

# Archaeobotanical studies at Suabarei, Puri district, Odisha, India

Satish S. Naik<sup>1,\*</sup>, Jeeban Kumar Patnaik<sup>2,\*</sup>, Eleanor Kingwell-Banham<sup>3</sup>, Charlene Murphy<sup>3</sup> and Dorian Q. Fuller<sup>3</sup>

<sup>1</sup>Department of AIHC and Archaeology, Deccan College Post-Graduate and Research Institute, Deemed to be University, Pune 411 006, India

<sup>2</sup>Excavation Branch-IV, Archaeological Survey of India, Bhubaneswar 751 002, India

<sup>3</sup>UCL Institute of Archaeology, 31-34 Gordon Square, University College London, WC1H 0PY, UK

**This article presents the results of archaeobotanical analysis of charred plant remains from Suabarei, a Neolithic–Chalcolithic mounded settlement site situated in Puri district, Odisha, India. A single rice grain has provided a new radiocarbon date of 3370–3210 cal BP. Crops identified include rice (*Oryza sativa* cf. subsp. *indica*), horse gram (*Macrotyloma uniflorum*), green gram/mung bean (*Vigna radiata*) and possibly some millets, including browntop millet (*Brachiaria ramosa*). Suabarei is part of the agricultural mounded settlement group that existed during the Chalcolithic period of the eastern fertile plains of India and the data recovered from this site provide only the third complete archaeobotanical dataset for this cultural group.**

**Keywords:** Archaeobotanical analysis, charred plant remains, mounded settlement, rice millet.

SUABAREI is a mounded Neolithic–Chalcolithic settlement site situated in the lowlands of Puri district, Odisha, India (20°09'14"N, 85°48'33"E) (Figure 1). Excavations were carried out at the site in 2015–2016 under the supervision of Jeeban Kumar Patnaik (Archaeological Survey of India (ASI)). They revealed a 6 m deep sequence comprised of a short Neolithic phase, followed by a hiatus and a deep series (4–5 m) of Chalcolithic layers. Circular floor plans with central hearths were identified within the Chalcolithic layers; however, none was discovered in the Neolithic level (Figures 2 and 3). The range of finds recovered from the Neolithic material was low. Chalcolithic finds included a rich variety of decorated pottery types, bone points, copper rings and fish hooks, semi-precious stone beads, polished celts and stone fish net or loom weights<sup>1,2</sup>.

The fertile coastal plain of Odisha is drained by several important rivers and their tributaries, including the Daya River and the Gangua rivulet, providing an ideal environment for summer crops<sup>1,2</sup>. This area is dotted with mounded Neolithic–Chalcolithic settlement sites, dating between 4000 and 3000 yrs BP, generally located along

the edge of rivers, which have produced archaeobotanical evidence for rice and pulse agriculture. Previous sites excavated in this area include Golbai Sasan, Khameswaripalli, Gopalpur and Harirajpur (Figure 1)<sup>3–10</sup>. However, among all of these sites, Neolithic levels have only been uncovered at Golbai Sasan. Nevertheless, previous studies have shown that Neolithic–Chalcolithic people in Odisha were subsisting on a diet of wild ungulates and river fish, domestic sheep/goat and cattle<sup>11</sup>, domestic rice, pulses and, possibly, some cultivated millets<sup>10</sup>. There is also evidence that *Citrus* trees were being cultivated here before the end of the Chalcolithic period (3500–3000 BP)<sup>12</sup>. Joglekar and Patnaik<sup>11</sup> have provided preliminary data on the faunal remains from Chalcolithic Suabarei showing that cattle and goat were of primary importance at this site. Other important faunal species included freshwater fish and wild game from the grasslands and forests. This evidence shows that the people of Suabarei were exploiting their wider local environment in a variety of ways beside agriculture, from fishing to hunting forest animals, possibly with the assistance of dogs which have also been identified at this site. The present archaeobotanical study provides insights into the plant foods utilized at Suabarei, consolidating our knowledge of agriculture practised in Chalcolithic Odisha.

## Materials and methods

The archaeobotanical remains were collected from habitation deposits, following visual inspection during the course of the excavations. Six soil samples from trench A1/2, two from A2/1, one from A3/3 and three from A5/3 (20 kg each) were taken from the Chalcolithic levels, while one sample from trench A1/2 (80 kg) was taken from the Neolithic level. These samples were floated using bucket flotation to retrieve the carbonized and sili-cified plant remains using 0.25 mm mesh geological sieve. The plant remains were segregated and categorized under a low-power stereo microscope (WILD Heerbrugg M200) at the Palaeobotany Laboratory in Deccan College, Pune, India and photographs of each recorded taxa were taken. Most of the seeds/grains of crop plants, weedy taxa and fruit remains were found in a good state of

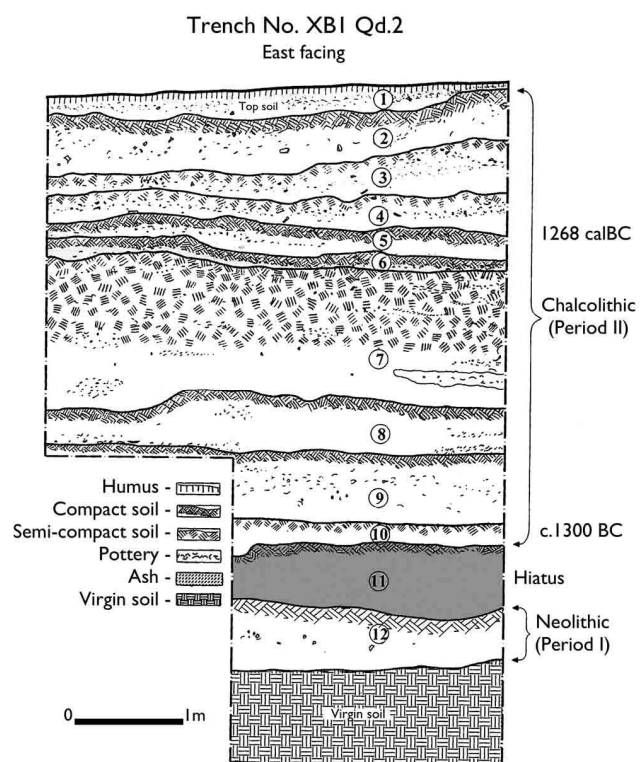
\*For correspondence. (e-mail: psatishnaik@gmail.com; jeeban84@gmail.com)



**Figure 1.** Map of Odisha, India showing the location of selected excavated mounded Neolithic–Chalcolithic sites (blue dots), Early historic settlements (purple dots) and Suabarei (red dot).



**Figure 2.** Archaeological site of Suabarei. *a*, General view showing the settlement mound with a tree on the top. *b*, Site view from the west. *c*, View of the trench A1. *d*, Section facing east after soil sampling.



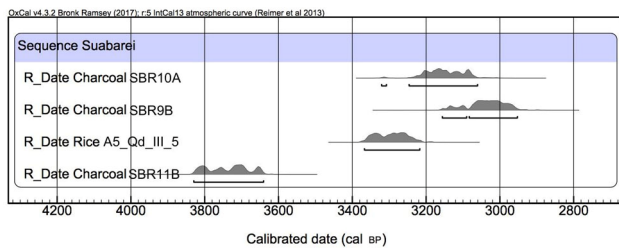
**Figure 3.** Stratigraphic sequence, trench XB1, quadrant 2. Sequence is the same across all trenches.

preservation. However, in a few cases severe carbonization prevented survival of diagnostic features. Grains and seeds were measured using a stage micrometer and an ocular disc. Identifications were made using the reference

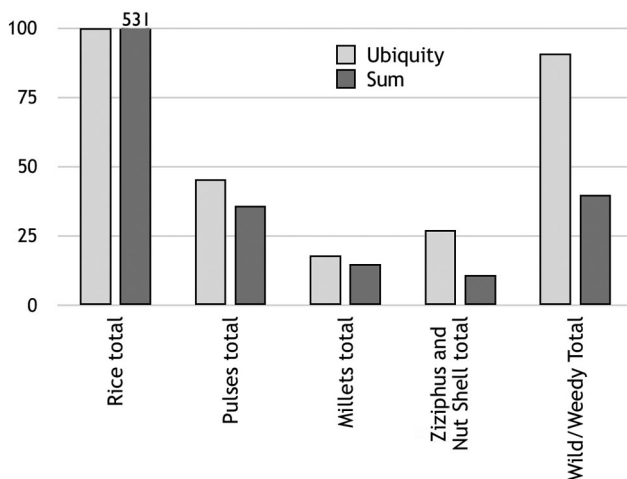
**Table 1.** Radiocarbon dates

Lab ID*	Stratigraphic position	Material	Delta <sup>13</sup> C	Date BP	Calibrated date (BP) 2σ	Median date (BP)
SUERC-73797	Chalcolithic; layer 5, 1.96–2.24 m	Charred rice ( <i>Oryza</i> sp.)	−26.3	3083 ± 29	3370–2950	3160
Beta-434597	Chalcolithic; layer 9, 3.45–3.6 m	Wood charcoal	−25.3	2900 ± 30	3160–2950	3055
Beta-434011	Chalcolithic, layer 10, below 3.65 m	Wood charcoal	−24.9	2980 ± 30	3321–3061	3191
Beta-434012	Neolithic; layer 11, 4.85–5.7 m	Wood charcoal	−26.4	3460 ± 30	3840–3640	3740

\*All radiocarbon dates were sent to SUERC or Beta Analytic. Standard pre-treatment methods were used (acid/alkaline washes). OxCal.v.4.3.2 and IntCal14 Bayesian sequence models were used.



**Figure 4.** Oxcal calibration of radiocarbon dates. OxCal.v.4.3.2 and IntCal14 Bayesian sequence model were used<sup>26–29</sup>.



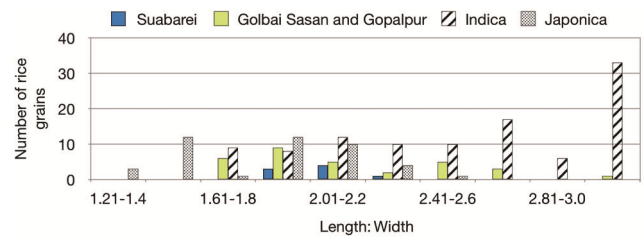
**Figure 5.** Ubiquity (%) and total sum of plant remains recovered.

collection housed at Deccan College, and relevant published material<sup>13–16</sup>.

## Results and discussion

### Radiocarbon dating

A charred cut rice grain from the Chalcolithic phase was sent for radiocarbon dating (SUERC-73797, UK) and returned a date of 3083 ± 29 (3370–3210 cal BP) (Table 1). Additionally, three bulk wood charcoal samples were sent for radiocarbon dates (Beta Analytic., USA). The sample from the Neolithic phase returned a date of 3840–3640 BP, while Chalcolithic phase wood charcoal samples



**Figure 6.** Length : width ratio of measured *Oryza sativa*, compared to published ratios by Castillo *et al.*<sup>18</sup> for *indica* and *japonica* subspecies, and combined data for Golbai Sasan and Gopalpur<sup>17</sup>.

returned a date of 3370–2950 BP. It therefore appears that there was a c. 500 year hiatus between the initial Neolithic settlement and subsequent Chalcolithic settlement (Figure 4).

### Archaeobotanical results

No macrobotanical remains were found from the Neolithic sample; however, several taxa were identified within the Chalcolithic samples (Table 2). Rice (*Oryza sativa* cf. subsp. *indica*) (Figure 5) showed its abundance, making up 90.74% of the total assemblage, suggesting that it was the principal crop at Suabarei. The length : width data for measurable rice grains (Figure 6) showed that limited data from Suabarei cannot be used to assign sub-species. However, considering these data in combination with those from Golbai Sasan and Gopalpur, Kingwell-Banham *et al.*<sup>17</sup> suggested that Chalcolithic rice in Odisha may have been a mixed population of *O. sativa japonica* and *O. sativa indica*. This is in agreement with metric and archaeogenetic data from the later early historic sites of Ter and Balathal, which also showed that mixed populations of *indica* and *japonica* rice were being grown at the sites<sup>18</sup>.

Description of the botanical remains is given below.

### Cereals

*Oryza sativa* L. (rice; Figure 7 a–g): These were recovered in the form of whole grains, fragmented grains, detached embryos, grain fragments with embryos, immature grains, immature grain fragments, immature grain

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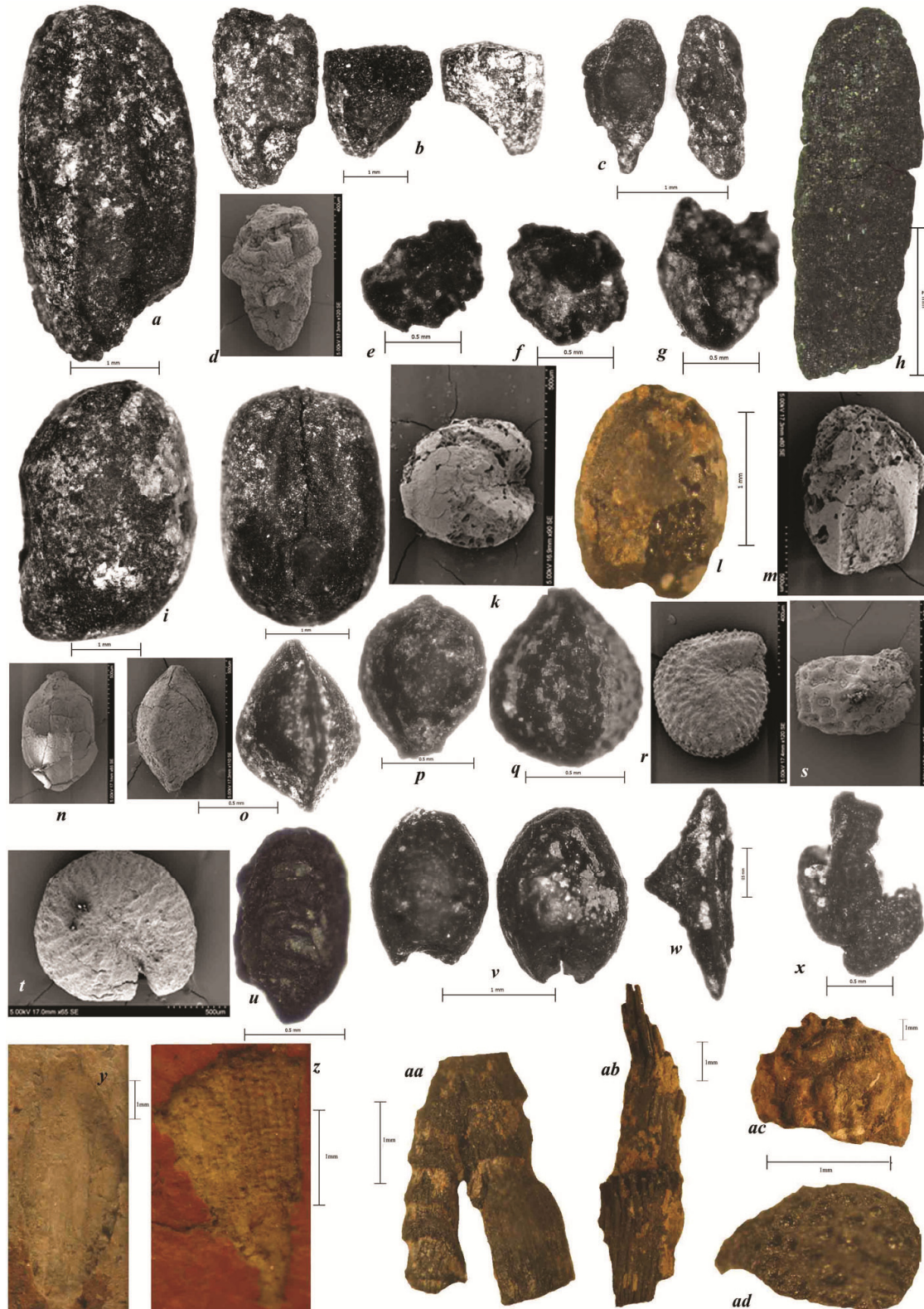
**Table 2.** Archaeobotanical remains

Trench/Quadrant/ stratum	Chalcolithic										Neo			
	A2/ 1/2	A2/ 1/2	A5/ 3/5	A5/ 3/5	A5/ 3/6	A3/ 3/6	A1/ 2/6	A1/ 2/7	A1/ 2/8	A1/ 2/9	A1/2/ 10	A1/2/ 11	A1/2/ 12	
Phase no. (depth, cm)	62	80	196 to 224	225 to 258	258 to 278	270	277			368 to 388	390	400	457 to 486	565 to 583
Number of litres	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Scientific name	Common name													
<b>Cereals</b>														
<i>Oryza sativa</i>		4	4	2	1	3	1	2		2				
<i>Oryza sativa</i>														
		5	1	1	10	45	4	27	16	256	12			
<i>Oryza sativa</i>						4								
<i>Oryza sativa</i>						5	3	1		10	1			
<i>Oryza sativa</i>						2	5	1						
<i>Oryza sativa</i>						37		44		6				
<i>Oryza sativa</i>						6	1	5		4				
<i>Oryza sativa</i>	4					2								
<i>Oryza</i> sp.						1								
<i>Oryza</i> sp.						1								
<i>Macrotyloma uniflorum</i>						1				1				
<i>Macrotyloma uniflorum</i>														
<i>Vigna radiata</i>						1		4	2	24	2			
<i>Brachiaria ramosa</i>	3								1					
<i>Digitaria</i> cf. <i>cruciata</i>						2								
<i>Echinochloa</i> sp.						8								
Nut shell indet.						6		3						
<i>Ziziphus</i> sp.					1	1								
<i>Cenchrus</i> cf. <i>ciliaris</i>										1				
<i>Cleome</i> cf. <i>gynandra</i>						1				1				
<i>Cyperus</i> sp.		1												
<i>Eleocharis</i> sp.		1												
<i>Eleusine indica</i>											2			
<i>Fimbristylis</i> sp.	1									1				
<i>Panicum</i> sp.					1	1				1	1			
<i>Oryza</i> cf. <i>rufipogon</i>			1	1				1				1		
<i>Oryza</i> cf. <i>rufipogon</i>						2		3		4	1			
<i>Oryza</i> cf. <i>rufipogon</i>									1					
<i>Rumex</i> sp.	1	1				1				1				
<i>Scirpus triqueter</i>						1				1				
Scrophulariaceae											1			
<i>Setaria</i> sp.											1			
<i>Silene conoidea</i>							1			1				
<i>Solanum</i> sp.	2													
Wood charcoal fragments				1				15		137	28	6	4	

fragments with embryos and spikelet bases of mature and immature rice grains. The whole rice grains were elongate to narrowly oblong, laterally flattened and prominently ribbed. Husk was noted on a few grains, but not quantified. Mature grains of *O. sativa* were measured

following the methodology of Castillo *et al.*<sup>18</sup> (Table 3, Figure 5).

*Oryza rufipogon* Griffith (wild rice; Figure 7 h): A wild weedy species of rice was occasionally harvested along with the cultivated crop. These were recovered in the



**Figure 7.** Archaeobotanical remains at Suabarei: **a–g**, Rice (*Oryza sativa* L.); **h**, Wild rice (*Oryza rufipogon* Griffith); **i**, Horsegram (*Macrotyloma uniflorum* (Lam.) Verdc); **j**, Greengram (*Vigna radiata* (L.) Wilczek); **k**, Browntop millet (*Brachiaria ramosa* (L.) Stapf.); **l**, Raishan millet (*Digitaria* cf. *cruciata* (Nees) A. Camus.); **m**, Barnyard millet (*Echinochloa* sp.); **n**, Anjan grass (*Cenchrus* cf. *ciliaris* L.); **o**, Knotweed (*Rumex* sp.); **p**, Spike sedge (*Elaeocharis* sp.); **q**, Club-rush (*Scirpus triquetus* L.); **r**, Catchfly (*Silene conoidea* L.); **s**, Scrophulariaceae; **t**, Spider flower (*Cleome* cf. *gynandra* L.); **u**, Indian goose-grass (*Eleusine indica* (L.) Gaertn.); **v**, *Panicum* sp.; **w**, Thorn, unidentifiable to species; **x**, *Solanum* sp.; **y, z**, Rice husk impression (*Oryza* cf. *sativa*); **aa**, Culm base of grass; **ab**, Culm node of grass; **ac**, Cut seed of *Zyzyphus* sp. (jujube), **ad**, Indeterminate seed.

**Table 3.** Measurements of charred rice (*Oryza* sp.)

Phase	Context	Depth (cm)	Length (cm)	Width (cm)	Breadth (cm)	L/W ratio
A1/Qd 2	Stratum 6	270	4.39	1.92	1.69	2.28
A1/Qd 2	Stratum 6	270	3.72	1.74	1.42	2.13
A1/Qd 2	Stratum 6	270	3.15	1.43	1.18	2.20
A1/Qd 2	Stratum 6	277	3.94	2.06	1.54	1.91
A1/Qd 2	Stratum 6	278	4.26	2.07	1.43	2.05
A1/Qd 2	Stratum 7	n/a	4.84	2.21	1.47	2.19
A1/Qd 2	Stratum 7	n/a	4.43	2.27	1.5	1.95
A1/Qd 2	Stratum 9	3.90	4.33	2.18	1.67	1.98
A1/Qd 2	Stratum 9	3.90	4.05	1.89	1.5	2.14

**Table 4.** Measurements of charred horse gram

Phase	Context	Depth (cm)	Length (cm)	Width (cm)	Breadth (cm)	L/W ratio
A1/Qd 2	Stratum 6	270	3.69	2.47	1.95	1.49
A1/Qd 2	Stratum 9	390	3.59	2.68	1.74	1.33

form of whole grains, fragmented grains and grain fragments with embryos (15 nos). The grains were comparatively more slender than cultivated rice, elongate to narrowly oblong and without husk.

### Pulses

*Macrotyloma uniflorum* (Lam.) Verdc. (horse gram; Figure 7i): These were ellipsoidal, somewhat kidney-shaped and laterally flattened, whole and fragmented seeds with smooth seed coats recovered from the Chalcolithic period. The complete horsegram seeds present in the assemblage were measured (Table 4)<sup>19</sup>.

*Vigna radiata* (L.) Wilczek (green gram/mung bean; Figure 7j): A single complete carbonized grain was recovered from layer 7 of Chalcolithic cultural level. The seed was elongated and somewhat cylindrical in appearance. It was characterized by squarish to rounded ends. A flat and elliptical hilum was situated at the level of seed-coat surface.

### Millet

*Brachiaria ramosa* (L.) Stapf. (browntop millet; Figure 7k): Three grains of browntop millet were recorded from layer 2. The seeds are broadly elliptic with a smooth-surfaced pericarp. The plant commonly occurs in wet places such as rice fields, along ditches and canals, and in marshes.

*Digitaria* cf. *cruciata* (Nees) A. Camus (Raishan millet; Figure 7l): Two complete grains of domesticated minor millet *Digitaria* were recovered from the Chalcolithic levels. The seeds were thin and pointed, with a small embryo. It is a rainfed crop and consumed mainly as a substitute for rice. The straw of Raishan is useful as fodder for cattle.

*Echinochloa* sp. (barnyard millet; Figure 7m): The grains were rounded, with a smooth surface and well-marked hilum scar. It is a type of wild grass usually found in waterlogged areas and as a weed in the paddy fields.

### Wild and weedy taxa

*Cenchrus* cf. *ciliaris* L. (anjan grass; Figure 7n): A charred single, ovate, hulled caryopsis with rugose surface.

*Rumex* sp. (knotweed; Figure 7o): Complete nutlets were recovered from different Chalcolithic levels. They were stalked and triangular in shape. The plants are commonly found in shallow fresh or brackish water; pools, marshy sites, along drains; lowland-irrigated and tidal rice fields, often abundant and gregarious.

*Eleocharis* sp. (spike sedge; Figure 7p): A few nutlets of spike sedge were recovered from layers 2 and 7. The nutlets were biconvex or plano-convex, smooth or faintly reticulate, triangular and compressed. These plants commonly occur in swamps, streams, rivers, ponds and lake margins.

*Scirpus triqueter* L. (club-rush; Figure 7q): The nutlets were trigonous with a reticulate surface, and were recovered from layers 6 and 9. These plants are commonly found in river banks, lakes and rice fields.

*Silene conoidea* L. (catchfly; Figure 7r): Two seeds of catchfly were recovered from layers 6 and 9. The seeds were very small and flattened with rounded margin. They had shiny and warty surface with distinct tubercles on the seed coat.

Scrophulariaceae (Figure 7s): A single carbonized seed, rectangular in shape, broadly pitted on all sides, was recovered from layer 7.

*Cleome* cf. *gynandra* L. (spider flower; Figure 7t): Two reniform seeds, compressed and conspicuously

tuberculoid, were recovered from layers 6 and 9. This is a weed of wastelands and cultivated fields.

*Eleusine indica* (L.) Gaertn. (Indian goose-grass; Figure 7u): Two seeds of goose-grass were documented from layer 10. They had distinctive undulations on the seed coat. It is a serious weed of rice crop.

*Panicum* sp. (Figure 7v): A few grains of wild *Panicum* sp. were recovered from layers 6 and 9. The grains were broadly elliptical. It is good fodder for cattle.

Thorn, unidentifiable to species (Figure 7w).

*Solanum* sp. (Figure 7x): A couple of seeds were noted from layer 2.

*Oryza* cf. *sativa* (rice husk impression; Figure 7y and z): Rice husk impressions were observed on many potsherds at the site<sup>1</sup>. The impressions were elongate to narrowly oblong, with prominent ribs across the lemma and palea<sup>1</sup>. Some impressions represented the typical chess-board pattern of rice husk on the potsherd.

Culm base of grass (Figure 7aa).

Culm node of grass (Figure 7ab).

### Fruits and nuts

*Ziziphus* sp. (jujube; Figure 7ac): Globose or somewhat oval fragmented stone. The stone pieces had tuberculoid patterning on the surface.

Indeterminate (Figure 7ad).

Pulses (horse gram and a single find of green gram/mung bean) made up 3.43% of the total assemblage (Figure 5). Horse gram (*M. uniflorum*) is a drought-resistant plant and a rich source of vegetable protein, with the highest calcium content among pulses<sup>19</sup>. Both of these pulses were reported by Harvey *et al.*<sup>20</sup> from the Neolithic–Chalcolithic site of Golbai Sasan, and horse gram was also identified at Chalcolithic Gopalpur.

Jujube (*Ziziphus* sp.) and unidentified nut shells (1.04% of the total assemblage) may have been eaten cooked or raw. These plants would have been available locally in wild state. The flesh of wild seeds is consumed and stone spitted out randomly, which grows as zarberi shrubs. Significant quantities of nut shell and fruit peel (unfortunately as yet unidentified to species), and *Citrus* sp. rind have previously been reported from Gopalpur, and this additional information from Suabarei adds to the implication that tree crops were important resources in Chalcolithic Odisha. Wild and weedy taxa represented 4.77% of the total assemblage (Figure 5). These included wild rice (*O. rufipogon*), barnyard millet (*Echinochloa* sp.), anjan grass (*Cenchrus* cf. *ciliaris*), knotweed (*Rumex* sp.), spike sedge (*Elaeocharis* sp.), club-rush (*S. triqueter*), catchfly (*S. conoidea*), Scrophulariaceae, spider flower (*Cleome* cf. *gynandra*), Indian goose-grass (*E. indica*), *Panicum* sp. and *Solanum* sp. All these are plausibly weeds of agricultural rice fields, but equally may have been incorporated into the assemblage as weeds of the settlement or natural background vegetation.

Three seeds of browntop millet (*B. ramosa*) were recovered from Suabarei. It has also been identified at Golbai Sasan, but again only in low numbers. It is unclear if browntop millet was a crop in Chalcolithic Odisha, or it represents a weed of rice. Based on the current low number of finds it seems more likely that it was a weed during this period. However, it is worth noting that browntop millet appears to have been an important staple food in Neolithic South India<sup>21</sup>. Although it is usually regarded as a weed, *B. ramosa* is still cultivated as a minor crop in some areas of southern India for both human and animal consumption<sup>21</sup>. Similarly, an edible form of *D. cruciata* (also identified in low numbers at Suabarei) is grown by the Khasi Hill tribals of Meghalaya for its grains<sup>22</sup>. According to Singh and Arora<sup>23</sup>, this crop is rainfed and cultivated by the hill tribes in a mixed cropping system with maize. As with browntop millet, this species is also a common agricultural weed.

All of the crops identified at Suabarei represent *kharif* summer crops without any traces of winter crops. This inference corresponds with the data from Golbai Sasan originally studied by Kajale and Sinha, which led to the identification of rice (*O. sativa*, *Oryza* sp.), impressions of rice husks on pottery and horse gram, etc. It also accords well with the data collected by Harvey<sup>24</sup>, and Kingwell-Banham *et al.*<sup>25</sup> from Golbai Sasan and Gopalpur. They suggested that either the summer monsoon rainfall was adequate enough during this period, as it is today, to allow for the production of rice that would provide food throughout the year (a system that would free up labour during the winter months for other activities, e.g. crafts or mining), or that two seasons of rice cropping were practised (*kharif*/summer and *rabi*/winter). As yet, no grain storage systems have been identified in Neolithic–Chalcolithic Odisha; however, the number of excavations is low and large-scale horizontal excavations that would uncover multiple structures within these villages have not yet been conducted.

### Conclusion

The archaeobotanical remains recovered from the stratified layers of four trenches belonging to the Chalcolithic phase show that the people of Chalcolithic Suabarei grew rice, protein-rich pulses like horse gram and green gram/mung bean, and also ate jujube fruits and nuts. While this archaeobotanical dataset is the source of limited information relating to food habits and ancient agricultural systems at this site, these findings represent the accumulation of knowledge on the plant-based subsistence of prehistoric Odisha.

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