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

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17 Economy

The following chapter evaluates the subsistence economy at Pernil Alto, which was—according to the results presented in Chapters 10, 11, and 12—composed of plant and animal use. As a first step, these two main parts of the economy will be analyzed and characterized independently. Then, these main parts will be brought together with other results of the overall investigation to offer a final characterization of the economy at Pernil Alto as a whole.

17.1 Characterization of animal use

Animal use at Pernil Alto was composed by some hunting of big animals, and catching of birds and cavies (see Chapter 11). Hunting was less important at Pernil Alto than at "typical" hunter sites known from the Central Andes. Thus, it can be interpreted as an additional activity in the subsistence of the inhabitants. Catching birds and cavies was—as a less costly activity—more evident at the site. Furthermore, the increasing amount of caught birds and cavies as represented in the remains indicates a higher concentration on the site and probably increasing cultivation. Hunting was, in contrast, more important during the beginning of the site, but decreased in importance from Phase 0 to Phase 3 (Figure 145), from which no remains of big animals were recovered. However, it seems that during Phase 4 hunting gained importance again, as some remains of big animals were recovered from this phase. The remains of Phase 5 are—as the plant remains—not representative. The development of activities connected with hunting corresponds to this trend (compare Chapter 14), and projectile points are only known from Phases 0 and 4. The hunting area can be assumed to be the surroundings of Pernil Alto within the riparian forest and the grass steppe. Within a distance of three walking hours around the site, a sufficient hunting ground would have been covered (see Figure 156). Catching of birds and cavies was possible in the direct surroundings of the site, the site itself, or the cultivation area in the meander.

All the mentioned developments are based on the MNI of the recovered animal species. The MNI are useful to investigate the diachronic developments and trends indicating increasing or decreasing importance, but to come to more comparable results, the biomass of the species would have to be included, even though the method has been criticized and the use of allometric factors has been recommended (Reitz et al. 1987). However, due to the nature of the remains, this is not possible at Pernil Alto.

The biomass is simply calculated by the MNI of the species, multiplied by the portion of useable meat of the faunal remains. The corresponding data was taken from different sources and sometimes—especially in the case of the birds—an estimation had to be made, as no concrete species were determinable (Table 63).

Species	Useable meat (kg)	Source	MNI	Biomass
Guanaco/camelid	61	(Aldenderfer 1998: 282, Tab. 9.5)	3	183
Taruca/deer	29	(Aldenderfer 1998: 282, Tab. 9.5)	3	87
Big animal	45	Averaged from Guanaco and Taruca weight	4	180
Cavies young	0.13	(FAO 2000)	18	2.34
Cavies adult male/nd	0.45	(FAO 2000)	11	4.95
Birds	0.5	estimated	20	10
total			**59**	**467.29**

Table 63: Biomass of the species of Pernil Alto.

The result distinctly shows that small animals (cavies and birds) represented 83.05 % of the MNI (Figure 146) and 78.24 % of the NISP (= number of identifiable species parts), and were thus obviously more frequently caught than big animals. Big animals only represented 16.95 % of the MNI and 21.76 % of the NISP. However, big animals are far bigger than small ones and thus deliver far more meat. When this is taken into account, the

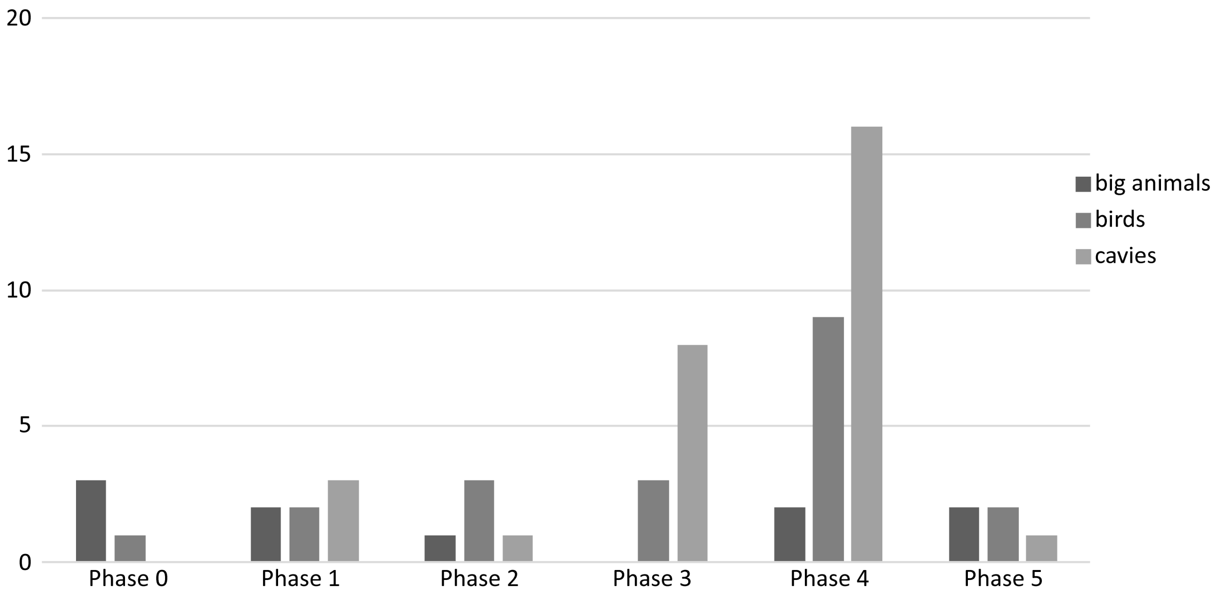

Figure 145: Diachronic distribution of MNI of big animals, birds, and cavies.

higher importance of big animals as meat source becomes obvious (Figure 147).

Considering the biomass, the amount of meat of big animals (including possible Guanacos or other camelids, deer, and not determinable big animals) is assumed to have been 450 kg in total, which is 96.3 % of the total biomass. This amount shows that hunting—even though in absolute number obviously was less frequently conducted—was far more productive for meat supply than catching small animals.

The evaluation of the vertebrates remains has shown that in general two activities can be distinguished regarding the meat supply. One activity was hunting of big animals, the other catching small mammals and birds. The latter one was more frequent and increased in importance through time, indicating an increasing concentration on the site, more (plant) food waste, and possibly larger fields. Hunting, on the other hand, was less frequently conducted but was more effective in obtaining meat. Whereas catching can be interpreted as an intra-site or near-site activity, hunting was executed in the surroundings of the site, probably in the riparian forest and the grass steppe. Some manifestations could indicate the early keeping of cavies, but in total there is no distinct evidence for such activities. Future research might help to solve this issue.

Generally, hunting was conducted at such a low frequency, especially when compared to amounts from hunting sites, that it has to be interpreted as a supplement to subsistence. This is supported also by the few artifacts found related to hunting activities. Because of their relatively low output in meat, even the catching activities seem to have been only a supplement to subsistence. However, catching increases in importance in the occupation phases (from Phase 1 onwards) when an increase in cultivated plants indicates increasing plant productivity at the same time. Thus, catching animals represents an additional subsistence strategy of the inhabitants which developed hand in hand with the increasing plant cultivation, and was in turn influenced by it (increasing plant waste attracting cavies, guarding fields from birds).

Hunting was nevertheless more important in the beginning of the occupation (Phases 0 and 1). In these phases, the amount of collected plants was still relatively high (Figure 151). Hunting and collecting were thus important in the beginning, but decreased in importance and had only a supplementary character. However, hunting was still conducted, maybe to bridge times of low food resources such as shortly before the harvest, or simply as a welcome change in the diet of the inhabitants. Hunting could have played as well a social or ritual role at Pernil Alto, in the sense of keeping up an old tradition or to strengthen the inner social cohesion. Furthermore, the remains of big animals could be the result of exchanges with other groups in the area which were more specialized in hunting.

None of the latter explanations are evident with the material from Pernil Alto, thus they are rather speculative. However, the character of hunting and catching was only of supplementary importance for the inhabitants.

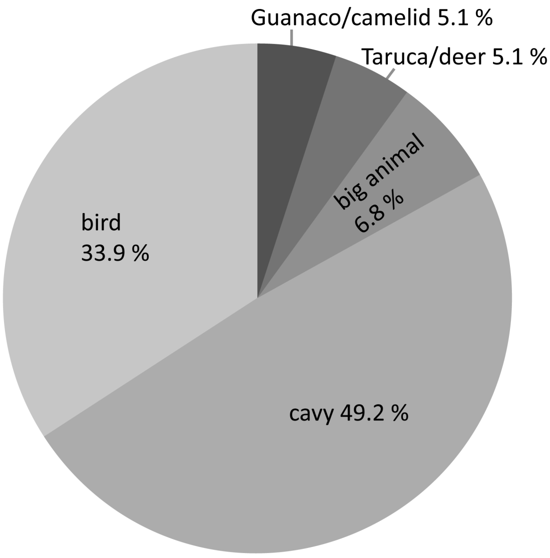

Figure 146: Proportion of the found species by MNI.

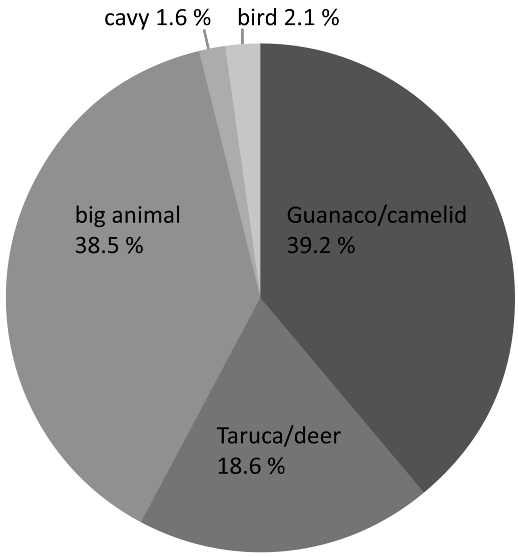

Figure 147: Proportion of the biomasses of the found species.

17.2 Ratios of the food plant remains

To evaluate the economy at Pernil Alto, it is first important to consider the relationship between cultivated and collected plants. This involves determining the relative importance of domesticated-cultivated or wild-collected plants for the diet of the inhabitants. A larger portion of a particular plant group indicates a greater importance in the diet, and thus a higher investment in labor, time, effort, and technology. Therefore, this information is decisive for assessing whether a more productive or a more appropriative-foraging economy prevailed at Pernil Alto. A productive economy later sustained the complex societies which emerged in Peru beginning with the monumental societies on the Central Peruvian coast at about 5000 BP (see among others Shady Solís 1997, 1999, 2000b; Haas et al. 2004b). Thus, understanding the economy of Pernil Alto is crucial to understand the economic development in the Central Andes, as Pernil Alto directly predates this cultural emergence on the Central Peruvian coast.

It is also important to quantify the relationship between production and appropriation (1) to obtain a valid basis for discussion; (2) to compare the results of Pernil Alto with the results of other sites; and (3) to place Pernil Alto in relation to the development of the emergence of agriculture in the Central Andes. The used indicator for the ratio between plant production versus plant collecting is the weight of the amounts of remains of the considered plant groups. This method is not without problems, which are a result of the varying preservation of the plant remains (Begler/Keatinge 1979). The varying degrees of preservation of the single species have been discussed before. The result is that particularly the cultivated plants—and especially the tuber plants—were probably preserved less on the site than the wild plants. The latter ones includes the remains of *Prosopis* which in all likelihood was dried and stored. Hence, it can be assumed that the remains of *Prosopis* were proportionally overrepresented. As a consequence it can be assumed that when the proportion of cultivated plants exceeds that of wild plants, a higher importance of plant cultivation and thus production is clearly indicated. Conversely, a higher proportion of wild plants would need a higher value to be interpreted as a definitive indicator for a higher importance of plant collecting. In addition to the problem of preservation is the problem of recovering the plant remains. This was done *in situ* and not by flotations. Thus, small remains were possibly not found. However, this restriction applies to both, wild as well as cultivated plants. Thus, it can be assumed that both groups are equally represented and that comparable amounts of both groups were not recovered. Flotation would furthermore not have been appropriate on the site given that the majority (over 95 %) of the remains were found desiccated and not charred. Thus an abrupt rinsing would have led to a direct maceration and destruction of smallest remains, leading to a result comparable to that of recovering *in situ*.

For these reasons, the weight of the recovered macro-remains is appropriate for estimating the importance of cultivated versus wild plants. Furthermore, no other methods—like the analysis of stable isotopes in the human remains or of coprolites—were available, or their results are still pending.

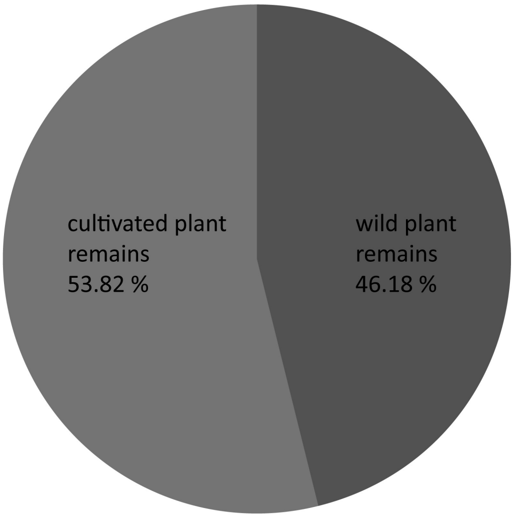

Figure 148: Total amounts of the remains of wild and cultivated plants.

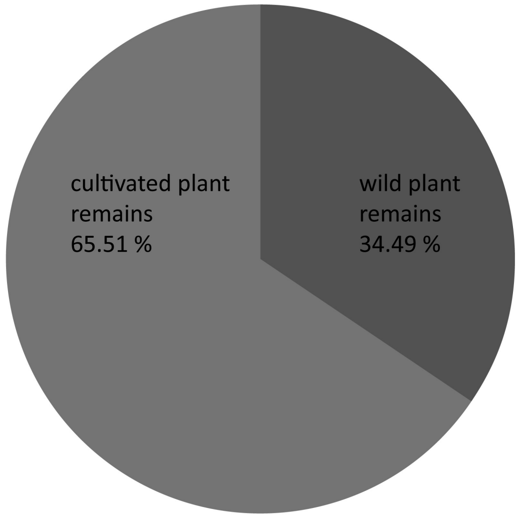

Figure 149: Total amounts of the ratios of wild and cultivated plants after excluding artifact 1021.

The majority of the remains originated from refuse in occupation layers and can therefore be interpreted as representative of subsistence patterns. However, the remains of plants from ritual contexts (burials) were included to get a complete picture, however even their exclusion would have led to no considerable differences in the results (see below). The amounts were based on calculated percentages of the weights of the edible plant remains. There are no absolute indexes calculated (e.g. the concentration of plant remains per volume of excavated soil). However, this was not necessary as the aim here is not to come to an absolute quantification but to a relative quantification of the ratio between wild plants and cultivated plants. The question here is not how intensive the plant consumption was in general, but how intensive the consumption of wild plants was in relation to the consumption of cultivated plants. Therefore, the percentages of the weights are used and not the concentrations (the relation of concentrations of wild and cultivated plants would be the same as the direct relation between wild and cultivated plant remains). This implies the assumption that both wild and cultivated plant remains were brought to and consumed on the site.

Having discussed the aim and the related problems, I finally come to the calculations. The calculations are based exclusively on the edible parts of food plants. All other plant remains as well as the remains of bottle gourds were excluded as they do not provide information about the diet. The total weight of the respective plant remains was 916 g. The individual amount of each plant is found in Table 64.

Plant	**weight (g)**	**percentage**
Phaseolus lunatus	225.5	24.62 %
Phaseolus cf. lunatus	10.5	1.15 %
Phaseolus vulgaris	5.5	0.60 %
Phaseolus sp.	2	0.22 %
Canavalia sp.	3	0.33 %
Ipomoea batatas	204	22.27 %
Psidium guajava	4.5	0.49 %
Cucurbita sp.	10.5	1.15 %
cf. Cucurbita	1	0.11 %
Pachyrrhizus sp.	14.5	1.58 %
Canna indica	12	1.31 %
cultivated plants	*493*	*53.82 %*
Prosopis pallida	418	45.63 %
Prosopis sp./*Acacia* sp.	2	0.22 %
Schinus molle	3	0.33 %
wild plants	*423*	*46.18 %*
total	**916**	**100.00 %**

Table 64: Total amounts of the edible food plant remains

Of this amount, 423 g or 46.18 % were of wild plants and 493 g or 53.82 % were of cultivated plants (Figure 148). This ratio based on all edible plant remains distinctly shows that cultivated plants were more important in the diet of the inhabitants than were wild-collected plants. This is especially true when taking in account that—as mentioned above—the remains of the cultivated plants were probably less preserved and are thus underrepresented.

However, as mentioned before, a large amount of *Prosopis* (165 g) was associated with one single artifact (1021) which was most probably a storage vessel. This exceptional finding with a high concentration of *Prosopis* remains thus distorts a representative ratio between cultivated and wild plant remains. When excluded, the ratio between the plant groups becomes even more distinct and is of 34.49 % wild plants and 65.51 % cultivated plants (Figure 149). The amount of two-thirds of cultivated plants corresponds to the amount which was reconstructable for societies of Southern Peru which already relied on food-production (see above; Silverman 1993). This result shows clearly that the production of food plants—as expressed by remains of cultivated plants—was in general more important for subsistence than the collection of wild plants, and reflects a distinct focus on those plants within the economy.

However, according to the phasing of the Preceramic occupation of the site it is possible to investigate a diachronic development of the ratios between cultivated and wild plants.[27] The related data is presented in Table 65.

The diachronic distribution shows in general an increasing trend of the amount of cultivated plants within the food plants (Figure 150). While the amount of cultivated plants during Phase 0 was still relatively low with 35.3 % of the food plants, it increased to 52 % in Phase 1 and then reached its peak at 68.7 % in Phase 2. Then the amount of cultivated plants decreased again and only represented 54.4 % of the food plants in Phase 3, decreasing further to 52.6 % in Phase 4. Only 3 g of food plants were recovered from contexts of Phase 5 which is too few to be representative for a ratio between cultivated and wild collected food plants. (The corresponding bar is therefore shaded in Figure 150.)

This generally increasing trend with a turning point after Phase 2 includes the remains of *Prosopis* associated with artifact 1021, and is therefore somewhat distorted. If the distortion produced by this artifact is taken into account and the *Prosopis* remains are excluded, a clearer trend becomes visible (Figure 151). The amounts of Phases 0–3 stay the same, but the amount of cultivated

Species	**Phase 0**		**Phase 1**		**Phase 2**		**Phase 3**		**Phase 4**		**Phase 5**	
	g	**%**	**g**	**%**	**g**	**%**	**g**	**%**	**g**	**%**	**g**	**%**
cultivated												
Phaseolus lunatus	2.5	3.3	9	36.0	71.5	48.6	25	24.5	117.5	20.9		
Phaseolus cf. lunatus	7	9.2	2	8.0			1	1.0	0.5	0.1		
Phaseolus vulgaris					1.5	1.0	1	1.0	3	0.5		
Phaseolus sp.	0.5	0.7			1	0.7					0.5	16.7
Canavalia sp.					2	1.4			1	0.2		
Ipomoea batatas	10	13.1			18	12.2	27	26.5	149	26.5		
Psidium guajava			0.5	2.0					4	0.7		
Cucurbita sp.	5	6.5	1.5	6.0	0.5	0.3	0.5	0.5	3	0.5		
cf. Cucurbita					1	0.7						
Pachyrrhizus sp.	2	2.6			5.5	3.7	1	1.0	6	1.1		
Canna indica									12	2.1		
wild												
Prosopis pallida	47	61.4	12	46.0	45.5	31.0	46.5	45.6	266	47.2	2	66.7
Prosopis sp./*Acacia* sp.	1	1.3			0.5	0.3			0.5	0.1		
Schinus molle	1.5	2.0	0.5	2.0					0.5	0.1	0.5	16.7
Ratios												
wild plants	49.5	64.7	12	48.0	46	31.3	46.5	45.6	267	47.4	2.5	83.3
cultivated plants	27	35.3	13	52.0	101	68.7	55.5	54.4	296	52.6	0.5	16.7
total	76.5	100	25	100	147	100	102	100	562.5	100	3	100

Table 65: Amounts of the edible food plant remains by Phase.

27 The amount includes all remains, even those associated with burials. The exclusion would not significantly change the calculated ratios between wild and cultivated plants: Plant remains of Phase 1 reduced by 2.5 g wild plants and 2.5 g cultivated plants from burials would result in a ratio of 47.5% of wild plants and 52.5% of cultivated plants. Plant remains of Phase 2 reduced by 18 g wild plants and 47 g cultivated plants from burials would result in a ratio of 34.1% of wild plants and 65.9% of cultivated plants. Plant remains of Phase 3 reduced by 2.5 g of wild plants from burials (no associated cultivated plants) would result in a ratio of 44.2% of wild plants and 55.8% of cultivated plants.

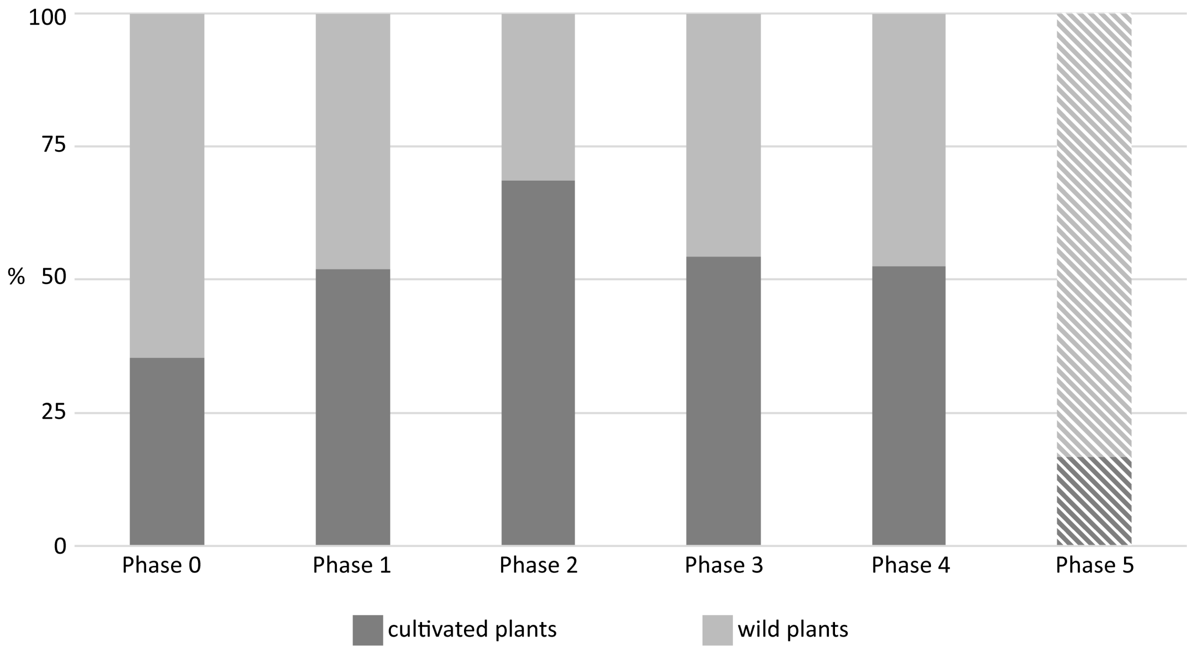

Figure 150: Diachronic distribution of the ratios of cultivated and wild plants. Phase 5 is shaded because the remains are not representative.

food plants of Phase 4—to which artifact 1021 was related—becomes 74.47 %. This offers a more adequate picture of a distinctly increasing trend for the amount of cultivated food plants, growing from about one-third in Phase 0 to nearly three-quarters in Phase 4 (with a drop during Phase 3).

The interpretation of this trend involves the valuation of the plant remains as representative of the importance of the corresponding group—cultivated versus wild plants. According to this, cultivated plants had low importance during the beginning of the Middle Archaic occupation but quickly gained importance. From Phase 1 onwards the plant diet was mainly based on produced plants, whereas the collecting of plants became less and less important for the alimentation of the inhabitants. This trend towards more productivity is documented for the first time in a single Preceramic site in the Central Andes. The reliance on produced, cultivated plants began between Phase 0 and 1, and from then on the reliance increased steadily. The decrease in Phase 3 is not clear, but could represent some problems with the inner organization of the plant cultivation or—to be more specific—problems with the integration of sweet potatoes. Sweet potatoes were less important than Lima beans in the assemblage of cultivated plants in Phases 1 and 2. They became, however, more important than Lima beans during Phase 3—as expressed by higher percentages. Possibly this change in the plant assemblage on the fields caused some problems—such as less harvest than expected, relative inexperience with processing the plant, etc.—that resulted in less productivity which was in turn off-set by greater collection of wild plants. The ratios for Lima beans to sweet potatoes were: 9:0 in Phase 1, 4:1 in Phase 2, 0.9:1 in Phase 3, and 0.8:1 in Phase 4. Thus, Lima beans lost importance in comparison to sweet potatoes, which resulted in new techniques which possibly produced problems in the beginning of this change in cultivation.

In general, the beginning of subsistence at Pernil Alto was characterized by plant collecting with additional plant production. Then subsistence patterns changed markedly to a subsistence based on plant cultivation, after which this new form of getting food continuously expanded. Interestingly, the trend occurs in parallel with the increase of activities related to plant use as described in Chapter 14. The two parallel diachronic trends with increasing activities corresponding to plant use sustain and thus validate each other, indicating that a change from collecting towards producing of plants took place.

In general, in the beginning the subsistence at Pernil Alto was characterized by plant collecting with additional plant production. But then the subsistence changed markedly to a subsistence that was based on plant cultivation and after the change this new form of getting food—not by foraging but by production—was continuously expanded. Interestingly the trend is paralleled with the increase of activities related to plant use as described in Chapter 14. The two parallel diachronic trends with increasing activities corresponding to plant

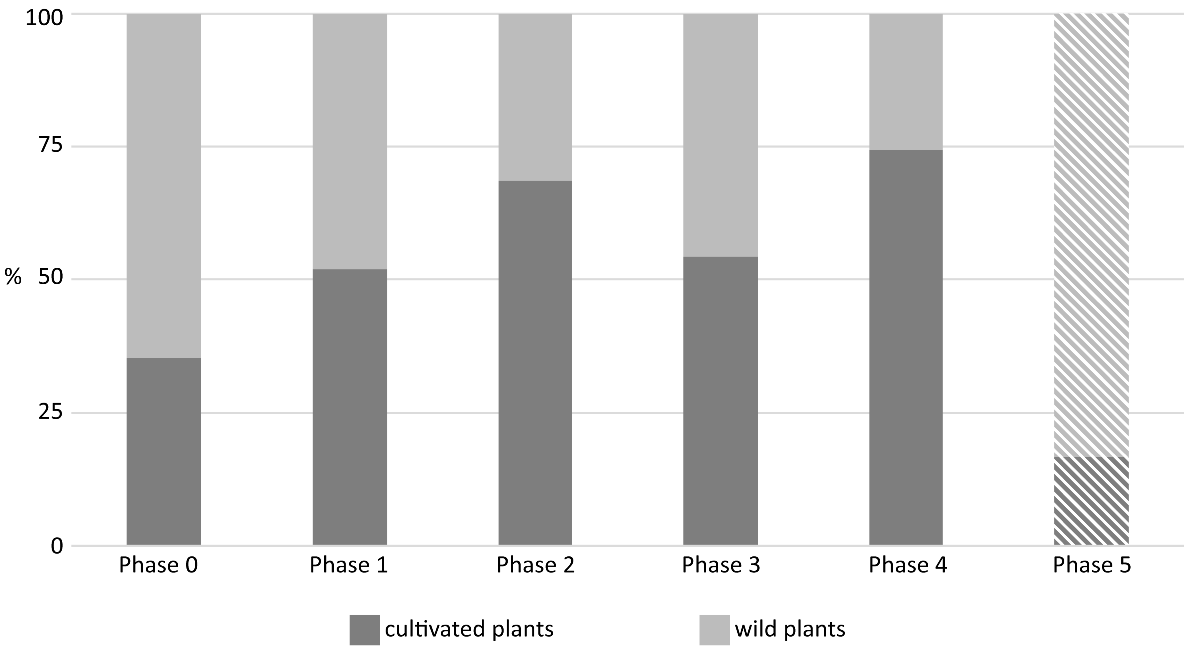

Figure 151: Diachronic distribution of the ratios of cultivated and wild plants without artifact 1021. Phase 5 is shaded because the remains are not representative.

use as drawn from the artifacts and the increasing importance of cultivated plants within the food plants sustain and thus validate each other, indicating that a change from collecting towards producing of plants took place.

Therefore, in Pernil Alto the change from a foraging to a producing economy in plant subsistence took place. However, this corresponds only to the plant alimentation of the inhabitants, while remains of animals and mollusks indicate that hunting and marine resources also formed a part of the settlement alimentation (see Chapter 11). An overall estimation and final characterization of the subsistence at Pernil Alto including both floral and faunal remains will be done in the Chapter 17.3.

17.3 The subsistence of Pernil Alto

After having described and discussed the botanical, faunal and caries information of Pernil Alto (in Chapters 10, 11, 12, 17.1, 17.4, and 17.2), now the economy will be characterized. The main question in this context is whether or not the economy of the inhabitants can be defined already as an agricultural economy. To begin, some basic definitions have to be made for the nomenclature of the terms.

Agriculture is understood as an economic rather than as a technological term. It refers to an economy that is primarily based on the use of domesticated or produced species, which is a widely accepted and applied definition (e.g. Harris 1996a: 446, 2007: 29, Fig. 2.1; Price/Bar-Yosef 2011: S165; Smith 2001: 9). It is thus a quantitative characterization.

Domestication is, in general, the result of a process of manipulating plants or animals which leads to species that are morphologically and/or genetically different from their natural or wild ancestors. This is a qualitative distinction. The use of domesticated species alone does not characterize an economy as agricultural. The "*Presence* of a domesticate is not the same as *dependence* on it (i.e., agriculture)" (Pearsall 2009: 609). Domestication is thus a necessary technological prerequisite for agriculture, but not the key factor. According to Rindos (1984), domestication is the result of a co-evolutionary relationship between humans and plants. The explanation given by Rindos about *how* plants could have been domesticated remains the most convincing model. The archaeobotanical history of the plants which were domesticated in the Central Andes and the northern part of South America still lacks some information. However, thanks to the application of enhanced analyses of microremains (phytoliths, starches, pollen) combined with macro-remain analyses, the domestication history has developed greatly throughout the last two decades. The work of Dolores Piperno and Deborah Pearsall has been instrumental in providing more precise information about the first temporal and spatial occurrences of these species (Pearsall 1992, 2008; Piperno 1998, 2006 2011b; Piperno et al. 2000a; Piperno/Pearsall 1998).

Horticulture is used in this section as a term describing a small-scale system of intensive or garden cultivation of plants with relatively high labor inputs per unit of area, but with a restricted scale of cultivation (in the sense of Bogaard 2005: 179). It is thus a term for describing an applied system of production in which plants were produced, and not as an economic system in contrast to agriculture. Technologically, agriculture would include the use of draft animals and large-scale fields, whereas horticulture is conducted using simple hoes or digging sticks. Furthermore, the system of horticulture intended here would be characterized by a complex ecosystem which would include many different species in a field, in contrast to an agricultural system which would consist of few species. This distinction is made based on the distinction of "vegeculture" and "seed-crop cultivation" as described by Flannery (1973: 273, referring to Harris 1972; see also Bates 2001). To be clear: agriculture indicates in this case the general economic system based on produced plants, whereas horticulture is a technological description based on scale, technology, and number of species.

Cultivation is defined as the preparation of the soil in plots and the planting of plants within these plots to produce plants within the horticultural system.

The task is thus to estimate the importance of horticulture within the subsistence economy of Pernil Alto in order to define the economic subsistence system as agricultural or not. Horticulture was the technique that was applied at Pernil Alto, but whether or not the economic system can be described as agricultural is another point. The distinction between an agricultural system and a non-agricultural system is not strictly binary in this context. There are, and were, numerous societies applying economic subsistence systems which included the cultivation of domesticated plants using a horticultural technological system. But the importance of horticulture was of secondary or tertiary importance within these subsistence economies which were based predominantly on the procurement of food by hunting, fishing or collecting wild plants. For example, Göbel (1993: Appendix 4, 418–424) lists 37 ethnographic and historical groups of the Americas in which horticulture was conducted, but was always of secondary or tertiary importance after food procuring activities. From the Middle Preceramic period there are numerous sites known in which the presence of domesticated plants indicates that horticulture was conducted, however other food procuring strategies—mainly the use of marine resources—dominated the economies. These include the sites of La Paloma (Benfer 1982, 1990, 1999, 2008; Engel 1980, 1982; Quilter 1989; Reitz 1988; Weir et al. 1988), Chilca 1 (Donnan 1964; Engel 1987a, 1988a; Jones 1988), the Huaca Prieta (Bird 1948, 1990; Bird/Hyslop 1985; Dillehay et al. 2012a, 2012b; Grobman et al. 2012), the Quebrada de los Burros (Carré et al. 2005, 2009; Lavallée et al. 1999a, 1999b; Lavallée/Julien 2012b), the sites of the Las Vegas culture in Southwestern Ecuador (Pearsall 2003; Piperno et al. 2000a; Piperno/Stothert 2003; Stothert 1985, 1992; Stothert et al. 2003), and others. Lanning (1967: 67) noted that the sites of the Ancón area up to and including the local Phase V contained already domesticated plants including possibly edible plants, but that the subsistence economies did not depend on them and were in general "mixed economies". He saw full agriculture with the beginning of Phase VI. Even though his chronological scheme was altered with new results, his separation illustrates that he did not see the simple presence of domesticated plants as indicative of agriculture, but rather saw the importance of these plants in relation to other resources as important for the interpretation of the subsistence.

Peter Kaulicke also distinguished distinctly between the presence of first domesticated plants and their importance in the subsistence which still was very low. He writes: "Every early cultivation does not signify a big advantage for its first performers. In nearly every early site, the evidence shows that the early domestication seems a modest addition to prior activities, while a big proportion of food procurement continued to be via by hunting and collecting." (1999: 14; original in Spanish[28], own translation)

Smith (2001) introduced the term "low-level food production" for these kinds of economies. Low-level food production economies should, in this context, not be understood as directly transitional on the route from domestication to agriculture. Thus, societies could have been stable by maintaining an economy of low-level food production. They established a stable way of life between the technological innovation and use of domesticated plants (or animals) and agriculture. Smith calls this economic area the "middle ground". In his opinion, there is a "boundary-zone transition into agriculture [which] can best be considered […] as a region of clinal increase, with isobars of 30, 40, and 50 % for the contribution of domesticates to annual caloric budgets" (Smith 2001: 17 f.) rather than a clear division between agriculture and low-level food production. The term "isobars" originates in Smith's analogy with a landscape but can be translated as the ratios of the amounts of domesticates

28 "Cada cultivo temprano no significó en sí una gran ventaja económica para sus primeros practicantes. En casí cada sitio temprano la evidencía muestra que la domesticación temprana más parece una modesta adición a las actividades anteriores, mientras que una gran proporción de la obtención de alimentos continuó obteniéndose mediante la caza y la recolección." (Kaulicke 1999: 14) within the subsistence or diet of the societies. This means that societies with an amount of 30–50 % of domesticates are located in a transitional economic area between low-level food production and agriculture. The economic beginning of agriculture—when produced food dominated the subsistence—is thus the point at which domesticates contributed at least 50 % to the diet (Zvelebil/Dolukhanov 1991; Zvelebil 1996).

The question is how this ratio of the contribution of domesticates in the subsistence economy of Pernil Alto can be estimated. It is clear that domesticated plants were cultivated at Pernil Alto, and therefore the economy is clearly based on food production. But determining if the economy was a low-level food production economy with less than 50 % of contribution of domesticates, or already an agricultural economy with more than 50 % of domesticates is another question. Zvelebil (1996), who developed a model for the beginning of agriculture for the Baltic area and within the scope of an adopted subsistence system, recommends using faunal remains as an indicator for the amount of domesticates. The "domesticates constituting 50–100 per cent of the faunal samples" would mark the "shift to full dependence on agriculture" (Zvelebil 1996: 325). However, the faunal remains at Pernil Alto are very sparse and are not useful as an indicator under these circumstances. In general, faunal remains are not a very good indicator for subsistence changes in prehispanic South America as faunal food was, with the exception of highland herders, of lower importance for food production in comparison to plants. Plant remains represent a more useful indicator. Changes in the quantities of wild and domesticated plants can be used as indicators for subsistence changes in South America in the same manner that faunal remains are proposed by Zvelebil as indicators for subsistence changes in the Old World. Thus, a multi-proxy approach is applied to estimate the contribution of domesticated plants to the diet of Pernil Alto, which brings together the lines of evidence of the subsistence on the site presented earlier. This multi-proxy approach for the reconstruction of the diet at Pernil Alto follows the approach proposed by Pearsall (2009). Her proposed approach is based on three, and later four, consecutive lines of evidence beginning with "direct, individual indicators of diet" (isotopes, coprolites, skeletal indicators, trace elements), then adding in "indirect, community or household indicators of diet" (cooking residues, faunal remains, macrobotanical remains, soil pollen, soil phytoliths, tools and cooking vessels) and "indirect, extra-community indicators of diet" (agricultural features, site location, site size, water control features, kill sites, sediment cores). These three argumentation lines, beginning with information on the individuals, then building in information on the site and information of the region, had already been proposed (Pearsall 2000), but she later added a further social line (including storage, exchange, and production of surpluses) (Pearsall 2009). Not all indicators proposed by Pearsall can be applied for the reconstruction of the diet at Pernil Alto given that information on all of them is not available.

17.3.1 Direct indicators for the diet at Pernil Alto

The main direct indicator for diet at Pernil Alto are the caries ratios. The caries ratios indicate a diet with a relatively high amount of carbohydrates, which would be in accordance with a high consumption of cultivated sweet potatoes found on the site (see Chapter 12.1). Other skeletal indicators for the diet are not available from Pernil Alto at present, and the analyses of coprolites are still in progress.

Stable isotope analyses were not applied at Pernil Alto. However, the application of C isotope analyses would not have made much sense as these analyses mainly distinguish between C3 and C4 plants, but the only C4 plant in the Central Andes which would have been identifiable with this method was maize (see Webb et al. 2013). No remains of this plant were recovered at Pernil Alto.

On the other hand, Sr-isotope ratio analyses were conducted on the teeth of some individuals (see Chapter 18). Even though primarily applied to get information about the mobility of the population of Pernil Alto, the Sr-isotope ratios provided some information about the diet. That is, a considerable consumption of resources from the littoral or sea—like mollusks or fish—should have been identifiable by higher Sr87/Sr86 ratios than those found in the rest of the study area (Andean foothills and highlands) (see Horn et al. 2008). This was not the case, and the Sr87/Sr86 ratios detected in the teeth of the individuals of Pernil Alto suggest that marine resources were not consumed, or at least were not important in the diet (Christian Dekant, personal communication).

Taken together, the direct indicators for the diet at Pernil Alto strongly suggest a diet with low consumption of marine resources and a high intake of carbohydrate plants, most probably cultivated sweet potatoes.

17.3.2 Indirect indicators of the diet

Here the principle indicators for the reconstruction of the diet of Pernil Alto are presented. The great advantage of most of these indicators is that they can be compared relationally. That is, the indicators of an agricul-

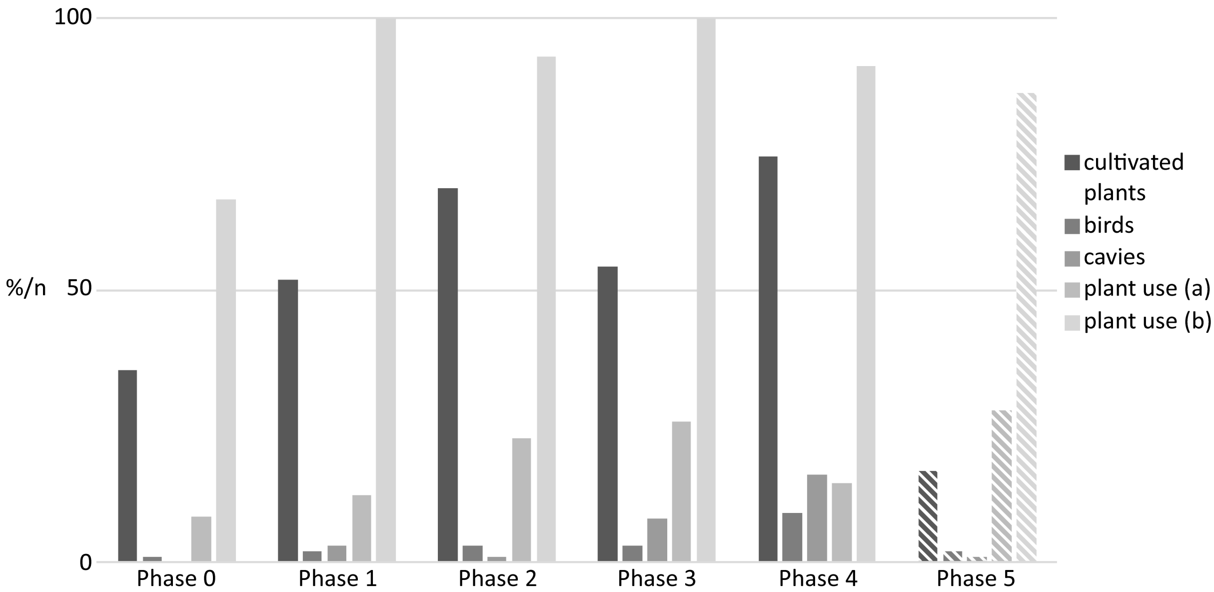

Figure 152: Diachronic development of the indicators for food production. Note that the amounts for "cultivated plants", "plant use (a)", and "plant use (b)" reflect the calculated ratios in percent (see Chapters 14 and 17.2), whereas the amounts of "birds" and "cavies" are given in absolute numbers. "Plant use (a)" represents the total percentage of those activities in relation to all other activity circles, whereas "plant use (b)" is the relation of only plant use activities in direct comparison to foraging activities in per cent. Phase 5 is shaded because the remains and indicators are not representative.

tural economy can be set in contrast to those indicative for food procurement. The related data is presented in Figure 152 illustrating the indicators related to plant-production, and Figure 153 illustrating the indicators related to foraging and plant collecting.

As outlined before, the sparse amount of faunal remains of big hunted animals in comparison with known hunting sites strongly indicates that hunting was not important and only of minor importance for the diet. However, hunting seems to have been more important during Phase 0. Thus 30 % by NMI and 32.14 % by NISP of the remains of big animals were attributed to this phase. This means that roughly one third of the big animal remains originated from this first phase, whereas the other remains were distributed over the five following phases. This indicates that hunting of big animals was more important during the beginning of the occupation. Catching of rodents and birds, on the other hand, seems to have gained importance over time. This can be interpreted as a stronger concentration on the site, resulting in an increasing amount of plant food remains attracting rodents (and maybe birds), which are, in turn, indirect indicators for the higher or increasing importance of plant production.

The remains of mollusks are also sparse, indicating that marine resources did not play an important role within the diet of the inhabitants. However, the ratio of mollusks in relation to fresh water shrimp which originated from the river increases over time, indicating increasing or stabilizing relations towards the littoral over time. However, the general amount of invertebrates is low and therefore this kind of food can be assumed to have been of low importance. Fish remains are practically missing, with the exception of one single remain.

The macro-remains of edible plants account for a total weight of 917 g and are thus a very important indicator for the diet at Pernil Alto (see Chapter 10). They were composed of eight taxa of cultivated plants and two taxa of wild, collected plants. The absolute relation between cultivated plants (65.51 %) and collected plants (34.49 %) characterizes the subsistence economy of Pernil Alto as already clearly agricultural, with a distinct reliance on produced food derived from cultivated plants. But the diachronic distribution of the amounts indicates that the reliance on cultivated plants developed over time. Thus, in Phase 0 the remains of cultivated plants account for only 35.3 %, while the remains of wild plants amount to 64.7 %. This means that during Phase 0, the relation between cultivated and collected plants represents an inverse relation of wild and collected edible plants, as compared to the absolute edible plant ratio. This corresponds with the relatively high amount of hunted big animals during this first occupation phase. From Phase 1 on, the amount of cultivated plants (52 %) exceeds 50 % of the proportion within the total amount of edible plants. This amount steadily increased during the following phases, with a drop during Phase 3. However, even in Phase 3 the remains of cultivated edible plants

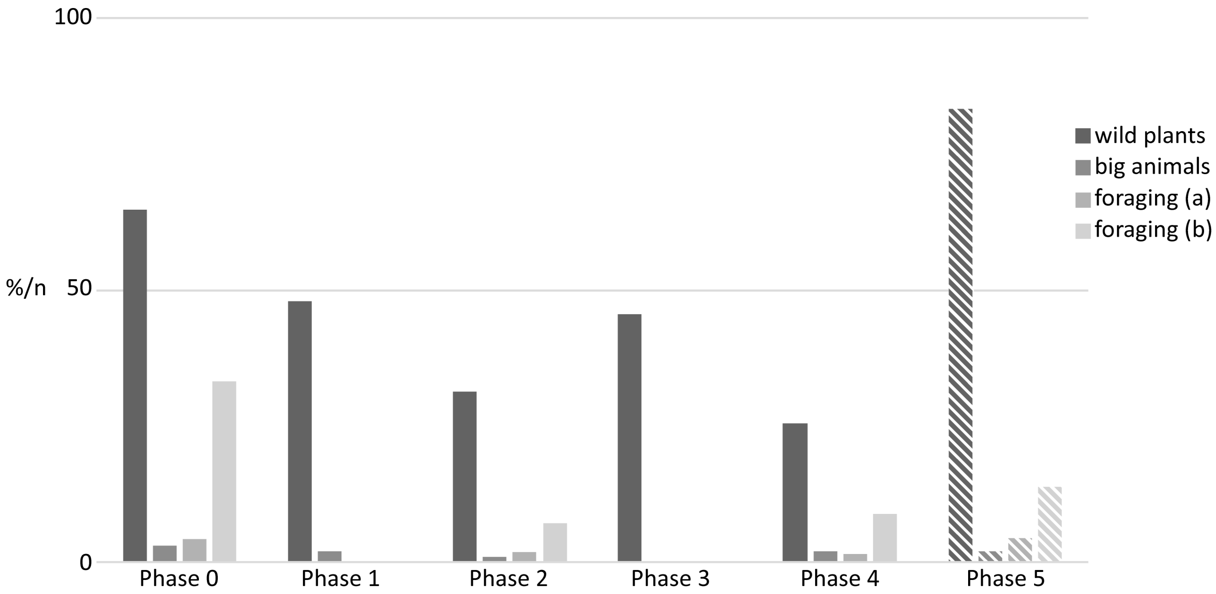

Figure 153: Diachronic development of the indicators for food procurement. Note that the amounts for "wild plants", "foraging (a)", and "foraging (b)" reflect the calculated ratios in percentage (see Chapters 14 and 17.2), whereas the amounts of "big animals" are given in absolute numbers. "Foraging (a)" represents the total percentage of those activities in relation with all other activities, whereas "foraging (b)" is the relation of only foraging activities in direct comparison to plant use activities in per cent. Phase 5 is shaded because the remains and indicators are not representative.

amounted to 54.4 %. The macro-remains of Phase 5 are too few in comparison to the amounts of the earlier phases, and thus are most likely not representative. This indicates that the subsistence economy developed in Pernil Alto from a low-level food production economy in the sense of Smith (2001) in Phase 0 (which was based predominantly in the collection of wild plants and additional hunting) towards an agricultural economy in Phases 1–4 (which was predominantly based on the cultivation or production of plants with a low importance of additional collecting and hunting).

The intra-site analyses of pollen remains (Chapter 10.5) and the remains of phytoliths, pollen, and starches (Chapter 10.4), were not useful in the reconstruction of the economy. However, they indicate that the ground stones were used for plant processing and—even though less clearly—that the assumed area of cultivation was located leeward of the site.

More accurate information could be drawn from the reconstruction of the activities based on the found artifacts (Chapter 14). This indicated that the activities related to plant use increased diachronically. Interestingly, this increasing trend of plant use activities parallels the increasing trend of the amount of cultivated plants, strongly indicating that the two trends were interrelated. On the other hand, activities related to foraging were generally low. The highest importance of foraging activities was evident during Phase 0, when these activities made up 4.18 % of the reconstructed activities. When the activities of foraging and plant use are directly compared, and the amounts of the other activities (handcraft, ritual, and so on) are left aside, then the relative importance of both activities becomes clearer.[29] In this direct comparison, the activities related to foraging make up 33.31 % of the activities in Phase 0, whereas activities related to plant use amount to 66.69 %. However, foraging seems to have been relatively unimportant in the following phases. It is not detectable in the artifact remains of Phases 1 and 3, and remains below 10 % in Phases 2 and 4 when directly contrasted to plant use activities. Only in Phase 5 it could have gained a little importance again, making up 13.79 % in direct comparison to 86.21 %. However, the remains of Phase 5 are not very representative. The general development of the activities fits well with the development of the hunting information and the information drawn from the macro-remains. This activity development is one more line of evidence for a low-level food productive economy with a stronger pronunciation of foraging in Phase 0, whereas the reconstructed activities from Phases 1–4

29 These amounts are depicted in Figure 152 for the plant use activities as "plant use (b)" and in Figure 153 for the foraging activities as "foraging (b)".

strongly indicate an economy predominantly based on agriculture.

Thus, based on the indirect indicators from the site—especially by macro-remains and artifact analyses—a transition towards an agricultural economy can be detected by the transition from Phase 0 to Phase 1 at 5300 BP. It is evident that the economy at Pernil Alto during Phase 0 was a low-level food production economy relying on plant collection, additional cultivation and—in relation to the following phases—still a pronounced degree of hunting. The economy changed by 5300 BP, and the economy from Phases 1–4 can be distinctly described as an agricultural economy based predominantly on the cultivation of plants, additional wild plant collecting, and very limited hunting. However, the catching of birds and rodents became somewhat more important during these later phases, but this seems to correspond with the general agricultural system. The macro-remains of Phase 5 are too few to be representative (only 3.5 g). Maybe hunting—as drawn from the artifacts—became a little bit more important again during this last phase, but it still was of low importance in general.

17.3.3 Indirect indicators of the economy from the site placement

No other archaeological features (like agricultural features, irrigation canals, killing sites, production sites, or similar) from the surroundings of the site are known which could correspond to the preceramic occupation of Pernil Alto. Some smaller test trenches directly adjacent to the site did not deliver any clear remains of the Preceramic period (see Chapter 5.3.3). Nor were any other Preceramic sites detectable in a survey in the middle section of the Rio Grande valley (see Chapter 20). However, the detection of such sites is very difficult due to the lack of distinct artifact types (besides projectile points), the lack of massive stone-wall architecture, the strong alluvial sedimentation, the intensive agricultural use until the present in the fertile river valley, and the general pattern of settling on the edge of the fertile zone throughout prehistoric times until the present which leads to superimposition. Thus, the lack of preceramic features or sites in the middle Rio Grande section does not necessarily mean that the surrounding of the site was not used, but that the use is not evident at this moment. Further investigations and maybe future excavations on later sites that superimpose older remains could bring more information.

Furthermore, indications of landscape use from sediment cores and especially pollen are not available. The landscape is too arid and no lakes or peat bogs are located in the area of the middle Rio Grande section.

The site location, on the other hand, seems to have been ideal for a foraging (in Phase 0) and agricultural economy (in Phases 1–4, and maybe 5). As shown in Chapter 4.3, the site was embedded in a landscape that offered excellent conditions for the economic tasks of the inhabitants: the riparian forest was dense and offered the possibility to collect *Prosopis* fruits. The river offered fresh water shrimp. Hunting could be conducted in the surroundings of the site which were characterized by grasslands and riparian forest where the hunting of cervids and camelids was possible. The latter were probably hunted when the herds were dismounting from higher zones towards the coastal lomas and passed the middle Rio Grande section. The easily accessible hilltop directly north of the site offered a spot from which large parts of the middle Rio Grande section were observable and herds could be easily detected (see Chapter 5.1). However, these foraging parts of the economy were more important during Phase 0, when a mixed economy based on collecting, hunting and low levels of edible plant production prevailed. The site location was also ideal for later agricultural tasks, as the river meander south of the site provided sufficient fertile land that was—due to assumed higher water capacity of the river—humid enough to conduct a polycultural horticulture which predominated the economy from Phase 1 onwards. All demands in regards to soil and humidity of the cultivated plants were met in this location (see Chapter 10.2.1) or could have been easily satisfied by employing simple techniques (see Chapter 17.4). Even a short-term lack of produced resources could have been compensated for with the use of the natural resources from the close surroundings (see Chapter 4.3).

The site itself was placed on a small spur a few meters above the fertile land, possibly to avoid soil humidity in the domestic area or the danger of flooding during strong rain events. However, some exceptional features indicate that the site was nevertheless occasionally hit by bad weather events (compare Chapters 7 and 15.3), as indicated by some eroded material and a few patches of alluvial sediments. However, these could also have been brought to the site by the inhabitants because they were exclusively found within dwelling remains. An increasing concentration on the site with less frequent forays or short time logistical movements for hunting or collecting is furthermore indicated by an increasing trend of handicraft and settlement activities (see Chapter 14). Taken together, the setting of the site in its contemporaneous landscape was ideal for all the economic tasks outlined.

The size of the site indicates a small but structured, nucleated village with a few inhabitants (see Chapter 15). The resources available for foraging and later agricultural production were thus sufficient to establish a stable food supply for the assumed small size of the population.

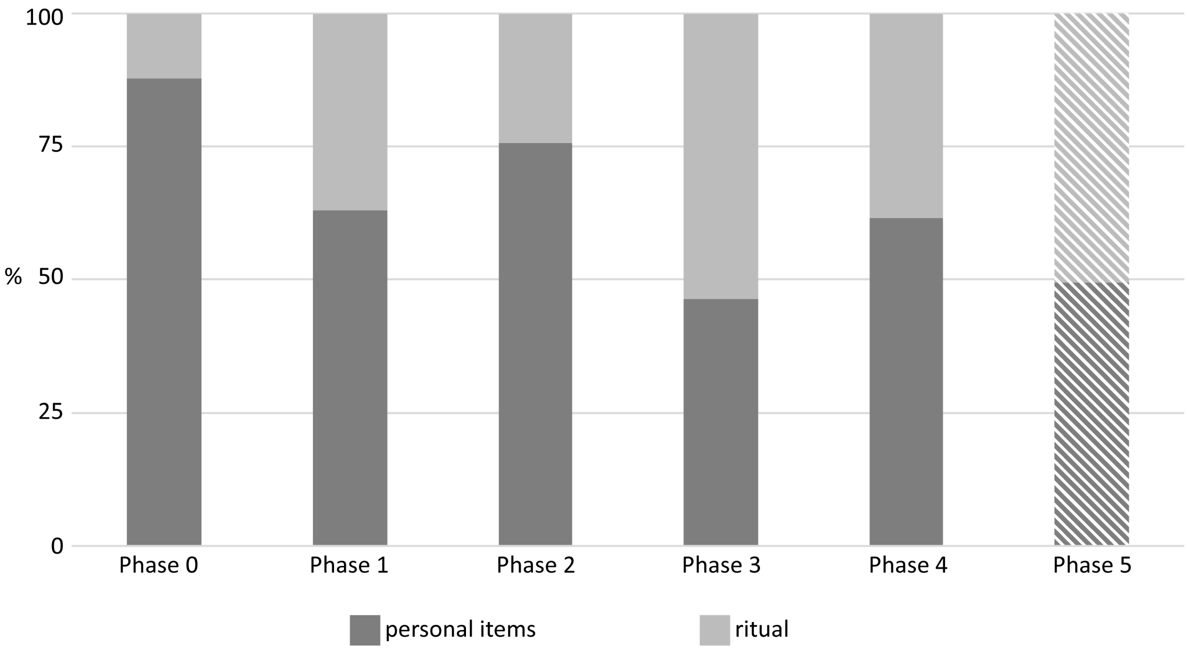

Figure 154: Relation between individual expression (personal items) and community expression (ritual). Phase 5 is shaded because the indicators are not representative.

17.3.4 Indirect indicators of social type

Three of eight pits interpreted as storage pits were attributed to the remains of Phase 0. The remaining five were from Phases 2 (n = 2) to 5 (n = 1 per phase in Phases 3–5). This indicates that storage was not very important at Pernil Alto, and does not necessarily correspond to an agricultural economy. However, as outlined in Chapter 17.4 continuous agricultural production would have been possible, making the need for storage less important.

Other information of a social nature related to the economy includes interrelations with other areas. Even though all needs of the population were met in the direct surroundings of the site, interrelations with other areas are indicated by artifacts. These interrelations were less pronounced with the highland areas, as expressed by the low amount of obsidian (Chapter 9.1.1). On the other hand, relations towards the littoral area were more pronounced, as expressed by remains of shells and shell beads. These relations could represent a kind of exchange which cannot be further characterized at the moment. To do so, more information about the sites of Las Brujas in the lower Rio Ica valley (Vogt 2007; Vogt 2008; Vogt 2011) and Santa Ana on the estuary of the Rio Grande (Engel 1963b, 1987a, 1981) would be necessary. Both sites are preceramic and could, due to their location between Pernil Alto and the littoral, represent possible examples of connection sites between the Andean foothills and the littoral. However, an exchange between these areas could only be evident if remains originating from the middle Rio Grande section could be identified in secure contemporaneous contexts within the mentioned sites. At the moment, an increasing relationship towards the littoral is indicated by an increasing ratio of invertebrates of marine origin in comparison with those from the river (Chapter 11.2). This trend corresponds with increasing agricultural production and therefore it can be assumed that there was a kind of exchange system in which mollusks from the littoral were exchanged for agricultural products from the middle Rio Grande section. However, as outlined before, more information from the preceramic sites towards the littoral is needed.

Another interesting social aspect which might be related to the economic development from Phases 0 to 1 is the relation between the individual and the community. As outlined in Chapter 14, some artifacts can be interpreted as representing an individual expression (personal items) while others represented an expression of the community (ritual). The latter probably had the function of binding the individual with the community, and helping to compensate for and balance conflicts between the interests of individuals and interests of the community. When only the indicators—based on the artifact information—of individual expression and community expression are compared and other activities are excluded, a trend towards a stronger importance of the community is visible (Figure 154). However, the trend is only weakly indicated when compared to the pronounced trends mentioned before. Furthermore, the interpretation is based on the assumption that rituals were conducted by the community, even though they could also have been conducted by single individuals.

However, it seems that personal expression was very important during Phase 0, when community expression was not very important. This situation changes from Phase 1 onwards. From this phase onward the community was more important than the individual. This could indicate that conflicts connected to the beginning of the agricultural economy had to be addressed. The new mode of productive economy needed a communal base, different modes of planning and organization, and a different distribution of resources to meet the demands of the population. This means that individuals in a predominantly foraging and low-level food production economy fulfilled more individual tasks (hunting, catching, collecting), in contrast to a group of agriculturalists which would have had to organize more communal tasks (preparation of the fields, harvest, distribution of the products). The expression of individuality through personal items and the expression of the community through rituals are interpreted as indicative of the importance of such individual or communal tasks.

However—as depicted in Figure 154—the general development towards a society conducting communal tasks drops in Phases 2 and 4, when the individual again gained importance in comparison to the community. These spikes of individual importance were never as high as during the foraging Phase 0, but were still higher than in Phases 1 and 3 and indicates an unstable trend. Interestingly, this unstable trend corresponds to the activities related to foraging (see Figure 153). That is, whenever foraging activities can be detected in the artifact spectrum in Phases 2 and 4, the expression of the individual rises in a parallel manner, which would mean that individual tasks sometimes gained importance in contrast to communal tasks. This pattern strongly suggests that rituals are the expression of a community engaged in communal tasks, and that the individual gained importance when more individual tasks had to be conducted. Therefore, the trend of increasing community expression can be interpreted as an increasing trend of communal integration which would have been necessary within a more organized and complex subsistence economy (indicating agricultural production rather than foraging). Even though less pronounced, the general trend towards communal integration corresponds with the changing mode of subsistence. Therefore, the economic transition is accompanied by a social transition towards more pronounced communal integration over individual expression. To reiterate: the individual was more important when the foraging, low-level food productive economic system in Phase 0 prevailed, whereas the community gained importance when the agricultural system was established.

The social structure—in contrast to the social mechanisms outlined above—is less indicative for social changes. As outlined in Chapter 16.2, social differentiation is very low at Pernil Alto. The only exceptions might be the individuals buried in burials 10 and 29. Burial 10 is assigned to Phase 0 and could represent an individual of high-standing, maybe a kind of "big man", but the interpretation of this burial as an indication of a more hierarchical social organization for phase 0 is not appropriate because of its singularity on the site. Furthermore, only two burials (one of which was disturbed) were associated with Phase 0. Therefore, arguments for a pronounced social structure would be extremely weak, given that the entire site could not be excavated, and outstanding individuals of an assumed high rank are supposed to be very infrequent. Nevertheless, it is possible that burials of high-ranking individuals also exist for later phases but have simply not been detected. With the available data, a relational-quantitative comparison would be misleading considering the low number of burials. The interpretation of burial 29—which contained a mummified individual—is complicated for other reasons, as it is not clear if the mummification was intentional or the result of a specific preservation. The latter interpretation seems more valid (see Chapter 8). In total, no distinct social structure for the society can be reconstructed, and thus no changes in social structures associated with the economic changes were evident in the excavation results.

A further social interpretation can be drawn from the comparison of the paleodemography of Pernil Alto with that of La Paloma. La Paloma is a site located on the central Peruvian coast, dating from 7800–4700 BP (Benfer 1982, 1990, 1999, 2008; Engel 1980, 1982; Quilter 1989). The economy was primarily based on the procurement of wild resources—predominantly marine—with some additional horticulture. The dwelling remains, artifacts, burial patterns, and settlement structure are comparable to that of Pernil Alto. Thus, it is a contemporaneous site of comparable cultural patterns, with the main difference found in the economy. A comparison between the death rates provides insight into the effects of the site economies on the populations. Further, La Paloma is one of the few preceramic sites with a considerable number of detected buried individuals with distinct analyses (Benfer 1990; Quilter 1989). If only the individuals from Phases 1–5—that is, only those Phases associated with an agricultural economy—from Pernil Alto are considered, and the paleodemography is compared to that of La Paloma (Figure 155), a comparison between the death rates of contemporaneous populations living in places with different economic

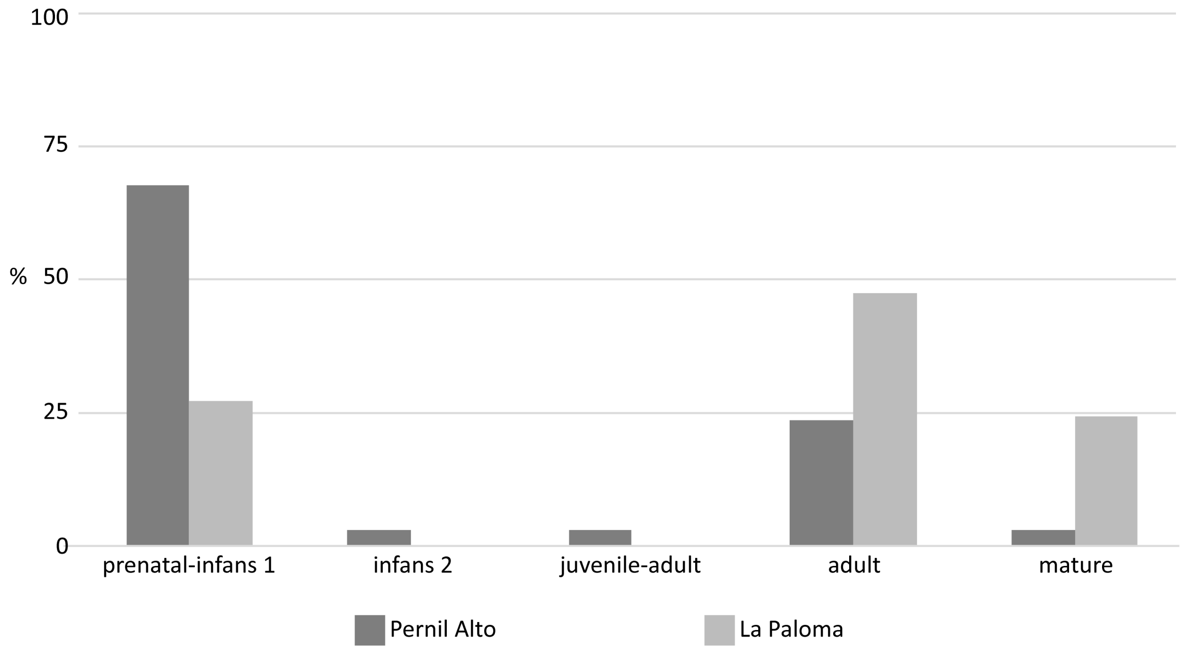

Figure 155: Comparison of paleodemographies from Pernil Alto and La Paloma. Indications are given in percentages. The data from Pernil Alto includes 34 individuals from Phases 1–5. The data from La Paloma is taken from Quilter 1989 and includes 99 individuals.

bases is possible. It is apparent that infant mortality at Pernil Alto was much higher than at La Paloma. This indicates that the foraging economy of La Paloma seems to have been more effective than the agricultural one of Pernil Alto in Phases 1–5. It is possible that organizational problems were associated with these difficulties. It is likely that a diet with protein—which was based in marine resources in La Paloma and beans in Pernil Alto—probably played an important role. In general, an early agricultural economy appears less efficient than the more "traditional" foraging and low-level food productive economy. However, these assumptions are drawn from the information of only two sites, and other aspects—like higher infection rates in the river valley—might have played a role in this paleodemography variation. Further research is needed to clarify if, and how, the adoption of agriculture could have affected infant mortality.

17.4 Cultivation at Pernil Alto

Some conclusions can be drawn from the depiction of the recovered food plants. The demands for growing conditions and habitats of all found cultivated species were fulfilled at Pernil Alto or near the site. However, some plants like *Canavalia* or sweet potatoes have higher precipitation needs than the reconstruction of the precipitation showed (Eitel et al. 2005). On the other hand, Lima beans prefer dry climates. However, the abundant remains of sweet potatoes distinctly indicate cultivation and therefore some kind of planned water use to bring enough water to the plants. There are some possibilities for such water planning: Engel (2010: 315) assumed that the planting of the cultivated plants at the Preceramic site of Chilca 1 took place directly in the fertile silt of the Río Chilca when it seasonally carried less water. This scenario is also plausible for Pernil Alto as the water flow of the Río Grande has seasonal changes. Probably the planting was done in the ancient river meander directly south of the site which lies about 2–3 m above the actual river bed. As mentioned before, sweet potatoes need wetter soil when they are planted, but too moist soil can have negative effects on the plants during the growing process. Therefore, the planting can be assumed for the time directly after the highest water flow in the Río Grande, when the water level decreased but the soil still was wet. If the seasonal distribution of the actual water transport in the Río Grande valley is assumed for an orientation to the situation of the Middle Holocene, then planting can be assumed in April and maybe May. Furthermore, if a cultivation aiming at self-subsistence and not aiming at surplus production is assumed, then a simple watering technique for the cultivated plants could have been applied. Watering would have been possible with the available bottle gourd vessels, and cultivation for self-subsistence not would have over-stressed the necessary work input as the Río Grande carries water during the entire year and is in very close proximity to the meander. If this simple water management technique was applied, year-round planting was possible at Pernil Alto. Even a simple form of an irrigation system including canals to manage the water might have been possible. Some structures were found in the area of the Zaña valley in Northern Peru which were interpreted as representing such simple small-scale gravity canals which were dated to at least 5600 BP or maybe even as early as 6700 BP (Dillehay et al. 2005), indicating a possible very early beginning for such irrigation systems in Peru. An exact dating for irrigation canals is somewhat problematic, as canals are no secure, closed contexts and old material could have been removed by their construction or be removed by water flow from the canal walls. Furthermore, irrigation canals are not known from any other Preceramic context in the Central Andes. The general beginning of continuous irrigation agriculture in the working area is dated to 3500 BP based on the studies of irragric anthrosols (Hesse/Baade 2009) and thus 1500 years after the abandonment of the Preceramic occupation of Pernil Alto. However very early and not continuously practiced irrigation agriculture might have left too few remains to be reconstructable by anthrosols. Thus, the exact method of water management applied to the planting is unknown at Pernil Alto but has to be assumed in some form due to the water needs of the found plants and the insufficient precipitation. The most probable solution appears to have been the use of the moist soils of the meander—which, with an area of about 6.5 ha, has a sufficient size—and maybe watering. The necessary tools—especially digging sticks—for loosening the soil, planting, and harvesting as well as for watering—in the form of vessel remains—were found on the site as shown in Chapter 9. Thus, all technological and environmental requirements for cultivation are evident at Pernil Alto.

Because of the favorable climatic situation during the Middle Holocene in the working area—including high insolation, precipitation, seasonally flooded alluvial, rich, and deep soils, and perennial water flow in the river—year-round planting was probably possible at Pernil Alto. Even today, up to three harvests are possible in the working area (compare Chapter 4.1.1). Especially sweet potatoes with a (modern) growing period of 4 to 6 months until harvest (Brücher 1989: 8) and Lima beans with an earliest possible time of harvest after about 100 days and two flowering periods per year (Hernández Bermejo/León 1994: 57) could have been planted twice or even three times a year. Therefore, depending on shifting planting—even within the various species—a year-round harvest at Pernil Alto could have been possible, as the seasons are not as pronounced as in temperate zones. A peak can, however, be expected towards the end or shortly after the rainy season. However, as shown in Chapter 4.1.1, the Río Grande never runs entirely dry and more precipitation than today can be assumed for the preceramic occupation. Thus, plant consumption was most probably possible year-round, storage was not very important and during times with less productivity of the cultivated plants, foraging of wild resources—as *Prosopis*, hunting and fresh water shrimp collection—could have helped to bridge those periods.

If the area of the meander south of Pernil Alto (about 6.5 ha) is assumed to have been entirely planted and is then placed in relation to the amounts of the cultivated plants, a—very tentative—calculation of a possible harvest can be completed. This calculation is based on the percentages of the weights of the found plant remains. These percentages are used as indicators for the percentage of the corresponding cultivation area in the 6.5 ha meander and the area can be calculated (% of plant remains = % of the area in the meander). The calculated area is then multiplied with the estimated yield for the corresponding plants. Only the remains of the cultivated plants are taken into account here, including bottle gourd, which had a total weight of 1211g. In a next step, the calories produced with these yields can be calculated. The result will be divided by the caloric needs of a fictive population.

The results are only valid for the two major cultivated food species of sweet potatoes and Lima beans. All other cultivated species represent less than 1 % of the weight of the cultivated plants, with the exception of *Pachyrhizus* which has an amount 1.2 %. However, the caloric productivity of bottle gourd is not included, as the plant is not edible. This calculation is in general very tentative and suffers from some problems. First, the preservation of the various edible plants differs greatly. Second, the space covered by the plants is not very well known. Third, the calculations include the plant remains from all occupation phases, thus representing a generally possible average harvest. However, this was done only to see if the meander would have offered enough space for the planting, and should be understood as a means of checking if the minimal spaces for cultivation were available close to Pernil Alto.

The yields for sweet potatoes are calculated with 8000 kg/ha (based on Brücher 1989: 8) and with 1611 kg/ha for Lima beans (based on the actual yields of Lima beans in the working area as reported by the Gobierno Regional de Ica 2002: 6). The caloric amounts are taken from USDA (2015) and are calculated with 85 kcal for 100 g sweet potato and 115 kcal for 100 g Lima beans. The results are presented in Table 66.

The calculation shows that it would have been possible to produce a total of 9,688,127 kcal with one harvest

plant	weight (g)	weight (%)	area (ha)	1 harvest / year		2 harvest / year	
				yield (kg)	kcal	yield (kg)	kcal
Phaseolus lunatus	225.5	18.62 %	1.21	1949.90	2,242,380	3899.79	4,484,759
Phaseolus cf. lunatus	10.5	0.87 %	0.06				
Phaseolus vulgaris	5.5	0.45 %	0.03				
Phaseolus sp.	2	0.17 %	0.01				
Canavalia sp.	3	0.25 %	0.02				
Ipomoea batatas	204	16.85 %	1.09	8759.70	7,445,747	17,519.41	14,891,495
Psidium guajava	4.5	0.37 %	0.02				
Cucurbita sp.	10.5	0.87 %	0.06				
cf. Cucurbita	1	0.08 %	0.01				
Pachyrrhizus sp.	14.5	1.20 %	0.08				
Canna indica	12	0.99 %	0.06				
Lagenaria siceraria	718	59.29 %	3.85				
total	**1211**	**100.00 %**	**6.50**	**10,709.60**	**9,688,127**	**21,419.20**	**19,376,254**

Table 66: Calculation for possible produced yields and kcal in the meander.

per year or 19,376,254 kcal with two harvests per year. The daily caloric intake of the Preceramic population was estimated based on skeletal remains and ethnographic comparisons for the Ayacucho basin (MacNeish 1983). The data is appropriate for calculations for the population of Pernil Alto as it represents the closest available data for a Preceramic population in space and time to Pernil Alto. The daily caloric intake for the Preceramic population of Ayacucho was—depending on age and sex—estimated between 1041 kcal for males in the age of 0–9 years and 2210 kcal for males in the age of 20–34 years (MacNeish 1983: 240, Tab. 8-3). If the highest estimated daily intake is taken into account to estimate the maximum caloric need, then the estimated caloric production at Pernil Alto would have been sufficient for 4384 days with one harvest a year or 8768 days with two harvests. Thus, the possible average productivity would have easily been sufficient for a small population of 12–30 people depending on the age and sex distribution. The only significance of this result is that the meander would have offered enough space for planting and was thus probably the area of cultivation of Pernil Alto.

An issue with the plant remains of Pernil Alto is, however, the varying preservation which leads to a varying representation. Especially tubers—like sweet potato and *Canna*—have a poorer preservation than seed plants. Furthermore, some plants were probably consumed as cooked vegetables—like Lima bean pods and *Canavalia*—leading to a poorer preservation. Only the seeds of squash are preserved, even though the fruits can be relatively big and heavy. Nevertheless, the amounts of some plants are so low in relation to the amounts of other plants that they could represent some experiments with new species for integration in cultivation. Another possibility is some exchange with other, close by, contemporaneous sites in the middle Río Grande section, but this is unknown. However, in total, the setting of Pernil Alto was ideal for the planting of sweet potatoes and Lima beans which is reflected by the highest amounts within the cultivated edible plants of these two species. These two plants represent 87.12 % of the weight of the cultivated edible plant remains. The remaining 12.01 % are distributed throughout yam beans, canna, squash, common bean, jack bean, guava, and other undeterminable beans.[30]

The two main cultivated species of sweet potatoes and Lima beans complement each other well in their nutritional value, as sweet potatoes are rich in carbohydrates and Lima beans are rich in protein. They formed the basis of the plant cultivation at Pernil Alto which most probably took place on the river meander south of the site.

On the other hand, few wild plant species were used at Pernil Alto, especially of *Prosopis*. But its importance in the diet corresponds already with that in fully agricultural societies of Southern Peru (see Chapter 10.2.2). It is now important to place the mode of plant production within the emergence of agriculture in the Central Andes. This is done in the following section.

30 0.87% of the amount is of *Phaseolus* cf. *lunatus*

17.5 Final characterization of the economy at Pernil Alto

Based on direct and indirect indicators, the economy at Pernil Alto can be characterized as follows: the center of economic activity was located on the site during all phases, and the direct area and its surroundings met all necessary requirements for the ascertained economic activities.

During Phase 0, the economy was predominantly based on foraging (hunting, plant collecting) and an additional low-level food horticultural production was of secondary importance. The accompanying social organization was probably oriented towards more individual tasks of food procurement. External relations towards the littoral and the highlands already existed, but were less pronounced or stable than in the following phases.

Beginning with Phase 1 the economy changed and was from then on predominantly based on an agricultural production within a horticultural cultivation technique. However, additional collection of wild plants, hunting, and catching of birds and small animals continued even though it was of distinctly less importance than before. In particular, the number of small animals was related to higher amounts of plant remains and more plants in the fields than before. The social organization probably changed along with this economic change, resulting in more communal work as a result of the organizational needs of the newly established economic system. External relations with the highlands continued but were less important than before. On the other hand, the relations with the coast—maybe within a kind of exchange system—were stabilized. The production of plants can be assumed in plots, conducted with a horticultural technique in which plants were grown in a polycultural assemblage. This new economic mode was maybe less effective than a foraging economy, as the comparison with other sites (La Paloma) suggests. Agriculture began at Pernil Alto by about 5300 BP and continued until the site was abandoned by about 4900 BP.

The reasons for the change towards an agricultural economy remain enigmatic and cannot be explained by the internal information of the site. The fact that even more burials from the phases with agriculture were detected does not help, because it is unclear if the population in the later phases was indeed higher, or if the individuals were buried at other places, or if simply not all burials were recovered. Furthermore, it is unclear if a higher population emerged before the change to agriculture, leading to population pressure which triggered the economic change (compare Cohen 1978), or if population pressure is the result of a changed economic system. More regional studies would be necessary to clarify if and when the population grew in the study area. However, internal changes (of social or ritual nature) during the first foraging phase have to be recognized as possible triggers. This is, due to the lack of finer dating, impossible. Thus the only factor which can roughly be connected to the beginning of agriculture at Pernil Alto is a slight increase in moisture in the highland catchment area of the Rio Grande by about 5500 BP (Schittek et al. 2015). However, the beginning of a slightly moister phase and the beginning of agriculture at Pernil Alto differ by about 200 years. It is possible that agriculture started even earlier, already by 5500 BP, at Pernil Alto. Yet this trend is not visible because the first Phase 0 cannot be dated more accurately and thus the phase cannot be subdivided into finer sub-phases which would be needed to identify the economic changes more precisely.

With the available data it is only possible to identify agriculture clearly by 5300 BP. Furthermore, the Preceramic period is in general poorly known from the working area and thus other—maybe more important—factors for economic changes are not visible at the moment.