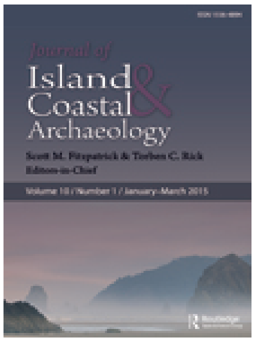

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Article

The Comings and Goings of Sheep and Pottery in the Coastal Desert of Namaqualand, South Africa

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ABSTRACT

This paper evaluates chronological trends in the presence and absence of domestic animal bone (sheep, goat, and cattle) and pottery in Namaqualand, the proposed gateway to the rest of South Africa for early herders or hunter-gatherers with sheep and ceramics. We update date calibrations with local ΔR *corrections and mixtures of recent calibration curves and include five previously unpublished dates. We use histograms of calibrated medians, sorted in 100-year bins, to assess sustained regional patterns with dates associated with domestic animal bone and pottery (*$n = 73$*). While too small to be useful as a population proxy, the current set of dates does reveal three pulses of occupation separated by two clear gaps, which we evaluate with a Bayesian model of three sequential phases. The model's boundaries are used as estimates of the dates of Early (*AD 80–210*), Middle (*AD 490–790*), and Late (*AD 1180–1690*) occupational phases separated by two substantial lapses of* 280 *and* 380 years, *respectively. The alternating phases of presence and absence are suggestively correlated with climate shifts, leading to a discussion of the idea that effective moisture was a crucial factor in choosing whether to occupy Namaqualand. The set of archaeological dates has greater*

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temporal and spatial resolution than many regional climate data, so we suggest that these trends may more accurately reflect the variable conditions specific to Namaqualand, at least until they are refined by future climate research.

Keywords Bayesian models, radiocarbon calibration, early pottery and sheep, Namaqualand

INTRODUCTION

There are no wild progenitors of sheep, goats, cattle, or dogs in southern Africa, yet when the early colonialists arrived in the Cape in the seventeenth century the indigenous Khoekhoe pastoralists kept large herds of these animals. As European sailors were malnourished and rife with scurvy, the early outpost at the Cape of Good Hope was very interested in obtaining pastoralists' animals for fresh meat. Archaeologically, these large herds and their progenitors are largely invisible, although Arthur (2008), Sadr (2008), and Webley (2007) point out that we have probably been looking in the wrong place (shelters instead of open areas) and for the wrong cultural remains. Russell (2017) has used ethnographic data from southern African herders to remind us that we should not expect to find domesticate bones at 'early herder' sites, as these animals are not used as meat larders but as 'social currency' within risk reduction trade networks. Additionally, in arid regions secondary products such as milk are far more valuable than meat protein that can be hunted locally. In fact, the complete Khoekhoe cultural package: large herds, kraals (livestock enclosures), seated cairn burials, hierarchical group structures, clan affinities, and territorial control, may be a very recent phenomenon.

It was originally proposed that domestic animals and pottery arrived in South Africa through the migration of pastoralists from East Africa. Oral traditions, rock art, and linguistic studies led Stow (1905), Cooke (1965), and Elphick (1977) to propose various routes southwest, but all three authors included a southern movement to the Orange River with Namaqualand acting as a gateway to the Cape (Figure 1). Current research suggests that domesticated animals and pottery were introduced into South Africa sometime between 2,200 and 2,000 years ago via the west coast of Namibia across the Orange River into Namaqualand. The oldest securely dated sheep bone in Namibia is from Falls Rock Shelter (Kinehan 2016; Pta-2929, 2100 ± 50 BP), with a calibrated range of cal 182BC–51BC (68 percent probability), while the earliest directly date sheep bone from South Africa is at Spoegriver Cave in Namaqualand (Sealy and Yates 1994; OxA-3286, 2105 ± 65 BP), with a calibrated range of cal 350BC–AD 70 (68 percent probability). The total archaeological evidence for early sheep is sporadic with large geographical gaps and small quantities of sheep bone and pottery appearing scattered around the country: /hei-/Khomas and Spoegriver Cave are in the north-west in Namaqualand (Webley 1992a, 1992b) while Blombos Cave is on the southern coast (Henshilwood 1996). The oldest confidently dated pottery comes from an AMS date of a sherd's fiber temper recovered from the Boundary Shelter site in the Upper Karoo (Sadr and Sampson 2006; Gr-A13564, 2160 ± 50 BP), which calibrates to 210–60BC (68 percent probability).

However, because there are so few early dates and they are from very distant sites, it remains unclear if sheep and pottery traveled together or separately with pottery potentially developing locally (see Sadr 2003; Sadr and Sampson 2006). It also remains unclear if sheep and pottery were universally adopted after their initial appearance or were there multiple reintroductions of these elements. In 1991 Smith et al. proposed a model of two societies living in tandem where 'herder' sites could be isolated from 'hunter-gatherer' signatures based on ratios of domestic to wild

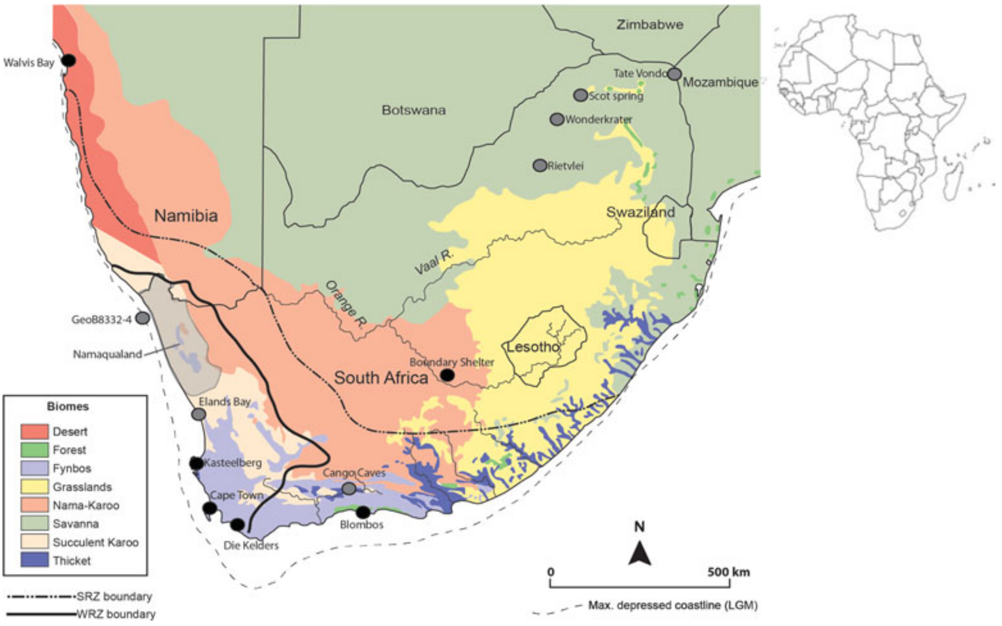

Figure 1. *Inset Map of Africa showing the location of South Africa at the base of the continent. Left: Map of southern Africa showing the location of Namaqualand (grey shaded area) within the Succulent Karoo biome. Sites mentioned in the text are shown as black circles while sites with palaeoenvironmental proxy data are presented with grey circles. The summer rainfall zone (SRZ) and winter rainfall zone (WRZ) boundaries are drawn as a dashed and solid black line respectively.*

animals, ratios of pottery to formal stone tools, and changing sizes of ostrich eggshell beads. However, evidence for a cultural shift reflected in material signatures pre-and post-AD 1 is lacking (Dewar 2008; Orton 2012a; Sadr 2003, 2008). An alternative explanation based on cultural diffusion was proposed by Sadr (2003), who suggests that the earliest sheep and pottery arrived via down-the-line trade, which were adopted by local 'hunters with sheep' rather than a wholesale immigration of different groups. Sadr (2003, 2008) does not see a change in the cultural material that could be attributed to a pastoralist society, i.e., the historically-documented Khoekhoen, until the second millennium AD. Additional research on human skeletal remains suggest that people pre- and post-AD 1 are from the same gene pool (Kurki et al. 2012; Stynder 2009; Stynder et al. 2007), while an isotopic study of human remains from the south coast identified the use of milk in the diet, presumably from domestic cattle, but only from AD 800, supporting Sadr's proposed time frame (Sealy 2010).

Although a country-wide picture is beginning to emerge, dated sites are very distant, making it unlikely that they adequately reflect trends in the Namaqualand coastal desert. Moreover, herders would have responded strongly to available water and pasture, which are scarce and variable in Namaqualand. Regardless of the mechanism by which these elements arrived, Namaqualand in the northwest of South Africa is the proposed gateway for the arrival of sheep, pottery, and herding at the Cape, so the chronology of these trends in Namaqualand is crucial to understanding the arrival of 'Neolithic elements' into South Africa.

Some previous interpretations of early herding in South Africa have relied on uncalibrated mean ages, give little attention to the associated error ranges, or give undue weight to the single earliest date. However, "one date is no date" (Aitken 1990:95 cited in Sadr and Sampson 2006:237), that is, a single date cannot represent a pattern with archaeological significance. Focusing on the earliest date often involves the dubious assumption that once sheep or pottery were present, they never left and were universally adopted. Additionally, calibration has an especially large impact on dates from South Africa: marine and eggshell require different calibration curves and different local ΔR reservoir corrections (Dewar et al. 2012; Vogel et al. 2001). Samples from individuals who had mixed marine and terrestrial diets can be better calibrated with mixed calibration curves (Dewar and Pfeiffer 2010). To improve on previous studies, this study incorporates these recent refinements in calibration, which have a significant effect on the overall dataset, and treat dates in aggregate with Bayesian models that evaluate probability ranges without simplifying dates to single-year estimates (Bronk Ramsey 2009).

This paper will track the chronological trends in the presence and absence of human occupations associated with sheep, cattle, and pottery in Namaqualand, building on previous studies (Dewar 2008; Dewar and Orton 2013; Orton 2012a). We begin with histograms of calibrated radiocarbon dates. Next, we group dates in a Bayesian model of three sequential phases, which allows us to interpolate dates for the phase boundaries and the gaps between them. As current models suggest that human populations responded quite closely to changing trends in available moisture in Namaqualand's coastal desert (see Dewar 2008; Dewar and Orton 2013), we compare these modeled dates to climate trends, which suggest rough correlations. This set of archaeological dates has greater temporal and spatial resolution than many regional climate data, so we suggest that these trends may more accurately reflect the variable conditions specific to Namaqualand. Finally, we interrogate the archaeological and bioarchaeological data from Namaqualand to look for evidence of material culture and/or subsistence changes that could be associated with a pastoralist lifestyle and the seventeenth-century Khoekhoen cultural package.

NAMAQUALAND ENVIRONMENT

Namaqualand is a cool semi-arid coastal landscape (Peel et al. 2007) and the southernmost extension of the Namib Desert (Figure 1). It is bounded by the Atlantic Ocean to the west, the Orange River to the north, the Kamiesburg Mountains ~100 km to the east, and the Olifants River 400 km to the south. It is within the Succulent Karoo biome bordering the Fynbos biome to the south and true desert to the north (Mucina and Rutherford 2006). The region receives >66 percent of its precipitation during the austral winter months (winter rainfall zone) with average values ranging from 150 mm in the south to 50 mm in the north (Cowling and Pierce 1999). While rain comes primarily in winter, it is spatially unpredictable and highly variable; coastal fogs are a more reliable source of water (Cowling and Pierce 1999). Flora is dominated by dwarf succulent shrubs. Aizoaceae are prominent, as are Euphorbiaceae, Crassulaceae, and succulent members of Asteraceae, Iridaceae, and Hyacinthaceae (Mucina and Rutherford 2006). Most fauna is adapted to dry open areas. There are numerous ephemeral rivers that cross cut the coastal plains draining water from the mountains towards the ocean, while the Olifants is a perennial river. The Orange River is the only consistently flowing river, with its headwaters in the summer rainfall zone ~1500 km to the east in the Maloti-Drakensburg Mountains of Lesotho. Two ephemeral rivers, the Buffels and the Spoeg, maintain estuaries even during periods when the rivers are not in flow. Access to potable water is a primary constraint to survival in this region as it directly affects the terrestrial biomass (predominantly C_3) available on the landscape. The coast itself offers access to plentiful marine species via cold nutrient rich upwelling cells (Dewar et al. 2012). The large majority of Holocene period archaeological sites consists of open shell middens located within 10 km of the current coastline (Dewar 2008; Orton 2012a).

MATERIALS AND METHODS

Data for this paper comes from an updated Namaqualand radiocarbon database with a total of 190 dates (Tables 1–4) that extend into the Early Holocene, including five previously unpublished dates. The great majority of dates are from the Late Holocene, but older dates are included in order to present a complete database for future analysis. For each date, we noted associated domestic animal bone (n = 25) and pottery (n = 62). These two datasets include the 14 dates with both material associations (Tables 1 and 2). In some cases, domestic animal bone was directly dated, though in most cases the taxonomic identification was established through gross morphology rather than aDNA analysis (see Horsburgh et al. 2016; Orton et al. 2013); some sheep identifications could also be goat bones. Three dates were associated with cattle bones, including a horn core that was identified with aDNA (Orton et al. 2013). As we are relying on some previously published dates, there is a chance that some of the domestic bone ages were measured on bone apatite rather than collagen, which can introduce potential errors due to the presence of secondary carbonates (Cherkinsky 2009; Del Sasso et al. 2014, 2016). As the majority of the bone samples were run within the past 10 years and they are from the late Holocene epoch, we believe that contamination and therefore error should be minimal.

The database includes updated calibrations, which have a significant effect on dates in South Africa. For terrestrial samples, we used SHCal13 (Hogg et al. 2013) and the offset of 180 ± 120 ^{14}C years for eggshell samples (Vogel et al. 2001). For marine samples, we used Marine13 (Reimer et al. 2013) and the regional ΔR average of 146 ± 85 ^{14}C years (Dewar et al. 2012). It seems that this regional ΔR varied over time and current data show quite strong potential variation (Dewar et al. 2012). Until this variation is better quantified, it seems sensible to use the overall ΔR average for all dates. The adjustment of the Marine13 curve is much more significant than the local ΔR. For both marine shell and eggshell, the secondary adjustments increase the error of each date. For the dated human bone samples, isotope studies have estimated the relative percentage of terrestrial and marine diets (Dewar and Pfeiffer 2010). To correctly calibrate these dates, we used this same percentage to mix the terrestrial and marine calibration curves in OxCal (Bronk Ramsey and Lee 2013; Dewar and Pfeiffer 2010). This significantly improves the accuracy of temporal estimates.

Dealing with error ranges and large sets of data is one of the principal advantages of working with dates in a Bayesian framework (Bronk Ramsey 2015). Bayesian models cross archaeological information and radiometric dates' probability distributions to arrive at more accurate temporal estimates (see Bayliss 2009:127–32). Stratigraphy is commonly used in Bayesian models, but there are not many Namaqualand sites with stratified sequences of radiocarbon dates. None of these sites had enough dates or reliable information to add Bayesian priors based on stratigraphy or temporally diagnostic artifacts (e.g., decorated ceramics). Spoegriver Cave has a detailed description of the stratigraphy (Webley 1992a) and a number of radiocarbon dates from associated carbon as well as direct dates on sheep bone. However, bone dates often do not agree with carbon dates from the same levels, which suggests that the dated bones migrated downward. In sum, we could not glean reliable Bayesian priors from this carefully excavated site. Potential stratigraphic mixing reduces the reliability of single dates or even multiple dates from single sites, but they remain useful when modeled with multiple dates from other sites. We opted for a more conservative approach and do not make any assumptions about the stratigraphic relationships of the dated samples. Even though stratigraphic information was not helpful on a site-by-site basis, material associations were.

Table 1. **Radiocarbon dates associated with domestic animals (sheep or cattle). Negative dates are BC; positive dates are AD. In the ceramics column, "no ceramics" means a confirmed absence while "—" indicates no clear presence.**

Lab No.	^{14}C age	±	Site	Calibrated Median (BC/AD)	68% probability (BC/AD)	95% probability (BC/AD)	Model Phase	Domestic animal bone	Ceramics	Material	Reference
OxA-3862	2105	65	Spoegriver	−92	−197–19	−353–70	Early	Sheep	—	*Ovis aries*	Sealy & Yates 1994
Pta-5530	1980	80	/hei-/khomas	62	−49–196	−138–245	Early	Sheep	Ceramics	Charred bone	Webley 1992a
GrA-9032	1900	50	Spoegriver	157	85–221	30–321	Early	Sheep	—	*Ovis aries*	Webley 2002
GrA-9028	1900	50	Spoegriver	157	85–221	30–321	Early	Sheep	—	*Ovis aries*	Webley 2002
GrA-9029	1890	50	Spoegriver	166	116–232	43–332	Early	Sheep	—	*Ovis aries*	Webley 2002
GX-32760	1740	75	JKB M	519	382–655	213–857	Middle	Sheep	Ceramics	Ostrich eggshell	Orton & Halkett 2010
OxA-22933	1625	25	KN2005/041	476	431–519	414–540	Middle	Cattle	No Ceramics	*Bos taurus*	Orton et al. 2013
GrA-9030	1490	50	Spoegriver	608	576–650	499–678	Middle	Sheep	—	Sheep bone	Webley 2002
Pta-6122	1420	25	JKB B	657	646–671	631–756	Middle	Sheep	Ceramics	Charcoal	Webley 1997
Pta-6101	1380	50	JKB B	701	648–765	600–843	Middle	Sheep	Ceramics	Charcoal	Webley 1997
Pta-5958	1330	60	JKB A	744	663–838	650–880	Middle	Sheep	Ceramics	Charcoal	Webley 1997
Pta-6100	1300	25	JKB A	745	684–836	680–861	Middle	Sheep	Ceramics	Charcoal	Webley 1997
GrA-9027	1260	50	Spoegriver	816	694–888	680–964	Middle	Sheep	—	*Ovis aries*	Webley 2002
Pta-8494	1250	50	JKB A	826	766–893	681–969	Middle	Sheep	Ceramics	Charcoal	Grey 2009
GX-32064	1250	60	LK2004/011B	1280	1201–1390	1076–1442	Late	Sheep	No Ceramics	Marine shell	Orton 2012a
OxA-22980	924	22	LK2004/011B	1174	1155–1202	1051–1218	Late	Sheep	No Ceramics	Charcoal	Orton 2012a
Pta-3512	800	50	Bethelsklip	1257	1225–1286	1182–1381	Late	Sheep	Ceramics	hearth? Charcoal	Webley 1984
Pta-5458	420	50	/hei-/khomas	1519	1449–1621	1442–1630	Late	Sheep	Ceramics	Charcoal	Webley 1992a
OxA-22981	400	22	SK2005/057A	1522	1463–1616	1455–1625	Late	Cattle	Ceramics	Bovid bone	Orton 2012a
OxA-24550	389	24	SK2005/095	1555	1477–1622	1459–1627	Late	Cattle	No Ceramics	Bovid bone	Orton 2012a
Pta-4741	360	40	Bethelsklip	1559	1502–1630	1464–1645	Late	Sheep	Ceramics	Charcoal	Webley 1992a
Pta-7942	355	15	Bloeddrift 23	1558	1509–1627	1500–1635	Late	Sheep	Ceramics	Charcoal	Smith et al. 2001
OxA-24522	355	24	KN2005/067	1559	1508–1627	1496–1641	Late	Sheep	Ceramics	Tortoise	Orton 2012a
UGa-5152	340	30	HKB2007/007	1561	1509–1638	1497–1650	Late	Sheep	Ceramics	Charcoal	Orton 2012a
Pta-5452	330	45	/hei-/khomas	1569	1508–1647	1464–1667	Late	Sheep	—	Charcoal	Webley 1992a

Table 2. **Radiocarbon dates associated with ceramics. For associations with domestic animal bone, "Sheep" indicates clear presence of sheep bone, "No Sheep" indicates a clear absence, and "—" indicates no clear presence. Negative dates are BC; positive dates are AD.**

Lab No.	^{14}C age	±	Site	Calibrated median	68% probability	95% probability	Model Phase	Domestic animals	Material	Reference
Pta-5530	1980	80	/hei-/khomas	62	−49–196	−138–245	Early	Sheep	Charred bone	Webley 1992a
Pta-6749	1930	50	Spoegriver	121	63–203	−38–240	Early	No Sheep	Charcoal	Webley 2002
Pta-4745	1920	40	Spoegriver	134	76–203	42–231	Early	No Sheep	Charcoal	Webley 2002
OxA-25353	1897	25	VR001	163	124–205	81–231	Early	No Sheep	*Oryx gazella*	Orton 2012a
OxA-25354	1840	26	VR001	224	145–249	129–336	Early	No Sheep	*Oryx gazella*	Orton 2012a
GX-32760	1740	75	JKB M	519	382–655	213–857	Middle	Sheep	Ostrich eggshell	Orton & Halkett 2010
OxA-22932	1598	25	KN2005/054	502	442–543	427–575	Middle	No Sheep	*Chersina angulata*	Orton 2012a
UBA-9941	1524	22	LK5-1	593	575–630	544–637	Middle	No Sheep	*Chersina angulata*	Dewar 2008
OxA-25349	1462	24	Komkans 2	634	605–651	590–660	Middle	No Sheep	*Chersina angulata*	Orton 2012a
Pta-6750	1450	50	Spoegriver	636	599–668	540–764	Middle	No Sheep	Charcoal	Webley 2002
Pta-6122	1420	25	JKB B	657	646–671	631–756	Middle	Sheep	Charcoal	Webley 1997
UGAMS-11685	1410	20	VR003	661	650–671	640–681	Middle	No Sheep	*Chersina angulata*	Orton 2012a
Pta-4753	1390	50	Spoegriver	686	643–765	596–834	Middle	No Sheep	Charcoal	Webley 2002

(*Continued on next page*)

Table 2. **(Continued)**

Lab No.	^{14}C age	±	Site	Calibrated median	68% probability	95% probability	Model Phase	Domestic animals	Material	Reference
Pta-6101	1380	50	JKB B	701	648–765	600–843	Middle	Sheep	Charcoal	Webley 1997
Pta-8495	1340	50	JKB O	733	668–770	650–860	Middle	—	Sediment	Grey 2009
Pta-5958	1330	60	JKB A	744	663–838	650–880	Middle	Sheep	Charcoal	Webley 1997
Pta-6100	1300	25	JKB A	745	684–836	680–861	Middle	Sheep	Charcoal	Webley 1997
Pta-8494	1250	50	JKB A	826	766–893	681–969	Middle	Sheep	Charcoal	Grey 2009
UBA-9946	1189	24	AK2006-006	1336	1277–1414	1183–1465	Late	No Sheep	Marine shell	Dewar et al. 2012
Pta-8910	1110	50	Rooiwal Midden	1388	1313–1455	1226–1551	Late	No Sheep	Marine shell	Orton 2005
GX-32060	1020	60	DP2004/014	1462	1350–1537	1304–1653	Late	No Sheep	Marine shell	Dewar 2008
GX-32058	990	60	TP2004/004	1490	1403–1590	1319–1670	Late	No Sheep	Marine shell	Dewar 2008
OxA-25350	932	24	Komkans 2	1166	1149–1205	1046–1218	Late	No Sheep	*Chersina angulata*	Dewar 2008
AA-89909	828	44	VR001	1243	1220–1275	1177–1293	Late	No Sheep	*Chersina angulata*	Orton 2012a
Pta-3512	800	50	Bethelsklip	1257	1225–1286	1182–1381	Late	Sheep	Hearth? Charcoal	Webley 1984
Pta-8500	720	50	JKB O	1323	1280–1386	1235–1398	Late	—	Sediment	Grey 2009
OxA-25346	701	23	Komkans 2	1350	1296–1382	1285–1390	Late	No Sheep	*Chersina angulata*	Orton 2012a
UBA-9943	665	21	DP2004/014	1345	1314–1391	1300–1396	Late	No Sheep	Small carnivore	Dewar 2008
GX-32761	660	100	JKB K	1347	1289–1408	1212–1459	Late	No Sheep	Charcoal	Orton 2012a
OxA-22975	654	23	SK2005/096A	1344	1318–1394	1301–1400	Late	No Sheep	*Chersina angulata*	Orton 2012a

UBA-9945	649	20	AK2006-006	1343	1320–1393	1309–1401	Late	No Sheep	Charcoal	Dewar et al. 2012
OxA-25351	644	23	Komkans 2	1343	1320–1396	1305–1404	Late	No Sheep	*Chersina angulata*	Orton 2012a
OxA-22876	622	21	VR001	1348	1325–1403	1318–1411	Late	No Sheep	Small sticks	Orton 2012a
OxA-22974	611	23	SK2005/096A	1394	1326–1410	1319–1420	Late	No Sheep	*Chersina angulata*	Orton 2012a
OxA-24513	589	23	VR001	1406	1395–1420	1326–1432	Late	No Sheep	*Chersina angulata*	Orton 2012a
OxA-24523	570	25	SK2001/024a	1414	1402–1426	1393–1440	Late	No Sheep	*Chersina angulata*	Orton 2012a
OxA-22982	474	22	VR001	1451	1439–1459	1429–1483	Late	No Sheep	Charcoal A. karoo	Orton 2012a
OxA-24561	442	24	LK2001/015	1473	1449–1487	1442–1615	Late	No Sheep	*Chersina angulata*	Orton 2012a
Pta-9099	430	45	SK400	1499	1447–1617	1438–1627	Late	No Sheep	Bone	Dewar 2008; Dewar et al. 2006
Pta-5458	420	50	/hei-/khomas	1519	1449–1621	1442–1630	Late	Sheep	Charcoal	Webley 1992a
Pta-9105	420	45	SK400	1512	1450–1620	1445–1627	Late	No Sheep	Bone	Dewar 2008; Dewar et al. 2006
OxA-24558	420	24	LK2001/015	1489	1456–1610	1448–1623	Late	No Sheep	*Chersina angulata*	Orton 2012a
OxA-24559	403	24	LK2001/015	1511	1461–1616	1454–1625	Late	No Sheep	*Raphicerus campestris*	Orton 2012a
OxA-25329	401	25	SK2006/006	1526	1461–1617	1455–1625	Late	No Sheep	Charcoal	Orton 2012a

(*Continued on next page*)

Table 2. **Continued**

Lab No.	^{14}C age	±	Site	Calibrated median	68% probability	95% probability	Model Phase	Domestic animals	Material	Reference
OxA-24560	401	22	LK2001/015	1514	1463–1616	1455–1625	Late	No Sheep	*Chersina angulata*	Orton 2012a
OxA-22981	400	22	SK2005/057A	1522	1463–1616	1455–1625	Late	No Sheep	Bovid bone	Orton 2012a
OxA-24562	398	25	LK2001/015	1542	1461–1619	1456–1626	Late	No Sheep	*Chersina angulata*	Orton 2012a
OxA-24557	394	24	LK2001/015	1550	1463–1620	1457–1627	Late	No Sheep	*Raphicerus campestris*	Orton 2012a
OxA-24077	377	24	SK2006/006	1560	1495–1624	1464–1630	Late	No Sheep	Shrub	Orton 2012a
Pta-9124	370	45	SK402	1556	1498–1627	1461–1641	Late	No Sheep	Bone	Dewar 2008; Dewar et al. 2006
Pta-4741	360	40	Bethelsklip	1559	1502–1630	1464–1645	Late	Sheep	Charcoal	Webley 1992a
OxA-24528	358	26	JKB K	1560	1506–1627	1491–1641	Late	—	*Raphicerus campestris*	Orton 2012a
OxA-24522	355	24	KN2005/067	1559	1508–1627	1496–1641	Late	Sheep	*Chersina angulata*	Orton 2012a
Pta-7942	355	15	Bloeddrift 23	1558	1509–1627	1500–1635	Late	Sheep	Charcoal	Smith et al. 2001
UGa-5152	340	30	HKB2007/007	1561	1509–1638	1497–1650	Late	Sheep	Charcoal	Orton 2012a
OxA-24520	339	24	KN2005/067	1559	1510–1637	1500–1649	Late	No Sheep	*Chersina angulata*	Orton 2012a
OxA-25347	334	23	Komkans 2	1560	1511–1641	1502–1649	Late	No Sheep	*Chersina angulata*	Orton 2012a
OxA-24518	321	23	KN2005/067	1568	1512–1649	1505–1655	Late	No Sheep	*Chersina angulata*	Orton 2012a
Pta-8492	310	15	JKB O	1635	1525–1652	1511–1657	Late	No Sheep	Sediment	Grey 2009
Pta-8493	303	50	JKB O	1615	1508–1667	1484–1800	Late	No Sheep	Sediment	Grey 2009
OxA-24517	262	23	KN2005/067	1668	1645–1795	1637–1799	Late	No Sheep	*Chersina angulata*	Orton 2012a
OxA-25348	175	23	Komkans 2	1807	1677– …	1670– …	Late	No Sheep	*Chersina angulata*	Orton 2012a

Table 3. **Radiocarbon dates not associated with a positively identified domestic animal bone or ceramic sherds. Charcoal and terrestrial samples are calibrated with SHCal, ostrich eggshell samples include the corresponding offset, marine shell samples are calibrated with Marine13 and the local ΔR. Negative dates are BC; positive dates are AD.**

Lab No.	^{14}C age	±	Site	Calibrated Median (BC/AD)	68% probability (BC/AD)	95% probability (BC/AD)	Material	Published dates
D-AMS 015300	8923	34	Spitzkloof B	−8074	−8202- −7967	−8230- −7841	Charcoal	This study
D-AMS011230	6196	30	HBK2014/015	−4556	−4619- −4489	−4686- −4436	Marine shell	Orton 2012a
AA-89912	5452	54	VR005	−4264	−4341- −4177	−4355- −4056	Terrestrial mammal	Orton 2012a
GX-32526	5390	70	MB2005/005B	−3691	−3780- −3614	−3896- −3517	Marine shell	Dewar 2008
GX-32754-AMS	4960	40	JKB N	−3200	−3304- −3121	−3349- −3014	Marine shell	Orton & Halkett 2010
GX-32755	4860	40	JKB N	−3263	−3494- −3024	−3654- −2931	Dec Ostrich eggshell	Orton & Halkett 2010
GX-32061	4820	60	ELK 4	−2994	−3075- −2890	−3260- −2844	Marine shell	Dewar 2008
Pta-9316	4630	70	KN6-3C	−2758	−2869- −2665	−2956- −2526	Marine shell	Dewar 2008
D-AMS 015302	4615	27	Spitzkloof B	−3329	−3486- −3129	−3496- −3105	Charcoal	This study
AA-89911	4551	54	VR005	−3208	−3344- −3106	−3371- −3016	Terrestrial mammal	Orton 2012a
Pta-6053	4510	50	BSB2	−2602	−2686- −2487	−2828- −2446	Marine shell	Halkett et al. 1993
Pta-8496	4500	50	JKB N	−2775	−2901- −2582	−3319- −2474	Ostrich eggshell	Orton & Halkett 2010
OxA-22986	4185	31	VR005	−2736	−2866- −2635	−2877- −2600	Charcoal	Orton 2012a
GX-32757	4180	90	MB2005/001E	−2154	−2292- −2011	−2436- −1888	Marine shell	Orton 2012a
UGAMS-11683	3890	20	VR005	−2315	−2401- −2210	−2456- −2206	Grass	Orton 2012a
GX-32063	3870	70	MS1	−1741	−1855- −1643	−1947- −1521	Marine shell	Orton 2012a
Pta-5960	3840	60	Die Toon	−2241	−2345- −2135	−2460- −2040	Charcoal	Webley et al. 1993
GX-32540	3820	60	SAM4931	−1796	−1906- −1685	−2026- −1570	Human Collagen	Dewar 2008
GX-32756	3810	145	MB2005/001E	−1675	−1862- −1491	−2074- −1298	Marine shell	Orton 2012a
UGAMS-8870	3760	25	KV2001/012	−1601	−1161- −1540	−1730- −1477	Marine shell	Orton 2012a
Pta-9325	3740	60	KN6-3C	−1577	−1664- −1490	−1758- −1401	Marine shell	Dewar 2008
Pta-9335	3720	45	KN6-3C	−1553	−1627- −1482	−1701- −1407	Marine shell	Dewar 2008
UGa-5153	3590	30	HKB2007/035	−1890	−1945- −1781	−2011- −1763	Charcoal	Orton 2012a
Pta-6987	3580	60	Spoegrivier Cave	−1871	−1947- −1771	−2034- −1692	Charcoal	Webley 1992a

(*Continued on next page*)

Table 3. **(Continued)**

Lab No.	^{14}C age	±	Site	Calibrated Median (BC/AD)	68% probability (BC/AD)	95% probability (BC/AD)	Material	Published dates
Pta-6754	3520	50	Spoegrivier Cave	−1802	−1882- −1704	−1936- −1661	Charcoal	Webley 1992a
GX-32528	3490	70	Somnaas Burial 2	−1727	−1873- −1613	−1898- −1510	Human Collagen	Dewar 2008
UGAMS-8425	3430	25	TP2004/014	−1214	−1282- −1147	−1366- −1067	Marine shell	Dewar 2008
GX-32056	3410	70	ELK 14	−1182	−1293- −1067	−1397- −963	Marine shell	Dewar 2008
OxA-22970	3355	28	KN6-3C	−1585	−1630- −1531	−1682- −1506	*Chersina angulata*	Dewar 2008
GX-32065	3330	70	JKB L	−1570	−1658- −1464	−1743- −1421	Charcoal	Orton & Halkett 2010
OxA-22984	3327	26	VR005	−1564	−1611- −1527	−1641- −1461	Charcoal A. karoo	Orton 2012a
GX-32062	3160	70	MS3	−874	−954- −787	−1093- −726	Marine shell	Orton 2012a
GX-32535	3140	60	MB2005/016	−852	−917- −777	−1037- −720	Marine shell	Orton 2012a
Pta-5963	3110	60	Die Toon	−1321	−1412-1259	−1492- −1127	Charcoal	Webley et al. 1993
OxA-22972	2993	27	KN2005/050	−1159	−1223- −1111	−1265- −1043	*Chersina angulata*	Orton 2012a
Pta-9306	2940	45	KV502	−635	−740- −557	−780- −437	Marine shell	Dewar 2008
Pta-6051	2930	50	BSB 3	−619	−732- −540	−772- −420	Marine shell	Halkett et al. 1993
Pta-9312	2870	60	LK5-1	−537	−648- −409	−742- −366	Marine shell	Dewar 2008
GX-32534	2860	60	MB2005/016	−523	−618- −396	−736- −355	Marine shell	Orton 2012a
OxA-24554	2796	27	MB2005/001E	−893	−924- −840	−993- −821	*Chersina angulata*	Orton 2012a
GX-32536	2750	50	UCT12755	−579	−729- −483	−772- −396	Human Collagen	Dewar 2008
GX-32538	2750	50	UCT12776	−556	−701- −417	−767- −376	Human Collagen	Dewar 2008
UGAMS-8871	2740	25	SK2005/096B	−365	−416- −320	−483- −216	Marine shell	Orton 2012a
Pta-5617	2720	60	GRM5	−591	−744- −505	−781- −401	Human Collagen	Jerardino et al. 1992
OxA-22971	2695	26	KN2005/040	−818	−834- −797	−895- −791	*Chersina angulata*	Orton 2012a
UGama-6607	2670	30	PN2009/001	−283	−354- −227	−392- −152	Marine shell	Orton 2012a
GX-32541	2660	60	SAM4932	−526	−706- −397	−771- −351	Human Collagen	Dewar 2008
OxA-24556	2641	29	MB2005/059	−792	−810- −774	−835- −589	*Chersina angulata*	Orton 2012a
Pta-9310	2640	60	SK2001/025	−245	−345- −171	−394- −45	Marine shell	Orton 2012a
GX-32525	2620	70	MB2005-005A	−221	−341- −138	−392- −6	Marine shell	Dewar 2008
D-AMS011229	2618	22	HBK2014/022	−222	−305- −162	−351- −86	Marine shell	Orton 2012a
OxA-22983	2578	25	VR001	−671	−793- −572	−800- −542	Charcoal A. karoo	Orton 2012a

D-AMS011228	2567	30	HBK2014/034	−150	−213- −70	−326- −16	Marine shell	Orton 2012a
GX-32524	2560	60	MB2005-005A	−143	−237- −34	−344- 36	Marine shell	Dewar 2008
AA-89910	2560	49	VR001	−640	−789- −546	−801- −431	*Chersina angulata*	Orton 2012a
OxA-22973	2523	27	KN2005/135A	−630	−757- −542	−775- −431	*Chersina angulata*	Orton 2012a
Pta-8915	2505	20	Rooiwal Hollow	−72	−139- −19	−186-55	Marine shell	Orton & Halkett 2005
GX-32539	2500	50	UCT12758	−153	−323- −53	−362-45	Human Collagen	Dewar 2008
Pta-6049	2430	40	BSB4	20	−47-90	−142-155	Marine shell	Halkett et al. 1993
UGAMS-6608	2420	30	SK2005/084	32	−31-88	−106-156	Marine shell	Orton 2012a
Pta-7200	2400	25	Spoegrivier Cave	−428	−478- −390	−539- −377	Charcoal	Webley 1992a
Pta-8909	2360	60	Rooiwal Hollow	100	8-185	−95-280	Marine shell	Orton & Halkett 2005
UGAMS-9708	2320	25	SK2001/025	142	82-199	26-266	Marine shell	Orton 2012a
GX-32542	2240	50	UCT164	154	48-241	−46-351	Human Collagen	Dewar 2008
UGAMS-8424	2230	25	TP2004/003	250	184-316	132-387	Marine shell	Orton 2012a
UBA-9939	2202	32	MB2005-005A	−219	−351- −146	−360- −110	Tortoise	Dewar 2008
OxA-24552	2190	27	MB2005/001E	−193	−349- −138	−357- −98	*Chersina angulata*	Orton 2012a
Pta-9326	2180	50	LK5-1	311	241-397	139-460	Marine shell	Dewar 2008
OxA-24553	2176	27	MB2005/001E	−172	−335- −111	−353- −66	*Chersina angulata*	Orton 2012a
OxA-22976	2172	25	SK2001/025	−167	−204- −111	−351- −66	*Raphicerus campestris*	Orton 2012a
Pta-6052	2170	50	BSB6	323	251-405	145-475	Marine shell	Halkett et al. 1993
OxA-24526	2132	27	SK2005/074	−114	−141- −65	−200- −54	*Raphicerus campestris*	Orton 2012a
GX-32537	2100	50	UCT172	331	226-422	129-538	Human Collagen	Dewar 2008
OxA-24527	2052	34	SK2005/074	−14	−55-22	−101-64	*Chersina angulata*	Orton 2012a
Pta-6334	2020	60	Spoegrivier Cave	363	280-430	211-535	Crayfish	Webley 1992a
OxA-24515	1921	25	VR005	131	79-202	65-209	Bone	Orton 2012a
OxA-25352	1646	25	VR005	458	414-517	392-532	*Chersina angulata*	Orton 2012a
OxA-22979	1631	23	KN2005/041	471	426-517	414-534	Charcoal	Orton 2012a
OxA-22977	1579	24	KN2004/012	535	496-580	438-587	Charcoal	Orton 2012a
D-AMS 005182	1473	27	Spitzkloof B	624	602-647	583-656	Charcoal	This study
D-AMS 015299	1411	21	Spitzkloof B	661	650-670	640-681	Charcoal	This study
UGAMS-9707	1380	20	KV2001/012	1140	1076-1188	1041-1249	Marine shell	Orton 2012a
GX-32527	1250	70	UCT579	1165	1068-1254	987-1325	Human Collagen	Dewar 2008

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Table 3. **Continued**

Lab No.	^{14}C age	±	Site	Calibrated Median (BC/AD)	68% probability (BC/AD)	95% probability (BC/AD)	Material	Published dates
OxA-22934	1219	23	KV2001/012	1168	1046–1278	854–1290	Ostrich eggshell	Orton 2012a
GX-32057	1200	60	Penguin Midden	1302	1240–1381	1175–1428	Marine shell	Dewar 2008
GX-32059	1080	50	Penguin Midden	1389	1337–1436	1295–1479	Marine shell	Dewar 2008
Beta-201929	1050	60	SK420a	1333	1290–1390	1236–1431	Marine shell	Orton 2012a
OxA-22930	973	24	KN2004/015E	1097	1045–1154	1032–1175	*Chersina angulata*	Orton 2012a
UBA-9942	932	45	LK5–1	1153	1049–1215	1032–1226	Steenbok	Dewar 2008
OxA-24519	891	23	KN2005/067	1199	1180–1220	1155–1260	*Chersina angulata*	Orton 2012a
Pta-6050	860	50	BSB2	1565	1501–1630	1456–1676	Marine shell	Halkett et al. 1993
GX-32522	850	70	Noup	1474	1340–1608	1315–1641	Human Collagen	Dewar 2008
GX-32521	850	60	MB2005/119	1476	1427–1522	1363–1628	Marine shell	Dewar 2008
GX-32523	800	70	LK2005/011B Legs	1357	1300–1410	1231–1459	Human Collagen	Dewar 2008
UBA-9944	750	20	AK2006–006	1507	1436–1614	1409–1646	Human Collagen	Dewar et al. 2012
D-AMS 005181	718	23	Spitzkloof B	1317	1289–1378	1281–1386	Charcoal	This study
OxA-24555	717	25	MB2005/013	1319	1289–1379	1281–1387	*Chersina angulata*	Orton 2012a
OxA-24078	712	24	DP2004/010	1337	1291–1380	1281–1389	Charcoal	Orton 2012a
UBA-9940	707	37	Penguin Midden	1339	1289–1384	1280–1392	Gemsbok	Dewar 2008
OxA-24626	680	25	MB2005/028A	1348	1301–1389	1296–1392	*Chersina angulata*	Orton 2012a
AA-89907	679	44	VR001	1527	1440–1651	1292–1797	Ostrich eggshell	Orton 2012a
OxA-22978	650	22	MB2005/027	1343	1319–1393	1304–1402	Charcoal	Orton 2012a
OxA-24525	609	25	SK2001/039	1394	1327–1411	1319–1422	*Chersina angulata*	Orton 2012a
OxA-24516	607	24	KN2001/009	1396	1327–1413	1319–1423	*Raphicerus campestris*	Orton 2012a
OxA-24524	606	25	SK2001/039	1396	1327–1414	1319–1425	*Chersina angulata*	Orton 2012a
D-AMS011231	570	21	HBK2014/015	1654	1408–1804	1392–1953	Ostrich eggshell	Orton 2012a
OxA-24551	468	25	SK2005/095	1454	1438–1471	1428–1497	*Chersina angulata*	Orton 2012a
OxA-24076	425	24	SK2006/006	1484	1455–1606	1446–1622	Unidentified shrub	Orton 2012a

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Table 3. **Continued**

Lab No.	^{14}C age	±	Site	Calibrated Median (BC/AD)	68% probability (BC/AD)	95% probability (BC/AD)	Material	Published dates
OxA-24514	394	23	VR001	1551	1464–1620	1457–1626	*Chersina angulata*	Orton 2012a
Pta-8498	370	35	Bloeddrift 32	1557	1498–1627	1465–1636	Charcoal	Grey 2009
OxA-22931	368	23	KN2005/135B	1561	1500–1626	1482–1634	*Chersina angulata*	Orton 2012a
OxA-24521	354	23	KN2005/067	1559	1509–1627	1497–1640	*Chersina angulata*	Orton 2012a
Pta-8497	350	30	Bloeddrift 32	1560	1508–1631	1493–1646	Charcoal	Grey 2009
OxA-22877	324	22	VR005	1565	1512–1648	1505–1653	Grass	Orton 2012a
UGAMS-11684	220	20	VR003	1758	1669–1796	1656–1805	Small stick	Orton 2012a
Pta-4763	160	45	Frummelbakkies	1829	1681–1951	1671–1953	Charcoal	Orton 2012a
Pta-5444	106	1	/hei-/khomas	1832	1817–1907	1816–1921	Charcoal	Webley 1992a

Table 4. **Radiocarbon dates on human bone collagen requiring mixed calibration (Dewar 2008:table 14.2). SHCal was mixed at the same proportion and error as the estimated terrestrial diet percentage, based on C and N isotopes. The remaining proportion of the curve mixture was based on Marine13 modified by the local ΔR. None of these dates are associated with domestic animal bones or ceramics. Negative dates are BC; positive dates are AD.**

Lab No.	^{14}C age	±	Site	Calibrated Median	68% probability	95% probability	% marine diet (±10)	Reference
UBA-9944	750	20	AK2006-006	1507	1436–1614	1409–1646	59.5	Dewar et al. 2012
Pta-5617	2720	60	GRM5	−591	−744– −505	−781– −401	50.0	Jerardino et al. 1992
GX-32523	800	70	LK2005/011B Legs	1357	1300–1410	1231–1459	31.0	Dewar 2008
GX-32522	850	70	Noup	1474	1340–1608	1315–1641	70.2	Dewar 2008
GX-32540	3820	50	SAM4931	−1796	−1906– −1685	−2026– −1570	71.4	Dewar 2008
GX-32541	2660	60	SAM4932	−526	−706– −397	−771– −351	50.0	Dewar 2008
GX-32528	3490	80	Somnaas Burial 2	−1727	−1873– −1613	−1898– −1510	7.1	Dewar 2008
GX-32536	2750	50	UCT12755	−579	−729– −483	−772– −396	59.5	Dewar 2008
GX-32539	2500	50	UCT12758	−153	−323– −53	−362–45	78.5	Dewar 2008
GX-32538	2750	50	UCT12776	−556	−701– −417	−767– −376	64.3	Dewar 2008
GX-32542	2240	60	UCT164	154	48–241	−46–351	76.2	Dewar 2008
GX-32537	2100	50	UCT172	331	226–422	129–538	79.7	Dewar 2008
GX-32527	1250	70	UCT579	1165	1068–1254	987–1325	73.8	Dewar 2008

The Bayesian model groups dates that are associated with domestic animal bones or ceramics. The goal of this model is to refine the chronology of the regional practice of herding and the use of pottery. Bayesian models incorporate a group of dates and estimate temporal limits based on the probability distributions of all the dates in the group, not just the earliest one. The traditional focus on the single earliest date often disregards the associated error range and may overemphasize a single isolated event that is not regionally representative. Instead of the first appearance, we are interested in identifying temporal limits of regional trends in herding and pottery use based on the contemporaneous appearance of domestic animals and ceramics at multiple sites in the region. One principal advantage of Bayesian models is that each phase can be bounded by starting and ending boundaries. These interpolated events are independent of the radiocarbon dates that comprise the phase and reflect the statistical tendency of all the dates in the phase. The model also quantifies the degree to which grouped dates agree with each other with agreement indices. Grouping dates in this way is an effective way of estimating when regional phases started and ended without giving undue weight to individual dates.

We present a single Bayesian model with three successive phases: Early, Middle, Late. The model assumes that these phases are in chronological order, which is supported by the absence of overlapping dates from adjacent phases. Each phase has its own starting and ending boundaries and the model assumes that dates within each phase are temporally related. Models and calibrations were run in OxCal 4.3 (Bronk Ramsey 2009). We used the Interval command between each phase to test for the possibility and length of gaps (Bronk Ramsey and Lee 2013). Dates are rounded by 10 years and posterior estimates are indicated in *italics* (Bayliss et al. 2007:5).

To evaluate the general trend of available radiocarbon dates, we ran a summed probability distribution. We also created histograms of calibrated medians of all dates (Figures 2 and 3; Tables 1–4) as well as dates associated with domestic animal bones and ceramics. Histograms shows similar overall patterns as a summed probability distribution. The histogram's 100-year bin size is arbitrary but the average laboratory error (ΔT) for the entire database is just 39, so these bins are greater than the one-sigma error ranges for most dates. Even though some individual dates have greater precision, 100-year bins are appropriate for our regional scale of analysis and are closer to the temporal resolution of the regional climate data. Similar temporal resolution is key for making useful comparisons between archaeological and climate chronologies (Calaway 2005).

RESULTS

There are too few dates to read population trends from the histograms or the summed probability distributions, not to mention a series of other biases that must be accounted for when treating summed radiocarbon dates as a population proxy (e.g., Williams 2012). At this point, these graphs serve as a simple visual summary of all dates in the region. As such, it can be used to generate hypotheses about population trends to be tested in the future. The histograms (Figures 2–4) show occupation in the early part of the Late Holocene. The first notable increase is from the fourth to the second century BC, followed by a noticeable decrease in the third century AD. Trends increase again and peak in the seventh century AD before dropping and reaching a low point three centuries later. At this point, radiocarbon date frequencies increase drastically. They peak in the fourteenth and sixteenth centuries AD. This may have been the period of the densest demographics in the entire human history of Namaqualand. After this, there is a marked drop in the most recent few centuries. This may simply reflect archaeologists not dating such recent contexts, but historically recorded events suggest that there may have been real population drops from the sixteenth-century peak. These trends re-

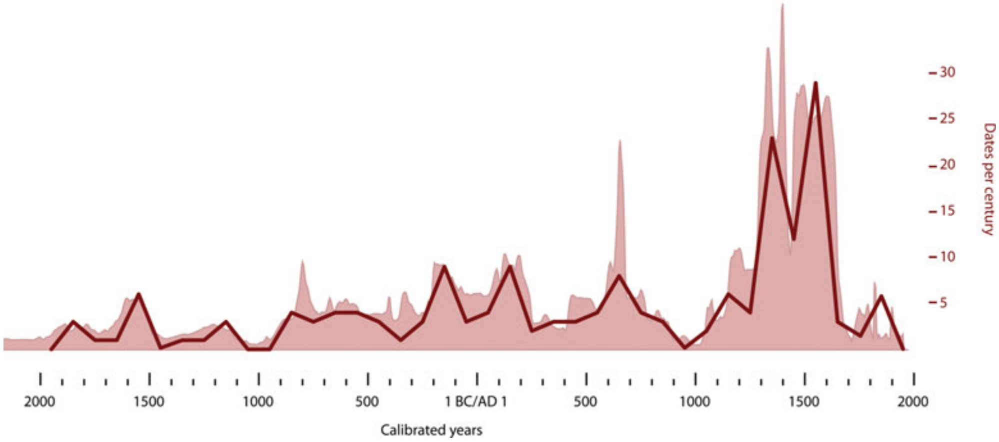

Figure 2. *Summed probability distribution (filled in light red curve) and histogram (solid red line) of all Late Holocene Namaqualand dates. It provides a very general indication of population trends. The histogram is based on calibrated medians in 100-year bins.*

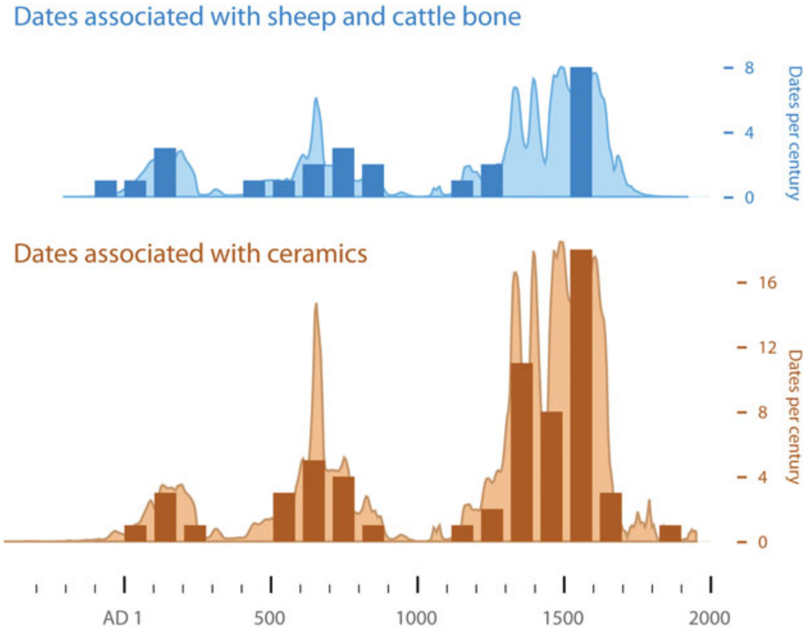

Figure 3. *Summed probability distributions (filled in curve) and histograms (solid vertical bars) of dates associated with domestic animal bone (top) and ceramics (bottom). It provides a very general indication of temporal trends in occupations of groups with sheep and ceramics. The histogram is based on calibrated medians in 100-year bins.*

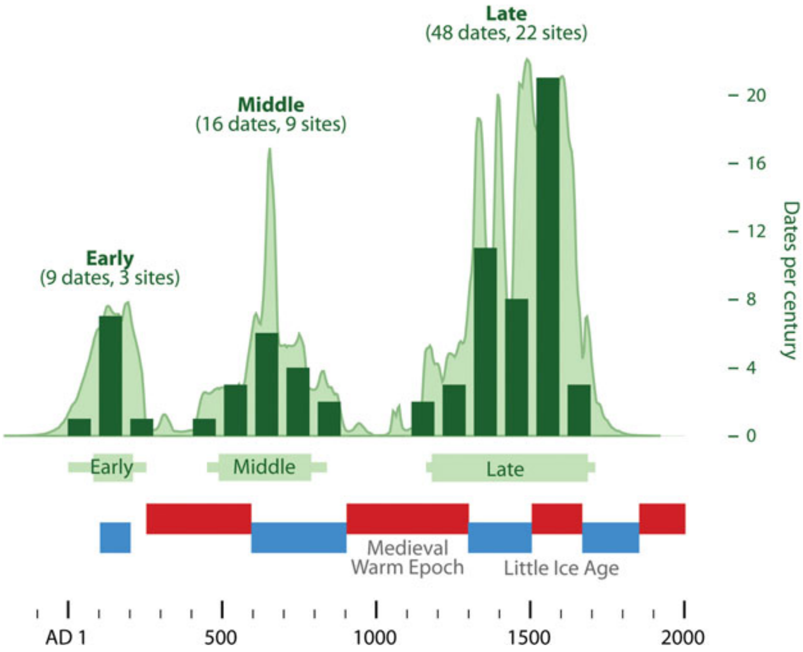

Figure 4. *Summary of radiocarbon dates, Bayesian model results, and climate comparisons. A visual summary of dates associated with domestic animal bone or ceramics is shown by a summed probability distribution (filled in light green curve) and histogram (solid vertical bars). Below the curve, the horizontal green bars indicate the approximate beginnings and ends of the Early, Middle, and Late phases, as estimated from the medians of the phase boundaries in the Bayesian model. The narrow bars indicate the inclusive 68 percent probability range of the phase boundaries, highlighting the clear gaps between phases. Finally, alternating red and blue bars reflect general warming and cooling trends, respectively, for the climate throughout South Africa (Tyson and Lindesay 1992).*

main highly tenuous and will certainly be revised by larger datasets, rigorous statistical treatments (e.g., Shennan et al. 2013), and accounting for other factors such as taphonomy (Surovell and Brantingham 2007). The effect of the calibration curve on the summed probability distribution is apparent when comparing it to the histograms. When we reduce the dataset to dates associated with domestic animal bones or ceramics, we see the same overall trends, in addition to two conspicuous gaps. Even considering other factors, we find the absence of dates notable and suggestive of changes in the human occupation of the region where people (and sheep) are dropping to such low numbers that they fall below archaeological visibility.

On a regional scale, the presence and absence of domestic animals is closely correlated with that of ceramics, though sheep are probably underrepresented. First, it is easier to identify dates associated with ceramics, which are simple to recognize, while sheep bones are difficult to distinguish from similar wild animal bones. Second, ceramic-using practices ubiquitously leave sherds, while herding practices may not leave bones. Modern pastoralists use their flock for milk and blood but rarely eat their flock and often prefer wild animals. The presence of domestic animal remains

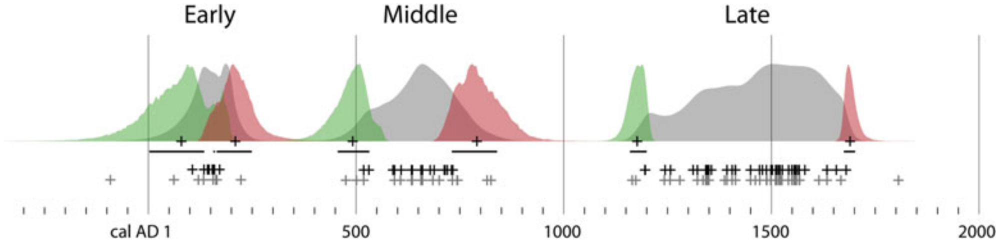

Figure 5. *Visual summary of results of the Bayesian model showing Early, Middle, and Late phases (see Table 4). The green curves are the phases' starting boundaries and the red curves are the phases' ending boundaries. Medians are marked as crosses and 68 percent probability ranges are marked as solid horizontal bars. This figure highlights the wider error ranges for the boundaries of the Early and Middle phase and quite narrow ranges for the better-defined Late phase as well as the gaps between phases. The grey curves are kernel density estimations of the underlying event distributions within each phase. These plots summarize the distribution of events in a much more robust way than summed probability distributions (Bronk Ramsey 2017). The clearest trend in these plots is the steady increase in event density over the course of the Late phase. Below the curves, black crosses represent the medians of the modeled dates; below those, grey crosses represent medians of calibrated, unmodeled dates.*

may reflect a time of great need or ritual feasting rather than everyday consumption (see Sadr 2003, 2007, 2008).

To better estimate the dates of these three pulses of occupation associated with domestic animals and ceramics, we turn to the Bayesian model, which groups dates associated with domestic animal bone and ceramics (n = 73) into three phases (Figures 4 and 5, Table 5): Early (9 dates from 3 sites), Middle (16 dates from 9 sites), and Late (48 dates from 22 sites). Even though the Early phase has few sites, they may generally represent regional trends, as they are separated by hundreds of kilometers (Figure 6). This grouping of dates is statistically robust, as indicated by a high agreement index for the model (98 percent), which is above the acceptable limit of 60 percent (Bronk Ramsey 2009). The only date with a low agreement index is the earliest one, 2105 ± 65 BP (OxA-3862), a directly dated sheep from Spoegriver Cave, with an agreement index of just 25 percent. This date calibrates to 90BC (200BC–AD 20, 68 percent probability), but when it is included in the Early Phase with eight other dates, the model estimates this date to AD 110 (30–210, 68

Table 5. **Phase boundaries of the sheep and pottery models from the Bayesian model compared to the general climate trends based on multiple proxies (see Benito et al. 2013; Stager et al. 2012; Tyson and Lindesay 1992; Weldeab et al. 2012).**

Phase	Bayesian model (AD)	Climate dates (AD)	Climate trend
Early	*80–210*	100–200	Cooling & wet
Gap 1		250–600	Warm & arid
Middle	*490–790*	600–900	Cooling & wet
Gap 2		900–1300	Medieval Warm Epoch, warm and dry
Late	*1180–1690*	1300–1850	Little Ice Age, cold and wet

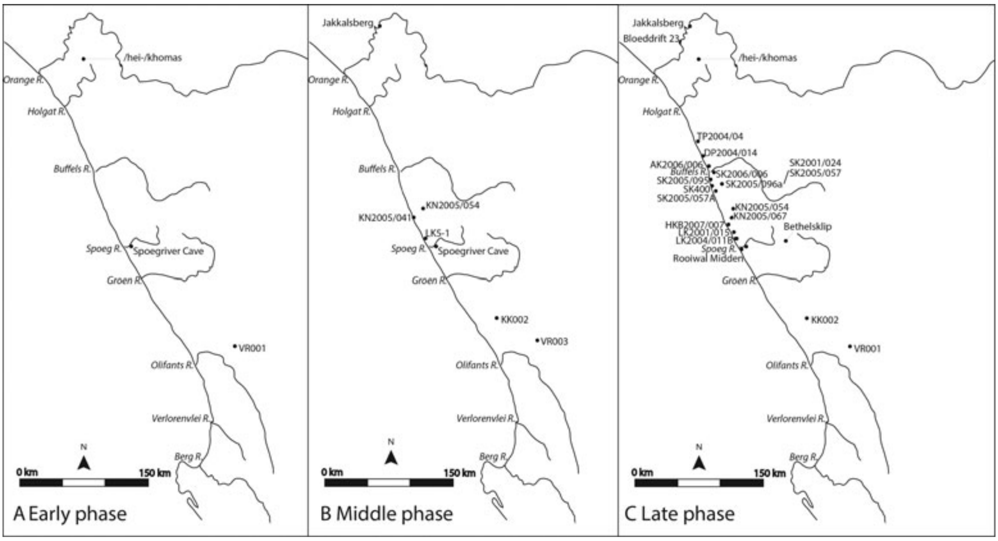

Figure 6. *Maps of Namaqualand showing the location of the sites with domestic animal bone or pottery and associated dates used in the Bayesian model during the A) Early phase AD 80–210; B) Middle phase AD 490–790; and C) Late phase AD 1180–1690.*

percent probability). The calibrated date seems to be statistically distant from the other Early phase dates, including five from the same site, but there is significant overlap. It is possible it represents an isolated and early appearance of sheep. However, considering the group of dates from this site and the rest of the region, we believe that this bone's date is better estimated with the Bayesian model. In either case, our goal is to estimate the regional date of changing economic strategies, which would exclude a single, isolated occurrence. In estimating the earliest date for the *regional* appearance of sheep, the best approach is to group this early date with others and rely on the phase's boundaries.

The model's phase boundaries are the best indicators of the temporal limits for each phase (Table 5). Here we list the median estimates with the 68 probability range in parenthesis. The model estimates that the Early phase began around *AD 80* (*1–190*) and ended around *AD 210* (*160–250*). Then there was a gap with no dates and probably very low occupational intensity of herders or ceramic-using groups, which lasted around *280 years* (*220–340*). The Middle phase began *AD 490* (*450–540*) and ended *AD 790* (*720–840*). The succeeding 'occupational hiatus' lasted *380 years* (*330–450*). The Late phase began *AD 1180* (*1060–1200*) and ended *AD 1690* (*1670–1710*). The length of the 'occupational gaps' was unexpected, and represent extended periods with no radiocarbon dates. The estimated lengths of the gaps do not approach zero, which would suggest that the gaps may not be real. Instead, the two gaps lasted at least *140* and *260 years*, even at the 95 percent probability range.

The temporal limits of each phase may not be well defined by the current dataset, as each phase seems to ramp up and ramp down gradually, as seen in the histograms. The beginnings and ends have few dates, so they may not be representative of larger patterns. New dates will adjust the results of the Bayesian model; even adjusting the bin size of the histogram can produce slightly different shapes to the phases.

Despite these limitations, we believe that the centers of the peaks and troughs are likely to be reinforced by future research and that the Bayesian model provides reasonable estimates, considering the error ranges, of the alternating presence and absence of people with domestic animal bone and ceramics on the landscape. The most intense occupation by ceramic-using 'people who keep sheep' in the Early phase centers on the second century AD. A trough of very low intensity occupation is centered on the fourth century AD. The number of sheep increase again and the Middle phase occupation was most intense in the seventh and eighth century AD, followed by a low-intensity trough in the tenth century. Sheep gradually increase and then occupation reached a stronger peak in the fourteenth to sixteenth century AD. In each successive phase, there are increasing numbers of dates: 9, 16, and 48, found at an increasing number of sites: 3, 9, and 22, respectively. This trend suggests that herding domestic animals and using ceramics became more common over time, despite dropping below visibility between phases. During these low visibility periods, it is possible that the same groups were also occupying adjacent regions with better conditions for domestic animals, such as Kasteelberg on the Vredenberg peninsula (see Smith 2006) or Die Kelders Cave (Schweitzer 1974, 1979) on the south coast (Figure 1). These trends are also suggestive of population increases, but this remains to be evaluated by future research.

DISCUSSION

The chronology of the earliest herders in South Africa is one of the region's central research topics (Sadr 2003, 2008; Sealy and Yates 1994; Smith et al. 2001; Orton 2012a; Webley 1992a, 1992b). However, these discussions are primarily based on comparisons of very few, uncalibrated dates and the difficulty in identifying a truly pastoralist society. There is agreement that the early Spoegriver date (OxA-3862) has a probability distribution that is generally earlier than other sheep dates in South Africa. Even though this date is not statistically earlier than other similar dates, it is used to support models of sheep entering South Africa through Namaqualand (Sealy and Yates 1994). Unfortunately, a single uncalibrated radiocarbon cannot bear the weight of explaining a regional trend. An improved chronology based on all relevant dates has direct impacts on the scenarios of the introduction of herding and if these early 'herders' used pottery. The sheep and ceramic models produce three overlapping phases reflecting an Early (*AD 80–210*), Middle (*AD 490–790*), and Late (*AD 1180–1690*) occurrence of these elements on the landscape (see Table 5 for probability distributions). These phases reflect the alternating presence and absence of radiocarbon dates associated with domestic animal bone and ceramics.

These trends overlap with early sheep and ceramic dates from adjacent regions as well as climate trends. Generally, there is a suggestive correlation between occupational intensity and environmental conditions. The archaeological dates and the Bayesian model presented here generally have higher resolution than many of the climate proxies. Also, many of the climate proxies are regional generalizations, which may not apply to conditions in Namaqualand and should be interpreted very cautiously. Such a discordance is suggested by a high-resolution rainfall record from the nineteenth century, which shows that while Namaqualand does follow general regional trends, there are important differences from southern and eastern Cape conditions (Kelso and Vogel 2007: fig. 4). Furthermore, conditions in Namaqualand may depend less on local rainfall than flood events that derive from increased moisture from the summer rainfall zone in the east (Benito et al. 2011; Stager et al. 2012; Weldeab et al. 2012). We suggest that current discrepancies between climate proxies and the human history of Namaqualand might be resolved by more local climate research that has a similar temporal resolution as the archaeological data.

The Early sheep and pottery phase range spans roughly *AD 80-210*. This phase is defined by dates from three sites: Spoegriver Cave on the Spoeg River, /hei-/khomas on the Orange River, and VR001 on the Varsche River (Sealy and Yates 1994; Webley 1992a) (Figure 6). This phase correlates well with a period of pronounced cooling across South Africa from AD 100–200 AD (Figures 4 and 5). Evidence for cooling is based on oxygen isotope data from the Cango Cave Speleothem (Talma and Vogel 1992) and palynological studies of spring-sites at Wonderkrater, Scot Spring, Tate Vondo, and the Rietvlei Dam (Scott 1990). Closer to the study region are two marine cores off Walvis Bay, Namibia, where two species of cold water foraminifera also suggest a cooling period (Johnson 1988; Tyson and Lindesay 1992). In the Southwestern Cape, pollen from Klaarfontein indicates a shift from moist sweet grasses to more xeric grasses around AD 50 (Meadows and Baxter 2001). While proxy data at Spoegriver Cave in Namaqualand identified a high diversity of micromammal species from these layers, indicating increased moisture with a moderate amount of grass (Avery 1992). If the local area was cooler and wetter than today we would expect an increase in effective moisture availability. The currently ephemeral rivers could have been in flow and local grasses available for fodder would have been more plentiful.

On the south coast over 700 km away, dates at Blombos Cave (1960 ± 50 BP; cal 23 AD–198 AD) are very similar for the initial appearance of both sheep and ceramics. Throughout South Africa, the earliest pottery is within a century or two of Namaqualand's Early phase. These regional similarities in dates suggest that the earliest appearance of sheep and ceramics was roughly contemporaneous.

Gap 1. There is a period of *280 years* where neither pottery nor sheep have been identified in Namaqualand, around *AD 210-490*. The palaeoenvironmental proxies for this period reflect a warming trend with low humidity beginning at AD 250 (Tyson and Lindesay 1992). With a potential reduction in water and grass availability the carrying capacity of the region would have eventually dropped. It seems that the footprint for herders, hunters with sheep, or hunters with ceramics is all but gone in the region. It is possible that there were people and sheep on the landscape, but the general population trend suggests that even in this case, occupational intensity was low. It is noteworthy however that sheep are present and potentially plentiful further south during this gap (i.e., >300 km away at Kasteelberg and the south coast sites) in the Fynbos biome with a higher average rainfall.

The Middle sheep and pottery phase spans about *AD 490–790 AD* (Figure 6, Table 5). In the first part of this period, regional palaeoenvironmental proxies indicate continued aridity (Tyson and Lindesay 1992). However, since there was a re-occupation by people with domestic animals and ceramics, this aridity may not have had as dramatic an effect in Namaqualand, or people were more capable of finding springs. The renewed and growing presence of human occupations suggests that the local climate may have been ameliorating by around *AD 490*, though this remains to be evaluated by future studies. By the middle of the phase, palaeoenvironmental proxies indicate a regional trend of variable cooling and increased winter rains from ~AD 600 to 900. This is based on the oxygen isotopes from the Cango Cave speleothem (Talma and Vogel 1992), the foraminifera from the Walvis Bay marine core, palynological studies from Wonderkrater, Scot Spring, Tate Vondo, and the Rietvlei Dam (Scott 1990), and numerous proxies from cores taken in the Verlorenvlei in the Western Cape (Stager et al. 2012).

Locally, Spoegriver Cave, the Jakkalsberg sites A and B, VR001, and KK002 are riverside sites, while LK5-1, KN2005/054, and KN2005/041 are at least 3 km from the nearest river but only 500 m from the coast (Figure 6). It is toward the end of this period around AD 800 that Sadr (2008) and Sealy (2010) propose that cattle and milk become more important or at least more visible and may reflect the arrival of the Khoekhoen culture or at least the development of a fully pastoralist society. In Namaqualand, we only have a single positively identified cattle element (KN2005/041 through aDNA; see Orton et al. 2013). The Middle phase ends around *AD 790*, slightly before the onset of aridity associated with the Medieval Warm Epoch.

Gap 2 and the Medieval Warm Epoch. The second gap was longer than the first, lasting *380 years* from *AD 790 to 1180*. Once more, people with sheep and pottery seem to have all but left the region or have fallen below archaeological visibility as conditions became warmer and drier state during a part of the Medieval Warm Epoch, which lasted from around AD 900 to 1300. Evidence for this warm and dry period is plentiful across southern Africa. This is based on oxygen isotopes from the Cango Caves Speleothem (Talma and Vogel 1992), the species of foraminifera from the marine cores off of Walvis Bay (after Johnson 1988 in Tyson and Lindesay 1992), oxygen isotopes and argonite:calcite ratios of shellfish at Elands Bay (Cohen et al. 1992), the pollen record from various sites (Scott 1990), the Verlorenvlei cores (Stager et al. 2012), and the micromammal species at Spoegriver Cave (Avery 1992).

The Late sheep and pottery phase spans *AD 1180–1690*. As in the first part of the Middle phase, the first part of the Late phase occupation begins as regional proxies suggest continued aridity (Figure 6, Table 5). Based on the increasing evidence for occupation, it may be that local conditions improved 1–2 centuries earlier than regional proxies suggest or people were able to find suitable microenvironments. Generally, the increasing intensity of occupation of people with both sheep and ceramics correlates with the Little Ice Age, dated from AD 1300 to 1850. Evidence for the Little Ice Age includes the Cango Caves speleothem (Talma and Vogel 1992), foraminifera off Walvis Bay (Johnson 1988 in Tyson and Lindesay 1992), pollen data from various sites (Scott 1990), tree ring analyses from Natal (Hall 1976) and the Cederberg (Dunwiddie and LaMarche 1980), and the proxies from the Verlorenvlei cores (Stager et al. 2012). Locally, the flood record for the Buffles River suggests increasing moisture availability through high frequency of flooding, particularly between AD 1390–1420 and AD 1800–1825 (Benito et al. 2011). An increased humid signal beginning around AD 1350 is supported by the analyses of fluvial sediments from marine core GeoB8332-4 off the Holgat River (Weldeab et al. 2012). During this phase, the sites with sheep and pottery are no longer tethered to rivers. In fact, the majority of sheep and pottery sites are located along the coastline between the Spoeg and Buffels Rivers (Figure 6). This is also the period that we see the highest frequency of sites for the entire region of Namaqualand (Figures 2–6). Importantly, we see a corresponding shift in subsistence and settlement strategies with mass harvesting species such as springbok; penguins, seals, tortoises, and crayfish at large (40 × 20 m) coastal base camps (Dewar 2008; Dewar et al. 2006). There would have been social implications for having control over food surplus and we find an increase in the production of trade goods that may reflect an increase in risk-reduction strategies (Dewar 2008; Dewar et al. 2006).

Unexpectedly, regional models indicate a warming period that interrupts the Little Ice Age around AD 1500–1675 (Tyson and Lindesay 1992:275). Yet in Namaqualand, this period includes the highest frequency of radiocarbon dates associated with sheep and ceramics (Figures 3–5), which leads us to believe that either the local area did not experience a severe period of reduce effective moisture or by this time people were capable of maintaining herds above archeological visibility during arid spells. More local proxies indicate a “continuous rise in fluvial sediments” from Namaqualand rivers from around AD 1350–1850 (Weldeab et al. 2012:2359), which agrees with other climate proxies. Climate data suggest only partial temporal correlations in the Middle and Late phases, which remain to be explained by future research. The Early phase has the best correlation, but is based on only nine dates, so all of these potential correlations will require future studies.

Evidence for the Khoekhoen and Pastoralism?

To date, material culture patterns pre- and post-AD 1 in Namaqualand do not support a migration of new people into the region (Dewar 2008; Orton 2012a). The histograms and summed probability distribution do not show a major change in population around this period (Figure 2). There are no new artefact types aside from pottery and sheep, nor a consistent shift in the size of ostrich eggshell beads (contra Smith et al. 2001). Phenotype data from the human skeletons from South Africa support a single gene pool pre- and post-AD 1 (Kurki et al. 2012; Stynder 2009; Stynder et al. 2007). Isotopic signatures of all 16 analyzed human burials from Namaqualand do not show any change in diet pre- and post- AD 1 (∂^{13}C $p = 0.137$, $t = 1.57$, $df = 14$; ∂^{15}N $p = 0.512$, $t = 0.672$, $df = 14$). Thus, to date there is no evidence for a migration of a new population with the arrival of sheep and pottery during the Early sheep and pottery phase. The evidence does suggest that pottery and sheep were introduced on a very low level, likely through a 'hunters with sheep and pottery' model. Russel (2017) reminds us that if hunter-gatherers included sheep and or goats into their pre-existing trade networks as social currency, there would be very little evidence for slaughtering animals. However, data remain scant and cannot exclude other possibilities such as a subtle or adjacent demographic shifts, for example, the introduction of foreign herder men or women through marriage who imported novel knowledge but adopted the local material culture.

Nor do we see a shift in material culture or diet in Namaqualand at AD 500 to 800 (∂^{13}C $p = 0.576$, $t = 0.57$, $df = 14$; ∂^{15}N $p = 0.435$, $t = 0.80$, $df = 14$) (see Sadr 2008; Sealy 2010) during this study's Middle phase. As this region is dominated by C_3 grasses we cannot use the same approach to identifying the consumption of milk from grazing cattle that was available in the study of the southern coast (see Sealy 2010). The majority of the human remains were discovered through mining activities, so we do not have information on their burial contexts. So overall the presence or absence of a herding society in Namaqualand during the Middle phase is inconclusive. However, we do know that a Late phase human burial from the site AK2006-006 was buried in a seated position with grindstones above his head (Orton 2012a), which is very similar to the style practiced by the seventeenth-century Khoekhoen at the Orange River (see Morris 1992; Sealy 2010). The Late phase is also when we see the introduction of tortoise burials below shell middens that Orton (2012b) has interpreted as likely reflecting increasing ritual behavior. Together these elements with the introduction of a new subsistence and settlement strategy (mass harvesting and large coastal base camps) hint at a more socially complex culture.

CONCLUSION

This study used radiocarbon dates and Bayesian statistics to build a model assessing the timing of sheep and pottery use in one gateway region: Namaqualand. We were able to expand the available dataset through the addition of new dates and by incorporating samples that included marine carbon: marine shell and human burials with a mixed marine and terrestrial diet. This was possible because we could calculate the proportion of marine protein in the diet (Dewar and Pfeiffer 2010) and calibrate marine carbon dates with the average local ΔR (Dewar et al. 2012). As the number of dates grow, so does the need to evaluate them in aggregate, and not individually, which can be effectively done through Bayesian models. Future research could offer improved data by directly dating faunal collagen with aDNA identification to species and more local fine grained palaeoenvironmental data.

The results indicate that people were intensively on the landscape with sheep and pottery in three pulses during periods that were largely cooler and wetter than today, when pasture and potable water would have been more abundant. There are two gaps when either the region was largely abandoned or the herds fell below archaeological visibility. The first occurs at the same time that sheep and pottery become numerous in the southern and western Cape, regions that receive higher rainfall than Namaqualand. The second gap roughly correlates with the onset of the Medieval Warm Epoch, a warm but increasingly arid period. Occupation in Namaqualand intensifies again before this dry period is over, suggesting that either local conditions improved before more regional proxies indicate or people had developed the required skills to maintain herd sizes in arid environments. We suggest that our data may more accurately reflect the availability of surface water in Namaqualand than regional palaeoenvironmental proxies.

Finally, the Late pottery and sheep phase includes the Little Ice Age period with clear evidence for a cooler and wetter Namaqualand that would have been favorable for pasture. This is also the period when we see an increase in the frequency of radiocarbon dates, an increase in the size of sites, and the introduction of a new subsistence and settlement strategy that allows for the production and control of a food surplus. This is in conjunction with an increase in the production of potential trade items, the ritual burial of tortoises, and evidence of at least one seated burial in the style of seventeenth-century Khoekhoen. While individually these elements are not clear indicators of a herding lifestyle, when taken together they hint at a changing cultural landscape of increased social complexity with components that are consistent with historically recorded Khoekhoe groups.

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