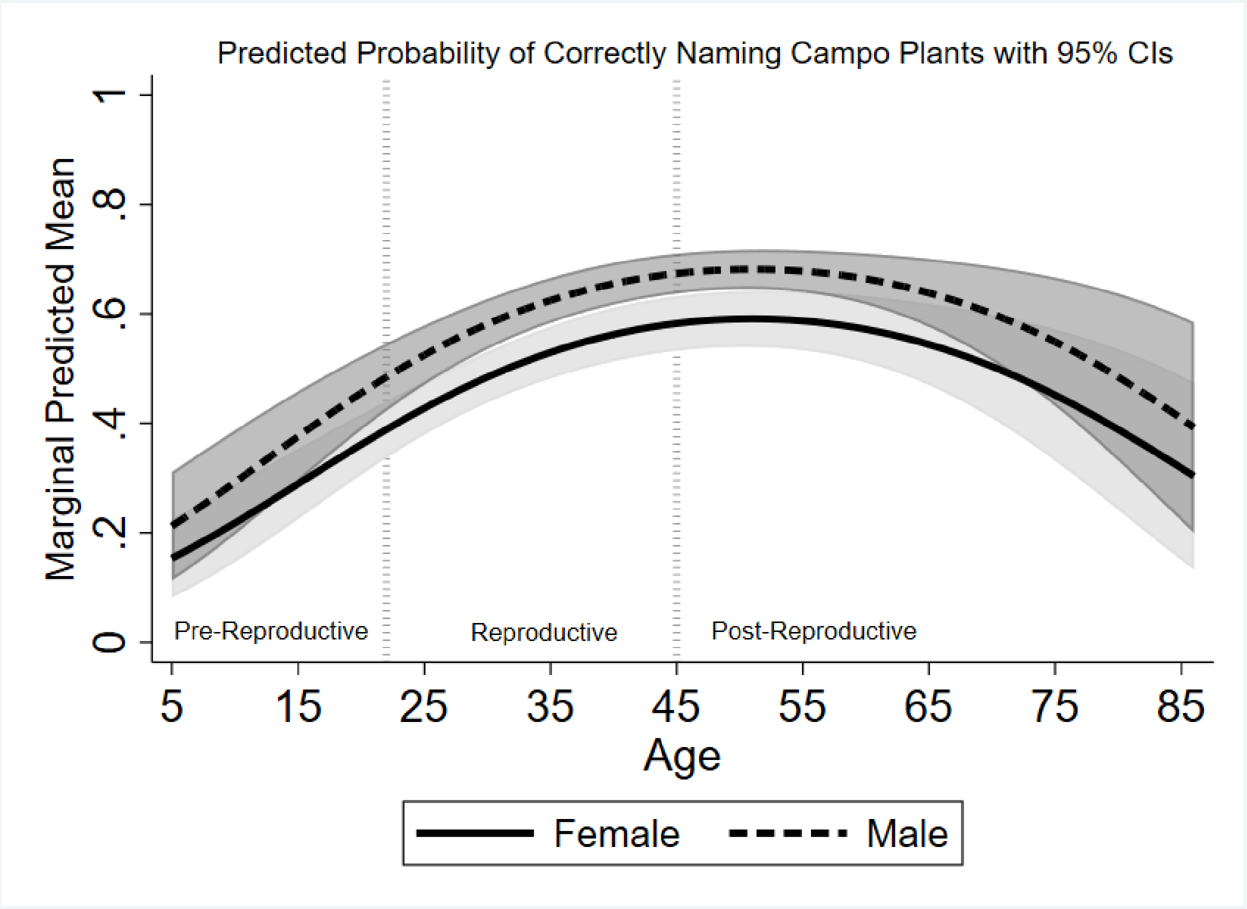


**Figure 6.** The predicted *Choyero* ability to correctly name wild (*campo*) plants is extracted from the regression model and plotted as a function of age, age square, sex, and visual acuity, with random effects for data nested at the level of ranches and individuals.

# Appendix A.

Note: For the “tumbling E” eye chart used to assess visual acuity and the original stimulus in the Ethnobiological Knowledge Assessment Tool consisting of 137 slides showing the images of plants and animals listed in the table below, see Schniter, E., Macfarlan, S. J., & Garcia, J. J. (2020). Choyero ethnobiological knowledge survey. *Mendeley Data, 1*. https://doi.org/10.17632/hgd8zdyf2c.1

Table 7. Plants and animals in the Ethnobiological Knowledge Assessment Tool.

| Item # | Family | *Genus* | *species* | Choyero common names | Plant=1 Animal=0 | Food =1 | Danger =1 | *Jardin* =1 | *Huerta* =1 | *Campo* =1 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Arecaceae | *Phoenix* | *dactylifera* | Datil, Mata de Datil; Datiles; Palma de Datil | 1 | 1 | 0 | 1 | 1 | 0 |
| 2 | Moraceae | *Ficus* | *carica* | Higo, Higuera | 1 | 1 | 0 | 1 | 1 | 0 |
| 3 | Myrtaceae | *Psidium* | *guajava* | Guayabo(a) | 1 | 1 | 0 | 1 | 1 | 0 |
| 4 | Fabaceae | *Tamarindus* | *sp.* | Tamarindo | 1 | 1 | 0 | 1 | 1 | 0 |
| 5 | Rosaceae | *Prunus* | *persica* | Durazno | 1 | 1 | 0 | 1 | 1 | 0 |
| 6 | Rutaceae | *Casimiroa* | *edulis* | Zapote (Amarillo o Blanco) | 1 | 1 | 0 | 1 | 1 | 0 |
| 7 | Rutaceae | *Citrus* | *sinensis* | Naranja(o) | 1 | 1 | 0 | 1 | 1 | 0 |
| 8 | Rutaceae | *Citrus* | *aurantium* | Naranja amarga (agria) | 1 | 1 | 0 | 1 | 1 | 0 |
| 9 | Rutaceae | *Citrus* | *limon* | Limón real, Limón | 1 | 1 | 0 | 1 | 1 | 0 |
| 10 | Rutaceae | *Citrus* | *medica* | Cidra, Limón agrio | 1 | 1 | 0 | 1 | 1 | 0 |
| 11 | Oleaceae | *Olea* | *europaea* | Olivo, Aceituna | 1 | 1 | 0 | 1 | 1 | 0 |
| 12 | Passifloraceae | *Passiflora* | *ligularis* | Granadilla, Granada china, Rosal de pasion, Maracuya | 1 | 1 | 0 | 1 | 1 | 0 |
| 13 | Rosaceae | *Prunu* | *armeniaca* | Chabacano, Alberechigo, Albericoque, Manzano | 1 | 1 | 0 | 1 | 1 | 0 |
| 14 | Fabaceae | *Pithecellobium* | *dulce* | Guamuchil, Mesquite con pechita dulce, Roscas | 1 | 1 | 0 | 1 | 1 | 0 |
| 15 | Fabaceae | *Prosopis* | *palmeri* | Palo fiero; Palo Hierro | 1 | 0 | 0 | 0 | 0 | 1 |
| 16 | Fabaceae | *Olneya* | *tesota* | Uña de gato | 1 | 0 | 1 | 0 | 0 | 1 |
| 17 | Fouquieriaceae | *Fouquieria* | *diguetii* | Palo Adan | 1 | 0 | 1 | 0 | 0 | 1 |
| 18 | Euphorbiaceae | *Jatropha* | *cuneata* | Matacora | 1 | 0 | 0 | 0 | 0 | 1 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 19 | Acanthaceae | *Ruellia* | *californica peninsularis* | Rama parda | 1 | 0 | 0 | 0 | 0 | 1 |
| 20 | Burseraceae | *Bursera* | *epinnata* | Copal Blanco | 1 | 0 | 0 | 0 | 0 | 1 |
| 21 | Fabaceae | *Acacia* | *farnesiana* | Huizache | 1 | 0 | 1 | 0 | 0 | 1 |
| 22 | Cactaceae | *Stenocereus* | *gummosus* | Pitaya agria | 1 | 1 | 1 | 0 | 0 | 1 |
| 23 | Fabaceae | *Mimosa* | *distachya* | Garabatillo | 1 | 0 | 1 | 0 | 0 | 1 |
| 24 | Fabaceae | *Parkinsonia* | *microphylla* | Lipua | 1 | 0 | 1 | 0 | 0 | 1 |
| 25 | Fabaceae | *Parkinsonia* | *praecox* | Palo brea | 1 | 0 | 1 | 0 | 0 | 1 |
| 26 | Rhamnaceae | *Colubrina* | *viridis* | Palo colorado | 1 | 0 | 0 | 0 | 0 | 1 |
| 27 | Anacardiaceae | *Cyrtocarpa* | *edulis* | Ciruela de campo/monte | 1 | 1 | 0 | 0 | 0 | 1 |
| 28 | Cochlospermaceae | *Amoreuxia* | *palmatifida* | Saya | 1 | 1 | 0 | 0 | 0 | 1 |
| 29 | Anacardiaceae | *Pachycormus* | *discolor* | Copalquin | 1 | 0 | 0 | 0 | 0 | 1 |
| 30 | Asteraceae | *Baccharis* | *salicifolia* | Guatamote | 1 | 0 | 0 | 0 | 0 | 1 |
| 31 | Zygophyllaceae | *Larrea* | *tridentata* | Gobernadora | 1 | 0 | 0 | 0 | 0 | 1 |
| 32 | Polygonaceae | *Antigonon* | *leptopus* | San Miguel | 1 | 0 | 0 | 0 | 0 | 1 |
| 33 | Anacardiaceae | *Mangifera* | *indica* | Mango | 1 | 1 | 0 | 1 | 1 | 0 |
| 34 | Convolvulaceae | *Merremia* | *aurea* | Yuca | 1 | 0 | 0 | 0 | 0 | 1 |
| 35 | Moraceae | *Ficus* | *palmeri* | Higuera cimarona, Higuera silvestre, Zalate | 1 | 1 | 0 | 0 | 0 | 1 |
| 36 | Euphorbiaceae | *Sebastiania* | *bilocularis* | Hierba de flecha | 1 | 0 | 1 | 0 | 0 | 1 |
| 37 | Fabaceae | *Calliandra* | *californica* | Tabardillo | 1 | 0 | 0 | 0 | 0 | 1 |
| 38 | Cactaceae | *Cylindropuntia* | *molesta var. clavellina* | Ciribe, Caribe, Clavellina, Clavin | 1 | 0 | 1 | 0 | 0 | 1 |
| 39 | Euphorbiaceae | *Adelia* | *brandegeei* | Pimientilla | 1 | 0 | 0 | 0 | 0 | 1 |
| 40 | Asteraceae | *Ambrosia* | *ambrosioides* | Chicura | 1 | 0 | 0 | 0 | 0 | 1 |
| 41 | Geraniaceae | *Geranium* | *spp.* | Geranio | 1 | 0 | 0 | 1 | 0 | 0 |
| 42 | Asteraceae | *Amauria* | *rotundifolia* | Manzanilla | 1 | 0 | 0 | 1 | 0 | 0 |
| 43 | Fabaceae | *Aeschynomene* | *nivea Brandegee* | Vara prieta | 1 | 0 | 0 | 0 | 0 | 1 |
| 44 | Cactaceae | *Mammillaria* | *albicans* | Viejito, "Chiltipin" | 1 | 1 | 1 | 0 | 0 | 1 |
| 45 | Apocynaceae | *Vallesia* | *glabra* | Huitatave, Hutatave | 1 | 1 | 0 | 0 | 0 | 1 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 46 | Malvaceae | *Hibiscus* | *spp.* | Obelisco | 1 | 1 | 0 | 1 | 0 | 0 |
| 47 | Typhaceae | *Typha* | *domingensis* | Tule | 1 | 0 | 0 | 0 | 0 | 1 |
| 48 | Portulacaceae | *Portulaca* | *grandiflora* | Amore, Hielitos | 1 | 0 | 0 | 1 | 0 | 0 |
| 49 | Lamiaceae | *Coleus* | *blumei* | Brocado | 1 | 0 | 0 | 1 | 0 | 0 |
| 50 | Simmondsiaceae | *Simmondsia* | *chinensis* | Jojoba | 1 | 0 | 0 | 0 | 0 | 1 |
| 51 | Solanaceae | *Solanum* | *hindsianum* | Mariola | 1 | 0 | 0 | 0 | 0 | 1 |
| 52 | Rubiaceae | *Randia* | *capitata* | Palo santo, papache | 1 | 1 | 0 | 0 | 0 | 1 |
| 53 | Nolinaceae | *Nolina* | *palmeri var. brandegeei* | Datilillo | 1 | 0 | 0 | 0 | 0 | 1 |
| 54 | Krameriaceae | *Krameria* | *bicolor* | Mesquitillo | 1 | 0 | 0 | 0 | 0 | 1 |
| 55 | Rutaceae | *Esenbeckia* | *flava* | Palo amarillo | 1 | 0 | 0 | 0 | 0 | 1 |
| 56 | Fabaceae | *Delonix* | *regia* | Arbol del fuego, Tabachin, Tabachina | 1 | 0 | 0 | 1 | 0 | 0 |
| 57 | Saururaceae | *Anemopsis* | *californica* | Hierba de manso | 1 | 0 | 0 | 0 | 0 | 1 |
| 58 | Stixaceae | *Forchhammeria* | *watsonii* | Palo San Juan | 1 | 0 | 0 | 0 | 0 | 1 |
| 59 | Asteraceae | *Tagetes* | *spp.* | Cenpasuchil, Cempasuchil, Tenpasuchil, Tempasuchil | 1 | 0 | 0 | 1 | 0 | 0 |
| 60 | Sapotaceae | *Sideroxylon* | *occidentale* | Bebelama | 1 | 0 | 0 | 0 | 0 | 1 |
| 61 | Euphorbiaceae | *Jatropha* | *vernicosa* | Lomboy sangrengado, Lomboy rojo | 1 | 0 | 0 | 0 | 0 | 1 |
| 62 | Euphorbiaceae | *Euphorbia* | *lomelii* | Candelilla, Liga, Periquito de Amor, Periquito, Perrico | 1 | 0 | 0 | 0 | 0 | 1 |
| 63 | Euphorbiaceae | *Euphorbia* | *pulcherrima* | Noche buena | 1 | 0 | 0 | 1 | 0 | 0 |
| 64 | Anacardiaceae | *Schinus* | *molle* | Pirul | 1 | 0 | 0 | 0 | 0 | 1 |
| 65 | Malpighiaceae | *Callaeum* | *macropterum* | Gallineta | 1 | 0 | 0 | 0 | 0 | 1 |
| 66 | Cactaceae | *Echinocereus* | *brandegeei* | Pitayita, Casa de Ratas | 1 | 0 | 1 | 0 | 0 | 1 |
| 67 | Asteraceae | Gazania | spp. | Solecito, Novia del Sol, Muchacho del Sol | 1 | 0 | 0 | 1 | 0 | 0 |
| 68 | Fabaceae | *Senna* | *covesii* | Hojasen | 1 | 0 | 0 | 0 | 0 | 1 |
| 69 | Apocynaceae | *Catharanthus* | *roseus* | Terecita | 1 | 0 | 0 | 1 | 0 | 0 |
| 70 | Asteraceae | *Encelia* | *farinosa* | Incensio, Incienso | 1 | 0 | 0 | 0 | 0 | 1 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 71 | Oleaceae or Fabaceae | *Ligustrum* or *Clitoria* | *japonicum* or *ternatea* | Manga de niño | 1 | 0 | 0 | 1 | 0 | 0 |
| 72 | Liliaceae | *Lilium* | *spp.* | Lirio, Asuzena | 1 | 0 | 0 | 1 | 0 | 0 |
| 73 | Cannaceae | *Canna* | *spp.* | Platanillo, Mariposa | 1 | 0 | 0 | 1 | 0 | 0 |
| 74 | Aizoaceae | *Trianthema* | *portulacastrum* | Verdolaga, Verdolaga de cochi | 1 | 1 | 0 | 0 | 0 | 1 |
| 75 | Asteraceae | *Ambrosia* | *camphorata* | Estafiete, Estafiate | 1 | 0 | 0 | 0 | 0 | 1 |
| 76 | Convolvulaceae | *Ipomoea* | *batatas* | Camote | 1 | 1 | 0 | 0 | 1 | 0 |
| 77 | Moraceae | *Ficus* | *benjamina* | Benjasmin | 1 | 0 | 0 | 1 | 0 | 0 |
| 78 | Combretaceae | *Combretum* | *indicum* | Madre selva | 1 | 0 | 0 | 1 | 0 | 0 |
| 79 | Fabaceae | Leucaena | leucocephala | Guaje, Guiachi, Guajil, Bombita/Bombito | 1 | 1 | 0 | 1 | 0 | 1 |
| 80 | Cactaceae | Stenocereus | eruca | Chirinola | 1 | 0 | 1 | 0 | 0 | 1 |
| 81 | Arecaceae | Brahea | brandegeei | Palmilla | 1 | 0 | 0 | 1 | 0 | 1 |
| 82 | Cactaceae | *Peniocereus* | *striatus* | Cardoncillo, Matraca | 1 | 0 | 1 | 0 | 0 | 1 |
| 83 | Fabaceae | *Caesalpinia* | *placida* | Cresta de gallo, Navajia | 1 | 0 | 0 | 1 | 0 | 1 |
| 84 | Cactaceae | *Myrtillocactus* | *cochal* | Gualama, Pilita, Pila | 1 | 1 | 1 | 0 | 0 | 1 |
| 85 | Asteraceae | *Zinnia* | *spp.* | Zinia | 1 | 0 | 0 | 1 | 0 | 0 |
| 86 | Malvaceae | *Gossypium* | *davidsonii* | Algodon | 1 | 0 | 0 | 1 | 0 | 0 |
| 87 | Lamiaceae | *Ocimum* | *basilicum* | Albacar, Albaca, Albahaca | 1 | 0 | 0 | 1 | 0 | 0 |
| 88 | Columbidae | *Zenaida* | *asiatica* | Paloma | 0 | 1 | 0 | 0 | 0 | 0 |
| 89 | Canidae | *Canis* | *latrans* | Coyote | 0 | 0 | 1 | 0 | 0 | 0 |
| 90 | Cathartidae | *Cathartes* | *aura teter* | Aura, Zopilote, Buitre | 0 | 0 | 1 | 0 | 0 | 0 |
| 91 | Cardinalidae | *Cardinalis* | *cardinalis* | Cardinal, Carindal Pardo | 0 | 0 | 0 | 0 | 0 | 0 |
| 92 | Felidae | *Lynx* | *rufus peninsularis* | Gato montes, Leoncillo, Linxe | 0 | 0 | 1 | 0 | 0 | 0 |
| 93 | Odontophoridae | *Callipepla* | *californica* | Chacuaca, Godorniz | 0 | 1 | 0 | 0 | 0 | 0 |
| 94 | Accipitridae | *Accipiter* | *cooperii* | Gavilansillo; Gavilan pollero | 0 | 0 | 1 | 0 | 0 | 0 |
| 95 | Leporidae | *Lepus* | *californicus* | Liebre | 0 | 1 | 0 | 0 | 0 | 0 |
| 96 | Icteridae | *Icterus* | *cucullatus* | Calandria, Caliandra | 0 | 0 | 0 | 0 | 0 | 0 |
| 97 | Phrynosomatidae | *Urosaurus* | *lahtelai* and | Cachora | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | *nigricaudus* | | | | | | | |
| 98 | Procyonidae | *Procyon* | *lotor* | Mapache | 0 | 0 | 1 | 0 | 0 | 0 |
| 99 | Strigidae | *Bubo* | *virginianus* | Tecolote | 0 | 0 | 1 | 0 | 0 | 0 |
| 100 | Falconidae | *Caracara* | *plancus auduboni* | Quelele, Cara cara | 0 | 0 | 1 | 0 | 0 | 0 |
| 101 | Sciuridae | *Otospermophilus* | *atricapillus* | Ardilla, Ardillon | 0 | 0 | 0 | 0 | 0 | 0 |
| 102 | Columbidae | *Columbina* | *passerina* | Torcasa, Tortulita, Zacatera, Paloma Zacatera | 0 | 1 | 0 | 0 | 0 | 0 |
| 103 | Troglodytidae | *Campylorhynchus* | *brunneicapillus* | Urraca | 0 | 0 | 0 | 0 | 0 | 0 |
| 104 | Accipitridae | *Parabuteo* | *unicinctus* | Halcón | 0 | 0 | 1 | 0 | 0 | 0 |
| 105 | Colubridae | *Pituophis* | *vertebralis* | Coralillo, Alicante | 0 | 0 | 0 | 0 | 0 | 0 |
| 106 | Mimidae | *Mimus* | *polyglottos* | Centzontle | 0 | 0 | 0 | 0 | 0 | 0 |
| 107 | Mimidae | *Toxostoma* | *cinereum* | Huirigo, Huirico, Urico, Huiri, Huitacoche, Huitlacoche | 0 | 0 | 0 | 0 | 0 | 0 |
| 108 | Polioptilidae | *Polioptila* | *caerulea* | Chivirito | 0 | 0 | 0 | 0 | 0 | 0 |
| 109 | Mustelidae | *Taxidea* | *taxus* | Tejon | 0 | 0 | 1 | 0 | 0 | 0 |
| 110 | Procyonidae | *Bassariscus* | *astutus palmarius* | Babisuri | 0 | 0 | 0 | 0 | 0 | 0 |
| 111 | Heteromyidae | *Chaetodipus* | *spinatus* | Ratón | 0 | 0 | 1 | 0 | 0 | 0 |
| 112 | Corvidae | *Aphelocoma* | *californica* | Pajaro azul | 0 | 0 | 0 | 0 | 0 | 0 |
| 113 | Strigidae | *Megascops* | *kennicotti* | Lechuza | 0 | 0 | 1 | 0 | 0 | 0 |
| 114 | Geomyidae | *Thomomys* | *umbrinus alticolus* | Tuza, Topo ciego, Topo | 0 | 0 | 0 | 0 | 0 | 0 |
| 115 | Ardeidae | *Ardea* | *herodias* | Garza (morena, azul, gris) | 0 | 0 | 0 | 0 | 0 | 0 |
| 116 | Ptiliogonatidae | *Phainopepla* | *nitens* | Cardenal negro, Carednal prieto, Cardenal parda | 0 | 0 | 0 | 0 | 0 | 0 |
| 117 | Iguanidae | *Ctenosaura* | *hemilopha* | Iguana de arbol, Iguana de palo, Iguana de mesquite | 0 | 0 | 0 | 0 | 0 | 0 |
| 118 | Phrynosomatidae | *Callisaurus* | *draconoides* | Cachimba | 0 | 0 | 0 | 0 | 0 | 0 |
| 119 | Rallidae | *Fulica* | *americana* | Gallineta | 0 | 0 | 0 | 0 | 0 | 0 |
| 120 | Phyllodactylidae | *Phyllodactylus* | *xanti* | Salamanques(a) | 0 | 0 | 0 | 0 | 0 | 0 |
| 121 | Phrynosomatidae | *Phrynosoma* | *coronatum* | Camaleon | 0 | 0 | 0 | 0 | 0 | 0 |
| 122 | Heteromyidae | *Dipodomys* | *merriami* | Rata canguro | 0 | 0 | 1 | 0 | 0 | 0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 123 | Charadriidae | *Charadrius* | *vociferus vociferus* | Tildillo | 0 | 0 | 0 | 0 | 0 | 0 |
| 124 | Falconidae | *Falco* | *sparverius peninsularis* | Aguililla | 0 | 0 | 1 | 0 | 0 | 0 |
| 125 | Cardinalidae | *Pheucticus* | *melanocephalus* | Pintillo, Pajaro chichareo / chicarero, Pajaro trigero | 0 | 0 | 0 | 0 | 0 | 0 |
| 126 | Sciuridae | *Ammospermophilus* | *leucurus* | Juancito, Juanito, Chichimoco | 0 | 0 | 0 | 0 | 0 | 0 |
| 127 | Dytiscidae | over 160 genera | about 4,000 species | Cucaracha (del agua), la vieja de los chubasco | 0 | 0 | 0 | 0 | 0 | 0 |
| 128 | Caprimulgidae | *Phalaenoptilus* | *nuttallii* | Tapa camino, Caudebe | 0 | 0 | 0 | 0 | 0 | 0 |
| 129 | Elateridae | *Chalcolepidius* | *rubripennis* | Tronadores | 0 | 0 | 0 | 0 | 0 | 0 |
| 130 | Colubridae | *Thamnophis* | *hammondii* | Culebra de agua/de pozo | 0 | 0 | 0 | 0 | 0 | 0 |
| 131 | Icteridae | *Icterus* | *parisorum* | Serrano | 0 | 0 | 0 | 0 | 0 | 0 |
| 132 | Accipitridae | *Buteo* | *jamaicensis calurus* | Gavilan, Aguililla cola roja | 0 | 0 | 1 | 0 | 0 | 0 |
| 133 | Laniidae | *Lanius* | *ludovicianus* | Pajaro cabezon, Pajaro lelo, Cenzontle tapojero/entapojado/atapojado | 0 | 0 | 0 | 0 | 0 | 0 |
| 134 | Troglodytidae | *Salpinctes* | *obsoletus* | Piedredero, Catalina, Pajaro de Cantil/de los Cantiles | 0 | 0 | 0 | 0 | 0 | 0 |
| 135 | Eleotridae | *Dormitator* | *latrifons* | Puyeki | 0 | 1 | 0 | 0 | 0 | 0 |
| 136 | Tyrannidae | *Sayornis* | *nigricans* | Albañil, Pajaro lodero, Lodorito, Cantilerito, Pajaro de las posas, Pajaro de lodo | 0 | 0 | 0 | 0 | 0 | 0 |
| 137 | Scolopacidae | *Calidris* | *pusilla* | Sarapico, Gallito | 0 | 0 | 0 | 0 | 0 | 0 |

Appendix B.

Table 8. Choyero ethnobiological knowledge for full sample (all), females, and males.

| Item category | Items $i$ (n) | Recognized $=\sum_{i=1}^{n} R_i$ Mean% (SD) | Median% | Min%, | Max% | Correctly Named $=\sum_{i=1}^{n} C_i$ Mean% (SD) | Median% | Min%, | Max% |
|---|---|---|---|---|---|---|---|---|---|
| **All (N=71)** | | | | | | | | | |
| all plants & animal | 137 | 76.4 (14.53) | 80.3 | 29.2, | 99.3 | 48.6 (15.37) | 48.9 | 7.3, | 91.2 |
| dangerous | 28 | 84.7 (13.20) | 89.3 | 39.3, | 100 | 54.0 (16.31) | 53.6 | 14.3, | 89.3 |
| food items | 32 | 82.1 (13.35) | 84.4 | 31.3, | 100 | 62.3 (17.15) | 65.6 | 6.3, | 96.9 |
| animal | 50 | 85.9 (13.95) | 90.0 | 34.0, | 100 | 59.0 (16.50) | 58.0 | 12.0, | 96.0 |
| plant | 87 | 71.0 (16.95) | 74.7 | 17.2, | 98.9 | 42.6 (16.73) | 42.5 | 2.3, | 88.5 |
| *jardin* plants | 36 | 74.1 (17.85) | 77.8 | 16.7, | 100 | 44.6 (19.80) | 47.2 | 0.0, | 91.7 |
| *huerta* plants | 16 | 80.2 (16.64) | 87.5 | 25.0, | 100 | 60.7 (20.11) | 62.5 | 0.0, | 100 |
| *campo* plants | 53 | 68.4 (18.22) | 69.8 | 15.1, | 100 | 39.5 (17.52) | 41.5 | 1.9, | 88.7 |
| **Females (N=33)** | | | | | | | | | |
| all plants & animal | 137 | 73.1 (16.23) | 75.2 | 29.2, | 97.1 | 44.6 (15.98) | 44.5 | 7.3, | 75.9 |
| dangerous | 28 | 80.5 (15.80) | 85.7 | 39.3, | 100 | 45.7 (14.17) | 46.4 | 14.3, | 78.6 |
| food items | 32 | 80.1 (15.62) | 81.3 | 31.3, | 96.9 | 59.4 (18.78) | 62.5 | 12.5, | 90.6 |
| animal | 50 | 80.1 (16.14) | 84.0 | 34.0, | 100 | 49.9 (14.57) | 52.0 | 12.0, | 84.0 |
| plant | 87 | 69.1 (18.27) | 72.4 | 17.2, | 95.4 | 41.5 (18.11) | 39.1 | 3.4, | 78.2 |
| *jardin* plants | 36 | 77.1 (18.58) | 83.3 | 16.7, | 100 | 50.8 (21.91) | 50.0 | 5.6, | 91.7 |
| *huerta* plants | 16 | 78.4 (18.95) | 81.3 | 25.0, | 100 | 59.1 (21.03) | 62.5 | 12.5, | 93.8 |
| *campo* plants | 53 | 63.1 (19.13) | 66.0 | 15.1, | 94.3 | 33.0 (16.64) | 32.1 | 1.9, | 67.9 |
| **Males (N=38)** | | | | | | | | | |
| all plants & animal | 137 | 79.3 (12.37) | 81.8 | 50.4, | 99.3 | 52.0 (14.12) | 53.3 | 13.9, | 91.2 |
| dangerous | 28 | 88.3 (9.20) | 89.3 | 67.9, | 100 | 61.2 (14.65) | 62.5 | 21.4, | 89.3 |
| food items | 32 | 83.9 (10.94) | 84.4 | 56.3, | 100 | 64.9 (15.39) | 65.6 | 6.3, | 96.9 |
| animal | 50 | 91.1 (9.24) | 93.0 | 66.0, | 100 | 66.8 (13.95) | 68.0 | 30.0, | 96.0 |
| plant | 87 | 72.6 (15.79) | 74.7 | 33.3, | 98.9 | 43.5 (15.61) | 43.7 | 2.3, | 88.5 |
| *jardin* plants | 36 | 71.4 (17.00) | 72.2 | 27.8, | 97.2 | 39.3 (16.26) | 38.9 | 0.0, | 88.9 |
| *huerta* plants | 16 | 81.7 (14.41) | 87.5 | 37.5, | 100 | 62.2 (19.44) | 62.5 | 0.0, | 100 |
| *campo* plants | 53 | 73.1 (16.23) | 72.6 | 32.1, | 100 | 45.2 (16.44) | 47.2 | 3.8, | 88.7 |

Note: Variables $R_i$ and $C_i$ are equal to 1 when item $i$ is recognized or named correctly, respectively, and zero otherwise.

**Appendix B.**

Table 9. Choyero ethnobiological knowledge in pre-reproductive lifestage (<23 years old) for full sample (all), females, and males.

| | | **Recognized** $= \sum_{i=1}^{n} R_i$ | | | | **Correctly Named** $= \sum_{i=1}^{n} C_i$ | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Item category** | **Items *i* (n)** | **Mean% (SD)** | **Median%** | **Min%,** | **Max%** | **Mean% (SD)** | **Median%** | **Min%,** | **Max%** |
| **All (N=7)** | | | | | | | | | |
| all plants & animal | 137 | 63.2 (20.22) | 70.1 | 32.1 | 81.8 | 30.8 (17.67) | 29.9 | 7.3 | 49.6 |
| dangerous | 28 | 73.0 (19.87) | 82.1 | 39.3 | 89.3 | 37.8 (16.73) | 35.7 | 14.3 | 60.7 |
| food items | 32 | 70.5 (17.01) | 81.3 | 40.7 | 84.4 | 46.9 (22.75) | 50.0 | 12.5 | 71.9 |
| animal | 50 | 69.7 (22.20) | 78.0 | 34.0 | 92.0 | 40.6 (22.27) | 44.0 | 12.0 | 66.0 |
| plant | 87 | 59.4 (19.16) | 65.5 | 31.0 | 78.2 | 25.1 (15.65) | 24.1 | 3.5 | 43.7 |
| *jardin* plants | 36 | 64.7 (18.75) | 72.3 | 38.9 | 91.7 | 29.0 (17.34) | 38.9 | 5.6 | 47.2 |
| *huerta* plants | 16 | 68.8 (20.09) | 75.0 | 37.5 | 87.5 | 45.5 (21.56) | 50.0 | 12.5 | 68.8 |
| *campo* plants | 53 | 56.3 (21.00) | 56.6 | 26.4 | 81.1 | 21.8 (17.63) | 20.8 | 1.9 | 47.2 |
| **Females (N=3)** | | | | | | | | | |
| all plants & animal | 137 | 47.7 (19.87) | 40.9 | 32.1 | 70.1 | 15.6 (12.48) | 9.5 | 7.3 | 29.9 |
| dangerous | 28 | 57.1 (22.30) | 50.0 | 39.3 | 82.1 | 22.6 (8.99) | 21.4 | 14.3 | 32.1 |
| food items | 32 | 58.3 (20.81) | 53.1 | 40.6 | 81.2 | 27.1 (20.09) | 18.8 | 12.5 | 50.0 |
| animal | 50 | 52.6 (22.74) | 46.0 | 34.0 | 78.0 | 23.3 (17.93) | 14.0 | 12.0 | 44.0 |
| plant | 87 | 44.8 (18.25) | 37.9 | 31.0 | 65.5 | 11.1 (9.57) | 8.0 | 3.5 | 21.8 |
| *jardin* plants | 36 | 55.6 (20.03) | 50.0 | 38.9 | 77.8 | 16.7 (19.25) | 5.6 | 5.6 | 38.9 |
| *huerta* plants | 16 | 52.1 (20.09) | 43.8 | 37.5 | 75.0 | 27.1 (20.09) | 18.8 | 12.5 | 50.0 |
| *campo* plants | 53 | 38.4 (16.05) | 32.1 | 26.4 | 56.6 | 6.3 (3.93) | 7.5 | 1.9 | 9.4 |
| **Males (N=4)** | | | | | | | | | |
| all plants & animal | 137 | 74.9 (11.56) | 79.9 | 57.7 | 81.8 | 42.2 (10.79) | 46.4 | 26.3 | 49.6 |
| dangerous | 28 | 84.8 (4.49) | 85.7 | 78.6 | 89.3 | 49.1 (10.26) | 50.0 | 35.7 | 60.7 |
| food items | 32 | 79.7 (5.42) | 81.3 | 71.88 | 84.4 | 61.7 (8.98) | 62.5 | 50.0 | 71.9 |
| animal | 50 | 82.5 (11.47) | 86.0 | 66.0 | 92.0 | 53.5 (16.03) | 59.0 | 30.0 | 66.0 |
| plant | 87 | 70.4 (11.77) | 75.3 | 52.9 | 78.2 | 35.6 (9.24) | 37.4 | 24.1 | 43.7 |
| *jardin* plants | 36 | 71.5 (17.03) | 72.2 | 50.0 | 91.7 | 38.2 (9.45) | 40.3 | 25.0 | 47.2 |
| *huerta* plants | 16 | 81.3 (7.22) | 81.3 | 75.0 | 87.5 | 59.4 (8.07) | 59.4 | 50.0 | 68.8 |
| *campo* plants | 53 | 69.8 (11.93) | 71.7 | 54.7 | 81.1 | 33.5 (13.73) | 33.0 | 20.8 | 47.2 |

Note: Variables $R_i$ and $C_i$ are equal to 1 if item $i$ is recognized or named correctly, respectively, and zero otherwise.

Table 10. Choyero ethnobiological knowledge in reproductive lifestage (= 23 to 45 years old) for for full sample (all), females, and males.

| | | **Recognized** $= \sum_{i=1}^{n} R_i$ | | | | **Correctly Named** $= \sum_{i=1}^{n} C_i$ | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Item category** | **Items $i$ (n)** | **Mean% (SD)** | **Median%** | **Min%,** | **Max%** | **Mean% (SD)** | **Median%** | **Min%,** | **Max%** |
| **All (N=26)** | | | | | | | | | |
| all plants & animal | 137 | 81.4 (9.35) | 82.1 | 59.1 | 98.5 | 52.7 (8.72) | 54.0 | 32.1 | 73.0 |
| dangerous | 28 | 88.5 (11.13) | 92.9 | 50.0 | 100.0 | 56.3 (12.75) | 57.1 | 25.0 | 85.7 |
| food items | 32 | 88.3 (6.76) | 87.5 | 71.9 | 100.0 | 70.8 (7.75) | 71.9 | 56.3 | 84.4 |
| animal | 50 | 89.0 (10.71) | 92.0 | 48.0 | 100.0 | 60.5 (12.59) | 60.0 | 30.0 | 86.0 |
| plant | 87 | 77.1 (10.75) | 77.6 | 54.0 | 97.7 | 48.1 (9.31) | 48.3 | 32.2 | 65.5 |
| *5jardin* plants | 36 | 81.0 (11.38) | 83.3 | 52.8 | 94.4 | 51.7 (13.34) | 50.0 | 30.6 | 80.6 |
| *huerta* plants | 16 | 88.5 (7.44) | 87.5 | 75.0 | 100.0 | 72.1 (10.19) | 71.9 | 50.0 | 87.5 |
| *campo* plants | 53 | 73.9 (13.96) | 71.7 | 45.3 | 100.0 | 43.8 (12.09) | 45.3 | 20.8 | 64.2 |
| **Females (N=11)** | | | | | | | | | |
| all plants & animal | 137 | 78.0 (10.08) | 80.3 | 59.1 | 89.1 | 48.7 (8.83) | 51.8 | 32.1 | 57.7 |
| dangerous | 28 | 83.1 (13.47) | 89.3 | 50.0 | 92.9 | 46.4 (9.58) | 46.4 | 25.0 | 60.7 |
| food items | 32 | 87.2 (6.91) | 87.5 | 71.9 | 96.9 | 69.0 (8.55) | 68.8 | 56.3 | 81.3 |
| animal | 50 | 82.9 (12.60) | 86.0 | 48.0 | 92.0 | 50.2 (9.31) | 52.0 | 30.0 | 62.0 |
| plant | 87 | 75.2 (10.53) | 78.2 | 54.0 | 87.4 | 47.9 (9.55) | 48.3 | 33.3 | 60.9 |
| *jardin* plants | 36 | 85.3 (7.57) | 86.1 | 66.7 | 94.4 | 61.4 (11.14) | 61.1 | 47.2 | 80.6 |
| *huerta* plants | 16 | 88.6 (7.30) | 87.0 | 75.0 | 100.0 | 72.2 (9.83) | 68.8 | 62.5 | 87.5 |
| *campo* plants | 53 | 67.6 (14.51) | 67.9 | 45.3 | 84.9 | 36.0 (10.59) | 34.0 | 20.8 | 50.9 |
| **Males (N=15)** | | | | | | | | | |
| all plants & animal | 137 | 83.9 (8.23) | 82.5 | 72.3 | 98.5 | 55.6 (7.65) | 54.7 | 44.5 | 73.0 |
| dangerous | 28 | 92.4 (7.25) | 92.9 | 75.0 | 100.0 | 63.6 (9.56) | 64.3 | 46.4 | 85.7 |
| food items | 32 | 89.2 (6.77) | 87.5 | 78.1 | 100.0 | 72.1 (7.13) | 75.0 | 59.4 | 84.4 |
| animal | 50 | 93.5 (6.39) | 94.0 | 78.0 | 100.0 | 68.1 (8.67) | 68.0 | 54.0 | 86.0 |
| plant | 87 | 78.5 (11.06) | 77.0 | 59.8 | 97.7 | 48.4 (9.45) | 48.3 | 32.2 | 65.5 |
| *jardin* plants | 36 | 77.8 (12.82) | 75.0 | 52.8 | 94.4 | 44.6 (10.10) | 41.7 | 30.6 | 66.7 |
| *huerta* plants | 16 | 88.3 (7.79) | 87.5 | 75.0 | 100.0 | 72.1 (10.80) | 75.0 | 50.0 | 87.5 |
| *campo* plants | 53 | 78.5 (11.99) | 77.4 | 56.6 | 100.0 | 49.4 (9.96) | 52.8 | 30.2 | 64.2 |

Note: Variables $R_i$ and $C_i$ are equal to 1 if item $i$ is recognized or named correctly, respectively, and zero otherwise.

Table 11. Choyero ethnobiological knowledge in post-reproductive lifestage (46+ years old) for for full sample (all), females, and males.

| | | **Recognized** $=\sum_{i=1}^{n} R_i$ | | | | **Correctly Named** $=\sum_{i=1}^{n} C_i$ | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Item category** | **Items *i* (n)** | **Mean% (SD)** | **Median%** | **Min%,** | **Max%** | **Mean% (SD)** | **Median%** | **Min%,** | **Max** |
| **All (N=38)** | | | | | | | | | |
| all plants & animal | 137 | 75.5 (14.90) | 77.0 | 29.2 | 99.3 | 49.0 (16.52) | 47.1 | 13.9 | 91.2 |
| dangerous | 28 | 84.3 (12.08) | 87.5 | 42.9 | 100.0 | 55.4 (17.09) | 51.8 | 21.4 | 89.3 |
| food items | 32 | 80.0 (14.23) | 79.7 | 31.3 | 100.0 | 59.4 (18.09) | 59.4 | 6.3 | 96.9 |
| animal | 50 | 86.8 (12.40) | 90.0 | 50.0 | 100.0 | 61.3 (16.00) | 60.0 | 30.0 | 96.0 |
| plant | 87 | 68.9 (18.72) | 72.4 | 17.2 | 98.9 | 42.0 (18.74) | 39.1 | 2.3 | 88.5 |
| *jardin* plants | 36 | 71.1 (19.97) | 72.2 | 16.7 | 100.0 | 42.7 (22.08) | 38.9 | 0.0 | 91.7 |
| *huerta* plants | 16 | 76.6 (18.30) | 75.0 | 25.0 | 100.0 | 55.8 (21.42) | 56.3 | 0.0 | 100.0 |
| *campo* plants | 53 | 66.9 (19.34) | 67.9 | 15.1 | 100.0 | 39.9 (18.97) | 38.7 | 3.8 | 88.7 |
| **Females (N=19)** | | | | | | | | | |
| all plants & animal | 137 | 74.3 (15.62) | 75.2 | 29.2 | 97.1 | 46.8 (15.42) | 43.8 | 16.8 | 75.9 |
| dangerous | 28 | 82.7 (13.69) | 85.7 | 42.9 | 100.0 | 48.9 (14.04) | 46.4 | 25.0 | 78.6 |
| food items | 32 | 79.4 (15.77) | 78.1 | 31.3 | 96.9 | 58.9 (17.62) | 59.4 | 15.6 | 90.6 |
| animal | 50 | 82.7 (13.40) | 84.0 | 50.0 | 100.0 | 54.0 (12.58) | 52.0 | 30.0 | 84.0 |
| plant | 87 | 69.4 (19.33) | 73.6 | 17.2 | 95.4 | 42.6 (18.50) | 39.1 | 9.2 | 78.2 |
| *jardin* plants | 36 | 75.7 (20.41) | 80.6 | 16.7 | 100.0 | 50.0 (21.91) | 50.0 | 8.3 | 91.7 |
| *huerta* plants | 16 | 76.6 (19.53) | 75.0 | 25.0 | 100.0 | 56.6 (20.14) | 56.3 | 12.5 | 93.8 |
| *campo* plants | 53 | 64.3 (19.72) | 66.0 | 15.1 | 94.3 | 35.5 (17.24) | 32.1 | 7.6 | 67.9 |
| **Males (N=19)** | | | | | | | | | |
| all plants & animal | 137 | 76.6 (14.47) | 81.0 | 50.4 | 99.3 | 51.3 (17.66) | 51.1 | 13.9 | 91.2 |
| dangerous | 28 | 85.9 (10.34) | 89.3 | 67.9 | 100.0 | 61.8 (17.73) | 67.9 | 21.4 | 89.3 |
| food items | 32 | 80.6 (12.91) | 81.3 | 56.3 | 100.0 | 59.9 (19.02) | 59.4 | 6.3 | 96.9 |
| animal | 50 | 90.9 (10.03) | 96.0 | 66.0 | 100.0 | 68.6 (15.96) | 70.0 | 34.0 | 96.0 |
| plant | 87 | 68.4 (18.59) | 70.1 | 33.3 | 98.9 | 41.4 (19.47) | 40.2 | 2.3 | 88.5 |
| *jardin* plants | 36 | 66.4 (18.91) | 63.9 | 27.8 | 97.2 | 35.4 (20.22) | 30.6 | 0.0 | 88.9 |
| *huerta* plants | 16 | 76.6 (17.53) | 75.0 | 37.5 | 100.0 | 54.9 (23.16) | 56.3 | 0.0 | 100.00 |
| *campo* plants | 53 | 69.5 (19.12) | 71.7 | 32.1 | 100.0 | 44.3 (20.02) | 45.3 | 3.8 | 88.7 |

Note: Variables $R_i$ and $C_i$ are equal to 1 if item $i$ is recognized or named correctly, respectively, and zero otherwise.