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The introduction of the bow and arrow in the Argentine Andes (29-34º S): A preliminary metric approximation

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Abstract:

The study size patterns in projectile points (n=39) from six sites in the Argentine Andes (29-34° S) associated with 17 radiocarbon dates with medians spanning 3080-470 cal. BP. In the northern part of our study area (29° S), one site has domestic llama (*Lama glama*) bones as early as 5800 cal. BP. In the central and southern part of the study area (32 and 34° S), clear evidence for pastoralism, horticulture, and potentially agriculture is no earlier than 1500 cal. BP. Our study area extends to 34° S, which is the southern limit of pastoral and food-producing societies in South America. In our study area, it is unknown if the bow was adopted early, as in the central Andes, or late and used alongside spears, as in Patagonia. This is the region's first attempt to metrically distinguish arrows and darts, which is based on shoulder or maximum width, following Shott. The northern sector located at 29° S includes the earliest arrow point, slightly after 3080 cal. BP. This suggests a rapid spread of this technology from the central Andes 16-26° S, where early arrows are dated ~3500-3000 cal. BP. However, at 32 and 34° S, arrows are not clearly present until 1280 cal. BP. For 1280-400 cal. BP (European contact), 96% of points were identified as arrows, suggesting the bow and arrow replaced spear-based weapon systems. A single late dart from 34° S may reflect a late use of this space by hunter-gatherers. The predominance of arrows beginning at 1280 cal. BP is associated with broader changes such as demographic growth, reduced mobility, low-level food production, and herding economies, following similar trends in other regions.

Keywords: projectile points; bow hunting; metric distinction of darts and arrows; weapon system replacement, Argentine Andes.

1. Introduction

There has been sustained interest in methods for distinguishing arrow and dart projectile points in North America (*e.g.*, Ames *et al.* 2010; Bradbury 1997; Erlandson *et al.* 2014; Fenenga 1953; Hildebrandt & King 2012; Rorabaugh & Fulkerson 2015; Shott 1997; Thomas 1978; Walde 2014) and more recently in South America (De Souza 2011; Oliszewski *et al.* 2018; Ratto 2003; Tomka 2013). Smaller arrows were most likely used with bows while darts

were used with throwing spears or atlatls, so distinguishing point types can shed light on the weapon systems people designed and used. Different weapon systems reflect prey choice, hunting tactics, subsistence patterns, degree of mobility, and social organization (Churchill 1993). Spears are a much older technology and the introduction of the bow accompanied other profound shifts in many regions around the world (*e.g.*, Bettinger & Eerkens 1999).

In South America, there was a regional shift from foraging to agropastoralism ~3540-3120 cal. BP in the Lake Titicaca Basin (Marsh 2015) as well as other parts of the central Andes. This radical and enduring change included the region's earliest use of ceramics and widespread use of the bow and arrow, though the earliest arrows are from contexts just prior to this shift (Klink & Aldenderfer 2005: 54). At this time, arrows are also found much farther south in northern Chile and Argentina (De Souza 2011; Hocsman 2010; Oliszewski *et al.* 2018; Ratto 2003). These early arrows are associated with the region's first domestic plants, growing populations, and increasing social complexity, which in many cases track environmental shifts (Morales *et al.* 2009). In contrast, in southern South America, Patagonian hunter-gatherers used spears throughout prehistory; they added bows to their hunting repertoire just a few centuries prior to European contact (Banegas *et al.* 2014; Charlin & González-José 2018).

Our study area (29-34° S) lies between these two regions and their very different histories with bow hunting. We evaluate projectile points (n=39) from contexts on the eastern slope of the Andes (1900-3800 masl) from the last three thousand years. These millennia saw major changes in mobility and social organization reflected in the appearance of ceramics, pit houses, and domestic plants and animals (Cortegoso *et al.* 2014; Frigolé & Gasco 2016; Frigolé 2017; Gil *et al.* 2009; Llano *et al.* 2018). In the northern part of our study area (29° S), one site has domestic llama (*Lama glama*) bones as early as 5800 cal. BP (Castro *et al.* 2013; Gasco 2014). In the central and southern part of the study area (32 and 34° S), clear evidence for pastoralism, horticulture, and potentially agriculture is no earlier than 1500 cal. BP. Our study area extends to 34° S, which is the southern limit of pastoral and food-producing societies in South America.

In our study area, it is unknown if the bow was adopted early, as in the central Andes, or late and used alongside spears, as in Patagonia. This paper addresses the following questions: When were bow and arrow introduced in at different latitudes? Did this technology spread quickly or slowly? Did the bow replace spear weapon systems or did the two co-exist? Was the bow introduced in conjunction with the earliest ceramics ~2200-2100 cal. BP (Marsh 2017), following the pattern from the central Andes? Was the bow associated with subsistence or mobility changes, as in the central Andes, or not, as in Patagonia? Toward clarifying these issues, this paper presents the region's first attempt at metrically distinguishing arrows and darts.

2. Study area, sites, and phases

The study area includes high-altitude environments in northern San Juan Province and northern and central Mendoza Province (Figure 1). The climate is arid to semiarid with summer rains in the valleys and winter snow in the mountains. The gradient of precipitation is irregular and decreases to the north, though in general annual rainfall is around 250 mm (Cabrera 1971). Mountain wetlands or *vegas* are very important because they have offer rich summer pastures, especially for guanacos (*Lama guanicoe*), which are the largest mammals and most important prey in the Andes. In the northern and central part of the study area, lithic raw materials are principally chert and rhyolite; in the southern area, there is good availability of obsidian (Castro *et al.* 2014; Durán *et al.* 2012; Cortegoso *et al.* 2017; Cortegoso 2008; Lucero *et al.* 2006).

Figure 1. Study area and archaeological sites.

The projectile points we evaluate here (n=39) are from six sites (Table 1): two at each latitudinal band of 29, 32, and 34° S. Our sample was reduced because we excluded projectile points with no associated radiocarbon dates as well as lithic artifacts that may have been used for other purposes than hunting. The northern area includes the rock shelter Arq-18 and the surface site Arq-5 in the Las Taguas River valley. Occupations associated with projectile points in this study have median dates between 3080 and 510 cal. BP (Castro 2018; Cortegoso 2014; Lucero *et al.* 2017). By the occupation dated to 3080 cal. BP, there is a clear presence of longer stays at this high-mountain valley with domestic llamas (*Lama glama*). These people continued hunting and gathering. This site could not have been feasibly occupied during the winter (Castro *et al.* 2013; Gasco 2014). The central area includes one site from the Precordillera highlands, Agua de la Cueva, and a surface site from the bottom of the adjacent valley, Uspallata Norte. The material from Uspallata Norte suggests that the site's occupation

was limited just a few centuries, as indicated by two dated surface hearths. There is no evidence for occupations before or after the pre-hispanic ceramic period. Most likely, the projectile points are from the temporal span suggested by the two dates or a few centuries later. Since these associations are less secure than excavated contexts, we deemphasize them in our assessment of regional trends. At Uspallata Norte, Agua de la Cueva, and other nearby sites, there is consistent evidence for mixed economies in occupations dated between 1500 and 470 cal. BP, however, only the valley bottom has a climate suitable for year-round occupation (Castro & Yebra 2018; Durán & García 1989; Frigolé & Gasco 2016). In the southern area, there are two sites on the shores of the alpine lake Laguna del Diamante (LD), S2-E1 and S4-E1, which have occupations associated with informal stone structures that have three dates between 1280 and 680 cal. BP. Snow cover would prevent winter occupation. These groups were seasonally mobile, but there is evidence of ceramics, domestic plants, and domestic animals (Durán *et al.* 2006).

We organized the dates into three phases: 3080-1360 cal. BP, 1280-550 cal. BP, and 550-400 cal. BP. These phases are delimited by inflection points of significant change in the regional culture history: (1) around three thousand years ago, when pastoralists first left an unambiguous material pattern in the northern area, (2) around two thousand years ago, roughly contemporaneous with the earliest ceramics, (3) shortly following 1500 cal. BP, when pastoralism and horticulture became more common in the central area, (4) 550 cal. BP, when the Inca empire arrived in the northern and central area, and (5) European contact ~400 cal. BP.

Table 1. Archaeological sites, dates, and phases associated with projectile points. Dates calibrated with SHCal13 (Hogg *et al.* 2013) and rounded by 10 years. In the text, we refer to calibrated medians but do not disregard the error ranges.

Site	Latitude (°S)	Altitude (masl)	Context	Laboratory Code	14C age	Median cal. BP	68% probability range	95% probability range	Phase	Reference
Arq-18	29	3750	C-I (outside rock shelter)	LP-1748	2980±70	3080	3210-2970	3340-2870	1	Cortegoso *et al.* 2014
				LP-1851	2300±60	2230	2350-2160	2380-2090	1	
				LP-1842	1900±70	1780	1880-1710	2000-1600	1	
				LP-2094	1750±60	1600	1710-1560	1810-1430	1	
				LP-2085	1540±60	1380	1430-1300	1530-1300	1	
			C-I (inside rock shelter)	LP-2098	790±60	690	740-650	790-560	2	
Arq-5			Stratum 2	LP-1987	510±60	510	550-470	630-320	3	
Agua de la Cueva	32	2990	Stratum 5 (CJ-5)	LP-1621	1330±60	1200	1290-1110	1300-1070	2	Cortegoso *et al.* 2014; Gil *et al.* 2014
				LP-1627	1220±70	1090	1180-980	1270-950	2	
			Stratum 6 (CJ-6)	LP-2994	780±50	700	730-650	750-560	2	Gasco *et al.* 2018
				LP-2950	600±60	550	630-520	660-500	2	
			Stratum 7 (CJ-7)	AC-1563	470±80	470	550-330	630-300	3	Gil *et al.* 2014
Uspallata Norte	32	1980	TN-1 (surface)	D-AMS-18774	1656±36	1500	1550-1430	1590-1410	1	Buehlman-Barbeau *et al.* 2017
			D1 (surface)	LP-3421	1540±50	1380	1430-1310	1520-1300	1	unpublished
LD-S2-E1	34	3300	Stratum 2-3	LP-1400	1410±40	1280	1320-1190	1350-1180	2	Durán *et al.* 2006
LD-S4-E1			C-III	LP-1043	1100±40	960	1050-920	1070-900	2	
			C-II	AA-58290	782±35	680	720-650	740-570	2	

3. Methods

There is a long history of research on quantitative methods for distinguishing darts and arrows (*e.g.*, Bradbury 1997; Fenenga 1953; Hildebrandt & King 2012; Shott 1997; Thomas 1978). So far, there is not a consensus on which variables or method is best; the appropriate index and variables seem to vary by region. In aquatic settings, harpoon tips for hunting birds and fish may obscure a clear distinction between arrows and darts (Erlandson *et al.* 2014). Our study area includes very limited aquatic settings so we can safely exclude this possibility.

Shott's function (1997) has been most widely applied means of metrically distinguishing darts and arrows. Building on Thomas (1978), Shott added the variable shoulder width, which he found to be the most discriminating variable in his ethnographic collection. His classification functions are:

Dart: 1.40 × (shoulder or maximum width) - 16.85

Arrow: 0.89 × (shoulder or maximum width) - 7.22

The width of a single point is inputted into both functions and the one with the higher value is the correct classification. In the comparative sample, this function identified 92.4% arrows and 76.9% darts, which were more variable. This single-variable function was preferable to multi-variable functions. Shott's study uses mostly stemmed points to determine shoulder width. The current study uses both stemmed and non-stemmed points, which do not have a shoulder. For non-stemmed points, we use the maximum width, following Shott (1993: 431).

Mass has also been used to distinguish between arrows and darts. Fenenga (1953) used mass to group small and large points as 0.4-3.5 g and 4.5-20 g, respectively. There are clearly two size classes, but this pattern is based on archaeological points whose weapon system was unknown, so it is unclear if these size classes correspond to darts and arrows (Shott 1997). Since mass continues to be used in current studies (*e.g.*, Okumura & Araujo 2015) it seems relevant to compare these two methods. The major disadvantage is that mass can only be used with complete points, which are much less common in the archaeological record.

4. Results

Shott's single-variable function separated the samples into two clear groups (Figure 2). Of the total sample, 34 (87%) were identified as arrows and five (13%) as darts (Table 2). All five of the points identified as darts fell in Fenenga's (1953) mass range for large points (4.5-20 g).

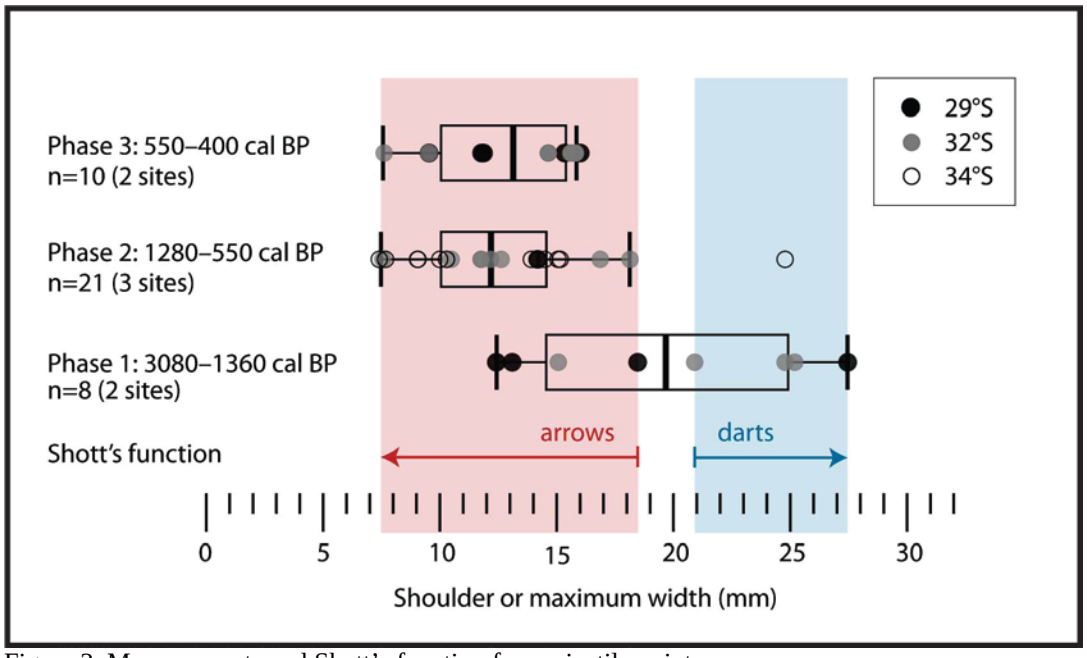

Figure 2. Measurements and Shott's function for projectile points.

Table 2. Measurements and function scores for projectile points, sorted by phase. The bold function score indicates the higher value and hence the dart or arrow classification. The two masses in bold fall into Fenenga's large class of points; the two masses in italics are intermediate between the small and large size classes.

Point	Phase	Site	Context (Unit- sector-level)	Mass of complete points (g)	Shoulder(*) or maximum width (mm)	Shott's dart function	Shott's arrow function
1	1	Arq-18 (C-I/outside)	A-NO-10		12.36	0.454	3.780
2			S2-6	*3.7*	18.36	8.854	9.120
3			A-NE-3	1.3	13.03	1.392	4.376
4			B-NO-3	10.8	27.38	21.482	17.148
5		Uspallata Norte (surface)	G270-1		14.97	4.108	6.103
6			D90-S2		25.1	18.29	15.119
7			D90-S2		24.74	17.786	14.798
8			TN-1	8.5	20.84	12.326	11.327
9	2	Arq-18 (C-I/inside)	S3-5		14.14*	2.946	5.364
10		Agua de la Cueva (stratum 5)	B-NE-34	0.3	10.5	-2.15	2.125
11			A-SE-27		12.12*	0.118	3.566
12			A-NO-25		18.12*	8.518	8.906
13			B-NE-24	0.1	7.56	-6.266	-0.491
14			A-NE-24	0.5	12.57*	0.748	3.967
15		Agua de la Cueva (stratum 6)	A-SE-18		11.77	-0.372	3.255
16			A-SO-19	0.1	11.74	-0.414	3.228
17			A-NE-21	1.9	16.82	6.698	7.749
18		LD-S2-E1	E1.1-NO		15.08	4.262	6.201
19		Laguna del Diamante S4 (E1 C-II)	B-4	0.1	9.04	-4.194	0.825
20			C-4		7.68	-6.098	-0.384
21			C-5		15	4.15	6.13
22			A-SE-5	0.1	7.41	-6.476	-0.625
23			A-SE-6		14.49	3.436	5.676
24			B-SO-5	0.7	10.24	-2.514	1.893

25			C-4		9.03	-4.208	0.816
26			C-4	*3.8*	24.69	17.716	14.754
27		Laguna del Diamante S4 (E1 C-III)	B-SE-8		14.19	3.016	5.409
28			C-8	0.5	9.98	-2.878	1.662
29			C-NO-8		13.85	2.54	5.106
30	3	Arq-5 (surface)	5	1.2	11.64*	-0.554	3.139
31			1		11.72*	-0.442	3.210
32			6		15.78	5.242	6.824
33			2		9.43*	-3.648	1.172
34			Structure 1		15.12*	4.318	6.236
35		Agua de la Cueva (stratum 7)	B-SO-15	0.1	7.5	-6.35	-0.545
36			B-NO-14	0.4	15.58*	4.962	6.646
37			B-NE-14	0.1	9.42	-3.662	1.163
38			B-SE-14		14.42	3.338	5.613
39			B-SE-12	1.2	15.39	4.696	6.477

Phase 1 (3080-1360 cal. BP) comprises four points from the northern and four from the central area. Four arrows were identified and three of them are from the northernmost site, Arq-18. The earliest arrow (Figure 3b) is from the layer just above the oldest date, 3080 cal. BP (LP-1748). Four darts were also identified, and three are from the central area. The points from the central area are from the end of the phase, with dates of 1380 and 1500 cal. BP. At this time, there were three darts and only a single arrow. If this small sample is representative of this phase, bow and arrow technology was more common earlier in the northern area, and may have reached the central area as early as 1500 cal. BP. In general, it seems that both weapon system were present in the region during this phase. The sample for this phase was too small to target the inflection point around two thousand years ago when ceramics were first used, which is a priority for future research.

Phase 2 (1280-550 cal. BP) comprises 21 points from all six sites and all three latitudes, and 20 (95%) were identified as arrows. This much larger sample shows a very consistent pattern, suggesting that by 1280 cal. BP, the bow had replaced the spear over a large region. The only dart (Figure 3i) is from the study's southernmost site (34° S) and associated with a late date of 680 cal. BP. It is possible that this reflects the presence of Patagonian hunters, who used arrows and darts until very late in prehistory (Banegas *et al.* 2014).

Phase 3 (550-400 cal. BP) comprises 10 points from the northern (29° S) and central (32° S). All points were identified as arrows (*e.g.*, Figure 3d, g, h), confirming the sustained pattern in phase 2 with improved chronological control.

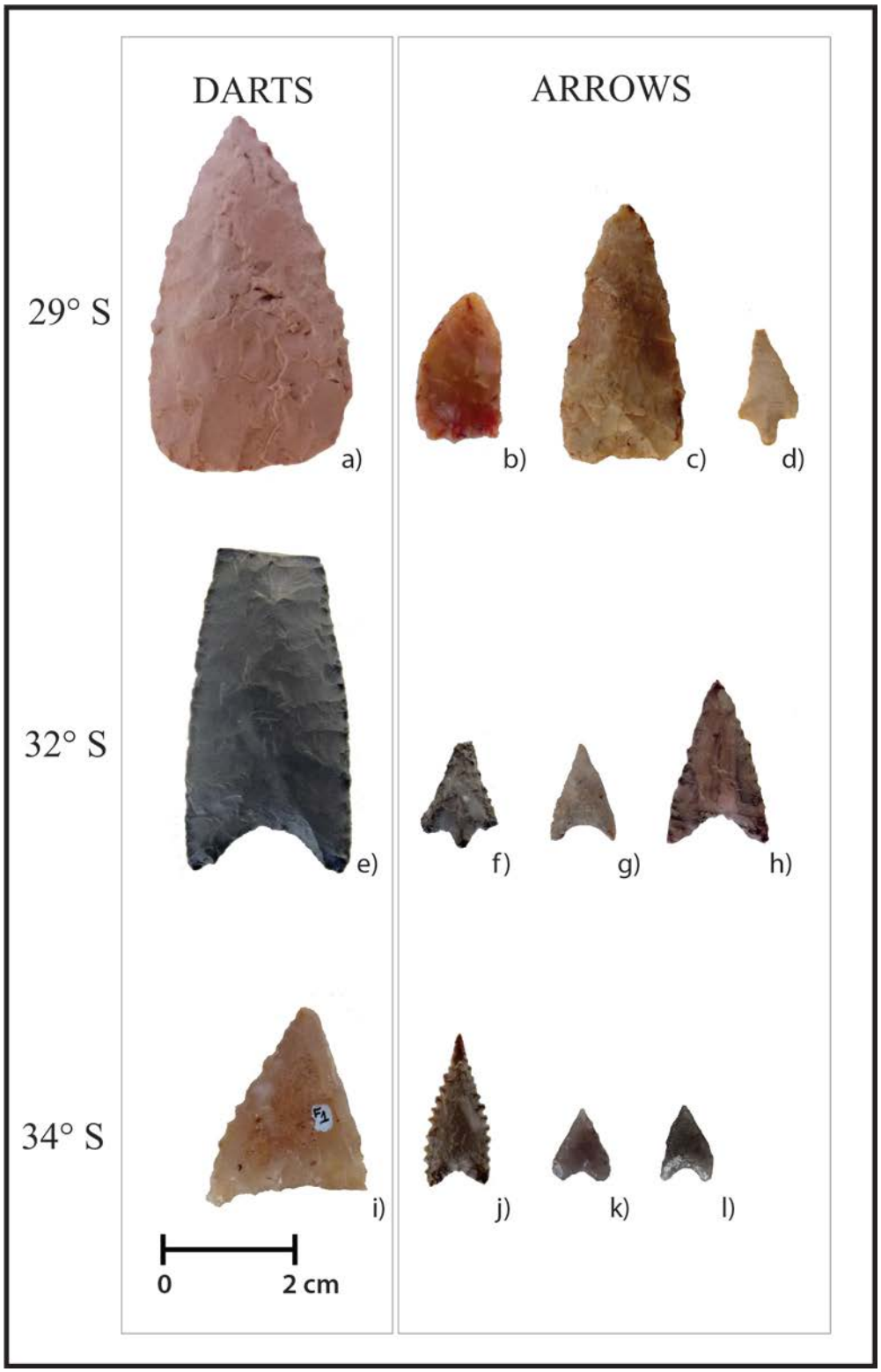

Figure 3. Darts and arrows points from Argentinian Andes (29° to 34° S). Phase 1 (3080-1360 cal. BP): a) point 4, which is similar in size and shape to those published by Gambier (1977:92-93) from 30-31° S associated with dates in the range of Phase 1; b) point 1, which has an impact fracture on the right edge (Castro 2017:9), c) point 2, e) point 7. Phase 2 (1280-550 cal. BP): f) point 11, i) point 26, j) point 28, k) point 19, l) point 22. Phase 3 (550-400 cal. BP): d) point 33, g) point 37, h) point 39.

5. Discussion

These preliminary results lead to discussions of (1) the date and origin of the earliest bow and arrows, (2) the association between the bow and arrow with patterns in subsistence, settlement, and mobility, and (3) the bow's replacement of other weapon systems or co-existence of multiple systems.

5.1. The date and origin of the earliest bow and arrows

The earliest record of arrows is in the northern area, which supports the idea that this technology was introduced from north to south, even though this preliminary analysis is based on a small sample. Farther north at 16-26° S, highland sites have documented arrow points around 3500-3000 cal. BP or slightly prior (De Souza 2004; Hocsman 2010; Oliszewski *et al.* 2018). The earliest arrow point in this study is from 29° S in a context deposited slightly after 3080 cal. BP. This suggests a spread of this technology along a large part of the Andes within a few centuries. However, there seems to be a break in this trend south of 29° S, as the earliest arrow at 32° S is from the end of this phase (point 5), a surface artifact near two surface hearths dated to 1500 and 1380 cal. BP at Uspallata Norte. These data make it possible that the bow and arrow was in use by this date at 32° S, but this remains to be confirmed with excavated contexts. For now, a more reliable date for the earliest arrow at 32° S is from stratum 5 of Agua de la Cueva, 1200 cal. BP (LP-1621). This stratum's five points are all arrows (points 11-14). The earliest arrow from 34°S is dated to 1280 cal. BP (LP-1400; point 18). South of 29° S, there is a temporal discontinuity, as the earliest arrows for 32 and 34° S are at 1200 and 1280 cal. BP, which suggests a roughly simultaneous adoption in these two areas. This suggests (1) there was a gap in social contacts south of 29° S during phase 1 or (2) people south of 29° S knew of the bow but chose not to adopt it. This should be evaluated with a larger sample from phase 1 dates, which could clarify when the earliest arrows were used at 32° S, since dates from surface contexts are a few centuries earlier than dates from excavated contexts. A larger sample is also needed to evaluate if any arrows were present as early as the first ceramics (2200-2100 cal. BP). However, current data suggest that bow technology arrived nearly a millennium after the earliest ceramics.

5.2. The association between the bow and arrow and subsistence and mobility patterns

The continental limit of food-producing economies is 34° S. To the south, foraging groups never transitioned to food production or herding and they adopted the bow very late (Cortegoso *et al.* 2014; Durán *et al.* 2006; Lagiglia 1977; Neme & Gil 2008). North of 34° S, people diversified foraging activities and began to grow food and eventually herded domestic animals. This shift began around 2200-2100 cal. BP with the earliest ceramics at 30-39° S (Marsh 2017) but did not intensify until after 1500 cal. BP, during phase 2 (Cortegoso 2006; Durán *et al.* 2012; Neme 2002). These patterns continued until European contact, closely tracking the dominant presence of arrows in phases 1 and 2. This suggests that the bow was adopted as part of a suite of broader shifts such as economic intensification, reduction in mobility, pottery production, and long-distance contacts. This follows the pattern of the central Andes from around 3500 cal. BP. With demographic growth, the adoption of the bow and arrow would have been an efficient strategy since it would have led to hunting prey of a wider size range (23-230 kg) and shorter hunting times (Churchill 1993; Tomka 2013). Bow technology is more flexible because it can be used effectively for individual or group hunts for small or large prey (Ratto 2003).

5.3. The bow's replacement of other weapon systems or co-existence of multiple systems

The presence of darts in the northern and central areas during phase 1 suggests continuity in the use of spears after the initial adoption of the bow and arrow. In phases 2-3, the sample is 96% arrows, suggesting that the bow had replaced spear-based weapon systems over a large area. However, a single late dart at 34° S (point 26) from 680 cal. BP (AA-58290) leaves open the possibility that spears persisted and co-existed with bows; the dart was found in the same level as two arrows (points 20 and 25). This follows the pattern of Patagonia hunters who may have briefly occupied this area at this time. This area could also have been a buffer zone between hunters and low-level food producers from north of 34° S (Lagiglia 1977).

6. Conclusion

This comparative study includes six sites over a large region, which allows us to outline preliminary trends relevant to the introduction of the bow and arrow at different latitudes. In this part of the Andes (29-34° S), the bow and arrow was first used slightly after 3080 cal. BP in the northern area (29° S) but not until 1280 cal. BP in the central and southern areas (32-34° S). During phase 1, both darts and arrows were present, but the sample size is very limited. The clearest pattern in the dataset is the dominant presence of arrows (n=28) after 1280 cal. BP at all sites (phases 2-3), with the exception of a single dart. These arrows are associated with demographic growth, reduced mobility, low-level food production, and herding economies, following similar trends in other regions. This preliminary study establishes a baseline to be contrasted with larger samples with improved spatial and temporal representation as well as comparisons to other methods of distinguishing arrows and darts.

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