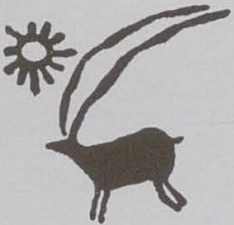


Modeling Neolithic Agriculture and Stock-Farming at Swiss Lake Shore Settlements-Evidence from Historical and Ethnographical Data

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ABSTRACT: Historical and ethnographical data from 30 villages are the basis for ecosystem analyses aiming to develop key features for agricultural systems that meet the Neolithic situation at Swiss lake shore settlements as exactly as possible. Basis of all calculations is the average composition of the people's daily diet. The results show that meat and animal products are unimportant for the nutrition compared with the importance of plant products. Cattle are kept above all to provide the people with traction work, dung and dairy products, other reasons may be prestige, religious meaning of cattle, investment or others. Fields and cattle compete with each other, because cattle need constant care while cultivation is highly seasonal. Fields always have first priority. Peak loads of work during the vegetation period are avoided by distributing the work as evenly as possible throughout the year. Free access to pastures in the form of transhumance systems increases the number of cattle per head. Maximum values are less than one cattle per head and about half a hectare of arable land per head. A heavy divergence from these key features in Neolithic times is regarded as unlikely. The paper concludes with a short consideration of the importance of these results for further reconstructions of Neolithic agricultural systems.

KEYWORDS: AGRICULTURE, STOCK FARMING, SWITZERLAND, NEOLITHIC, ECOSYSTEM

RESUMEN: La información histórica y etnográfica procedente de 30 aldeas constituye la base de un análisis de ecosistemas cuyo objetivo es detectar rasgos claves de los sistemas agrícolas que coincidan, de manera tan precisa como sea posible, con la situación durante el Neolítico en los yacimientos lacustres suizos. La base de todos los cálculos es la composición media de la dieta diaria de la gente. Los resultados demuestran que tanto la carne como los productos de origen animal son secundarios en la nutrición al ser comparados con la importancia de los productos vegetales. El ganado vacuno se mantiene, ante todo, para proporcionar a la gente fuerza de tracción, estiércol y productos lácteos, siendo otras razones el prestigio, las implicaciones religiosas de dicho ganado o la simple inversión de capital. Los campos de cultivo y el vacuno compiten entre sí dado que este ganado precisa de cuidados constantes mientras que el cultivo es fuertemente estacional. Los campos siempre tienen prioridad en las tareas de mantenimiento. Cargas máximas de trabajo durante la fase de crecimiento vegetal se neutralizan hasta cierto punto repartiendo dicho trabajo de manera equilibrada a lo largo de todo el año. El acceso libre a los pastos, bajo la forma de sistemas de trashumancia, incrementa el número de cabezas de ganado criadas. Los valores máximos suelen estar por debajo de una vaca per capita y alrededor de media hectárea de tierra cultivable. Cualquier divergencia marcada de estos rasgos claves durante épocas neolíticas se considera altamente improbable. El trabajo concluye con una breve consideración sobre la importancia de estos resultados a efectos de reconstrucción de los sistemas agrícolas neolíticos.

PALABRAS CLAVE: AGRICULTURA, GANADERÍA, SUIZA, NEOLÍTICO, ECOSISTEMA

ZUSAMMENFASSUNG: Auf der Basis von historischen und ethnographischen Daten aus 30 Dörfern werden mithilfe von ökologischen Systemanalysen Eckwerte für landwirtschaftliche Systeme entwickelt, die in möglichst vielen Punkten mit den Verhältnissen der neolithischen



Seeufersiedlungen der Schweiz übereinstimmen. Basis der Berechnungen sind jeweils durchschnittliche Nahrungszusammensetzungen der Bevölkerung. Als Ergebnis lässt sich festhalten, dass Fleisch und tierische Produkte im Vergleich zu pflanzlichen bei der Ernährung unbedeutend sind. Rinder werden in erster Linie zur Versorgung mit tierischer Arbeitskraft, Dung und Milchprodukten gehalten, andere wichtige Kriterien können Prestige, religiöse Gründe oder Rinder als Kapitalanlage sein. Da Rinder das ganze Jahr hindurch konstante Pflege brauchen, Arbeiten auf dem Acker aber saisonale Schwerpunkte haben, konkurrenzieren sich Viehhaltung und Ackerbau. In jedem Fall wird dem Acker der Vorzug gegeben. Eine möglichst gleichmässige Verteilung der zur Verfügung stehenden Arbeitskraft übers Jahr verhindert Spitzenbelastungen während der Anbausaison. Freie Weidefläche für das Vieh, die in einem Transhumanz-System genutzt werden kann, erhöht die Anzahl der gehaltenen Tiere pro Kopf. Obere Werte für den Viehbesatz liegen bei weniger als einem Rind pro Kopf, für die Ackerfläche bei etwa einem halben Hektar pro Kopf. Eine massive Abweichung von diesen Zahlen in neolithischen Zeiten ist eher unwahrscheinlich. Die Bedeutung dieser Ergebnisse für zukünftige Rekonstruktionen neolithischer Landwirtschaft auf der Basis von quantifizierenden Modellen wird kurz angesprochen.

INTRODUCTION

Neolithic lake shore settlements of Switzerland with their excellent preservation of organic materials and comparatively dense data base offer great possibilities for complex ecosystem analyses¹. Still methodological problems and gaps in the source materials prevent the use of inherent data for analysing a number of important aspects of agriculture. For example it is not possible to quantify the importance of different plant species like cereals and pulse or plant and animal sources of nutrition with archaeobiological material alone². Complex analogies on the basis of historical and ethnographical data may help to understand interdependencies between different subsystems of agriculture and to develop models for Neolithic agricultural systems of Swiss lake shore settlements³.

The following paper presents preliminary results of a quantitative analysis of the agricultural systems of 30 villages which aims at delivering reliable data for such models⁴.

MATERIAL AND METHOD

To learn about traditional agriculture and its limiting factors, data of 30 villages were collected concerning the subsistence economy and the average composition of the diet. The chosen villages had to meet the following conditions to be comparable with the Neolithic situation:

- unity of producer and consumer, that is self sufficient subsistence economy for basic needs
- traditional agriculture without artificial fertilizer and mechanization
- diet based upon cereals and domesticated animals, especially cattle
- climate with marked seasonality, that is with a vegetation period and a non-vegetation period, during which people have to live from stored goods
- easy access to different ecological zones

Villages fulfilling all conditions were most frequently found in geographic and ethnographic sources from the Himalaya area⁵, also in historic sources from Central Europe⁶ and in a few ethno-

¹ See for example Glass (1991); Gross, Jacomet & Schibler (1990); Sakellariadis (1979); about ecosystem analysis: Moran (1990).

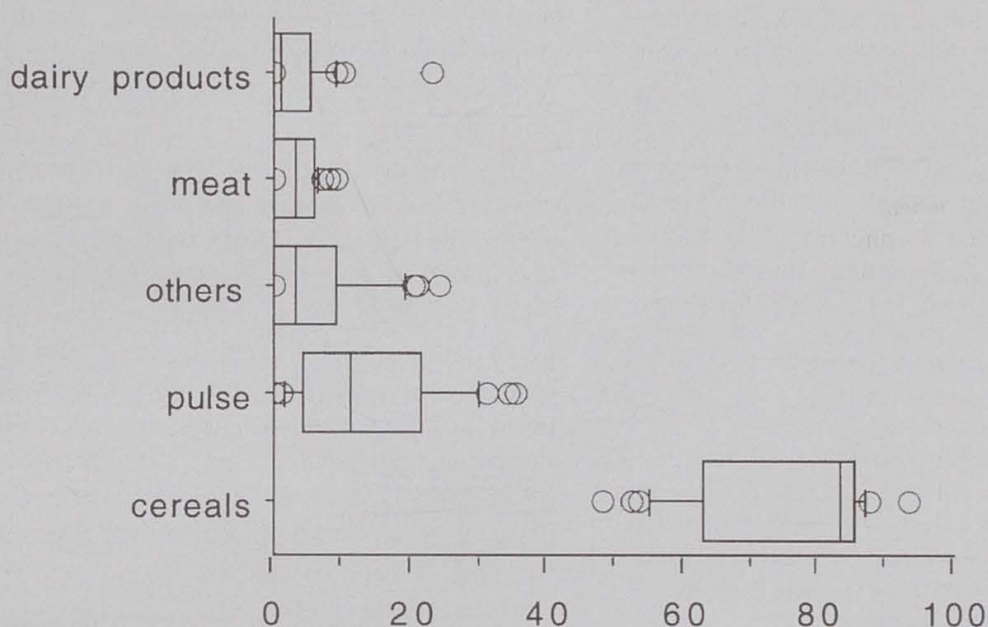
² Detailed discussion about problems of quantification can be found in Gross, Jacomet & Schibler (1990).

³ About analogies and the use of ethnographic data see for example: Bernbeck (1997); Eggert (1993); Gould & Watson (1992); Kramer (1979); Noll (1996) & Wylie (1985).

⁴ Ph.D. thesis at the Institute of Prehistory, University of Basel (Prof. J. Schibler), finished in summer 1999.

⁵ Most important works: Berreman (1993); Bishop (1990, 1998); Brauen (1994); Chafi & Donner (1994); Fox (1993); Fricke (1986); Haas (1970); Herbers (1998); Herbers & Ströber (1995); Kleinert (1983); Kreutzmann (1989); Rhoades & Thompson (1975); Sagaster (1989); Schicklgruber & Pommaret (1998); Singh (1993).

⁶ Best examples: Beck (1986) (with a lot of references about ecological approaches in the historical sciences) and Netting (1981); others: Anneler & Anneler (1917); Biddick (1989); Budmiger (1970); Cole & Wolf (1974); Unstead (1932).



Descriptive Statistics

	cereals	pulse	others	meat	dairy products
Mean	74.517	13.345	5.828	3.034	3.310
Std. Dev.	12.919	10.831	7.383	3.006	4.950
Std. Error	2.399	2.011	1.371	.558	.919
Count	29	29	29	29	29
Minimum	48.000	0.000	0.000	0.000	0.000
Maximum	93.000	35.000	24.000	9.000	23.000
# Missing	0	0	0	0	0

FIGURE 1

Average composition of diet, described in percent of calories per person and day (count: 30 villages). Box-and-whisker plot showing median, 25-percent and 75-percent quartiles as boxes, 10-percent and 90-percent quartiles as "whiskers" and extreme values as circles.

graphic sources from other areas outside Europe or the Himalaya⁷. The Himalaya examples chosen use systems of mixed mountain agriculture with varying importance of animal husbandry (Schweinfurth, 1993). Situated mostly in the moist conifer-oak-forest of Northern India and Nepal and in the steppe-forest of the northwestern parts of the Himalaya (Singh & Singh, 1992), they have

the possibility to incorporate large areas of forest and Alpine meadows into their agricultural systems - a situation similar to the given conditions in Neolithic Switzerland.

As expected, there is no data meeting exactly the same set of conditions given in the Neolithic period, but the collected data sample provides a basis for calculating models of different agricultu-

⁷ Africa: Kreuzer (1997); Krings (1991); South America: Ruiz de Arévalo (1987).

ral systems. The basis for all calculations is a computer-aided calculation of every village, which describes the given agricultural system with the help of index numbers like the quantity of hectares of arable land per head, the average yield of cereals per year, the average number of cattle per head and others. The calculation results in a model regarding the average daily amount and composition of food per person, counted in kilocalories and grams of protein⁸.

RESULTS

The most important food to meet the daily demand of calories are cereals (Figure 1). They form between 65% and 85% of the whole input of calories with an average at 75%.

Next important is pulse with an average frequency of 13% and values reaching up to one quarter of all calories. Pulse is cultivated and eaten by nearly all villagers of the data sample. The amount of calories per kilogram is nearly the same as in cereals and the amount of protein is exceptionally high. Served as side dish together with cereals pulse forms a complete meal. Furthermore, it is easy to store. Important species belonging to pulse are lentils, peas and especially beans.

Dairy products include fresh and sour milk, butter, cheese and clarified butter, to mention only the most important ones. They can achieve values above 10%, but there are also many villages, where cattle in general and dairy products in particular, are not important. Therefore the average importance of dairy products is only 3.3%.

Meat is generally not important, reaching an average value of only 3% with several values below 1%.

Vegetables and fruits are difficult to quantify, therefore they are subsumized in the group of "others". The amount of calories is usually low, but they provide people with vitamins and therefore are an important component of the diet. "Others" can also be oil fruits or other food species being locally or culturally very important. Some groups in the Himalaya area have sophisticated fruit-tree cultures, especially apricots, which are important as dried food in the winter and supply the people with valuable calories and fats in the form of apricot oil. Others cultivate sun hems, sugar cane or flax, to mention only the important

species. As all these species are of divergent importance and appear only in one or a few of the 30 villages, they are not included in the following considerations.

Because of the positive ratio of volume input to calories output cereals form the most important part of the daily diet. A sufficient supply with cereals always has to be provided for. All available labor and time has to be invested in cereals to achieve this aim. As cereals together with the other cultivated species grow only during the vegetation period, the amount of labor is especially high during this period. This special factor, the amount of working capacity given and its distribution over the year, turns out to be one of the most important limiting factors of all the agricultural systems analysed in the sample.

Data from a village situated in the Hunza valley (Karakorum mountains) allow to compare the composition of the diet on the one hand (Figure 2) and the time demand for every agricultural activity on the other hand (Figure 3). Again, cereals have the best ratio of time input to calories output, while dairy products, vegetable and fruit (apricots and apples) have worse ratios. All these categories of

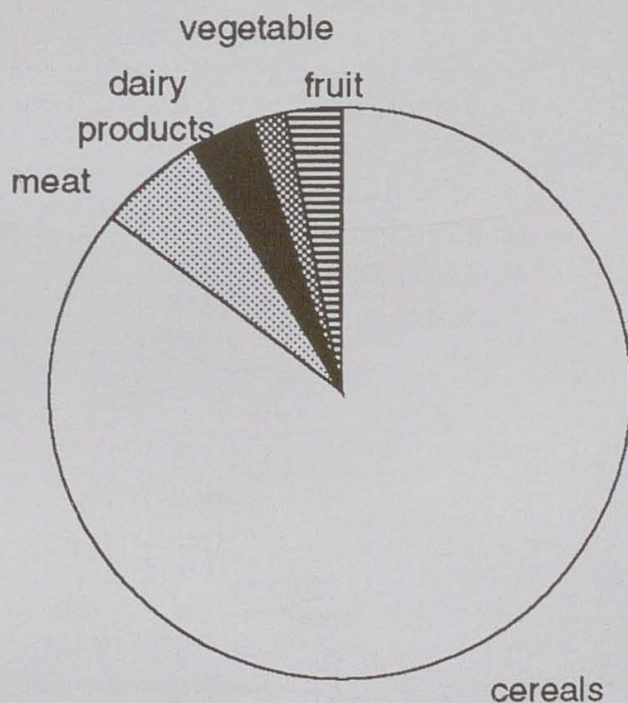


FIGURE 2

Daily calories input per category of food for a village in the Hunza valley, Karakorum (after Kreutzmann, 1989). Basis of calculation: average percent of total calories per person and day.

⁸ For a detailed description of the model see Gross, Jacomet & Schibler (1990).

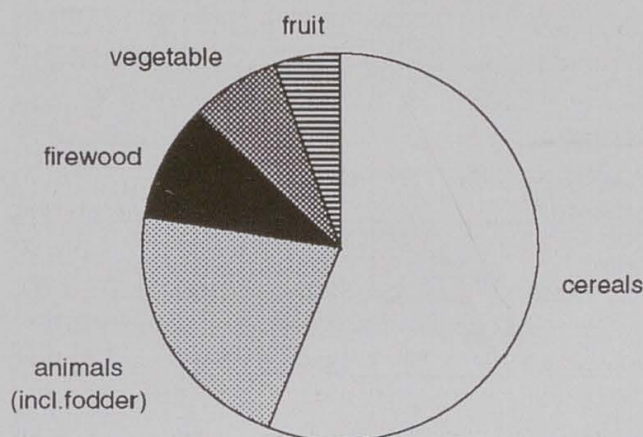


FIGURE 3

Calculated working time per activity expressed as percent of year average for the same village as in Figure 2 (after Kreutzmann, 1989).

food are relatively time-demanding and do not contribute very much calories to the daily diet.

Surprisingly high is the amount of work that has to be done for the collection and storage of firewood.

The distribution of labor over the year shows a high manpower deficit during the time of the vegetation period, while in the winter time there is a manpower surplus (Figure 4).

The time demand for cereals and for livestock is very different (Figure 5). During the vegetation period the people of the village spend between 60% and 80% of their whole agricultural activities at the fields each month, while other regular activities

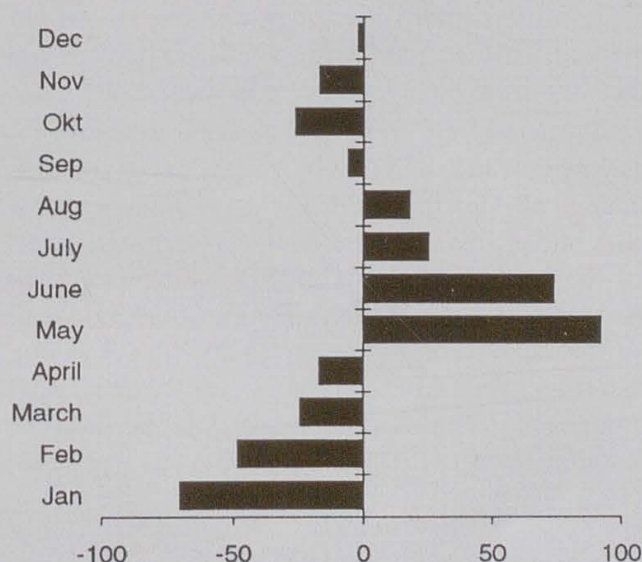


FIGURE 4

Distribution of working hours over the year. Divergence from the year-round-average per month in percent (after Kreutzmann, 1989). Left side (negative values): manpower surplus, right side (positive values): manpower deficit.

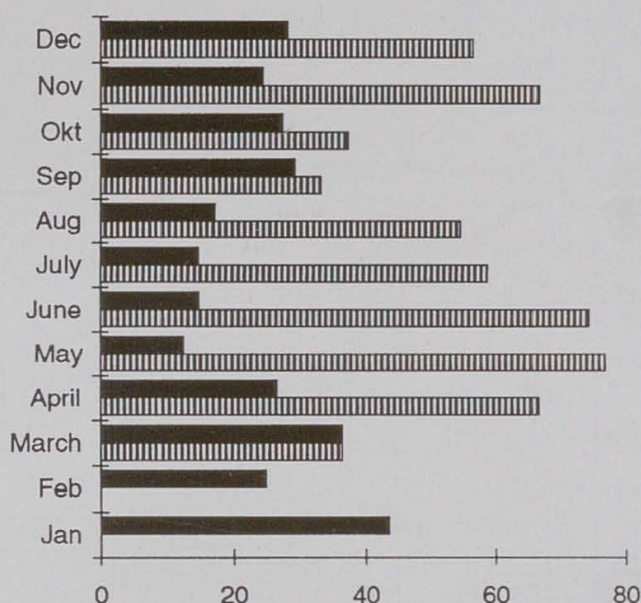


FIGURE 5

Distribution of working hours over the year for two different important activities: producing cereals (striped bars) and cattle breeding (black bars). Basis of the calculation are percent of monthly average (after Kreutzmann, 1989).

vities like herding cattle have to be reduced to a minimum. In the winter time cattle needs more care and more work has to be invested to provide fodder. The work that has to be done for cattle and other domesticated animals is constant all year in opposite to the work on the fields. Therefore cattle and fields limit each other. As the fields are more important for the diet, they have first priority and cattle are handled in the second place only.

DISCUSSION

If cattle and fields compete for manpower, the question arises: Why actually have cattle? Of course the reasons to have cattle are many and complex. Food is not the only one, usually it is not even an important one. The agricultural societies in the sample use cattle principally because of the following goods: tractive force, manure production and the use of dairy products. Other important reasons to keep cattle can be: traction/transport, prestige, investment, religious reasons (cattle as sacrificial animal).

Meat is usually a by-product but not the reason why to have cattle. In societies with very intensive agriculture traction work and dung are usually very important for the fields and milk is a mere by-product. The numbers of oxen can reach about 30% of all cattle in these groups.

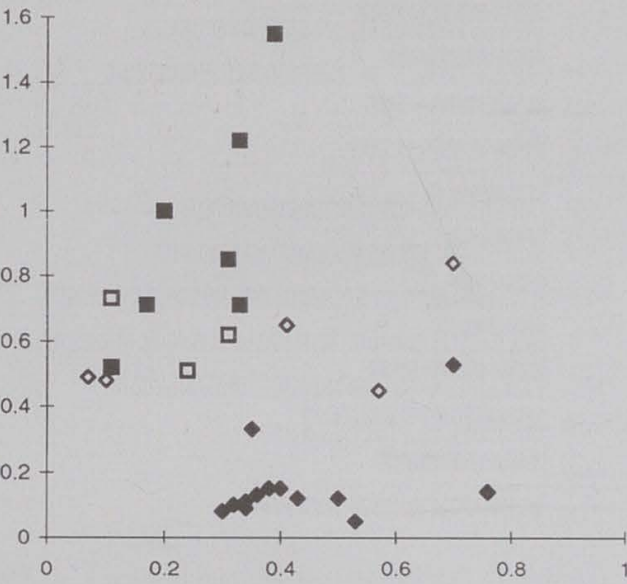


FIGURE 6
Number of cattle per head (y-axis) and hectares of arable land per head (x-axis) for 29 villages. Squares indicate villages practising any forms of transhumance, rhombs indicate villages without transhumance. Open symbols present villages with important ovicaprids breeding (i.e. the number of ovicaprids is twice as high or higher than the number of cattle).

As cattle need constant care and have to be provided with fodder during the winter time, the number of cattle that can be kept in different agricultural systems is an interesting value. It is one of the most discussed values when reconstructing prehistoric agriculture and stock farming as well.

The number of cattle per head are plotted against the hectares of field per head (Figure 6). Squares indicate villages with seasonal movements of livestock, that is with any kind of transhumance, rhombs indicate all other villages. In villages with open symbols ovicaprids are more important than cattle.

At first sight the villages with transhumance can be divided from the other villages. The group of villages with a dominance of ovicaprids is intermediate. The cattle-keeping groups with transhumance have smaller average values for the field size than the other villages, but there is a distinct overlapping. In general the field size is between half a hectare and one fifth of a hectare, rarely dropping below or above this value. The values for cattle density are significantly higher within the groups that practise transhumance than within the others. They fluctuate between 1 cattle per head and half a cattle per head, with rare cases up to 1.5 cattle per head. Villages without transhumance systems rarely have more than half a cattle per head.

all villages (Count: 29)	hectare per head	cattle per head
min	0.07	0.05
max	0.78	1.55
average	0.36	0.47

with transhumance (Count: 12)	hectare per head	cattle per head
min	0.07	0.48
max	0.39	1.55
average	0.22	0.78

sheep/goat dominant (Count: 8)	hectare per head	cattle per head
min	0.07	0.45
max	0.7	0.84
average	0.32	0.6

without transhumance (Count: 17)	hectare per head	cattle per head
min	0.3	0.05
max	0.76	0.84
average	0.45	0.24

TABLE 1
Average statistical values for field size (hectare) per head and number of cattle per head. Compared are a) all villages, b) villages with any kind of transhumance (see Figure 6: squares), c) villages with a high number of ovicaprids (see Figure 6: open symbols), d) villages without transhumance (see Figure 6: rhombs).

In nomadic groups at least 6 cattle per head have to be kept for to make a living out of cattle herding (Scholz, 1995). All agricultural societies of the sample and also others documented in the literature are far away from this value.

The statistical values for all three groups show that the possibility to use pastures in a system of transhumance enlarges cattle keeping (Table 1). More cattle is more traction power and more field manure. This leads to higher yields per hectare and thus allows to have smaller fields per head.

Because of the complex interdependencies between cattle and field this development cannot continue in all directions. Even in agricultural systems with intensive cattle herding and year-round transhumance between forests and high altitude pastures the important part of the daily calories is produced on the fields. The figures given in Table 1 define the framework of possibilities: only exceptional villages live with more than one cattle per head or less than one fifth of a hectare arable land per head.

SYNTHESIS AND ARCHAEOLOGICAL RELEVANCE

The quantitative analysis of the agricultural systems of 30 villages on the basis of nutritional needs has shown that:

- Plants are the one and only important source of daily diet, meat is generally not important.

- Working the fields is a highly seasonal task. Manpower deficits may occur during the vegetation period.

- Cattle need constant care and therefore compete for manpower during the vegetation period.

- An important problem of the agricultural systems analysed is to distribute the limited manpower more evenly over the year to avoid manpower deficits.

- Reasons to have cattle are traction work, dung production, dairy products, investment, prestige and others. Nutritional considerations are generally not important.

- Easy access to free pastures (systems of transhumance) increases cattle keeping.

- Densities of more than 1 cattle per head and more than half a hectare of arable land per head seem to be unrealistic.

Neolithic societies in Switzerland held cattle and cultivated cereals since the time of their first appearance. They settled in an environment with marked seasonality and easy access to different ecological zones. New questions arise from the above results working with the archaeological record of their villages like for example:

How did they manage their manpower throughout the year? An enormous increase in the importance of flax and poppy, both cultivated as summer crops, can be recognized in settlements of the late Neolithic Horgen culture (between 3200 and 2800 BC). Earlier Neolithic cultures cultivated predominantly barley and wheat as winter crops. The Horgen agriculture could be an attempt to make higher yields per hectare with maintaining the same demographic structure of people by distributing the work more evenly throughout the year.

When does transhumance occur the first time? Single finds of Neolithic tools in the Alps are usually difficult to date exactly and may also indicate other activities than transhumance, for example trade. Another way to learn about transhumance is the analysis of faeces of sheep, goat and cattle. New investigations undertaken by Akeret for the late Neolithic settlement of Horgen-Scheller at lake Zurich (Akeret & Jacomet, 1997; Ebersbach, Favre & Akeret, 1999) indicate that the small ruminants stayed in the village only in the winter/spring period of the year.

These two questions may exemplarily illustrate how new perspectives arise from the above remarks looking at Neolithic agriculture in Switzerland.

Prehistoric societies may have known agricultural systems other than those documented in historical or ethnographical sources, but working with the key features developed above will allow to calculate reliable models on Neolithic agricultural systems.

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