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Pernil Alto: an agricultural village of the Middle Archaic Period in Southern Peru

der Reihe / of the series

Forschungen zur Archäologie Außereuropäischer Kulturen; Bd. 17

DOI: https://doi.org/10.34780/faak.v17i0.1000

Herausgebende Institution / Publisher:
Deutsches Archäologisches Institut

10 Botanical Remains

Macro-remains of numerous plants were detected and collected during the excavation.[19] The remains were given to Gabriela Bertone of the Museo Nacional de Historia Natural in Lima for analysis. Some basketry artifacts were also given for botanical analysis. The latter provided insight into the used materials. However, only some few specimens were analyzed in this way. The analysis of the material of the artifacts was difficult due to their processing and in many cases only resulted in the determination of plant classes and families. An exception were the remains of *Lagenaria siceraria* or bottle gourds, which were interpreted as the remains of calabash vessels. The respective results were incorporated into the results of Chapter 9.6. However, with the exception of bottle gourd remains, they are not included in this chapter.

The macro-remains of plants found at Pernil Alto weighed 1350.5 g in total. The remains included leaves, stems, fruits, flowers and seeds. Due to the varying states of preservation of the plant remains it was not possible to determine all remains to the same level. Thus, well preserved plant remains were determined as remains of 11 species, for less preserved plants it was only possible to determine 10 genera. Some of the latter ones could include some of the determined species. Less preserved plant remains were classified to seven families, one subfamily, one group, and one class. Even though it was possible to group the plant remains into 31 taxa, some remains were uncertain (denoted by cf.) in their determination. Table 43 lists the found taxa, their classification, number of remains, MNI, and weights.

10.1 Analyses of the macro-remains

One major aim of this research is the reconstruction of the subsistence of the inhabitants of Pernil Alto, thus the remains of non-edible plants and the non-edible parts of food plants are of secondary importance. Furthermore, the plant remains which were determined to only the family level have to be excluded here. It is indeed possible that remains of food plants are represented within these. However, the plant families are very large and even include numerous non-edible plants, so that the incorporation of those remains in an analysis of the food economy would make the results too speculative.

The edible plants found at Pernil Alto are listed in Table 44. The remaining plants, which are not discussed further, include remains which were not further determinable and those which were—even though determined—not edible. They include the genera of *cf. Paspalum, Gynerium* and *Typha* sp. as well as the species *Equisetum giganteum*, *Gynerium sagittatum* and *Tessaria integrifolia*. The last mentioned genera and species generally represent various grasses or reeds of the river valley and the riparian forest, and therefore most probably originated from the direct surroundings of Pernil Alto (see Chapter 4). They were of some importance for the production of basketry artifacts (see Chapter 9.5.1) and were probably also used as roof toppings of the dwellings (see Chapter 8). However, they were not relevant for subsistence in Pernil Alto and will therefore not be discussed further.

In contrast, the remains of food plants are important for an understanding of the subsistence economy. First, it is of interest which food plants were consumed at Pernil Alto. The single species and their archaeological development in the Central Andean preceramic subsistence will therefore be presented. The main question is, however, if the plant subsistence was based on cultivated or wild plants. Was collection or plant production the basis of subsistence? This will be analyzed in detail in Chapter 17. However, before proceeding it is important to understand if the plants indicated by the preserved remains would have been sufficient in their nutritional value, and if it would have been possible to cultivate them in the surroundings of Pernil Alto.

Later (Chapter 17.2) the question of chronological development in the ratios of wild and cultivated plants in Pernil Alto will be analyzed. Only the edible parts of the plants were included in these calculations. These include seeds, fruits, and roots of different plants. Stems

19 One box containing botanical material of Unit 5 of the campaign 2008 was stolen on the transport to the museum of Ica. Therefore, this material could not be included in the analyses, and information about the use of plants in this area of the site cannot be estimated.

taxon	classification	n remains	MNI	weight (g)
Canavalia sp.	genus	4	2	3
Canna indica	species	1	1	12
cf. Acacia	genus	4	4	2
cf. Acacia/Prosopis	cf. genus	1	1	2
cf. AGAVACEAE	subfamily	1	1	6
cf. *Cucurbita*	genus	2	1	1
cf. CYPERACEAE	family	44	44	13.5
cf. EUPHORBIACEAE	family	164	164	13.5
cf. FABACEAE	family	7	1	3
cf. *Gynerium*	genus	1	1	4
cf. LILIOPSIDA	class	2	1	0.5
cf. MAGNOLIOPSIDA	class	1	1	2
cf. *Paspalum* sp.	genus	5	5	43.5
cf. *Phragmites/Gynerium*	cf. genus	1	1	0.5
cf. SOLANACEAE	family	1	1	0.5
Cucurbita sp.	genus	124	103	10.5
CUCURBITACEAE	family	89	89	14
CYPERACEAE	family	1	1	3
Equisetum giganteum	species	7	3	16.5
FABACEAE	family	18	9	3
Gynerium sagittatum	species	17	7	31.5
Ipomoea batatas	species	79	51	204
Lagenaria siceraria	species	219	116	35.5
LILIOPSIDA	group	4	4	4
MAGNOLIOPSIDA	class	73	40	87.5
Pachyrhizus sp.	genus	32	9	14.5
Phaseolus cf. *lunatus*	cf. species	59	15	10.5
Phaseolus lunatus	species	535	302	225.5
Phaseolus sp.	genus	12	3	2
Phaseolus vulgaris	species	22	22	5,5
POACEAE	family	11	11	14
Prosopis pallida	species	5283	1287	418
Prosopis sp./*Acacia* sp.	cf. genus	14	14	2
Psidium guajava	species	4	4	4.5
Salix sp.	genus	7	5	28.5
Schinus molle	species	29	29	3
Tessaria integrifolia	species	5	4	16
Typha sp.	genus	19	7	39
ND		29	14	51
total		**6931**	**2378**	**1350.5**

Table 43: List of the found taxa of plant macro-remains of Pernil Alto.

and flowers are usually not edible and are therefore not further considered. The amount of edible plant parts found in Pernil Alto totals 916 g.

The found food plants can generally be divided into cultivated and wild plants. The use of cultivated or wild plants makes an important difference between a subsistence economy that can be characterized as foraging and one that can be characterized as horticultural. Therefore the range of cultivated plants in contrast to the range of wild plants is important.

10.2 Food plant remains

The recovered plant species, their amounts, presence, and absence during the settlement phases and an estimation of their state of cultivation are listed in Table 44. The given weights include only the edible parts of the plants which are, depending on the plant, seeds, fruits, or roots. Other plant parts such as stems are not included.

plant	weight (g.)	phase						state
		0	1	2	3	4	5	
cultivated								
Canavalia sp.	3			x		x		cultivated
Canna indica	12					x		wild/cultivated
cf. *Cucurbita*	1			x				nd
Cucurbita sp.	10.5	x	x	x	x	x		nd
Ipomoea batatas	204	x		x	x	x		cultivated
Pachyrhizus sp.	14.5	x		x	x	x		semi-wild
Phaseolus cf. lunatus	10.5	x	x		x	x		cultivated
Phaseolus lunatus	225.5	x	x	x	x	x		cultivated
Phaseolus sp.	2	x		x			x	nd
Phaseolus vulgaris	5.5			x	x	x		cultivated
Psidium guajava	4.5		x			x		cultivated
total	493							
collected								
Prosopis pallida	418	x	x	x	x	x	x	wild
Prosopis sp./*Acacia* sp.	2	x		x		x		wild
Schinus molle	3	x	x			x	x	wild
total	423							

Table 44: The amounts of the edible parts of food plants and their presence in the settlement phases.

The estimation of the state of cultivation was given by G. Bertone. All plants that she determined to be in a state of full plant domestication are defined as "cultivated" in the table. The state of the remaining plants listed in Table 44 in the "cultivated" section is botanically not that clear to determine (*Canna indica, Pachyrhizus* sp.). Nevertheless, all of these plants are typically cultivated plants and were found outside their supposed origin areas (compare Brücher 1989; Franke 1997; Lieberei/Reisdorff 2007). Furthermore, all plants which are listed in the category "cultivated," but are indeed not definitely determinable regarding this state were found in comparatively low quantities. This makes a more precise determination difficult. Given that they are plants typical for cultivation and were found together with numerous plant remains of definitely cultivated plants, it can be assumed that they were cultivated as well and can thus be included as indicators for horticulture.

The plant remains that were determined as *Phaseolus* sp. were so low in quantity in comparison with the remains of *P. lunatus* and *P. vulgaris* that it is likely that these remains actually represent remains of one or the other of those species. However, the parts that were analyzed were not distinct enough to include them as one of the two species. Therefore they are included in the category of cultivated plants.

Two important results can be derived from this first view of edible plant remains: First, the species of the cultivated plants clearly outnumber those of the wild plants. They include five species (*Canna indica, Ipomoea batatas, Phaseolus lunatus, Phaseolus vulgaris*, and *Psidium guajava*) and three genera (*Canavalia* sp., *Cucurbita* sp., and *Pachyrhizus* sp.). In a former publication (Gorbahn 2013), a questionable remain of maize was briefly mentioned, but during a subsequent review it turned out that this remain was not from maize but maybe from a reed plant of the river valley. In contrast, the wild plant remains originated from just two species (*Prosopis pallida* and *Schinus molle*) and maybe one other genus (*Acacia* sp.). The wider range of the cultivated plants is an indicator that inhabitants placed greater emphasis on cultivated plants.

Second, the pure amounts of the cultivated and wild plant remains differ from each other. The cultivated plants weighed 493 g, and wild plants weighed 423 g. Cultivated plants make up 53.82 % of the food plants, whereas the wild plants represent 46.18 %. This result indicates that cultivated plants were slightly more important than wild plants in the subsistence of Pernil Alto. Thus, horticulture was of a very high importance in the economy. However, at 46.18 % the wild plants still represent a very high amount in the used plants. Therefore the general plant use at Pernil Alto can be characterized as horticulture with strong supportive collecting.

The great majority of the plant remains originated from occupation layers (see Table 45). Over 75 % of the plant remains were recovered from those contexts. In contrast, the remains from other context categories are rather sparse. Only in the burials was a mentionable amount recovered, at 7.92 % of the total plant remains. This indicates that the vast majority of the recovered plant remains from Pernil Alto represent waste and can be interpreted as the remains of all-day food. The plant remains from the burials may indicate that some food was given to the buried individuals as grave goods. However, the plant remains are not of pure or special ritual use, but of quotidian use.

feature type	weight of edible plants	%
burials	72.5	7.92
dwellings	52.5	5.74
fireplaces	21.5	2.35
occupation layers	699.5	76.36
pit	6.5	0.71
post hole	5	0.55
post mark	2	0.22
special finding	14	1.53
storage pit	42.5	4.64
total	916	100

Table 45: Origins of edible plant parts from different feature types.

The various edible plants found at Pernil Alto have different nutritional values, need certain treatment, and have different archaeological developments. Therefore, the more important species will be individually analyzed.

10.2.1 Cultivated plants

Jack bean (*Canavalia* sp.)

Four fragments of *Canavalia* sp. remains, commonly known as jack bean, were recovered in a desiccated state from occupation layers at Pernil Alto (an example of an entire seed from the Initial Period remains is given in Figure 107e). All are remains of fruits of the plant and originated in Phases 2 and 4. Even though only the genus could be determined at Pernil Alto, Gabriela Bertone identified the remains as being from cultivated plants. Canavalia is a pantropical genus, including 50 species (Brücher 1989: 76). The most important domesticated species are *C. ensiformis* (Franke 1997: 140) and *C. plagiosperma*. The plants are 1–2 m high, climbing, annual bushes. They are self-pollinating or insect pollinated (Franke 1997: 140). The fruits are bent, up to 32 cm long and about 2.5 cm wide, flat pods which contain 12–18 large, white flat seeds (Franke 1997: 140).

The pods are usually harvested when they are half grown and cooked as a green vegetable (Salunkhe/Desai 1984: 150). The seeds are also consumed, but when dry and mature require extensive boiling (Salunkhe/Desai 1984: 151). This is because the plant—the pods as well as the seeds—contains high amounts of toxic Canavanin and Concanavalin A, which has to be reduced and destroyed by cooking (Franke 1997: 141). However, the plant is attractive for consumption because it contains high amounts of protein. Mature seeds of *C. ensiformis* contain 25.5 % protein, 10.7 % water and 50 % carbohydrates (Franke 1997: 134, Tab. 20). The intensive processing with boiling and a preferred use of immature fruits of *Canavalia* at present can be assumed as well for the use in the past. This could explain the low amount of *Canavalia* remains found at Pernil Alto. Even though cultivated and consumed, the fruits were most probably consumed more or less directly after harvesting and were not stored or dried. This could have resulted in few remains in general and a poor preservation of moist remains.

Canavalia is referred to as a robust and high-yielding plant which can grow under marginal conditions with depleted soils and unpredictable climates (Salunkhe/Desai 1984: 150). The cultivated forms are annuals (Brücher 1989: 77). The planting conditions include 14–27° C, 700–4200 mm of precipitation and poor soils are tolerated (Franke 1997: 141). It is planted at wide distances (Franke 1997: 141). It is possible that the planted *Canavalia* of Pernil Alto were grown in the same fields with other cultivated plants, but in lower density.

Canavalia ensiformis has its origin area in the tropical Americas (Franke 1997: 140). Pearsall (2008: 1825, Fig. 2) assumes that the area of origin of the domesticated jack bean is in the coastal area of Southern Ecuador and Northern Peru, which is the same origin area as cotton, lima bean, and squash. Her assumption is based on archaeological remains.

The hitherto oldest archaeological remains are from Real Alto of the Santa Elena Peninsula in coastal Southwestern Ecuador (Damp et al. 1981). These were carbonized remains, "probably of the domesticate *C. plagiosperma*" (Damp et al. 1981: 811), and were dated to about 5800 BP. Pearsall (2008: 1834, Tab. 6) puts the dating of the *Canavalia* remains from Real Alto to about 6500–4250 BP, based on a dating that was "estimated graphically" (Pearsall 2008: 1824). The oldest remains from the Peruvian coast are nearly the same age, dating to about 6500–4900 BP (in the "graphical estimation" of Pearsall 2008: 1834, Tab. 6), and originated from the site of Chilca 1 on the central Peruvian coast (Engel 1988a;

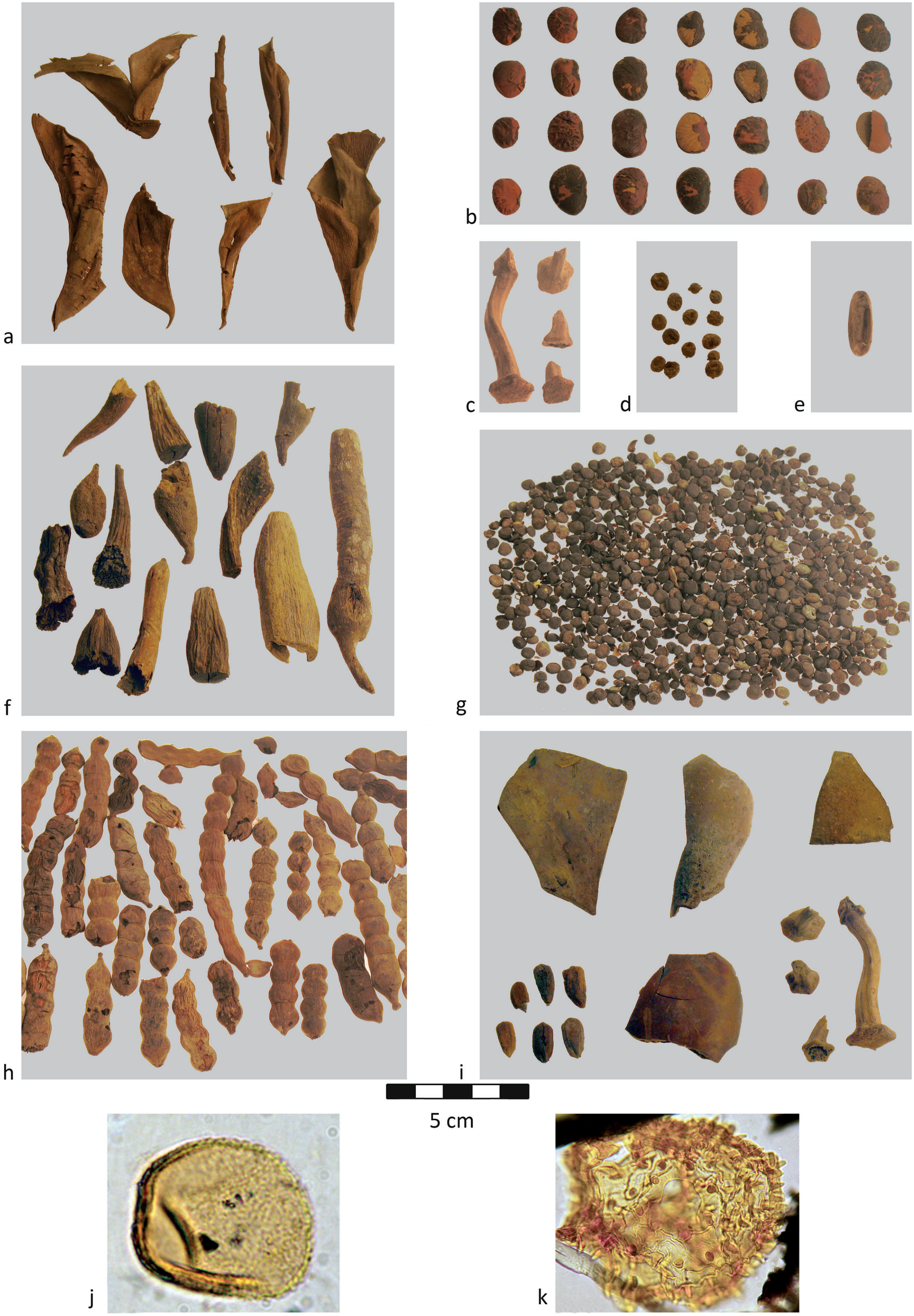

Figure 107: Photos of botanical remains. a: Remains of fruits of Lima beans (*Phaseolus lunatus*). b: Seeds of Lima beans (*Phaseolus lunatus*). c: Peduncles of squashes (*Cucurbita* sp.). d: Examples of seeds of Peruvian pepper (*Schinus molle*). e: Seed of jack bean (*Canavalia* sp.). f: Remains of sweet potatoes (*Ipomoea batatas*). g: Seeds of huarango (*Prosopis pallida*). h: Fruits of huarango (*Prosopis pallida*). i: Remains of bottle gourd (*Lagenaria siceraria*). j: Pollen of cf. Typha sp. (without scale). k: Pollen of Cucurbitaceae (without scale).

Jones 1988). Other old remains of *Canavalia* are from the site of Pampas on the central Peruvian coast, where they date to a Phase of about 4500–4300 BP (Cohen 1978: 119), and from the younger strata of the preceramic site of the Huaca Prieta dating to about 4500 BP (Bird/Hyslop 1985: 233). Remains of this plant are even known from the La Galgada site (*Canavalia* sp.), dating to about 4600–4000 BP (Grieder 1988; Smith 1988).

Thus, *Canavalia* most probably came under cultivation in Southwestern Ecuador as assumed by Pearsall (2008: 1825, Fig. 2) and was relatively quickly distributed southward to sites of the Peruvian coast. The remains of Pernil Alto fit into this distribution pattern and indicate that the Southern Peruvian coastal area was reached by about 5400 cal BP. *Canavalia* was probably not used in areas of slightly higher elevations as it was not identified among the preceramic plant remains of the Zaña valley in the western Andean slopes of Northern Peru (Piperno 2011a: 278), even though modern cultivated *Canavalia* can be grown in altitudes up to 1800 m (Franke 1997: 141).

However, *Canavalia* was apparently not of a high importance in preceramic subsistence in general, just as it was not at Pernil Alto. It was grown at Pernil Alto probably together with *Cucurbita* sp. and *Phaseolus* as it can be generally assumed for this plant (Brücher 1989: 77). Therefore it can be interpreted as a cultivated plant of secondary importance at Pernil Alto, where it was grown along with other plants. The lower importance could be due to the toxic contents and relatively high water requirements—even though some cultivars are resistant to droughts (Salunkhe/Desai 1984: 150). However, it has to be kept in mind that *Canavalia* was probably used as a cooked, or immature vegetable, which probably lead to poor preservation conditions. Therefore, the plant could be underrepresented in the total remains of Pernil Alto where it represents only 0.3 % of the weight of the food plants.

Edible canna (*Canna indica*)

One fragment of a root of *Canna indica* was found at Pernil Alto in an occupation layer of Phase 4. It was desiccated and had a weight of 12 g. The plant was fully domesticated and cultivated.

Canna indica, commonly known as edible canna is a plant that reaches a height of about 2 m (Lieberei/Reisdorff 2007: 102). The edible part of the plant is the root which contains very little protein (1 %), but a relatively high amount of starch (24 %) (Lieberei/Reisdorff 2007: 102).

Cut sprouts or parts of the rhizome are used for planting in wet and hot climates, but edible canna has low precipitation needs (Lieberei/Reisdorff 2007: 101). However, the soil needs to contain enough water and has to be loose (Lieberei/Reisdorff 2007: 101). Thus, the ancient river meandering directly south of Pernil Alto, which was probably wet during parts of the year, offered good growing conditions and planting can be assumed in this area. The plants grow for about 11 months until the roots can be harvested (Lieberei/Reisdorff 2007: 101).

An origin area of initial cultivation is assumed to be the eastern slopes of the Andes (Lieberei/Reisdorff 2007: 102) or the Northern Andes in Colombia (Piperno 2011a: 277, Fig. 14.1; 278).

Remains of domesticated *Canna* were found in coastal Peruvian sites such as Chilca 1 where they dated to about 5700-4400 BP (Engel 1988a; Pearsall 1992: 183, Tab. 9.6). By about 4700 BP the plant was a common finding in preceramic coastal sites and was recovered at Los Gavilanes, dating to 4700–4200 BP (Bonavia 1982: 150), the Huaca Prieta, dating to 4400–3200 BP (Bird/Hyslop 1985: 229, 233; Pearsall 1992), the Ancón-Chillón area (Cohen 1978: 110, Tab. 2), and Aspero (Feldman 1980) and La Galgada (Grieder 1988; Smith 1988) which are coastal sites with monumental architecture.

However, the plant was possibly also in higher altitudes, as indicated by remains of the plant at the preceramic sites of the Guitarrero Cave (Smith 1980: 96) in the North-central Peruvian highlands, and the Ayacucho area on the Southern Peruvian highlands (MacNeish et al. 1980). In the latter case, the remains date to about 5100 BP. The dating of the remains of the Guitarrero Cave is—due to the problems with the original and later revised dating (Kaplan/Lynch 1999)—not clear, but may be preceramic.

Pickersgill (2007: 927, Tab. 1) lists *Canna edulis* for the Andean region for the time shortly after 5000 BP. By about 2500 BP it is part of the general pattern of cultivated plants in the Peruvian North, North central, and central coast (Pearsall 1992: 178, Tab. 9.2).

Therefore, the plant was introduced to the Peruvian coast shortly before it was used also in Pernil Alto. The presence at Pernil Alto indicates a use of the plant in Southern Peru. However, the plant—even though cultivated—was of minor importance at Pernil Alto as the amount of the plant remains by weight represents only about 1 % of the edible plant remains. Nevertheless—as only the roots were edible—the plant could be underrepresented, given that moist roots are somewhat difficult to store and preserve poorly.

Squash (*Cucurbita* sp.)

A total of 124 remains of seeds of *Cucurbita* sp., commonly known as squash, have been recovered at Pernil Alto. These represent the remains of cultivated plants. The species, however, was not determinable. The remains have a total weight of 10.5 g. All recovered macro-remains were the remains of seeds (some peduncles found in remains of the Initial Period are depicted in Figure 107c as an example of the found genus).

Furthermore, one pollen of *Cucurbita* sp. was found in the pollen analyses (Chapter 10.5).

The majority of the remains (5.5 g) originated from Phase 0. Only 0.5 g of them were found in an occupation layer, while all other remains were found in the remains of dwelling 19. The remains of Phases 1–3 were few (2 g). In Phases 1 and 2 they were associated with burials. The remains of Phase 3 (0.5 g) were found in an occupation layer. The remains of Phase 4 (3 g) were all associated with occupation layers.

This temporal distribution seems to indicate that *Cucurbita* was relatively important during the beginning of the preceramic occupation, but lost its importance during Phases 1–3. However, it was still in use, possibly for traditional reasons. The higher amount of plant remains during Phase 4 could indicate a return to a prior cultigen. The absence of *Cucurbita* sp. remains in Phase 5 should not be given too much significance, as macro-remains of this phase were in general very sparse.

There are 20 known species of the genus *Cucurbita*, all from the Americas (Sauer 1993: 46). All modern domesticated and cultivated plants are vines (Simpson/Ogorzaly 1986: 113). Most of them are annual plants and usually native to riparian habitats (Sauer 1993: 46), which corresponds to the situation of Pernil Alto.

Modern squashes are usually used for their flesh, but the original use of wild forms was probably centered on the seeds, as the flesh of wild squashes is stringy and bitter (Piperno/Pearsall 1998). The seeds are rich in fat and protein (Sauer 1993: 46) and might have also provided vitamins and minerals (cf. Smith 1980: 108f.). The flesh of domesticated squashes is usually cooked and consumed (Sauer 1993: 50).

Three species of higher importance are known from the Americas: *Cucurbita ficifolia*, *C. maxima*, and *C. moschata*.

Cucurbita ficifolia is similar to watermelon in size, shape, and color (Sauer 1993: 50). It is adapted to the highlands and cultivated in cooler, Andean zones (Piperno/Pearsall 1998: 142). The wild progenitor is unknown but originates from "fairly high elevations in the Andes" (Sauer 1993: 50). Even mtDNA analyses could not identify the wild progenitor (Sanjur et al. 2002). However, as adapted to cooler and higher mountainous zones, *C. ficifolia* can be excluded as having been the squash cultigen at Pernil Alto.

Cucurbita maxima is, like *C. ficifolia*, adapted to cooler growing conditions in the Andean zones (Piperno/Pearsall 1998: 142). It was domesticated in South America (Simpson/Ogorzaly 1986: 114) from the wild progenitor *C. andreana* which grows today in the temperate areas of Argentina and the central lowland of Bolivia (Sanjur et al. 2002: 538). *C. maxima* is cultivated in the mid-elevations of the western Andes (Piperno/Pearsall 1998: 142). Thus, a form of *C. maxima* could have been a probable cultigen used at Pernil Alto.

Cucurbita moschata is another squash cultigen. It might have been domesticated in Central America (Simpson/Ogorzaly 1986: 114). It is distributed in humid lowlands of the Americas from Southern Mexico down to northern and southern South America (Sauer 1993: 49). It is adapted to high temperatures and humidity, but its wild progenitor remains unknown (Sanjur et al. 2002: 540). Its adaption to lowland conditions (Pickersgill 2007: 929) makes it as well a probable cultigen used at Pernil Alto. This assumption is supported by findings of this species in coastal preceramic sites in Peru, such as Los Gavilanes (Bonavia 1982: 149, Cuadro 10) and the Huaca Prieta (Bird/Hyslop 1985: 237). Though post-dating Pernil Alto, those sites have had comparable climatic conditions which indicate that the conditions were acceptable for *C. moschata*.

One further *Cucurbita* species should be mentioned: *C. ecuadorensis*. It is endemic to western Ecuador today (Sanjur et al. 2002: 538). Nevertheless, old findings of *C. ecuadorensis* demonstrate the early use of this plant in preceramic contexts.

Modern squashes are planted from the seeds (Simpson/Ogorzaly 1986: 113), which can be assumed as well for Pernil Alto. The cultivars are frost-sensitive, and demand warmth and sufficient water supply (Lieberei/Reisdorff 2007: 239). Overly wet conditions are not accepted by the plant (Piperno/Pearsall 1998: 142). Therefore, the habitat needs for cultivating squashes were fulfilled in the area of the river directly south of Pernil Alto. Recently used summer squashes—which were most probably the types used at Pernil Alto—are harvested when still immature (Salunkhe/Desai 1984: 81). But if storage was intended at Pernil Alto, a harvest of mature fruits has to be supposed, because good storage possibilities depend on intact, hard rinds (Simpson/Ogorzaly 1986: 114). Sauer (1993: 50) reports that *C. ficifolia* fruits can be stored for an entire year. However, given that the preservation conditions in Pernil Alto are very good, as indicated by the found root parts, and no rind parts of *Cucurbita* were identified among the macro-remains, a relatively quick consumption after harvest can be assumed.

Based on mtDNA analysis, Sanjur et al. (2002) investigated the genealogy of modern squash species. According to their results, all species were domesticated from individual progenitors. The origin of *C. maxima* is located in the temperate areas of Argentina and maybe the central Bolivian lowlands, but a later diffusion to Bolivia cannot be excluded. The origin of *C. moschata* is assumed to be the northern lowlands of South America. The area of origin of *C. ficifolia* is less clear, but based on archaeological information, the authors suppose a domestication area in South America (Sanjur et al. 2002: 537).

Even though the species used in preceramic Pernil Alto is unclear, the use of *Cucurbita* reflects the use of a domesticate which was in use in the Central Andes long before the occupation at Pernil Alto began.

Findings of phytoliths of *Cucurbita* in the preceramic Las Vegas culture in coastal Southwestern Ecuador indicate a very early use and domestication of this genus (Piperno 2011b; Piperno et al. 2000a; Piperno/Pearsall 1998; Piperno/Stothert 2003). Seeds or other macro-remains were however not preserved, and the pollen preservation was very poor (Piperno et al. 2000a: 200). The Las Vegas culture is subdivided into a pre-Las Vegas Phase (11,000–10,000 BP), Early Las Vegas (10,000–8000 BP) and Late Las Vegas (8000–6600 BP) (Stothert 1985). The local development is followed by a 1500 year hiatus (Stothert 1992: 45). The economy is characterized as a mixed broad-spectrum economy incorporating hunting, collecting, fishing, and plant cultivation (Stothert 1992: 45), but the latter was of only minor importance in subsistence. *Cucurbita ecuadorensis* is endemic to the area. Two *Cucurbita* phytoliths were detected in a pre-Las-Vegas stratum in the Las Vegas 80 site, which is interpreted as an indication of "some kind of exploitation of squash" (Piperno/Pearsall 1998: 187) that could have been still a wild form. However, due to further phytolith assemblages, including remains of *Cucurbita* with an increased size of the phytoliths, a domestication process is assumed for squash between about 9000 and 7000 BP in Las Vegas (Piperno et al. 2000a). In a later study another assemblage of *Cucurbita* phytoliths found in the Las Vegas 67 site was directly dated and delivered a very old dating. This lead to the interpretation that a local domestication process of *Cucurbita* had already started between 12,000 and 10,000 BP in Southwestern Ecuador (Piperno/Stothert 2003). But direct dating of phytoliths seems to be problematic and the dates can incorrectly appear very old, as Santos et al. (2012) have shown for dated grass phytoliths. However, the domestication process starting at about 9000 BP makes squashes very old domesticates in South America.

Even older phytolith evidence comes from Siches in coastal Northern Peru which was context-dated to about 10,500 BP (cf. Piperno 2011b: 459, Tab. 1). Early macro-remains of *Cucurbita* were found in the older strata of the Huaca Prieta on the Northcentral Peruvian coast, and were they dated to Phase I (9000–7500 BP) and interpreted as a minor food element (Dillehay et al. 2012b: Suppl.: 7). Thus the distribution of the plant towards the south was relatively quick. Macro-remains on the central Peruvian coast found at the site of La Paloma date to 7700–5000 BP (cf. Pearsall 1992: 183, Tab. 9.6). Other macro-remains of *Cucurbita* sp. were reported from the central Peruvian coastal site PV35-106 in the area of Huarmey, where they were context dated to 5750–4950 BP (Bonavia et al. 2001). Further findings are known from Chilca 1 on the central Peruvian coast, dating to 5700–4400 BP (cf. Pearsall 1992: 183, Tab. 9.6 referring to Jones 1988), the late preceramic site of Asia 1 in the same area (cf. Pearsall 1992: 183, Tab. 9.6), the site Los Gavilanes, dating to 4700–4200 BP (Bonavia 1982) and the late preceramic and already monumental site of Aspero dating to 4400–4000 BP (Feldman 1980).

But old remains of cultivated *Cucurbita* are also known in higher zones. Thus, two charred fragments of probable *Cucurbita moschata* found in preceramic contexts in the Zaña Valley in Northern Peru were directly dated to 10,403–10,163 and 8535–8342 BP (Dillehay et al. 2007: 1892) which makes them hitherto the oldest known macro-remains of domesticated squashes in the Central Andes. The use of squashes in the area of the Zaña Valley is further supported by findings of other macro-remains of the Las Pircas Phase (8500–7000 BP) (Rossen/Dillehay 1999) and the remains of starches of *Cucurbita* on human teeth from burials dating to about 8600 BP (Piperno/Dillehay 2008). It is possible that some of the macro-remains from the Zaña Valley do not represent cultivated species, as some findings from contemporaneous preceramic sites of the area were not determinable in their state of domestication and could in fact represent wild species (Nee and Andres in Rossen et al. 1996: 398). However, the Zaña Valley in Northern Peru shows definitely the oldest use of squashes in higher areas of the Central Andes and an early cultivation is very probable. Old squash remains of *Cucurbita* sp. were cultivated as well in the Southern Peruvian highlands in the area of Ayacucho, maybe as early as 7500–6300 BP during the Piki complex (MacNeish et al. 1980).

Squash obviously came in use and was domesticated long before the preceramic occupation at Pernil Alto began. The domestication of the plant happened in the northern or possibly eastern areas of South America, but according to archaeological information the plant was distributed to Southern Peru from the north. However, a distribution from Argentina over the Ayacucho basin to the area of Pernil Alto cannot securely be excluded. The plant was found in various preceramic sites and was established rather fast. It is one of the first and most important cultigens, but was apparently always of minor importance in comparison with other cultigens or foraging. Pernil Alto fits well into the distribution pattern of domesticated squashes, and a full domesticate was used and incorporated into the subsistence. However, as in other sites, squash was not of highest importance as the remains make up just about 1 % by weight of the food plant remains. However, it has to be taken in account that only seeds were recovered, which represent remains of relatively large and heavy fruits of which other parts were—maybe due to moist conditions—not preserved. Thus, the amount of the plant could be underrepresented at Pernil Alto.

Sweet potato (*Ipomoea batatas*)

The remains of *Ipomoea batatas*, commonly known as sweet potato, make up a high amount of the macro-remains of food plants found at Pernil Alto (Figure 107f). The remains recovered from Pernil Alto were determined as from fully domesticated and cultivated plants. A total of 79 remains with a complete weight of 204 g were recovered. All remains were desiccated root remains. The root is the edible part of sweet potato. The remains were found in contexts of Phases 0 (10 g), 2 (18 g), 3 (27 g), and 4 (149 g). The temporal distribution of the amount indicates the increasing importance of the plant, which possibly was strongest during Phase 4. The majority of the remains were associated with occupation layers (180 g). Only minor amounts were found in one dwelling (9 g), one burial (9 g), one storage pit (2 g) and one fireplace (3 g). The "internal" findings in a dwelling and a burial (18 g) were associated with Phases 0 and 2, respectively. This spatial distribution indicates that sweet potato was an everyday food which was probably consumed in a group or in public.

Sweet potatoes are trailing vines (Simpson/Ogorzaly 1986: 248). The roots, which are preferably consumed, contain 68–73 % water, 1–2 % protein, 0.3 % fat, and a relatively high ratio of carbohydrates of 25–28 % (Brücher 1989: 7). They are thus rather poor in protein, but generally have a high nutritional value due to the quantity of starch. Furthermore, they contain high amounts of potassium, vitamin A, calcium, phosphorus and iron (Vogel 1996: 231). Sweet potatoes can be consumed cooked or roasted, desiccated roots can be used to produce flour and starch, and alcoholic beverages can be made with fermentation (Lieberei/Reisdorff 2007). As the remains at Pernil Alto only showed fire impact in some exceptional cases (22 g), sweet potatoes were most probably not roasted, but prepared in some other manner. The processing of desiccated roots is furthermore very probable and indicated by the numerous mortars and groundstones found on the site. Sweet potatoes were thus in general a very important plant in the diet of the inhabitants because of their quantity, their carbohydrate value, and the amount of artifacts which possibly served for their processing.

Planting of sweet potatoes is done by tubers (Franke 1980: 337) or stem cuttings (Brücher 1989: 8). The plant needs an average temperature of 20–22° C, is very sensitive to cold, and dies with frost (Franke 1980: 335f.). The plant needs usually 850–900 mm (Lieberei/Reisdorff 2007: 85) or up to 750–1250 mm (Piperno/Pearsall 1998: 128) of precipitation, but lower precipitation with 500–1250 mm were also reported to be sufficient (cf. Franke 1980: 336). These precipitation rates were, according to the paleoclimatic reconstruction (Eitel et al. 2005), not reached during the preceramic occupation at Pernil Alto. However, more important is that the plants are sufficiently supplied with water during the first month after planting (Lieberei/Reisdorff 2007: 95, 338). Stagnant moisture and flooding are not accepted by the plant afterwards (Vogel 1996: 232). Thus, sweet potatoes are usually grown on dams or mounds in rainy regions for a better drainage (Sauer 1993: 38). In arid regions the plants can be irrigated (Sauer 1993: 38). In the situation of Pernil Alto, sweet potatoes could have been planted shortly after the end of the highest water flow of the Río Grande in the area of the river south of the site, when the soil there was still wet. It was possibly irrigated with a simple system, of which no information is known. Another possibility is that the sweet potatoes were planted on the edge of the river during the end of high water levels and that the soil stored enough moisture, or that the precipitation had its peak after the high waters, which seems less probable. Therefore, a simple irrigation of the plants is supposed. A system in the form of canals was not detected, but water could simply have been carried from the nearby river and poured on the plants. In any case, keeping in mind the high amount of remains, sweet potatoes must have been cultivated at Pernil Alto. The soil, which has to be moist, loose, nutrient-full, and permeable to water underground (Franke 1980: 335) was ideal on the edge of the river meander. Sweet potatoes are perennial in the tropics (Simpson/Ogorzaly 1986: 248) and can be planted and harvested year-round with just 3–4 months time until harvest (Sauer 1993: 38). Thus, two harvests were possible at Pernil Alto if a simple irrigation was used with the plants. The yields of sweet potatoes under actual conditions—which are distinctly more arid than during the preceramic occupation at Pernil Alto (compare Chapter 4.2.4) but include sophisticated irrigation systems—are of an average of 14,977 kg/ha (Gobierno Regional de Ica 2002). Under ideal conditions, yields of 35,000 kg/ha can be reached, but recently "native fields oscillate around 7000–

9000 kg/ha" (Brücher 1989: 8). Due to the simple technology used at Pernil Alto of simple digging sticks, an assumed simple irrigation by pouring water, and relatively low precipitation in contrast to the ideal needs of the plant, a yield of 7000–9000 kg/ha serves as a reasonable expectable yield of sweet potato at Pernil Alto.

The storage of sweet potato tubers is, in general, relatively problematic. The plant needs to be harvested carefully without injuring the flesh, and must be dried well after harvest (Franke 1980: 342; Piperno/Pearsall 1998: 128; Sauer 1993: 38). The poor suitability for storage is explained partly by the shorter dormancy period but some older varieties "still retain the trait of long dormancy and can be stored for many months if properly cured" (Sauer 1993: 38). Thus, in Pernil Alto—where older varieties can be expected—sweet potato tubers could have been stored for some months if kept dry and warm.

According to rDNA studies (Srisuwan et al. 2006), the wild progenitor of *Ipomoea batatas* is *I. trifida*. It is widely distributed in Mexico, Central America, Northern South America and the Caribbean (Piperno/Pearsall 1998: 127). Thus the area of Southern Central America and Northern South America is considered to be the domestication zone of sweet potato even though the origin area is not easy to determine (Piperno/Pearsall 1998: 163). The sweet potato cultivated in Oceania is, according to genetic studies, derived from the South American sweet potato (Roullier et al. 2013). Furthermore, the use of sweet potato in Oceania is younger than that in South America, and thus of no importance for this study.

Duccio Bonavia (1984) has critically reviewed the reports of early domesticated and cultivated sweet potatoes from the site of Tres Ventanas in the Chilca valley in Central Peru, which indicated a use of this plant as early as 8000 BP (Engel 1970a). The detailed and convincing review comes to the conclusion that the early datings of the sweet potatoes are not acceptable. Thus, the oldest known findings of cultivated sweet potatoes by now are from the Peruvian coast, where the plant seems to have been well established in sites from 4600 BP onwards (Bonavia 1984; Piperno/Pearsall 1998: 274ff.; Sauer 1993: 38; Ugent et al. 1982, 1984). Remains of *Ipomoea batatas* were found in more recent excavations on the Huaca Prieta on the Northern Peruvian coast (Dillehay et al. 2012b), but a detailed publication is still outstanding. At the moment, the group of plants to which *Ipomoea batatas* belongs is dated roughly to the Phases II to IV, but after 6500 BP (Dillehay et al. 2012b: 7 f. Suppl.), which would put the emergence of the plant on the site somewhere between 6500 and 3500 BP (Dillehay et al. 2012b: 63–65). As the remains from Pernil Alto were derived from a context as early as Phase 0, these remains represent the oldest known remains of cultivated *Ipomoea batatas* at the moment, dating to 5800 BP. The sweet potato findings are not exceptional at the site, but represent an important cultigen of the settlers which was strongly incorporated into subsistence and horticulture. The old dating of sweet potato from Southern Peru should not be overestimated. The domestication area was probably located in Northern South America, and Pearsall (1992: 194) pointed out that the lack of findings of sweet potato remains in the hearth area and the old findings of sweet potato on the Peruvian coast can be explained with better preservation conditions in this arid area. The domesticated *Ipomoea batatas* found at Pernil Alto were probably introduced via the same route as other domesticates from the north to Southern Peru. The lack of older remains in the areas north of Pernil Alto or Southern Peru is probably a result of worse preservation conditions for the plant, as sweet potatoes are tubers which decay relatively easy. What is notable then, are the distinctly good preservation conditions at Pernil Alto, rather than the representation of the earliest use of the plant. An older use of the plant on the Central and Northern Peruvian coast, as well as further north towards the origin area can be assumed. The date of 5800 BP represents therefore a *terminus ante quem* for the use of the plant in Peru rather than initial use. The detailed results from the excavations of the Huaca Prieta and a more precise dating of the beginning of sweet potato use on the Central Peruvian coast might give more insight into the development.

Interestingly, sweet potato was mentioned as one of the most important plants used in Prehispanic times for Southern Peru and Northern Chile (Sauer 1993). Thus, the use of this plant in the area was not only intense but began very early, indicating the good conditions for the plant there.

As mentioned, the remains of *Ipomoea batatas* are some of the most important used plants at Pernil Alto. Their weight represents 22.3 % of the total weight of the edible plants found at the site. Taking in account the poor preservation for tubers in general, and possibly problematic storage conditions which would have led to mostly direct consumption, the plant could even be underrepresented. The artifact assemblage presented in Chapter 9 was adequate for the planting, harvesting and processing of the plant with mortars, groundstones, and digging sticks. The high value of the plant at the site is most probably based on its caloric value and carbohydrate content. In later times the carbohydrate intake was fulfilled with the consumption of maize, a plant that was not yet in use at Pernil Alto. Thus, the sweet potato was probably the economic forerunner of maize in the subsistence in Southern Peru.

Lima bean (*Phaseolus lunatus*)

The remains of Lima beans (*Phaseolus lunatus*) represent, together with sweet potatoes, the most important cultivated food plants at Pernil Alto (Figure 107a–b). A total of 592 remains of Lima beans with a complete weight of 235.5 g were recovered in desiccated form. The remains were composed by 157.5 g of fruit remains and 78 g of seed remains. A few remains (9.5 g of the fruits; 0.5 g of the seeds) were less secure in their determination and identified as *Phaseolus* cf. *lunatus*. They are, however, included into this account.

The remains of Lima beans were recovered from contexts of Phases 0–4. However, the amounts fluctuated. 16.5 g were from Phase 0, 4 g from Phase 1, 71.5 g from Phase 2, 26 g from Phase 3, and 118 g from Phase 4. No remains were recovered from Phase 5, but the remains from this Phase are few in general. It seems that Lima beans increased in importance with a climax in Phase 4. The reason for the relatively low amount in Phase 3 is not clear. The majority of the remains (149 g) were recovered from occupation layers, indicating an all-day processing and consumption by inhabitants in the public. Another relatively large amount (39 g) was found in burials, but the largest part were found within one single burial of Phase 2, indicating that Lima beans were not very important as a general offering in burials. Furthermore, the remains originated from burial 29, which is a single burial of a partly mummified young individual (see Chapter 8), and is therefore an exceptional grave. Therefore the high amount of Lima beans found reflects a very special treatment of one individual rather than a general burial rite. The relatively high amount (20.5 g) of remains recovered from storage pits indicates that the edible parts of the plant were stored as well for later consumption. This is important information for the estimation of the state of sedentariness vs. mobility. The other remains were found in lower amounts inside of dwellings (9.5 g), fireplaces (8 g), and a special finding of Phase 2 (10 g).

Lima beans are found in many varieties, as annual and perennial biotypes (Brücher 1989: 92). However, the Lima bean is, with the exception of some modern cultivars, usually perennial (Hernández Bermejo/León 1994: 55). The plants are self-pollinating and grow fruits with 12 cm long and 3 cm wide pods which contain 3–5 seeds (Vogel 1996: 662). Shrubby and climbing variants are known (Franke 1997: 135). The variety which was used at Pernil Alto is not known given that only fruits and seeds were recovered, but the plants were fully domesticated and cultivated.

Lima beans are legumes and are particularly rich in protein. Modern immature pods are edible and contain 66 % water, 8 % protein, 23 % carbohydrate, and 0.7 % fat (Brücher 1989: 93). Modern dried mature seeds contain 11.5 % water, 20.6 % protein, 1.4 % fat, 45 % carbohydrate, and 3.7 % raw fiber (Lieberei/Reisdorff 2007: 122, Tab. 4.8). Thus, the plant is rich in protein especially after drying. Although lima beans contain toxic components of linamarin or phaseolunatin which have to be destroyed by intensive soaking and cooking (Franke 1997: 135; Piperno/Pearsall 1998: 138; Vogel 1996: 662; Hernández Bermejo/León 1994: 54), they are more easily digested than common beans (*Phaseolus vulgaris*) (Vogel 1996: 663). Wild Lima beans contain a very high amount of 1500 ppm of linamarin in contrast to cultivated ones which contain just 200 ppm (Piperno/Pearsall 1998: 138). The immature fruits and seeds are consumed as a cooked vegetable and the mature hard seeds are a staple food in some countries in modern times (Vogel 1996: 663). This fits well with the distribution of the remains at Pernil Alto, where a large part of the plant was found within occupation layers. This indicates that seeds and fruits were consumed on the site, however another amount was recovered from storage pits, of which mostly seeds were recovered. Thus the plant was consumed, but the possibility to store it in comparison to sweet potatoes was also important on the site. This was likely to cover times of scarcity rather than to bypass seasons without available resources, as those hardly existed in the middle Holocene circumstances in Southern Peru.

Lima beans are not frost resistant and need temperatures well above 15.6 °C for germination (Salunkhe/Desai 1984: 143). The plant has no special needs for soil conditions, but favors dry climates and deep soils (Hernández Bermejo/León 1994: 57). It is sensitive to compacted earth after strong rainfall, in which case loosening of the ground is recommended (Vogel 1996: 665). The plants can stay wetter conditions than garden beans, but in turn need drier weather for the seed maturation (Piperno/Pearsall 1998: 138). Today they are planted in altitudes between 50 and 2750 m in Peru (Hernández Bermejo/León 1994: 55). The beans were frequently planted in coastal Peru on banks of mountain streams, where the floodwater was absorbed (Hernández Bermejo/León 1994: 55). Thus, the planting conditions for Lima beans were ideal at Pernil Alto. The climate was dry enough and the river meander south of the site offered perfect soil, and was watered by flood waters. Therefore, an early planting technique such as this can be assumed for the Lima bean planting at Pernil Alto. Earliest genotypes flower 35 days after planting and are ripe after about 100 days (Hernández Bermejo/León 1994: 57). Healthy plants continuously build pods, thus a harvest over several weeks is possible (Vogel 1996: 665). The yield of the shrubby variants of Lima beans are about 2000 kg/ha, and about 3000 kg/ha for the climbing species (Hernández Bermejo/León 1994: 58). Today, shrubby varieties are preferred in the working area and can be assumed as well for Pernil Alto. The actual yield of Lima beans in the working area is 1611 kg/ha (Gobierno Regional de Ica 2002). Because of the ideal conditions for the plant at Pernil Alto and the relatively high amount of remains of the plant in the record, a high yield of Lima beans can be assumed during the Archaic occupation of the site.

There are two accepted domestication areas for *Phaseolus lunatus*: one in Mesoamerica where the domesticated smaller form is commonly known as the Sieva bean, and another one where the form is larger and called the Lima bean. The two areas where independent domestications took place are proven by studies of the distribution of seed proteins and chloroplast DNA in domesticated and wild forms (Fofana et al. 2001; Gutiérrez Salgado et al. 1995; Lioi 1996; Lioi et al. 1999). The variant of *Phaseolus lunatus* of Pernil Alto is the Lima bean. The domestication area of the Lima bean is defined to have been on the western slopes of the Andes in Southern Ecuador and Northern Peru (Fofana et al. 2001; Gutiérrez Salgado et al. 1995; Lioi 1996). Thus, the introduction of Lima bean to the arid Peruvian coast was from the north, and probably not from the east as previously assumed (Pickersgill 1969). However, some bias in the origin studies is not excludable given that better conditions of preservation are found on the western Andean slopes and the tested wild forms could represent hybrids from cultivated and wild forms (Piperno/Pearsall 1998: 138). However, according to the data the origin zone of the large-sized Lima bean is located in Ecuador and Northern Peru, where the wild form is distributed in altitudes from 320–2030 m (Hernández Bermejo/León 1994: 57). Because the toxic content only concentrates in the seeds, the pods of wild Lima beans are edible when still immature and no seeds have developed (Piperno/Pearsall 1998: 139).

It was long presumed that the domestication or earliest planting of Lima beans took place in the Central Andean highlands, as remains of domesticated and cultivated *Phaseolus lunatus* recovered in Complex II of the Guitarrero Cave in the Callejón de Huaylas were context dated to about 10,500–7500 BP (Kaplan et al. 1973; Kaplan 1980; Lynch 1980b; Lynch et al. 1985; Smith 1980). In a later study, Kaplan and Lynch (1999) directly dated the remains of the beans using the more modern AMS technique. Two *Phaseolus lunatus* remains were dated by this method and delivered dates of 3830–3700 and 3620–3470 calBP (Kaplan/Lynch 1999: 265). Other bean remains of *Phaseolus vulgaris* found together with the Lima bean also returned young dates, bringing the authors to conclude that "It may be that all of the beans in Complex II were introduced into that stratum as a result of disturbance and intrusion from the Late Preceramic, Initial Ceramic and Early Horizon Periods" (Kaplan/Lynch 1999: 269). Thus, even if sometimes used as an indication of an early use of domesticated Lima beans in the Central Andean highlands (e.g. Pearsall 2008: 1834, Tab. 6), the remains from the Guitarrero Cave do not help in understanding the early use and domestication of the plant, because other known remains are far older.

Another old use of domesticated Lima beans is proposed for the Zaña valley in Northern Peru (Piperno/Dillehay 2008). Starch grains from the teeth of buried individuals from several sites, dating to 9000–7500 calBP, were analyzed. The result was that a large portion of the apparent starch grains were of Lima beans. However, it was not possible to determine if the starch grains originated from domesticated or wild Lima beans. The authors argue that the sites from which the samples were taken lie in altitudes of 500 m, but that wild Lima beans would be distributed today in the Zaña valley between 1800 and 3000 m which "strongly suggest[s] that the starch grains represent cultivars" (Piperno/Dillehay 2008: 19,623). However, this interpretation is problematic for the following reasons: First, the natural distribution of wild Lima beans is between 320 and 2030 m (Hernández Bermejo/León 1994: 57), therefore a distribution of wild Lima beans would have been possible in the area of the sites. Second, the Zaña valley is well situated in the proposed origin area of wild Lima beans in Southern Ecuador and Northern Peru. Third, the climatic conditions of today are assumed to be the same as the climatic conditions of the Archaic Period in the area, while they could have been different. Fourth, even if the climatic conditions of the past were the same as of today and wild Lima beans were not distributed in altitudes of 500 m, the geographic distance to altitudes of above 1800 m is very short and could have been easily reached to collect or consume wild Lima beans. Fifth, wild Lima beans are edible in a certain development stage (Piperno/Pearsall 1998: 139). Sixth, no macro-remains of Lima beans were recovered from the Las Pircas Phase (9800–7800 BP) and Tierra Blanca Phase (7800–5000 BP) sites of the Zaña valley (Rossen 2011b: 184). For these reasons, the interpretation that the starch grains indicate an early use of domesticated and cultivated Lima beans has to be rejected. There is no doubt that Lima beans in the Zaña valley were consumed, however the plants were probably wild Lima beans, as those were probably distributed there or could have been reached easily. The results thus indicate an early concentration on a later domesticated species rather than their actual domestication.

Some remains of Lima beans were recovered in recent excavations at the Huaca Prieta on the Northern Peruvian Coast, where they were derived from stratums dating to 9000–7500 BP (Dillehay et al. 2012b: Suppl.: 7). Even though the domestication status is not yet discussed, these remains could represent the oldest secure findings of domesticated and cultivated Lima beans in South America, as the site is located outside the natural distribution of wild Lima beans. So far only summary results have been published, but would indicate a *terminus ante quem* for the domestication of Lima beans in Southern Ecuador and Northern Peru at not less than 7500 years BP. However, cultivated plants from the Huaca Prieta played a minor role in subsistence (Dillehay et al. 2012b: Suppl.: 7).

The second–oldest known remains of domesticated *Phaseolus lunatus* are from the site of Chilca 1 on the Central Peruvian Coast (Engel 1988a). A pod of a domesticated Lima bean was directly dated and an age of 6440–6310 cal BP resulted (Kaplan/Lynch 1999: 266, Tab. 1). However, marine resources at Chilca 1 were the most important source of protein for alimentation (Engel 1987a: 54). A little bit younger are the remains of domesticated *Phaseolus lunatus* which were reported for preceramic sites located on the estuary of the Rio Ica in Southern Peru and were directly dated to 6270–5996 BP cal BP (Beresford-Jones et al. 2015: 201).

The next younger known remains of domesticated and cultivated *Phaseolus lunatus* are known from Pernil Alto. They appear already in Phase 0, thus giving a *terminus ante quem* for the appearance of the plant in Southern Peru before 5800 cal BP. A Lima bean from burial 29 (Feature 4042) directly dated via AMS-dating resulted in an age of 4521 ± 24 radiocarbon years BP or 5268–5036 cal BP (MAMS-12417), and is thus the third oldest directly dated Lima bean after the one from the Rio Ica estuary.

These early findings of Lima beans support a southward distribution from Southern Ecuador/Northern Peru. The domestication took place somewhat before 9000–7500 cal BP in the origin area. The plant was then distributed following the Peruvian coast southward, reaching the Northern Peruvian coast by 9000–7500 cal BP, the Central Peruvian coast by 6500 BP, and the Southern Peruvian coast by 6200 cal BP. Even though common beans were recovered, Lima beans are not known to be part of the preceramic sequence of the Ayachuco basin in the Southern Peruvian highlands (MacNeish 1992: 62, Tab. 2.3). Therefore a central or southern Andean origin of this species, as was assumed before (Pearsall 1992: 195), is not supported by the data.

Interestingly, it appears that Lima beans were cultivated very early on the Peruvian Northern and Central coast, but that the primary source of protein was still based in marine resources (Dillehay et al. 2012b: Suppl.: 7; Engel 1987a: 54). This situation was different at Pernil Alto and will be discussed later.

Legumes like Lima beans make up a significant portion of the dietary protein consumed in the Andes (Pickersgill 2007: 929). This was probably already the case at Pernil Alto, where the remains of Lima beans made up 25.7 % of the weight of all food plants. It seems that Lima beans were cultivated as a source of protein, whereas the carbohydrate intake was derived from sweet potatoes.

Common bean (*Phaseolus vulgaris*)

A few remains of common beans (*Phaseolus vulgaris*) were recovered at Pernil Alto. The 21 remains had a total weight of 5 g. With the exception of the remains of one fruit with a weight of 1 g, all remains were from seeds. They were recovered from contexts of Phases 2–4. The majority (3 g) originated from Phase 4, whereas from Phases 2 and 3 only 1 g each was found. None of the remains were recovered from burials. One remain (0.5 g) originated from a pit of Phase 2, another (0.5 g) from a fireplace of Phase 4. All other remains were associated with occupation layers.

Common beans are very multi-variant (cf. Simpson/Ogorzaly 1986: 201) and have in general, like Lima beans, a high protein content which is 21.3 % in dried mature seeds (Lieberei/Reisdorff 2007: 122). The consumable parts are green pods, shell beans, and dry mature seeds (Gepts 2001: 1444), and the plant contains the toxic glycoside phasein which has to be destroyed by cooking (Vogel 1996: 640). Common beans are usually vines, the bush forms are recent selections (Simpson/Ogorzaly 1986: 202). Common beans are therefore often planted together with maize, as the plants need support. The needs for temperature and soil conditions are comparable to those of Lima beans, but it seems that common beans are more vulnerable to illness and pest infestation (cf. Vogel 1996: 638–650). It could be that due to this need for support and higher vulnerability that common beans played a minor role in comparison to Lima beans, which are easier to cultivate without support and less vulnerable. Another reason could be that they might have been more difficult to store than Lima beans (cf. Vogel 1996: 652) and were thus were consumed directly, leading to less preservation at Pernil Alto.

Again, there are two areas of origin for this *Phaseolus* species in Mesoamerica and South America which have been proven by various studies (see Papa et al. 2006). The wild progenitor of both domesticates is located in Southern Ecuador and Northern Peru (Gepts 2001; Papa et al. 2006). However, the domestication areas of common beans are located in the north from Mexico to Colombia and in the south from Southern Peru to Northwestern Argentina (cf. Papa et al. 2006; Piperno 2011a: 277, Fig. 14.1, area D5).

The remains of domesticated common beans recovered in the Guitarrero cave were similar to the Lima beans, according to newer direct AMS dating of a younger age than previously thought (Kaplan et al. 1973; Kaplan 1980; Lynch 1980b; Lynch et al. 1985; Smith 1980). However, they were distinctly older than the Lima beans and dated to about 5000 BP (Kaplan/Lynch 1999: 265, Tab. 1). This old date suggests a very early use of domesticated common beans in the Andean highlands, which is however younger than the coast. There, the oldest known remains were found during recent excavations at the Huaca Prieta on the Northern Peruvian coast where they were introduced after 6500 BP (Dillehay et al. 2012b: 7 f. Suppl.). With the available information it seems that common beans only played a minor role in subsistence (Dillehay et al. 2012b: 8, Suppl.). The oldest remains of common beans in Southern Peru were found in the Pikimachay cave in the Ayachuco basin at an altitude of 2850 m (MacNeish 1981a). One single "round, white *Phaseolus lunatus* bean" was recovered from zone (layer) VIII in the north room of the cave which was dated to 6050 to 5050 BP (MacNeish/Vierra 1983b: 158). Taking this date as a secure dating of introduction or the beginning of planting and use of common beans in the highland Ayacucho basin is nevertheless problematic: the layer was found with intrusions and numerous remains of rodents, which were interpreted as having been intrusive (MacNeish 1981a: 39; MacNeish/Vierra 1983b: 158). This makes bio-intubation of the single found remain of common bean very likely; a situation comparable to that of the bean remains in the Guitarrero cave. Furthermore, the remains were dated to the Chihua phase of the chronology established for the Ayacucho basin (MacNeish 1981b), which was dated to 6500–6050 BP and was established on results of 18 excavated and 25 surface sites in the Ayacucho area (MacNeish 1981b: 222). However, just one common bean remain was found in the single site of the Pikimachay of this phase, and was apparently an exceptional finding (cf. MacNeish 1992: 62, Tab. 2.3). Common beans seem to have been more frequent only from 4600 BP onwards (cf. MacNeish 1992: 62, Tab. 2.3). It seems improbable that with generally good plant preservation and the numerous excavated sites in the Ayacucho basin, that a crop plant would have been deposited and found in just one single site. Furthermore, the general chronology of the Ayacucho basin (MacNeish 1981b) was criticized (Lynch 1984) because of methodological problems. For these reasons, the early dating of the use of common beans in the Southern Peruvian Ayacucho basin has to be rejected.

With the available data it seems that the common bean came into use first on the Northern Peruvian coast, as the remains of the excavations at the Huaca Prieta indicate. From there it was distributed southward, reaching the Southern Peruvian coastal area by about 5500 cal BP as indicated by the findings of Pernil Alto. It was distributed into highland areas, as indicated by the directly dated remains of the Guitarrero cave by about 5000 cal BP. The Southern Peruvian highlands later formed part of the distribution of common bean. This distribution pattern suggests a general origin in northern areas, maybe in Southern Ecuador / Northern Peru, where the wild progenitor is distributed and could have been domesticated as the earliest available datings "point" in that direction. Nevertheless, as mentioned above, a Southern Andean domestication area is suggested as well and the early remains of common beans are very few. Thus, further research is indicated to prove the origin zone and distribution development of the common bean in the Central Andes.

However, the common bean was not an important crop plant at Pernil Alto, as the remains represent only 0.55 % of the weight of edible plants found at the site. It is possible that the inhabitants at Pernil Alto experimented with some other protein-rich plants, or that there were other unknown settlements in the area which focused on growing the plant, perhaps due to slightly different conditions in soil humidity because of greater distances to the stream of the Río Grande. However, these later ideas are hypothetical. The important result is that common beans had reached the Southern Peruvian coast. but that it was of minor importance for subsistence.

Other bean remains (*Phaseolus* sp.)

Some further remains of beans were recovered at Pernil Alto but the species of these remains was undeterminable. Since they were found besides the remains of *Phaseolus lunatus* and *P. vulgaris,* it can be assumed that they represent remains of one of those species. These 12 remains had a total weight of 2 g. They originated from Phase 0 (0.5 g), Phase 2 (1 g), and Phase 5 (0.5), and were associated with pits (1 g) and an occupation layer (1 g). The few remains represent just 0.22 % of the weight of the found food plants and probably represent part of the cultivated determined *Phaseolus* species.

Yam bean (*Pachyrhizus* sp.)

Remains of yam beans (*Pachyrhizus* sp.) were recovered in a smaller amount at Pernil Alto. All 33 remains are from roots and weigh 14.5 g in total. The plant remains were determined to originate from cultivated plants but the concrete species was not determinable. They were found in contexts of Phases 0 (2 g), 2 (5.5 g), 3 (1 g), and 4 (6 g). The majority of the remains were recovered from occupation layers (7.5 g). Another high amount (4 g) was found in a plant concentration (Feature 4380) in AQ 46. Therefore, a public use or consumption of the plant is indicated. Fewer remains were associated with one burial (0.5 g), a fireplace (0.5 g), and a dwelling (2 g).

The three species *Pachyrhizus ahipa*, *P. erosus*, and *P. tuberosus* are cultivated (Franke 1997: 64). All are vines or semi-erect perennial plants and have tuberous roots (Sørensen et al. 1997: 18). The tubers are consumed raw or cooked, and contain 82 % water, 9.7 % starch, 5 % sugar, and 1.5 % protein (Lieberei/Reisdorff 2007: 64). Only edible parts of the plant were found at Pernil Alto.

The origin area of *Pachyrhizus ahipa* is unknown but assumed in the east Andean area of Bolivia where the highest variation of the plant is found (Sørensen et al. 1997: 24). Pearsall also assumes the origin area for yam bean (jicama) to be in Andean Bolivia and Southeastern Peru (Pearsall 1992: 192, Tab. 9.10, 2008: 1825, Fig. 2). Therefore, in Pernil Alto one domesticate was cultivated which, it seems, had a southern origin. This is in contrast to the majority of the cultivated plants at Pernil Alto which had their origin areas in the north, most probably in Southern Ecuador/Northern Peru, from where they were distributed southward in a route following the Peruvian coast. This route is even supported by the earliest datings of the cultigens. In the case of yam bean the situation might have been different and a "southern" domesticate came into use as well.

The oldest remains from the Archaic Period of the Central Andes are known from the highland site of Tres Ventanas (Engel 1973; Ugent et al. 1982) in Central Peru where they dated to 7800 BP (cf. Pearsall 2008: 1834, Tab. 6). Remains of yam beans from Chilca 1 on the Central Peruvian coast were dated to 6500–2900 BP (Pearsall 1992: 1835, Tab. 6), or possibly more precisely to about 5000 BP (Piperno 2011a: 278). Other findings of yam bean (*Pachyrhizus* sp.) were reported from phase 3 of the site of Los Gavilanes dating to 4420–3909 BP (Bonavia 1996). These findings would put the remains of Pernil Alto in an early stage and could support a southern origin of the plant. However, the origin of yam bean and its inclusion into plant cultivation in the Central Andes is unclear due to the lack of remains in general. Pickersgill assumes that the first appearance of *Pachyrhizus tuberosus* in the archaeological record of Peru is after 3000 and before 2000 uncal BP, and the appearance of *P. ahipa* is after 1000 uncal BP (Pickersgill 2007: 927, Tab. 1).

As mentioned, the origin of yam bean and its inclusion into the cultivation is at the moment rather unclear. An additional difficulty with the remains of Pernil Alto is that the species could not be identified. The plant, which was cultivated by the inhabitants, was apparently of minor importance as the remains represent only 1.6 % of the weight of the food plants. However, as the tubers are consumed raw or cooked and are very moist, they might have been poorly preserved at the site and could be underrepresented. Any use going beyond an additional food plant is not indicated.

Guava (*Psidium guajava*)

A few remains of guava (*Psidium guajava*) were recovered from Pernil Alto. The weight of the 4 remains totaled 4.5 g. All remains were remains of fruits. The largest part (3 g) was recovered from occupation layers of Phase 4, whereas a smaller amount of 0.5 g originated from an occupation layer of Phase 1.

The guava is a 3–8 m high shrub which, because of cuttings, appears as a tree (Lieberei/Reisdorff 2007: 179) and is sometimes referred to as such. The fruits of the plant are very rich in vitamin C and contain 78–80 % water, 5–11 % sugar, 0.7–1.3 % protein, 0.4–0.9 % minerals, and 0.3–0.5 % fruit acid (Brücher 1989: 241). *Psidium guajava* is a domesticated and cultivated plant. The edible fruits are usually cooked or processed to fruit products, because the raw fruits have a "distinctly pungent taste" (Simpson/Ogorzaly 1986: 141).

The domestication of guava is not very well known, but there is some evidence for its early use and cultivation already in the Preceramic period of the Central Andes. The oldest known remains are from the Peruvian coast from the sites of La Paloma and Chilca 1, dating to about 7800–5000 BP (Pearsall 1992: 183, Tab. 9.6 with further literature there). It is well documented on the Peruvian coast and found at sites like the Huaca Prieta, Los Gavilanes, La Galgada, Aspero, Asia, and Caral after 5000 BP (Bird/Hyslop 1985: 235; Pearsall 1992: 183–185, Tab. 9.6; Sandweiss et al. 2009). It was thus a commonly used cultivated plant in the Archaic, and was also in use at Pernil Alto.

The plant remains at Pernil Alto are relatively few and represent by weight 0.5 % of all plant remains. Even though the fruits of the plant contain a high amount of water and were probably consumed after cooking—which could have led to poorer preservation and an underrepresentation within the plant remains—the cultivation of *Psidium guajava* was probably unimportant at Pernil Alto. The plant remains found could represent some experimentation with the inclusion of a plant rich in vitamin C into cultivation and subsistence, but it could also have been brought to the site from contemporaneous sites in the area which are unknown.

10.2.2 Wild collected plants

Huarango (*Prosopis pallida*)

The remains of *Prosopis pallida* were the most frequent and most numerous finding at Pernil Alto (Figure 107g–h). In total, 5383 remains with a weight of 418 g were recovered from the contexts of the site. About half of the remains (210 g) were from fruits or pods, the other half from seeds (208 g). Furthermore, 14 remains with a weight of 2 g had an uncertain determination and were determined to be *Prosopis* sp./*Acacia* sp. They are, however, included in this overview because they represent a very minor portion of the plant remains.

A special finding of *Prosopis pallida* has to be mentioned: A storage vessel of a bottle gourd (artifact 1021) was found in the occupation layer 4429 in Unit 6 which was associated with Phase 4. It was filled with numerous remains (3777) of seeds of *Prosopis pallida*. The entire artifact had a weight of 330 g. Because the gourd was filled with soil and the vessel itself had a certain weight, half of the artifact weight was taken as the vessel's weight, the other half (165 g) as the weight of seeds. This finding depicts, on the one hand, the importance of *Prosopis pallida* at the site and verifies its use as an edible plant as well as its storage. On the other hand, this is an outstanding finding and distorts the comparative study of the importance of food plants among each other. The remains will thus be included in this depiction, but the inclusion of this special finding will always be highlighted.

The tree genus *Prosopis* is commonly known in Northern Peru as Algorrobo and as Huarango or Guarango in Southern Peru. Algorrobo is also the Southern Peruvian name for *Schinus molle*. To avoid confusion, the common names of *Prosopis* are not used here.

Remains of *Prosopis* were recovered from all occupation phases at Pernil Alto. The amounts vary from 48 g in Phase 0, to 11.5 g in Phase 1, 46 g in Phase 2, 46.5 g in Phase 3, and 266 g (including the finding of artifact 1021) or 101 g (excluding the finding of artifact 1021) in Phase 4. Just a very small amount of 2 g was recovered from contexts of Phase 5, but this last occupation phase was generally underrepresented in the plant remains.

The majority of the remains (315.5 g with 1021/150.5 g without 1021) were found in occupation layers of Phases 1–4. This indicates a general public use and consumption of *Prosopis* in the settlement. However, the next highest amount (24.5 g) originated from dwellings, but exclusively from Phases 0 (22 g) and 2 (2.5 g). It is possible that *Prosopis* was stored or consumed individually and later became a "public" food plant, indicating some changes in food sharing on the site. Other remains were found in burials (23 g) from Phase 1–3, but of that, a large amount (18 g) was recovered from one single burial, indicating that *Prosopis* was only rarely important as a grave good. Fewer remains were found in pits (6 g) and storage pits (18 g). Probably parts of the collected plants were thus stored. An interesting result is the finding of a smaller amount (5.5 g) in eleven post holes and post marks. Even though one might interpret this distribution as a result of some ritual activities connected with dwelling construction, it should be kept in mind that *Prosopis* is a tree and the wood was probably used for posts in dwellings as well. During the construction of dwellings using *Prosopis* posts, some seeds or fruits of the tree could have accidentally entered the contexts.

The genus *Prosopis* has about 40 species in the Americas which are distributed from the Southwestern United States to Patagonia (Giovannetti et al. 2008: 2973). The wild growing trees are distributed in arid areas close to rivers were they grow in the drier parts of the river valleys. Dense stands of *Prosopis* in the middle section of the Río Grande valley can be assumed for the time of the preceramic occupation at Pernil Alto (see Chapters 4.2.4 and 4.3).

The tree bears edible pods of 10–25 cm in length and of about 1.5 cm in width, containing on average 25 seeds (Pasiecznik 2001: 85). The fruits are rich in protein and contain 9–12 % when fresh , followed by 14–23 % fiber, 3–5 % ash, and about 1.7 % fat (Pasiecznik 2001: 85). The seeds contain 31 % protein (Pasiecznik 2001: 87). The fruits can be consumed when fresh but are mostly cooked or dried and then processed to flour using mortars and pestles (Giovannetti et al. 2008: 2973). This procedure is assumable for Pernil Alto as indicated by the found mortars and pestles. Even the production of the alcoholic beverage "chicha de algarrobina," which is made of the seeds is also possible (Duncan et al. 2009: 13,203; Horkheimer 1960: 77). As a wild fruit, *Prosopis* is a food source for wild animals, and Horkheimer mentions deer depicted in *Prosopis* forests on Mochica ceramics (Horkheimer 1960: 78).

Due to the high variety of ecosystems, the yields of *Prosopis* are difficult to estimate. Yields ranging from 1 to 8 t/ha are reported (Pasiecznik 2001: 5), but in Peru the yields range from 1.6 to 6 t/ha (Pasiecznik 2001: 93).

Southern Peru apparently offered very good conditions for *Prosopis*. Horkheimer cites Antonio Vásquez de Espinoza from the beginning of the 16th century describing the *Prosopis* forests at the road between Ica and Nazca—which includes the area of Pernil Alto—as extremely dense and at some points impenetrable (Vásquez de Espinosa, ca. 1628: 484–485, cited by Horkheimer 1960: 77). The lower Río Grande valley still today has some relict stands of dense *Prosopis* forests (see Chapter 4.1.1). The more humid climate during the middle Holocene (compare Chapter 4.2.4) could have resulted in even better conditions. Therefore, a high yield of about 5–6 t/ha can be assumed for the *Prosopis* stands around Pernil Alto.

Storing the fruits is possible. The fruits are sometimes roasted on hot coals, but are usually dried in the sun for three consecutive sunny days, and kept inside during wet nights. They are covered with ashes during the drying to destroy insects (Pasiecznik 2001: 103). The pods can then be stored for years if they are kept dry and protected from insects and animals (Pasiecznik 2001: 103). This simple method of curing, reportedly still in use, could have been applied at Pernil Alto, as the area is very sunny. Furthermore, some large burned zones found on the site could represent areas of ashes in which the pods were dried in this manner.

The early consumption of *Prosopis* is archaeologically well documented: The Las Pircas Phase (9800–7800 BP) in the Zaña valley of Northern Peru—which is characterized as a "hunting-gathering period"—had "a strong focus on algarroba [*Prosopis*] seeds, wild grasses, and tree and cactus fruits" (Rossen 2011b: 185). This is the hereto earliest known use of *Prosopis* in the Central Andes. Older remains of *Prosopis nigra* found in the caves of Leon Huasi 1 and Huachichocana in Northwestern Argentina in the Department of Jujuy were the oldest radiocarbon datings and indicate the beginning of use at about 10,000 BP (cf. Giovannetti et al. 2008: 2974, see Tab. 1 with further literature). Remains of *Prosopis* are even reported from several Archaic sites in the Chao valley in Northern Peru dating to 6000–3800 BP where they were found in all investigated sites and were used next to cultivated plants (Cárdenas Martin 1999). However, the importance within subsistence is not very clear in those cases. Other remains were identified in the Huaca Prieta dating to about 4500 BP (Strong/Evans 1952 cited by Beresford-Jones 2004: 215).

An interesting finding of *Prosopis* comes from the Late Preceramic monumental site of Buena Vista, 35 km inland the Central Peruvian coast: The starches on vessel remains of squash and gourd found within the site were analyzed (Duncan et al. 2009). The results indicate that the vessels contained *Prosopis*, along with other domesticated species, and were possibly used to produce alcoholic beverages which were consumed at festivities taking place on this monumental site at about 4200 BP. A production of alcohol derived from *Prosopis* would have been already possible at Pernil Alto as *Prosopis* remains and gourd vessels were found there as well. Therefore, alcoholic production could have been developed prior to its ritual use in monumental sites as early as 5800 BP. However, no starch analyses were conducted on the vessel remains at Pernil Alto and—as the vessel filled with *Prosopis* seeds indicates—starch remains on vessels could simply represent storage.

Following from this, the use of *Prosopis* in the Central Andes can be assumed to have been widely distributed in Archaic times. The gathered wild seeds of this plant were an important food resource, and at times formed as much as 50 % of the human diet—even long after the introduction of agriculture (Whaley et al. 2010a: 618). A continuous use of *Prosopis* from preceramic to modern times in Northwestern Argentina is presented by Giovannetti et al. (2008). However, there is also information on the consumption of *Prosopis* during ceramic times in Peru. The most interesting in view of Pernil Alto comes from the Nasca site of Cahuachi, close to the modern town of Nazca and about 50 km southeast of Pernil Alto. Cahuachi is a large ceremonial site of Early and Middle Nasca (about 1950–1400 BP) (Orefici 2012; Silverman 1986, 1993). It is interpreted as a pilgrimage center of the Nasca culture (Silverman 1994), which was a fully agricultural society in Southern Peru. The botanical remains recovered from an excavation project on the site (Silverman 1993: 289–293) indicate a high importance of *Prosopis,* which was identified as *Prosopis chilensis* there. The amount of *Prosopis* within the edible plant remains of Cahuachi was 32.3 % by weight. Maize remains represented 36 % and Lima bean remains 1.5 % of the total. Thus, *Prosopis* was an important food plant even within the fully agricultural Nasca society. The remains of *Prosopis* from Pernil Alto, on the other hand, represent 45.78 % (if the special finding of artifact 1021 is included but only 33.89 % when it is excluded). Hence, the ratio between the wild collected *Prosopis* and the cultivated plants at Pernil Alto corresponded to that of later fully agricultural societies of Southern Peru. This is an important indication for the evaluation of the importance of plant cultivation within the economy of Pernil Alto during the Middle Archaic Period. Although only based on the results of only two sites of one area in different times, it seems that the importance of cultivation during the Middle Archaic Period had already reached that of the state of later fully agricultural societies of the area. However, more detailed studies are necessary for better and more valid comparisons.

The importance of *Prosopis* within subsistence is even known from historical sources of the 16th Century. As Ovieda reports of a case of the Almagro expedition to Northern Chile: "En aquellos pueblos, destas algarrobas que allí avia recogidas en cantidad, se hiço dellas miel é pan para sostenerse la gente […]." (Oviedo y Valdés 1535: 265, In these villages there were many of these algarrobo fruits from which honey and bread was made to sustain the people.)[20]

Even though the tree is a wild tree, it was sometimes planted along Inca streets and the fruits were used in prehispanic times as emergency food when harvests were insufficient (Horkheimer 1960: 77). Therefore, the wild tree *Prosopis* was an important food source in some areas and especially in Southern Peru. Even after the emergence of a productive subsistence economy—like in Nasca times—the plant obviously still had a well established place within subsistence. The example from Cahuachi clearly shows that even a high amount of *Prosopis* can be associated with plant remains of agricultural societies.

20 Translation taken from Beresford-Jones (2004: 230).

Peruvian pepper (*Schinus molle*)

A few remains of Peruvian pepper (*Schinus molle*) were recovered at Pernil Alto (some remains from the Initial Period are shown in Figure 107d as an example). The 29 remains total 3 g and were all from fruits. A larger part (1.5 g) was found from contexts of Phase 0, whereas from Phases 1, 4, and 5 an amount of 0.5 g each was recovered. The remains originated from occupation layers (1 g), storage pits (1 g) and two postholes (1 g).

Peruvian pepper is a wild growing tree of the riparian forest. The fruits were thus collected wild like *Prosopis*. Fruits and leaves of the tree were used as medical plant and the juice was sometimes added to *chicha* (Horkheimer 1960: 83). Maybe *Schinus molle* was used in such beverages, but in general it played a rather unimportant role as the plant remains represent only 0.3 % of the weight of the edible plants.

10.3 Industrial plants

The bottle gourd (*Lagenaria siceraria*) was the only cultivated industrial plant at Pernil Alto (Figure 107i). The plant was widely used to produce vessels, bottles, bowls, net swimmers, and other artifacts and is thus an industrial plant. It is well known from contexts of the Archaic Period. The plant has bottle shaped fruits with a bulbous basis and a slender neck. The pericarp becomes hard and woody when mature, is then impermeable to water and can be used as a vessel (Lieberei/Reisdorff 2007: 241). Even though not edible, it should be mentioned, because of to its distinct and frequent use as artifact (see Chapter 9.6.1). It was certainly cultivated in Pernil Alto and is thus interesting for understanding the economy on the site.

The fragmented remains found at Pernil Alto total 1271 pieces with a weight of 717.5 g. The majority of these, weighing 682.5 g, came from fruit remains in the form of pericarp pieces representing at least 44 fruits (MNI) which were all interpreted as the remains of vessels. The other remains came from seeds (n = 208 / 32 g) and stems (n = 10 fragments / 3 g) of *Lagenaria siceraria*, indicating cultivation and processing as the fruits reached the site complete before having been processed into vessels. The remains were recovered from contexts of all settlement phases indicating the extended use and importance of the plant. The amount of the remains fluctuates slightly during the phases, with remains of six interpreted vessels in Phase 0, two in Phase 1, eight in Phase 2, eight in Phase 3, 16 in Phase 4, and three in Phase 5. With the remains of 27 vessels, the majority were found in occupation layers, six were found in burials, one in a dwelling, two in fireplaces, four in pits, and four in other contexts.

Bottle gourd is cultivated today throughout the tropics (Lieberei/Reisdorff 2007: 241). It is accepted as the oldest cultivated plant in the Americas and was already "persistently present in northern South America and Panama between 10,200 and 7600 BP" (Piperno 2011b: 489). However, the oldest known macro-remains from South America are from the Quebrada Jaguay in coastal Southern Peru dating to 8884–8381 BP (Kistler et al. 2014: Tab. 1). The origin and area of domestication of the bottle gourd is still disputed. Erickson et al. (2005) assumed—based on aDNA analysis of archaeological remains—that bottle gourds were brought from Asia to the Americas in an already domesticated form during the initial peopling of the continent via the Bering strait route. Kistler et al. (2014) however doubt that the plant could have been brought through the Arctic zones. They assume—based on a widened aDNA study—that fruits of bottle gourds were transported via currents over the Atlantic from Africa to the Americas where they then were domesticated close to "established centers of food production" (Kistler et al. 2014). In any case, bottle gourd has its biological origin in the Old World and was brought to the Americas.

This old cultigen was of importance before the introduction of ceramics. Being one of the oldest cultivated plants, it might be the origin of plant cultivation in South America before food production became important. This is indicated by findings of the plant in sites of the Peruvian coast that had a subsistence economy based on marine resources, such as the Huaca Prieta (Bird/Hyslop 1985; Dillehay et al. 2012b), La Paloma (Engel 1980; Benfer 1982, 1999), Chilca 1 (Engel 1988a) and others. The cultivation of the bottle gourd and its establishment before the rise of edible plant cultivation is an important technological step in the development of subsistence forms based on edible plant production as first experiences with cultivation, including planning of preparation of fields, planting, and harvesting. It is thus an important step in the emergence of agriculture.

In Pernil Alto—where the plant came into use after its domestication and after having been well established in the Preceramic period—the fruits served as a kind of pre-ceramic vessel. These vessels were important to process the edible plants. Furthermore it can be seen as an—although weak—indicator for sedentariness or concentration on the site, because it was planted and the fields had to be taken care of. However, the use of the plant is no indicator at all for subsistence based on food plants or food plant production as it was in use in other economic contexts, as mentioned above.

10.4 Pollen and phytolith remains from grinding tools

Ten samples were taken from the grinding surfaces of ten grinding tools, including four big ground stones, four mortars, one medium ground stone, and one stone bowl (Table 46). The descriptions of the tool categories can be found in Chapter 9.1.3. The aim of the analysis was to recover and determine remains of ancient pollen, phytoliths and starches from the pores in the grinding surfaces to get information about the use of the grinding tools and information about the plant spectrum in use on the site. Comparable analyses in the Americas have been carried out, especially in areas with poor organic preservation due to higher humidity (for example Nieuwenhuis 2008; Pagán Jiménez/Oliver 2008; Pearsall et al. 2004; Piperno et al. 2000b, 2004). The method is thus well established.

The sample was principally comprised of big grinding tools, following the idea that those with bigger grinding surfaces would have been used more intensely and that sampling would result in a higher number of, and thus more convincing, pollen and phytoliths remains. Secondly, the aim was to get information from all occupation phases and thus the samples covered all of them except Phase 0.

The analyses of the samples were done by Linda Scott Cummings of the PaleoResearch Institute, Golden, Colorado, USA. The sampling itself was done by the author with the support of Josef Herrmann, who was supporting the Palpa Archaeological Project during the campaign of 2010 and is the head of the laboratory of the Bayerisches Landesanstalt für Weinbau und Gartenbau (Bavarian State Institute of Viticulture and Horticulture) in Veitshöchheim, Germany.

The applied method aimed to destroy the ancient post-use calcareous closings of the pores in the grinding surfaces and to extract the material held within. The extracted material was then analyzed. The sampling was conducted in close consultation with the PaleoResearch Institute and followed their procedures. It included the following steps: The grinding stones were watered and cleaned with a clean brush. Then the grinding surface was splashed with warm 5 % vinegar and cleaned with a clean toothbrush to open the pores. The vinegar was then rinsed with distilled water. Then the grinding surface was brushed using an electric tooth brush and distilled water. The particles loosened by this last step came out of the pores of the grinding tools and the solution composed of the particles and the distilled water was absorbed using clean syringes. Each grinding stone was treated in this way individually. The samples were later separated in Germany by centrifugation to get higher concentrations of the particles with less water from the original rinsing. The concentrated samples were then sent to the PaleoResearch Institute, where the determination and counting of the contained pollen and phytoliths took place.

The results of the analyses are listed in Table 47 (pollen) and Table 48 (phytoliths and starches). The results show that pollen were in general less frequent (n = 285) than remains of starches and phytoliths (n = 2237).

Within the determined 66 pollen taxa no species could be identified. The determined remains reflect in most cases large plant genera and families. Thus, concrete information about the processing of food plants is not possible with the data. An exception is the determination of *Prosopis* in three samples (4, 6, and 9). However, as *Prosopis* stands are assumed in the close riparian forest, it is not clear whether those remains actually represent processed plants or just pollen transported to the site by the wind. Furthermore, the pure amount of the pollen within the taxa is very poor. A large part was only determinable by single finds (n = 29), which represented 43.93 % of all taxa. With the exception of *Prosopis*, no pollen of the used edible plants, which are evident by the numerous macro-remains, was found. On the other

Sample	Artifact-No.	Artifact	Feature-No.	Context	Structures	Phase
1	203	big ground stone	4086-1	filling layer	07; dwelling	3
2	206	mortar	3979	burial 24	05; burial area	3
3	201	big ground stone	4083	stone concentration	01; dwelling	5
4	202	big ground stone	3979	burial 24	05; burial area	3
5	196	mortar	4043-2	occupation layer		1
6	198	big ground stone	4042	burial 29		2
7	204	medium ground stone	4042	burial 29		2
8	1470	stone bowl	4263E	filling layer	10; dwelling	4
9	197	mortar	4057	filling layer	06; dwelling	4
10	205	mortar	3223	stone concentration	01; dwelling	5

Table 46: List of the sampled grinding tools.

hand, the determined taxa represent genera and families which would be expected from the riparian forest close to the site. Thus, the pollen probably represent this vegetation, even though concrete species were not determinable. This is especially the case for the most frequently found taxa (Cheno-am, Cyperaceae, and Poacea) which are basically grass taxa and could originate from sedges or rushes of the wetland of the river. The pollen of the riparian forest were most probably transported to the site by wind, indicating that the grinding tools were used in open air in the public and were not—as the contexts would indicate—of indoor or "private" use, but rather brought to the contexts after they came out of use.

The lack of pollen from the cultivated species discussed earlier could indicate that the fields were located leeward of the site and that no pollen of the cultivated species are represented in the few pollen remains of the ground stone samples. It is possible that some pollen of beans are included in the pollen of the Fabaceae family. However, this is only an assumption and cannot be proven by the determinations. Furthermore, the edible plant parts (fruits, seeds, tubers, and roots)—which are suspected to have been processed on or in the grinding tools by grinding and/or meshing—do not yield pollen and would thus have left no or very small traces.

	Sample										**total**
Sample No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Artifact No.	**203**	**206**	**201**	**202**	**196**	**198**	**204**	**1470**	**197**	**205**	
Taxa											
Acacia				5		1					**6**
Aesculus-type				1							**1**
Alnus	1	4		1		1					**7**
ANACARDIACEAE Lithraea				1		1					**2**
ANACARDIACEAE				1							**1**
Coprosma									1		**1**
Juniperus									1		**1**
MYRTACEAE			2			1			1		**4**
Nothofagus		1		3							**4**
Picea						1					**1**
Pinus		2		4		1					**7**
Prosopis				2		3			1	1	**7**
Triumfetta				3						1	**4**
Artemisia						1				1	**2**
LOW-SPINE ASTERACEAE				1		4					**5**
HIGH-SPINE ASTERACEAE		1	1	2		3			1	1	**9**
ASTER cf. Ophryosporus		1							1		**2**
LIGULIFLORAE						2					**2**
BRASS-Menonvillea-type						1			2	1	**4**
BRASSICACEAE		6		1		2				1	**10**
Brousonetia-type diporate				6							**6**
CAMPANULACEAE										4	**4**
CHENO-AM		11	1	17	2	3	1		2	2	**39**
Alternanthera		2									**2**
Cissus-type				1							**1**
Cleome-type						1					**1**
Convolvulus-type		1									**1**
CORYLACEAE									1		**1**
CYPERACEAE				31		1					**32**
ERICACEAE						1					**1**
FABACEAE				2		1			2		**5**
Gayophyton-type				1							**1**
Haloragis-type				3							**3**
Hoffmanseggia-type						1			1		**2**

	Sample										total
Sample No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Artifact No.	**203**	**206**	**201**	**202**	**196**	**198**	**204**	**1470**	**197**	**205**	
Taxa											
Lomatia-type (Casuarina-type)	1										**1**
MALVACEAE				1							**1**
Menodora (retic)				2							**2**
Myrica				4							**4**
Pitavia-type									1		**1**
POACEAE		12		3		1			2	2	**20**
POLYG Lastarriaea-type				1							**1**
POLYGONACEAE				2							**2**
Psoralea										1	**1**
RHAMNACEAE									1		**1**
Rhamnus				2		1					**3**
ROSACEAE				1							**1**
ROSACEAE STRIATE						4					**4**
ROSACEAE Alchemilla-type									1		**1**
RUBIACEAE Oldenlandia-type										2	**2**
Sida-type	1										**1**
Typha angustifolia-type										1	**1**
URTICACEAE Pilea-type		1									**1**
VALERIANACEAE Plectritis-type					1						**1**
BROM Puya-type				1							**1**
Capsicum				1		1					**2**
Cerealia-type				4							**4**
Oryza-type Buliform									1		**1**
SOLANACEAE						1					**1**
SOLANACEA LG				7		1					**8**
ROS/SOLAN STRIATE		1	1								**2**
Zea mays	1	1				1					**3**
INDETERMINATE		3		6		2			9	1	**21**
UNIDENTIFIED – TCP Retic lg						1					**1**
UNIDENTIFIED – 4CP transv RETIC				1							**1**
Polylobate phytolith			1			2	3			5	**11**
MONOLETE SMOOTH FERN SPORE				1							**1**
total	**4**	**47**	**6**	**123**	**3**	**45**	**4**	**0**	**29**	**24**	**285**

Table 47: Pollen identifications and counts of the grinding tool samples from the PaleoResearch Institute.

The three pollen of maize (*Zea mays*) should be briefly mentioned: No single remain of maize was found in the macro-remains of the Preceramic occupation at Pernil Alto. The pollen remains are furthermore very sparse and were all represented by just one remain on one artifact. This is the only indication for maize use at Pernil Alto. In general, maize was not used at all, as indicated by the macro-remains. If the pollen of *Zea mays* are interpreted as representing maize use, than maize did not play any important role at the site but was only exceptionally used during Phases 2 and 3. However, the few pollen of maize are better interpreted as representing some contamination of the samples. In general, there is too limited evidence from the site to assume maize cultivation or use.

	Sample										total
Sample No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Artifact No.	**203**	**206**	**201**	**202**	**196**	**198**	**204**	**1470**	**197**	**205**	
Taxa											
ARECACEAE PHYTO									4	9	**13**
bilobate		6				3			3	19	**31**
stipa-type squat bilobate						6	2			6	**14**
buliform		2	3		2	1	4	1	28	8	**49**
chloridoid	1	3	4			6	1		3	20	**38**
MARANTACEAE Seed Phyto									1		**1**
CYPERACEAE										1	**1**
dendriform					1				5	3	**9**
elongate	28	20	30			8	12	1	32	93	**224**
elongate spiny	1	2	12			1		1		12	**29**
globular echinate		55	1					1			**57**
globular psilate	51				36		91		200	581	**959**
parallelipiped							1		9	14	**24**
polyobate phytolith			1			2	3			5	**11**
rondel		11	15	2	1	3	3		22	90	**147**
rondel bambusoid	9	1					1	1	1	7	**20**
prickle			3								**3**
trichome		1					4	1	7	17	**30**
trapezoid sinuate	5	14	13			2	3		8	37	**82**
Leaf/Bark Phytolith	7	1	108					33	5		**154**
diatome marine			2					1	2	20	**25**
diatome centric	5	18	17	4	3	17	9	3	28		**104**
diatome long	1		1			1			2	3	**8**
sponge spicule	16	6	13	1	1	11	9	4	14	22	**97**
starch centric cooked						1					**1**
starch w/skirt				1							**1**
Hordeum/Elymus starch				3							**3**
lenticular starch		1	1								**2**
tiny starch						13					**13**
eccentric starch						1					**1**
stellate hairs							1				**1**
fibers								40			**40**
MONOLETE SMOOTH FERN SPORE				1							**1**
CHARRED POACEAE CELLS									1		**1**
VOLCANIC ASH					2		8		18	15	**43**
total	**124**	**141**	**224**	**12**	**46**	**76**	**152**	**87**	**393**	**982**	**2237**

Table 48: Phytoliths and starch identifications and counts of the grinding stone sample from the PaleoResearch Institute.

The remains of phytoliths and starches are found, on the one hand, in a relatively high amount, but on the other hand, a determination of species, genera, and even families was mostly not possible and, when so, only very small amounts (in the cases of Arecaceae, Marantaceae, and Cyperaceae). In the vast majority of cases it was only possible to come to separations by descriptive shapes of the found taxa, but the plants represented remain unknown. Thus, the analyses of phytoliths and starches did not provide any information about the processed plants nor about the subsistence and diet of the inhabitants.

Nevertheless, the results are useful for interpreting the grinding tools. They were intensively used, which is especially the case for the mortars as the numerous remains from samples 9 and 10 indicate. Furthermore, the results indicate that even the medium ground stones (represented by sample 7) were intensively used for grinding. The big ground stones were in general used intensively as well, but a high variation is indicated by the differences of the amounts. This reflects probable different time spans of use, which can however not be specified. In contrast, the stone bowl (sample 8, artifact 1470) did not deliver many remains, indicating a special and exceptional use which corresponds to its exceptional elaboration compared to the other lithic artifacts.

In general no valid result of the used edible plants can be drawn by the analyses of pollen, phytoliths, and starches from the grinding stones at Pernil Alto. Nearly no edible plant was identifiable. The remains of maize are very questionable and no species represented by the macro-remains was determinable. This is not a weakness of the method, but represents the astonishingly poor preservation of the microremains in contrast to the good preservation of the macro-remains. The only useful result is that the grinding tools were intensively used to process plants. Furthermore, as the pollen of various plants probably originating from the riparian forest indicate, the grinding tools were used in public and were not private items.

10.5 Pollen remains from intra site samples

A total of 90 intra-site samples were taken during the campaign of 2009 in the excavation units 5 and 17 for pollen analyses. They were extended by 4 comparison samples from the close surroundings of the site. The pollen analyses were planned to complete the information from the botanical macro-remains and to get further evidence of fields for cultivation. The samples were taken during the excavation from various secure contexts. The sampling was done using a clean trowel and filling a small amount of in-the-moment exposed and untouched material from the context into a small plastic bag which was immediately closed. Afterwards the samples were sent to Karsten Schittek, Institute of Geography and Geographical Education of the University of Cologne, Germany, who conducted the pollen analyses.

The analyses followed a standard procedure. It included a dry sieving of the sample material, separating it into fractions of >2 mm, <2 mm, >630 µm, and <630 µm. The smallest fraction was then taken and the volume measured exactly. All mineral and organic contents except for the pollen were then removed by warmed 10 % hydrochloride acid and warmed 10 % potassium hydroxide solution. In a second sieving the fraction of >112 µm was separated and then treated with hydrofluoric acid to destroy the silicates of the sediments. The organic components were then destroyed, and the pollen cleaned and colored by a catalyzed acetolysis. Finally, the sample was cleaned in an ultrasonic bath and all particles smaller than 10 µm were removed using gauze.

A standard of 37,168 lycopodium markers was given to each sample to be able to compute the pollen concentration afterwards. The sample was then covered with glycerin for preservation. From each sample, two preparations were analyzed and the pollen completely counted using optical microscopes with magnifications of 100 and 400.

The concentration of the pollen (pollen/cm³) of the found taxa was computed using the following formula[21]:

$$c_t = \left(\frac{\frac{P_t \times M_{total}}{M_{count}}}{V} \right)$$

Even though the sampling during the field work and the sample analyses were done with rigor, it turned out that the majority of the pollen samples were sterile (compare list in the digital supplement). This contrasts with the very good preservation of the macro-remains and is not explainable at present. Karsten Schittek supposes that an oxidation of repeated waterlogging could explain the poor preservation, which would be supported by the high amount of fungi spores (personal communication). However, ten samples (11.11 %) contained enough pollen remains to be analyzed. The corresponding samples with their origins and phase associations are listed in Table 49. The evaluable pollen samples are restricted in their diachronic distribution (n = 9 samples from Phases 4 and 5) and were furthermore in their majority (n = 7) from the interiors of structures. Thus, they are insufficient to reconstruct temporal developments in the site, which was possible with the macro-remains. Furthermore, they yield mainly information about the pollen spectra inside the dwellings and burial areas, respectively, and were thus not representative for the open air pollen spectra.

The absolute pollen count (Table 50) already shows a very high amount of cf. *Typha* sp. which is a tall grass or sedge locally known as totora. The pollen (Figure 107j) probably reflects the roof material of the dwellings (see Chapter 8). This explains its high amount in the interior

21 c_t = concentration of taxon; P_t = number of counted pollen of a taxon; M_{total} = number of added lycopodia marker; M_{count} = number of counted lycopodia marker; V = volume of sample

Sample	Feature	Unit	feature type	Phase	Structure
13	4266	17	burial 41	5	10; burial area
19	4266	17	burial 41	5	10; burial area
23	4269	17	pit	1	
33	4038	5	occupation layer	4	
41	4277	17	burial 45	4	
62	4272E	17	filling layer	4	08; dwelling
63	4263E	17	filling layer	4	10; dwelling
64	4263E	17	filling layer	4	10; dwelling
66	4272F	17	filling layer	4	08; dwelling
69	4263E2	17	filling layer	4	10; dwelling

Table 49: Origins and phase associations of the intra-site pollen samples.

of those contexts. An amount of 39 g of *Typha* sp. was also found in the form of macro-remains (Table 43). The rhizomes of totora are in general edible (Ugent/Ochoa 2006: 275), but the plant was obviously only used as an industrial plant and was unimportant for the subsistence, as only non-edible parts of the plant were found in the form of macro-remains.

Another interesting result of the pollen analyses was the determination of some Cucurbitaceae pollen (Figure 107k) in sample 19. Even though detected in only a small amount and only determinable to the plant family level, these pollen correspond to the macro-remains of *Cucurbita* sp. and could indicate the proximity of fields in which the plants were cultivated. They were derived from a burial in structure 10, which is located on the lowest part of the spur on which the site is situated. Therefore, the pollen finding is a (weak) indicator for a location of fields below the spur. Probably they were located south of it, in the ancient river meander, as discussed before.

Sample	Vol. (ml)	Lycopodium comparison marker	cf. *Typha sp.*	*Prosopis*	*Alnus*	Asteraceae	Cucurbitaceae	Cyperaceae	Malvaceae	Mimosoideae	Poaceae	Solanaceae	nd Type 1 (triangular)	nd Type 2 (wrinkle)	other	*Glomus*
13	1.6	283	27	7						4	2	1	1	2	1	2
19	2.3	192	40	19		4	5	1			2		1			3
23	1.9	277	6	2				6						3		8
32	0.9	259	75	2	1									3		3
33	0.7	582	81	8		2					19				2	15
41	1	254	26	2		1					8					2
61	1.3	243	29	9		1		2			6	1				12
62	2.5	424	32	2		3		5								23
63	1.2	1024	76	62	4	8		99	2			1	4	20	7	35
64	2.5	278	28	2		8		9					2	1		5
66	3.3	401	1			1										7
67	2	806	15			2		4			2				4	28
69	2.3	214	10	3				4		1				2	1	5
73	3.1	247	23	3		5							13		6	80
total			**469**	**121**	**5**	**35**	**5**	**130**	**2**	**5**	**39**	**3**	**21**	**31**	**21**	**228**

Table 50: Pollen samples with pollen counts.

The relative amount of pollen (Table 51) (computed by the formula mentioned before) shows that pollen of Cucurbitaceae only made up a total of 0.5 % of the found pollen remains. Probably the cultivation fields were thus located in lee of the site.

The remaining determined plant families and genera reflect the vegetation of the riparian forest close by. Pollen of the vegetation there were brought to the site by wind and no concrete species was determinable. However, the pollen of *Prosopis* correspond to the macro-remains of *Prosopis pallida,* which were discussed before. This indicates on the other hand, that the riparian forest—which was located east of the site—was windward. With 10.6 %, *Prosopis* had the second highest frequency of the determined pollen indicating a dense distribution of *Prosopis pallida* trees in a close proximity to the site.

Glomus is a fungi genus which is symbiotic to plant roots. Spores, but no pollen, were found of this genus and were not included in the relative amounts.

The poor pollen preservation prevented the possibility of deriving more detailed information about plant use related to subsistence on the site. The most important information is (1) that totora was used for the roof construction of the dwellings, and (2) that the cultivation of squash is indicated in an area below the spur.

Sample	**cf. *Typha sp.***	***Prosopis***	***Alnus***	**Asteraceae**	**Cucurbitaceae**	**Cyperaceae**	**Malvaceae**	**Mimosoideae**	**Poaceae**	**Solanaceae**	**nd Type 1 (triangular)**	**nd Type 2 (wrinkle)**	**other**
13	60.0	15.6						8.9	4.4	2.2	2.2	4.4	2.2
19	55.6	26.4		5.6	6.9	1.4			2.8		1.4		
23	35.3	11.8				35.3						17.6	
32	92.6	2.5	1.2									3.7	
33	72.3	7.1		1.8					17.0				1.8
41	70.3	5.4		2.7					21.6				
61	60.4	18.8		2.1		4.2			12.5	2.1			
62	76.2	4.8		7.1		11.9							
63	26.9	21.9	1.4	2.8		35.0	0.7			0.4	1.4	7.1	2.5
64	56.0	4.0		16.0		18.0					4.0	2.0	
66	50.0			50.0									
69	47.6	14.3				19.0		4.8				9.5	4.8
73	46.0	6.0		10.0							26.0		12.0
abs. %	**57.6**	**10.6**	**0.2**	**7.5**	**0.5**	**9.6**	**0.1**	**1.1**	**4.5**	**0.4**	**2.7**	**3.4**	**1.8**

Table 51: Pollen samples with amount of pollen (all in %).