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ORIGINAL PAPER

What is on the craftsmen's menu? Plant consumption at Datrana, a 5000-year-old lithic blade workshop in North Gujarat, India

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Abstract The exploitation of lithic resources was an important aspect of prehistoric resource exploitation strategies and adaptation. Research has mostly focused on technological and spatial aspects of lithic factory sites, often overlooking how these sites were integrated within local socioecological dynamics in terms of food acquisition and consumption. The aim of this paper is to study plant consumption at Datrana, a 5000-year-old lithic blade workshop in North Gujarat, India, in order to understand its occupants' subsistence strategies. The results of archaeobotanical, mineralogical and soil pH analyses show that the occupants of this factory site were consuming local crops but not processing them, suggesting that either (a) food was being processed in other areas of the site or (b) it was acquired in a 'ready-to-consume' state from local food-producing communities. This study highlights the integration of a lithic factory site within its surrounding cultural and natural landscape, offering an example of how the inhabitants of a workshop interacted with local communities to acquire food resources.

Keywords Lithic workshop · Craft specialisation · Archaeobotany · Mineralogy · Subsistence strategies · South Asia

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Introduction

The appearance of craft specialisation has been traditionally linked with the emergence of stratified societies and powerful elites (Peregrine 1991). However, the existence of a specialised production centre is the result of a variety of processes, and a certain degree of specialisation occurs in all societies (Kenoyer et al. 1991). Moreover, the level of production is often controlled by the craftsmen and women themselves and not necessarily by the ruling elite (Shafer and Hester 1991).

The term 'craft specialist' refers to 'an individual who repeatedly manufactures a craft product for exchange' (Shafer and Hester 1991:79). Archaeologically, craft-specialised communities are recognised by the production of one (or a few) standardised item in excess of household needs and the appearance of this item beyond its centre of production.

The most ubiquitous examples—both spatially and temporally—of craft production centres in archaeological contexts are lithic workshops (e.g. Beck et al. 2002; Biagi and Cremaschi 1991; Johnson 1984; Laughlin and Marsh 1951; Sanger et al. 2001; Sankalia 1967; Shafer and Hester 1991; Snarskis 1979; Stiles et al. 1974; Subbarao 1955). The archaeological record of lithic workshops varies according to their size, the time span of their occupation and the nature of the activities carried out within the site. Indeed, the activities performed at a particular workshop depend on how it is articulated within the landscape in terms of distance to the residential base, raw material sources and trading networks, and the local ecology (Beck et al. 2002; Johnson 1984; Sanger et al. 2001).

One vital aspect of lithic factory sites that has often been overlooked is how these sites were integrated within local and regional socioecological dynamics in terms of food acquisition and consumption.

The aim of this paper is to study plant consumption at Datrana, a 5000-year-old lithic workshop in North Gujarat, India, in order to understand the plant acquisition and consumption strategies and the socioeconomic organisation of their occupants at a local and regional level.

Datrana, a 5000-year-old lithic workshop in North Gujarat, India

North Gujarat is a semi-arid (400–600 mm) ecotone located between the Thar Desert and semi-humid South Gujarat (Fig. 1). The region is characterised by a monsoon regime (Indian Summer Monsoon) in which most of the rainfall occurs between June and September, shaping agricultural and pastoral activities. Datrana IV (23° 46′ 41.7″ N, 71° 07′ 26.2″ E), locally known as Hadka-valo Timbo, is located on a large crescent-shaped stabilised sand dune about 2 km northeast of Datrana village, Patan district. This site is part of a large (40 ha) archaeological complex formed by discrete clusters of artefacts spread through ten mounds around a large interdunal depression.

The excavations conducted by the Department of Archaeology and Ancient History of the M. S. University of Baroda (MSUB, India) at Datrana IV between 1993 and 1995 uncovered a Mesolithic hunter-gatherer occupation with superimposed Chalcolithic deposits (IAR, 1993–1994, 1994–1995). Otoliths from the Mesolithic level were AMS dated to the mid-eighth millennium cal. BC (unpublished data). The majority (>95 %) of the ceramic assemblage from the Chalcolithic deposits is characterised as pre-Prabhas, a handmade pottery assemblage previously recovered only at Somnath on the Saurashtra coast (400 km south of Datrana, Fig. 1) and dated to the early third millennium cal. BC (Ajithprasad 2002, 2011; Rajesh et al. 2013; Sonawane and Ajithprasad 1994). Pre-Prabhas pottery was also recovered during explorations at neighbouring Datrana V and Datrana IX, but it has not been found at any other Chalcolithic occupation in North Gujarat (Ajithprasad 2002, 2011). The ceramic assemblage from Datrana IV further included a minor (<5 %) presence of Early Harappan Sindh (Indus Valley, ca. 2800–2600 cal BC) and Anarta pottery (North Gujarat, ca. 3700–2200 cal. BC) (Ajithprasad 2002). Moreover, the evidence found at Datrana IV suggested the production of beads from agate, chert, amazonite and, especially, small carnelian disc beads using a technology not reported from other Chalcolithic sites in North Gujarat (Madella et al. 2012). The exceptionality of its pottery and disc bead assemblages highlights the uniqueness of Datrana among the Early Chalcolithic occupations in North Gujarat. However, the subsistence strategy of the inhabitants of Datrana and how they interacted with other hunter-gatherer and agro-pastoral groups were issues that required further research.

The North Gujarat Archaeological Project (NoGAP), a collaboration between the MSUB (India) and the IMF-CSIC (Spain) (Madella et al. 2010), excavated a 4 × 4-m trench at Datrana IV in 2010 in the richest area in terms of surface material—particularly lithic tools. The new excavation aimed at understanding site formation processes and obtaining more information on the subsistence strategies of its occupants. The excavation revealed a 50-cm cultural deposit belonging to the Chalcolithic occupation, AMS dated ca. 3300–3000 cal. BC and thus preceding the pre-Prabhas occupation at Somnath (Table 1). Unlike the previous excavations, no significant habitation deposit of hunter-gatherer occupation was uncovered during the 2010 field season (Madella et al. 2012). The artefacts recovered included lithic implements, pottery, copper/bronze punch points, stone beads and bead rough-outs, a cluster of heated carnelian nodules, stone drill bits, facetted crayons, hammer stones and grinding tools. No structural remains, hearths or ash concentrations were found. During excavation, we did not encounter any evidence of an activity floor, but several clusters of animal bones, potsherds and lithic tools were encountered. Faunal remains were very fragmented, and some were partially charred.

An exhaustive study of the lithic assemblage revealed over 10,000 stone blades, a few geometric and non-geometric tools and over 77,000 pieces of lithic debitage, mostly made of chalcedony (Gadekar et al. 2013). Two nearby sources of chalcedony nodules were encountered during an exploratory survey, both located about 20 km from the site (Madella et al. 2012). Blades were removed by crested guiding ridge technique, a practice associated with Chalcolithic settlements of the Indus Civilisation (Cleland, 1977). In addition, the lithic assemblage included a few examples of Rohri chert blades from the Rohri Hills in Sindh, Pakistan (Biagi and Cremaschi 1991), over 500 km northwest of Datrana. The absence of Rohri chert debitage indicates that these blades were not locally produced but imported (Gadekar et al. 2013).

The Indus or Harappan Civilisation flourished throughout the Indus Valley in northwest South Asia between ca. 3300–1300 cal. BC, extending from modern northeast Afghanistan to Pakistan and northwest India (Kenoyer 1991a; Possehl 2002; Wright 2010). Indus Civilisation sites are characterised by the appearance of a relatively homogenous corpus of material culture, including handicrafts (pottery, beads, seals, lithic tools) and metallurgy (Chase et al. 2014; Wright 2010). The

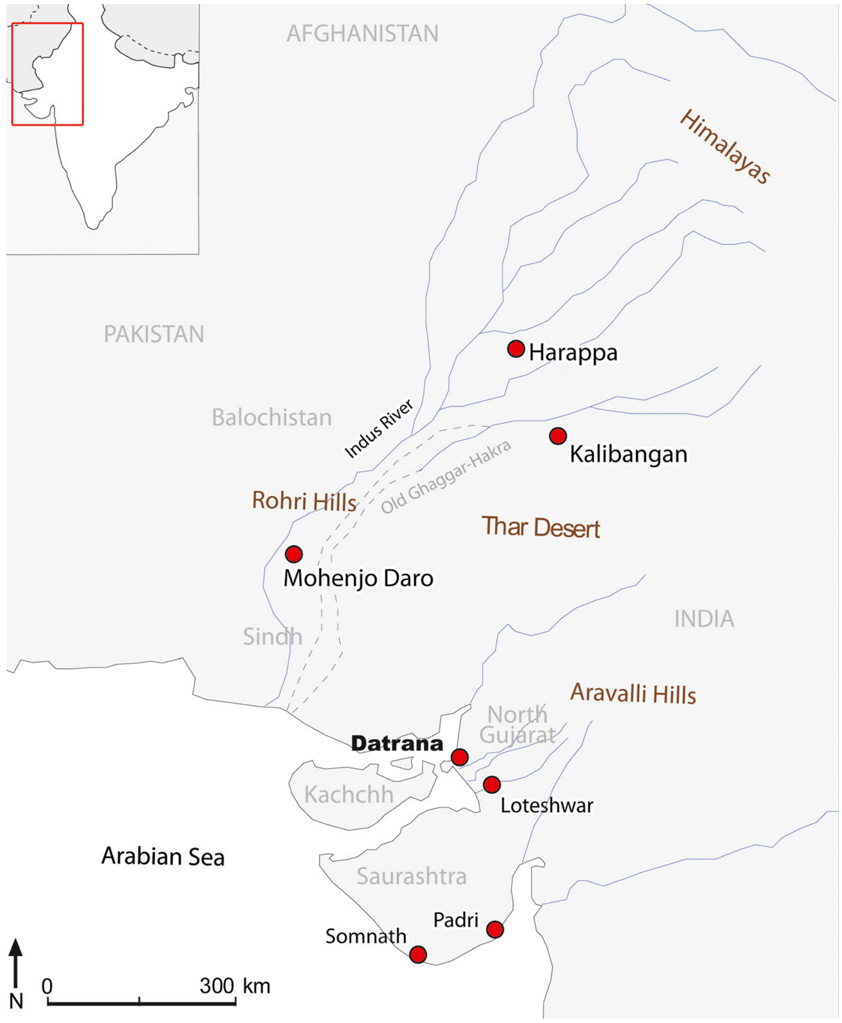

Fig. 1 Map of Gujarat showing the location of Datrana IV and other sites mentioned in the text. Image by Francesc C. Conesa

recovery of Early Harappan Sindh pottery in mortuary and residential contexts in Gujarat suggests that the interaction between the Indus Valley and Gujarat began during the early third millennium BC (Ajithprasad 2002, 2011). However, it is during the Urban Phase of the Indus Civilisation (ca. 2500–1900 cal. BC) that the Harappan influence is most evident in Gujarat, with the appearance of a series of walled urban settlements with the characteristic Harappan city plan and associated material culture along trade and travel corridors (Chase et al. 2014).

The use of the crested ridge technology for local blade production and the presence of imported Rohri chert blades

Table 1 Sediment samples analysed in this study and radiocarbon estimations from wood charcoal provided by the Centro Nacional de Aceleradores, Sevilla, Spain

Sample ID	Description	^{14}C-age (year BP)	2-σ cal. age (year BC)	Lab code
DTR 9	General archaeological deposit	–	–	–
DTR 10	Material cluster	–	–	–
DTR 11	Material cluster	–	–	–
DTR 12	Material cluster	–	–	–
DTR 13	Material cluster	4465 ± 35	3339–3204, 3197–3023	2227.1.1
DTR 25	General archaeological deposit	4505 ± 35	3353–3096	2229.1.1
DTR 27	General archaeological deposit	–	–	–
DTR 30	Discarded carnelian cluster	–	–	–
DTR 34	General archaeological deposit	–	–	–
DTR 44	General archaeological deposit	–	–	–

suggest that the inhabitants of Datrana interacted with the Indus Valley during the late fourth millennium BC, at the beginning of the pre-Urban or Early Harappan Phase of the Indus Civilisation (ca. 3300–2600 cal. BC). Such early interaction is unprecedented in Gujarat and suggests that Datrana may have functioned as a lithic workshop occupied by pre-Urban Harappan communities from Sindh to exploit local chalcedony outcrops. These same groups would have later exploited chalcedony outcrops in the Saurashtra coast during the early third millennium BC, as attested by the presence of crested ridge blade technology and pre-Prabhas pottery at Somnath (Ajithprasad 2002, 2011; Sonawane and Ajithprasad 1994). Alternatively, the origin of the pre-Prabhas ceramic communities at Datrana can be traced back to the hunter-gatherer occupation of the site (Rajesh et al. 2013). However, this hypothesis seems unlikely under the light of the temporal gap between both occupations (over 4000 years) and the uniqueness of the Chalcolithic lithic and ceramic assemblages from Datrana.

The agricultural system during the pre-Urban Harappan Phase in Sindh was characterised by West Asian winter crops such as wheat (*Triticum* sp.), barley (*Hordeum vulgare* L.), peas (*Pisum sativum* L.), lentils (*Lens culinaris* L.) and chickpeas (*Cicer arietinum* L.), whereas the subsistence strategy of the inhabitants of North Gujarat relied on native summer crops such as small millets and tropical pulses (Fuller and Madella 2002; García-Granero et al., 2015a). The markedly different nature of the subsistence strategies in the region of origin of the craft specialists (Sindh) and the area were the lithic workshop was located (North Gujarat) offers a unique opportunity to study how the plant-related subsistence strategies of the inhabitants of Datrana were incorporated into the local socioecological dynamics. Food acquisition strategies depend on the nature of the occupation (permanent, seasonal, etc.) and the level of interaction with local populations. At Datrana, three hypothetical scenarios can be considered:

a) The workshop is occupied only by specialised craftsmen and women, who carry their own food supply from their residential base. This strategy would probably take place if the workshop were exploited during short periods of time. Archaeologically, it would result in the high presence of storage containers and winter crops characteristic of Sindh.
b) The workshop is occupied only by specialised craftsmen and women, who obtain food through exchange with local hunter-gatherer and/or agro-pastoral populations. This strategy could take place regardless of the length of the occupation and would imply a high level of interaction between the occupants of the workshop and the local populations. Archaeologically, it would result in the presence of small millets characteristic of North Gujarat at the workshop and the spread of crafts throughout its hinterland.
c) The workshop is occupied by not only specialised craftsmen and women but also people who carry out food-procurement activities. This strategy would take place if the workshop was occupied permanently or for relatively long periods of time and implies a deep knowledge of the local ecology. Archaeologically, it would result in the presence of semi-permanent architectural settings and the ecofactual remains of a food-procuring economy.

Materials and methods

We carried out archaeobotanical, mineralogical and pH analyses on samples collected during the 2010 field season, in which a systematic sampling strategy for macro- and microbotanical remains was performed. Samples from the general archaeological deposits and several clusters of animal bones, potsherds and lithic tools were analysed for plant macro- (wood charcoal, seeds and fruits) and microremains (phytoliths and starch grains), Fourier transform infrared spectroscopy (FTIR) and soil pH (Table 1). Moreover, microbotanical remains were analysed from grinding stones (Table 2).

Bulk samples (20 l) were collected from each excavation spit (ca. 10 cm) of the 2 × 2-m grid to recover macrobotanical remains through bucket flotation with a 0.25-mm mesh. All macroremains in the fraction >0.5 mm were recovered and observed using a Leica EZ4 D stereoscope. Taxonomical identification of all plant remains relied on the plant reference collection of the BioGeoPal Laboratory (IMF-CSIC, Barcelona) and seed atlases (Cappers and Bekker 2013; Cappers et al. 2009; Neef et al. 2012).

Microbotanical remains from sediments and grinding tools were extracted following the protocols described in García-Granero et al. (2015a) and observed with a Leica DM 2500 microscope equipped with a Leica DF 470 camera for microphotography. All phytolith samples were quick-scanned at ×200 magnifications. Due to the scarcity of phytoliths, only seven samples—two sediment samples and five grinding stones—were fully scanned at ×630 magnifications. Multicell phytoliths (silica skeletons) were counted independently. Phytolith concentration was calculated per gram of acid insoluble fraction (AIF) according to Albert and Weiner (2001), and phytoliths were described using the International Code for Phytoliths Nomenclature (ICPN; Madella et al. 2005).

All starch samples were analysed. Slides were fully scanned at ×200 magnifications, and all the observed starch grains were photographed under transmitted and cross-polarised light at ×630 magnifications. Starch concentration was calculated per gram of processed sediment, and starch

Table 2 Grinding stones analysed in this study. Descriptive terms after Wright (1992)

Sample ID	Description	Context
GS 1	Frag. basin grinding slab	DTR 10
GS 2	Frag. saddle-shaped grinding slab	DTR 12
GS 3	Frag. saddle-shaped grinding slab	DTR 12
GS 4a	Frag. saddle-shaped grinding slab, face a	DTR 12
GS 4b	Frag. saddle-shaped grinding slab, face b	DTR 12
GS 5	Frag. saddle-shaped grinding slab	DTR 12
GS 6a	Frag. saddle-shaped grinding slab, face a	DTR 12
GS 6b	Frag. saddle-shaped grinding slab, face b	DTR 12
GS 7	Frag. saddle-shaped quern	DTR 12
GS 8	Unifacial discoidal handstone	DTR 12
GS 9	Frag. saddle-shaped grinding slab	DTR 10
GS 10	Frag. saddle-shaped grinding slab	DTR 9
GS 11a	Frag. saddle-shaped grinding slab, face a	DTR 12
GS 11b	Frag. saddle-shaped grinding slab, face b	DTR 12
GS 12a	Frag. saddle-shaped grinding slab, face a	DTR 13
GS 12b	Frag. saddle-shaped grinding slab, face b	DTR 13
GS 13	Frag. saddle-shaped grinding slab	DTR 13
GS 14	Frag. saddle-shaped grinding slab	DTR 13
GS 15	Frag. saddle-shaped grinding slab	DTR 13
GS 16	Frag. saddle-shaped grinding slab	DTR 13
GS 17	Frag. saddle-shaped grinding slab	DTR 27

grains were described according to the International Code for Starch Nomenclature (ICSN 2011).

Infrared spectroscopy was used to identify the gross mineral components of the sediments. Infrared spectra were obtained using KBr pellets at 4 cm^{-1} resolution with a Nicolet iS5 spectrometer. In order to assess the origin of the calcite, we applied the infrared grinding curve method developed by Regev and Poduska (Regev et al. 2010; Poduska et al. 2011) based on the measurement of the ratio of v_2/v_4 heights (1420 and 713 cm^{-1}, respectively) normalised to a v_3 height (874 cm^{-1}). Clays exposed to high temperatures were identified using specific absorptions in the clay spectrum following Berna et al. (2007). Soil pH was measured using a Combo pH & EC HI98129 by HANNA® instrument to understand how soil acidity/alkalinity might have affected the preservation of plant remains.

Results

Archaeobotanical remains

The anthracological analysis could not be carried out due to the scarcity and small size (mostly 0.5–1 mm) of the charred wood recovered from all contexts (Table 3). Charred seeds and fruits were also scarce (Table 3). The macrobotanical assemblage includes wild seeds and grains—crowfoot grass (*Dactyloctenium aegyptium* (L.) Willd.), Cyperaceae (sedges) and Caryophyllaceae—a weed usually associated with small millet cultivation (*Chenopodium* sp.) and a barley rachis (Fig. 2).

Phytoliths were very scarce in all samples (Tables 4 and 5), and silica skeletons were only found in sediment samples. Some phytoliths showed signs of chemical dissolution, but this trait was not generalised (Fig. 3).

Starch grains were scarce in sediment samples but abundant on grinding stones (Tables 4 and 5, Fig. 4). In particular, samples GS 6a, GS 14 and GS 17 contained a high amount of type 1 (3–10 μm) and type 2 (10–20 μm) Panicoideae (Poaceae), most likely from small millets (Madella et al. 2013). A few type 3 (>20 μm) Panicoideae and cf. Panicoideae grains were also recovered. The starch assemblage further included grains from the Triticeae tribe (Pooideae, Poaceae)—probably from wheat and/or barley (Yang and Perry 2013)—and the Faboideae subfamily (Fabaceae). Faboideae starch grains cannot be identified to genus or species level, and therefore, they could belong either to local pulses—such as horsegram (*Macrotyloma uniflorum* (Lam.) Verdc.) or mung bean (*Vigna radiata* (L.) R. Wilczek)—or to West Asian crops such as lentils. Two morphotypes (tuber undetermined 1 and 2) could not be assigned to any specific taxonomic group, but their morphology suggests they are most probably originating from underground storage organs (rhizomes/tubers), as does one grain belonging to the Zingiberaceae family (the ginger family). Finally, several starch grains could not be identified due to severe damage.

Mineralogical and pH analyses

All sediment samples were mainly composed of quartz and clay, with a minor presence of calcite (Table 4). Overall, sediments from the material clusters contained less calcite than those from general archaeological layers. Wood ash was the source of the calcite in samples DTR 25, 27, 30, 34 and 44, whereas it was not possible to assess the origin of the calcite in the remaining samples. Samples DTR 10 (material cluster) and 30 (cluster of heated carnelian) contained possibly burned clays. Soil pH values were moderately high throughout the sequence (Table 4), indicating the presence of slightly alkaline soils.

Discussion

Plant processing and consumption at Datrana IV

The scarcity of archaeobotanical remains at Datrana IV is to be interpreted in terms of the depositional and post-depositional

Table 3 Results of the macrobotanical analyses

	DTR 9	DTR 10	DTR 11	DTR 12	DTR 13	DTR 25	DTR 30	DTR 34	DTR 44
Sediment volume (l)	60	20	20	20	80	80	40	60	100
Charred seeds									
Amaranthaceae									
Chenopodium sp.	.	.	.	.	1	.	.	.	.
Caryophyllaceae	1	.	.	.	.	.	.	.	.
Cyperaceae	5	.	.	.	.	.	.	.	.
Poaceae									
Dactyloctenium aegyptium	.	.	.	.	1	1	.	.	.
Hordeum sp. rachis	.	.	.	.	1	.	.	.	.
Charred wood (mg/l)	0.5	0.7	2.9	1.1	12.3	2.9	4.7	1.3	0.2

processes that would have made possible their preservation. Plant remains are incorporated into the archaeological record as by-products of plant processing and consumption activities. The nature of such activities determines which plant remains are preserved and thus recovered in the archaeobotanical assemblage. The different types of plant remains analysed in this study represent diverse processing and consumption activities and have different preservation pathways (García-Granero et al. 2015a). Therefore, understanding the depositional and post-depositional processes that may have affected their preservation allows for the reconstruction of the plant-related activities that took place at the site.

The local ecological settings—high soil salinity and alkalinity, wet-dry monsoon cycles—may have negatively affected the preservation of certain plant remains. Macrobotanical remains are usually preserved charred as a result of fire activities related to plant processing (roasting, parching, cooking), fuel use and cleaning episodes (van der Veen 2007). The scarcity of wood charcoal, charred seeds and fruits and phytoliths from woody taxa might indicate that (a) fire was not an important element of the daily life of the inhabitants of this lithic workshop, (b) post-depositional processes have prevented their preservation or (c) this activities were carried out in a different part of the site. The absence of hearths and ash concentrations and the predominance of unburned clays support the former hypothesis. However, the presence of charred faunal remains, heated carnelian nodules and wood ash calcite indicates the existence of some sort of combustion. Overall, this evidence suggests that fire was present but its use was not widespread throughout the site, and therefore, the scarcity of charred macrobotanical remains might

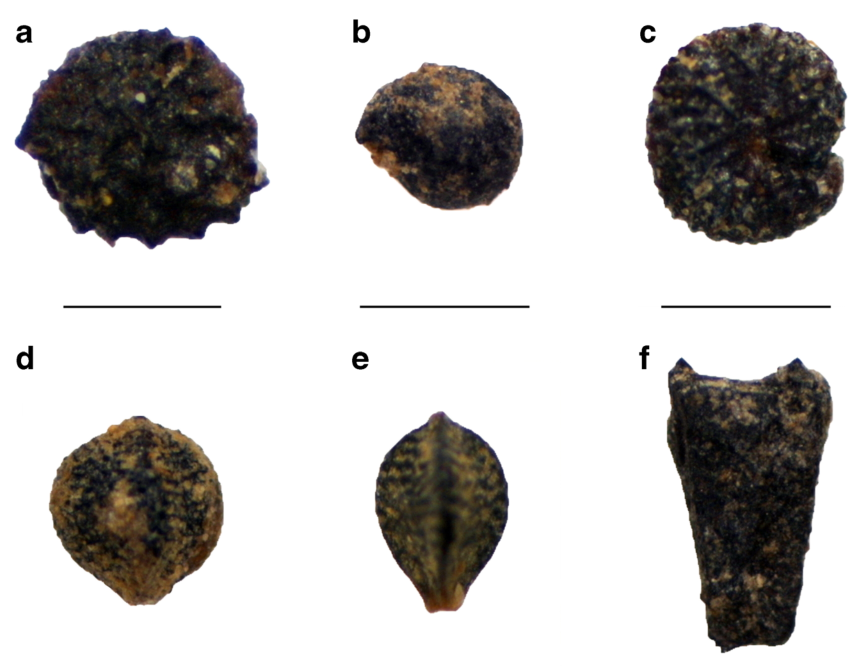

Fig. 2 Charred seeds and fruits recovered from Datrana IV: **a** *Dactyloctenium aegyptium* caryopsis, **b** *Chenopodium* sp. seed, **c** Caryophyllaceae seed, **d**, **e** Cyperaceae seeds, **f** *Hordeum* sp. rachis. *Scale bars* 0.5 mm in **a** and 1 mm in **b**–**f**

Table 4 Results of phytolith, starch, soil pH and mineral component (FTIR) analyses from sediment samples

	DTR 9	DTR 10	DTR 11	DTR 12	DTR 13	DTR 25	DTR 27	DTR 30	DTR 34	DTR 44
Phytoliths										
Silica skeletons										
Inflorescence	1	–	–	.	–	–	–	–	–	–
Leaf/culm	1	–	–	1	–	–	–	–	–	–
Total silica skeletons	2	–	–	1	–	–	–	–	–	–
Total cells in silica skeletons	5	–	–	2	–	–	–	–	–	–
Single cells										
Poaceae										
Long cells										
Leaf/culm	22	–	–	6	–	–	–	–	–	–
Undetermined	5	–	–	1	–	–	–	–	–	–
Bulliform (leaf)	4	–	–	2	–	–	–	–	–	–
Short cells										
Chloridoideae	2	–	–	2	–	–	–	–	–	–
Panicoideae	6	–	–	1	–	–	–	–	–	–
Pooideae	4	–	–	2	–	–	–	–	–	–
Undetermined	6	–	–	2	–	–	–	–	–	–
Dicotyledons	2	–	–	.	–	–	–	–	–	–
Undetermined taxa	84	–	–	37	–	–	–	–	–	–
Unidentified phytoliths	26	–	–	9	–	–	–	–	–	–
Total single cells	161	–	–	62	–	–	–	–	–	–
Phytolith concentration	598	–	–	157	–	–	–	–	–	–
Starch grains										
Fabaceae										
Faboideae	1	.	.	.	.	1	.	.	.	.
Poaceae										
Panicoideae										
Type 2	4	.	2	.	.	.	.	2	2	.
Type 3	.	.	1	.	.	.	.	1	.	.
cf Panicoideae	.	.	.	.	.	.	.	1	.	.
Pooideae										
Triticeae	.	.	1	.	.	1	.	.	1	.
Tuber undetermined 1	1	.	.	.	.	.	.	.	1	.
Damaged unidentified	.	1	.	.	.	.	.	1	.	.
Total starch grains	6	1	4	.	.	2	.	5	4	.
Starch concentration	14	2	11	.	.	5	.	13	10	.
Soil pH	8.61	8.55	8.59	8.46	8.46	8.63	8.47	8.56	8.34	8.49
Mineral components										
Clay	NB	B?	NB	NB	NB	NB	NB	B?	NB	NB
Quartz	P	P	P	P	P	P	P	P	P	P
Calcite	MP	MP	MP	MP	MP	MP	P	P	P	P

Phytolith concentration is expressed in phytoliths per gram of acid insoluble fraction (AIF). Starch concentration is expressed in grains per gram of original sediment

– sample not analysed, *NB* not burned, *B?* possibly burned, *P* present, *MP* marginally present

be due to (a) high soil alkalinity (e.g. Braadbaart et al. 2009; Cohen-Ofri et al. 2006; Schiegl et al. 1996), (b) the repetitive occurrence of water run-off during the heavy rains of the Indian Summer Monsoon that might have exposed the occupational surfaces or (c) anthropogenic factors such as trampling, re-working and cleaning episodes.

Table 5 Results of phytolith and starch analyses from grinding stones

	GS 1	GS 2	GS 3	GS 4a	GS 4b	GS 5	GS 6a	GS 6b	GS 7	GS 8	GS 9	GS 10	GS 11a	GS 11b	GS 12a	GS 12b	GS 13	GS 14	GS 15	GS 16	GS 17
Phytoliths																					
Single cells																					
Poaceae																					
Long cells																					
Leaf/culm	–	–	–	3	–	–	–	–	–	–	.	1	–	–	–	–	.	–	–	–	1
Undetermined	–	–	–	.	–	–	–	–	–	–	.	1	–	–	–	–	.	–	–	–	.
Bulliform (leaf)	–	–	–	3	–	–	–	–	–	–	.	1	–	–	–	–	.	–	–	–	1
Short cells											.						.				
Chloridoideae	–	–	–	1	–	–	–	–	–	–	.	.	–	–	–	–	.	–	–	–	2
Panicoideae	–	–	–	2	–	–	–	–	–	–	.	3	–	–	–	–	.	–	–	–	.
Pooideae	–	–	–	5	–	–	–	–	–	–	.	4	–	–	–	–	.	–	–	–	1
Undetermined	–	–	–	1	–	–	–	–	–	–	.	.	–	–	–	–	.	–	–	–	.
Dicotyledons	–	–	–	.	–	–	–	–	–	–	.	1	–	–	–	–	.	–	–	–	.
Undetermined taxa	–	–	–	6	–	–	–	–	–	–	.	5	–	–	–	–	1	–	–	–	11
Unidentified phytoliths	–	–	–	8	–	–	–	–	–	–	.	3	–	–	–	–	.	–	–	–	4
Total single cells	–	–	–	29	–	–	–	–	–	–	0	19	–	–	–	–	1	–	–	–	20
Phytolith concentration	–	–	–	588	–	–	–	–	–	–	0	973	–	–	–	–	141	–	–	–	1099
Starch grains																					
Fabaceae																					
Faboideae	.	1	.	.	1	2	2	.	.	.	1	.	.	2	2	1	2	.	1	.	6
Poaceae																					
Panicoideae																					
Type 1	1	.	1	.	.	.	8	.	.	.	1	.	.	.	.	1	1	99	.	.	13
Type 2	2	2	1	3	.	.	44	.	.	1	1	1	.	2	1	1	4	1	.	.	2
Type 3	.	1	.	.	.	1	.	2	.	2	.	.	.	1	.	1	.	.	.	1	.
cf Panicoideae	.	.	1	.	.	.	1	.	.	.	2	.	.	.	.	.	.	.	1	.	.
Pooideae																					
Triticeae	.	1	1	.	.	.	.	.	.	1	.	.	1	.	1	.	.	.	.	1	1
cf Triticeae (spherical)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	1
cf Triticeae (bell-shaped)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Zingiberaceae	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tuber undetermined 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Tuber undetermined 2	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Damaged unidentified	.	13	.	.	1	.	.	1	.	.	.	.	1	.	8	4	1	.	.	.	7
Total starch grains	3	18	4	3	3	3	56	3	.	4	5	1	2	5	13	9	9	100	2	2	31
Starch concentration	679	816	303	56	132	319	4079	294	.	134	773	46	375	263	220	277	1633	5817	61	289	2790

Phytolith concentration is expressed in phytoliths per gram of acid insoluble fraction (AIF). Starch concentration is expressed in grains per gram of original sediment

– sample not analysed

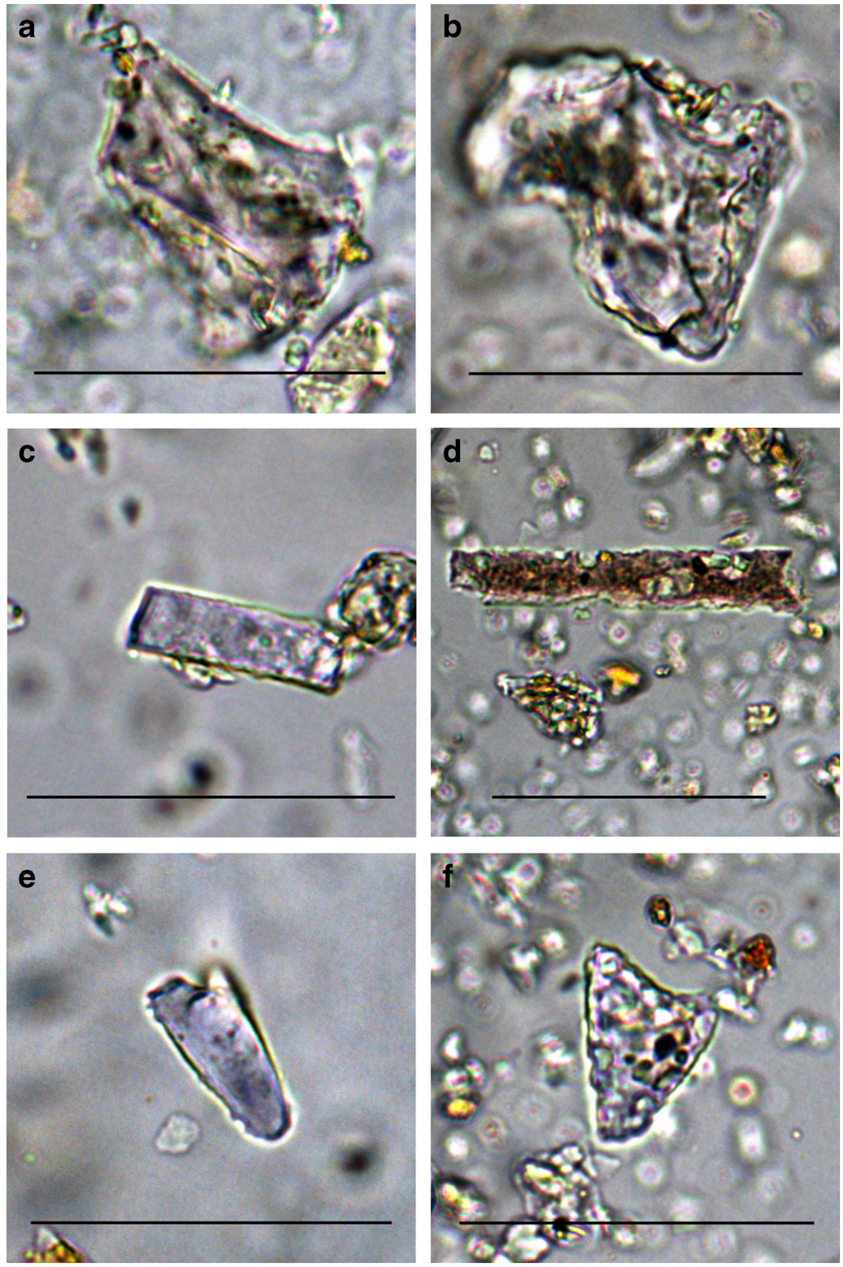

Fig. 3 Phytoliths recovered from Datrana IV: **a** bulliform cuneiform, **b** taphonomised bulliform cuneiform, **c** elongate psilate, **d** taphonomised elongate psilate, **e** trichome, **f** taphonomised trichome. *Scale bars* 50 μm

Phytoliths are mostly produced in non-edible plant parts and are therefore indicative of plant processing activities, mainly grasses (Harvey and Fuller 2005; Piperno 2006). Several post-depositional processes may affect the preservation of phytoliths (Madella and Lancelotti 2012 and references therein). In particular, soil alkalinity and burning may cause phytolith dissolution (Cabanes et al. 2011; Fraysse et al. 2006), although phytoliths have been recovered from highly alkaline soils and charred deposits (Piperno 2006). Phytoliths were very scarce at Datrana IV, and some of them presented signs of dissolution. A plausible cause of phytolith dissolution is the repetitive occurrence of monsoonal water run-off, particularly if the site was unoccupied for long periods of time. This possibility is suggested by the similarity of the mineralogical composition of a control sample from a nearby interdunal deposit (Balbo et al. 2014) with sample DTR 9, the top-most archaeological layer. This layer would be exposed for long periods of time, thus maximising the effect of post-depositional processes on plant remains. However, sediment alkalinity and water flow, and hence dissolution, cannot be considered as the only cause for the absence of phytoliths since phytoliths have been recovered from archaeological contexts in North Gujarat with equally alkaline soils (García-Granero et al. 2015b). Moreover, the presence of wood ash calcite in some of the samples attests for the good state of preservation of sediments, and therefore, the absence

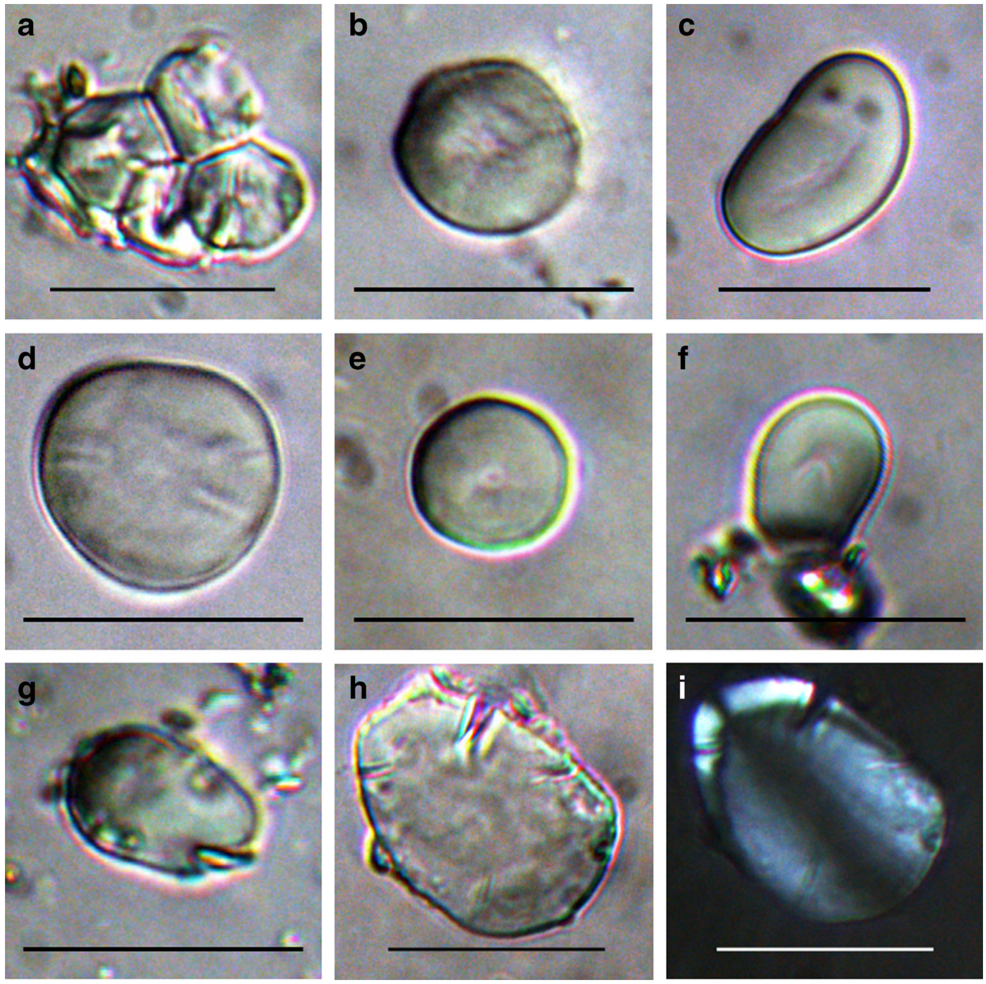

Fig. 4 Starch grains recovered from Datrana IV: **a** Panicoideae type 2 grains, **b** cf. Panicoideae grain, **c** Faboideae grain, **d** Triticeae grain, **e** cf. Triticeae (spherical) grain, **f** cf. Triticeae (bell-shaped) grain, **g** tuber undetermined 1 grain, **h**, **i** Zingiberaceae grain under transmitted (**h**) and cross-polarised light (**i**). *Scale bars* 20 μm

of phytoliths—particularly from the material clusters—cannot be solely explained as a result of post-depositional processes and must be interpreted in terms of past human activities. Thus, the scarcity of phytoliths suggests that non-edible plant parts were not being processed at Datrana IV. Another plausible explanation is that crop-processing activities took place in another area of the site, and the area excavated in 2010 was devoted exclusively to craft production.

The scarcity of phytoliths contrasts with the relative abundance of starch. Starch grains are mostly produced in edible plant parts, such as seeds, fruits and roots (Torrence 2006), and their presence in grinding tools indicates that they were used for grinding food. Starch grains are less resistant to taphonomic processes than phytoliths, and their presence further reinforces the hypothesis that the absence of phytoliths is the result of human practices. The relative abundance of starch grains in grinding tools and their scarcity in sediment samples can be explained by the preferential preservation of starch in artefacts (Haslam 2004).

Overall, the evidence from Datrana IV suggests that the inhabitants of this lithic workshop consumed mostly local summer crops such as small millets, the staple of contemporaneous food-producing communities in North Gujarat (García-Granero et al. 2015b). West Asian winter crops, probably cultivated in the Indus Valley, were also a marginal part of the diet. The scarcity of phytoliths from both summer and winter cereals indicates that either (a) crops were processed in other areas of the site or (b) they were not processed on site but acquired de-husked:

a) The development of cereal processing activities in a different area of the site is concomitant with a well-structured division of working space for diverse routine daily activities. The inhabitants of Datrana IV would engage not only on specialised craftsmanship but also on food production (third hypothetic scenario). Monsoon-adapted small millets could have been cultivated in the large interdunal depression adjacent to the dune, which is a naturally fertile ground due to water retention after the monsoonal rains (Conesa et al. 2014). It is worth highlighting that the area excavated in 2010 presented the highest concentration of surface lithic material, and it is thus possible that craftsmen and women worked in this area while other daily routines were carried out elsewhere. Archaebotanical samples from a larger area of the site should be analysed in order to understand possible spatial division of labour. Unfortunately, this is no longer possible because an extension of the Narmada canal in 2014 cut across the Datrana archaeological complex, completely destroying it (S.V. Rajesh pers. Comm.).

b) De-husked cereals are more prone to be affected by pests when stored for long periods of time (Bouby et al. 2005; Reddy, 1997), and therefore, food would have been acquired in a 'ready-to-consume' state. The acquisition of de-husked cereals fits with the second hypothetic scenario, in which only specialised craftsmen and women migrated from Sindh, and food was obtained through exchange with local hunter-gatherer and agro-pastoral groups. Plant foodstuffs could have been acquired from neighbouring millet-producing communities, such as the inhabitants of the Chalcolithic settlement of Loteshwar (ca. 3700–2200 cal BC). This model implies a high level of interaction between the inhabitants of Datrana and the native inhabitants of North Gujarat, a situation in which two communities would occupy the same ecological niche but different economic niches, carrying out complementary activities: food production and specialised craftsmanship. As a result of such interaction, crafts produced at Datrana IV (blades and stone beads) should appear in the archaeological record of contemporary occupations in North Gujarat. The archaeological record of the later fourth millennium BC in North Gujarat (and Gujarat in general) is, however, scant. Only two radiocarbon-dated sites fall into this chronology—Loteshwar in North Gujarat and Padri in the eastern Saurashtra coast—and the kind of crafts produced at Datrana IV were not encountered at either of them (Ajithprasad 2002, 2011). The only site with similar material culture (including pre-Prabhas pottery) is Somnath, in southern Saurashtra, which was radiocarbon dated to the early third millennium BC, suggesting a migration process from Datrana to Saurashtra.

At present, we lack enough evidence to favour one hypothesis over the other. Moreover, they are not mutually exclusive: plant foodstuffs could have been acquired through on-site production and also traded with local populations. In any case, it seems clear that the inhabitants of Datrana IV did not rely on winter cereals, characteristic of Sindh, and rather were integrated in local socioecological dynamics.

Datrana in a regional perspective

The archaeological record found at Datrana IV clearly advocates for its function as a specialised production centre. The workshop is located in the centre of the natural corridor between Sindh and Gujarat and near the Ranns of Kachchh, advocating for trade as the major purpose driving specialised production. However, chalcedony blades are seldom reported from Early Harappan sites in Sindh or Baluchistan (Pakistan) (Cleland 1977). Instead, chert from the Rohri hills was exploited from the very beginning of the Early Harappan period using the crested ridge technique (Biagi and Cremaschi 1991). The only exception to this are Kalibangan (Rajasthan, India), where the Early Harappan lithic industry incorporates local chert, chalcedony and jasper due to the inaccessibility of Rohri chert and the availability of local raw material in the region (Lal et al. 2003); and Kunal (Haryana, India), where microblade tools made of chalcedony were also reported in the Early Harappan desposits (Acharya 2008).

Carnelian beads, on the other hand, are found throughout the Indus Valley (Kenoyer 1991b; Law 2011), suggesting that Datrana may have functioned as a bead-production centre. However, a preliminary assessment of the beads produced at Datrana IV indicates that the technique employed for their production is somehow different than the technique used to produce the beads usually found in Harappan sites. Therefore, until an in-depth study of the bead-production technique is carried out, the presence of beads produced at Datrana IV beyond this site cannot be ascertained.

The lack of a clear distribution network suggests that the production was probably not controlled by ruling elites but by the craftsmen and women themselves (Shafer and Hester 1991). However, the final destination of such massive production (particularly of chalcedony blades) is currently unclear. Further studies are needed to fully understand the function of Datrana at a local and regional level. Future research needs to address the mineralogical origin of carnelian beads found throughout Indus Civilisation sites to test the hypothesis that the crafts produced at Datrana were part of interregional trade networks. Moreover, the study of faunal remains and residue analyses on pottery, both ongoing, will help to further understand the subsistence strategies developed by the inhabitants of Datrana IV and how they were integrated in the local socioecological dynamics.

Conclusions

Lithic tools were fundamental for most prehistoric societies, and thus, the exploitation of lithic resources was an important aspect of prehistoric land use and adaptation. The importance of lithic materials has long been acknowledged by archaeologists, who have studied several characteristics of the lithic technology—the use of different raw materials and quarrying techniques, the spatio-temporal spread of lithic tools, etc.—for over a century. However, research has often underestimated the impact of lithic workshops at a smaller (local) scale. This study highlights the integration of a lithic workshop within its surrounding cultural and natural landscape. Moreover, the evidence from Datrana IV highlights the need for taking into account the effect of taphonomic processes when interpreting archaeobotanical assemblages, as well as the benefits of a multi-proxy approach when studying past plant exploitation strategies. In this study, the integration of charred macroremains, phytoliths and starch grains helped overcome taphonomic biases, thus offering a broad picture of the food acquisition strategy at Datrana IV.

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