Plants in Transit Communities: Circulating Tubers and Maize in the Lake Titicaca Basin, Bolivia

Sophie Reilly and Andrew P. Roddick

Archaeologists working in the Late Formative Lake Titicaca Basin have identified several "transit communities"—villages that benefited from long-distance exchange. Some scholars suggest that such places played a key role in the development of the Middle Horizon city of Tiwanaku. In this article, we explore the movement of plant goods into transit communities during both the Late Formative (300 BC–AD 500) and Middle Horizon (AD 600–1100) periods. After presenting the current understanding of transit communities, we summarize previous work on both local plants, including tubers and quinoa, and the presence of maize. We then report on a recent microbotanical study of ceramics recovered from excavations at Late Formative Challapata (in the eastern basin) and a burial from the Middle Horizon occupation at Chiripa (in the southern basin). For the first time we identify lowland tubers in the Lake Titicaca Basin, including yuca, sweet potato, and arrowroot. These findings reveal the critical importance of microbotanical analyses for tracing regional connections and foodways in emergent Middle Horizon worlds, as well as the need for more complex interpretive models for things/plants-in-motion.

Keywords: Andes, foodways, Late Formative, paleoethnobotany, Tiwanaku

Los arqueólogos que trabajan en la cuenca del Lago Titicaca en el Formativo Tardío han identificado una serie de "comunidades de tránsito." Algunos investigadores sugieren que tales lugares jugaron un papel clave en el desarrollo de la ciudad de Tiwanaku durante el horizonte medio. En este artículo, exploramos el movimiento de bienes vegetales a las comunidades de tránsito durante el Formativo Tardío (300 aC-500 dC) y el horizonte medio (600-1100 dC). Después de presentar los conocimientos actuales sobre las comunidades de tránsito, resumimos el trabajo previo de ambas plantas locales, incluidos los tubérculos y la quinua, y la presencia del maíz. Luego informamos sobre un reciente estudio microbotánico de cerámica recuperada de excavaciones en Challapata del Formativo Tardío (cuenca oriental) y un entierro de la ocupación del Horizonte Medio en Chiripa (cuenca sur). Por primera vez hemos identificado tubérculos de tierras bajas en la cuenca del lago Titicaca, incluyendo yuca, camote, y arrurruz. Estos hallazgos revelan la importancia crítica de los análisis microbotánicos para rastrear conexiones regionales y vías alimenticias en los mundos emergentes del Horizonte Medio, y la necesidad de modelos interpretativos más complejos para las cosas / plantas-en-movimiento.

Palabras claves: Andes, practicas alimentarias, Formativo Tarde, arqueobotánica, Tiwanaku

This article is about the movement of plant foods into and around the Lake Titicaca Basin. Questions about networks, circulation, and trade are central to Altiplano archaeology as scholars have studied the movement of goods to understand political power, as well as the circulation of people and knowledge between communities. In this article, we present data from our recent microbotanical study that identified both highland and lowland foods in Late Formative and Middle Horizon Altiplano contexts. We use this data to contribute to understandings of connectivity at this time, synthesizing the literature and considering how studies of plant foods can complicate and advance understandings of ancient networks of exchange.

Archaeologists working in the Titicaca Basin have long studied issues of mobility. Browman

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(1978, 1981), for instance, argues that llama caravans permitted the exploitation of lowland resources, integrated the high Bolivian plains (or Altiplano), and ultimately contributed to the emergence of the urban center of Tiwanaku (AD 600–1100). He suggests that specific settlements became hubs for trading because of their position within caravan circuits. Scholars have begun to identify such communities for the Formative period (Levine et al. 2013; Smith and Janusek 2014; Stanish et al. 2010) and are tracing their relationships with other caravan "nodes" in the southern Altiplano and Atacama Desert (Berenguer 2004; Capriles 2011; Nielsen 2006; Plourde 2006; Stanish 2003).

We focus on two such nodes here. Chiripa, on the Taraco Peninsula, was an important settlement by the ninth century BC. Although it is best known as a Formative center, lowland goods continued to move through Chiripa in the Middle Horizon period (AD 600–1100). The less well-known Late Formative (300 BC–AD 500) site of Challapata is located in the eastern Lake Titicaca Basin. Recent work recovered nonlocal goods and an associated road infrastructure, suggesting connections with the lowlands. Both sites show characteristics of "transit communities," a concept that foregrounds the relationship between social power and the acquisition of precious foreign objects (Bandy 2005a; Helms 1988, 1993). Yet scholars have also argued that mundane things were equally embedded in a range of social and political interactions and were perhaps more important than luxury goods to ancient Andean economies (Roddick 2015; Sillar 2016; Tripcevich 2009). Researchers of both perspectives pay insufficient attention to the movement of plant goods. Although few would question that plants were moving across the Altiplano up and down the Andean slopes, sampling protocols and taphonomic issues often limit in-depth studies of the issue.

We discuss current evidence for both native highland crops, such as tubers and quinoa, and the tropical introduced plant of maize. Although such a local/nonlocal binary would seem to support a mundane/luxury distinction, we argue that plants complicate such easy categorization. Our analysis of starch grains and phytoliths recovered from Chiripa and Challapata ceramics demonstrate such complexities (Reilly 2017). In her samples, Reilly identified not only maize but also lowland plant starches never before reported for the Titicaca Basin, including arrowroot, sweet potato, and yuca. These findings from a study of just a few vessels reveal the critical importance of microbotanical analyses in furthering our understanding of regional connections and foodways in emergent Middle Horizon worlds.

Titicaca Basin Exchange Networks and Transit Communities

Scholars believe that llama caravans played a key role in the early circulation of both goods and ideas throughout the Andes (Browman 1981; Nielsen 2006, 2013; Núñez Atencio and Dillehay 1978). The recovery of foreign goods, often in small quantities, suggests that complex household and community networks defined many Andean regions for generations. Ethnohistoric (Murra 1968) and ethnographic (Nielsen 2001; Tripcevich 2016) research into camelid caravans shows the array of social and economic processes underlying such movements. The circulation of goods played a particularly important role in the development of Middle Horizon polities, where a flourishing of interregional connections contributed to new social, political, and economic arrangements (Browman 1980, 1981; Roddick 2015; Sharratt et al. 2015; Smith 2016; Smith and Janusek 2014). Although scholars continue to debate what kind of economic systems structured exchange in the Titicaca region and in the Andes as a whole (Stanish and Coben 2013), it is clear that, as Tiwanaku emerged, certain portable goods were essential in new regimes of value. As the Middle Horizon world developed, similar tastes emerged over a larger area, ultimately constituting a larger "imagined community" (Lau 2016:205).

Archaeologists have studied the movement of "high-status" goods in the Late Formative (200 BC–AD 400) and Middle Horizon (AD 400–1000) Lake Titicaca Basin. Although some suggest that certain communities controlled the circulation of prestige goods as early as the Formative period (Bandy 2005a; Burger et al.

2000; Levine et al. 2013; Plourde 2006; Stanish 2003:162–163), we are still not sure how these goods moved or whether and how individuals or communities controlled these networks. In the Tiwanaku "heartland," for example, Stanish and colleagues (2010) demonstrate that although Tiwanaku benefited from long-distance relationships by the fifth century, urban elites certainly did not control broad economic landscapes. Even though elites may have briefly connected parts of the social landscape, these networks likely had much longer histories reaching back into the Formative period and do not appear to have been substantially disrupted in the Middle Horizon (Smith and Janusek 2014).

There is also the question of how "prestige" goods connected communities, particularly in comparison to other kinds of circulating goods such as agricultural tools (Bandy 2005a:95–97) and raw materials for craft production and architecture (Janusek et al. 2013; Roddick 2015). The movement of special items may have been important for certain kinds of social power, whereas "mundane" things may have moved in more embedded ways (Nielsen 2013:391–392). Emphasis on the long-distance exchange of limited prestige goods underrepresents the interaction and connectivity of many periods (Sillar 2016). It also erases the fact that the meanings and values of goods can change. For example, obsidian may have shifted in meaning over time, and efforts to characterize it as elite or ordinary may be "overly influencing our interpretations of regional circulation" (Tripcevich 2009:70).

Titicaca scholars generally agree that some communities benefited from the movement of goods through their settlements and became nodes in wider landscapes of movement (sensu Ur 2009). During the Formative period, sites such as Taraco and Pukara in the northern Titicaca Basin (Burger et al. 2000; Klarich 2005; Levine et al. 2013) and settlements on the Taraco Peninsula and in the Desaguadero Valley in the south (Bandy and Hastorf 2007; Janusek 2015; Roddick et al. 2014) were key places in complex regional networks. "Axis settlements" (Dillehay and Núñez Atencio 1988; Núñez Atencio and Dillehay 1978) along the Desaguadero River, such as Khonkho Wankane, Iruhito, and Cerro Chicha, anchored complex llama caravan circuits (Smith 2016; Smith and Janusek 2014). Bandy calls such strategic trading settlements "transit communities" in which certain individuals enhanced their symbolic capital by extracting tolls from passing traders. This ongoing process produced a "growth spiral": as more trading partners were drawn in, more tolls were collected, and more symbolic capital was produced (Bandy 2005a:97).

Several transit communities have been identified on the Taraco Peninsula (Figure 1). Places like Chiripa were particularly well positioned because trade routes would have passed around either the northern or southern edge of the lake (Figure 2; Bandy 2005a:97). As early as the Early Formative period, small quantities of sodalite beads (likely from Cerro Sapo, near Cochabamba); obsidian (as finished bifaces from the Chivay sources, 350 km away); Pacific coast seashells (including *Spondylus* from southern Ecuador); and gold, copper, and silver were all moving through Chiripa. These networks were maintained through the Middle Formative when finished agricultural tools made of nonlocal olivine basalt begin to appear from both local and nonlocal sources (Bandy 2005a:95–97; Penfil and Williams 2018).

Though Chiripa's importance as a ritual center and transit community waned around AD 300 when nearby Kala Uyuni became the regional "political center" (Bandy 2005a:106; Roddick et al. 2014) and in the Middle Horizon when inhabitants were drawn to Tiwanaku, the site remained inhabited and continued to grow (Bandy 1999, 2001, 2005a:107). The main mound and surrounding area were converted into a Tiwanaku cemetery; Tiwanaku phase burials have been uncovered in the Santiago sector of Chiripa. Grave construction styles are maintained through the Late Formative–Middle Horizon transition, but new kinds of grave goods appear. Whereas nonlocal sodalite and turquoise beads were common offerings in the Formative period, Tiwanaku phase graves include plainware ceramic vessels (ollas, *keros*, and *tazones*; Blom and Bandy 1999). As we discuss later, ceramic styles and associated botanical materials suggest that network relations with lowland regions were maintained from earlier periods.

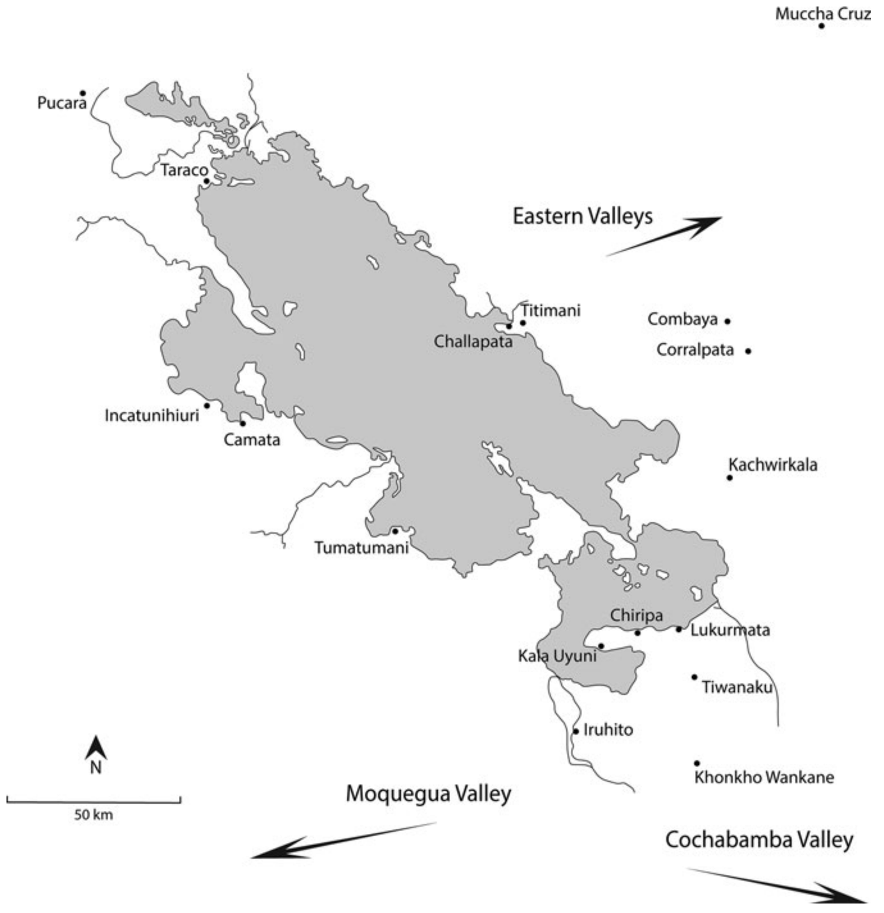

Figure 1. Map of the Lake Titicaca Basin with location of sites mentioned in text (adapted by Reilly from Roddick 2009).

The channels into the eastern and western valleys were not limited to the Taraco Peninsula and Tiwanaku but also included eastern Titicaca Basin settlements, which had strong connections to eastern valley sites like Muccha Cruz, Combaya, and Corralpata (Figure 1). These eastern valleys (Larecaja y Muñecas) and the Yungas of La Paz played an extremely important trade role in the Formative and Tiwanaku periods (Browman 1981; Capriles and Flores 2000; Faldín 1995; Lémuz and Aranda 2008; Paz 2000). Challapata lay on the edge of a vibrant corridor of movement and trade that linked the Altiplano to warmer, lower valleys on the east side of the Eastern Cordillera. Chiripa-style ceramics have been recovered at the neighboring Titimani, a large Formative period residential and ceremonial site, suggesting connections between the eastern and southern Titicaca Basin (Janusek 2004:134; Portugal Ortiz 1984, 1988; Portugal Ortiz et al. 1993; Stanish 2003). Until quite recently, our knowledge about Challapata was restricted to brief reconnaissance and minor unpublished excavations (Arce 2002; Chávez and Chávez 1995; Fernández 2006; García 2006; Portugal Ortiz 1998; Portugal Zamora 1961).

In 2013, the Proyecto Arqueológico de Redes de Interacción Altiplano y Valles Interandinos (PARIAVI) conducted an extensive survey on the Challapata Peninsula, along the Suches River and areas to the northeast of Escoma toward the mesothermal valleys of Italaque and Moco Moco. The project identified an ancient road that connected the lowland valleys to Challapata and Titimani. Our work suggests

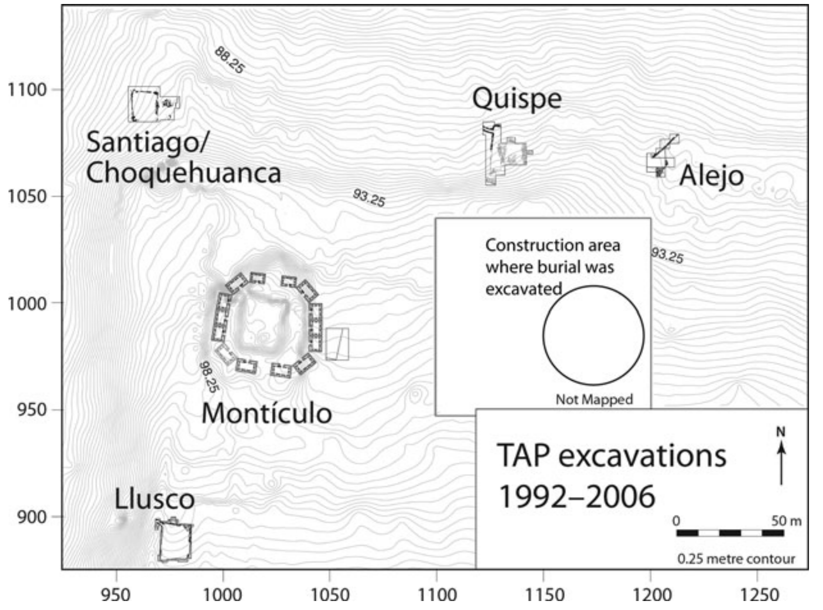

Figure 2. Map of Chiripa (drawn by William Whitehead, adapted from Roddick and Hastorf 2010), with location of the construction project where the burial was uncovered.

that Challapata was an extensive 12 ha Formative center with a massive 150 × 100 m earthen platform known today as Oqo Qoya Pata (Figure 3; Janusek et al. 2014). The mound is surrounded by walled terraces, occupational middens with high densities of Middle and Late Formative fiber-tempered ceramics, and a densely packed area of smaller mounds and some elaborately carved stones (Roddick and Janusek 2018:309–310). In 2014 and 2016 the PARIAVI team conducted small-scale and strategic excavations to delineate the construction sequence of this mound and to trace quotidian and ritual practices (Janusek et al. 2014, 2017). This work is helping refine chronologies of the region while tracing the movement of a range of goods through this "transit community." The strategic position of Challapata, like that of Chiripa, makes it an ideal place to consider the movement of goods, including plants, in the ancient Lake Titicaca Basin.

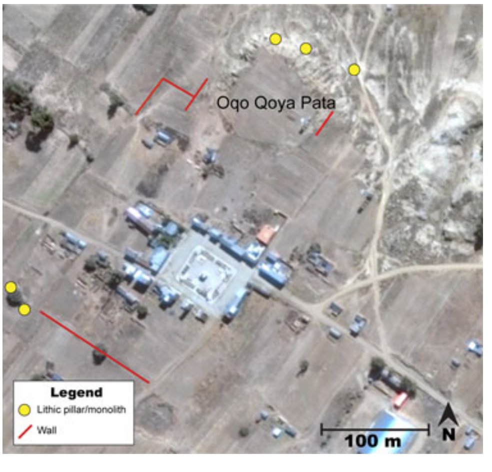

Figure 3. Map of Challapata, with location of excavation units (reproduced from Janusek et al. 2014).

Tracing Prestigious Plants and Everyday Ingredients

Archaeologists are increasingly tracing the movement of plants, especially those that grow in limited environmental zones, to examine connectivity and how people used nonlocal goods. Perry and colleagues (2006), for example, recovered arrowroot (a lowland plant) at highland sites in Arequipa, Peru, which is evidence for highland–lowland connectivity during the Middle Horizon. Miller and colleagues (2019) report on a well-preserved ritual bundle containing psychoactive drugs on a trade route to Tiwanaku,

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which suggests broader movements of medicinal/ritual taxa and their associated itinerant experts. Similarly, lowland plant goods, such as coca, cotton, chili peppers, and tropical hardwoods, may have been moving through Formative period sites (Bandy 2005a). Yet Titicaca Basin archaeologists often focus on maize when they consider "plants-in-motion" because of its ubiquity, its visibility through a variety of analytical means (Berryman 2010; Bruno 2008; Logan 2006; Wright et al. 2003), and its framing as a "luxury food" (Goldstein 2003; Hastorf 2003a, 2003b, 2012; Logan et al. 2012; Roddick and Hastorf 2010).

Titicaca Basin communities began acquiring maize at least as early as the Middle Formative (Logan et al. 2012). Stable isotope analysis suggests that in the Late Formative, maize consumption was higher at sites with public ceremonial architecture, including transit communities like Tiwanaku, Chiripa, and Khonkho Wankane (Berryman 2010; Miller 2005). Hastorf and colleagues' (2006) morphological study of maize kernels and cupules suggests that Tiwanaku inhabitants obtained their maize from several regions, including the Moquegua Valley, the Cochabamba Valley, and at least one more unidentified source. Certainly, transit communities in the Desaguadero region that connected the Titicaca Basin with the Cochabamba Valley saw an increase in maize use during the Middle Horizon (Smith and Janusek 2014).

It seems unlikely that llama caravans moved heavy staple foods, particularly with the diversity of locally available wild and domesticated taxa. Quinoa is native to the Titicaca Basin and is commonly recovered in Formative and Middle Horizon sites (Bruno 2014; Whitehead 2007), with *Chenopodium* remains being the "most common by far" at Middle Horizon Tiwanaku (Wright et al. 2003:391). A wide variety of tuber species grow in the basin, including potatoes (*Solanum tuberosum*), oca (*Oxalis tuberosa*), ulluco (*Ullucus tuberosus*), and isañu mashua (*Tropaoleum tuberosum*; Hastorf 2012; Logan 2006; Rumold and Aldenderfer 2016). Charred storage tissue (parenchyma) and damaged starch grains of nonidentifiable tubers have been recovered at several sites on the Taraco Peninsula, along with *Solanum* sp. and *Oxalis* sp. seeds (potatoes and oca; Bruno 2008; Logan 2006). These remains increase in the Late Formative, suggesting an increased reliance on tubers (Bruno 2014). In the Tiwanaku Valley, parenchyma (the only means through which tubers were tracked) increased from the Late Formative to the Tiwanaku period (Wright et al. 2003). The advent of raised fields at this time could indicate agricultural intensification or a new strategy to stagger agriculture production to balance subsistence with the state demand for tubers (Bandy 2005b; Kolata 1991).

It is tempting to assume a simple dichotomy in plants in the Titicaca Basin. Were local, ubiquitous, highland crops (like tubers and quinoa) associated with day-to-day life and nonlocal plants (like maize) with feasts and luxury? Plant goods can certainly be prestige items (Hastorf 2003a), and their sensory effects may also have played an important role in Middle Horizon "worlding" (Lau 2016). As a nonlocal plant that people consumed at feasts, maize could be considered a luxury. In fact, Titicaca Basin archaeologists have labeled it a "political plant" (Hastorf et al. 2006:429) and argued that it "achieved a social prominence (as evidenced by its use in ritual contexts) before it became a useful grain" (Chávez and Thompson 2006:426).

Yet the contexts of recovery of both maize and highland plant remains complicate luxury/everyday binaries. For example, Middle Formative Chiripa feasting vessels contained not only maize but also potato and *Chenopodium* remains, and Late Formative feasting vessels produced signals for C_3 plants, such as tubers, quinoa, or legumes (Miller 2005). At Tiwanaku, tubers were "regularly distributed" in ritual contexts, including in an offering on the summit of the Akapana (Wright et al. 2003:392). Maize remains, in contrast, were more common in households and least common in ceremonial settings (Wright et al. 2003:397–399). Similarly, ceramic assemblages associated with chicha and feasts were most common in Tiwanaku households (Goldstein 2003:165). Quinoa was common at Tiwanaku in both household and public spaces.

Although spaces were not simply divided into "private households" and "public ceremonial," the presence of local and nonlocal plants across a variety of contexts shows that there was not a simple link between nonlocal and luxury. Just as a regular pot might become a ritually appropriate vessel when "framed" in a particular way (Miller 1985; Roddick 2009:91–93), it was not just a plant's type that determined its status but also its context, how people prepared or consumed it, and who may have been permitted to share in the act of consumption.

There are also methodological and taphonomic challenges to consider when comparing the presence of certain plants in transit communities. Maize is highly visible in the archaeological record and can be identified through the analysis of charred remains (including cobs and kernels), phytoliths, starch grains, and stable isotopes (Berryman 2010; Chávez and Thompson 2006; Hastorf et al. 2006; Logan et al. 2012; Wright et al. 2003). Quinoa seeds are ubiquitous in macrobotanical samples in the region and are easy to track. Tuber macroremains, however, do not preserve as well because they are high in water, which makes them particularly vulnerable to degradation; in addition, people often eat tubers in their entirety (Duke et al. 2018:74). It is also difficult to identify the genus or species of parenchyma, whereas seeds of species such as *Solanum* sp. and *Oxalis* sp. could be from either wild or domesticated plants (Bruno 2008:334, 337). However, many tubers do produce diagnostic starch grains and thus are visible through microbotanical analyses (Rumold and Aldenderfer 2016).

Starch analysis is perhaps the best means of tracing tubers, though these methods do have limitations. Starch grains are easily damaged during cooking and are particularly vulnerable to postdeposition degradation (Babot 2003; Barton and Matthews 2006:85; Henry et al. 2009). Sampling from artifacts can mitigate this challenge because artifacts help protect starches from degradation in soils (Williamson 2006). This strategy is particularly important for large starch grains (like those produced in highland tubers) because they are more susceptible to degradation. Phytoliths, in contrast, are less susceptible to damage from food processing and postdeposition degradation (Piperno 2006a:106). This means that plants that preserve best as starches may be underrepresented, and those that produce high counts of phytoliths (like grass family plants including maize) may be overrepresented (Piperno 2006a:104).

Despite these limitations, microbotanical techniques allow us to trace plants like tubers that were essential to ancient Titicaca Basin inhabitants. Although macrobotanical analyses are relatively common in the Titicaca Basin (Bruno 2008; Bruno and Whitehead 2003; Whitehead 1999, 2007; Wright et al. 2003), few have used microbotanical techniques (but see Chávez and Thompson 2006; Logan 2006; Logan et al. 2012; Rumold and Aldenderfer 2016). This study is a step toward addressing that gap.

Sampling and Methods

We extracted microbotanical samples directly from ceramics. Samples from Challapata were procured early in the 2016 excavation season and thus are relatively random samples ($n = 6$) from taphonomically secure units surrounding Oqo Qoya Pata (Table 1; Figure 4). Four ceramics are from Unit 1, an area east of the mound characterized by deposits rich in construction fill and Formative period materials (loci 15–17), with the earliest (locus 17) likely characterizing Middle–Late Formative transitions. Two ceramics were analyzed from Trench 1, a 1 × 6 m unit excavated in the center of the mound. Although we do not yet have radiocarbon dates, ceramic analysis phased materials to the Late Formative.

Those sampled from Chiripa ($n = 5$) did not come from archaeological excavations but rather from a 2015 community construction project east of the Monticulo (Table 1; Figure 5; Reilly 2017:27). Although this limits their contextual information, the vessels were clearly produced during the Middle Horizon. Because they were not excavated as part of an archaeological project, they remained unwashed in the community museum until Reilly completed microbotanical extractions in 2016. Reilly (2017) also completed ceramic attribute analysis in laboratory settings in Bolivia after finishing the washes. This helped contextualize botanical results and linked them to larger discussions of ceramic production and use in the Lake Titicaca region.

Table 1. Microbotanical Food Remains Identified in Studied Ceramic Vessels.

					Phytoliths			Starch Grains								
Site	Sample	Artifact	Context	Wash	*Zea mays*	Cf. *Z. mays*	Total	*Ipomoea batatas*	*Manihot esculenta*	*Maranta arundinacea*	*S. tuberosum*	*Z. mays* (blocky)	*Z. mays* (spherical)	Unidentifiable lowland tuber	Total	Starch Identiffication Notes
Challapata	CHALL1	Bowl rim	Unit 1, Locus 15	Sonicated												
				Wet		1	**1**									
				Dry												
	CHALL2	Body sherd	Unit 1, Locus 15	Sonicated												Unidentifiable lowland tuber: semi-spherical with two pressure facets and clear non-90° extinction cross. Consistent with starches that Piperno and Holst (1998:771, Figure 19) identify as possible *M. esculenta*. Reilly has also observed this form in comparative collections of lowland tubers including *I. batatas*.
				Wet										1	**1**	
				Dry		2	**2**									
	CHALL3	Necked vessel rim	Unit 1, Locus 16	Sonicated												*M. arundinacea:* ovular with indentations around edge and eccentric linear fissure (Piperno and Holst 1998). Similar in size and morphology to a starch that Duncan and colleagues (2009:13205 Figure 3E) securely identified as arrowroot.
				Wet	1		**1**			1						
				Dry												
	CHALL4	Body sherd	Trench 1, Locus 4	Sonicated												*Z. mays:* smooth and sperhical with 90° extinction cross (Pearsall 2004). Stellate fissure consistent with roasting (Babot 2003). *I. batatas*: pressure facets with distinct margins, 90° extinction cross arms widening at edges (Pagan-Jimenez et al. 2015; Piperno and Holst 1998). Some qualities similar to blocky faceted maize, but a secure identification because of diagnostic traits and striking similarity to starches in MPERF reference collection.
				Wet									1		**1**	
				Dry				1							**1**	
	CHALL5	Handle	Trench 1, Locus 3	Sonicated												*Z. mays:* blocky and faceted with crisp 90° extinction cross and central hilum (Pearsall 2004). Small linear fissure at center consistent with dehydration (Babot 2003).
				Wet												
				Dry								1			**1**	

(*Continued*)

Table 1. Continued.

					Phytoliths			Starch Grains								
Site	Sample	Artifact	Context	Wash	*Zea mays*	Cf. *Z. mays*	Total	*Ipomoea batatas*	*Manihot esculenta*	*Maranta arundinacea*	*S. tuberosum*	*Z. mays* (blocky)	*Z. mays* (spherical)	Unidentifiable lowland tuber	Total	Starch Identiffication Notes
Chiripa	CHP1	Wide vasija	Burial	Sonicated							1				**1**	*S. tuberosum:* ovular, round when rotated, with pronounced lamellea, non-right angled extinction cross (Logan 2006; Reichert 1913). Damage consistent with chuño production or milling: one has a bent-armed extinction cross and open fissure and other has small fissures around edge (Babot 2003).
				Wet												
				Dry							1				**1**	
	CHP2	*Cuenco*	Burial	Sonicated					2					1	**3**	*M. esculenta:* bell-shape with no visible lamellae (Piperno and Holst 1998; Piperno 2006b). One grain had enlarged cross-shaped fissure and two pressure facets. Other has small stellate fissure and one pressure facet. Both have obscured extinction cross, damage consistent with milling (Chandler-Ezell et al. 2006). Unidentifiable lowland tuber: see notes from CHALL2.
				Wet												
				Dry	3		**3**									
	CHP3	Llama effigy vasija	Burial	Sonicated								1			**1**	*Z. mays:* blocky polygonous morphology with pressure facets and crisp 90° extinction cross (Pearsall et al. 2004) Extinction cross slightly obscured by circular hole at the hilum, damage associated with dehydration or milling (Babot 2003).
				Wet		1	**1**									
				Dry												

Note: All maize phytoliths are narrow elongate rondels as described by Logan (2006).

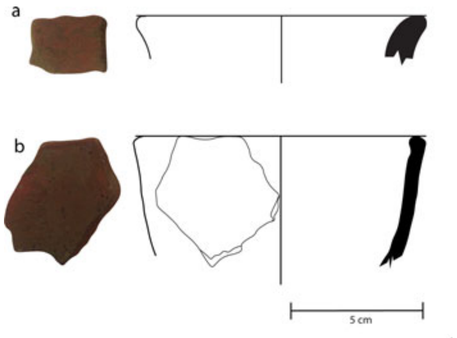

Figure 4. Challapata artifacts: (a) Bowl rim (CHALL1): (b) necked vessel rim (CHALL3) (photos and illustrations by Sophie Reilly).

To obtain microbotanical samples, Reilly performed three washes, using clean petri dishes, as well as new gloves and pipettes, for each wash to mitigate the risk of contamination.

(1) The dry wash reveals plants deposited in the same area as the artifact or at a site but not those directly associated with the analyzed vessels. Adhering sediments are brushed off the inner surface of each ceramic sherd with gloved fingers. This sediment is then transferred to a centrifuge tube.
(2) The wet wash informs us of vessel use or the surrounding soil, corroborating findings from the final sonicated wash. Distilled water is pipetted onto the artifact. The sediment is removed using gloved fingers and then pipetted into a labeled centrifuge tube.
(3) The sonicated wash provides information on vessel use. Distilled water is pipetted onto the artifact. A handheld sonicator targets specific areas of the sherd to extract sediments from artifact pores. This aqueous sample is transferred to a labeled centrifuge tube.

All centrifuge tubes were exported to Canada for microbotanical analysis at the McMaster Paleoethnobotany Research Facility (MPERF). Initial work on Challapata samples did not yield high counts of phytoliths or starch grains, and Reilly therefore applied heavy liquid flotation to isolate phytoliths and starch grains and facilitate their identification (Morell-Hart 2011:287–288). A heavy liquid solution (2.3g/mL) of water and sodium polytungstate was added to samples with volumes higher than 2 mL to float and isolate microbotanicals. The concentrate from each sample was then rinsed using a series of washes in distilled water to remove traces of the sodium polytungstate. This step increased the number of identifiable microbotanical remains.

Each sample was mounted on an individual slide and scanned using a high-powered transmitted light Zeiss microscope. Photos were taken of any diagnostic or potentially diagnostic specimens. Phytoliths and starch grains were identified with the help of the MPERF reference collection, previously published works, and in consultation with Shanti Morell-Hart (McMaster University) and Amanda Logan (Northwestern University). Unknown specimens were photographed and recorded using standards laid out in the International Code for Phytolith Nomenclature (ICPN; Madella et al. 2005).

Results

Phytoliths and starch grains were recovered from samples at both Challapata and Chiripa. Erring on the side of caution, we only linked plants to vessel use when they were recovered in the sonicated washes, though we recognize that plant remains from wet wash samples could be linked to use. In this section and in Table 1, we describe the diagnostic morphological features of each phytolith and starch grain identified as food. We also briefly describe damage to starch grains and our associated inferences about how these ingredients were cooked. For a more in-depth discussion of starch damage, including detailed descriptions, see Babot (2003) and Henry and colleagues (2009).

Our analysis at Challapata yielded food remains only after heavy liquid flotation (Figure 6); none were recovered from sonicated washes and therefore could not be securely linked with vessel use. We found maize in all Challapata samples, though some identifications are tentative. In one case (CHALL5; Figure 6a and 6b), a linear fissure on a maize starch grain suggested possible dehydration. Another starch grain (CHALL4; Figure 6c and 6d) had a star-shaped fissure, damage that is consistent with roasting.

Figure 5. Chiripa artifacts: (a) Llama effigy *vasija* (CHP3); (b) bowl; (c) effigy handled *vasija*; (d) wide *vasija* (CHP1); (e) *Cuenco* (CHP2) (photos by Sophie Reilly). (Color online)

Challapata samples also revealed the presence of other nonlocal plants. The wet wash sample of CHALL2 included a starch grain of an unidentifiable lowland tuber (Figure 6i and 6j), similar in form to yuca (*M. esculenta*) or perhaps sweet potatoes (*I. batatas*). This grain has damage consistent with milling. The wet wash of CHALL3 resulted in the identification of arrowroot (*M. arundinacea*; Figure 6g and 6h). The dry wash of CHALL4 contained a sweet potato (*I. batatas*) starch grain (Figure 6e and 6f).

Of the five artifacts in the analyzed Chiripa burial, three contained likely food remains (Figure 7): the wide *vasija*, the *cuenco*, and the llama effigy *vasija*. With the exception of maize phytoliths, all food remains were starch grains. Most were identified in sonicated wash samples, meaning that they can be securely

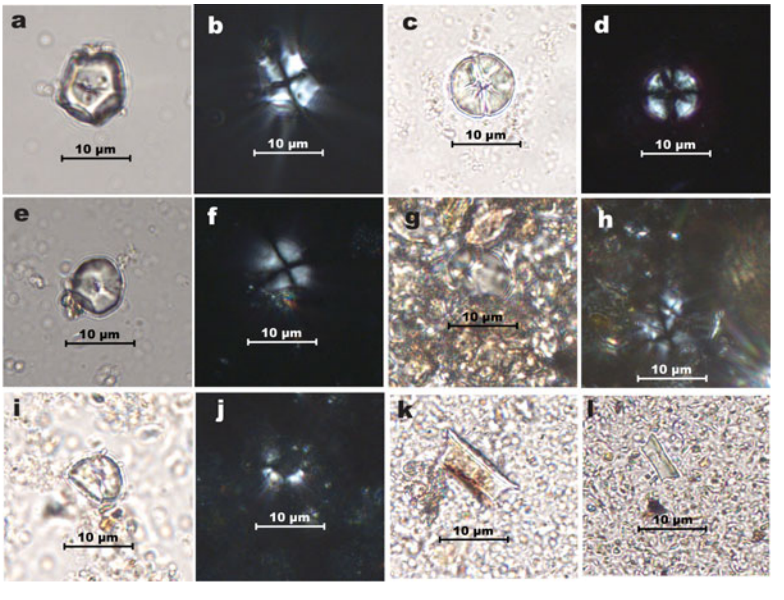

Figure 6. Starch grains and phytoliths from Challapata samples. (a–b) *Z. mays* starch from CHALL5; (b–c) *Z. mays* starch from CHALL4; (d–e) *I. batatas* starch from CHALL4; (g–h) *M. arundinacea* starch from CHALL3; (i–j) unidentifiable lowland tuber from CHALL2; (k–l) cf. *Z. mays* narrow elongated rondels from CHALL2. (Color online)

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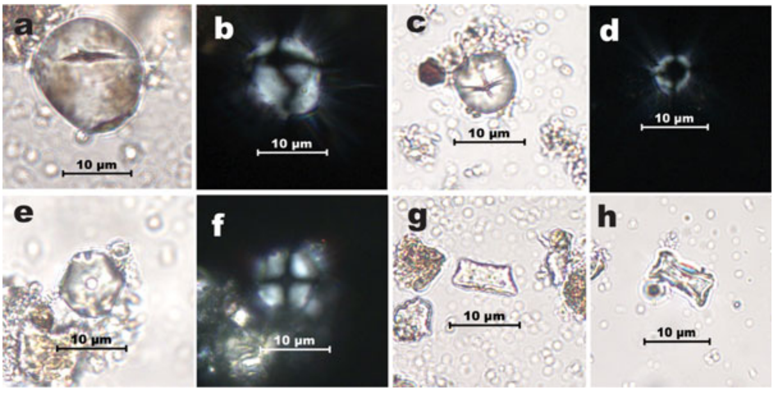

Figure 7. Starch grains and phytoliths from Chiripa samples: (a–b) *S. tuberosum* starch CHP1; (c–d) *M. esculenta* starch CHP2; (e–f) *Z. mays* starch CHP3; (g–h) cf. *Z. mays* phytoliths CHP2. (Color online)

linked to vessel use. The presence of securely and tentatively identified maize phytoliths in wet wash and dry wash samples from multiple artifacts indicates that maize was likely present in the soil matrix of the burial, which could mean that maize cobs were included as offerings as well. Three maize phytoliths (Figure 7k and 7l) were recovered in the dry wash of CHP2 (*cuenco*). The wet wash in CHP3 (llama *vasija*) had a maize phytolith, and the sonicated wash had a maize starch grain (Figure 7e and 7f) with damage associated with dehydration or milling (Babot 2003:76–78).

Reilly also identified potato (*S. tuberosum*) starch grains in both the sonicated wash and the dry wash CHP1 (wide *vasija*; Figure 7a and 7b). Both showed damage associated with *chuño* (freeze-dried potatoes) production (Babot 2003; Rumold and Aldenderfer 2016). Two yuca (*M. esculenta*) starch grains were securely identified in the sonicated wash sample of CHP2 (*cuenco*; Figure 7c and 7d), one with enlarged fissures and both with obscured extinction crosses. These forms of damage are linked with milling (Chandler-Ezell et al. 2006). The sonicated wash of this same sherd revealed an unidentifiable lowland tuber starch grain similar to the one described from CHALL2.

Discussion

Our data show that microbotanical analyses provide a more complete view of foodways and exchange. These techniques reveal taxa, such as tubers, that are very vulnerable to degradation, are often consumed in their entirety, and do not leave behind byproducts like seeds that can be traced macrobotanically. Even with a small sample size, microbotanical analysis provides a window into an otherwise unknown world of plants, some of which may have been quite common. Starch grain analysis is particularly well suited to studies in the Titicaca Basin. Although a high number of phytoliths were present in all studied samples, most were grass (Poaceae) and cannot be securely identified as food (Reilly 2017:135–137). Tentative subfamily identification of the grass phytoliths suggests that most are in the festucoid subfamily of highland grasses, whereas maize is in the panicoid subfamily of lowland tropical grasses. This is significant because phytoliths are much more durable than starch grains yet may not be best suited to tracing food in this region. The paucity of starch analysis in the Titicaca Basin (but see Logan 2006; Rumold and Aldenderfer 2016) is likely partially responsible for the overrepresentation of maize and quinoa and the underrepresentation of tubers. Like elsewhere in the Andes, we must go beyond macrobotanicals by sampling for starch grains on artifacts where they are better protected from decomposition (Duke et al. 2018; Duncan et al. 2009; Rumold and Aldenderfer 2016; Williamson 2006).

Our study recovered a variety of species of lowland crops at Late Formative Challapata, including arrowroot, maize, sweet potato, and unidentifiable lowland tuber. Particularly significant here is the identification of lowland tuber species, the first to be recorded in the Titicaca Basin; their presence is a sign of possible connections with Amazonian valleys. Ongoing ceramic analysis at Challapata is identifying foreign pastes with a firing profile similar to those seen in the eastern Andean valleys. The presence of maize at Challapata complements Hastorf and colleagues' (2006) study by suggesting that the eastern Amazonian valleys may have been an additional source of Tiwanaku maize. A next step would be to sample modern maize from the eastern region to compare with the archaeological maize recovered in macrobotanical work, which would help determine how common this type of maize was in the Titicaca Basin.

The Middle Horizon Chiripa burial hints at the movement of nonlocal things and knowledge into the Titicaca Basin, where people seem to have integrated them into local practices. The burial contains an effigy handled *vasija* (Figure 5c) with a serpent motif similar to ceramics recovered in the Cochabamba Valley (Janusek 2003:75), as well as an effigy *vasija* depicting a llama (Figure 5a), an animal strongly linked to local Altiplano practices and identity (Vallières 2012). The microbotanicals recovered in these vessels—which may be the remains of plants included in the burial as food offerings—further support such local–nonlocal connections. The burial includes potato, likely grown locally in the Titicaca Basin; yuca, which may have been acquired from eastern Amazonian valleys; and maize.

Other than maize, all foods identified in this study—potato, arrowroot, sweet potato, and yuca—are tubers. The presence of lowland tubers in these contexts suggests we may want to revisit previously identified macrobotanical tuber remains. Most archaeological evidence for tuber consumption in the southern Titicaca Basin is in the form of preserved parenchyma that cannot be identified to the genus or species level. Given the high number of tuber species domesticated and available in the Titicaca Basin, there has been an implicit assumption in much of the region's archaeobotanical research that parenchyma remains are those of local species (Bruno 2008; Hastorf 2012). However, given our findings that Titicaca Basin communities consumed lowland tubers as well, such assumptions should now be questioned. To develop a better understanding of highland versus lowland tuber use, future projects should integrate microbotanical analysis to complement macrobotanical results.

Our findings also suggest the need for further work into Late Formative–Middle Horizon foodways dynamics, specifically to consider the movement of starches (Boivin et al. 2012). Considerations of tubers in the Andes often come with certain assumptions. For instance, according to Duke and colleagues (2018:78), Moche archaeologists working on the Peruvian north coast long assumed that potatoes were a "novelty food" reserved for high-status people; this assumption was largely based on the lack of archaeological evidence for potato consumption across Moche sites (though Ugent and colleagues [1982] recovered potatoes from much earlier contexts [2000–1200 BC] in the Casma Valley). Duke and colleagues' (2018) recent starch grain analysis, however, suggests that potatoes were regularly consumed in quotidian contexts. Our findings of potato alongside maize and yuca in an offering context further support the argument that potatoes were consumed not only in quotidian contexts but also were ceremonially potent in the Titicaca Basin.

As we suggest earlier, food consumption often defies simple domestic–ceremonial binaries. For instance, in her study of camelid consumption in the Mollo Kontu neighborhood at Tiwanaku, Vallières (2012) demonstrates that camelid meat, a local ingredient, was consumed on a day-to-day basis. She argues that this daily consumption did not render camelid meat trivial; rather, the ingredient's importance in people's everyday lives made it socially valued (Vallières 2012:335–336). The same might be said for potatoes and other varieties of highland tubers. Their availability to Titicaca Basin communities through local agricultural practices made them both local staples and socially valued ingredients. The choice to acquire nonlocal tubers is yet another indication of the value of these ingredients.

In fact, the familiarity of highland tubers may have made lowland varieties easier to incorporate into Titicaca Basin culinary practice because new species of tubers could have easily been blended with or hidden in highland meals (Wilk 2006). These tubers may also have been used as substitutes; for instance, thrown into a stew to replace familiar ingredients like potatoes. New foods act as agents of change, yet they can be indigenized through their incorporation into preexisting practices (Lau 2016). It is also possible that the acquisition of lowland tubers was another strategy to stagger food production throughout the year. In a potentially similar strategy to Bandy's (2005b) proposed use of raised fields, Titicaca Basin communities may have acquired lowland crops in periods of the year when the cultivation of highland crops was not as fruitful.

This issue of "acquisition" returns us to discussions around transit communities and the movement of goods. Inhabitants in communities like Late Formative Challapata may have gained access to plants from eastern Amazonian Valleys. Although Chiripa's importance as a transit community likely faded by the Middle Horizon, the community continued to have access to nonlocal goods. The lowland crops at Challapata—arrowroot, sweet potato, and maize—likely moved up the road that we recently identified as connecting eastern basin sites with the eastern valleys. Ceramic analysis has previously demonstrated that pots circulated between sites in the eastern and southern Titicaca Basin (Janusek 2004; Stanish 2003:154); it is therefore possible that plant goods did as well, perhaps even in pots, as we see in the ethnographic and ethnohistoric record. Like other prestige goods, these plants may have arrived at sites where elites extracted tolls, feeding an ongoing "growth cycle" as per Bandy's hypothesis.

But our work also suggests the need for more complex approaches to diverse things and plants in such places and to think beyond classifications of prestigious or the everyday. The burial at Chiripa is a microcosm of Titicaca Basin circulation, demonstrating that goods from different sources come together in Altiplano practices and alluding to the complexity of things and foods in motion. Although there has been a tendency to look for single kinds of trade networks in the Titicaca Basin, with attention focused on prestige goods, our current data suggest that during the Late Formative and likely into Tiwanaku phases, there were a diversity of mechanisms behind the movement of goods (Lazzari et al. 2017). This decentralized model might have involved separate networks for the movement of different kinds of artifacts and plants.

Nielsen (2013) has suggested that the exchange of objects in the southern Altiplano likely took place in domestic settings or at caravan camps at the edge of settlements. He also claims that many objects moved across the landscape not only by the "specialized traffic" of llama caravans but also in an embedded capacity, within a particular verticality scheduled around hunting and gathering (Nielsen 2013:412). Those of us working in the Titicaca Basin must also begin to think of trade not as a single (and controlled) route but instead as "the result of multiple heterogeneous and redundant practices" (Nielsen 2013:413). Certainly, the movement of goods such as tubers suggests the need to complicate our thinking not just of transit communities but also of all communities consuming nonlocal goods and to consider the diverse possibilities of both horizontal and vertical economies through our long archaeological sequence.

Conclusion

Studies of foodways provide us with a distinct way for thinking about the circulation of ancient things, particularly because ingredients cannot be easily boxed into categories of "luxury" and "mundane." Microbotanical analyses ensure that archaeologists capture a more complete picture of plants that were both locally available and entering the Titicaca Basin from surrounding lowland communities. In the cases of Challapata and Chiripa, microbotanical analysis reveals that these two transit communities had access to a wide range of lowland plants—not only maize but also arrowroot, sweet potato, and yuca. Our analysis at Chiripa shows that people continued to consume highland tubers (potato) even while they had access to lowland species. Continued investigations of foodways at transit communities in the Titicaca Basin, as well as the lowland communities outside the region, will contribute to a more complete understanding of connectivity between these communities in the Formative period and Middle Horizon.

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Data Availability Statement. Primary data discussed in this article were generated by the authors, and all other data are available in the referenced literature. Relevant botanical data are outlined in this article, but interested parties can find the full botanical dataset generated by this research in Reilly's (2017) master's thesis, cited here and available through McMaster University's institutional repository MacSphere. Botanical residues were analyzed at the McMaster Paleoethnobotany Research Facility (MPERF), and samples continue to be housed there. Ceramic artifacts discussed are currently housed in government and community repositories in Bolivia.

Competing Interests. The authors declare none.

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