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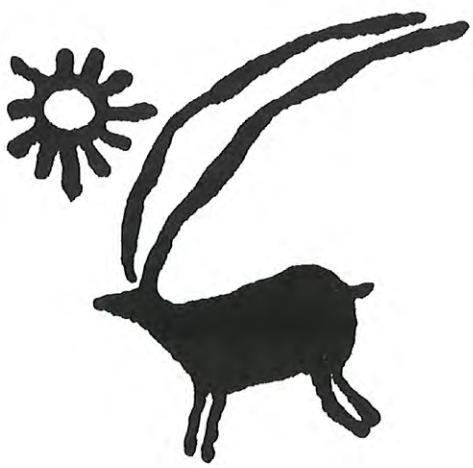

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Dedicated to the memory of Philippe Morel

Nota de los editores

En el presente número, ARCHAEOFAUNA, retorna parcialmente a su línea editorial clásica centrada en la publicación de artículos de corta y mediana extensión, línea rota en el volumen de 1998 de carácter monográfico. Enfatizamos, no obstante, el término parcialmente toda vez que en estas páginas se recoge un trabajo de muy superior extensión referido al desarrollo de la pesca en el Mar Báltico. Este artículo constituye la primera entrega de una importante revisión arqueozoológica cuya segunda entrega, prevista para el año 2000, refiere la evolución de esta actividad en el Mar del Norte. Consideramos que la recopilación ofrecida por Inge Bødker Enghoff habría perdido parte de su utilidad de haberse ofrecido de manera más fragmentaria y confiamos en que nuestros lectores aprecien el esfuerzo editorial realizado. Un segundo bloque de trabajos recoge una parte sustancial de las ponencias ofrecidas en la sección "Economical and Ecological Settings in Prehistoric Europe" que se organizó en el pasado 8º Congreso Internacional del I.C.A.Z (Consejo Internacional de Arqueozoología), celebrado en Victoria (Columbia Británica, Canadá) entre los días 23 a 29 de agosto de 1998. El presente número se completa con tres artículos de bien distinta naturaleza recibidos por los cauces convencionales. En conjunto, el espectro metodológico abarcado es ciertamente amplio y el interés de los artículos más que notable. La nota negativa, que saltó durante la fase de edición de la revista, la puso la trágica pérdida de uno de los más entusiastas de entre los jóvenes arqueozoólogos, Philippe Morel. Sirva el presente número a modo de reconocimiento de su labor y como tributo de todos aquellos que lo conocimos y lo quisimos. Descanse en paz.

AMM
ERI
Marta Moreno García

Editors' note

In the present issue, ARCHAEOFAUNA returns partially to its traditional editorial policy, offering short to medium-length papers, which was temporarily interrupted by the 1998 monographic number. We nevertheless stress the term "partially" since, as the readers will see, the ensuing pages incorporate a certainly extensive contribution dealing with the development of fishing in the Baltic Sea. This contribution represents the first release of a comprehensive archaeozoological review whose second stage, to be published in the year 2000, will be devoted to the evolution of this activity in the North Sea. We consider that the effort made by Inge Bødker Enghoff would have been partially lost had her research paper been offered in a more fragmented way. It is for this reason that we hope our readers will appreciate the editorial effort undertaken. A second group of papers represent a substantial portion of the works presented in the session "Economical and Ecological Settings in Prehistoric Europe" organized on the ocassion of the celebration of the 8th International Congress of the I.C.A.Z.(International Council for Archaeozoology) held at Victoria (BC, Canada) 23rd to 29th August from 1998. Three papers of very different scope and nature, edited through our conventional publication procedures, contribute to enlarge the methodological spectrum covered in the following pages. During the editing stage of this volume we learned about the untimely death of one of the youngest and most dynamic European archaeozoologists, Philippe Morel. May this issue of our Journal pay tribute to his merits and memory. We will all miss him. May he rest in peace!

AMM
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Marta Moreno García

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Pre-European Catches of Barracouta, *Thyrsites atun*, at Long Beach and Shag River Mouth, Otago, New Zealand

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ABSTRACT: Two archaeological sites with abundant remains of barracouta (*Thyrsites atun*) were subjected to intensive study. Long Beach produced a MNI of 4,504 fish from a NISP of 29,233 barracouta bones, of which 15,558 were able to be measured. Shag River Mouth had an MNI of 1,354 fish from a NISP of 6,319 bones, of which 1,920 could be measured. The measurements were used to estimate live fork length and ungutted body weight. Size-frequency curves representing the original fish catches were reconstructed. Fish size decreased significantly at Long Beach over some 500 years, and there are signs of a similar decrease at Shag River Mouth over a shorter period. These observed changes are not thought to be caused by human impact on the fishery.

The barracouta catches at both sites show a dominance of fish older than six years. Separation of the size-frequency curves into constituent age-grades reveals a pattern whereby both early assemblages are dominated by fish of one or two ages, whereas the late assemblage has four age-grades of similar proportions. This observed pattern may indicate that the age-growth relationship for barracouta was different 600 years ago from what it is now, and that the actual age mix in the past may have been similar throughout the sequence.

The barracouta at these sites represent a rich source of protein and oil. However, the people would have needed a source of food rich in carbohydrate in addition to fish. Fern root (*Pteridium esculentum* var. *aquilinum*) and *tī* (cabbage tree, *Cordyline australis*) are two possibilities. *Tī* is a superior food in many respects. We estimate that a minimum of 45% by weight of such a plant food would have been required for a nutritionally adequate diet, in addition to the readily available sources of protein and oil such as barracouta and seal blubber. The economy of these people would have been a delicate balancing act, striving to avoid two dietary dangers - azotaemia on the one hand, and ketonuria on the other.

KEY WORDS: ARCHAEOLOGY, ARCHAEOZOOLOGY, NEW ZEALAND, FISH, BARRACOUTA, *Thyrsites atun.*

RESUMEN: En el presente trabajo se lleva a cabo un pormenorizado estudio de dos yacimientos arqueológicos con abundantes restos de sierra (*Thyrsites atun*). En Long Beach se contabilizó un NMI de 4.504 individuos procedentes de 29.233 huesos de este pez, 15.558 de los cuales resultaron mensurables. En Shag River Mouth el NMI fue de 1.354 individuos y el NR de 6.319, 1.920 de ellos mensurables. Las medidas tomadas en los huesos se utilizaron para inferir la longitud corporal a la horquilla caudal y el peso corporal no eviscerado. A partir de estos datos se reconstruyeron curvas de frecuencia de tamaño que representaban las capturas originales de estos peces. Las tallas de los peces decrecen de modo significativo en Long Beach a lo largo de unos 500 años y existen señales de una disminución parecida en Shag River Mouth en un lapso temporal más corto. No se piensa que estos cambios hayan sido provocados por el impacto humano sobre la pesquería.

Las capturas de sierra en ambos yacimientos evidencian una dominancia de ejemplares por encima de los 6 años. La separación de las curvas de frecuencia-tamaño en sus elementos constituyentes según cohortes evidencia un patrón por el cual las muestras iniciales en ambos casos vienen dominadas por peces de una o dos cohortes mientras que las muestras tardías tienen cua-

tro grupos de edad en similares proporciones. Este patrón puede indicarnos que la relación de crecimiento cronodependiente en la sierra era diferente hace 600 años de lo que es en la actualidad y que la mezcla de cohortes detectada en el pasado puede haber sido similar a lo largo de toda la secuencia.

Las sierras en ambos yacimientos suponen una rica fuente de proteínas y de aceites. No obstante la gente habría necesitado asimismo una fuente nutricia rica en hidratos de carbono además del pescado. Dos posibilidades las presentan el helecho (*Pteridium esculentum* var. *aquilinum*) y el *tī* o árbol de la col (*Cordyline australis*). En muchos aspectos el *tī* es un nutriente de superior calidad. Estimamos que un mínimo de 45% en peso de tal nutriente vegetal habría sido necesario para una dieta nutricionalmente equilibrada, además de las fuentes siempre disponibles de proteínas y aceites como la sierra y la grasa de foca. La economía alimentaria de estas poblaciones habría sido por tanto un cuidadoso ejercicio de equilibrio diseñado para evitar dos peligros asociados con la dieta: la azotemia y la cetonuria.

PALABRAS CLAVE: ARQUEOLOGÍA, ARQUEOZOOLOGÍA, NUEVA ZELANDA, PEZ, SIERRA, *Thyrsites atun*.

INTRODUCTION

The New Zealand barracouta, *Thyrsites atun*, is widespread and common around New Zealand, although it is generally more abundant about and south of Cook Strait. Barracouta swim in schools, are voracious surface-feeding carnivores and are easily caught on a trolling lure. In the past, Māori often caught them by jigging with a feather- and/or shell-decorated lure or even a plain piece of wood with a bone hook inserted through it. Early commercial fishermen also jig-fished surface-feeding barracouta using a piece of red wood with a nail driven through it on a short line (Graham, 1956: 310 ff.).

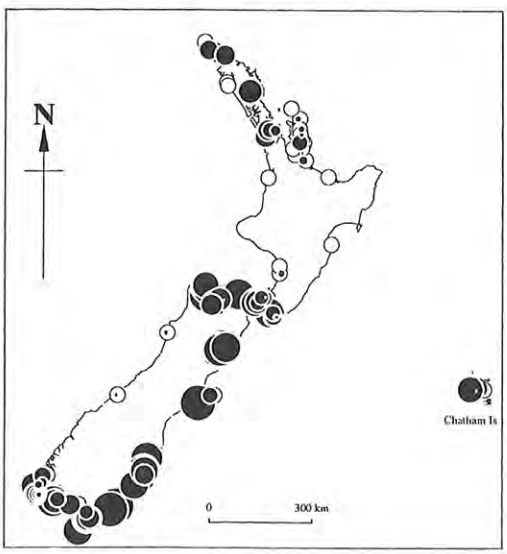

FIGURE 1

The proportions of barracouta MNI at 96 of the 126 New Zealand archaeological sites where archaeological fish remains have been studied. The size of the black circle indicates the relative abundance (logarithmic scale).

Barracouta are present in most archaeological sites in New Zealand. Their relative abundance is documented in Appendix 1, and illustrated in Figure 1. They are found in 96 of the 126 archaeological sites for which we have detailed knowledge about pre-European fish catches of Māori and Moriori.

Two of these 96 sites, Long Beach and Shag River Mouth, account for 58% of all barracouta identified from archaeological sites in New Zealand. Excavations at these sites covered considerable areas and resulted in large assemblages, in which barracouta were especially plentiful. Long Beach has stratified layers representing a considerable period of time; Shag River Mouth, while also containing stratified layers, is believed to cover a relatively short period of time. Because of the large size of the barracouta samples and the fact that they are stratified over a significant period, these two assemblages offer an excellent opportunity for detailed study of this species. The purpose of this paper is to reconstruct the original fish catches at these two sites (the size frequency diagrams) and to examine these for possible changes over time. We also explore some dietary implications.

THE LONG BEACH ARCHAEOLOGICAL SITE (I44/23)

Long Beach is a sandy, north-facing bay just north of Dunedin on the east coast of the South Island. It has long been known as a productive source of artefacts. In 1977, Atholl Anderson undertook investigations to establish the extent of the site and the nature of any remaining undisturbed material. Although evidence of occupation was found to extend over nearly 30 ha of old consolidated dunes inland of the more recent beach dunes, only 2 ha appeared to be undisturbed by curio hunting. An area of 5 x 10 m was excavated in November-December 1977 by Helen Leach and Jill Hamel (Leach & Hamel, 1981).

Two major occupations were identified, separated by a layer of wind-blown dune sand. The upper occupation (Layer 2) was "a mosaic of patches of dense fish bone midden and working floors with the wall of a substantial house at one end of the excavation" (Leach & Hamel, 1981: 112). This layer contained artefacts of Classic Māori type and yielded a radiocarbon date of AD 1630 ± 89. The lower occupation was represented by three midden layers (4a, 4b, 4c) containing artefacts of Archaic types, scoop hearths and a child burial. Radiocarbon dates considered acceptable by the excavators

Family	Common Name	MNI	%	SE	NISP	%	SE
Gempylidae	Barracouta, etc.	4504	78.06	± 1.08	29233	85.89	± 0.34
Moridae	Red cod, etc.	823	14.26	± 0.91	3553	10.44	± 0.30
Ophidiidae	Ling	240	4.16	± 0.52	901	2.65	± 0.16
Osteichthyes	Other bony fishes	103	1.79	± 0.35	150	0.44	± 0.07
Percichthyidae	Groper	58	1.01	± 0.27	146	0.43	± 0.06
Labridae	Spotty, etc.	22	0.38	± 0.17	28	0.08	± 0.03
Nototheniidae	Maori chief	7	0.12	± 0.09	9	0.03	± 0.02
Latrididae	Blue moki, etc.	6	0.10	± 0.09	7	0.02	± 0.02
Mugiloididae	Blue cod	5	0.09	± 0.08	6	0.02	± 0.01
Cheilodactylidae	Tarakihi, etc.	1	0.02	± 0.04	1	0.003	± 0.007
Centrolophidae	Blue warehou	1	0.02	± 0.04	1	0.003	± 0.007
Total		**5770**	**100**	**-**	**34,035**	**100**	**-**

TABLE 1

MNI and NISP of fish at Long Beach (all provenances combined).

Family Name		Early	Late	Early	Late	Total	%
Gempylidae	Barracouta, etc.	3831	550	81.7± 1.1	64.3± 3.3	4381	79.0
Moridae	Red cod, etc.	583	177	12.4± 1.0	20.7± 2.8	760	13.7
Ophidiidae	Ling	182	38	3.9± 0.6	4.4± 1.4	220	4.0
Osteichthyes	Other bony fishes	72	16	1.5± 0.4	1.9± 1.0	88	1.6
Percichthyidae	Groper	10	47	0.2± 0.1	5.5± 1.6	57	1.0
Labridae	Spotty, etc.	6	12	0.1± 0.1	1.4± 0.8	18	0.3
Nototheniidae	Maori chief	3	4	0.1± 0.1	0.5± 0.5	7	0.1
Latrididae	Blue moki, etc.	1	5	0.02± 0.1	0.6± 0.6	6	0.1
Mugiloididae	Blue cod	-	5	-- -	0.6± 0.6	5	0.09
Cheilodactylidae	Tarakihi, etc.	-	1	-- -	0.1± 0.3	1	0.02
Centrolophidae	Blue warehou	1	-	0.02± 0.1	-- -	1	0.02
Total		**4689**	**855**	**100 - -**	**100 - -**	**5544**	**100**

TABLE 2

MNI of fish at Long Beach, early and late periods.

were AD 1217 ± 59 for the dense fish bone midden of layer 4c and AD 1460 ± 58 for the thin midden of layer 4a (Hamel & Leach, 1979; Leach & Hamel, 1981: 112).

Excavation was by hand trowel according to natural layer. All deposits were sieved through ¼ inch (6.4 mm) mesh, and all material retained by the sieves was bagged by $1m^2$ and layer and sent to the laboratory for analysis. Fish bone was analysed initially by Fyfe (1982) and later reanalysed in the Archaeozoology Laboratory of the Museum of New Zealand Te Papa Tongarewa (Leach & Boocock, 1993).

As Leach & Hamel note (1981: 109), it is uncommon for Classic Māori assemblages to be stratified above Archaic assemblages in Otago sites. The Long Beach excavation provided an important instance of two chronologically and culturally distinct occupations, each associated with abundant fish remains.

The relative abundance of fish families at Long Beach, from all provenances combined, is listed in Table 1, where both NISP and MNI are given. The fish catch at the site was very heavily dominated by barracouta. Apart from barracouta, only red cod contributed more than 10% and ling more than 2% of the catch. The category Osteichthyes consists of fishes which could not be matched in the comparative collection. Table 2 gives the MNI according to early and late assemblages and excludes some bones from mixed or uncertain provenances. It is apparent that there was a significant decline in the proportion of barracouta through time and a concomitant increase in red cod, although barracouta was still by far the most important fish in the catch of the late period. Also significant is an increase in groper and possibly in labrids and blue cod.

THE SHAG RIVER MOUTH ARCHAEOLOGICAL SITE (J43/2)

The Shag River Mouth site, situated on the sand spit at the mouth of the Shag River in north Otago, is one of the best known archaeological sites in southern New Zealand. It was first excavated during the 1870s, during the controversy about the relationship between moa-hunter and Māori, and has been the scene of numerous subsequent investigations. Between 1987 and 1989 a series of excavations was carried out under the direction of Anderson, Allingham & Smith (Anderson *et al.* [eds.], 1996). These centred in two main areas: a high dune towards the southern and landward end of the sand spit, and the northern and inner edge of the low-lying sand flat on the inner side of the dune, although extensive test pitting was carried out over much of the site.

Cultural deposits were relatively shallow on the sand flat, but deep stratigraphy was encountered in the high dune, where seven distinct occupation layers were separated by layers of wind-blown sand.

Forty-six radiocarbon samples of charcoal, marine shell, moa bone collagen, moa eggshell and flax were dated at two laboratories. After a through review of the results, it was concluded that "...Shag Mouth was continuously occupied for a period of perhaps 20-50 years in the 14th century AD." (Anderson, Smith & Higham, 1996: 67).

Excavation was by trowel according to natural layer (except for some test pits dug by spade, and removal of dune overburden by bulldozer). Items were either hand picked during excavation or extracted during screening through ⅛ inch (3.175 mm) sieves. Unsieved bulk samples from all major stratigraphic layers were retained. However, fish bone recovered by sieving was processed in the field "to extract the skeletal elements most useful for identification to species" (Smith & Anderson, 1996: 70) and the rest discarded. This procedure may have introduced some bias, as those doing the field extraction would not have been well trained in fish anatomy, and has also precluded further analysis of other skeletal elements.

Fish remains from the dune excavation were identified by Angela Boocock using the procedures of the Archaeozoology Laboratory at the Museum of New Zealand Te Papa Tongarewa, and the data entered in the Archaeozoology Laboratory's database. Fish remains from other areas of the site were identified by Anderson. All identifications were also entered in the Shag Mouth data base and NISP, MNE and MNI tabulated and reported by Anderson & Smith (1996). They noted differences in MNI for the dune calculated by themselves, by Boocock (n.d.) and by Leach and preferred to use their figures. In this paper, we use the fish remains from the dune and the figures calculated from the Archaeozoology Laboratory database. For the purposes of this study the barracouta bones were remeasured in the Archaeozoology Laboratory in Wellington.

As a result of their analysis, Anderson & Smith (1996: 240) concluded that the lower layers of the

dune (layers 6 to 11) stood out from all other deposits. According to this analysis, barracouta were less important than elsewhere in the site (37%), although still dominant, while there were higher proportions of blue cod (21%), labrids (12%), trumpeter (10%) and black cods (7%). Anderson & Smith suggest that almost two thirds of the fish from these layers were probably caught with baited hooks over rocky ground and reefs. There was a marked trend towards an increase in barracouta through time and a decrease in blue cod and other species. In the upper layers of the dune and elsewhere in the site, barracouta made up 67% to 80% of the catch and Anderson & Smith argue for deliberate targeting of this schooling species. Unfortunately, the sample sizes from all parts of the site except the upper dune layers are far too small for this interpretation to be other han suggestive.

Table 3 shows the relative abundance of fish families in the total catch from the dune excavation. A wider range of families is represented than at Long Beach, and several families besides barracouta and red cod were making a reasonable contribution to the catch. Even so, barracouta still dominate, at a level comparable to that in the late catch at Long Beach.

MODERN BARRACOUTA RESEARCH CATCHES

When examining archaeological fishes catches, it is necessary to have some form of baseline for comparison, particularly if one is interested in changes in catch composition through time and the effects of human exploitation on fish stocks. Fortunately, fisheries scientists have been studying barracouta in New Zealand waters for some years so there is a sizeable database to draw upon. Size-frequency diagrams may be drawn from research trawl data held by the National Institute of Water and Atmospheric Research (NIWA), and some of these are presented in Figure 2. These derive from trawls in the vicinity of the Chatham Islands and from Stewart Island southwards. For comparison, the archaeological catches (described below) are also shown in Figure 2.

Several things are evident from the size-frequency diagrams. Firstly, some of the different age grades of barracouta, particularly the younger fishes, are clearly separated. Secondly, the age mixture is markedly different from one trawl area to another. It is also notable that the youngest age grades seem to be mainly present in shallower waters down to 100 m.

Family	Common Names	MNI	%	SE	NISP	%	SE
Gempylidae	Barracouta, etc.	1354	63.45	± 2.07	6319	78.95	± 0.90
Moridae	Red cod, etc.	339	15.89	± 1.57	1022	12.77	± 0.74
Mugiloididae	Blue cod	155	7.26	± 1.12	230	2.87	± 0.37
Labridae	Spotty, etc.	116	5.44	± 0.99	169	2.11	± 0.32
Ophidiidae	Ling	57	2.67	± 0.71	102	1.27	± 0.25
Nototheniidae	Maori chief	46	2.16	± 0.64	71	0.89	± 0.21
Latrididae	Blue moki, etc.	30	1.41	± 0.52	40	0.50	± 0.16
Scorpaenidae	Scarpee, etc.	20	0.94	± 0.43	28	0.35	± 0.14
Percichthyidae	Groper	11	0.52	± 0.33	13	0.16	± 0.09
Cheilodactylidae	Tarakihi, etc.	2	0.09	± 0.15	3	0.04	± 0.05
Anguillidae	Freshwater eels	1	0.05	± 0.12	2	0.03	± 0.04
Sparidae	Snapper	1	0.05	± 0.12	2	0.03	± 0.04
Centrolophidae	Blue warehou	1	0.05	± 0.12	2	0.03	± 0.04
Mugilidae	Yelloweyed mullet, etc.	1	0.05	± 0.12	1	0.01	± 0.03
Totals		**2,134**	**100**	- -	**8,004**	**100**	- -

TABLE 3

MNI and NISP of fish at Shag River Mouth dune excavation (all provenances combined).

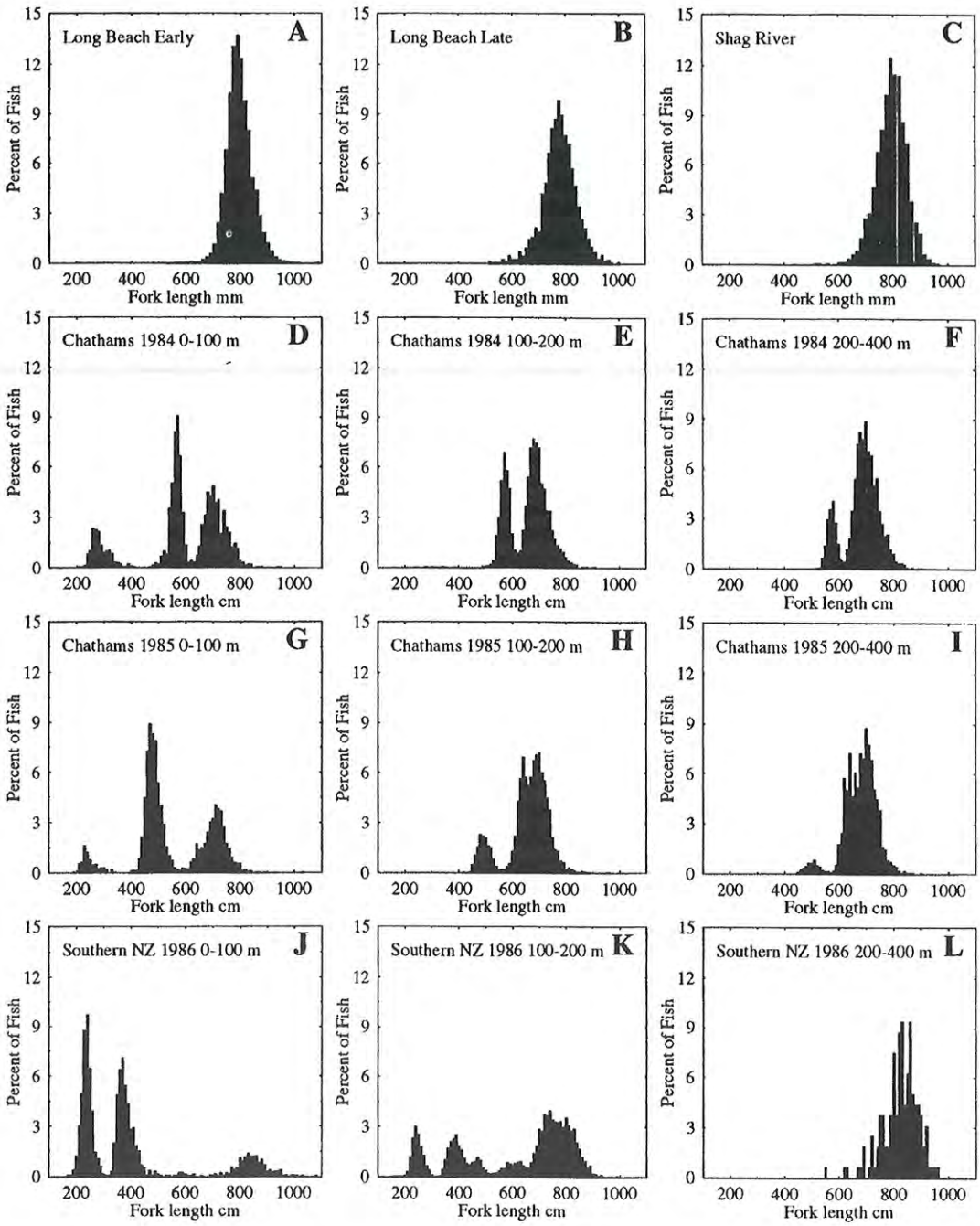

FIGURE 2

D to L: Length frequency diagrams of barracouta from research trawls at various depths in southern New Zealand and the Chatham Islands. Different age grades are evident. The archaeological catches are shown in A, B and C for comparison.

PRE-EUROPEAN BARRACOUTA CATCHES

A large sample of modern specimens of barracouta was studied to work out the relationship between fork length and ungutted body weight. A sub-sample of 278 fish was macerated, the head bones measured, and statistical analysis carried out. This permits the original live length and weight to be estimated from archaeological bone measurements with an acceptable margin of error (Leach *et al.,* 1996).

The large assemblages of barracouta bones from Long Beach and Shag River Mouth provide an opportunity unique in New Zealand to collect a large number of measurements so that variations in reconstructions based on different parts of the anatomy can be investigated. At Long Beach there was a total MNI of 4,504 barracouta with a NISP of 29,233, and at Shag River Mouth the MNI was 1,354 with a NISP of 6,319. The ratio of NISP/MNI is somewhat different for the two sites, being 6.49 for Long Beach and 4.67 for Shag River Mouth.

The relative abundance of the different parts of barracouta anatomy which were identified is given in Table 4, from which it will be seen that the spread is very even. Taking the larger assemblage (Long Beach), the percentage spread is as follows:

Premaxilla	22%
Dentary	21%
Maxilla	19%
Articular	19%
Quadrate	18%
Total	**99%**

The figures for Shag River Mouth are not quite as even, but the sample size is smaller, which may account for this. Dentaries are represented by 25% of the total number, and quadrates by only 16%.

In this kind of study, the whole bone is measured wherever possible. Measurements can be taken on broken bones also, and where more than one measurement is possible on a bone, the largest dimension is always taken. Only one measurement is made on any one bone. In all, 15,558 measurements were made on barracouta bones from Long Beach and 1,920 on bones from Shag River Mouth.

These data were entered into a database, using a program custom written for this purpose called FORKING. This program records the bone provenance information in a convenient form using a mouse and pull-down menus cross-linked to the identification software called KUPENGA, described by Leach (1997). Diagrams of the various bones belonging to any one fish species are thrown up on the monitor and the mouse is used to select predefined measurement options. Measurements are entered into the database using digital callipers integrated with FORKING through the serial port. Various checking procedures are invoked to minimise errors. These programs run under Windows 3 environment.

Additional software was written to estimate live fork length and ungutted weight from the bone measurements that had been entered in the database, using the regression constants published by Leach *et al.* (1996).

When these steps have been completed, size-frequency diagrams can be established which represent the original fish catches for different layers and squares in the excavation. The Long Beach site has two quite distinct phases of human habitation, one relatively early in the New Zealand pre-

	Long Beach		Shag River Mouth	
Anatomy	**Left**	**Right**	**Left**	**Right**
Dentary	3084	3097	822	809
Articular	2823	2835	562	556
Quadrate	2640	2630	518	488
Premaxilla	3250	3186	734	687
Maxilla	2815	2873	604	539
Total NISP for Barracouta	**29,233**		**6,319**	
Total NISP for all species	**34,035**		**8,004**	
Percent Barracouta by NISP	**85.9**		**78.9**	

TABLE 4

Barracouta NISP by anatomy at Long Beach and Shag River Mouth dune (all provenances combined).

European sequence, and the other much later. Size-frequency diagrams were established for these two time periods. However, Shag River Mouth is believed to have been occupied only for a relatively short period early in the sequence, so the catch is presented in one size-frequency curve.

These curves are illustrated in Figure 2, which also shows the modern research trawl data for barracouta. It is immediately apparent that the archaeological fish catches are dominated by very large fish and do not contain younger age grades which are so evident in the modern catches.

The two size-frequency curves are close to normal in their distributional characteristics. The Long Beach catch has very slight but significant negative skewness (gl/wl = -0.03/9.3), and significant positive kurtosis (g2/w2 = 4.9/47.4). At Shag River Mouth the same pattern is observed (g1/w1 = -0.4/11.5, g2/w2 = 3.8/7.0). The mean fork

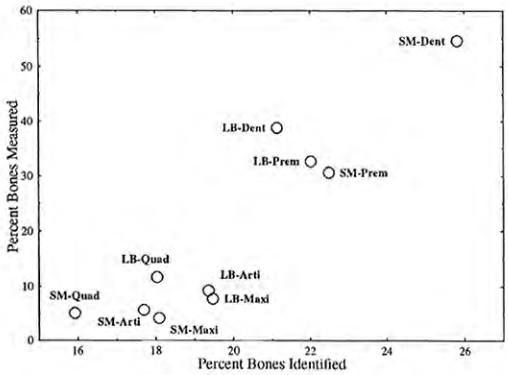

FIGURE 3

Comparison between the proportion of bones identified for each part of the anatomy and the proportion able to be measured. LB = Long beach, SM = Shag River Mouth. Bones from Shag River Mouth are more fragmented than at Long Beach. Note that with the exception of dentary and premaxilla, only a small proportion of bones from Shag River Mouth were able to be measured.

LONG BEACH		**Whole Bones**			**Bone Fragments**	
Anatomy	**Code**	**Left**	**Right**	**Code**	**Left**	**Right**
Dentary	LD1/RD1	108	92	LD2/RD2	1123	1086
Dentary	-	-	-	LD3/RD3	1764	1859
Articular	LA1/RA1	6	3	LA2/RA2	767	660
Quadrate	LQ1/RQ1	945	866	-	-	-
Premaxilla	LP1/RP1	10	11	LP2/RP2	2536	2522
Maxilla	LM1/RM1	128	121	LM2/RM2	489	462
Sub-Totals		**1197**	**1093**		**6679**	**6589**
Sub-Totals		**2,290**			**13,268**	
Total				**15,558**		
Proportions		**14.7%**			**85.3%**	

SHAG RIVER MOUTH DUNE	**Whole Bones**			**Bone Fragments**		
Anatomy	**Code**	**Left**	**Right**	**Code**	**Left**	**Right**
Dentary	LD1/RD1	12	8	LD2/RD2	47	41
Dentary	-	-	-	LD3/RD3	459	481
Articular	LA1/RA1	6	8	LA2/RA2	46	48
Quadrate	LQ1/RQ1	55	42	-	-	-
Premaxilla	LP1/RP1	0	2	LP2/RP2	300	286
Maxilla	LM1/RM1	3	5	LM2/RM2	38	33
Sub-Totals		**76**	**65**		**890**	**889**
Sub-Totals		**141**			**1,779**	
Total				**1,920**		
Proportions		**7.3%**			**92.7%**	

TABLE 5

Number of measurements of barracouta according to anatomy, and whole and fragmentary bones.

length is very similar at the two sites (Table 6; Long Beach 795.2 ± 0.4 mm and Shag River Mouth 794.6 ± 1.2 mm).

SAMPLING STRATEGIES AND TAPHONOMIC EFFECTS

As mentioned above, not all the barracouta bones from these sites were complete, and measurements were therefore also taken on fragmentary bones. It is useful to examine the relative number of whole and fragmentary parts of the anatomy in case bias could be introduced in assessing changes in dispersion statistics between sites, or over time. The number of measurements able to be captured for various parts of the anatomy at the two sites is presented in Table 5. In Figure 3 each piece of anatomy is plotted out as a percentage of the total number of bones measured against the percentage of total number identified.

At Long Beach, we were able to measure 15,558 of the 29,233 barracouta bones (53.2%); whereas at Shag River Mouth only 1,920 bones could be measured of the 6,319 available (30.4%). This indicates that the degree of fragmentation was much greater at Shag River Mouth. Why this should be so is not known, but it was certainly a noticeable feature during analysis, and is borne out by these figures.

It is also notable that the dentary and premaxilla were far more numerous at Shag River Mouth than other bones, and a much higher proportion of dentaries could be measured than at Long Beach. It is possible that selective bias was involved during the retention stage of sorting. It can be noted that not all fish remains were kept from either of these sites. At Long Beach, as many fish bones as possible were collected at the site and processed in the laboratory. However, after sorting, only those bones able to be identified by Fyfe (1982) were retained, and the rest were dumped. At Shag River Mouth dune excavation, fish remains were sorted on site and only those standardly used in identification were retained; the rest were discarded. The retention strategy at these two important sites has been criticised elsewhere (Leach, 1997: 23).

This large database of bone measurements may be split up so that dispersion statistics relating to fish size can be calculated for different parts of the anatomy. Once again, it is useful to do this in order to see whether various forms of bias could be involved in

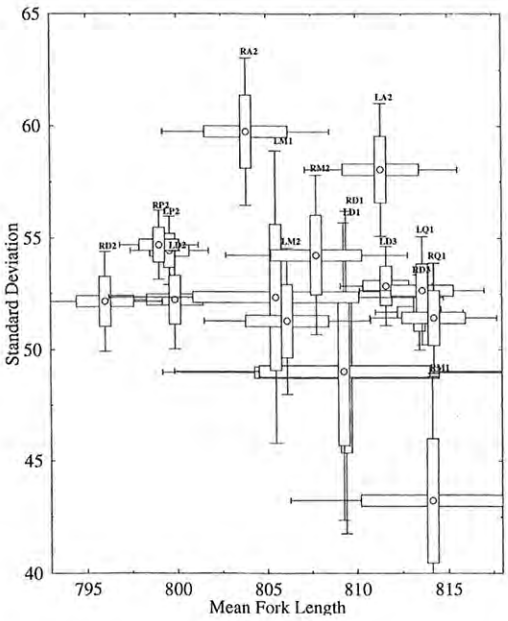

FIGURE 4

Estimated mean fork length and standard deviation, together with standard errors, for each part of the anatomy in the Long Beach barracouta assemblage, all layers combined (15,558 measurements on 29,233 bones).

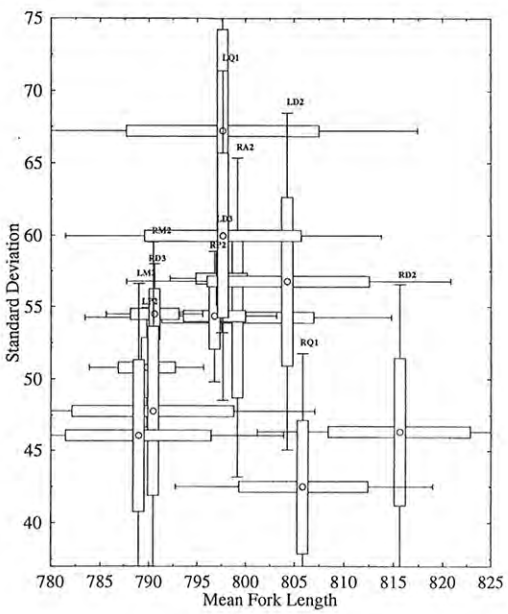

FIGURE 5

Estimated mean fork length and standard deviation, together with standard errors, for each part of the anatomy in the Shag River Mouth barracouta assemblage, all layers combined (1,920 measurements on 6,319 bones).

this analysis, particularly in relation to the bone retention strategy. This study produced a large amount of statistical data which can be conveniently summarised by illustrations.

Figures 4 and 5 show the individual means (x axis) and standard deviations (y axis) of fork lengths for each bone measurement able to be taken. The measurement codes are as follows:

Left	Right	Anatomy
LD1	RD1	Dentary Maximum Length
LD2	RD2	Dentary Fragment 1
LD3	RD3	Dentary Fragment 2
LA1	RA1	Articular Length
LA2	RA2	Articular Fragment 1
LQ1	RQ1	Quadrate Maximum Length
LP1	RP1	Premaxilla Maximum Length
LP2	RP2	Premaxilla Fragment 1
LM1	RM1	Maxilla Maximum Length
LM2	RM2	Maxilla Fragment 1

The Long Beach example (Figure 4) has some interesting features. Pairs of measurements (e.g., the pairs LD2/RD2, LQ1/RQ1, LD3/RD3, etc.) plot quite close to each other and their standard errors overlap, which is what we would expect. It is noticeable that some pairs of measurements provide significantly different fork lengths than other pairs. Thus, the pair LD2/RD2 plots at the lower end of the fork length range, while LQ1/RQ1 plots at the upper end of the range. A number of possible explanations might be offered for these patterns, some plausible, but all hard to verify. For example, we could propose that the quadrates provide a relatively large estimate of the mean fork length because these bones are small and do not break easily, but those from small specimens might more easily be missed in sorting through large quantities of bones, or might even pass through the sieves. In theory, this hypothesis is at least testable in that the material that passed through the sieves could be examined. Unfortunately, as pointed out earlier, only the identified bones have been retained from both Long Beach and Shag River Mouth, so this explanation cannot be tested in reality. However, this would be worth examining on some future occasion at another excavation. It is not so easy to explain why LD1/RD1 form a pair with practically identical mean and standard deviation at the large end of the fork length range, whereas the pair LD2/RD2 form a second tight cluster at the lower end of the fork length range. This suggests that small dentaries break more easily into fragments than large dentaries. This does not seem very plausible, but once again could be tested experimentally.

The spread of these mean values in fork length, derived from different parts of the anatomy and from both whole and broken bones, is about 20 mm overall. This must be seen in perspective. The mean and standard deviation of the fork length of the Long Beach barracouta catch as a whole are 795 mm and 51 mm (Table 6). The variation observed amongst these different parts of the anatomy is therefore less than 3% of the mean, and less than half of the standard deviation. Nevertheless, there are interesting patterns here which warrant further investigation at another site when all the bone material is retained.

The overall range in the Shag River Mouth barracouta remains is rather greater at about 45 mm (Figure 5), but the standard errors are considerably larger too, since a much smaller sample size is available. The pairs of measurements do not form such tight clusters of mean fork length as in the case of Long Beach. Again, this is mainly due to smaller sample size, evident in the much larger standard errors in the graph.

CHANGES THROUGH TIME

Anderson & Smith (1996: 241 ff.) have suggested that at Shag River Mouth there was an increase over time in barracouta fishing as a targeted activity, and a concomitant decrease in blue cod and other inshore rocky species. The information on possible changes in relative abundance of different species is plotted out in Figure 6 for Long Beach and in Figure 7 for Shag River Mouth. Unfortunately, as so often happens with statistics relating to prehistoric fish catches, problems of small sample size make it difficult to be certain about these suggested changes. Some appear significant, while others do not. However, there does seem to be a trend at Shag River Mouth whereby barracouta increase towards the more recent layers and blue cod decrease. The Layer 1 data are probably unreliable, as this material was disturbed and may actually be derived from spoil thrown out, possibly from several layers, by Teviotdale, an earlier investigator.

At Long Beach, the situation is clearer because sample sizes are much larger. In this case, barracouta clearly decrease significantly over archaeological time, even though they are always by far the most dominant fish in the catch. Red cod in this

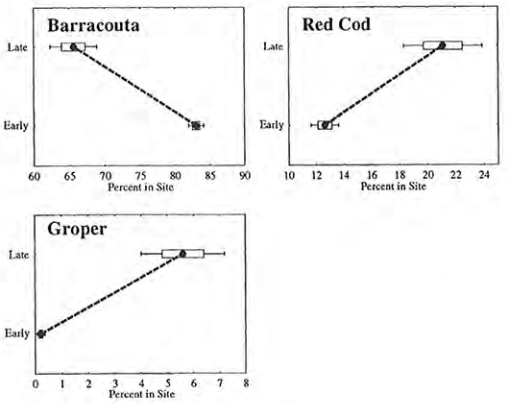

FIGURE 6

Changes in relative abundance of some fish species over time at Long Beach. Barracouta decrease significantly, whereas other species increase in importance.

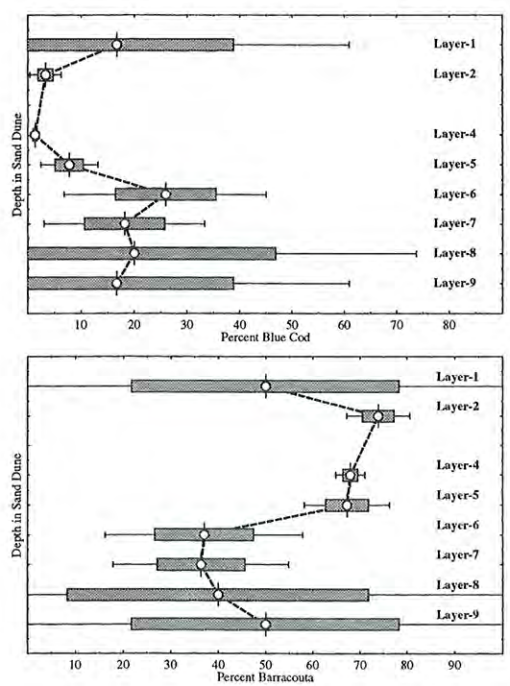

FIGURE 7

Changes in relative abundance of barracouta and blue cod in the different layers of the sand dune sequence at Shag River Mouth. Layer 1 may contain material from mixed provenances. Barracouta show possible signs of an increase in abundance over time, whereas blue cod may show signs of a decrease. These trends are the opposite of those at Long Beach, but smaller sample sizes make it difficult to establish statistical significance.

case increase in importance, as do groper and much less certainly, labrids and blue cod.

The second aspect of possible change through time which can be explored concerns fish size. The figures for mean fork length in the various layers at Shag River Mouth are plotted out in Figure 8 (from Table 6). Although the standard errors are large and there is considerable overlap, there seems to be a trend towards decreasing size over time. It is very difficult to know how to interpret

Provenance	N	Mean	-	SE	SD	-	SE
Long Beach							
Late Period	1586	778.4	±	1.6	63.2	±	1.1
Early Period	13257	797.9	±	0.4	47.9	±	0.3
All Layers	15558	795.2	±	0.4	51.2	±	0.3
Shag River Mouth Dune							
Layer 1*	9	808.4	±	11.7	35.0	±	8.2
Layer 2	324	786.1	±	3.5	63.3	±	2.5
Layer 4	1194	796.6	±	1.6	53.8	±	1.1
Layer 5	214	792.9	±	3.2	46.6	±	2.3
Layer 6	16	800.8	±	11.9	47.8	±	8.4
Layer 7	15	819.3	±	11.6	45.0	±	8.2
Layer 8	3	830.8	±	-	-	±	-
Layer 9	1	902.0	±	-	-	±	-
All Layers	1920	794.6	±	1.2	54.6	±	0.9

* This layer may incorporate disturbed and redeposited material.

TABLE 6

Fork lengths of archaeological barracouta.

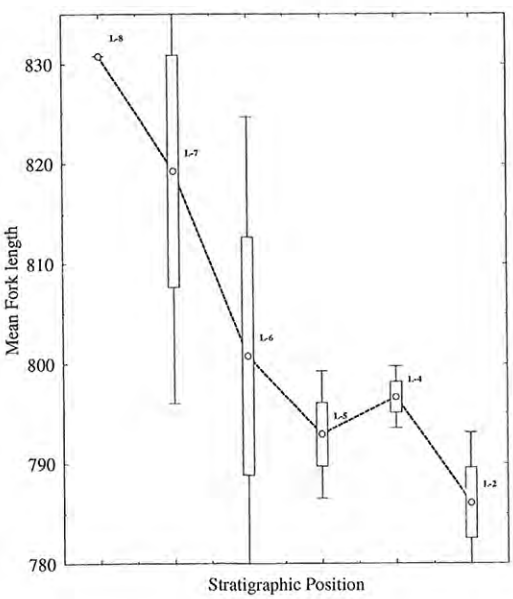

FIGURE 8

The mean fork length of barracouta catches from different stratigraphic layers in the sand dune sequence at Shag River Mouth. There are signs of decreasing size over time, but establishing statistical significance is made difficult by small sample size for some layers.

this. The apparent trend could be entirely due to chance, given the large size of the standard errors. However, it is certainly intriguing.

In the case of Long Beach, there is no such ambiguity - here the barracouta mean size decreases by 21 mm (Table 6) and is highly significant (Student's t = 11.89 with 14,841 degrees of freedom). Moreover, the standard deviation increases by 15.3 mm over time. This is again highly significant (standard error = 1.1 mm).

Barracouta grow very quickly for the first few years of their life, so it is possible to determine their age from fork length with reasonable accuracy. Hurst and Bagley (1987: 20) provide suitable mean and standard deviation figures which are given below.

Age Years	Fork Length mm	SD mm
1	289	33
3	578	35
4	665	35
5	702	35
6	752	33
7	778	30
8	795	46
9	843	47
10	850	17

When these values are plotted out over the top of the size-frequency diagrams of the prehistoric barracouta fish catches (Figure 9) it is clear that the fish being captured were all relatively old individuals. This is also apparent in Figure 2, where the modern research trawl data are shown.

It is possible to decompose a size-frequency diagram where there is a mixture of age components like this. A considerable amount has been

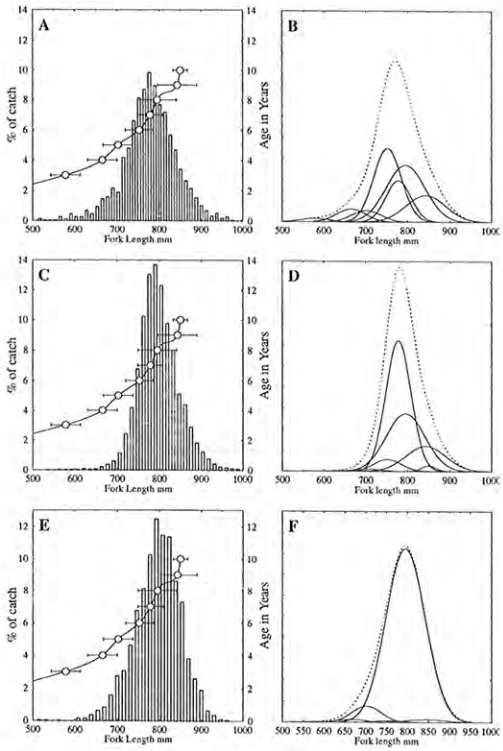

FIGURE 9

A, C, E: Size-frequency diagrams of barracouta catches at Long Beach and Shag River Mouth. A, Long Beach late. C, Long Beach early. E, Shag River Mouth all. The growth curve of barracouta (modern data) is superimposed on each catch diagram. B, D, F: Each catch decomposed into its constituent age grades. The late catch from Long Beach shows a more even mix of fishes of four ages, whereas the earlier catches at both Long Beach and Shag River Mouth show much greater dominance of one age grade, with only one or two other ages in the mix. This is particularly marked at Shag River Mouth.

Age in Years	Long Beach Early	Long Beach Late	Shag River Mouth
3	0.1	1.5	0.3
4	0.4	5.4	1.2
5	1.0	4.8	6.7
6	4.7	28.8	0.7
7	46.8	14.7	0.001
8	31.8	30.9	95.2
9	14.1	14.9	1.7
10	1.1	0.001	0.001

TABLE 7

Percentage age composition of archaeological barracouta.

published on the subject (Everitt & Hand, 1981; MacDonald, 1987; MacDonald & Pitcher, 1979; McLachlan & Basford, 1988; Schnute & Fournier, 1980; Titterington *et al.,* 1985). Peter Macdonald at McMaster University in Canada has developed an algorithm which is now widely used for separating age grades of fish from trawl catch data. By using the MIX software iteratively until the χ^2 value is lowest, indicating the best fit, the proportions of the different age grades in the barracouta catches may be estimated. We used the MIX program (version 3.0) to separate out the age components in the catch diagram from Long Beach (early and late assemblages) and Shag River Mouth. The results are provided in Table 7 and Figure 9.

There are some interesting features in these age-frequency results. Two different time periods are represented at Long Beach: the early settlement can be referred to as Archaic or moahunter in character, ad the later as Classic Māori. Shag River Mouth is chronologically and culturally aligned with the early period at Long Beach. A narrow range of age grades is represented in both the early fish catches. Shag River Mouth is almost completely dominated by eight-year-old fish, with a minor number of five-year-olds. The early people at Long Beach caught barracouta from three age grades - mainly seven-year-olds, with a smaller number of eight-year-olds, and a few nine-year-old fish.

The late sample from Long Beach contrasts markedly with both these earlier barracouta catches. In this case, four different age grades are quite evenly represented. Six- and eight-year-old fish were caught in about the same proportion; and seven- and nine-year-olds are equally represented but in smaller amounts.

It must be remembered that decomposing these age mixtures from different periods of time is not without its hazards. Recruitment and growth rates of fish are markedly affected by sea water temperature and there are good reasons to think that this has varied significantly in New Zealand coastal waters during the last millennium. The mean size of barracouta of different ages could therefore be somewhat different in the two periods of occupation at Long Beach. However, the size-frequency distributions are clearly rather different. Just what this change can be attributed to is a moot point. Given the very large biomass of barracouta in southern waters, we can effectively rule out human influence on the population. These fish move inshore in this area during the summer, and are drawn from a very large benthic population well away from where pre-European Māori were catching them. Although a small human community might have an effect on the inshore fish population during any one summer period, the population would be fully replenished from the main offshore stock the following summer. The significant decrease in mean size at Long Beach is therefore not human induced.

SOME DIETARY ASPECTS OF BARRACOUTA

The ungutted meat weights of the barracouta catches at these sites can be estimated. Various calculations can be made to assess the edible meat weights, caloric value, and the amounts of protein, fat, and carbohydrate which these catches represent. The procedures involved are given in Appendix 2. The catches represent 10,572 kg of fish at Long Beach and 3,355 kg at Shag River Mouth. The caloric energy represented by these catches is 8,505,000 and 2,702,000 kcal respectively.

This energy is made up of 64% from protein, 35% from fat, and 0.7% from carbohydrate. For a number of reasons, humans could not survive on a diet consisting entirely of barracouta. The nutritional issues are discussed in Appendix 2, but we note here that the proportion of energy deriving from protein is far too high, and would lead to toxicity. The people living in this region would need a source of energy deriving from carbohydrate. This is far too far south for the tropical cultigens introduced into New Zealand by early Polynesian settlers.

There are only two possible sources of significant carbohydrates which these people could have had access too - fern root (*Pteridium esculentum* var. *aquilinum*) and *tī* (cabbage tree, *Cordyline australis*). The latter is a superior food in many respects (Fankhauser, 1986). Assuming that adequate supplies of *tī* were readily available, it would have been possible to live on barracouta and this plant alone; although of course this would have been a monotonous diet and is not seriously suggested. Special earth ovens used to cook *tī* are very common in the Otago district (Frankhauser, ibid.). The absolute minimum amount of *tī* which would be required to sustain life in a nutritionally adequate manner would have been 35% by weight (see Appendix 2 for details). Thus, the 9,075 kg of barracouta represented by the fish remains from the early period at Long Beach would have required the harvest-

ing of a minimum of 3,176 kg of *tī* to form the basis of a satisfactory diet. At this level of contribution of *tī* in the diet, caloric energy from protein is almost 32%, which is still very high. To bring this down to 27% would require *tī* at a level of 49% by weight and barracouta at 51% by weight (see Appendix 2 for further details). It can be readily seen that obtaining satisfactory carbohydrate must have been a critically important factor for people living in this region.

DISCUSSION AND CONCLUSIONS

These two sites in the Otago area of New Zealand were significant settlements where a wide variety of fish and other animals were prepared for consumption. Barracouta were clearly very important to the people living at these sites.

It has been shown that fish size decreased significantly at Long Beach over the lengthy period of settlement at this site. There are modest signs of a similar decrease at Shag River Mouth, but the time period in this case is much shorter. There is an accompanying trend of increase in inshore fishing at Long Beach, which could possibly relate to worsening sea conditions for offshore canone-based fishing (Leach & Anderson, 1979). These observed changes could not be caused by human impact on the fishery - the biomass of barracouta in this region is far too large for such a low human population to have any significant effect.

The barracouta catches at both these sites show a dominance of fish older than six years. Fish younger than this certainly frequent the inshore Otago waters, and Graham (1956: 310 ff.) recorded large migrations of immature fish (100-130 mm long) coming into the Otago Harbour in early summer and autumn. Young fish do not appear to have been caught by the pre-European Māori; the reason for this is a mystery. Barracouta catches early in the sequence of habitation at these two sites were dominated by a smaller number of age grades than is found later in time. The late catch shows four age grades of similar relative abundance, though again these are all older fish. There are a number of possible explanations for this, but deciding between them is difficult. One possibility is that the biological relationship between growth and age was different 600 years ago than it is today and, since we are using modern parameters in trying to decompose the catch into its age constituents, the results for the earlier catches may be incorrect. For example, if the standard deviations of the fork length for each age grade were narrower in the past than today, the age structures of the catches at different periods might have been more similar than they appear. Similarly, if the growth rate was higher 600 years ago, with warmer sea conditions, than it is today, this would also explain why the earlier catches were somewhat larger fish. These suggestions are speculative at this stage because we do not have reliable information on surface sea water temperatures around New Zealand during the last thousand years. This points to a need for quality research in this field, perhaps through otolith studies from archaeological sites.

The clear dominance of older individuals in the catches at both these archaeological sites at all periods is somewhat puzzling. Graham (1956) observed large numbers of younger barracouta migrating into shallow inshore Otago waters during the summer months, but it appears that these fish were not being caught by pre-European fishermen. Their absence from the archaeological catches is mysterious. It is possible that the catching techniques employed (lure) preferentially favoured large fish, but this does not seem likely. Alternatively, small fish may have been discarded. This does not seem likely either, as there is ample evidence that very small specimens of other species were caught in abundance (Leach, n.d.).

Barracouta are a rich source of protein and oil, and would have been an excellent food for people living in these southern parts of New Zealand. They can be mass harvested during summer months and would need to be sun-dried and stored for winter use. However, a source of carbohydrate-rich food would have been needed in addition to fish. Fern root and *tī* are possibilities. We estimate that a minimum of 45% by weight of such plant food would have been required for a nutritionally adequate diet.

ACKNOWLEDGEMENTS

Sincere thanks are due to Larry Paul at the National Institute of Water and Atmospheric Research (NIWA) for many useful discussions about fishing and fisheries issues over a long period. We are grateful to Neil Bagley, also of NIWA, and Mr Ling Lim of Seafresh Fisheries (NZ) Ltd, who provided many of the fish specimens for this study. Penny Leach, research assistant in the

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APPENDIX 1
BARRACOUTA IN NEW ZEALAND ARCHAEOLOGICAL SITES

The relative abundance of barracouta in New Zealand archaeological sites can be documented from the fish bone database maintained by the Archaeozoology Laboratory, Museum of New Zealand. This database has grown over many years and at present contains information from 126 sites throughout New Zealand, with a total NISP of 137,041 identifications, representing an MNI of 44,553. Of these sites, 96 contain barracouta. These are listed below.

Site N°	Site Name	Site MNI	% Barracouta
P26/218	Titirangi Pa, Marlborough	1	100.00
O31/5	Takahanga Post Office Site, Kaikoura	120	90.83
O31/15	Peketa Pa, Kaikoura	54	90.74
G47/50	Papatowai, Catlins	27	88.89
J44/4	Pukekura Pa, Taiaroa Head	105	88.57
C46/31	Sandhill Point 3, Foveaux Strait (SHP/3)	363	86.23
H47/1	Pounawea, Otago	428	85.98
O32/8	Omihi, Kaikoura	118	81.36
J44/77	Taiaroa Head, Otago Peninsula	40	80.00
N37/12	Tumbledown Bay, Banks Peninsula	39	79.49
P26/217	Titirangi Cattleyards, Marlborough	14	78.57
I44/23	Long Beach, Otago	5770	78.06
G47/50	Papatowai (S184/5), Otago	29	75.86
C46/31	Sandhill Point 1, Foveaux Strait (SHP/1)	214	70.56
I43/1	Huriawa Peninsula, Areas A, B, Salvage	453	66.23
J43/2	Shag River Mouth, Otago	2134	63.45
C46/16	Port Craig Cave, Foveaux Strait (PC/1)	114	63.16
O32/10	Hudson's Site, Goose Bay, Kaikoura	27	59.26
N26/214	N26/214, Tasman Bay	261	56.32
J43/4	Pleasant River (Smith), Otago	145	55.86
S28/54	Makotukutuku M3 Fort Site, Palliser Bay	8	50.00
P26/229	Goose Bay Midden, Titirangi, Marlborough	2	50.00
J43/4	Tumai, Pleasant River Mouth South	106	50.00
J42/22	Waianakarua Mouth, North Otago	6	50.00
C46/31	Sandhill Point 2, Foveaux Strait (SHP/2)	2	50.00
P26/208	Titirangi Sandhills, Marlborough	45	48.89
I44/21	Purakanui Inlet, Otago	2745	48.01
N26/18	Awaroa (N26/18), Tasman Bay	32	43.75
O31/30	Old Pier Point, Avoca, Kaikoura	24	41.67
I44/1	Omimi, Otago	27	40.74
S28/48	Makotukutuku M1 Camp Site, Palliser Bay	5	40.00
E49/15	Kelly's Beach, Stewart Island	13	38.46
N26/16	Bark Bay, Tasman Bay	50	36.00
I44/17	Mapoutahi (S164/13), Otago	140	34.29
I44/5	Otokia Mouth, Brighton Beach, Otago	3	33.33
R27/42	Makara Terrace Midden, Wellington	19	31.58
J43/4	Pleasant River (Anthropology), (S155/8)	54	31.48

Site N°	Site Name	Site MNI	% Barracouta
Q27/30	Te Ika a Maru, Eastern Flat, Wellington	60	30.00
E48/30	Te Kiri Kiri, Ruapuke Island (KK/1)	56	28.57
N25/50	Taupo Point, Tasman Bay	11	27.27
E48/34	Parangiaio, Ruapuke Island (PP/1)	11	27.27
C240/277	Te Ngaio, Petre Bay, Chatham Island	4	25.00
O27/56	Haulashore Island, Tasman Bay	25	24.00
B45/1	Cascade Cove, Dusky Sound (CC/1)	123	23.58
Q7/58	Northland Harbour Board Site, Whangarei	5	20.00
C46/31	Sandhill Point 4, Foveaux Strait (SHP/4)	105	20.00
R27/41	Makara Beach Midden, Wellington	44	18.18
O27/1	Rotokura, Tasman Bay	585	17.61
R11/142	Hamlins Hill (N42/137), Auckland	12	16.67
E48/29	West Point, Ruapuke Island (WP/1)	63	15.87
N27/118	Appleby, Nelson	128	14.84
R11/898	Westfield (N42/941), Auckland	21	14.29
B45/23	Milford, Fiordland	7	14.29
R10/38	Davidson Undefended Site, Motutapu Is	50	14.00
D46/38	Wakapatu, Western Southland	94	13.83
E48/36	Lee Island Site, Ruapuke Island (LI/1)	8	12.50
I43/22	Ross Rocks, Otago	139	12.23
B45/14	Southport 4, Cave Site, Fiordland (SP/4)	86	11.63
N3/582	Aupouri Dune Middens, 90 Mile Beach	18	11.11
S28/103	Black Rocks Fan, Palliser Bay	20	10.00
B44/41	Breaksea Sound 1, Discovery Cove (BSS/1)	1153	8.85
R26/122	Paremata, Wellington	140	8.57
S28/104	Black Rocks BR4 Crescent Midden, Palliser	683	8.20
U12/5	Slipper Island, Coromandel	13	7.69
N36/72	Panau, Banks Peninsula	68	7.35
C46/19	Port Craig Midden, Foveaux Strait (PC/4)	28	7.14
S28/49	Washpool Site, Palliser Bay	750	7.07
R10/26	Station Bay Pa, Motutapu Island	145	6.90
B45/11	Southport 1, Fiordland (SP/1)	439	6.83
Q27/36	Te Ika a Maru, Flat at Base of Pa	194	6.70
R26/141	Mana Island North Settlement (R26/141)	1155	6.23
E47/13	Tiwai Point, Bluff Harbour	102	5.88
B45/15	Southport 5, Cave Site, Fiordland (SP/5)	120	4.17
B44/22	Coopers Island, Dusky Sound (CI/1)	219	3.65
U13/1101	Midden 8, Matakana Island	124	3.23
B44/1	Long Island, Dusky Sound (LI/1)	250	2.80
B45/17	Southport 7, Fiordland (SP/7)	111	2.70
B45/16	Southport 6, Fiordland (SP/6)	185	2.70
T9/139	Port Jackson, Coromandel	42	2.38
B45/22	Chalky Is, Chalky Inlet, Southport (CH/1)	45	2.22
S28/104	Black Rocks BR3 Black Midden, Palliser	189	2.12
K30/2	Fox River, Te Onumata, Potikohua River	100	2.00
G36/1	Bruce Bay, south Westland	54	1.85
S28/104	Black Rocks BR2 Pond Midden, Palliser	56	1.79
O27/13	The Glen, Tasman Bay	179	1.12
V15/80	Kohika, Bay of Plenty (N68/104)	184	1.09
O6/317	Kokohuia, Hokianga	838	0.95
C240/283	Waihora, Chatham Islands	4197	0.93

Site N°	Site Name	Site MNI	% Barracouta
T8/3	Harataonga Bay Pa, Great Barrier Island	231	0.87
R26/141	Mana Island South Midden (R26/141A)	591	0.85
T11/115	Hot Water Beach, Coromandel	277	0.72
T11/242	Hahei, Coromandel (N44/215)	202	0.50
T10/399	Cross Creek Site, Coromandel	481	0.42
S24/3	Foxton, Manawatu	270	0.37
R10/25	Sunde Site soft shore midden, Motutapu Is	401	0.25
N3/59	Houhora, Northland	2425	0.08

APPENDIX 2
SOME CALCULATIONS ON BARRACOUTA IN DIET

In the following discussion, Long Beach All refers to all samples from Long Beach, including bone collections from mixed provenances. Thus, the MNI figures include bones other than those listed elsewhere in this paper as from the early and late provenances. Shag River All refers to all samples from the dune area, including bone material from mixed provenances.

The ungutted weight (g) of the various samples can be estimated using the regression information provided by Leach *et al.* (1996)

Sample	Mean - SE	SD - SE
Long Beach Early	2369 ± 4	448 ± 3
Long Beach Late	2220 ± 14	570 ± 10
Long Beach All	2347 ± 4	471 ± 3
Shag River All	2478 ± 11	473 ± 8

The Edible Weight of barracouta is approximately 0.7 * Total Weight (Smith, 1985), thus:

Sample	MNI	x	Mean	=	Weight kg	Edible Wgt
Long Beach Early	3831	x	2369	=	9706	6353
Long Beach Late	550	x	2220	=	1221	855
Long Beach All	4504	x	2347	=	10572	7400
Shag River All	1354	x	2478	=	3355	2349

In the example at the end of this Appendix we will use the figure of 9076 kg referring to the Long Beach Early assemblage.

Barracouta whole fish protein is 18.4 g/100g, oil is 4.5 g/100g (Vlieg, 1988: 23), and carbohydrate is 0.2 g/100g (ibid.: 5). Barracouta gross caloric energy is 107 kcal/100g (ibid.: 48). The figures for kcal/100g for protein, fat and carbohydrate (400, 900 and 400) derive from Smith (1985: 131). The various samples then represent:

Sample	Edible kg	Protein kg	Oil kg	Carb kg
Long Beach Early	6353	1169	286	13
Long Beach Late	855	157	38	2
Long Beach All	7400	1362	333	15
Shag River All	2349	432	106	5

It is possible to calculate the amount of energy derived from the protein, oil and carbohydrate in barracouta as follows:

	Protein	Oil	Carb	Total
Energy kcal/100g	400	900	400	
Whole Barracouta g/100g	18.4	4.5	0.2	
So, kcal/100g whole fish	73.6	40.5	0.8	114.9
So, the energy percent values are	64.1	35.2	0.7	100.0

NB: This total compares favourably with Vlieg's figure of 107 kcal/100g for whole fish. So these samples provided energy as follows:

Sample	Protein kg x 4000	Oil kg x 9000	Carb kg x 4000
Long Beach Early	1169 = 4676000	286 = 2574000	13 = 52000
Long Beach Late	157 = 628000	38 = 342000	2 = 8000
Long Beach All	1362 = 5448000	333 = 2997000	15 = 60000
Shag River All	432 = 1728000	106 = 954000	5 = 20000

Therefore, the Total Energy is:

Long Beach Early	4,676,000 + 2,574,000 + 52,000 = 7,302,000
Long Beach Late	628,000 + 342,000 + 8,000 = 978,000
Long Beach All	5,448,000 + 2,997,000 + 60,000 = 8,505,000
Shag River All	1,728,000 + 954,000 + 20,000 = 2,702,000

However, the upper limit to the amount of food energy which can be derived from protein is 20-30% of average daily needs, say 25% (Leach, n.d.: Chapter 8). If this figure is exceeded, unhealthy conditions arise, such as azotaemia (excess nitrogen) and a rise in plasma ammonia concentrations which can be lethal (Noli & Avery, 1988: 397). Moreover, there is an upper limit to the amount of caloric energy which can be derived from fat without dangerous levels of acidic ketone bodies accumulating in the bloodstream (ketonuria); this is about 40% of daily caloric needs (Leach, n.d.: Chapter 8).

What this analysis shows is that one could not live on barracouta alone, since the percentage of energy deriving from the three main ingredients (protein 64.1, fat 35.2, and carbohydrate 0.7) is out of balance for a satisfactory human diet. A diet of barracouta is far too rich in protein. It would easily provide all the daily protein and fat requirements, but there is a dramatic shortage of carbohydrates. We can hypothesise an unknown source of carbohydrate (perhaps fern root and/or *tī*) to the level required to bring down the contribution of protein from barracouta to say 25% of caloric needs. *Tī*, for example, provides protein at 2 g/100g, fat at 6 g/100g and carbohydrate at 30-74 g/100 (say average of 50). This is equivalent to caloric energy levels of:

Tī Protein	2 * 4 =	8 kcal = 3.1%
Tī Fat	6 * 9 =	54 kcal = 20.6%
Tī Carbohydrate	50 * 4 =	200 kcal = 76.3%
Total kcal/100g for *tī*		262

We could therefore have a diet mixture providing caloric energy for the main three components along the following lines:

	Proportions of Caloric Energy		
	Protein%	Oil%	Carb%
Barracouta	64.1	35.2	0.7
Tī	3.1	20.6	76.3

This could be a satisfactory dietary mix, assuming that adequate supplies of *tī* were available. A series of simple calculations can be made to assess the energy which would derive from various levels of contribution of *tī*. These are given below for the Long Beach early assemblage in which the total weight of barra-

couta was 9076 kg. *Tī* could be added to this source of protein-rich food in varying amounts from 5% to 50% of the weight of fish eaten.

Apportionment of Food Energy deriving from Protein, Oil and Carbohydrate

Fish kg	*Tī* kg	Proportion	Blubber kg	Protein %	Oil %	Carb %
9076	454	0.05	0	55.5	33.2	11.3
9076	908	0.10	0	49.1	31.7	19.3
9076	1361	0.15	0	44.0	30.4	25.5
9076	1815	0.20	0	40.0	29.5	30.5
9076	2269	0.25	0	36.7	28.7	34.6
9076	2723	0.30	0	33.9	28.0	38.1
9076	3176	0.35	0	31.6	27.5	41.0
9076	3630	0.40	0	29.5	27.0	43.5
9076	4084	0.45	0	27.8	26.5	45.7
9076	4538	0.50	0	26.3	26.2	47.6
5 Percent by weight of blubber added						
9076	454	0.05	454	37.5	54.9	7.6
9076	908	0.10	454	34.5	51.9	13.6
9076	1361	0.15	454	32.0	49.4	18.6
9076	1815	0.20	454	29.9	47.3	22.8
9076	2269	0.25	454	28.0	45.5	26.5
9076	2723	0.30	454	26.4	43.9	29.7
9076	3176	0.35	454	25.0	42.5	32.5
9076	3630	0.40	454	23.8	41.2	35.0
9076	4084	0.45	454	22.7	40.1	37.2
9076	4538	0.50	454	21.7	39.1	39.2

It can be seen from this that *tī* has to be added to the weight of barracouta to a level of more than 50% by weight of the total fish available if the energy deriving from protein is to be low enough to avoid azotaemia (this was earlier mentioned as about 25% of energy intake). On the other hand, it will also be observed that if an additional source of high energy oil from seal blubber is added to the diet, the proportion of *tī* required falls. Adding blubber to a level of 5% by weight of the fish means that *tī* can be lowered by a similar amount, to say 45% of the weight of fish. Energy from fat sources now rises uncomfortably close to the 40% threshold where ketonuria might result.

This shows that a carbohydrate food like *tī* would be required to a level of 45% to 50% of the weight of fish consumed, and that it would have been a delicate balancing act, striving to avoid two dietary dangers - azotaemia on the one hand, and ketonuria on the other.

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Fragmentation and Preservation of Bird Bones in Food Remains of the Golden Eagle *Aquila chrysaetos*

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ABSTRACT: Uneaten remains of Golden Eagles' preys in Finland from 20 eyries have been examined. The most numerous prey were galliforms (*Tetrao*, *Lagopus*), followed by geese, ducks, corvids, charadrids and others. The fragmentation and preservation of all major skeletal elements of Golden Eagles' victims are for the first time analyzed in detail. It appears that Golden Eagles leave a characteristic "signature" on their victims' bones which can be successfully recognized in appropriate fossil and/or archaeological deposits. Many limb bones are well-preserved and not fragmented, the proportion of complete bones often exceeds 80% of the total number of their fragments. Victims' heads are very scarce but trunk skeletons are abundant, although heavily damaged. The highest MNI values are obtained with sterna, followed by coracoids, humeri and scapulae. The results are compared with those describing both recent and subfossil food remains of Golden Eagles. The pattern of fragmentation produced by Golden Eagles is also compared with those of Imperial Eagles, Gyrfalcons, four species of owls, and human predation. Differences allowing the recognition of the predator involved are highlighted. Bones of victims retrieved from uneaten food remains of Golden Eagles are far less fragmented and damaged than bones found in pellets of diurnal birds of prey and owls. Therefore, it is believed that more fossil assemblages can be attributed to uneaten food remains of diurnal birds of prey than to their pellets.

KEYWORDS: TAPHONOMY, BIRD BONES, FOOD REMAINS, *Aquila chrysaetos*

RESUMEN: El trabajo examina los restos no consumidos de presas del águila real en 20 nidos en Finlandia. Las presas más numerosas están constituidas por Galliformes (*Tetrao, Lagopus*) seguidas por gansos, patos, Córvidos, Carádridos y otros. Se analiza en detalle por vez primera la fragmentación y preservación de todos y cada uno de los principales elementos esqueléticos de las presas de esta rapaz. Parece claro que el águila real deja una serie de rasgos característicos en los huesos de sus víctimas que podrían ser detectados con éxito en muestras fósiles o arqueológicas adecuadas. Muchos huesos apendiculares están bien conservados y no se fragmentan. La proporción de huesos completos con frecuencia excede del 80% del número total de sus fragmentos. Las cabezas de las presas son muy infrecuentes pero los esqueletos troncales son abundantes si bien resultan muy dañados. Los valores más altos del NMI se han obtenido con esternones seguidos de coracoides, húmeros y escápulas. Estos resultados se comparan con aquéllos que describen restos alimentarios de águilas reales tanto recientes como subfósiles. El patrón de fragmentación producido por este águila se compara también con los del águila imperial, el halcón gerifalte, cuatro especies de lechuzas y presas depredadas por el hombre. Se enfatizan aquellas diferencias que posibilitan el reconocimiento del depredador implicado en cada caso. Los huesos de presas procedentes de restos de comida desechada por el águila real están mucho menos dañados y fragmentados que los huesos encontrados en las egagrópilas de rapaces diurnas y lechuzas. Por ello se cree que más muestras subfósiles pueden ser atribuidas a restos de comida desechada por rapaces diurnas que a los aparecidos en sus egagrópilas.

PALABRAS CLAVE: TAFONOMÍA, HUESOS DE AVE, RESTOS DE ALIMENTACIÓN, *Aquila chrysaetos*

INTRODUCTION

The Golden Eagle is one of the largest birds of prey occurring in the Northern Hemisphere from West Europe and North Africa to Kamchatka and Japan, across Alaska, Canada and the western USA to Mexico. It inhabits mountains, uplands and also lowland forests or wetland terrains (Hagemeijer & Blair, 1997). Its favourite prey is mammals and birds ranging in size usually between 0.5 and 5 kg.

Tetraonids are very important prey of Golden Eagles in the north-west Palearctic where their share in the eagles' diet is 25-65% of prey items (Cramp & Simmons, 1980; McGrady, 1997; Sulkava & Rajala, 1966; Sulkava *et al.*, 1984). Remains of galliforms are also often the most numerous finds among fossil and archaeological bird bone materials in the Palearctic. Thus, the possibility exists that some of the fossil bird deposits from this area are food remains of Golden Eagles. This conclusion has already been put forward by Bramwell *et al.* (1987). This paper is the first one to provide detailed, quantitative data on the damage to bird bones in food remains of Golden Eagles in an attempt to provide differences which could help discriminate diurnal preybird's thanatocenoses from those produced by other raptors.

MATERIAL AND METHODS

The material investigated is a sample from long-term studies of the diet of Golden Eagles in Finland (Sulkava *et al.*, 1984). At first, a number of pellets were examined but then, due to the small amount of recognizable bones recovered, the pellet material was excluded from detailed analysis. Thus, for the current paper only uneaten bird remains (approx. 2000 bones) collected in northern parts of central Finland (65-66° N) from beneath 20 eyries and nearby roosts during July and August in 1988-1996 have been examined.

All identifiable elements of the skeleton were determined by comparing them with specimens from the osteological collection of the Institute of Systematics and Evolution of Animals, PAS, Poland.

The categories of bird bones' fragmentation used in the study are the same as those proposed for owls (Bocheński *et al.*, 1993: Figs. 1-5). Bones from the left and right side of the body were pooled within each category.

Chi-square test (with Yates' correction for continuity) was used to check for differences in the degree of fragmentation suffered by the two most numerous prey species (*T. urogallus* and *T. tetrix*).

Bone ratio of the wing to leg elements was calculated as the number of wing fragments (humerus, ulna, carpometacarpus) divided by the sum of wing and leg fragments (femur, tibiotarsus, tarsometatarsus), expressed as per cent (Ericson, 1987; Livingston, 1989).

The minimum number of individuals (MNI) was calculated for each bone separately in two different ways: (i) bones from each eyry were treated separately, identified to species (genera, orders), proximal and distal parts were fitted together, and the MNI was taken from the more frequent side (left or right); (ii) the MNI was computed for the whole material (not for separate eyries), bones were neither identified to species nor were the proximal and distal parts fitted together; instead, the most numerous elements (whole and either proximal or distal) from the left or right side were counted. The latter procedure was the same as in previous studies (Bocheński, 1997; Bocheński *et al.*, 1993, 1997, 1998; Bocheński & Tomek, 1994).

Damage to the bone surface (articular parts, shafts and beaks) was studied under light microscope, applying categories of damage described by Bocheński & Tomek (1997).

RESULTS

After examining a number of Golden Eagles' pellets, it appeared that they consisted mostly of fur, feathers and macerated organic tissues. Remains of bones were extremely rare, and they were limited to a few small, heavily digested fragments of shafts and ungular phalanges. In many cases it would be difficult to determine whether the bony remains belonged to mammals or birds. Apart from bony remains, in about 30 pellets examined, a couple of horny coverings of ungular phalanges and three coverings of bird mandibles were found. One pellet contained teeth of a rodent, without a trace of its skull, and a mandible or a very similar looking bone.

Contrary to the pellet material, the uneaten food remains (i.e. those which were defleshed and left by the eagles, mostly in or under the eyries) were not only numerous but also slightly damaged. The most numerous prey found among the uneaten food remains of *A. chrysaetos* was galliforms (*Te-*

SPECIES	EYRIES																				TOTAL	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	N	%
Tetrao tetrix	5	5	13	10	8	4	6	11	2	2	5	8	2	8	2	7	1	2			101	28.8
Tetrao urogallus	3	6	6	2	5	4	4	9	2	5	7	3	6	2	1	4	2	2			73	20.8
Lagopus sp.	6	2	13	14	3	1	6	2	1	1	3	3	3	2			1				61	17.4
Bonasa bonasia							1														1	0.3
Galliformes indet.																			7	3	10	2.8
Charadriiformes (*Numenius, Larus*)		4			3	1	6	9					5		1	1	4				34	9.7
Geese (*Anser/Branta*)		2	1		1				1	1	3	1	2		1	1		1			15	4.3
Ducks		3	1			1	1	1		2		1	2	1	3		1				17	4.8
Corvus sp. (*corax,corone*)		2	2			1	1	1			1	1	1	1	2			1			14	4.0
Strigiformes						1	1		1				1								4	1.1
Grus grus		3	1				2														6	1.7
Ciconia sp.						1															1	0.3
Columba sp.									1												1	0.3
Aves indet.		1	4				2				1		1		1		3				13	3.7
TOTAL	14	28	41	26	20	14	30	33	8	11	20	17	23	14	11	13	12	6	7	3	351	100

TABLE 1

List of prey identified from uneaten food remains of *A. chrysaetos*. The figures correspond to the highest values obtained, irrespective of the type of bone.

trao, *Lagopus*), totalling over two-thirds of all prey items. Additional prey included geese, ducks, charadrids, corvids and others (Table 1). Galliforms predominated in most eyries, reflecting the general food preferences of the Golden Eagle in Scandinavia.

1. FRAGMENTATION PATTERNS

Axial skeleton

Fragments of heads (skulls and mandibles) were very scarce in the material studied (Table 2). Beaks prevailed among the recognizable fragments.

Remains of sterna constituted one of the most numerous finds. Most fragments contained the rostrum sterni (Table 2, Figure 1). Small and large fragments ("less than 1/2" and "more than 1/2") were equally numerous.

Remains of the synsacrum prevailed among the moderately numerous fragments of the pelvis (Table 2: columns 2 and 4, Figure 1).

Long bones

With the exception of scapula, the category "whole bone" greatly outnumbered smaller fragments in all types of bones (Table 3, Figure 2). In the scapula fragments with articular parts prevailed. Shafts were extremely rare; only three shaft fragments were found in the material. Proximal elements of the skeleton (i.e., scapula, coracoideum, humerus, femur and tibiotarsus) were much more numerous than more distal bones (ulna, radius, carpometacarpus and tarsometatarsus) (Table 4).

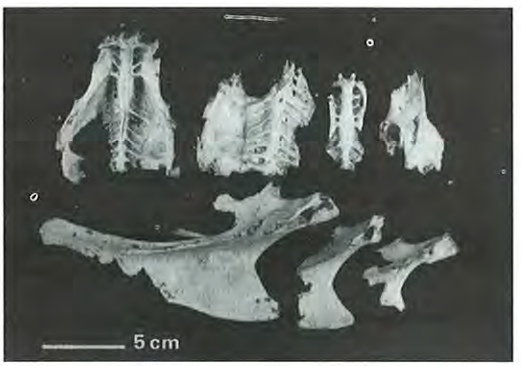

FIGURE 1

Pelvis and sternum of grouse damaged by *A. chrysaetos*. Categories of fragmentation are described in Table 2. Upper row, from left to right: synsacrum with two ilium-ischii-pubis bones (i.e. whole pelvis), synsacrum with one ilium-ischii-pubis bone, whole synsacrum, acetabulum region. Bottom row: more than 1/2 with rostrum (i.e. whole sternum), less than 1/2 with rostrum (two fragments).

For all bones, proximal and distal ends exhibited roughly equal abundances, differences being statistically insignificant.

Statistically significant differences in the degree of fragmentation suffered by *T. urogallus* and *T. tetrix* were found in two bones only (coracoideum: $p<0.01$, DF=1 and humerus: $p<0.05$,

SKULL

Number of fragments	Whole skull %	Skull with beak and brain case without back part %	Brain case without back part %	Brain case %	Whole beak %	End of beak %	Other fragments %	MNI with identification N	MNI without identification N	MNI %
N = 17	6	6	0	12	65	0	12	17	12	5

MANDIBLE

Number of fragments	Whole N	One branch N	Articular part N	Tip of mandibula N	Middle part of branch N	MNI with identification N	MNI without identification N	MNI %
N = 2	0	1	0	1	0	2	1	0.4

STERNUM

Number of fragments	More than 1/2 with rostrum %	Less than 1/2 with rostrum %	Fragments without rostrum %	MNI with identification N	MNI without identification N	MNI %
N = 266	40	45	15	235	227	100

PELVIS

Number of fragments	Synsacrum with 1 or 2 ilium-ischii-pubis bones %	Ilium-ischii- pubis bone %	Synsacrum whole or partial %	Acetabulum region %	MNI with identification N	MNI without identification N	MNI %
N = 163	47	4	27	22	132	120	53

TABLE 2

Fragmentation of the axial skeleton in uneaten food remains of *A. chrysaetos*. In skulls, sterna and pelvis the fragmentation is expressed as percentages of the total number of all skull, sternal or pelvic fragments found; in mandibles - absolute numbers are given (see Bocheński *et al.*, 1993: Figs. 1-4). MNI% is the percentage of the highest value of the "MNI without identification" (obtained with sternum) formed by the number of individuals estimated on the basis of a given bone.

Bones (Total number of fragments)	Whole bone %	Proximal part %	Distal part %	Shaft %	MNI with identification N	MNI without identification N	MNI %
Scapula (N = 267)	12	87	0	1	176	140	62
Coracoideum (N = 313)	83	10	7	0	204	155	68
Humerus (N = 297)	90	8	2	0	192	149	66
Ulna (N = 69)	93	7	0	0	53	36	16
Radius (N = 64)	76	19	5	0	40	32	14
Carpometacarpus (N = 42)	95	5	0	0	30	21	9
Phalanx I dig maj. alae (N = 31)	97	3	0	0	24	16	7
Femur (N = 175)	81	15	4	0	120	91	40
Tibiotarsus (N = 115)	73	10	15	2	84	51	22
Tarsometatarsus (N = 46)	80	7	15	0	36	25	11

TABLE 3

Fragmentation of long bones in uneaten food remains of *A. chrysaetos* expressed as percentages of the total number of all long-bone-fragments found (see Bocheński *et al.*, 1993: Fig. 5). In scapula: distal part and shaft are shown jointly in the category "shaft". In coracoideum: proximal=sternal, distal=scapular. For MNI (%), see Table 2.

FIGURE 2

Long bones of grouse damaged by *A. chrysaetos*. Categories of fragmentation are described in Table 3. From left to right: three elements still in articulation (ulna, radius and carpometacarpus), scapular part of coracoideum articulated, with proximal part of scapula, whole coracoideum articulated with whole scapula, whole humerus, proximal part of humerus, whole tibiotarsus articulated with whole femur, whole femur, proximal part of femur articulated with the acetabulum region of pelvis.

DF=1). In both cases *T. tetrix* was the more affected taxon (Table 5).

Minimum number of individuals

MNIs (and their percentages), calculated separately for every type of bone, appear in the last three columns of Tables 2 and 3. For long bones, the values of the MNI with identification were 20-39% higher than those of the MNI without identification. Differences were smaller for sterna and pelvis (3% and 9%, respectively). The sequences of bones that provided the best results in the calculation of the MNI with - and without identification were identical. The highest values for the MNI without identification were obtained with sterna (MNI=227, MNI (%)=100), followed by coracoids, humeri and scapulae (MNI (%) = 62-68). Two bones (pelvis and femur) provided moderately good results (MNI (%) around 50), and the remaining bones scored poor (MNI (%) well below 50).

Wing/leg ratio

The percentage of the wing bones as a proportion of wing and leg bones was 56%. The deviation (wing elements prevailed) from the expected 50% (1:1 proportion) was statistically significant ($p<0.01$, DF=1).

2. SURFACE DAMAGE

The elements of the axial skeleton (skull, mandible, sternum and pelvis) were either intact or had holes and cracks with sharp edges. All broken surfaces were sharp and rough.

Surfaces of long bones remained undamaged in most cases (Table 6). Those which were dam-

Elements	Golden Eagle Uneaten food remains			Imperial Eagle (Bocheński *et al.* 1997)		Gyrfalcon (Bocheński *et al.* 1998)	Snowy Owl (Bocheński 1997)	Long-eared Owl (Bocheński & Tomek 1994)	Tawny Owl (Bocheński *et al.* 1993)	Eagle Owl (Bocheński *et al.* 1993)
	Present data (%)	Tjernberg's data (Bramwell *et al.* 1987) (%)	subfossil data (Bramwell *et al.* 1987) (%)	Uneaten (%)	Pellets (%)	Pellets (%)	Pellets (%)	Pellets %	Pellets %	Pellets %
Proximal	84	90	94	64	54	54	72	56	59	59
Distal	16	10	6	36	46	46	28	44	41	41

TABLE 4

Relative proportions of the proximal elements (scapula, coracoid, humerus, femur, tibiotarsus) and distal elements (ulna, radius, carpometacarpus, tarsometatarsus).

Bone		*Tetrao urogallus*	*Tetrao tetrix*
Coracoid	Whole bones	79	74
	Broken parts	7	24
Humerus	Whole bones	78	79
	Broken parts	4	15

TABLE 5

Uneaten food remains of *A. chrysaetos* - total number of fragments of coracoids and humeri belonging to *T. urogallus* and *T. tetrix*.

BONES (Number of fragments)		BONE SURFACE	
		Undamaged	Sharp
Scapula	Articular N=265	86	14
	Shaft N=229	97	3
Coracoideum	Prox & dist N=572	65	35
	Shaft N=285	98	2
Humerus	Prox & dist N=559	83	17
	Shaft N=283	99.6	0.4
Ulna	Prox & dist N=133	95	5
	Shaft N=67	100	0
Radius	Prox & dist N=113	99	1
	Shaft N=62	100	0
Carpometacarpus	Prox & dist N=82	98	2
	Shaft N=40	100	0
Phalanx I dig maj. alae	Prox & dist N=61	98	2
	Shaft N=30	90	10
Femur	Prox & dist N=315	77	23
	Shaft N=167	99	1
Tibiotarsus	Prox & dist N=196	68	32
	Shaft N=106	99	1
Tarsometatarsus	Prox & dist N=85	92	8
	Shaft N=45	98	2

TABLE 6

Percentage of surface damage to long bones in uneaten food remains of *Aquila chrysaetos*. Categories of damage follow those described by Bocheński & Tomek (1997).

aged had holes or cracks with sharp edges. Articular parts exhibited this same kind of damage more often than shafts (1-35% and 0-10%, respectively). All broken surfaces, regardless of the type of bone, were sharp and rough, at right angles to the shaft axis. No rounding of edges (i.e. typical damage resulting from digestion) was observed.

DISCUSSION: COMPARISONS AND COMMENTS

The scarcity of skull and mandible remains in uneaten food remains of Golden Eagles may be due to (i) decapitation and plucking of prey by adult eagles before they take it to their nest (Fisher, 1979) and/or (ii) ingestion of victims' heads by the eagles. The latter explanation is supported by our finding of three horny coverings of mandibles in the pellet material. Regardless of the reason, it is clear that uneaten remains gathered near eyries contain very few remains of victims' heads.

The recorded damage to sterna in our material (most were represented by the anterior end with the rostrum sterni) is consistent with that described by Bramwell *et al.* (1987). The same is true for the remains of the pelvis (synsacra prevailed in both studies).

In terms of relative numbers of particular elements, the present material is very similar to those of Golden Eagles (contemporary and subfossil) analyzed by Bramwell *et al.* (1987). The four most frequently found elements (coracoid, scapula, humerus, sternum) are the same in all studies, although their sequence is different. The results are also consistent with those of uneaten food remains of Imperial Eagles (*Aquila heliaca*) (Bocheński *et al.*, 1997) where, besides these four elements, ulnas are also very numerous. On the other hand, in pellets of various species of owls (Bocheński *et al.*, 1993; Bocheński & Tomek, 1994), Gyrfalcons *Falco rusticolus* (Bocheński *et al.*, 1998) and Imperial Eagles (Bocheński *et al.*, 1997), the relative frequencies of particular elements differ from that of uneaten food remains of Golden Eagles.

The differences in relative frequencies of bones between pellet materials and uneaten food remains are also well-marked in the proximal/distal element ratio (Table 4). In uneaten food remains of Golden Eagles (present data, Bramwell *et al.*, 1987) proximal elements outnumbered distal bones to a much larger extent (84-94% to 6-16%) than they did in owls' pellets, Gyrfalcons and Imperial Eagles (54-59% to 41-46%) (Bocheński *et al.*, 1993, 1997, 1998; Bocheński & Tomek, 1994). This finding agrees with the observation that most of the owl assemblages (i.e. pellet materials) only exhibit a slight loss of the distal elements (Andrews, 1990: data for small mammal prey). There are two exceptions to this rule: (i) uneaten food remains of Imperial Eagles (Bocheński *et al.*, 1997), and (ii) pellets of Snowy Owls (Bocheński, 1997). In both cases the share of proximal elements (64% and 72%, respectively) lies between the "typical" values for pellets and uneaten remains. This can be due to a drastically different proportion of prey/raptor size (Imperial Eagles took much smaller prey [rooks and crows] than Golden Eagles [galliforms]), and, perhaps, to an unknown bias small amount of related to the material analyzed (Snowy Owls).

In addition to the food remains of Golden Eagles, statistically significant predominance of wing elements over leg bones was also found in pellet materials of Tawny and Eagle Owls (Bocheński, 1997). According to Ericson (1987), such proportion would be indicative of a "natural bone ratio" i.e. decomposition without human influence. Livingston (1989) however, also found wing elements to be more numerous in fossil assemblages attributable to raptors' activities. This problem is more complicated since the survival of particular elements probably depends to some extent on their mechanical properties (Bjordal, 1988; Livingston, 1989; Worthy & Holdaway, 1994, 1996).

The degree of fragmentation of long bones in uneaten food remains of Golden Eagles (measured as the total share of broken fragments present) is clearly lower (often by 20-50% or even higher) than that in pellets of Gyrfalcons (Bocheński, *et al.*, 1998) or in pellets of any species of owl thus far examined (Bocheński, 1997; Bocheński *et al.*, 1993; Bocheński & Tomek, 1994). The high proportion of whole (i.e. unbroken) bones in our material is only equivalent to that from uneaten food remains of Imperial Eagles (Bocheński *et al.*, 1997). Bones recovered from uneaten food remains of Gyrfalcons are also less fragmented than bones taken out from their pellets (Huhtala *et al.*, 1996).

Differences in the degree of fragmentation of humeri and coracoids of two species of prey (*T. urogallus* and *T. tetrix*) lend support to the idea that survival of particular bones depends not only on the species of predator but also on the species of prey (Worthy & Holdaway, 1996). More robust and stronger bones (in our case those of *T. urogallus*) are less vulnerable to damage (Bjordal, 1988; Livingston, 1989).

Four types of bones that provide the highest values of the MNI (%) in Golden Eagles (sternum, coracoid, humerus, scapula) are the same as those for Imperial Eagles (Bocheński *et al.*, 1997); the only difference is in their sequence. Uneaten food remains of Golden and Imperial Eagles (present data, Bramwell *et al.*, 1987; Bocheński *et al.*, 1997) are characterized by high values of the MNI (%) in the case of the victims' sterna (100% and 84%, respectively), and low values of the MNI (%) for carpometacarpi (9% and 33%), femora (40% and 18%), tibiotarsi (22% and 35%) and tarsometatarsi (11% and 41%). The reverse situation occurs in pellet materials of Snowy, Tawny, Long-eared and Eagle Owls (Bocheński, 1997; Bocheński *et al.*, 1993; Bocheński & Tomek, 1994), where the MNI (%) for sterna are low (30-67%, depending on the species), whereas high values of the MNI (%) were recorded for carpometacarpi (63-86%), femora (57-71%), tibiotarsi (54-72%) and tarsometatarsi (71-96%). Thus, the differences seem to correlate with the origin of the material (uneaten food remains versus pellets) and with the size of prey involved.

The fact that most of the skeletal elements were not damaged indicates that eagles remove flesh from large bones without breaking them. This is consistent with descriptions of the way eagles feed on larger prey (Glutz von Blotzheim *et al.*, 1971; Fisher, 1979). The type of damage to the surface of the bones affected was the same as that which results from mechanical agents (Bocheński & Tomek, 1997) in our case, the fractures, scratches and other damage was made by the eagles. As is the case with traces of digestion in pellet materials (Andrews, 1990; Bocheński & Tomek, 1997), shafts of eagles' victims, being made up of harder bone than articular parts, were less affected by damage caused by the eagles.

Diurnal birds of prey were placed in a separate category of predators producing more breakage of postcrania than owls though less than mammalian carnivores (Andrews, 1990). It is true (Bocheński *et al.*, 1997, 1998) but only if we consider pellet materials. Bones of victims coming from uneaten food remains of Golden Eagles (and possibly other diurnal birds of prey) are less damaged and fragmented than those from pellets of owls. Moreover, uneaten food remains of eagles incorporate many more bones of victims than their pellets. Although on occasions fossil deposits have been succesfully attributed to pellets of diurnal birds of prey (Mayhew, 1977; Worthy & Holdaway, 1995), it is far more likely that in most cases fossil assemblages accumulated by diurnal birds of prey come rather from their uneaten food remains than from their pellets. This must have also been the case in the material analyzed by Bramwell *et al.* (1987).

CONCLUSIONS

Golden Eagles leave their own "signature" on their victims' bones. The signature can be successfully recognized on archaeological and fossil materials deposited by the species.

Bones from uneaten food remains of Golden Eagles have better chances to be preserved than bones from their pellets. Consequently, it is believed that in the future more fossil assemblages can be attributed successfully to uneaten food remains of diurnal birds of prey.

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Fishing in the Baltic Region from the 5th century BC to the 16th century AD: Evidence from Fish Bones

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ABSTRACT: Archaeological fish bone assemblages from the Baltic region of Europe are reviewed for the period from the 5th century BC to the 16th century AD. The evidence from the fish bones is used to illuminate fishing, fish consumption and fish trade. At almost all sites, the selection of fish species in the assemblages indicates a very strong influence from the local fish fauna. The species of fish and the size of the individuals indicate that a variety of fishing methods have been employed throughout the period studied, including nets, hooks and weirs. In some countries, a chronological development in fishing, for example, a tendency towards more sea-going fishing, is reflected in the fish bone assemblages.

KEYWORDS: FISH, FISH BONE ASSEMBLAGES, BALTIC, IRON AGE, VIKING AGE, MIDDLE AGES, PREHISTORIC FISHING, PROTOHISTORIC FISHING, FISHING IN HISTORICAL TIMES

RESUMEN: En este trabajo se lleva a cabo una revisión pormenorizada de las muestras ictioarqueológicas de la región del Báltico en el periodo comprendido entre el siglo V a.C. y el siglo XVI d.C. Los acúmulos de peces nos sirven para arrojar luz sobre las técnicas pesqueras así como el consumo y comercio de pescado. En casi todos los asentamientos la selección de especies en las muestras indica una muy fuerte influencia de las faunas locales de peces en el espectro ictiofaunístico. Las especies de peces y el tamaño de los individuos indican que a lo largo de todo el periodo estudiado fueron utilizadas una serie de artes de pesca que incluyen redes, anzuelos y trampas. En algunos países las muestras ictioarqueológicas reflejan una serie de tendencias diacrónicas en las estrategias pesqueras como, por ejemplo, una tendencia hacia desarrollar pesquerías en zonas progresivamente más alejadas de las costas.

PALABRAS CLAVE: PECES, ASOCIACIONES ICTIOARQUEOLÓGICAS, BÁLTICO, EDAD DEL HIERRO, EDAD VIKINGA, EDAD MEDIA, PESCA PREHISTÓRICA, PESCA PROTOHISTÓRICA, PESCA EN ÉPOCAS HISTÓRICAS

INTRODUCTION

Fish bones are often preserved in remains from former cultures as a more or less direct result of fishing. Fish bones recovered during archaeological excavations provide evidence of catch, consumption and trade of fish in former times. The species of fish represented in the remains, the sizes of the individual fish, and other aspects of the fish bone evidence can indicate the kind of water in which they were caught (lake, river, coast or open sea), the season during which the fishing took place and which methods were used.

In the present paper evidence from fish bones is used to elucidate fishing, fish consumption and fish trade in the Baltic region of Europe during the period from the 5th century BC (beginning of the Iron Age in Denmark) to the mid-16th century AD (end of the Middle Ages). The southern North Sea region will be dealt with in a similar way in a

forthcoming paper (Enghoff, submitted) which covers the period from the 1st to the 16th century AD. The North Sea paper will also include a general discussion of the fish trade which applies to both regions.

Significant developments in Baltic fishing equipment and techniques took place during the period covered, including the development of seagoing ships which made fishing on the open sea and long-distance trade possible. This is clearly reflected in the fish bone evidence which in this review is allowed to "speak for itself": written sources have not been taken into account although they are available for the latter part of the period.

MATERIAL AND METHODS

The Baltic region has, for the purposes of this review, been defined as comprising the following countries: Denmark (except the North Sea coast of Jylland), southern Norway, Sweden, Finland, Estonia, Latvia, Lithuania, westernmost Russia, Poland (except the southernmost parts) and Germany (except the North Sea coast and the southernmost parts).

The review is based mainly on published studies by the author and many others, and a number of unpublished reports have kindly been put at my disposal by various colleagues. Furthermore, original analyses of material from five Danish sites (Smedegård, Gl. Lejre, Birkely, Selsø-Vestby and Sebbersund) are included.

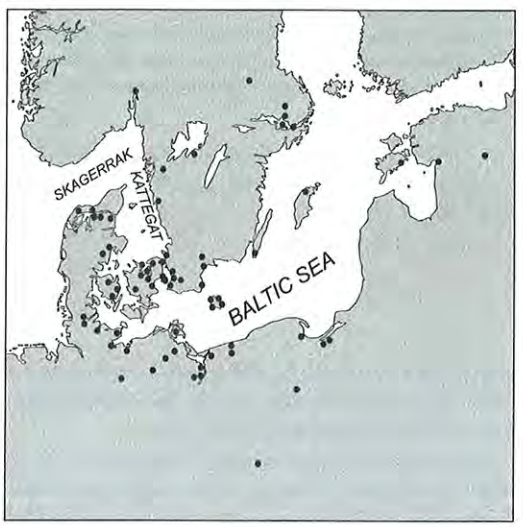

FIGURE 1

Map of the Baltic region of Europe, showing the location of the reviewed sites. See also the more detailed maps for each country (Figures 2, 6, 9-11).

The locations of the reviewed sites are shown in Figure 1. Records from Denmark, Norway, Sweden, Estonia, Poland and Germany are given in Tables 2-7. No information was available from Russia, Lithuania, Latvia and Finland. The entries in Tables 2-7 are numbers of fish bones for each species where such numbers were available. Where absolute numbers were not given, or frequency was indicated as a percentage or by a letter code, entries in the tables are given as presence/absence. This method of presentation was chosen for the sake of uniformity, at the expense of loss of information in some cases. Scales, dermal denticles etc. have not been included in the bone counts, instead their presence is recorded in footnotes to Tables 2-7. In the tables, as well as in the sections on individual sites from each country, sites are arranged chronologically, according to the age of their oldest phase. The fish species are divided into marine, migratory and freshwater species in Tables 2-7. Within each of these ecological groupings the species are listed systematically (i.e. by taxonomic group).

Table 1 summarizes the occurrence of fish species in the fish bone assemblages analyzed here, with English and Latin names according to Whitehead *et al.* (1984-1986) for marine species and, as far as possible, Blanc *et al.* (1971) for freshwater ones; when these were not applicable, Wheeler (1978) was used. Since the English names of fish species may be unfamiliar to many readers, the species are arranged alphabetically in Table 1.

The fish bone evidence included in the review is obviously of very variable quality, having been influenced by several taphonomic factors. These include, for example, the different conditions for preservation of bones prevailing at the sites, the different susceptibility to decay of bones from different species, the influence of various treatments (for instance cooking) on the chances of survival (Nicholson, 1992a, 1992b, 1993) and the different excavation techniques used through time. With regard to the last factor, small fish bones will only be recovered in any quantity if sieving of the sediment through a fine mesh is employed (Payne, 1972; Enghoff, 1993). It is very important to keep this in mind when evidence from different sites is compared and general conclusions are drawn. It is, however, often possible to evaluate smaller, less

	DK	N	S	EST	PL	D
Alpine bullhead, *Cottus poecilopus*	.	.	.	.	.	.
Asp, *Aspius aspius*	.	.	+	.	+	+
Atlantic bluefin tuna, *Thunnus thynnus*	+	+	.	.	.	.
Atlantic horsemackerel, *Trachurus trachurus*	.	.	.	.	.	+
Atlantic mackerel, *Scomber scombrus*	+	+	+	.	.	+
Ballan wrasse, *Labrus bergylta*	.	+	.	.	.	.
Barbel, *Barbus barbus*	.	.	.	.	+	.
Black goby, *Gobius niger*	+	.	.	.	.	.
Brill, *Scophthalmus rhombeus*	.	.	.	.	.	.
Bullhead, *Cottus gobio*	.	.	.	.	.	.
Bullrout, *Myoxocephalus scorpius*	+	.	+	.	.	+
Burbot, *Lota lota*	+	.	+	+	+	+
Cartilaginous fishes, Chondrichthyes	+	+	+	.	.	+
Chub, *Leuciscus cephalus*	.	.	.	.	+	+
Clupeids, Clupeidae	+	.	+	+	+	+
Cod, *Gadus morhua*	+	+	+	+	+	+
Common bream, *Abramis brama*	+	.	+	+	+	+
Common carp, *Cyprinus carpio*	.	.	.	.	+	+
Common sole, *Solea vulgaris*	+	.	.	.	.	.
Crucian carp, *Carassius carassius*	+	.	+	.	+	+
Cyprinids, Cyprinidae	+	+	+	+	+	+
Dab, *Limanda limanda*	.	.	.	.	.	+
Dace *Leuciscus leuciscus*	.	.	.	+	+	+
Eel, *Anguilla anguilla*	+	+	+	+	+	+
Eelpout, *Zoarces viviparus*	+	.	+	.	.	+
Flatfish, Heterosomata	+	+	+	+	+	+
Flounder, *Platichthys flesus*	+	.	+	+	.	+
Gadids, Gadidae	+	+	+	+	+	+
Garfish, *Belone belone*	+	+	+	.	.	+
Gobiids, Gobiidae	+	.	.	.	.	.
Golden Redfish, *Sebastes marinus*	.	+	.	.	.	.
Goldsinny Wrasse, *Ctenolabrus rupestris*	+	.	.	.	.	.
Greater Weaver, *Trachinus draco*	+	.	.	.	.	.
Haddock, *Melanogrammus aeglefinus*	+	+	+	.	.	+
Hake, *Merluccius merluccius*	+	.	+	.	.	+
Halibut, *Hippoglossus hippoglossus*	.	.	+	.	.	+
Herring, *Clupea harengus*	+	+	+	+	+	+
Ling, *Molva molva*	+	+	+	.	.	+
Norway pout, *Trisopterus esmarki*	.	+	.	.	.	.
Orfe, *Leuciscus idus*	.	.	+	+	+	+
Perch, *Perca fluviatilis*	+	+	+	+	+	+
Percids, Percidae	+	+	+	+	+	+
Pike, *Esox lucius*	+	+	+	+	+	+
Pikeperch, *Stizostedion lucioperca*	.	.	+	+	+	+
Plaice, *Pleuronectes platessa*	+	.	+	.	.	+
Pollack, *Pollachius pollachius*	.	.	.	.	.	.
Poor-cod, *Trisopterus minutus*	.	+	.	.	.	.
Porbeagle, *Lamna nasus*	+	.	.	.	.	+
Ray, *Raja* sp.	+	+	+	.	.	+
Roach, *Rutilus rutilus*	+	+	+	+	+	+
Rudd, *Scardinius erythrophthalmus*	+	.	+	.	+	+
Ruffe, *Gymnocephalus cernua*	.	.	.	.	+	+
Sailray, *Raja lintea*	.	.	.	.	.	+
Saithe, *Pollachius virens*	+	+	+	.	.	+
Salmon, *Salmo salar*	.	+	+	.	+	+
Salmonids, Salmonidae	+	+	+	+	+	+
Shad, *Alosa* sp.	.	.	.	.	+	+
Sharks, Pleurotremata	+	+	+	.	.	+
Skate, *Raja batis*	.	.	+	.	.	.
Smallspotted catshark, *Scyliorhinus canicula*	.	+	.	.	.	.
Smelt, *Osmerus eperlanus*	.	.	.	.	+	.
Smoothhound, *Mustelus* sp.	+	.	.	.	.	+
Spurdog, *Squalus acanthias*	+	+	+	.	.	.
Starry skate, *Raja radiata*	.	.	.	.	.	+
Sturgeon, *Acipenser sturio*	+	.	+	+	+	+
Swordfish, *Xiphias gladius*	.	.	.	.	.	+

Tench, *Tinca tinca*	+	.	+	+	+	+
Thornback Ray, *Raja clavata*	+	.	+	.	.	+
Three-spined Stickleback, *Gasterosteus aculeatus*	+	.	.	.	.	+
Topeshark, *Galeorhinus galeus*	+	.	.	.	.	.
Torsk, *Brosme brosme*	.	+	.	.	.	.
Trout, *Salmo trutta*	+	.	+	.	+	+
Turbot, *Psetta maxima*	+	.	+	.	.	+
Twaite shad, *Alosa fallax*	.	.	.	.	+	.
Wels, *Siluris glanis*	.	.	+	+	+	+
White bream, *Blicca bjoerkna*	.	.	.	.	+	.
Whitefish, *Coregonus* sp.	+	.	+	+	+	+
Whiting, *Merlangius merlangus*	+	+	+	.	.	.
Wrasses, Labridae	+	+	.	.	.	.
Zährte, *Vimba vimba*	.	.	.	+	+	+
Ziege, *Pelecus cultratus*	.	.	.	.	+	.
Zope, *Abramis ballerus*	.	.	+	.	+	+

TABLE 1

List of the fish taxa (species and a few genera and higher categories) of fish mentioned in the text, and indication of the countries from which they have been recorded in Iron Age to Medieval fish bone assemblages.

The list is arranged alphabetically according to the English names, with corresponding Latin names added. The nomenclature follows Whitehead *et al.* (1984-1986) for marine species and, as far as possible, Blanc *et al.* (1971) for freshwater ones; when these were not applicable, Wheeler (1978) was used.

D = Germany, DK = Denmark, EST = Estonia, N = southern Norway, PL = Poland, S = Sweden.

Species which are not indicated as occuring is any of the countries are included because they occur in the national lists as unconfirmed possibilities (e.g., brill which has been recorded only as "turbot/brill").

meticulously excavated samples against the background of large, sieved ones. In order to obtain as complete a coverage as possible, small, non-sieved materials have therefore been included in the present review.

Denmark is treated in somewhat more detail than the other countries, owing to the author's personal experience with several of the sites. The Danish evidence has been divided according to cultural periods: Iron Age, Viking Age and Middle Ages, in addition to being assigned to a particular century or centuries. For the sake of comparability, evidence from other countries is as a rule only referred to by century, since the cultural periods may be differently defined and delimited.

Some of the papers dealing with fish bones refer to finds of fishing equipment. This information has been taken into account but a systematic search for literature on this subject has not been made, just as written sources dealing with fish trade etc. have not been consulted.

DENMARK, INDIVIDUAL SITES

The review is based partly on already published evidence and partly on material from a number of hitherto unpublished sites which have in part been analyzed by the author within the framework of the present project. These are Smedegård, Gl. Lejre, Birkely, Selsø-Vestby and Sebbersund. Three sites from the island of Bornholm are reported on the basis of unpublished studies by Henrik Høier.

The site numbers refer to Figure 2 (see Table 2 for detailed species lists).

FIGURE 2

Map of Denmark, showing the location of the reviewed sites. Site numbers refer to the section "Denmark, individual sites". The three sites marked with A (Nørre Fjand), B (Ribe) and C (Trøjborg) are treated in detail elsewhere (Enghoff, submitted).

Sejlflod (1)

An Iron Age village on the Limfjord (Nielsen & Rasmussen, 1986). The fish bones mostly derive from chalk layers in house floors dating from 500 BC to AD 1050 (Pre-Roman, Roman and Germanic Iron Age as well as Viking Age). The fish bones were recovered by sieving through a 2 mm mesh and are generally well preserved (Enghoff, 1992, unpublished report c).

The fish bone samples appear to be quite uniform throughout this long period of time and are dominated by flatfish, especially flounder (68% of the bones). Dog coprolites found at Sejlflod also contained many remains (bones and dermal denticles) of flounder (Figure 3). Garfish (20%), which is a seasonal species occurring in Danish waters only from spring to autumn, is an indicator of summer fishing. Greater weaver (10%) has also played an important role, and whitefish is present as well. The fishing from Sejlflod may very well have taken place in the Limfjord which, at the beginning of the Iron Age, had several openings to the North Sea (Petersen, 1987) and was more saline than today. Even today all the species on the Sejlflod list, perhaps with the exception of whitefish, can be caught in the easternmost Limfjord.

FIGURE 3

Top. Dog coprolites found at Sejlfold, $2^{1/2}$ × natural size. Bottom. Bones and dermal denticles from flounder, found by dissolution of the coprolites, 3 × natural size.

Mellemholm (2)

Another Iron Age village on the Limfjord. The fish bones derive from a rubbish pit, dated on the basis of ceramics to about 400 BC (Pre-Roman Iron Age). The fish bones were recovered by sieving through a 2 mm mesh (Rosenlund, unpublished report a) and are strongly dominated by plaice/flounder/dab; in addition there are a few bones of garfish and eel.

Smedegård (3)

A Pre-Roman to Roman Iron Age village (300 BC - AD 100) located between the Skagerrak and the Limfjord. The conditions for preservation of organic material at the site are good. The fish bones were recovered by flotation and wet sieving through a 4 mm mesh and have been identified by Enghoff (present work). The animal bones other than fish bones from Smedegård are currently subject of a Ph.D. study by T. Nord Andreasen.

The catch at Smedegård was quite varied, being dominated by garfish (30%), plaice/flounder/dab (26%), especially flounder, and eel (21%) (Figure 4). A very special feature of Smedegård is the presence of topeshark and smoothhound (8%), plus a single bone from spurdog. Also noteworthy is a characteristic scute from sturgeon. Whitefish is represented as well, as at Sejlflod. Today, whitefish does not occur north of the Limfjord but is common in the Limfjord itself where the inhabitants at Smedegård may have caught it. Summer fishing is documented by the presence of garfish. All in all, there are indications of fishing both in the North Sea (especially the sharks) and in the Limfjord, and perhaps even fishing in fresh water for pike, roach and perch, although these species may also have been caught in the brackish parts of the Limfjord.

Lundeborg (4)

A trading centre on the island of Fyn. Occupation was probably limited to short periods of the year (Thomsen, 1994). The settlement dates from

Site	Sejlflod	Mellemholm	Smedegård	Lundeborg	Sorte Muld	Gl. Lejre	Aggersborg	Birkely	Selsø-Vestby				Sebbersund	Århus Sønderve	
Site nº.	1.	2.	3.	4.	5.	6.	7.	8.	9.				10.	11.	
Age (centuries)	6 BC-11 AD	5 BC	4 BC-2 AD	3-4 AD	6-7 AD	7-11 AD	8-10 AD	8-11 AD	8-9 AD	9-10 AD	10-11 AD	12-13 AD	10 AD	10-12 AD	10-14 AD 1
Recovery technique	s	s	s	s	s	s	h	s	s	s	s	[6]	s	h	h
MARINE SPECIES															
Porbeagle	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Smoothhound	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.
Topeshark	.	.	16	.	.	.	.	.	.	.	.	.	.	.	.
Spurdog	.	.	2	.	.	.	.	.	.	.	.	.	.	1	+
Thornback ray	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Cartilaginous fishes, unspecified	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.
Herring	.	.	.	.	13332	965	.	32	616	8	362	>>9770	+	.	.
Garpike	398[1]	a few	125	1	.	56	224	.	30	3	2	.	+	2	+
Hake	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Gadids, total	2	.	15	59	495	343	86	559	1138	6	146	.	.	904	?
Cod	1	.	11	59	495	44	81	164	30	1	20	.	.	856	+
Haddock	.	.	1	.	.	12	5	1	.	.	8	.	.	46	+
Whiting	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Saithe	.	.	.	.	.	.	.	.	1	.	.	.	.	2	.
Pollack/Saithe	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ling	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gadids, unspecified	1	.	3	.	.	287	.	394	1057	5	118	.	.	.	.
Goldsinny wrasse	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Greater weaver	184	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Atlantic mackerel	.	.	.	.	2	1	.	.	1	.	.	.	.	.	.
Atlantic bluefin tuna	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eelpout	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Black goby	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gobiids, unspecified	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bullrout	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Three-spined stickleback	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Site	Sejlflod	Mellemholm	Smedegård	Lundeborg	Sorte Muld	Gl. Lejre	Aggersborg	Birkely	Selsø-Vestby				Sebbersund	Århus Sønderve	
									8-9 AD	9-10 AD	10-11 AD	12-13 AD	10 AD	10-12 AD	10-14 AD 1
Flatfishes, total	1319	.	151	15	3	67	172	27	1693	232	323	.	?	20	?
Turbot	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Turbot/Brill	.	.	8	.	.	.	.	.	.	.	.	.	.	.	.
Plaice	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Flounder	17	.	7	.	.	1	.	.	18	1	2	.	+	.	.
Plaice/Flounder/Dab	1301	ca. 500	134	15[3]	3	66	172	27	1675	231	321	.	98%	20	+
Common sole	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Flatfishes, unspecified	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
MIGRATORY SPECIES															
Sturgeon	.	.	1	.	2	.	.	.	.	.	.	.	.	.	.
Trout	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trout/Salmon	7	.	.	1[4]	79[5]	24	.	.	.	.	1	.	.	.	.
Whitefish	1[2]	.	22	.	.	.	.	.	.	.	.	.	+	.	.
Salmonids, unspecified	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Eel	20	1	123	.	22	8	.	22	1	1	1	.	+	.	.
FRESHWATER SPECIES															
Pike	.	.	2	.	.	11	.	14	.	.	.	.	.	1	.
Cyprinids, total	.	.	43	.	.	40	.	388	1	.	21	.	.	3	?
Crucian carp	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Tench	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.
Roach	.	.	9	.	.	2	.	1	.	.	.	.	.	.	.
Rudd	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Common bream	.	.	.	.	.	4	.	25	.	.	.	.	1	+	3
Cyprinids, unspecified	.	.	34	.	.	34	.	362	.	.	21	.	.	.	.
Burbot	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Perch	.	.	6	.	.	21	.	64	5	1	4	.	.	.	+
Total	1931	ca. 500	518	76	13935	1537	482	1106	3485	251	860	>>9770	ca. 1500	932	?

[1] excluding 11 scales.
[2] excluding 62 scales.
[3] orig. ref.: flatfish unspecified.
[4] orig. ref.: Salmon.
[5] orig. ref.: Salmon.
[6] untreated sediment samples.
[7] original publication: flatfish unspecified.
[8] original publication: Salmon.
[9] original publication: Salmon.
[10] excluding 2 scales.
[11] excluding 3 dermal denticles.
[12] excluding 104 dermal denticles.
[13] excluding 74 scales.
[14] excluding 137 scales.
[15] 2 scales only.
[16] 1 scale only.
[17] excluding 232 scales.
[18] excluding 2450 scales.
[19] original reference: Salmon.

TA

Numbers of identified fishbones from Danish sites. Recc

Møllebjerg	Kobbegaard	Munkerup	Pedersborg Voldsted	Svendborg Matr. 482	Svendborg Matr. 449a	Næsholm	Køge	Holbæk	Tårnby Torv			Odense Sortebrøde	Dragør	Øm Kloster
12. 11 AD s	13. 11 AD s	14. 11 AD s	15. 12 AD s	16. 12-15 AD ?	12-15 AD ?	17. 13-14 AD h	18. 13-14 AD h	19. 13-15 AD h+s	20. 13-14 AD s	14-15 AD s	16 AD s	21 13-16 AD s	22 14-15 AD h+s	23 15-16 AD h
.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
2988	1305	2984	1	12	.	.	80	743	375	1164	.	57	+	.
.	.	.	.	27	.	1	.	203	.	.	.	3	.	2
.	.	.	.	.	.	.	.	.	.	.	.	3	.	.
147	533	686	327	162	?	77	10	1496	9	219	7	450	?	7
147	533	686	327	129	+	29	10	880	1	55	7	201	+	3
.	.	.	.	15	+	48	.	134	.	1	.	248	+	4
.	.	.	.	.	.	.	.	7	.	.	.	.	.	.
.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
.	.	.	.	.	.	.	.	2	.	.	.	.	.	.
.	.	.	.	2	.	.	.	4	.	.	.	1	.	.
.	.	.	.	16	+	.	.	468[10]	8	163	.	.	.	.
.	.	.	.	.	.	.	.	2	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	1	.	.	.	.	.	3	.	2	.	.
.	.	.	.	.	.	.	.	.	.	.	1	.	+	.
1	.	.	.	.	.	.	.	28	1	1	.	3	.	.
.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
.	.	.	.	.	.	.	.	10	.	.	.	.	.	.
.	87	.	.	7	.	.	2	16	.	.	.	1	.	.
.	.	.	.	.	.	.	.	3	.	.	.	.	.	.

Møllebjerg	Kobbegaard	Munkerup	Pedersborg Voldsted	Svendborg Matr. 482	Svendborg Matr. 449a	Næsholm	Køge	Holbæk	Tårnby Torv 13-14 AD	14-15 AD	16 AD	Odense Sortebrøde	Dragør	Øm Kloster
.	.	6	1	448	?	.	.	1120	1	26	.	124	?	1
.	.	.	.	1	.	.	.	5[11]	.	2	.	.	.	.
.	.	.	.	.	.	.	.	2	.	.	.	.	.	.
.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
.	.	.	.	.	.	.	.	54[12]	1	2	.	.	.	.
.	.	6	1	447[7]	+	.	.	1011	.	22	.	124	+	1
.	.	.	.	.	.	.	.	11	.	.	.	.	.	.
.	.	.	.	.	.	.	.	36	.	.	.	.	.	.
.	.	.	3	.	.	.	.	.	.	.	.	.	.	.
.	3	.	.	.	.	.	.	.	.	.	.	.	.	.
.	11	25	.	1[8]	+[9]	.	.	1	.	.	.	.	.	1[19]
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4	1	4	.	2	.	.	.	183	4	237	.	69	+	7
.	.	.	21	10	.	.	.	9[13]	.	.	.	17	.	32
.	.	.	14	2	?	3	.	18	1	1	.	14	.	59
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	14	.	.	3	.	.	.	.	.	7	.	.
.	.	.	.	.	.	.	.	2	.	.	.	1	.	9
.	.	.	.	.	.	.	.	1	.	.	.	1	.	2
.	.	.	.	.	.	.	.	4	.	.	.	1	.	36
.	.	.	.	2	+	.	.	11[14]	1	1	.	4	.	12
.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
.	.	.	22	1	.	[15]	[16]	10[17]	.	3	.	181[18]	.	83
3160	1940	3705	389	673	?	82	92	3843	391	1654	8	925	?	198

; 2

technique: h = hand-collected, s = sieved, ? = unknown.

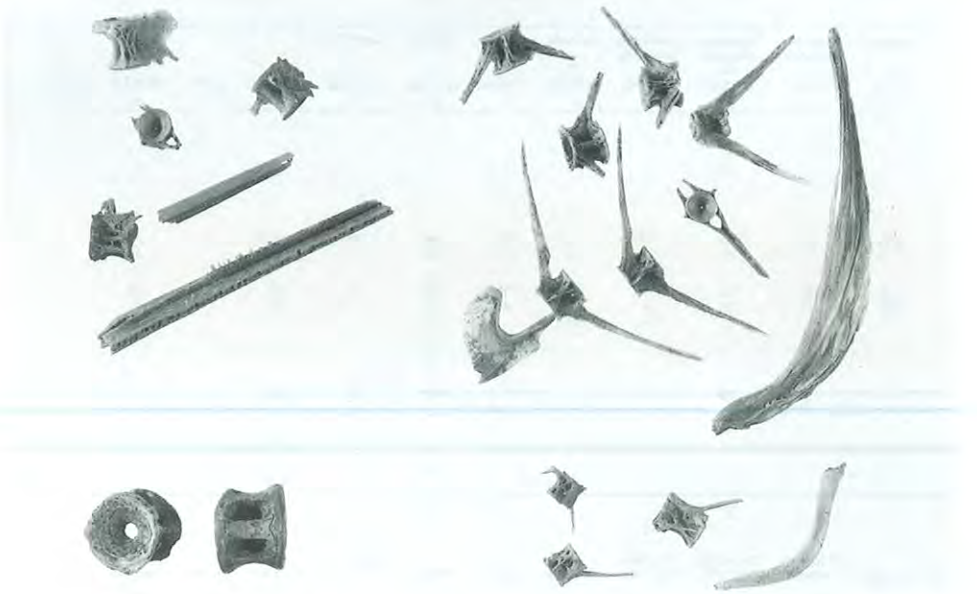

FIGURE 4

A selection of fish bone from Smedegård. The most important species in the Smedegård material are garfish (upper left: vertebrae and two jaw bones), plaice/flounder/dab (upper right: vertebrae, os anale, urohyale of flounder) and eel (lower right: vertebrae, cleithrum). A characteristic trait of the Smedegård material is the relative large percentage of cartilaginous fishes (lower left: topeshark vertebrae, note drilled hole in center), $1^{1/2}\times$ natural size).

the beginning of the 2nd to the end of the 7th century AD, but the main occupation period is dated to the 3rd and 4th centuries, i.e., late Roman Iron Age. The fish bones were recovered by wet sieving (mesh size unknown) (Hatting, 1989, 1994).

The fish bone material from Lundeborg differs from that discussed so far by being composed exclusively of marine species: cod dominates, and garfish shows that the site was used during the summer half of the year. However, the modest size of the material (76 bones) precludes detailed speculations.

Sorte Muld (5)

A chieftain's seat and cult site on the island of Bornholm, dating from the Germanic Iron Age (6th-7th centuries AD). The fish bones were recovered by wet sieving through a 3 mm (in a few cases 4 mm) mesh (Watt, 1991).

The fish bone material from Sorte Muld is very strongly dominated by herring (13332 bones). The only other well-represented species is cod, but 79 bones of salmon/trout is also a large number for this species. There are two of the easily decomposed bones of mackerel, indicating summer fishing. The recovery of such a large number of the small bones of herring is due to the meticulous sieving technique employed (Hatting, 1989).

Gl. Lejre: Mysselhøjgård (6)

A chieftain's farm close to Roskilde, dated to the 7th-11th centuries AD. The fish bones were recovered by dry sieving through 4 mm mesh (Enghoff, unpublished report b and present work).

The material includes many bones of herring, 63% of the identified bones. Cod and haddock were important too, comprising up to 22% of the assemblage. The presence of garfish, and a single bone of mackerel, indicate summer fishing. A notable number of salmon/trout bones and a single bone of thornback ray deserve special mention, as these species were then regarded as luxury food reserved for the upper class (Zbierski, 1976). The

herring bones seem not to be the result of a particular processing technique since bones from all body regions are represented.

Aggersborg (7)

A Viking Age village located at an important point of passage across the Limfjord, dated to AD 700-980 (Roesdahl, 1986).

The fish bone material was hand-collected (Hatting & Rosenlund, unpublished report; Rosenlund, 1976). The inhabitants seem to have eaten mostly garfish since about half of the bones belong to this species. Plaice/flounder/dab and gadids were also important.

Birkely (8)

The grubenhaus settlement Birkely was located on a major lake, Arresø, in Sjælland close to Kattegat. It is dated to the 8th-11th centuries AD. The fish bone material was recovered by dry sieving through a 4 mm mesh and mostly derives from inside the houses (Enghoff, unpublished report a).

Consistent with the site's geographical location, rather more than half of the fish bones derive from marine fish, just less than half come from freshwater fish and the remainder come from migratory species. The list consists of species commonly eaten. Gadids and cyprinids (especially common bream), in particular, were important.

Selsø-Vestby (9)

The settlement Selsø-Vestby lay on Roskilde Fjord (Sørensen & Ulriksen, 1995). The Viking Age settlement was abandoned during the 11th century AD and was succeeded, early in the 12th century AD, by a Middle Age village. The fish bone evidence covers the 8th-13th centuries AD but can be subdivided into three Viking Age phases: 8th-9th, 9th-10th, and 10th-11th centuries plus a Medieval (13th century) phase. The fish bones from the Viking Age phases were recovered by wet sieving through a 4 mm mesh of sediment samples from inside the grubenhauser. The Medieval material consists of sediment samples with a high concentration of herring bones.

During all three Viking Age phases there are three important groups of fish species, i.e. plaice/flounder/dab (mostly, perhaps even exclusively, flounder), gadids and herring. There is also a smaller but constant presence of garfish. The relative fre-

FIGURE 5

Untreated sediment sample from early Medieval layers at Selsø-Vestby. The sediment consists almost exclusively of bones of herring.

FIGURE 6

Herring bones from Selsø-Vestby. All the bones belong to the hyoid arch, the gill arches, and the shoulder girdle, $1^{1/2} \times$ natural size.

quencies of these important groups vary through time. Herring bones thus constitute 42% of the bones from the 10th-11th centuries, against 18% in the 8th-9th centuries, suggesting an increasing importance of herring. The cod from the 10th-11th centuries seem to be larger (the majority 0.55-0.60 m long, a few up to 1.04 m) than those from the 8th-9th centuries (the majority 0.40-0.45 m). There are no signs of the processing cod for stockfish.

The early Medieval material consists exclusively of huge amounts of herring bones (Figure 5). On the basis of the biased representation of bone elements this material is interpreted as the remains of an industry where herring were salted after removal of the gills. All bones in the sample (Figure 6) belong to the region just behind the head (hyoid arch, gill arches, shoulder girdle; see Enghoff (1996) for further details). The entire Selsø-Vestby material may tentatively be interpreted as reflecting increasingly important herring fishery, culminating in a surplus which formed the basis of a herring industry.

Sebbersund (10)

A Viking Age trading place on the Limfjord. More than 150 grubenhauser have been recognized, as well as a market place and a craftmen's area. Sebbersund has been dated to about AD 700-1000. The fish bones were recovered by sieving sediment from a 10th century grubenhaus through a 3 x 4 mm mesh (P. Birkedahl, pers. comm.).

A preliminary analysis of the fish bones (Enghoff herein) shows a strong dominance of plaice/flounder/dab, esp. flounder (98% of 1500 fish bones). Eel, garfish and herring have played minor roles. As is typical of material from the Limfjord area, whitefish is also present.

Århus Søndervold (11)

A Viking Age settlement located on a coastal hillock facing the sea (Kattegat). The settlement evolved into a Medieval town (Hellmuth Andersen *et al.*, 1971). The well-preserved bone material can be divided into two phases: 10th-12th centuries AD (Viking Age) and 13th-14th centuries AD (Middle Age), plus mixed material from both periods (Møhl 1971; Rosenlund, 1976).

Fishing for cod seems to have been of overwhelming significance during both phases, although Møhl (1971) interpreted the cod fishing during the Viking Age phase as more intensive. Apart from cod, haddock and ling were also exploited; the latter is a deep-water species.

Møllebjerg (12), Kobbegaard (13), and Munkerup (14)

Three Viking Age to early Medieval farm sites on the island of Bornholm in the Baltic Sea, dated to the 11th century AD.

The fish bones were retrieved by sieving through a 3 mm mesh. They were studied by Henrik Høier (pers. comm.). At all three sites the assemblages are strongly dominated by herring, with 0.20-0.40 m long cod in a clear second place. The relatively large number of bones of trout/salmon is noteworthy. There are no bones of freshwater fish whatsoever.

Pedersborg Voldsted (15)

Early Medieval castle mounds with fish bone material dated to ca. AD 1100 (Rosenlund 1976).

Cod dominates the material, although quite a number of freshwater fish (pike, tench, perch) were eaten as well. The absence of cranial bones from cod was interpreted by Møhl (unpublished correspondence) as showing that decapitated, dried and salted cod were imported. As there were no moats at Pedersborg, Møhl interpreted the freshwater fish as having been caught in nearby fishing waters. The find of sturgeon, which is not common in Danish material, is of note.

Svendborg (16)

Medieval port on the island of Fyn (Jansen, 1988) where fish bones have been identified from excavations in "Land register lot numbers 449a and 482" (Aaris-Sørensen, 1976; Hatting 1979, 1988). The material has been dated to the 12th-15th centuries AD.

So far, only a preliminary species list for fish remains is available (Hatting, 1988) according to which plaice/flounder/dab in particular, but also cod and haddock were important. Herring is also present, but in smaller quantities.

Næsholm (17)

The castle Næsholm was functional from about AD 1240 to about 1340 (La Cour, 1961). The fish bones mainly derive from the castle ground itself, but there are some from the moat too (Møhl, 1961). The bones were hand-collected and are therefore not numerous.

Most of the fish bones are from haddock and cod, but even herring and garfish are represented. Freshwater fishing is indicated by tench and perch.

Køge: Vestergade 24 (18)

Fish bones from the Medieval town of Køge. The fish bones were hand-collected from midden layers at a house and are dated to about AD 1250-1350 (Hatting & Pedersen, 1982).

In spite of the collection method, herring bones dominate, followed by cod.

Holbæk: Ahlgade 15-17 (19)

A Medieval town on Holbæk Fjord. The fish bones are dated to the 13th early 15th centuries AD. The bones were partly hand-collected, partly extracted by sieving through a 1.5 mm mesh (Enghoff, 1995, 1997).

The fish bone material is very varied, 23 species having been identified. Gadids seem to have been most important (39%) and are represented by cod, haddock, whiting, ling and saithe. Cod is represented both by quite small individuals (four fifths of them measured 0.30-0.60 m in length) and both by very large specimens (1.00-1.30 m). Even the other gadids are represented by large individuals: the saithe are much longer than 1 m, and one of the ling measured around 1.30 m. A few cod and haddock bones show cutmarks indicating decapitation, but there are no indications that remnants of stockfish are involved. This is because bones from all body regions are present, and all sizes of cod are represented in the material. Flatfish were important too, in particular flounder. They are followed by herring which constitute 19% of the bones. Sieving was employed on only part of the excavated area. This is where the many herring bones were found, suggesting that the herring may have been even more important than indicated by the results obtained. The fish bone material from Holbæk has been interpreted as representing varied local fishing for local consumption. There are no indications of changes through the study period, nor are there indications of import or export of fish (Enghoff, 1995).

Tårnby Torv (20)

Farm complexes from Medieval Tårnby village on the island of Amager in the Øresund (Svart Kristiansen *et al.*, 1994). Fish bones were recovered in the field by wet sieving through a 3 mm mesh, and separation into 0.5 mm, 1 mm and 2 mm fractions. The samples can be linked to different houses and to various periods of time from, AD 1250 to 1900, but only samples from the 16th century and earlier are considered here.

Most of the fish bones are from the 14th-15th centuries, and out of these, 70% are from herring (which had not been processed, cf. Selsø-Vestby). The only additional species of some importance are eel and gadids, including quite small, 0.30-0.65 m long cod. The presence of mackerel indicates fishing during the summer half of the year. Freshwater fish seem to have played an insignificant role (Enghoff, 1994 b).

Odense Sortebrødrekloster (21)

A Medieval monastery. The fish bones derive from the kitchen area and are dated to about AD 1400-1540 (Rosenlund, 1976, unpublished report b). Sieving has been employed but mesh size is unknown.

Haddock and cod seem to have been the most utilized species. Plaice/flounder/dab, eel and herring also constituted ordinary monastery food, along with a number of freshwater species.

Dragør, Stakhaven (22)

A Medieval fishing village on the island of Amager, with a peak in activity each year during the "herring season". The fish bones almost exclusively derive from the period ca. AD 1342-1425 and were hand-collected with the exception of a single soil sample which was sieved (Liebgott, 1979; Rosenlund, 1976).

A comparison with Tårnby, the other fishing village on Amager which has been studied, is hampered by the different sampling techniques. It is, nevertheless, obvious that largely the same fish were exploited, although more species are represented in the Tårnby material (probably due to the sieving). The single sieved sample from Stakhaven contained herring, and this species probably played a greater role than indicated by the total number of fish bones recovered from this site.

Øm Kloster (23)

A Cistercian monastery at Øm in Jylland. The find has been dated to the 15th-16th centuries AD and consists of hand-collected bones. An inventory list of the monastery for the year 1554 is available (Rosenlund, 1984).

The fish bone material includes a number of freshwater species, as well as salmon/trout, eel, garfish, gadids and plaice/flounder/dab. The surviving inventory list may be used as a kind of key to the evidence. According to the list in 1554 the monastery imported six barrels of eels, as well as 80,000 dried gadids and 15,000 flatfish. The inventory list also mentions fishponds for live storage of freshwater fish. Rosenlund (1984) emphasized that the list of species represented by recovered bones provides more detailed information about the species composition and that there is no disagreement between this and the inventory list. However, a remarkably large taphonomic loss has been demonstrated.

DENMARK, OVERVIEW

The material from Danish sites covers the period from the 5th century BC to the 16th century AD, corresponding to the Iron Age (500 BC - AD 800), the Viking Age (AD 800-1050) and the Middle Ages (AD 1050-ca.1550). Three sites (Nørre Fjand, Ribe and Trøjborg), situated on the Danish North Sea coast, are treated in detail elsewhere (Enghoff, submitted) but will also be included in the present overview.

Iron Age fishing in Denmark

It seems to be a common feature of the settlements in the Limfjord Region (i.e., Sejlflod, Mellemholm and Smedegård) that flounder was the most commonly caught fish. In addition, many garfish were taken, and whitefish is present at two of the sites. The fish bone assemblages from these Limfjord sites are very similar, leading to the conclusion that the main fishing from the sites took place in the Limfjord itself. At the same time there are some differences reflecting the location of each settlement on the Limfjord. For instance, quite a number of greater weaver were taken at Sejlflod; this species is particularly abundant in this part of Denmark. The weavers may have been caught in the eastern mouth of the Limfjord, or there may have been supplementary fishing in the Kattegat. The many sharks at Smedegård were probably caught in the Skagerrak. Today, most of the shark species known from Denmark are distributed in a belt just extending around the northern tip of the country. The same shark species, including the southern species smoothhound, were also found on Mesolithic sites in the same part of Denmark (Enghoff, 1994a).

During the Mesolithic, the Limfjord Region was characterized by another particular type of fishing, with eel being the main target species (Enghoff, 1987, 1993, 1994a). It is tempting to interpret the shift from eel to flounder as a result of a change in fishing technique. During the Mesolithic, fishing was apparently conducted mainly by means of stationary fish traps, for example, basket traps with weirs. Finds of net sinkers from the Iron Age (for example at Nørre Fjand) indicate that fishing with nets had become usual then, which would explain the observed change in the fish bone evidence.

The fish bone assemblages from Nørre Fjand and Lundeborg, where iron fish-hooks have been found, are too small to allow significant conclusions to be drawn. It does, however, seem that fishing here was different from that on the Limfjord. The Nørre Fjand material consists only of freshwater fish, and Lundeborg is dominated by cod.

At Sorte Muld on the island of Bornholm the situation is again entirely different. The large amount of material clearly shows fishing for herring, herring and more herring - more than 13,000 herring bones have been recovered, and also a number of salmon/trout bones. Herring and salmon are characteristic of fishing on Bornholm today. The dominance of herring fishing fits neatly with the idea that net fishing became common in the Iron Age. It is notable that, in spite of very meticulous sieving at several Danish Mesolithic sites, these have yielded at most only a few herring bones. It is not until the Iron Age that large catches of herring are indicated. Nets seem to be necessary in order to catch this species in any quantity.

Bones of the seasonal species, garfish and/or mackerel, are present at all the Iron Age sites, with the exception of Nørre Fjand where bone numbers were small. This indicates that fishing generally took place during the summer half of the year.

To summarize, fishing prior to the Viking Age did not concern new species relative to those caught during the Mesolithic (Enghoff, 1994a). The size of the fish also seems not to have changed (here a reservation must be made since size estimations are not available from the previously published Iron Age sites). The differences vis-a-vis the Mesolithic evidence concern the relative frequency of the species. The general impression is still that of local fishing strongly dominated by species

which were common in local fishing waters, but during the Iron Age, net fishing seems to have been the most important technique. There are no indications of fish trade or processing.

Viking Age fishing in Denmark

The pronounced dominance of flounder and garfish which characterizes the Iron Age settlements in the Limfjord region continues throughout the Viking Age (Aggersborg, Sebbersund, Sejlflod). The presence of whitefish at Limfjord sites also continues. Nowadays, whitefish occur commonly in the Limfjord and these fish also migrate into watercourses flowing into the North Sea south of the Limfjord.

Fishing from the trading centre of Ribe, further south in Jylland, is also dominated by flounder. This is consistent with the fact that flounder was a characteristic target species for fishing in the Wadden Sea during later periods. The cod from Ribe seem to have been slightly larger (ca. 0.37-0.60 m long) than cod caught during the Stone Age (cf. Enghoff, 1994a). Haddock is another species caught from Ribe which is rare in earlier finds. The rare find of thinlip grey mullet at Ribe can be interpreted, against the background of prehistoric finds, as resulting from fishing from Ribe. Even whitefish are present at the site (cf. above).

Fishing from Århus Søndervold mostly produced cod, but also some haddock.

At the Viking Age settlements on Roskilde Fjord on the island of Sjælland, herring enters the scene. There are not many herring at Birkely, but at Gl. Lejre, herring constitutes 63% of the fish bones. At Selsø Vestby the frequency of herring increases through the Viking Age, starting at 18% and increasing to 42%.

The three Viking Age to early Medieval sites on the island of Bornholm: Møllebjerg, Kobbegaard and Munkerup, show the same pattern as that seen at the island's Iron Age site (Sorte Muld): very strong dominance of herring and occurrence of salmon/trout.

To summarize, fishing during the Viking Age seems still to have been a local activity, the nature of the catch being strongly influenced by the fish fauna in the surrounding waters. Flounder and garfish were still characteristic and dominant in the Limfjord region, and herring was frequent in eastern Denmark. For the first time in Danish history, haddock was common at several sites. There is also a tendency for the cod to be larger than in samples from the Stone Age: Ribe 0.37-1.13 m (mostly 0.45-0.70 m), Selsø-Vestby 8th-9th centuries 0.34-1.04 m (mostly 0.35-0.50 m), Selsø-Vestby 10th-11th centuries 0.33-1.04 m (mostly 0.50-0.65 m, i.e. larger than in 8th-9th centuries). The cod from the Bornholm sites are, however, smaller (0.20-0.40 m). Fishing with nets must still be regarded as having been commonplace. The cod and haddock remains could be interpreted as indicating hook fishing with long lines. Finds of fishing equipment from the Viking Age include hooks (Århus Søndervold, Aggersborg), leister prongs (Århus Søndervold, Sebbersund, Aggersborg) and net sinkers (Ribe).

No major differences are evident between material from settlements, trading places and the chieftain's farm. Attention should, however, be drawn to the single bone of thornback ray from Gl. Lejre. Neither is there any indication of the export or import of fish, nor of fish brought along by strangers as travelling provisions. There is no evidence for large-scale processing of fish.

Medieval fishing in Denmark

The Middle Ages offer fish bone assemblages from monasteries as well as castles and towns. Due to the surviving inventory list, we know for certain that dried gadids and flatfish were imported to the monastery Øm Kloster, along with barrels of eels. At another monastery, Odense Sortebrødrekloster, gadids were also very important, with haddock taking first place. Two new gadid species make an appearance, viz., ling and hake; both deep water species. Flatfish and eels were also eaten, and freshwater fish were common at both monasteries.

The three castles, Næsholm, Pedersborg and Trøjborg, show the same pattern: Gadids, especially haddock, were important, in addition to flatfish and various freshwater fish.

The towns are represented by Svendborg, from where there are mostly flatfish, although with an important element of cod and haddock. At Holbæk, another town site, gadids are most numerous and are represented by cod, haddock, whiting, ling and saithe; flatfish and herring were also important. Herring appears again, this time in abundance, at Tårnby (70% of the bones) and Dragør, two fishing villages on the Øresund. Øresund was famous during the Middle Ages for an astonishing abundance of herring during a couple of months each year, when the fat autumn herring migrated through the

sound. Bones of Atlantic bluefin tuna found both at Tårnby and Dragør also deserve to be mentioned. Tuna is nowadays a rare species in Denmark, but Øresund was, until a few decades ago, known for its seasonal occurrence of this fish. Herring dominates further at the nearby village of Køge, but the greatest manifestation of herring bones is seen at Selsø-Vestby, where there is clear and unique evidence indicating a proper herring industry.

To summarize, cod and especially haddock became conspicuously frequent in the Middle Ages. Haddock became common for the first time at Viking Age sites, but was much more frequent at Medieval ones. Flatfish and herring were other frequent fishes. It must, however, be emphasized that the large occurrences of herring are still predominantly concentrated in eastern Denmark.

New species entered the list, viz., ling (Århus Søndervold, Svendborg, Holbæk, Odense Sortebrødrekloster) and hake (Århus Søndervold, Odense Sortebrødre Kloster), indicating fishing

FIGURE 7

Map of Sweden and Norway, showing the location of the reviewed sites. Site numbers refer to the sections "Sweden, individual sites" (dots) and "Norway, individual sites" (square).

Site	Oslo, Kanslergt. 10			Oslo, Mindets Tomt			Oslo Oslogt. 4	Oslo Søndre Felt
Site n°	1.			1.			1.	
Age (centuries)	11-12 AD	12-14 AD	14-18 AD	11-12 AD	12-14 AD	14-17 AD	11-13 AD	11-17 AD
Recovery technique	s	s	s	h	h	h	s	h+s
MARINE SPECIES								
Smallspotted catshark	.	.	.	.	.	.	.	43
Spurdog	.	.	.	1	.	.	1	.
Shark, unspecified	.	7	.	.	.	.	11	.
Ray, unspecified	.	1	.	.	.	.	.	.
Herring	5	223	.	.	.	.	3366	.
Garpike	.	5	.	5	.	.	52	.
Gaddis, total	1	735	12	1028	6027	96	316	1457
Cod	.	302	8	857	4567	69	237	1025
Haddock	1	43	.	.	1	.	3	5
Whiting	.	94	.	.	.	.	.	.
Saithe	.	13	.	89	231	.	12	201
Ling	.	56	4	82	1228	27	59	226
Poor-cod	.	65	.	.	.	.	5	.
Norway pout	.	35	.	.	.	.	.	.
Torsk	.	26	.	.	.	.	.	.
Gadids, unspecified	.	1	.	.	.	.	.	.
Ballan wrasse	.	36	.	.	.	.	69	.
Atlantic mackerel	3	69	.	1	.	.	135	13
Atlantic bluefin tuna	.	.	.	.	.	2	.	.
Golden redfish	.	.	.	.	1	.	.	6
Flatfishes, unspecified	.	15	.	.	.	.	123	.
MIGRATORY SPECIES								
Salmon	.	.	.	.	4	.	.	2
Salmonids, unspecified	.	27	.	.	.	.	20	.
Eel	.	63	.	.	.	.	73	.
FRESHWATER SPECIES								
Pike	.	.	.	.	1	.	.	11
Cyprinids, total	.	26	.	.	.	.	.	1
Roach	.	.	.	.	.	.	.	1
Cyprinids, unspecified	.	26	.	.	.	.	.	.
Perch	.	.	.	.	.	.	26	.
Total	9	1107	12	1035	6033	98	4192	1533

TABLE 3

Numbers of identified fishbones from Norwegian sites. Recovery technique: h = hand-collected, s = sieved, ? = unknown.

in deeper waters than previously. Deep-water fishing is also indicated by the presence of large individuals, for example, 1.30 m ling and saithe greater than 1.00 m. The cod in the Medieval assemblages were 0.27-1.20 m long, mostly 0.30-0.60 m (Enghoff, 1995) and are thus larger than cod from Danish Stone Age sites (cf. Enghoff, 1994a).

At Medieval sites we see the first indications of fish trade, in the form of imported fish to monasteries and castles, where the inventory list for Øm Kloster, or the fish bone evidence (Pedersborg, Møhl unpublished letter, 1973) demonstrate that dried fish was imported. Furthermore, large-scale processing of fish is documented by the refuse from the herring industry at Selsø-Vestby.

Fishing equipment from Danish Medieval sites includes hooks (Holbæk, Dragør), a gorge (Holbæk), a leister prong (Tårnby), as well as net floats (Køge, Århus Søndervold) and a networking tool (Tårnby). These finds agree well with the evidence from the bone finds.

Written Medieval sources provide evidence of the importance of dried, salted fish during fast periods, as well as the incredibly rich herring fishery in the Øresund region which formed the basis for the Scania market. The Medieval fish bone finds reflect both these traits, but also reveal details of the less well-known, local day-to-day fishing.

NORWAY, INDIVIDUAL SITES

In the present review, only sites in southern Norway have been considered. Finds of pre-Middle Age bone assemblages in southern and eastern Norway are extremely scarce and mostly consist of small burnt fragments (A.-K. Hufthammer, pers. comm.).

The site number refers to Figure 7 (see Table 3 for detailed species lists).

Oslo, old city: Kanslergt. 10, Oslogt. 4, Søndre Felt, and Mindets Tomt (1)

Medieval fish bone assemblages are available from four sites in the old city of Oslo which was already an urban area during the Middle Ages. At three of the sites (Kanslergt. 10, Oslogt. 4, and Søndre Felt) material was obtained by sieving, whereas bones were hand-collected from Mindets Tomt. The Oslogt. 4 material is early Middle Ages: mid-11th to 13th centuries AD. The others cover longer periods: 11th-17th or even 11th-18th centuries AD. These are, however, divisable into shorter periods, as shown in Table 3. The fish bones from Mindets Tomt and Søndre Felt were studied by Lie (1988), those from Oslogt. 4 and Kanslergt. 10 by Lie (1991). Marine species make up the vast majority of fish bones at all sites, and gadids, especially cod, play an important role. Herring is also important at Kanslergt. 10 and dominates strongly at Oslogt. 10.

NORWAY, OVERVIEW

Taken as a whole, the southern Norwegian material covers the interval from the 11th century AD to well beyond the end of the study period.

Local influences on Norwegian fishing

Most of the marine species could have been caught in the Oslo Fjord. Three of the species on the list, viz., poor-cod, Norway pout and golden redfish, have not been found at any other sites under consideration here. The golden redfish is the only one among the species dealt with here (see Table 1) which has a northern distribution, being common in colder regions of the North Atlantic (Wheeler, 1978). The presence of torsk and ling in the Norwegian materials is also expected because Norwegian waters, including the Oslo Fjord, offer optimal conditions for catching these species.

Indications of fish trade in Norway

Lie (1988) mentioned that in the earliest period of the Mindets Tomt material (11th-12th centuries) "Both cod and ling are represented by vertebrae of fairly large individuals, and it is therefore reasonable to assume that this group of material, and in particular cod, have come from dried fish imported from the north". Lie (1988) noted, furthermore, that in the next period of the Mindets Tomt material, the importance of ling increased greatly, and since these ling are better represented by head bones than are the contemporaneous cod, a shift in preference from imported cod stockfish to locally caught ling may have taken place. Lie (1988) also drew special attention to the garfish which is not eaten in present-day Norway.

The absence of herring in the sieved material from Søndre Felt is striking, given its absolute

Site	Eketorp II	II/III	III	Varla			Fjälkinge	Gårdstånga	Birka[4]	Birka[5]	Sigtuna	Visby	Rinkaby	Oxie	Fo
Site n°	1.			2.			3.	4.	5.		6.	7.	8.	9.	
Age (centuries)	5-8 AD	5-8/11-14 AD	11-14 AD	5-9 AD	9-11 AD	11-13 AD	9-13 AD	10-11 AD	10 AD	10 AD	10-12 AD	10-13 AD	11 AD	11 AD	11
Recovery technique	h	h	h	?	?	?	s	s	?		?	?	?	?	
MARINE SPECIES															
Spurdog	.	.	.	.	.	4	.	.	.	.	.	.	.	.	
Thornback ray	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Skate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Herring	558	623	54475	.	.	8	1195	+	22	542	+	.	.	80	
Garpike	.	.	1	.	.	.	.	.	.	.	.	.	.	.	
Hake	.	.	.	.	3	11	.	.	.	.	.	.	.	.	
Gadids, total	156	578	3117	5	4	41	2	+	.	2	+	65	.	56	
Cod	154	571	3106	5	4	12	2	+	.	2	+	65	.	56	
Haddock	.	.	4	.	.	.	.	.	.	.	.	.	.	.	
Whiting	.	.	.	.	.	14	.	.	.	.	.	.	.	.	
Saithe	.	2	.	.	.	1	.	.	.	.	.	.	.	.	
Ling	2	5	7	.	.	14	.	.	.	.	.	.	.	.	
Gadids, unspecified	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Atlantic mackerel	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Eelpout	.	.	1	.	.	.	.	.	.	.	.	.	.	.	
Bullrout	15	31	139	.	.	.	.	.	.	.	.	.	.	.	
Flatfishes, total	91	178	736	.	.	.	4	+	.	.	.	.	.	4	
Turbot	23	.	4	.	.	.	.	.	.	.	.	.	.	.	
Turbot/Brill	.	2[1]	10[2]	.	.	.	.	.	.	.	.	.	.	.	
Halibut	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Plaice	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Flounder	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Dab/Plaice/Flounder	68	176	722	.	.	.	4	.	.	.	.	.	.	4	
Flatfishes, unspecified	.	.	.	.	.	.	.	+	.	.	.	.	.	.	

Site	Eketorp II	II/III	III	Varla			Fjälkinge	Gårdstånga	Birka[6]	Birka[7]	Sigtuna	Visby	Rinkaby	Rinkaby	Fo
				5-9 AD	9-11 AD	11-13 AD									
MIGRATORY SPECIES															
Sturgeon	8	11	78	.	.	.	.	.	.	.	.	.	.	.	
Salmon	.	.	.	.	.	.	.	.	.	3	.	.	.	.	
Trout	.	.	.	.	.	.	.	.	.	12	.	.	.	.	
Trout/Salmon	1	2	4	.	.	.	.	.	.	4	.	.	.	.	
Whitefish	1	3	24	.	.	.	.	.	5	6	.	.	.	.	
Salmonids, unspecified	.	.	.	.	.	.	.	.	1	.	.	.	.	.	
Eel	3	19	66	.	.	.	1	.	2	8	+	.	.	.	
FRESHWATER SPECIES															
Pike	51	141	532	.	.	.	30	+	195	594	.	2	6	.	
Cyprinids, total	16	40	173	.	.	.	64	+	473	792	+	.	46	.	
Crucian carp	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Tench	.	.	.	.	.	.	.	.	7	17	.	.	.	.	
Orfe	2	4	39	.	.	.	.	.	2	45	.	.	.	.	
Roach	.	.	2	.	.	.	6	.	10	28	.	.	.	.	
Rudd	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Common bream	2	4	36	.	.	.	58	.	352	526	.	.	46	.	
Zope	.	.	.	.	.	.	.	.	3	7	.	.	.	.	
Asp	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Cyprinids, unspecified	12	32	96	.	.	.	[3]	+	99	169	+	.	.	.	
Wels	.	.	.	.	.	.	.	.	.	1	.	.	.	.	
Burbot	.	.	.	.	.	.	.	.	3	6	.	.	.	.	
Perch	15	36	207	.	.	.	2	+	20	100	+	.	1	.	
Pikeperch	2	2	23	.	.	.	.	.	548	1363	+	.	.	.	
Total	917	1664	59576	5	7	64	1350	–	1269	3263	–	67	53	140	

[1] recorded as "Bothidae".
[2] recorded as "Bothidae".
[3] 932 scales.
[4] Ericson et al. (1988).
[5] L. Lougas (pers. comm.).
[6] Ericson et al. (1988).
[7] L. Lougas (pers. comm.).
[8] excluding 4 scales.

TA

Numbers of identified fishbones from Swedish sites. Rec

dominance at Oslogt. 4 (3366 out of 4192 fish bones) and frequent occurrence at Kanslergt. 10.

SWEDEN, INDIVIDUAL SITES

The review is based mostly on published evidence, supplemented by unpublished information put at my disposal by Annica Cardell (Ven, Minerva) and Lembi Lougas (Birka).

The site numbers refer to Figure 7 (see Table 4 for detailed species lists).

Eketorp (1)

A circular settlement at the island of Öland. Great numbers of fish bones were excavated during 1964-1974. They come from two phases: Eketorp II and Eketorp III. Eketorp II has been dated, by means of artifacts and radiocarbon analyses, to

Lund I 11. 11 (+13-14) AD ?	Lund II 11-14 AD ?	Kyrkheddinge 12. 11-15 AD h+s	Ven (Cardell) 13. 12-13 AD h+s	Simrishamn 14. 12-13 AD ?	Helsingborg 15. 12-13 AD s	Skara Rådhuset 16. 12-15 AD ?	Gamla Lödöse 17. 12-15 AD ?	Skara, kv. Sparbanken 16. 13-14 AD h	Uppsala 18. 13-17 AD h+s	Stockholm 19. 14 AD ?	15 AD ?	Borganäs 20 14-15 AD s
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	+	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	6538	4881	1436	+	.	12	.	.	.	+	.
.	.	2	9	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	191	1	.	.	.	.
1382	ca. 100	1364	843	62	+	24	222	13	552	+	+	11
1370	ca. 100	1359	842	62	+	22	95	3	549	+	+	11
11	.	2	.	.	.	.	.	.	1	.	.	.
.	.	2	1	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	43	.	.	.	.	.
1?	.	.	.	.	.	2	84	10	2	.	.	.
.	.	1	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	+	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
19	5	155	242	47	+	.	1	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	3	.	.	.	.	.	.	.	.	.	.
3	.	4	6	.	.	.	.	.	.	.	.	.
16	5	148	236	47	+	.	1	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.

Lund I	Lund II	Kyrkheddinge	Ven	Simrishamn	Helsingborg 12-13 AD	Skara Rådhuset 12-15 AD	Gamla Lödöse 12-15 AD	Skara, kv. Sparbanken 13-14	Uppsala 13-17 AD	Stockholm 14 AD	15 AD	Borganäs
2	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	+	.	.	.
.	.	.	.	.	.	.	.	.	.	+	+	.
.	.	.	.	.	.	.	.	.	+	.	+	1
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	114	74	1	.	.	.	.	+	.	+	.
30	.	4	.	.	.	3	1	2	1503	+	+	436
5	1?	2	2	.	.	1	1	.	+	+	+	133
.	.	.	.	.	.	.	.	.	+	.	.	.
.	.	.	.	.	.	1	.	.	+	.	.	.
1	1?	.	.	.	.	.	.	.	+	.	+	1
.	.	.	.	.	.	.	.	.	+	+	+	72
.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	1[3]	.	+	+	+	1
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	+	.	.	.
.	.	2	.	.	.	.	.	.	.	.	.	59
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	+	.	.	.
3	1	79	.	.	.	.	2	.	+	+	+	348
.	.	.	.	.	.	8	.	2	+	.	+	2
1455	ca. 107	8258	6049	1546	81	36	430	18	>2055	+	+	931

; 4

' technique: h = hand-collected, s = sieved, ? = unknown.

the Germanic Iron Age, 5th-8th centuries AD. Eketorp III has been dated to the period extending from the end of the Viking Age to the late Middle Ages, 11th-14th centuries AD. During the intervening period of 300-400 years, the camp was not used. Part of the material cannot be referred to either phase but is a mixture of both ("Eketorp II/III"). The fish bone material was hand-collected, and in addition, large concentrations of herring bones from Eketorp III were collected as sediment samples which were subsequently sieved, (Boessneck, 1979; Hallström, 1979).

More than 62000 fish bones from Eketorp have been identified. Herring, cod, plaice/flounder/dab and pike were the most important species during both phases. Herring is represented by a large majority of the bones: 61% from Eketorp II, and 91% from Eketorp III. The herring remains from Eketorp III include two accumulations which have been interpreted as consisting mainly of herring

heads. The cod bones are partly from entire small specimens (< 0.5 m), partly (vertebrae) from large cod (>0.85 m for Eketorp II, 0.80-1.20/1.30 m for Eketorp III). The large cod seem thus to have been imported to Eketorp in a decapitated state. A few bones, one supracleithrum (a shoulder bone) and 13 vertebrae, of large ling (1.10-1.50 m) are present and represent both phases, whereas haddock does not appear until the Eketorp III phase. Two vertebrae of large saithe (1.20 m) were found in the Eketorp II/III material. In the plaice/flounder/dab group only flounder has been identified with certainty. The presence of sturgeon and whitefish in both phases (and in the mixed material) is also noteworthy.

Varla (2)

A site on the Swedish west coast with possibilities for fishing in the open sea as well as in the inlet, Kungsbacka Fjord. Bones were excavated during 1989-1993 from a former settlement area. The bone material was studied by Johansson (unpublished report) and can be allocated to one of three phases, viz., late Iron Age (5th-9th centuries AD), Viking Age (9th-11th centuries AD) and late Viking Age - early Medieval (11th-13th centuries AD). Unfortunately the fish bones are poorly preserved and the method of their recovery is not revealed. The best represented species in this small sample are whiting, cod and hake. Ling is also present. Most of the cod bones are from small specimens less than 0.40 m long; one vertebra is, however, from a ca. 0.80 m cod. Cod and hake are represented by bones from both head and trunk.

Fjälkinge (3)

A site on the east coast of Scania, with possibilities for fishing in large lakes nearby, as well as the Baltic Sea. In 1995 well-preserved fish bone material was excavated from a settlement area. The material was recovered by dry and wet sieving through a 3 mm mesh and was dated to the Viking Age/early Middle Ages, 9th-13th centuries AD.

The most frequent species is herring which constitutes 52% of the identified fish bones. There are bones from all regions of the herring's body, although head bones predominate. Cyprinids follow herring in abundance and are represented by common bream and roach. There are two bones of cod, representing individuals about 0.50 m long (Cardell, 1997).

Gårdstånga (4)

A site in Scania, southernmost Sweden, about 25 km from the coast. The material from Gårdstånga derives from a rescue excavation carried out in 1989. The fish bones were recovered by flotation and wet sieving. The bones were deposited during the Viking Age and early Middle Ages, 10th-11th centuries AD. Sten (1994) did not indicate the number of fish bones identified, but listed the species and provided a diagram showing the dominance of herring, the remains of which constitute about half of the identified fish bones. Herring is followed by flatfish, cod and a few freshwater species. The cod were apparently about 0.70 m long. According to Sten (1994) the bones indicate that the fish were taken home to the site in an entirely unprocessed state. Sten (1994) considered fish to have played an important role in the subsistence at Gårdstånga.

Birka (5)

An important Viking Age trading centre situated on the island of Björkö in the Lake Mälaren near the east coast of Sweden. Extensive bone material was excavated during 1969-1971 and a preliminary analysis was carried out by Ericson *et al.* (1988). The material was dated to the 10th century AD and was recovered by sieving. It is dominated by pikeperch, followed by common bream and pike. The finds have been interpreted as representing local fishing in the Lake Mälaren. The only dubious species in this respect is herring which is represented by 22 bones.

New excavations were conducted at Birka in 1993-1994, during which sieving through a fine mesh was carried out. This yielded still more fish bones of which 3263 have so far been identified by Lembi Lougas (pers. comm.). The results resemble closely those produced by Ericson *et al.* (1988). Cod (two bones) and wels (one bone) are new on the list. The newly-analyzed material is also dominated by pikeperch, followed by cyprinids (common bream) and pike. A significant difference is constituted by the large number of herring bones in the new material (542 bones, i.e. 17% of the bones, as opposed to 22/1269 = 1.7% in the former material).

Sigtuna, "kvarteret Trädgårdsmästaren 9 & 10" (6)

A site surrounded by fresh water, situated ca. 35 km from the Baltic coast north of Stockholm. Fish

bones were excavated during 1988-1990 and were dated to the 10th-12th centuries AD. The recovery technique was not given, (Hårding, 1990) nor is a complete list of species with numbers of identified bones available. Hårding (1990) mentioned pikeperch, perch and cyprinids as the most frequent species. Herring and eel are also mentioned. Layers from the 12th century contain many vertebrae of large cod, whereas bones from the cod's head are entirely absent. Hårding interpreted this as indicating the import of dried cod from the Atlantic, possibly from Norway.

Visby, "kvarteret Apoteket" (7)

A site on the island of Gotland. Fish bones were excavated during the 1970s from remains of Viking Age houses (recovery technique not given). The material has been dated to the 10th-13th centuries AD. Only 67 out of 367 excavated fish bones were identified, comprising 65 from cod and two from pike. Westholm and Sigvallius (1982) believed that more species are present among the unidentified bones.

Rinkaby (8)

A settlement on the east coast of Scania. Bone material dated to the 11th century AD has been excavated (Lepiksaar, 1961) but the recovery technique is not given. The fish bones are all from freshwater species, viz., common bream, pike and perch.

Oxie (9)

A grubenhaus settlement at the southern tip of Sweden, about 10 km from the coast of Øresund (Mandahl, 1974). The fish bone material was recovered from a grubenhaus dated to the 11th century AD. There is no mention of sieving being was employed. The fish bones derive from common marine species: herring, cod, and plaice/flounder/dab. Several cod are recorded as having been 0.50-0.60 m long, and bones from both head and trunk are present (Lepiksaar, 1974b).

Fosie SN, Trehögsparken (10)

A site in Scania facing Øresund. The material, dated to the 11th-12th centuries AD, was recovered from a grubenhaus and a pit; there is no indication of sieving being employed. Herring dominates the material, and the bones derive mainly from the head region. The estimated length of the herring is 0.24-0.30 m, and they are thought to have been caught in the Kattegat or even further north. In addition, there are a few bones of cod and plaice/flounder/dab (Lepiksaar, 1974a).

Lund I, the Thule area (11)

Lund is a town in Scania, southernmost Sweden. Fish bone material from the Thule area of Lund was excavated during the 1960s (recovery technique not given). The material has been dated to the 11th century AD. A small amount of material was also recovered from 13th-14th century wells. However, the two samples were not kept separate (Ekman, 1971). Most of the fish bones are from cod, estimated to have been 0.39-1.15 m long; all body regions are represented. Other gadids present are haddock and perhaps a single bone of ling. In addition there are a number of freshwater species, as well as flounder, herring and sturgeon. According to Ekman (1971), fishing was important at this site and took place locally in the surrounding fresh waters (rivers) and in Øresund where, for example, the cod are thought to have been caught on hooks.

Lund II, Stortorget (the Marketplace) and plot no. 5 of the Färgaren block (11)

The majority of this material from the town of Lund (see above) was recovered during excavations of the Marketplace. The entire material is dated archaeologically to the period AD 1020-1400. About 90% of the fish bones are, however, from the 11th-12th centuries. The recovery technique is not given (sieving seems, however, improbable). Most of the bones are from cod, and these are almost exclusively from the head, plus the foremost vertebrae. Severed heads appear therefore to have been the source of the bones. In addition there are a few bones of flatfish, perch and cyprinids (Bergquist & Lepiksaar, 1957).

Kyrkheddinge (12)

A Medieval town site in Scania, about 12 km from the Swedish west coast. A large amount of bone material was excavated in 1995. The majority of the fish bones were found in floor layers inside houses and have been dated to the 13th-15th

centuries AD. A minor portion is dated to 11th-12th centuries AD. Fish bones were recovered both by hand-collection and by sieving. All the sediment from the above-mentioned floor layers was wet sieved through a 3 mm mesh. The bones are very well preserved. Herring dominates, constituting 80% of the identified bones. The entire herring skeleton is represented, although there seems to be a preponderance of vertebrae. Cod is the second most frequent species and is also represented by the entire skeleton. The lengths of the cod are estimated to 0.28-0.90 m. Haddock and whiting are also present. The marine species are thought to have been caught in the Øresund or perhaps bought at market places or the like. There are a few bones of freshwater species; these could have been caught in a nearby stream (Cardell, unpublished report c).

Ven (13)

A number of early Medieval farms were excavated in 1989 in Tuna village on Ven, a small island in Øresund. The fish bone material has been dated to the 12th-13th centuries AD. The bones are very well preserved, and only a few are burnt. Fish bones were partly hand-collected, partly recovered by sieving through a fine mesh. All in all, 42 bones of herring, cod, plaice/flounder/dab and garfish were recovered (Sten & Ericson, 1989). Furthermore, a "fish bone layer " collected *in toto* was later analyzed by Annica Cardell (unpublished report b) who identified 6049 bones. Cardell's analysis shows a great dominance of herring. In addition there are quite a number of cod. Both herring and cod are represented by all body regions. Most of the cod were about 0.50 m or less in length. Some large cod (less than 1 m, however) are also represented.

Simrishamn, kvarteret Taltrasten 60 (14)

A town on the Baltic coast of Scania. A number of so-called "lerbottnar" (literally: clay-bottoms) were excavated in 1982. The "lerbottnar" are thought to have been connected with the Medieval herring fishing in the Øresund, although their function has not yet been identified. The "lerbottnar" in question have been dated to the 12th-13th centuries AD and have yielded well-preserved fish bones. No information is given about whether sieving was used for the recovery. Most of the fish bones are from herring, represented by the entire skeleton. In addition there are bones of cod, plaice/flounder/dab and eel, of which head bones seem to be best represented. The cod are small, mostly 0.21-0.29 m long (Cardell, 1995).

Helsingborg, kvarteret Minerva (15)

A town on the Øresund coast, situated at the narrowest part of Øresund. The material comes from a "lerbotten" (see Simrishamn, above) and has been dated to the 12th-13th centuries AD. The fish bones were recovered by sieving through 0.5 mm and 3 mm meshes. Herring, cod and plaice/flounder/dab are represented. The cod bones are from individuals less than 0.35 m long. The fish were probably caught locally (Cardell, unpublished report a).

Skara, kvarteret Rådhuset, Tellus 2, Tellus 14 A and B (16)

A town in west Sweden ca. 120 km from the coast. Fish bones were excavated during 1970-72 in Medieval Skara; they are dated archaeologically to the 12th-15th centuries AD. The method of recovery is not recorded but sieving seems improbable. Only a small number of fish bones were found, many of which are from cod. Ling, pikeperch, pike and tench are also represented. Lepiksaar (1976) regarded the cod and ling as having been imported as stockfish from the port of Gamla Lödöse.

Gamla Lödöse (17)

A town of the 12th-15th centuries on the Swedish west coast. The material was excavated in the early 1960s, the recovery method has not been published but hand-collecting seems probable. The dominating species is hake (total length 0.66-1.04 m), followed by ling (1.16-1.20 m), cod (0.95 m) and saithe (0.82-1.07 m). The estimated lengths all indicate large individuals of these gadid species. Lepiksaar (1965) thought fish were imported, including hake from more westerly waters, and ling perhaps from Norway (see, however, the regional overview).

Skara, kvarteret Sparbanken (16)

Fish bones were recovered by hand-collecting from refuse dated to the 13th-14th centuries AD in the inland town of Skara (see above). The small

amount of material contains the same species as the material from kvarteret Rådhuset in Skara with the interesting exception of a single bone of hake (Vretemark, 1984).

Uppsala, kvarteret Kransen (18)

A town in eastern Sweden, north of Stockholm, situated about 80 km from the Baltic coast with possibilities for fishing in nearby rivers. A large amount of bone material was excavated in 1978 in "kvarteret Kransen" in Uppsala. The fish bones are of Medieval age and are assignable to seven phases, covering the period from the late 13th to early 17th centuries AD. Both hand-collecting and sieving were employed, and the conditions for bone preservation were good. Although a complete species list giving the number of bones of each species was not included in the publications by Jonsson (1984, 1986), it was mentioned that 3000-4000 fish bones were excavated, and that the majority (1503) are from pike, followed by cod. Haddock and ling are also present, as well as a considerable number of freshwater and migratory species. Herring is not very frequent. Total length and representation of single bone elements have been calculated for the two most frequent species, pike and cod, for each of the seven phases. Through the entire period, pike of all sizes are present, and the number of vertebrae is low in comparison with the number of head and shoulder bones. This is interpreted as showing that the bones are remains of dried pike, a conclusion supported by characteristic cutmarks on the dentary bones which must be the result of gill removal. The cod appear to fall into two sized classes throughout the entire period: large (0.70-1.30 m long, average about 1.00 m) of which vertebrae are overrepresented, and small (0.20-0.70 m, average 0.40 m) represented by head and shoulder bones. Considering the long distance to the coast, the cod from Uppsala were probably imported in a preserved condition. Jonsson's opinion is that the large cod were imported from the west coast of Scandinavia (probably Lofoten, Norway) in a decapitated, dried, and possible even salted condition. The smaller cod were probably caught in the Baltic or the Botten Sea and were dried in the same way as the pike (cf. the representation of bone elements). Large cod dominate in layers from the late 13th to early 14th centuries, thereafter their frequency is low. Small cod become increasingly frequent throughout the entire suite of layers. The frequency of pike decreases from the 13th to the early 14th centuries whereafter it increases exponentially (Jonsson, 1984, 1986).

Stockholm, Helgeandsholmen (19)

Material consisting primarily of kitchen rubbish thrown into a watercourse from the institution Helgeandshuset (an asylum for sick and elderly people) in the city of Stockholm. This material has been dated to the 14th century AD. In addition there is a smaller amount of material, dated to the 15th century. The latter was collected as sediment samples. The recovery technique for the 14th century material is not recorded but sieving was not used. There is no record of the number of identified fish bones, but the material from the 14th century includes pike, cod, perch, common bream, roach, salmon and thornback ray. Pike is by far the most frequent species, constituing 75% of the bones. Most of the pike are estimated to have been 0.20-0.50 m long. The majority of the pike dentary bones were cut in the same way as seen in the Uppsala material (Jonsson, 1986). The length of the cod has been estimated to a maximum of 0.50 m. This species is therefore thought to have been caught locally in the Baltic Sea. An interesting element is the single dermal denticle of thornback ray. This species was regarded as a great delicacy, reserved for the upper class.

The 15th century material contains more species, possibly as a function of a more meticulous recovery technique. The most frequent species are perch, cod and pike.

Cod bones in the Helgeandsholmen material show an overrepresentation of vertebrae, and the cod is therefore thought to have arrived at the site in a preserved condition. Perch and pike, on the other hand, seem to have been cleaned on site (Vretemark, 1982).

Borganäs (20)

A castle on the river Dalälven about 100 km from the Baltic coast. The bone material was recovered by wet sieving through a 2 mm mesh in 1985 and is dated to ca. AD 1390-1434 (Sten, 1988, pers. comm.). The most frequent species by far are pike and perch. All the species could have been caught in Dalälven except cod which must have been imported. The dentary bones of pike are cut in the same way as seen in the material from Uppsala and Helgeandsholmen.

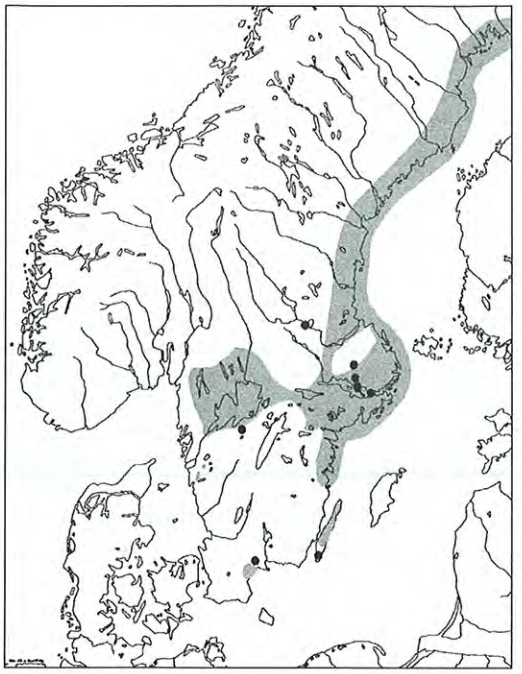

FIGURE 8

Map of Sweden, showing the present distribution of pikeperch (from Curry-Lindahl (1985), hatched) and the sites on which pikeperch bones have been found (dots).

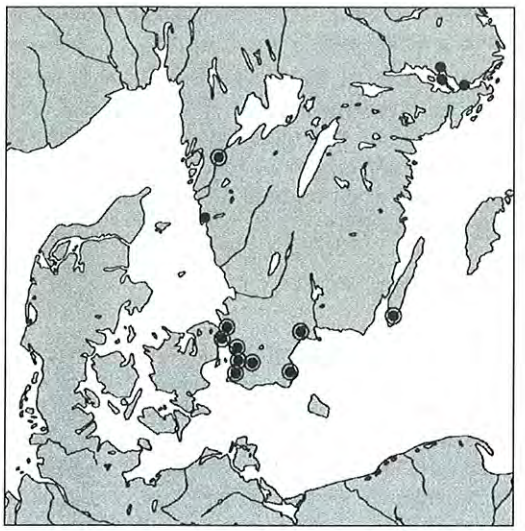

FIGURE 9

Map of Sweden, showing the sites where bones of herring (dots) and plaice/flounder/dab (circles) have been found.

SWEDEN, OVERVIEW

The Swedish material covers the 5th-17th centuries AD. Thus the Iron Age, Viking Age and Middle Ages are represented. The Iron Age is, however, represented at only two sites, viz., Eketorp and Varla, the latter sample being unfortunately quite small.

Local influences on Swedish fishing

Pikeperch is present in the material from Borganäs, Uppsala, Sigtuna, Birka, Stockholm, Eketorp, Fjälkinge and Skara. The geographical location of these sites agrees to an astonishing extent, even in detail, with the present-day, quite well-defined distribution of pikeperch in Sweden (Figure 8).

Pike was of very great importance within a delimited part of the country, i.e., at the sites Borganäs, Uppsala, Birka and Stockholm which are all situated in the southern-central part of eastern Sweden. Pike abounds in fresh water all over Sweden but is also common in brackish water along the coasts of the Baltic Sea, including the Botten Sea, as far as 90 km from the coast (Curry-Lindahl, 1985). Pike bones are also present at many other Swedish sites but they are much less numerous than at the above-mentioned localities.

Herring is present at most of the Swedish Iron Age, Viking Age and Medieval coastal sites, from Gamla Lödöse on the west coast to Stockholm on the east coast (Figure 9). Herring is conspicuously absent at the inland sites of Skara, Uppsala and Borganäs. Nowadays, herring occurs in all waters off the Swedish coast, including the innermost Baltic Sea. Quite overwhelming numbers of herring bones are present in the material from both phases at Eketorp, although the quantity is greater during the Medieval phase from which more than 54000 herring bones have been recovered. Herring bones are also particularly abundant at the towns of Kyrkheddinge, Simrishamn and Fjälkinge on the coast of Scania (southernmost Sweden).

Most bones of the plaice/flounder/dab group cannot be identified to species and are therefore reported collectively. This group of species has too a characteristic distribution in the Swedish material. They occur at Gamla Lödöse on the Swedish west coast, at the majority of towns along the Øresund, further up the eastern coast of Scania and as far into the Baltic as Eketorp on the island of

Öland (Figure 9). At the latter site, only flounder has been identified with certainty. Dab, flounder and plaice are all marine species, but flounder can survive in very brackish water or even fresh water. All three are common in the Kattegat, Øresund and southern Baltic, but flounder occurs further north in the Baltic (nowadays as far as Stockholm) than the two others (Curry-Lindahl, 1985).

The occurrence of wels at Birka should also be noted, this site being slightly to the north of the present-day distribution of this species. Sturgeon has only been found at Eketorp and Lund.

Bones of gadids have been found at all sites except Rinkaby (but the bone material here was very small and possibly not representative). The commonest gadid, cod, occurs in all Swedish marine waters from the Skagerrak to the Botten Sea. Many of the publications dealing with fish bone analyses from the Swedish sites reach the conclusion, based on the representation of individual bone elements, that the cod in question were entire, often small, specimens. This is true, for example, at Varla, Fjälkinge, Oxie, Kyrkheddinge, Simrishamn, and in part at Eketorp. Therefore cod remains found at these sites probably represent local fishing. There are, however, also towns where remains of entire large cod have been found, for example, Gamla Lödöse (0.70-1.00 m). At this site many bones of large hake, ling and saithe were also found. Lepiksaar (1965) suggested that these species were imported; hake from more westerly waters and ling from Norway. It should, however, be mentioned that Gamla Lödöse is located exactly in that part of Sweden from where all the above-mentioned species could have been caught. For instance, hake occurs every year in the Skagerrak, albeit with varying abundance, and also off the coast of the province of Bohuslän (where Gamla Lödöse is situated). Hake also occurs in the Kattegat and sometimes in the Øresund (Curry-Lindahl, 1985). Otterstrøm (1914) recorded a similar distribution of hake and mentioned that the species occurs in the Kattegat and the northern Øresund, especially in the autumn (confirmed by N. Bødker Thomsen, fishing skipper, pers. comm.). Ling and saithe may occur as far south as the Øresund (Curry-Lindahl, 1985; Otterstrøm, 1914). It therefore appears more straightforward to suggest that cod, hake, ling and saithe were fished for locally at Gamla Lödöse. This suggestion is supported by the fact that the only other finds of hake in material from the same period are from Varla, which lies just south of Gamla Lödöse, and from Skara, to where fish is thought to have been imported from Gamla Lödöse. The Varla material includes hake from the Viking Age and both hake and ling from the Middle Ages. Further support is provided by the finding by Vretemark (pers. comm.) of 41 hake bones in material from Kungahälla (12^{th}-13^{th} centuries AD), another town near the Bohuslän coast.

To summarize, the fish bone assemblages from Iron Age, Viking Age and Medieval Sweden are generally characterized by a strong local element. For many of the towns in question all the fish on the species list could theoretically have been caught locally. This is true, for example, of the trading centre Birka, but also of the majority of towns along the Scanian coast, as well as Gamla Lödöse and Varla.

Remains of fishing equipment from Swedish sites

Several of the Swedish sites have yielded finds of fishing equipment. Net sinkers, hooks and leisters have been found at Birka and Eketorp III. Hooks and bark floats are reported from Sigtuna. The tools found suggest varied fishing, consistent with the species lists.

Indications of fish trade in Sweden

Some assemblages which include the remains of large cod show an over-representation of vertebrae (or vertebrae may be the only bone elements present). This is true of Eketorp, Sigtuna (12^{th} century AD) and Uppsala. In both phases at Eketorp (II and III) there are remains of entire, small cod (see above) together with vertebrae of large cod (0.80-1.30 m). In the 13^{th}-14^{th} century material from Uppsala, vertebrae of cod estimated to have been 0.70-1.30 m long are very common. These large cod, represented only by vertebrae, are interpreted as the remains of dried, perhaps salted fish, i.e., stockfish. Hårding (1990) and Jonsson (1986) suggested that these cod may have come from the Atlantic Ocean and were probably imported from Norway. It should be taken into consideration, however, that large cod are available from waters closer to Sweden, as are ling and hake, which are also thought to have been imported from other countries (see above).

Bones of haddock have been found at a few sites: Eketorp, Lund, Kyrkheddinge and Uppsala, i.e., there are no finds of haddock until the 11^{th} century

AD. Haddock and ling are often conspicuously linked in the assemblages. This might be taken as indicating the importing of both species. Finds of haddock and ling in Uppsala and Eketorp must, in any case, be regarded as a result of trade, whereas local fishing of these species was at least theoretically possible from Lund, Kyrkheddinge and Varla.

The importing of gadids is further documented in material from the inland sites of Skara and Borganäs.

The great importance of pike at Borganäs, Uppsala and Stockholm was mentioned above. It is characteristic of these finds that a large proportion of the dentary bones (ca. 50% at Uppsala) have been cut in two. Jonsson (1986) interpreted this as being the result of processing the pike for drying; he presumed that the pike were opened and had their gills removed with a special cut which divided one of the dentary bones. Jonsson thought that the pike were imported from Norrland (northern Sweden). He also thought that the small cod from Uppsala were processed and preserved in the same way.

The thornback ray from Stockholm must have been imported. Since this species was at the time regarded as a great delicacy more or less reserved for the upper class (Sten, 1995) it appears strange that it was found in material deriving from an institution for poor and elderly people.

On the negative side, it is worth noting that, even though herring is common at coastal sites, there is no indication of the importing of herring to inland sites. The same is true of plaice/flounder/dab (Figure 9).

The material from Eketorp and Uppsala belongs to a number of phases and therefore offers an opportunity to trace possible historical developments in fishing and trade. At Eketorp the same impression is gained from both phases; herring fishing was by far the most important. Large cod and ling also seem to have been imported in both phases, whereas haddock does not appear until the later phase (11th-14th centuries AD). At Uppsala, large imported cod dominate from the 13th to the beginning of the 14th century AD, later their frequency is low. Small cod, which are regarded as a result of local trade, occur with increasing frequency throughout the phases. The frequency of

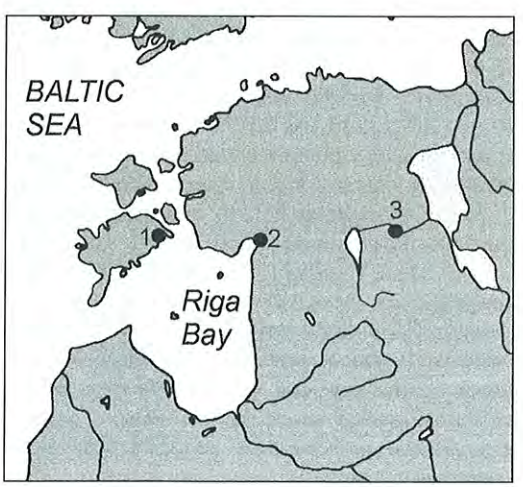

FIGURE 10

Map of Estonia, showing the location of the reviewed sites. Site numbers refer to the section "Estonia, individual sites".

Site	Pöide	Pärnu	Tartu
Site n°	1.	2.	3.
Age (centuries)	8-9 AD	14-16 AD	14-16 AD
Recovery technique	h	h+s	h
MARINE SPECIES			
Herring	.	120	.
Gadids, total	.	51	5
Cod	.	51	5
Flatfishes, total	.	7	.
Flounder	.	7	.
MIGRATORY SPECIES			
Sturgeon	.	1	.
Trout/Salmon	.	3	.
Whitefish	.	6	.
Eel	.	3	.
FRESHWATER SPECIES			
Pike	1	32[1]	43
Cyprinids, total	1	143	37
Tench	.	.	1
Dace	.	1	.
Orfe	.	13	2
Roach	1	115	1
Common bream	.	.	32
Zährte	.	5	1
Cyprinids, unspecified	.	9[2]	.
Wels	.	.	1
Burbot	.	.	2
Pikeperch	.	160[3]	4
Perch	12[4]	391[5]	76
Total	14	917	168

[1] excluding 77 scales.
[2] excluding 33 scales.
[3] excluding 31 scales.
[4] excluding 148 scales.
[5] excluding 2649 scales.

TABLE 5

Numbers of identified fishbones from Estonian sites. Recovery technique: h = hand-collected, s = sieved, ? = unknown.

pike, on the other hand, falls from the 13th to the beginning of the 14th century AD; later it increases exponentially. Sten (1995) discussed trade with fish in Medieval Sweden using examples from several of the above-mentioned towns.

ESTONIA, INDIVIDUAL SITES

The information for Estonia has been provided by Lembi Lougas (pers. comm.).

The site numbers refer to Figure 10 (see Table 5 for detailed species lists).

Pöide (1)

A Viking Age hillfort on the island of Saaremaa (Ösel), which was apparently used only in cases of emergency. A small amount of material, dated to the 8th-9th centuries AD, has been hand-collected at this site. All the bones are from freshwater species, mostly perch.

Pärnu (2)

A Medieval town situated on an estuary on the coast of Riga Bay. Material dated to the 14th-16th centuries AD has been recovered here by hand-collection, as well as sieving at places where the concentration of fish bones was greatest. The material includes marine, migratory and freshwater species, all of which could have been caught from a base at Pärnu. Perch is most common, followed by pikeperch and herring. The presence of sturgeon is noteworthy.

Tartu (3)

An inland town situated on the banks of a river. Fish bones dated to 14th-16th centuries AD have been hand-collected. They are almost exclusively from freshwater species, but there are five bones of cod which must have been imported. The most frequent species are perch, pike and common bream.

ESTONIA, OVERVIEW

From Estonia we have a small amount of material from a Viking Age site and two larger assemblages from Medieval sites, one from the coast, one from inland. All three sites are characterized by spe-

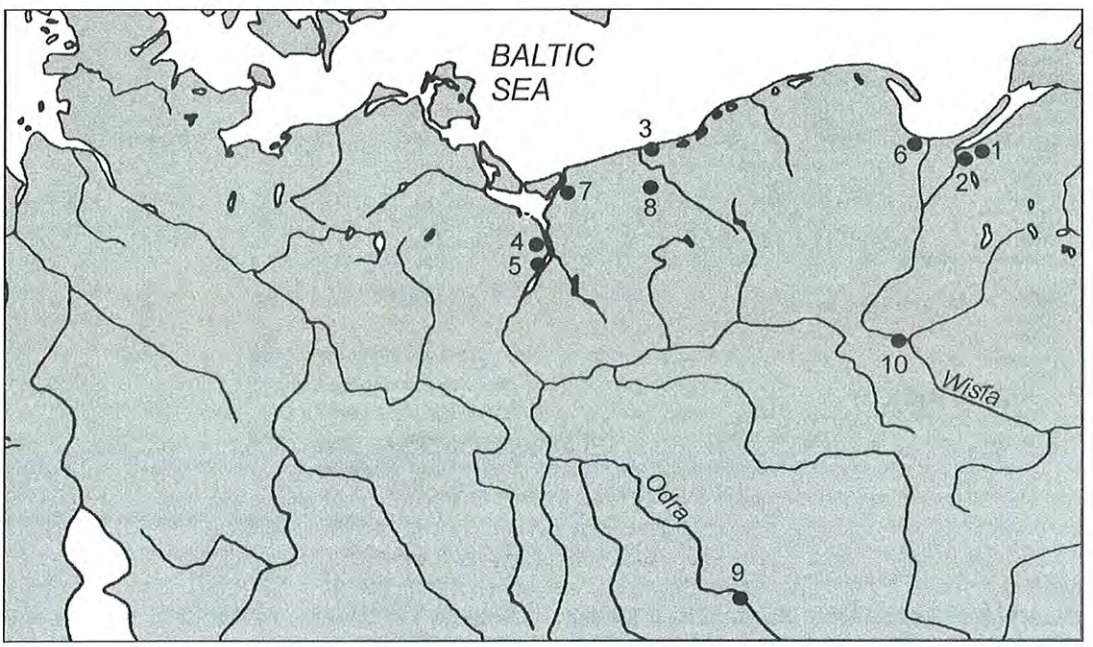

FIGURE 11

Map of northern Poland, showing the location of the reviewed sites. Site numbers refer to the section "Poland, individual sites".

Site	Tolkmicko	Łęcze	Kolobrzeg-Budzistowa	Szczecin-Mścięcino	Szczecin Rynek Warzywny	Gdansk I	Gdansk II Prince's Quarter
Site n°	1.	2.	3.	4.	5.	6.	
Age (centuries)	7-5 BC	7-5 BC	8/9-11/12 AD	9-11 AD	9/10-13 AD	10-13 AD	Early Medieval
Recovery technique	?	?	?	?	?	?	?
MARINE SPECIES							
Herring	.	.	.	.	.	.	.
Clupeids, unspecified	.	.	3235	.	+[2]	342	.
Gadids, total	.	.	3	.	.	10	.
Cod	.	.	3	.	.	10	.
Gadids, unspecified	.	.	.	.	.	.	.
Flatfishes, total	.	.	16	.	.	42	.
Dab/Plaice/Flounder	.	.	16	.	.	42	.
Flatfishes, unspecified	.	.	.	.	.	.	.
MIGRATORY SPECIES							
Sturgeon	36	1	60	101	214	4994	432
Twaite shad	.	.	.	.	.	.	.
Salmon	.	.	.	.	.	.	.
Trout	.	.	.	.	.	.	.
Trout/Salmon	1	3	3	.	.	3	.
Whitefish	.	.	.	.	.	1	.
Salmonids, unspecified	.	.	.	.	.	.	.
Smelt	.	.	.	.	.	.	.
Eel	.	.	1	14	56	4	1

Site	Tolkmicko	Łęcze	Kolobrzeg-Budzistowa	Szczecin-Mścięcino	Szczecin Rynek Warzywny	Gdansk I	Gdansk II Prince's Quarter
FRESHWATER SPECIES							
Pike	45	.	18	10	264	331	1
Cyprinids, total	3190	41	62	175	3431	3954	17
Common carp	.	.	.	.	.	.	.
Crusian carp	1	.	.	.	18	13	[4]
Barbel	.	.	.	.	.	.	.
Tench	.	.	.	25	704	297	2
Dace	.	.	.	.	.	.	.
Chub	.	.	.	.	10	5	.
Orfe	1	.	.	.	27	16	.
Dace/Chub/Orfe	.	.	.	.	.	83	.
Roach	215	4	32	81	979	171	2
Rudd	.	.	.	.	12	14	.
White bream	92	1	.	.	3	42	.
Common bream	2757	34	29	66	1553	1454	12
Zope	.	.	.	.	21	.	.
Bream/Zope	.	.	.	.	.	157	.
Zährte	1	.	1	.	5	92	.
Asp	11	.	.	3	98	143	1
Ziege	112	2	.	.	1	12	.
Cyprinids, unspecified	.	.	.	.	.	1455	.
Wels	5	.	.	32	588	113	4
Burbot	2	.	.	.	.	3	.
Perch	55	.	7	13	292	234	2
Pikeperch	393	1	6	345	1101	2977	17
Ruffe	.	.	.	.	4	.	.
Bullhead/alpine bullhead	.	.	7	.	.	.	.
Total	3727[1]	46	3418	690[3]	5950	13008	474

T

Numbers of identified fishbones from Polish sites. Rec

cies which could have been caught in local fishing waters. Perch, pikeperch, cyprinids and pike are the most frequent species and are all very common in the inner Baltic Sea as well as in fresh waters in Estonia. The presence of herring at Pärnu is also very striking. Furthermore, it is worth noting that the flatfish are represented by the flounder, the flatfish species which extends furthest into the Baltic.

Quarter	Kamień-Pomorski	Kędrzyno	Wrocław	Mała
	7.	8.	9.	10.
	10-13 AD	early Med.	10-14 AD	14-15 AD
?	?	?	?	?
.	.	2	16[5]	.
.	.	.	.	.
.	.	.	.	561
.	.	.	.	561
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
71	.	1	1[6]	31
.	.	.	.	.
.	.	.	1[7]	.
.	.	20	2[8]	.
.	.	.	13[9]	.
1	.	.	.	.
.	.	.	4	.
.	.	.	.	.
3	.	.	.	.

Quarter	Kamień-Pomorski	Kędrzyno	Wrocław	Mała
05	3	60	30[10]	114
34	11	236	171	47
.	.	.	29[11]	.
5	.	.	8[12]	3
.	.	.	7[13]	.
76	4	68	12	.
.	.	.	3[14]	.
5	.	4	5[15]	.
5	.	1	19	.
.	.	.	.	.
43	3	31	6[16]	11
1	.	[17]	6	.
1	1	1	[18]	.
05	2	131	66[19]	32
.	.	.	.	.
.	.	.	8	.
3	1	[20]	[21]	.
37	.	.	2	1
2	.	.	.	.
.	.	.	.	.
02	.	.	11	5
3	.	4	[22]	.
17	2	255[23]	23[24]	9
61	20	52	14[25]	13
.	.	2	.	.
.	.	.	.	.
297	36	632	286	780

1 excluding 23,717 scales, mostly from saberfish.
2 present, not counted.
3 excluding scales.
4 scales.
5 excluding scales.
6 excluding scales.
7 excluding scales.
8 identified to subspecies fario, excluding scales.
9 excluding scales.
10 excluding 534 scales.
11 excluding scales. 18 bones tentatively identified.
12 excluding scales.
13 excluding scales.
14 excluding scales.
15 excluding scales.
16 excluding scales.
17 sporadic occurrence.
18 scales.
19 excluding 1334 scales.
20 sporadic occurrence.
21 scales.
22 scales.
23 frequent occurrence.
24 excluding 3814 scales.
25 excluding 211 scales.

6

echnique: h = hand-collected, s = sieved, ? = unknown.

The only deviation from the purely local impression given by the material is the presence of cod which must have been imported to Tartu and therefore documents trade with fish.

POLAND, INDIVIDUAL SITES

The review is based on published results. All the material was hand-collected.

The site numbers refer to Figure 11 (see Table 6 for detailed species lists).

Tolkmicko (1) and Leçze (2)

Two sites at Vistula Bay on the Baltic Sea. Two fish bone assemblages, both dated to the 7th-5th centuries BC, are available here. The Tolkmicku material is by far the largest and is strongly dominated by common bream. Pikeperch, roach and ziege were also important. The material from Leçze is very similar (Filuk, 1968).

Kolobrzeg-Budzistowa (3)

Kolobrzeg lies on the Baltic coast and has yielded fish bone assemblages dated to the 8th/9th to 11th/12th centuries AD. Most of the bones are from clupeids (herring/shad), the majority probably from herring. Other marine species include cod, and there are a number of migratory and freshwater species, particularly sturgeon. The species list was taken from Rulewicz (1994).

Szczecin-Msciecino (4)

A settlement situated immediately outside a castle, on a branch of the River Odra near the lagoon Szczeciner Haff. Fish bone material was excavated in 1954 and has been dated to the 9th-11th centuries AD. The bones are well-preserved and are regarded as kitchen refuse. Thirteen species of fish are represented, all of which, with the exception of sturgeon, are common in the Odra and/or Szczeciner Haff nowadays. The most frequent species is pikeperch, with sturgeon in second place (Chelkowski, 1959).

Szczecin, Rynek Warzywny (5)

Fish bone material is available from Medieval (9th/10th to 13th centuries AD) Szczecin in the Vegetable Market (Rynek Warzywny) area. Most of the identified fish bones are from common bream, pikeperch and roach, but there are also a good number of bones of wels. Clupeidae (herring/shad) are indicated as present, not counted. The species list was taken from Rulewicz (1994).

Gdansk I (6)

The city of Gdansk is situated near the coast of a large bay on the Baltic Sea near the River Wisla and its estuary. Extensive fish bone material, from 17 habitation levels dated to AD 980-1308, has been excavated in the old town of Gdansk. As there seems to be no change throughout these centuries, only the total number of bones of each species are shown in Table 6. It should, however, be emphasized that all ten bones of cod are from the 13th century. The most important species appear to have been sturgeon, pikeperch and common bream. All species on the list occur naturally in nearby waters. The majority of the fish bones are from migratory species, and Suslowska and Urbanowicz (1967) therefore thought that fishing took place near the Wisla estuary, in its branches, in bays and in coastal waters. Size estimations showed that the older layers contain larger individuals than the younger ones. Marine fish are represented merely by the clupeid family, and a small number of cod bones.

Gdansk II (6)

Suslowska (1966) reported on fish bone assemblages from two other sites in Gdansk, the Prince's Quarter and the Fishing Quarter, respectively. Both are early Medieval but no more precise datings are available. Suslowska (1966) compared the two assemblages and found them to be very similar. Only those species represented by a few bones in the large material (Fishing Quarter) are absent from the smaller material, presumably due to the numerical difference between the assemblages. Sturgeon dominates, followed by pikeperch and common bream. Suslowska (1966) warned that sturgeon tends to dominate fish bone assemblages because of its numerous large bony plates.

Kamien-Pomorski (7)

An early Medieval town close to the Baltic coast north of Szczecin. During a number of pilot excavations carried out in 1958 fish bone material was recovered from kitchen refuse from a settlement layer, spanning the 10th-13th centuries AD. The amount of material is small and it comprises exclusively freshwater species, mostly pikeperch (Chelkowski, 1960).

Kedrzyno (8)

A site in the Kolobrzeg district close to the Baltic coast north of Szczecin. Fish bones were recovered in 1959 from samples of kitchen refuse, dated

to the 8th-9th centuries AD (Lozinski, 1982), from an area with early Medieval castle walls. Most of the bones are from common bream and perch. The marine element is constituted by two herring bones (Chelkowski & Chelkowska, 1966).

Wroclaw "L'Ile-du-Dome" (9)

A city almost 400 km from the Baltic Sea. Fish bones and, in particular, fish scales dated to the 10th-14th centuries AD were recovered from the site of "L'Ile-du-Dome". Most bones and scales are from common bream, perch, pike and pikeperch. It is worth noting that herring is represented at this truly inland site - this species must have been imported, and that the domesticated common carp also occurs (Kozikowska, 1974).

Mala Nieszawka (10)

A site near Torun town on the River Wisla, about 160 km from the Baltic coast. Fish bones dated to the 14th and the first half of the 15th century AD were recovered within the former Teutonic castle. It is notable that most bones at this inland site are from cod, a marine species, but only head bones are represented. In addition there are bones of freshwater species and the migratory sturgeon (Iwaszkiewicz, 1991).

POLAND, OVERVIEW

The fish bone assemblages from Poland cover the period from the 7th century BC to the 15th century AD, i.e., from the early Iron Age to the Middle Ages. There is, however, a lacuna of more than 1000 years within this interval. The assemblages are strongly dominated by migratory species and fish of fresh and brackish water. In contrast, there are very few marine species present (cod, herring and plaice/flounder/dab).

Local influences on Polish fishing

The Polish fish bone assemblages bear very strong evidence of local conditions. In all cases, bones of pikeperch, sturgeon, pike and perch are very common. These species must have been of great importance for the human population. Pike and perch are absent from the material from Leçze, but this assemblage is, however, very small and hardly representative. Even today, pikeperch, pike and perch are very common in the Baltic Sea and in Polish fresh water. Although nowadays very rare, sturgeon was still common in the area in the 19th century. Suslowska and Urbanowicz (1967) and Zbierski (1976) were of the opinion that the large quantity of sturgeon bones in the assemblages is misleading with regard to the importance of this species. They argue that the sturgeon, unlike other fish, is armed with several rows of large bony plates along its body, therefore the probability of preservation in the soil, and subsequent retrieval of the plates is high. On the other hand, the cartilaginous skeleton of sturgeon has a very low probability of preservation. Furthermore, even though the number of individuals may be less than thought at first glance, each individual sturgeon is much bigger than most other fish. All in all, it must be assumed that sturgeon played an important role in prehistoric Poland.

Cyprinids are amply represented at most of the sites, a large number of species being present. This is most pronounced at Wroclaw far inland where 13 species of cyprinids have been found. Among the cyprinids, ziege deserves special mention; it is very common at Polish sites but is not found in the other countries under consideration.

Herring is common off the Baltic coast of Poland. Not surprisingly, bones of clupeids, probably mainly herring, are abundant in the material from the coastal site of Kolobrzeg-Budzistowa. Out of 3418 fish bones, 3235 are from clupeids, and there are only a few bones of freshwater species. Rulewicz (1994) drew attention to the existence of salty springs on Kolobrzeg islands, these would have facilitated the salting of herring at this site. Clupeid bones are less abundant in the material from Gdansk; they are also present at Szczecin, Kedrzyno and Wroclaw. The fact that even greater numbers of clupeid bones were not found, may be due to the recovery technique. This, unfortunately, is not known. If sieving has not been employed, the chances of the small herring bones having been lost are high. Zbierski (1976) suggested that the clupeid bones found in Gdansk are remains of every day consumption in the town, whereas most of the herring caught at the coast were probably exported. Suslowska and Urbanowicz (1967) speculated as to why so few herring bones have been found in Gdansk and suggested that this may be due to a concentration of herring fishing along the coast.

Two of the Polish assemblages are of early Iron Age date, viz., Tolkmicko and Leçze. In spite of

their considerably greater age they do not differ markedly from the younger material, with perhaps the exception that they contain no marine species. Both Iron Age sites are located near the Baltic Coast and the absence of a marine element may be fortuitous (the material from Lecze is quite small).

The Gdansk material includes 17 habitation levels dated to the period AD 980 to 1308. There seems to have been no change through time in the composition of species, except that cod is present only in 13th century layers. Suslowska and Urbanowicz (1967) mentioned, however, that the oldest habitation levels contain larger individuals of fish than the younger ones; they suggest that this may be due to a change in fishing technique. The difference may also reflect taphonomic processes (small bones disappear first), or overfishing may be responsible.

Variation in fishing is reflected by the finds of fishing equipment (see below) but also by the species lists. Rulewicz (1994) and Zbiersky (1976) discussed fishing from early Medieval Gdansk in relation to other towns in Pomorze (Pomerania) on the basis of archaeological and osteological evidence and written sources.

Remains of fishing equipment from Polish sites

Impressively rich finds of early Medieval fishing equipment have been made in the towns of Gdansk, Szczecin, Kolobrzeg-Budsistowa and Kamien-Pomorski (Rulewicz, 1994). The tools include fish-hooks, fish spears, harpoons, lines, needles for net-making, net sinkers, net floaters and many others. Net floaters in particular have been found in astonishing abundance. The tools testify to a varied fishing tradition; net-fishing in particular must have been of great importance.

Indications of fish trade in Poland

Trade with fish is proven beyond doubt by the material from Wroclaw. Although the town lies about 400 km from the sea, 16 herring bones were found. These herring must necessarily have been imported, probably from the Baltic coast. Considering the distance, the herring must have been preserved, probably salted, cf. the salty springs at Kolobrzeg mentioned above. Material from Poznan (12th century AD, 240 km from the sea) and Santok (13th century AD, 160 km from the sea) also contains remains of herring (Daniel Makowiecki pers. comm.).

The second inland assemblage dealt with here, i.e. from Mala, also includes evidence of fish trade. Out of a total of 780 fish bones from the remains of a Teutonic castle, 561 are from cod. The castle was situated on the banks of the River Wisla, so it would have been easy to transport cod from Gdansk to Mala along the Wisla. All the cod bones are from the head region. As the size of the cod, as well as the recovery technique, is not known, it is difficult to determine whether this uneven representation of bone elements is the result of butchering or a function of the recovery technique which did not retrieve the smaller vertebrae. In any case, it is thought-provoking that so many cod bones were found on a Teutonic site. The Teutonians were a Germanic tribe, and in Germany many cod bones have been found at contemporaneus Germanic settlements, whereas cod is largely absent from the Slavonic ones. Apart from Mala, the only other cod bones from Polish sites are ten from Gdansk (from where the cod were presumably exported to Mala) and three from Kolobrzeg-Budzistowa.

Pike is represented exclusively by bones from the head and shoulder girdle in the material from Gdansk, Tolkmicko and Szczecin-Msciecino. It is possible that these bones are the remains of dried pike, cf. the discussion of Swedish finds.

The only find of domesticated carp is from the inland site of Wroclaw.

The Polish material is partly from castles, partly from towns/villages. In the latter group, material from different areas, for example, the Prince's Quarter and the Fishermen's Quarter in Gdansk, can sometimes be distinguished. There is, however, no sign of any "social" difference between these areas, the same species being represented. Trout/salmon, which in the Middle Ages were highly esteemed fish and, according to written sources were more or less reserved for the upper class (Zbierski,1976) are found scattered throughout most of the assemblages. The only find which is distinguishable in this respect is the cod-dominated assemblage from the Teutonic castle in Mala.

GERMANY, INDIVIDUAL SITES

The review of German sites is based entirely on published results.

The site numbers refer to Figure 12 (see Table 7 for detailed species lists).

Drense, Kreis Prenzlau (1)

A Slavonic castle, dated archaeologically and by radiocarbon analysis to the 7th mid-13th centuries AD. The bone material was hand-collected, and as the bones are well-preserved, the small number of fish bones is ascribed to the recovery technique. The castle is situated inland, far from the coast.

Sturgeon and wels (found in the phase from the 11th-13th centuries AD) are regarded as having been imported, the remaining species live in nearby fresh water (Benecke & Prilloff, 1989).

Oldenburg, Starigard (2)

Remains of a castle in the town of Oldenburg, situated on a peninsula between Kieler Bucht and Mecklenburger Bucht. The castle was occupied during at least five Slavonic periods from AD 650 until AD 1150. A late Medieval Germanic occupation followed which lasted until AD 1260. Fish bones were mainly recovered by sieving (Prummel, 1986, 1991, 1993). The material can be assigned to different horizons.

Twenty-three species of fish are represented in this large assemblage, the most important ones being cyprinids, eel and herring. Freshwater fishing is seen as predominating. The species spectrum suggests that the inhabitants went fishing both in the surrounding fresh water and in the Baltic Sea. In general, the fish are represented by bones from all body regions, indicating that entire fish were brought into the castle. This is also true of the herring which have therefore not had their gills removed. It is difficult to determine whether the inhabitants of the castle caught the herring themselves or whether they purchased them. The presence of entire herring, combined with the presence of garfish and mackerel (possibly secondary catches from herring fisheries), is however interpreted as an indication that fishing by the inhabitants themselves is most likely. The five cod bones in the material represent individuals of 0.57-0.78 m in length which might have been caught in the Baltic Sea. There is no evidence of stockfish.

Hitzacker (3)

A Slavonic-Germanic castle situated inland, on the River Elbe. The material can be assigned to three phases; a Slavonic settlement from the 8th-11th centuries AD, a Slavonic-Germanic transition phase from the 11th/12th centuries AD, and a German settlement from the 12th-16th centuries AD.

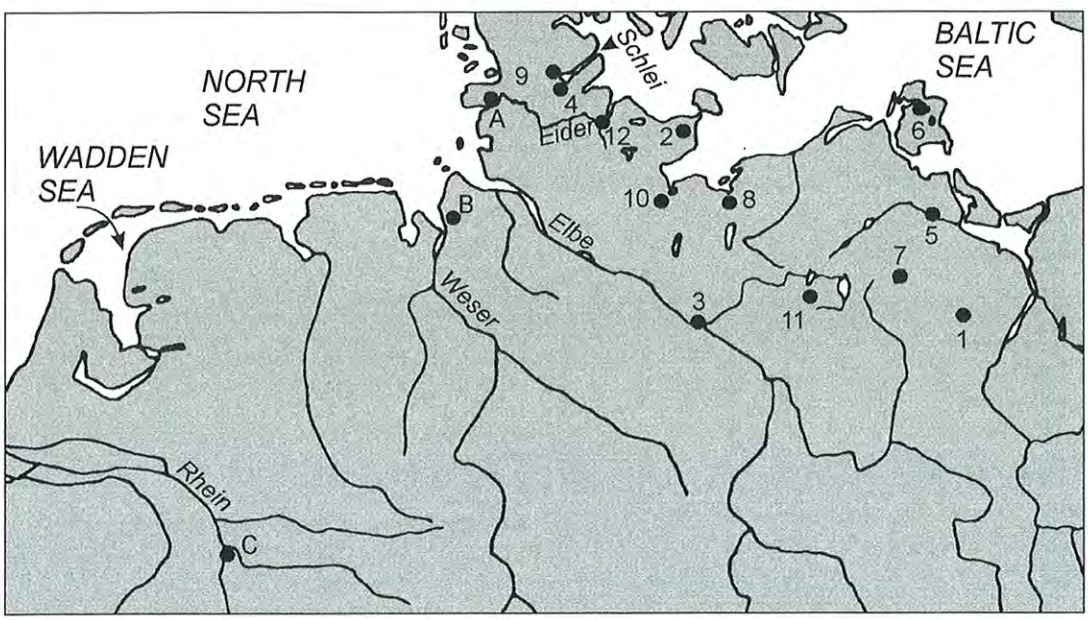

FIGURE 12

Map of northern Germany, showing the location of the reviewed sites. Site numbers refer to the section "Germany, individual sites". The three sites marked with A (Elisenhof), B (Feddersen Wierde) and C (Duisburg) are treated in detail elsewhere (Enghoff, submitted).

Site	Drense	Oldenburg	Hitzacker			Haithabu	Menzlin	Ralswiek	Lieps	Mecklenburg	Schlesv
Site n°	1.	2.	3.			4.	5.	6.	7.	8.	9.
Age (centuries)	7-13	7-13	8-11 AD	11/12 AD	12-16 AD	9-11 AD	9-10 AD	early Med.	10-13 AD	7-13 AD	11-12 A
Recovery technique	h?	h+s	?	?	?	s	h	s	h	h	h
MARINE SPECIES											
Porbeagle	.	.	.	.	.	1	.	.	.	.	.
Smoothhound	.	.	.	.	.	1[6]	.	.	.	.	.
Thornback ray	.	.	.	.	.	.	.	.	.	.	.
Starry skate	.	.	.	.	.	1	.	.	.	.	.
Sailray	.	.	.	.	.	.	.	.	.	.	.
Cartilaginous fishes, unspecified	.	.	.	.	.	.	.	.	.	.	.
Herring	.	1159	.	.	.	5337	6575	10506	3	1	51
Garpike	.	68	.	.	.	190	1	266	.	3	5
Hake	.	.	.	.	.	.	.	.	.	.	.
Gadids, total	.	5	.	5	5	116	.	.	.	.	584
Cod	.	5	.	3	5	109	.	.	.	.	565
Haddock	.	.	.	.	.	.	.	.	.	.	5
Saithe	.	.	.	.	.	2	.	.	.	.	.
Ling	.	.	.	2	.	5	.	.	.	.	9
Gadids, unspecified	.	.	.	.	.	.	.	.	.	.	5
Atlantic horsemackerel	.	17	.	.	.	.	.	.	.	.	.
Atlantic mackerel	.	.	.	.	.	4	.	2	.	.	.
Swordfish	.	1	.	.	.	.	.	.	.	.	.
Eelpout	.	1	.	.	.	.	.	.	.	.	.
Bullrout	.	4	.	.	.	.	.	.	.	.	.
Three-spined stickleback	.	10	.	.	.	.	.	.	.	.	.
Flatfishes, total	.	402	.	3	1	1026	.	2471	.	.	20
Turbot	.	.	.	.	.	.	.	.	.	.	1
Turbot/Brill	.	.	.	.	.	.	.	.	.	.	.
Halibut	.	.	.	.	.	3	.	.	.	.	.
Dab	.	1	.	.	.	.	.	.	.	.	.
Plaice	.	2	.	3	1	.	.	.	.	.	3
Flounder	.	7	.	.	.	.	.	.	.	.	1
Plaice/Flounder/Dab	.	392	.	.	.	1023	.	.	.	.	15
Flatfishes, unspecified			.	.	.	.	.	2471	.	.	.

Site	Drense	Oldenburg	Hitzacker			Haithabu	Menzlin	Ralswiek	Lieps	Mecklenburg	Schlesw
MIGRATORY SPECIES											
Sturgeon	1	2	36	80	98	2	225	50	.	.	3
Shad	.	.	.	.	.	.	.	.	.	.	.
Salmon	.	1	2	6	4	.	.	.	.	.	2
Trout	.	2	.	.	.	.	.	.	.	.	.
Trout/Salmon	.	65	.	.	.	129	.	10	.	.	1
Whitefish	.	. 2	.	.	.	382[7]	.	.	.	.	.
Salmonids, unspecified	.	.	.	.	.	.	.	.	.	.	.
Eel	.	1040	.	.	.	102	13	18	1	1	8
FRESHWATER SPECIES											
Pike	14	476	132	258	287	1535	81	104	42	37	82
Cyprinids, total	18	1044	86	181[4]	169	1458	1183	2933	67	41	119
Common carp	.	.	1	2	3	.	.	.	.	.	.
Crusian carp	.	.	.	.	.	.	.	.	1	4	.
Tench	2	32	6	10	22	6	6	.	10	18	.
Dace	.	.	.	1	1	.	.	.	.	.	.
Chub	.	.	6	7	10	.	.	.	.	.	.
Orfe	.	.	2	4	5	22	.	.	.	.	4
Dace/Chub/Orfe	.	.	2	4	5	.	.	.	.	.	.
Roach	.	106	2	8	6	85	94	.	4[8]	3[9]	4
Rudd	.	1	1	.	5	13	1	.	1	16[11]	.
Common bream	4	81	15	27	20	145	281	.	51[10]	.	52
Zope	.	.	.	1	1	.	.	.	.	.	.
Zährte	.	.	3	1	1	.	.	.	.	.	.
Asp	.	.	1	1	5	.	4	.	.	.	.
Cyprinids, unspecified	12[1]	824[2]	47	115	85	1187	797	2933	.	.	59
Wels	1	.	4	8	14	.	2	.	83	1	.
Burbot	.	.	.	.	2	.	.	.	.	.	.
Perch	2	453[3]	.	18[5]	11	3454	182	2566	31[12]	5[13]	183
Pikeperch	1	.	.	.	1	104	518	86	5[14]	2[15]	6
Ruffe	.	2	.	.	.	.	5	28	.	.	.
Total	37	4754	260	559	592	13842	8785	19040	232	91	1064

T

Numbers of identified fishbones from German sites. Rec

		Lübeck König-straße	Freyen-stein	Kiel	Lübeck Heiligen-Geist Hospital
		10.	11.	12.	10.
16 AD	15-16 AD	12-16 AD	13 AD	13 AD	13-20 AD
h	h	h	h	s	h
.	.	.	.	.	.
.	.	.	.	.	.
.	1	.	.	.	.
.	2?	.	.	.	.
.	2?	.	.	.	.
.	.	.	.	.	.
23	134	.	25	17	.
20	.	.	.	.	.
1	.	.	.	.	.
325	206	20	16	10	100
324	10	20	16	.	100
85	193	.	.	.	.
7	.	.	.	.	.
6	3	.	.	.	.
3	.	.	.	10	.
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
13	6	3	.	30	.
7	.	.	.	4	.
.	.	.	.	.	.
.	.	.	.	.	.
1	.	.	.	.	.
25	.	.	.	.	.
4	.	3	.	.	.
76	6	.	.	26	.
.	.	.	.	.	.
		Lübeck Königstr.	Freyen-stein	Kiel	Lübeck Heiligen-Geist Hospital
18	.	1	.	.	.
.	.	.	.	.	.
1	.	.	.	.	.
6	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
1	4	.	.	14	.
57	.	3	11[16]	.	.
360	2	4	8	17	.
.	.	3	.	.	.
.	.	.	.	.	.
26	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
2	.	.	.	.	.
.	.	.	.	.	.
9	.	.	.	1	.
1	.	.	.	.	.
19	.	.	7	.	.
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
03	2	.	1[17]	16[18]	.
.	.	.	.	.	.
.	.	.	.	.	.
154	83	.	2[19]	26[20]	.
.	.	.	.	.	.
.	.	.	.	.	.
679	440	31	62	114	100

[1] excluding 150 scales.
[2] excluding 3354 scales.
[3] excluding 80 scales.
[4] excluding 30 scales.
[5] excluding 1 scale.
[6] orig. ref.: spurdog, revised by IBE.
[7] excluding 1400 scales.
[8] excluding 20 scales.
[9] excluding a few scales.
[10] excluding 1950 scales.
[11] excluding 1300 scales.
[12] excluding 140 scales.
[13] excluding a few scales.
[14] excluding 15 scales.
[15] excluding a few scales.
[16] excluding scales.
[17] excluding scales.
[18] excluding scales.
[19] excluding scales.
[20] excluding scales.

echnique: h = hand-collected, s = sieved, ? = unknown.

The recovery technique was not recorded (von den Driesch, 1982). The location of the castle was optimal for freshwater fishing in the Rivers Elbe and Jeetzel as well as in nearby marsh areas. Accordingly, most fish bones derive from freshwater fish: about half of the identified fish bones are from pike, and about a third from cyprinids. The numerous bones of sturgeon are noteworthy; sturgeon have been caught in the Elbe even in historic times (von den Driesch, 1982). Of particular interest are bones of common carp found in layers dated as early as the 9th-10th centuries AD. These represent the oldest find of common carp from the Elbe area. Marine fish do not appear until the 11th/12th century material and they were probably imported to the castle dried and salted. Von den Drisch (1982) concluded that fish were not of major importance for the inhabitants of the castle.

Haithabu (4)

A famous trading center located on the southern shore of the inner Schlei estuary, close by the main road leading to Jylland, Denmark. Also known under the Danish name of Hedeby. Through the brackish Schlei there was easy access from Haithabu to the Baltic Sea, where a somewhat higher salinity prevailed. To the west, access to the North Sea was relatively easy down the River Treene. Haithabu's location was thus very central and, at the same time, ideal for fishing.

The fish bone material dates from the 9th-11th centuries AD and was mostly recovered by wet-sieving (mesh size unknown). Lepiksaar and Heinrich (1977) provided an extremely thorough analysis of the material. The highly diverse assemblage includes 26 species of fish. Herring is on the whole the most frequent species, constituting 38.6% of the bones. It is followed by perch (24.9%) and pike (11.1%). The vertical distribution of the bones shows that marine species, especially herring, are more frequent in older layers. Size estimates of the herring do not exclude the possibility that they could have been caught in the Schlei. Lepiksaar and Heinrich emphasized that the oldest known "herring period" around AD 1000 is contemporaneous with Haithabu. The herring bones are very well-preserved and the entire herring skeleton is represented. This means that entire herring were brought to Haithabu.

Local fishing at Haithabu is demonstrated, not only by the herring but also by the presence of such species as, for example, perch, roach, common bream and whitefish which are all common in the Schlei. Halibut, saithe and ling, on the other hand, could not have been caught in nearby waters and are thought to have been travellers' provision brought to Haithabu by strangers. Cod was not of major importance and the relatively few cod bones in the material may also derive from travellers' provision. The presence of garfish provides evidence for fishing during the summer half of the year.

Menzlin (5)

A center for crafts and trade located on the bank of the River Peene 40-50 km from the Baltic coast. The fish bone material dates from the 9th-10th centuries AD and was hand-collected (Benecke, 1987).

The varied material is strongly dominated by herring: 75% of the bones. Most of the herring bones were found in the form of a concentration inside one of the prehistoric houses. Benecke (1987) thought that the bones represent severed herring heads. These herring were probably caught in the Baltic Sea around the island of Rügen, and were presumably salted before being transported to Menzlin. Since the size spectrum of the herring is limited (0.22-0.32 m) Benecke suggested that some sorting took place.

Cyprinids are second to herring in frequency; a considerable number of sturgeon bones are also worth noting.

Ralswiek (6)

A Slavonic trading centre on the island of Rügen, located on a brackish inlet opening into the Baltic Sea. Benecke (Benecke, 1983) analyzed fish bones from Ralswiek, but as I have been unable to consult this thesis, I have obtained information about Ralswiek from Benecke (1982) and Prummel (1986). The material is dated to the early Middle Ages (more precise dating was unavailable) and was recovered by sieving.

More than half of the fish bones derive from herring, but cyprinids, perch and flatfish were also of major importance.

Lieps (7)

Five Slavonic settlements on islands in the southern part of the lake Tollensesee. The bones were hand-collected. They are dated to the early Middle Ages (10th - 13th centuries AD) and repre-

sent 11 species (Benecke, 1984b). There is only one marine species, viz., herring. Since these settlements are far from the sea the herring bones must derive from imported, probably salted herring. Common bream appears to have been the most important freshwater species. The material also includes many bones of wels but Benecke (1984b) interpreted the relative dominance of these large bones as a function of the recovery technique.

Mecklenburg (8)

A major Obodrith (Slavonian) castle in Kreis Wismar, about 7 km from the Baltic coast (Wismarer Bucht). The small assemblage dates from the 7th to13th centuries AD and was hand-collected. Most of the bones represent freshwater species. Pike, tench and common bream seem to have been most important, but the material is really too small to be regarded as representative. There is one bone of herring and three of garfish, tentatively suggesting fishing in the Baltic Sea (herring fishing with garfish as a secondary catch?). All the species might have been caught in nearby waters (Benecke, 1984a).

Schleswig (9)

A town on the northern shores of the Schlei estuary, i.e. the same optimal location as Haithabu which it gradually replaced. The fish bone material derives from the 11th to mid-14th centuries. Heinrich (1987) divided the material into two phases, an early phase (11th-12th centuries) and a late phase (13th-14th centuries). In addition, a minor amount of material was collected from a cesspit dating from the 15th/16th centuries. The fish bones were hand-collected and were analyzed in great detail by Heinrich (1987).

The 11th-14th century material is in general dominated by gadids, followed by perch, cyprinids and pike. Sturgeon is also present. Since the material was hand-collected, one must bear in mind that small fish could have been much more frequent than suggested by the analysis. This might for instance be true of herring, cf. the importance of herring at Haithabu where fish bones were recovered by sieving.

Gadids are most frequent during the early phase, whereas the importance of freshwater fish, primarily perch, is greater during the late phase. Neither do haddock, saithe, ling or cod as large as those found (0.80-1.50 m) occur in the Schlei or in the western Baltic Sea. Heinrich (1987) therefore regarded the gadids as having been imported to Schleswig from the North Sea or from even more distant places.

Cod from the late phase had an estimated length of 0.46-0.85 m based on the dentary and cleithrum (bones from head and shoulder, respectively) and 0.70-1.30 m based on vertebrae. Since only the smaller cod (0.46-0.85 m) are represented by head and shoulder girdle bones they may represent local fishing in the western Baltic, whereas the larger cod, represented mainly by bones from the trunk, may have been imported as in a dried, salted and headless state (Heinrich, 1987).

Haddock was much more important during the late than during the early phase.

The pike remains show an interesting dominance of bones from the head and shoulder girdle (only five vertebrae out of 239 pike bones). This discrepancy may be due to the recovery technique, or the pike bones may represent refuse from processing, or from dried fish (cf. discussion of pike from certain Swedish and Polish sites).

The herring seem to have been brought to Schleswig in an entire state.

Most of the fish bones in the refuse from the 15th/16th century cesspit are from gadids, almost exclusively haddock. It thus appears as if the increase in importance of haddock from the early to the late phase was maintained. The representation of haddock bone elements supports the idea that this fish was imported in a processed condition. The cesspit contains, furthermore, a large number of herring bones and an unusual element of cartilaginous fish.

Lübeck (10)

A town on the River Trave which flows into the Baltic Sea. Lübeck succeded Schleswig as the most important trading centre in the western Baltic. Medieval Lübeck has provided two fish bone assemblages.

A minor amount of material was hand-collected during excavations in Königstrasse 59-63. It was dated on the basis of ceramics to the 12th-16th centuries AD. This material is dominated by cod, but a single find of sturgeon is also of note (Paul, 1980).

Another small amount of material was hand-collected at the site Heiligen-Geist Hospital and was dated on the basis of ceramics to the 13th-20th centuries AD. This material consists of 100 cod bones (Pudek, 1980).

Freyenstein (11)

The site is situated far from both the Baltic and the North Sea. Sixty-two fish bones dated to the 13th century AD were hand-collected and cannot be regarded as representative (Benecke, 1989). It is, however, interesting that both herring and cod are represented. These species must have been imported to Freyenstein, and considering the distance to the coast they were probably in a preserved a state.

Kiel (12)

Fish bones dated to the 13th century AD were recovered from Medieval Kiel on the Baltic coast. They were recovered as a secondary find during sieving for plant remains through 0.3 mm, 0.5 mm, 1.0 mm and 2.0 mm meshes. Due to these special circumstances the sample sizes are small, and so are the individual fish remains. The bones represent freshwater, migratory and marine species which may all have been caught in nearby waters (Heinrich *et al.*, 1993/1994).

GERMANY, OVERVIEW

The German material covers the period from the 7th to the 16th centuries AD; one of the sites even extends up into the 20th century. Three sites located on the German North Sea coast or in the North Sea hinterland (Feddersen Wierde, Elisenhof and Duisburg) will be treated in detail by Enghoff (in press) but are included in the present discussion where relevant.

Local influences on Baltic fishing in Germany

As already emphasized by Benecke (1982), herring has been heavily exploited in the Baltic part of Germany for a very long time. Herring bones have been found in Schleswig, Haithabu, Kiel, Oldenburg, Mecklenburg, Menzlin, Freyenstein, Lieps and Ralswiek. Some of these sites are situated on the Baltic coast, but others are inland sites far from the sea.

The large quantities of herring remains from Haithabu deserve particular mention. Based on size estimations, Lepiksaar and Heinrich (1977) interpreted this find as representing herring caught in the Schlei estuary. The entire herring skeleton is represented, which means that removal of gills did not form part of any processing method used. Fish weir complexes ("Heringszäune") are known to have been placed in the Schlei during the late Middle Ages. These are fish traps built from stakes and wickerwork and equipped with two converging weirs with a catching net in the angle where they meet. Radtke (1977) assumed that traps such as these might also have been used earlier, i.e. in Haithabu. Special mention should also be made of the finds from Menzlin, where remains of severed herring heads were found (Benecke, 1987), and Ralswiek, where herring seem to have been landed together with a secondary catch of garfish and mackerel (Benecke, 1982).

Perch is another species which has played a major role at sites on the southern Baltic coast. In the assemblages from Kiel, Schleswig and Haithabu, perch is the most or second most frequent species. Perch occurs in both fresh and brackish water and is very common along the coasts of the Baltic Sea (Muus & Dahlstrøm, 1967). Benecke (1987) further discussed the role of perch in material from Baltic Germany.

Local fishing is extremely well documented in the very large amount of material from Haithabu, not only by remains of herring and perch, but also by species like roach, common bream and whitefish which can all be caught in the Schlei. Whitefish bones are known to preserve poorly in the soil, the 382 whitefish bones found at Haithabu represent, therefore, an unusually large sample.

Naturally enough, cyprinids and pike are generally frequent both at sites on the Baltic coast and those further inland. Heinrich (1987) discussed finds of pike from northern German sites, where there seem to be great differences in the representation of the different bone elements. It is, however, difficult to determine whether this is due to differences in recovery technique, or to processing of the fish.

The site of Oldenburg is distinguished by a particularly large number of eel bones. Prummel (1986, 1991, 1993) saw the dominance of eel as being a result of the site's location near eel-rich waters suitable for trapping.

In conclusion, the sites on the Baltic Sea and in the Baltic hinterlands are mostly characterized by fresh and brackish water species caught partly in the Baltic itself, partly in its inlets, bays and estuaries, and partly in rivers and lakes.

Remains of fishing equipment from German sites

One gorge, 4-6 iron barbs from fish spears, and possibly a huge iron hook were found at the site of Oldenburg.

The weir complexes ("Heringszäune") in the Schlei have also been referred to above, under the discussion of Haithabu.

Four fragments of fish spears, thought to have been used for fishing for pikeperch and perch (Benecke, 1987), were found at Menzlin.

Indications of fish trade in Germany

There is evidence of trade in many of the German fish bone samples.

The settlements on the Baltic Sea are characterized by finds of herring bones, often in great quantity. Furthermore, herring were obviously imported to inland sites in the Baltic hinterland, for example, Menzlin, Lieps and Freyenstein. The latter lies more than 100 km from the nearest coast. Transport over such a long distance has required preservation of the fish, probably by salting. Lepiksaar and Heinrich (1977) believed that salting is the explanation for the fine preservation of herring bones seen at Haithabu. Benecke (1987) suggested that the herring found in Menzlin were sorted before being transported inland, since only certain sizes of herring are represented. All in all, extensive trade with salted herring seems to have taken place. Processing of the herring in the form of gill removal, as seen in the Danish material from Selsø-Vestby (12^{th}-13^{th} centuries AD) has, however, not been documented in Germany.

Even though the sites on the Baltic are strongly dominated by local fishing they also contain a supplement of marine species, in particular gadids. The species in question are ling, saithe, haddock and large cod; these could not have been caught in the Baltic, but must have been imported from the North Sea. A chronological development in this trade with gadids can be traced, for example in the consecutive materials from Haithabu, Schleswig and Lübeck (Heinrich, 1983, 1987). In Haithabu local fishing in the Schlei dominated, and gadids were of no importance: the few gadid bones may well be remains of provisions brought to the town by travellers (Lepiksaar & Heinrich, 1977). In the Schleswig material, by contrast, bones of large gadids dominate[1]; these could not have been caught locally and must represent imported stockfish. The large gadids were most important in Schleswig during the oldest phase (11^{th}-12^{th} centuries AD). This was followed by a younger phase (13^{th}-14^{th} centuries AD) where the frequency of gadid bones decreases somewhat, whereas that of freshwater fish increases. The gadids from the younger phase included both large and small individuals, unlike those from the older phase. This gives the impression that long-distance trade had decreased while local fishing and trade flourished (Heinrich, 1987). The two, slightly younger assemblages from Lübeck are dominated by large cod bones, presumably coming from imported fish. The frequency of the different gadid species also varies with time. Haddock thus seems to gain in importance from older to younger samples. No haddock bones were found in Haithabu, in the older phase of Schleswig (11^{th}-12^{th} centuries AD) there are several, in the following phase (13^{th}-14^{th} centuries AD) still more, and in the cesspit from 15^{th}-16^{th} centuries AD (admittedly a small and very special sample) almost all gadid bones are from haddock. This increase in haddock through the Middle Ages seems to be a general phenomenon in Germany (Heinrich, 1986, 1992, 1994).

Gadid remains are absent from a number of the analyzed sites, including Mecklenburg, Lieps, Ralswiek and Drense, most of which are Slavonic. Heinrich (1986, 1987) noted this lack of gadids from Slavonic sites. This is illustrated, for example, by the material from the castle Hitzacker on the river Elbe, far inland (von den Driesch, 1982). This can be divided into a Slavonic, a transitory Slavonic/Germanic and a Germanic phase. Gadids are absent in the Slavonic phase, in the transitory material there are three gadid bones, and in the German phase, five.

Bones of sturgeon are present at nearly all sites included in the present analysis, and in most cases, sturgeon may have been caught locally. Drense is an exception, and Benecke and Prilloff (1989) thought that sturgeon was imported to this site. Heinrich (1987) and Benecke (1986) discussed the importance of sturgeon at a number of Medieval sites on the southern Baltic Sea. Benecke showed that fishing for sturgeon decreased in the course of the Middle Ages and hypothesized that the decline was due to overfishing.

[1] It must be remembered, however, that small species like herring may be underrepresented in the Schleswig material as the material was not recovered by sieving.

REGIONAL OVERVIEW

In the preceding sections, archaeo-osteological evidence for fishing in the Baltic region in the period from the 5th century BC to the 16th century AD has been reviewed on a national basis. This compilation of a considerable amount of evidence from a number of sources has revealed some regional trends concerning the influence of local conditions on fishing.

When individual sites are referred to below outside a national context, the country in question is indicated with the same letter codes as those used in Table 1.

Local fishing for local fish

Virtually all the fish bone assemblages included in the present review contain species which could have occurred in local waters, suggesting that fishing was conducted locally. This general interpretation is supported by a number of more specific examples of local influence.

For some species, their occurrence in the subfossil material reflects their present-day distribution, and in some cases with an amazing degree of accuracy. This is for instance the case with pikeperch, a freshwater species with an eastern distribution in Europe which has been found in subfossil material from Sweden, Estonia, Poland and Germany, just the countries (among those considered here) where it occurs naturally today. In Sweden where pikeperch is now very locally distributed (Curry-Lindahl, 1985) there is virtually perfect correlation between the present-day distribution and the subfossil finds.

An other freshwater fish with a limited distribution in Europe, reflected in the subfossil finds and which has been found in Swedish, Polish and German material is asp. Ziege occurs - within the region under consideration - in Poland, Lithuania, Latvia and Estonia; in the subfossil material it is abundantly represented in Poland and nowhere else. Zährte is a further example of a species with a limited distribution, i.e. the countries around the Baltic Sea plus western Germany. It has been found in Estonian, Polish and German assemblages.

Turning to the marine species, the subfossil occurrences of herring show some very clear tendencies. Herring bones occur abundantly in assemblages from eastern Denmark and further along the Danish and Swedish Øresund coasts, as well as in material from the countries on the Baltic Sea. Herring abundance is known to oscillate dramatically. At certain intervals, so-called herring periods occur during which the availability of herring is immense. These herring periods have significantly influenced the course of European history and are well documented in historic manuscripts. The oldest known herring period was around AD 1000, i.e. contemporaneous with Haithabu (D) where huge numbers of herring bones have accordingly been found (Lepiksaar & Heinrich, 1977). The extremely rich Medieval occurrence of herring in Øresund (ca. AD 1150-1550) between modern Denmark and Sweden is particularly famous (Jensen & Olsen, 1991). The autumn passage of herring through Øresund into the spawning grounds in the Baltic Sea gave opportunities for herring fishing of incredible dimensions. The abundance of herring is reflected in the material from Danish and Swedish Medieval sites but also in contemporaneous material from sites on the Baltic coast where the extra input of herring from Øresund supplemented the local breeding stocks.

As a last detail it should be noted that material from Poland and Estonia contains very few marine species: only herring, cod and flounder. All three species live in the Baltic Sea and the latter two are known to tolerate brackish conditions, with flounder even being found in fresh water.

Fishing methods

The finds of a rich selection of fish species, especially at coastal sites, indicate that many different fishing methods have been used. The most important methods seem to have been net fishing, hook-and-line fishing and the use of fishweirs. Further equipment, such as fish traps and leisters, were probably used on a smaller scale.

NET FISHING

The very extensive catches of herring seen in several countries must have been secured by an efficient method such as net fishing.

In eastern Denmark, large herring catches such as these appear as early as the Iron Age (Sorte Muld, 6th-7th centuries AD). This is in stark contrast to older Danish finds which have yielded only a few herring bones in spite of extensive sieving. Consistent with the large herring assemblages we have sev-

eral finds of net sinkers from Denmark, for example from Nørre Fjand (2nd century BC - 2nd century AD) and Ribe (8th-9th centuries AD) (Enghoff, submitted). There are also finds of net floats, for example from Køge (13th-14th centuries AD) and Århus Søndervold (14th century AD). Even a tool for net-making has been found at Medieval Tårnby.

It is characteristic of the large finds of herring bones from the Danish island of Bornholm (Møllebjerg, Munkerup, Kobbegård, all 11th century AD) that they are accompanied by bones of small cod. A similar combination is seen at several Swedish sites from the same general area (Øresund and western Baltic Sea): Ven, Helsingborg, and Simrishamn (all 12th-13th centuries AD). The small cod were presumably a secondary catch when fishing for herring with nets. This contrasts with older (Mesolithic) finds of cod from Bornholm where the individuals were relatively large and were interpreted as having been caught with hook and line (Enghoff, 1994a).

Benecke (1982) thinks that the advance of the herring fishing in the Baltic Sea is due to advances in fishing technique. The herring remains from early Medieval Ralswiek (D) are accompanied by bones of Atlantic mackerel and garfish. The same picture is seen at another German site, viz., Oldenburg (7th-13th centuries AD) where Prummel (1993) interpreted the presence of this secondary catch as indicating local herring fishing.

Herring fishing with nets from Poland is strongly suggested by finds of numerous net floats, pieces of nets and net-making tools in Gdansk (10th-13th centuries AD) (Rulewicz, 1994).

Fishing nets were of course used for catching many species other than herring. Atlantic mackerel, garfish and small cod have already been mentioned. In the Limfjord region, Denmark, we see a change from fishing predominantly after eels in the Stone Age to fishing predominantly after flounder in the Iron Age onwards. This probably reflects a change from traps for eels to ground nets for flounder. The large finds of plaice/flounder/dab at Ribe (DK) may also be a result of net fishing (net sinkers have been found in Ribe) (Enghoff, submitted).

HOOK-AND-LINE FISHING

Large individuals of gadids (cod, haddock, ling) and/or hake are known from most of the countries. These fish mainly occur in not-too-shallow waters where they roam close to the sea-bottom and would have been most efficiently caught using hooks attached to long lines.

In Denmark the gadids represented in the finds became larger during the course of the Viking Age and Middle Ages, and species other than cod appeared, viz., haddock, ling and hake. Both tendencies indicate fishing at greater depths, probably using hooks. Hook fishing is most efficiently conducted using long lines to which several hooks are attached. Except on very steep coasts, the lines must be laid out from a fishing boat. Starting with the Iron Age, boats were available which would have made it possible to sail to the places where the large fish live - this is neatly reflected in the fish bone assemblages. Finds of fish-hooks at Århus Søndervold (10th-12th centuries AD) and Holbæk (13th-15th centuries AD) support this interpretation.

Several assemblages from the Swedish west coast include large gadids, for instance Varla (11th-13th centuries AD) and Gamla Lödöse (12th-15th centuries AD) where large ling and hake were probably caught using hook and line. The Swedish west coast is rocky in this region and it is probably no coincidence that fishing for large gadids, including ling, took place already during the Stone Age from the settlement Bua Västergård in the same general area (Lepiksaar, 1983). Further south on the Swedish west coast there are the remains of large cod in the material from Lund; these were probably caught on hooks.

Lie (1988) found evidence in the material from Oslo (Mindets Tomt), Norway, that large cod and ling were probably imported during the 11th-12th centuries AD but that a shift in preference took place in favour of locally caught large ling in the 12th-14th centuries AD.

Fish-hooks were probably also used for catching other species than gadids, such as sharks which were caught from several sites, for example, Smedegård (DK, 4th century BC - 2nd century AD) and Oslo (N, 11th-14th centuries AD).

FISHING WITH WEIRS

A weir is a kind of barrier that leads the fish to a spot where they can easily be caught and taken out of the water. Very large catches may be obtained using weirs, which would typically be placed in running water such as rivers, estuaries, or on tidal coasts.

The important herring fishery in the Schlei estuary at Haithabu (D, 9th-11th centuries AD) possibly involved the use of weirs, because these are known to have existed at the site in somewhat later periods (Radtke, 1977).

OTHER METHODS

Stationary fish traps were regarded by Enghoff (1994a) as the most important means of fishing in the Danish Mesolithic. Traps were probably still used in the period discussed here but on a smaller scale than net and hook fishing. They would still have been useful, for example for eel fishing. The relatively large numbers of eel bones found at Oldenburg (D, 7th-13th centuries AD) are thus interpreted as resulting from trapping (Prummel, 1993). Leister prongs have been found at sites in several countries. At Sebbersund (DK, 10th century AD) for instance where they were probably used to impale flounder. Benecke (1987) supposed that leister prongs found at Menzlin (D, 9th-10th centuries AD) were used for catching pikeperch and perch.

CONCLUDING REMARKS

The fish bone assemblages reviewed here indicate a chronological development in Baltic fishing. Despite this, the fishing retained a strong local character. For this reason, the fish bone assemblages provide an insight into the former distribution of species which nowadays have a restricted geographical distribution. The fish bone assemblages also provide clues to fish trade; this aspect will be discussed in greater detail in a forthcoming paper (Enghoff, submitted).

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APPENDIX

This review is based on literature known to the author as per october 1996. Since then, a few additional papers have come to attention which are of relevance for the subject matter.

Nicholson (1998) reported on fish bones in primarily latrine deposits from Viborg Søndersø, Denmark, 11th to 14th centuries AD. Viborg Søndersø is situated ca. midway between sites n°s 10 and 23 on Figure 2. A total of 320 fish bones ere identified. Eel, herring and perch were the most numerous species in the samples.

Vretemark (1997) discussed fish and other animal bone material from Medieval Sweden, with particular emphasis on Skara. Many of the assemblages treated by Vretemark are also covered by the present review.

NICHOLSON, R. A. 1998: Fiskerester i humane fækalier. In: Hjermind, J.; Iversen, M. & Kristensen, H. K. (eds.): Viborg Søndersø 1000-1300. Byarkæologiske undersøgelser 1981 og 1984-1985. *Jysk Arkæologisk Selskabs Skrifter* 34: 325-327.

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Human Impact on the Habitat of Large Herbivores in Eastern Switzerland and Southwest Germany in the Neolithic

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ABSTRACT: The Neolithic lake shore settlements in Switzerland and Southern Germany offer excellent conditions for the preservation of various organic matter. Based on dendrochronological dating the economic and ecological changes in the Alpine foreland may be traced within a precise chronological framework. Using typological and radiocarbon data this chronological framework could be extended to the adjacent settlement areas with terrestrial sites providing additional archaeobiological evidence.

The archaeobiological analysis shows that during the Neolithic occupation of the lake shores (4300-2500 BC), the originally dense forest was gradually opened up by the exploitation by people, at least in the wider area around the settlements, and a more open mixed deciduous woodland increasingly developed. Consequently, the anthropogenic influence in the immediate and more distant areas around the settlements ought to have had a positive effect on the living conditions of large herbivores.

Despite this, the bones of wild cattle (*Bos primigenius*, *Bison bonasus*) and elk (*Alces alces*) are clearly found less regularly and in lower frequencies after 3300 BC than between 4300 and 3500 BC. Besides the settlers' great need for wood, the fodder demands for their stock also had a great impact on the environment. The on site-botanical investigations point to an intensive use of all the natural areas of grassland, as well as the herb-rich undergrowth of deciduous and wet woodlands, as pastoral land for cattle. But these were exactly the sort of locations that would have been the preferred pastures of wild cattle. This food competition certainly intensified by the increasing importance of cattle keeping together with hunting resulted in decreasing population densities of large wild herbivores within the Neolithic and the following periods.

Red deer obviously adapted to the changing ecological situation and remained the most important hunted species throughout the Neolithic period. The intensification in red deer hunting during the second half of the 37th century BC eventually led to the killing of increasing proportions of not yet fully grown deer. During a longer-lasting period of more intensive hunting (>80 years) this could have become a danger for the red deer population. In extreme cases we could be looking at the total extinction of local red deer populations. Technologically and culturally this had far-reaching consequences, since a heavily used raw material (antler) would then no longer be available. Evidence for such a decline in raw material has been found in a few settlements known today from the 35th to 33rd centuries BC (early Horgen culture) in the eastern part of Switzerland.

Between 4000 BC and 3500 BC substantial amounts of horse remains occur in the Neolithic bone assemblages from the Alpine foreland and the adjacent areas in the north. These bone finds are considered to represent small wild populations living in natural areas of grassland (e.g. flood-plains and bogs). According to the available biometric evidence the two contemporary populations have similar body proportions, but the northern one is caracterized by a slightly higher body mass. This difference may reflect the Early and Middle Neolithic human impact probably improving the living conditions of the wild horses in this area.

KEYWORDS: NEOLITHIC, SWITZERLAND, GERMANY, HUMAN IMPACT, LARGE HERBIVORES

RESUMEN: Los yacimientos lacustres neolíticos de Suiza y Alemania meridional exhiben excelentes condiciones de conservación de las diferentes materias orgánicas. Basándonos en dataciones dendrocronológicas, los cambios económicos y ecológicos en las tierras prealpinas

pueden rastrearse dentro de un marco cronológico preciso. Con el uso de dataciones tipológicas y radiocarbónicas, tal marco cronológico podría ampliarse a las áreas de asentamiento adyacentes con yacimientos terrestres que proporcionan evidencia arqueobiológica adicional.

El análisis arqueobiológico evidencia que, durante la ocupación neolítica (4300-2500 a.C.) de las márgenes lacustres, el originalmente denso bosque se clareó gradualmente como consecuencia de su explotación por parte del hombre, cuando menos en zonas amplias alrededor de los asentamientos, de tal suerte que se fue desarrollando un bosque deciduo mixto más abierto. En consecuencia la influencia antrópica sobre las áreas más inmediatas y distantes alrededor de los asentamientos hubo de haber influido de manera positiva en las condiciones vitales de los grandes herbívoros.

A pesar de esto, los huesos de grandes bóvidos (*Bos primigenius, Bison bonasus*) y el alce (*Alces alces*) se encuentran de modo menos regular y en frecuencias más bajas después del 3300 a.C. que entre el 4300 y el 3500 a.C. Además de las grandes necesidades de madera por parte del hombre, los requisitos de pasto de sus ganados tuvieron también gran impacto sobre el ambiente. Las investigaciones botánicas locales evidencian un uso intenso de todas las zonas de praderas naturales así como del sotobosque rico en herbáceas de los bosques deciduos y húmedos como tierras de pasto para el vacuno. Eran éstas precisamente las zonas de pasto preferente de los grandes rumiantes silvestres. Esta competencia por el pasto ciertamente se intensificó como consecuencia de la creciente importancia del vacuno doméstico simultaneado con la caza lo cual resultó en decrecientes densidades de población de los grandes herbívoros silvestres a lo largo del Neolítico y periodos posteriores.

El ciervo se adaptó a las cambiantes condiciones ecológicas y permaneció como la especie cinegética más relevante a lo largo de todo el Neolítico. La intensificación de la caza del venado a lo largo de la segunda mitad del siglo XXXVII a.C. eventualmente condujo a la caza de cada vez mayores proporciones de ciervos subadultos. De haberse mantenido un periodo más dilatado (> de 80 años) de esta caza tan intensiva se podría haber llegado a un colapso de las poblaciones de ciervos. En casos extremos estaríamos incluso atestiguando la extinción completa de poblaciones locales de ciervo. Tecnológica y culturalmente, este hecho tendría enormes consecuencias en la medida en que una de las materias primas de mayor utilización (el asta) no estaría ya disponible. La evidencia del declinar del asta se ha detectado en unos pocos yacimientos de la cultura Horgen inicial (siglos XXXV-XXXIII a.C.) en la zona oriental de Suiza.

Entre el 4000-3500 a.C. aparecen cantidades sustanciales de restos de caballo en las asociaciones óseas neolíticas de las tierras prealpinas y de áreas adyacentes hacia el norte. Se considera que estos hallazgos representan pequeñas poblaciones silvestres que subsisten en zonas de pradera natural (por ejemplo, llanuras aluviales y pantanosas). De acuerdo con los datos biométricos disponibles las dos poblaciones contemporáneas presentan similares proporciones corporales, si bien la septentrional viene caracterizada por una masa corporal ligeramente superior. Esta diferencia podría reflejar el impacto humano durante el Neolítico inicial y medio que habría mejorado las condiciones de subsistencia de los caballos silvestres en toda esta área.

PALABRAS CLAVE: NEOLÍTICO, SUIZA, ALEMANIA, IMPACTO HUMANO, MEGA-HERBÍVOROS

INTRODUCTION

The Neolithic settlements of the Northern Alpine Foreland provide outstanding archaeological preconditions for the study of the economic and ecological significance of individual domestic and wild animal species. For one thing, the density of Neolithic lakeside settlements is extraordinarily high. During the last 25 years, in conjunction with the construction of the motorway and urban building activities, partly continuous areas of the shores of the Alpine Foreland lakes could be intensively investigated archaeologically. In addition, the excellent preservational conditions have provided a very comprehensive insight into the living conditions of the various settlers. Because the cultural layers were located below the ground water level, the remains of the lakeside settlements have produced extremely well preserved organic find assemblages. As a general rule, both the animal bones and the plant remains, mostly in uncarbonized state, have remained well preserved over the millennia. Besides food remains such as seeds and fruits, the numerous wooden construction ele-

ments of the houses that have been recovered are of particular value. With the help of dendrochronology the settlements can be dated with relative accuracy.

In combination with typological comparisons and ^{14}C data this chronological framework could be extended to the settlement areas bordering the region to the north. This provides an indispensable prerequisite for the supra-regional comparison of archaeobiological results (Table 1 and Figure 1).

THE ECOLOGICAL BACKGROUND

Pollen-analytical investigations in off-site situations indicate that throughout the entire research period the Northern Alpine Foreland was heavily wooded, based on the very low amount of non-arboreal pollen recorded (Richoz & Haas, 1995; Rösch, 1990; Liese-Kleiber, 1995). If however, we look at the results of botanical analyses of macrofossils from all settlement levels (on-site), a more complex picture emerges (Jacomet *et al.*, 1989; Brombacher & Jacomet, 1997; Rösch, 1990; Maier, 1990; Maier, 1995). During the "*Jungneolithikum*" time period (4300–3400 BC) there is only evidence for small, naturally open areas and small arable fields. Towards the end of the Lake Shore Neolithic in particular, the indicators of open locations increase significantly.

In the "Jungneolithikum" (4300–3400 BC) the seeds and fruits of plants which grow in woods and in woodland edge communities, or in clearings (coppiced areas) (such as *Moehringia trinervia*, *Ajuga reptans*, *Clinopodium vulgare*, *Agrimonia eupatoria*) regularly appear in cereal stores. They make it clear that the arable fields were small and surrounded by woodland; but as annual species were also present, we can assume that these areas were permanently open. In the later period of the Lake Shore Neolithic, between 3400 and 2500 BC, the plants named above appear more infrequently, and instead many more (mainly winter) annual weeds (such as *Lathyrus* and *Vicia* species) can be

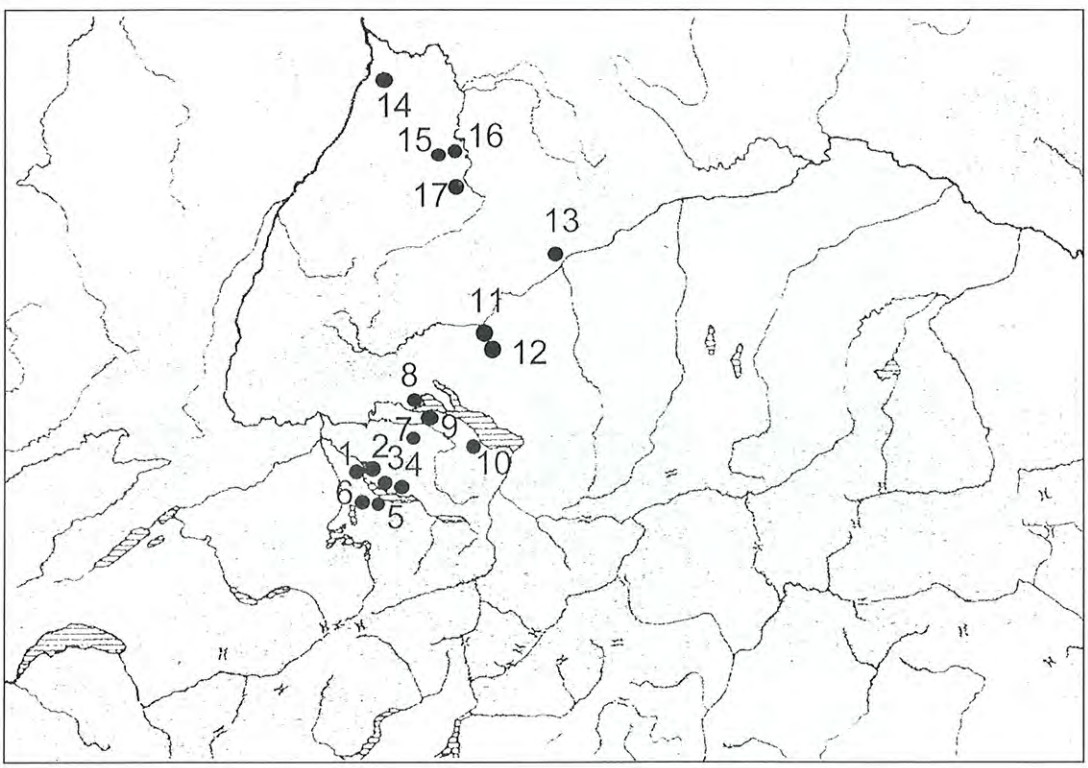

FIGURE 1
Location of the Neolithic sites in Eastern Switzerland and Southwest Germany.

Time BCcal	Nr.	Eastern Switzerland		Nr.	Southwestern Germany	
		Sites	References		Sites	References
2500						
	1	Zürich Mythenschloss 2.1	Hüster-Plogmann/Schibler 1997			
	2	Zürich Mozartstrasse 2 oben	Hüster-Plogmann/Schibler 1997			
2600	2	Zürich Mozartstrasse 2 unten	Hüster-Plogmann/Schibler 1997			
	1	Zürich Mythenschloss 2.2-3	Hüster-Plogmann/Schibler 1997			
	2	Zürich Seefeld Kan.San. A	Hüster-Plogmann/Schibler 1997			
	1	Zürich Mythenschloss 2.4	Hüster-Plogmann/Schibler 1997			
	2	Zürich Seefeld Kan.San. C/B	Hüster-Plogmann/Schibler 1997			
	2	Zürich Seefeld Kan.San. D	Hüster-Plogmann/Schibler 1997			
2700	2	Zürich Pressehaus C2	Hüster-Plogmann/Schibler 1997			
	2	Zürich Seefeld Kan.San. E	Hüster-Plogmann/Schibler 1997			
	2	Zürich Seefeld Kan.San. F	Hüster-Plogmann/Schibler 1997			
2800	2	Zürich Kleiner Hafner 2A-D	Schibler 1987			
2900						
3000	4	Meilen Rohrenhaab 2	Sakellaridis 1979			
	3	Feldmeilen Vorderfeld 1x	Schibler/Veszeli 1998			
	3	Feldmeilen Vorderfeld 1y	Schibler/Veszeli 1998			
	2	Zürich Pressehaus E	Hüster-Plogmann/Schibler 1997			
	2	Zürich Seefeld Kan.San. 2	Hüster-Plogmann/Schibler 1997			
	2	Zürich Mozartstrasse 3 oben	Hüster-Plogmann/Schibler 1997			
3100	2	Zürich Mozartstrasse 3 allg.	Hüster-Plogmann/Schibler 1997			
	2	Zürich Mozartstrasse 3 unten	Hüster-Plogmann/Schibler 1997			
	1	Zürich Mythenschloss 3	Hüster-Plogmann/Schibler 1997			
	3	Feldmeilen Vorderfeld 1	Schibler/Veszeli 1998			
	2	Zürich Pressehaus G	Hüster-Plogmann/Schibler 1997			
	2	Zürich Seefeld Kan.San. 3	Hüster-Plogmann/Schibler 1997			
3200	2	Zürich Kleiner Hafner 3A+B	Schibler 1987			
	2	Zürich Seefeld Kan.San. 4	Hüster-Plogmann/Schibler 1997			
	3	Feldmeilen Vorderfeld 3	Schibler/Veszeli 1998			
3300						
	3	Feldmeilen Vorderfeld 4	Schibler/Veszeli 1998			
3400	10	Arbon Bleiche	Markert 1985a			
3500						
	6	Zug Vorstadt total	Rehazek/Schibler unp.			
	9	Steckborn Schanz	Markert 1985b			
	2	Zürich Seefeld Kan.San. 5	Hüster-Plogmann/Schibler 1997			
3600	2	Zürich Mozartstrasse 4 oben	Hüster-Plogmann/Schibler 1997			
	2	Zürich Mozartstrasse 4 mitte	Hüster-Plogmann/Schibler 1997			
	2	Zürich Mozartstrasse 4 unten	Hüster-Plogmann/Schibler 1997			
	4	Meilen Rohrenhaab 3	Sakellaridis 1979			
	5	Horgen Dampfschiffsteg	Sakellaridis 1979			
	4	Meilen Rohrenhaab 4/4a	Sakellaridis 1979			
	7	Gachnang Niederwil	Clason 1991			
	2	Zürich Seefeld Kan.San. 6	Hüster-Plogmann/Schibler 1997			
	2	Zürich AKAD/Pressehaus J	Hüster-Plogmann/Schibler 1997			
	2	Zürich Seefeld Kan.San. 7	Hüster-Plogmann/Schibler 1997			
3700	2	Zürich Seefeld Kan.San. 8	Hüster-Plogmann/Schibler 1997	11	Oedenahlen	Kokabi 1995
	3	Feldmeilen Vorderfeld 5	Schibler/Veszeli 1998			
	3	Feldmeilen Vorderfeld 6	Schibler/Veszeli 1998	12	Reute-Schorrenried	Kokabi 1990
	3	Feldmeilen Vorderfeld 7	Schibler/Veszeli 1998	14	Bruchsal-Scheelkopf	Steppan 1998
	3	Feldmeilen Vorderfeld 8	Schibler/Veszeli 1998	14	Bruchsal-Aue II	Steppan 1998
	3	Feldmeilen Vorderfeld 9	Schibler/Veszeli 1998			
	2	Zürich Pressehaus L	Hüster-Plogmann/Schibler 1997			
	2	Zürich Seefeld Kan.San. 9	Hüster-Plogmann/Schibler 1997			
3800	2	Zürich Kleiner Hafner 4G	Schibler 1987			
	2	Zürich Mozartstrasse 5 oben	Hüster-Plogmann/Schibler 1997	8	Wangen-Hinterhorn	Kokabi 1990
	2	Zürich Mozartstrasse 5 unten	Hüster-Plogmann/Schibler 1997			
	2	Zürich Kleiner Hafner 4F	Schibler 1987			
	4	Meilen Rohrenhaab 5	Sakellaridis 1979			
	9	Steckborn Turgi	Markert 1985c			
3900	2	Zürich Kleiner Hafner 4E	Schibler 1987	8	Hornstaad Hörnle IA	Kokabi 1990
	2	Zürich Mozartstrasse 6 oben	Hüster-Plogmann/Schibler 1997			
	2	Zürich Kleiner Hafner 4D	Schibler 1987	13	Ehrenstein	Scheck 1977
	2	Zürich Mozartstrasse 6 unten	Hüster-Plogmann/Schibler 1997			
4000				14	Bruchsal-Aue I	Steppan 1998
4100	2	Zürich Kleiner Hafner 4C	Schibler 1987	16	Ludwigsburg-Schlösslesfeld	Nobis 1977
	2	Zürich Kleiner Hafner 4B	Schibler 1987			
4200	2	Zürich Kleiner Hafner 4A	Schibler 1987	15	Hochdorf	Makovicz-Poliszot 1988
4300	2	Zürich Kleiner Hafner 5A+B	Schibler 1987	17	Aldingen	Kokabi 1988

no assemblages

TABLE 1
List of settlements in Eastern Switzerland and Southwest Germany yielding archaeozoological assemblages.

found in the cereal stores. These facts are an indication of the greater extent of cleared, cultivated areas; moreover, it is is now evident that these areas were kept open permanently. In this later period, after 3400 BC, it also appears from layer samples that there were woodland edges and hedgerows great in extent. Evidence for this is provided, for example, by sloe (*Prunus spinosa*), which is encountered more frequently in macrorest samples. Treading-resistant indicators of pasture, which suggest grazing of fallow fields, also occur more frequently, and were to some extent also found in storage samples - a sign that they grew on the arable fields (e.g. *Prunella vulgaris*, *Plantago major*, *Potentilla reptans*). Indications of pastoral woodland, too, become clearer - species such as *Calluna vulgaris*, *Juniperus* and *Ilex aquifolium* in particular are now encountered more frequently in the pollen spectra of the sites. These changes in the species spectrum can readily be interpreted as a sign that the landscape was becoming more open, and that the settlements were surrounded by larger arable fields, light woodland pastures, and managed woodland.

The wild animal fauna also confirms a general opening-up of the landscape: among the birds (Figure 2) there is in the later period of the Neolithic (3400-2400 BC) an increase in species which prefer open landscape as their habitat (e.g. beangoose, partridge, crow species), while the mean ubiquities of species which are mostly at home in dense woodland is higher by far in the older period of the "Jungneolithikum" (e.g. black kite, woodcock, jay).

The shy badger is one of the mammals that can be classified as a classic woodland animal. It is clear that badger occurs more frequently and in greater quantities in the settlement layers from before 3600 BC than in the younger levels (Figure 3). Conversely, we find significantly higher proportions of fox and brown hare in the youngest settlements of the "*Schnurkeramik*" (Corded Ware) period, from about 2800 BC (Figure 3). Both species need structured woodland landscapes and open fields as an ecological requirement for stable population density.

On the basis of the botanical and zoological parameters available to us, we can, in summary, ascertain that the landscape in the Alpine foreland changed fundamentally during the course of the Neolithic. At least in the area around the Neolithic farming villages, the dense woodland of the "Jungneolithikum" (4300-3400 BC) gave way to a structured, open landscape in the "Spät- und Endneolithikum" (3400-2500 BC).

In the northern part of the study area the archaeobiological evidence from a total of ten sites is sparse and limited to the period of the "Jungneolithikum". Due to the specific preservational conditions of the settlements situated in loess covered regions the animal bones are often well preserved. Unfortunately, the botanical remains consist primarily of carbonized cereal stores providing very little information about the surrounding landscape (Stika, 1996).

Here, high proportions of brown hare already occur in the late fifth millennium pointing to structured woodland and open fields. The dense and continous Neolithic settlement of this region since the middle of the 6th millenium BC probably resulted in a likely opening up of the landscape.

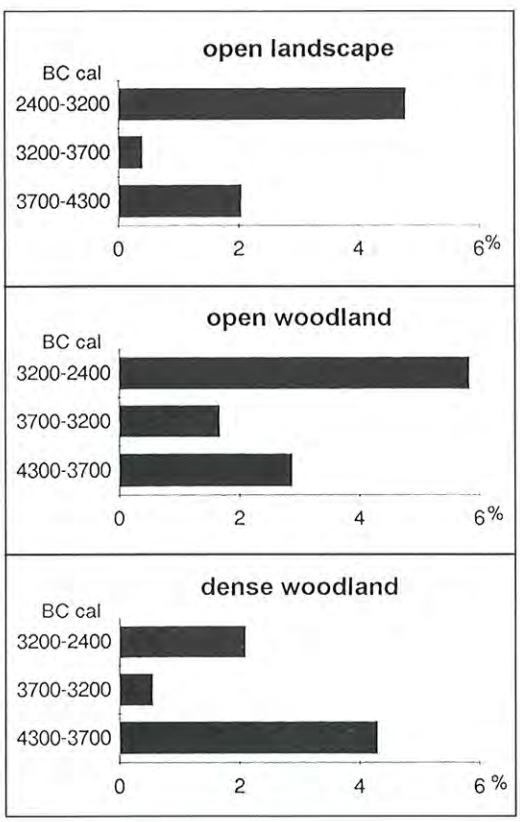

FIGURE 2
Ubiquities of bird taxa from different habitats in the Neolithic settlements of Eastern Switzerland (ecological classification see Schibler/Hüster-Plogmann 1995, Abb. 33). 4300 - 3700 BC, 100%: 28 settlements; 3700 - 3200 BC, 100%: 36 settlements; 3200 - 2400 BC, 100%: 48 settlements.

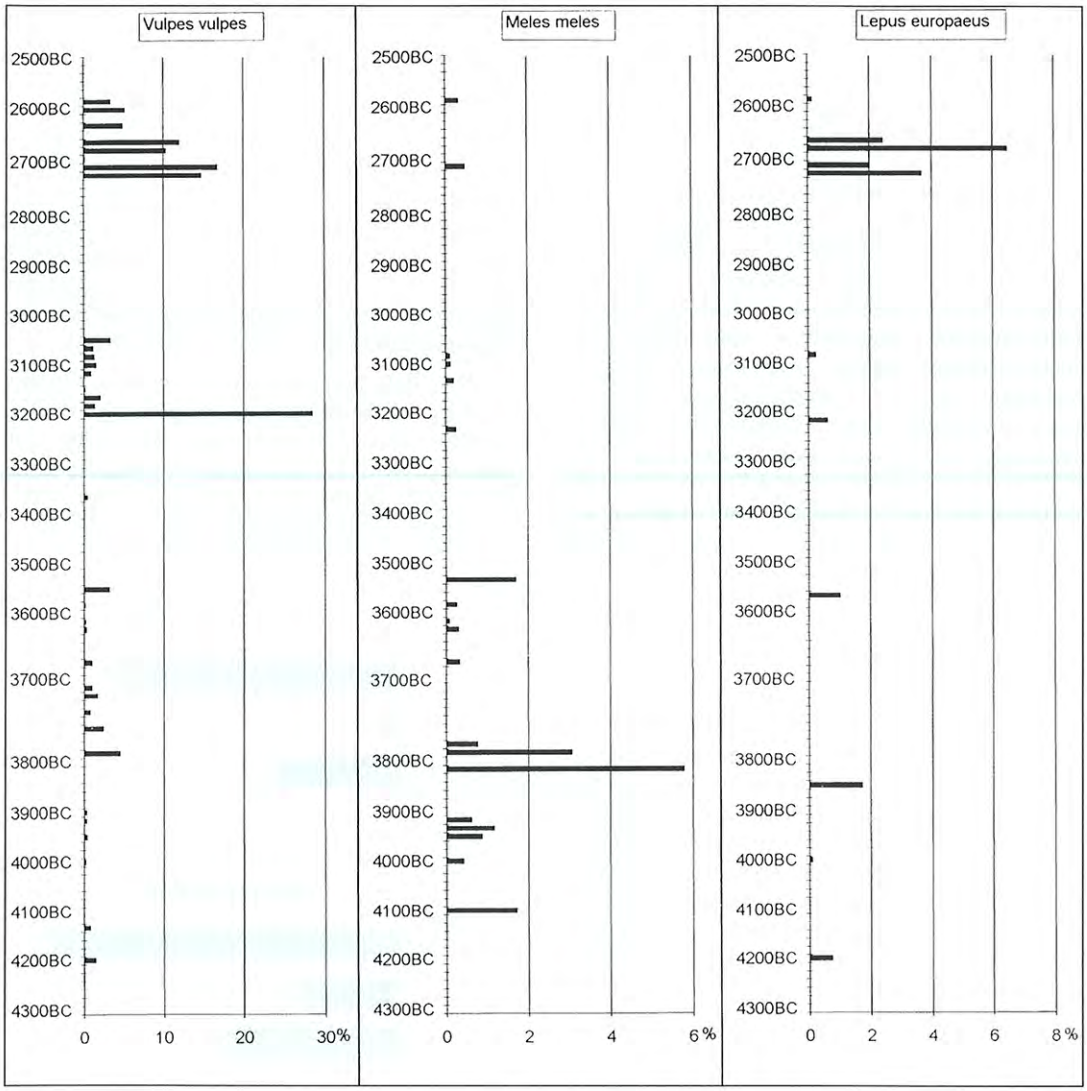

FIGURE 3
Bone frequencies (100%: wild animal bones) of red fox (*Vulpes vulpes*), badger (*Meles meles*) and brown hare (*Lepus europaeus*) in the Neolithic settlements of Eastern Switzerland.

THE ECONOMIC BACKGROUND

Archaeobotanical and archaeozoological investigations in Neolithic lakeside settlements – in particular on the lake Zurich - have provided deep insights into the economic systems of early farming villages on the Swiss Plateau. On the basis of model-calculations (Gross *et al.*, 1990) as well as calculations of find concentrations we can assume that the greatest part of the calories required had to be provided by plants. In addition, the concentration of bone finds points to relatively small herds of domestic animals in the period between 4300 and 3300 BC (Hüster-Plogmann & Schibler, 1997; Schibler, 1997). It was not until 3300 BC that there was an intensification in pig rearing, which was followed from about 2800 BC by significantly larger herds of ruminants, which included cattle, sheep and goats. That cattle herding in particular was not practised more intensively until the end of

the Lake Shore Neolithic, probably has to do with the provision of fodder for the animals: before the 3rd millennium there were no large areas of pasture, aside from river meadows and the areas along the lake shores. The provision of fodder for domestic ruminants was based in the summer months on woodland pasture in the wider area around the settlements, while in late summer and autumn the fallow fields were presumably grazed. In winter the animals most likely had to be fed on leaf-fodder, which was time-consuming to procure (Schibler *et al.*, 1997a). All in all, it becomes clear that the provision of fodder was the most important limiting factor in the prehistoric cattle economy, influencing the size of the herds.

Under these conditions, the scarce natural grassland habitats must surely have been valuable sources of fodder, as they provided very nutritious cattle feed. Natural grass and herb meadows consisted above all of flood and pioneer grasslands in the meadow area of the delta of the river Sihl and along the river Limmat, but also included woodlands along the lake shores which had been opened up by human activities, and where the first beginnings of dispersed meadows can be seen (Brombacher & Jacomet, 1997). Under these conditions, difficulties in the food economy could not be overcome by a short-term increase in meat production by intensifying the rearing of domestic animals. A quick and effective increase in quantity was only possible through the deliberate use of wild re-sources. Consequently, during crises in the food economy, hunting - in particular of red deer - and gathering - in particular of the fatty and starch-rich fruits and seeds of the hazel (*Corylus avellana*), turnip (*Brassica rapa*) and 'fat hen' (*Chenopodium album*) - was strongly intensified. Economic crises, which required immediate measures in order for the population to survive, occurred in the first instance when the most important source of food, cereal, was not available in adequate quantities because of poor harvests. These failed harvests are, in turn, closely connected to short-term climatic fluctuations, as comparisons with climate-historical data have shown (Schibler *et al.*, 1997a, b, 329ff.; Gross-Klee & Maise, 1997; Magny, 1995). There are strong indications of a connection between economic crisis situations and short-term climatic fluctuations around the transition from the 40th to the 39th centuries BC and during the second half of the 37th century BC (Figure 4).

The effects of climatic changes and their economic consequences are undoubtedly dependent on the respective natural factors prevailing in the different regions at that time. There are also high proportions of wild mammals in the early thirty-eighth century BC in the climatically favourable old settlement areas, such as the Kraichgau. In south-west Germany, too, analogous strategies for coping with climatically-based subsistence crises were pursued (Steppan, 1998a, b).

HUMAN IMPACT AND FAUNAL DIVERSITY

As a measure of diversity we have calculated an index of "number of species/number of identifiable wild animal bones", which takes into account the size of the assemblages. Since the sediment in none of the assemblages discussed here was systematically wet-sieved, we consider a comparison of indices to be legitimate.

Despite all the methodological problems, statistical comparisons of species diversities between the assemblages of the Pfyn and Corded Ware settlements from Zürich show a significant increase in species diversity in the later period (Hüster-Plogmann & Schibler, 1997).

On the one hand, it is obvious that through the increasing impact of people on the environment not only were new biotopes created which provided better living conditions for newly immigrated or rare species, but resident species were also being forced out of their traditional habitats. On the other hand, it is noticeable that when hunting is intensified it also becomes more selective, and therefore the species diversity mostly turns out to be very small.

Aurochs (*Bos primigenius*) and Elk (*Alces alces*)

In the Alpine Foreland maximum values for wild cattle are calculated at 18% of all wild animal bones. The maximum number of elk bones is about 5%. Like the remains of wild cattle, elk bones from the "Spät- und Endneolithikum" (3400-2500 BC) of the Swiss Plateau appear in lower numbers (Figure 5).

In the old settlement areas bordering the Alpine Foreland to the north the situation is different (Steppan, 1998a, b). Between 4100 and 3600 BC aurochs are the most important game species in the Northern Upper Rhine area (Kraichgau) with a maximum value of 72% (Figure 5).

At Lake Zurich wild cattle - mostly aurochs - and elk bones are, on the basis of the concentration

values of domestic to wild animal bones, found in time periods where lower levels of hunting activity can be expected (Figure 6).

The ecological conditions during this time period would probably not have been capable of accommodating larger populations of wild cattle or elk, as the results of the botanical analyses, which we have already addressed, still point to dense forestation for this time period. Although the ancestor of our domestic cattle disappeared in the 17th century A.D., so that we have no exact information on its ecological requirements, it can hardly be assumed that dense primeval forest would be one of its preferred habitats. The habitats of bovines in general, as well as the elk, are more likely to be found in undergrowth-rich river meadow woodlands, light deciduous forests with a rich understorey, natural grasslands, as well as marshy areas. Such conditions were not created by people until after 3300 BC. Thus the influence of people, both close to and in the wider areas around the settlements, in fact should have had a positive effect on the living conditions and population density of the aurochs. Nevertheless, the bones of wild cattle and elk are found significantly less frequently and in lower quantities after 3300 BC than between 4000 and 3500 BC.

One explanation for this contradiction may lie in the lifestyle and economic customs of the settlers: based on the botanical results it may be suspected that the lakeside settlers regularly exploited as pastures for cattle all the natural areas of grassland, as well as the herb-rich understorey of deciduous forests and wet woodlands in the immediate and more distant areas around the settlement. Since these are the same locations which would

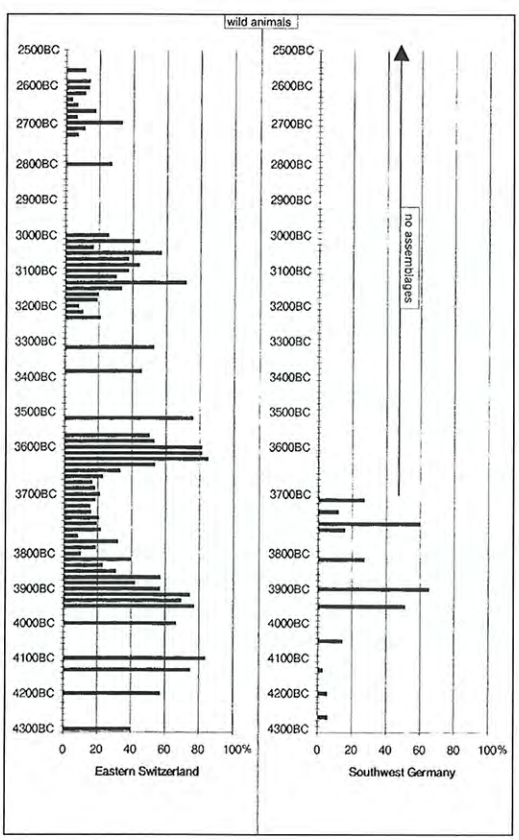

FIGURE 4
Frequencies of wild animal bones in the Neolithic settlements of Eastern Switzerland and Southwest Germany.

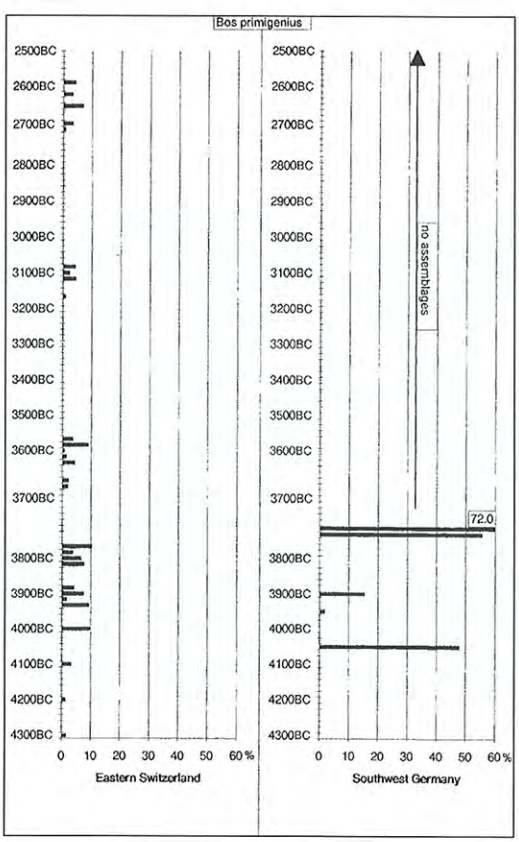

FIGURE 5
Frequencies of aurochs bones (100%: wild animal bones) in the Neolithic settlements of Eastern Switzerland and Southwest Germany.

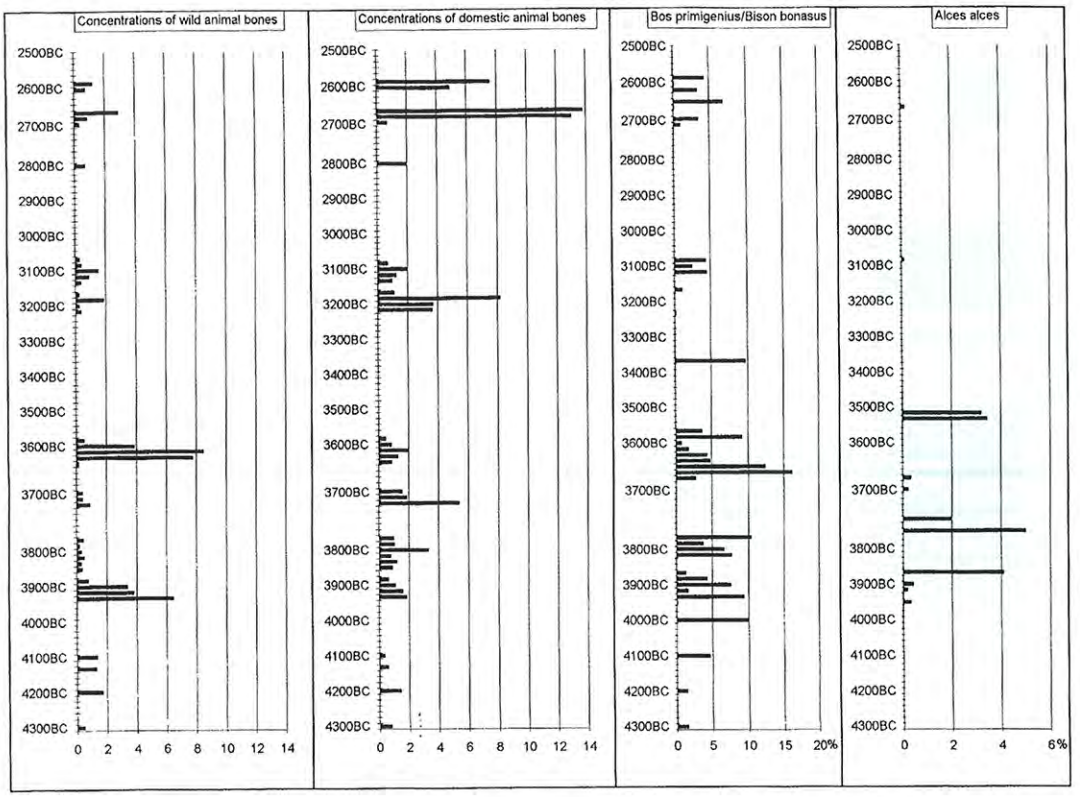

FIGURE 6
Concentrations (number of bones per squaremeter and occupation phase) of wild respectively domestic animal bones and frequencies of aurochs and elk bones in the Neolithic settlements of Lake Zurich.

presumably have been part of the preferred habitats of the aurochs and the elk, it is likely that these species and domestic cattle became competitors for food.

This circumstance, but above all the increasingly intensive presence of people, and the exploitation of these biotopes by people and their domestic animals (as pasture, for the acquisition of wood for timber and firewood, for the gathering of seeds and fruit, and for hunting) could in the end have led to a reduction in the population density of the aurochs and elk. Hunting alone, which, according to our figures cannot have been very intensive, would surely not have resulted in great decreases in the population of these large herbivores.

Red deer (*Cervus elaphus*)

Among the wild animals, red deer dominates over aurochs everywhere in the settlements of the Alpine Foreland, irrespective of whether the basis of calculation is the number or the weight of bones recovered. The red deer bones reach frequencies of up to 90% of all wild animal remains (Figure 7).

The intensification in red deer hunting, especially in the 40th and 37th centuries BC in the Alpine Foreland affected the size variability of the local red deer populations. According to the osteometric data from Lake Zurich the increasing hunting pressure led to a decrease in red deer size and vice versa (Figure 8 and Table 2). Whether this phenomenon is caused by the killing of not yet fully grown deer and/or an unbalanced sex ratio will be the subject of further research. According to the results of model calculations only during a longer-lasting period of more intensive hunting (>80 years) could this have become a danger for the local red deer population (Müller, in prep.).

Despite this intensive hunting, red deer obviously adapted to the changing ecological situation

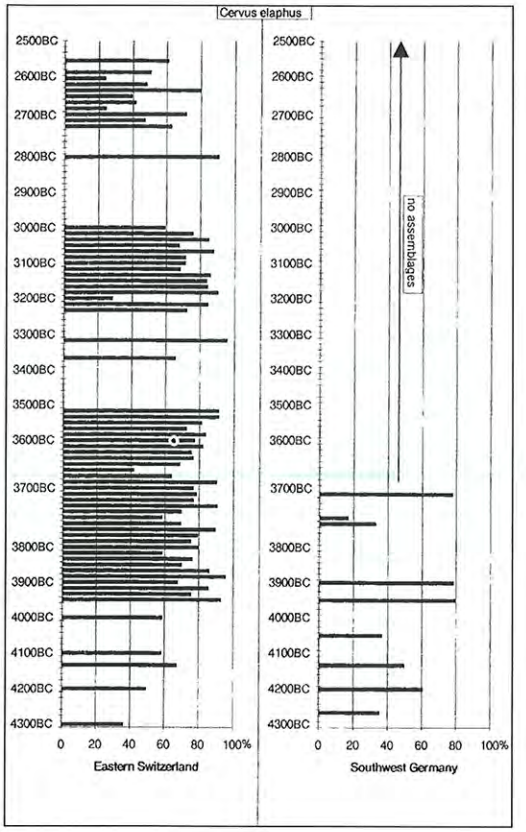

FIGURE 7
Frequencies of red deer bones (100%: wild animal bones) in the Neolithic settlements of Eastern Switzerland and Southwest Germany.

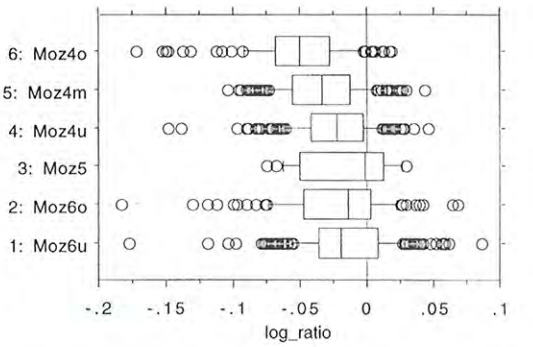

FIGURE 8
Box-plot with the logarithmic size indices of red deer bones from the occupation phases 4 - 6 in Zurich-Mozartstrasse (see Table 2).

Level	n	Median	IQR	Minimum	Maximum
Moz4o	115	-0.049	0.040	-0.172	0.018
Moz4m	249	-0.034	0.042	-0.104	0.043
Moz4u	245	-0.022	0.039	-0.148	0.045
Moz5	22	-0.001	0.063	-0.075	0.029
Moz6o	104	-0.014	0.049	-0.183	0.069
Moz6u	294	-0.019	0.045	-0.178	0.086

TABLE 2
Descriptive statistics (IQR: Interquartile Range) of the logarithmic size indices of red deer bones from the occupation phases 4 - 6 in Zurich-Mozartstrasse (see Table 1).

and remained the most important hunted species throughout the Neolithic period of the Swiss Plateau.

Horse (*Equus* sp.)

Generally, substantial amounts of horse bones only occur in time periods with intensified hunting (Figure 9). These bone finds are considered to represent small wild populations. Natural grasslands (e.g. flood-plains and bogs) are supposed to be the preferred habitats of the horse based on its food requirements. The horse populations from the 38th/37th centuries had similar body proportions. According to the logarithmic size indices (Uerpmann, 1990) the populations in southwestern Germany were characterized by a slightly greater body mass (Figure 10 and Table 3). Certainly, this difference is due to local or regional living conditions and reflects the ecological adaptability of this species.

The absence of horse remains from the archaeological record after 3600 BC in eastern Switzerland probably points to the local extinction of the species. The horse remains from the Corded Ware settlements (2600 BC) may already be attributed to domestic horses (Hüster-Plogmann & Schibler, 1997) and do not prove the persistence of wild horses in this region.

CONCLUSIONS

As our results have shown, even the early human impact 6000 to 4000 years ago, can be recognized within the archaeozoological assemblages on the Swiss plateau. This human impact has had positive and negative effects on the wild animal popula-

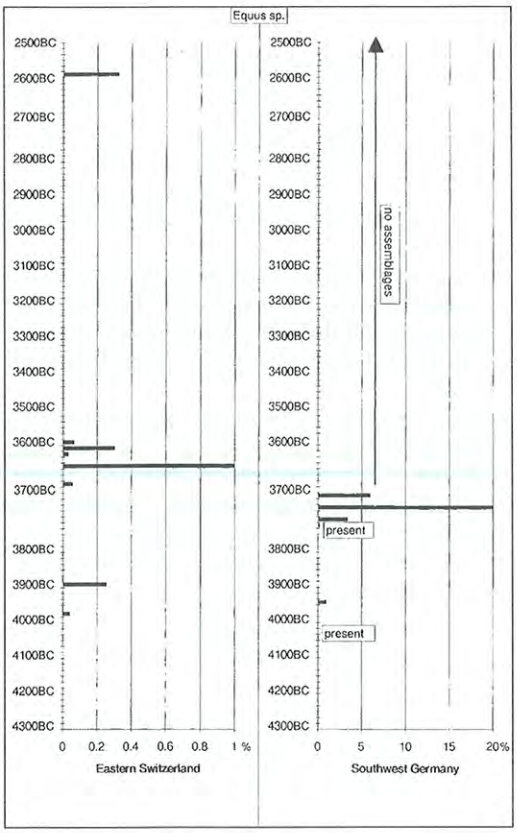

FIGURE 9
Frequencies of horse bones (100%: identified animal bones) in the Neolithic settlements of Eastern Switzerland and Southwest Germany.

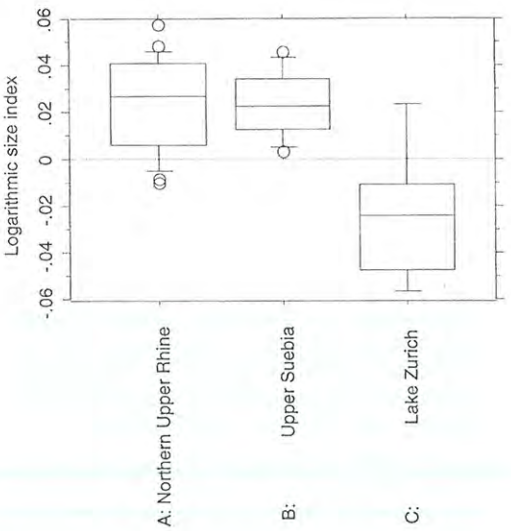

FIGURE 10
Box plot with the logarithmic size indices of horse bones from Eastern Switzerland and different regions in Southwest Germany (see Table 3).

Region	n	Median	IQR	Minimum	Maximum
Northern Upper Rhine	23	0.027	0.035	-0.010	0.057
Upper Suebia	7	0.023	0.022	0.004	0.046
Lake Zurich	5	-0.024	0.036	-0.057	0.023

TABLE 3
Descriptive statistics (IQR: Interquartile Range) of the logarithmic size indices of horse bones from Eastern Switzerland and different regions in Southwest Germany.

tion. On one hand by the use of the nearer settlement surroundings by man, new biotopes were created and gave place for new species or certain seldom species became more frequent. On the other hand man and his domestic animals exploited environments where wild species were frequent, specially large herbivores as aurochs and elk. Therefore early farmers and their domestic animals became competitors for food for certain wild species. This could have led to a reduction in the population density of wild species. Also the intensive hunting of certain wild species as red deer could have led to a reduction of the population and also to a negative selection within the population which can be recognized by a reduction of the body size. Over all this human impact was limited only to small areas and therefore positive effects as the rising biodiversity are more important as negative effects.

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Eating horsemeat: the evidence in the Roman Netherlands

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ABSTRACT: Bones of horses occur in almost every Roman site in the Netherlands: bones with and without butchering marks, found among other refuse and as separate burials, inside and outside settlements. The subject of this paper is whether horsemeat was eaten by the various population groups (military, native, *villa*, inside and outside the Roman empire) and what the reason was for this custom or avoidance.

KEYWORDS: THE NETHERLANDS, ROMAN PERIOD, HORSE, MEAT, FOOD

RESUMEN: Restos óseos de caballos se recuperan en prácticamente todos los yacimientos romanos de los Países Bajos: huesos con y sin huellas de despiece, recuperados tanto entre desechos alimentarios como en enterramientos individualizados, dentro y fuera de los yacimientos. El objeto de este trabajo es el de averiguar si la carne de caballo era consumida por parte de los diferentes grupos humanos (militares, indígenas, *villa*, dentro y fuera del Imperio romano) y cuales podrían ser las razones para esta costumbre o tabú alimentario.

PALABRAS CLAVE: PAÍSES BAJOS, ÉPOCA ROMANA, CABALLO, CARNE, COMIDA

INTRODUCTION

To modern people the term 'eating horsemeat' produces very different reactions. To the English, for instance, it is repulsive, to a Kazakh a tasty necessity and to the Dutch it is a good alternative for their sandwich filling (Gade, 1976; Levine, 1998). These preferences and avoidances are economically, religiously and culturally determined and are connected with the different functions meat and the animal, from which the meat comes, can have.

In the Roman agronomic literature we do not read about the horse as an animal for consumption. But most of this literature is written from the 'Italian' part of the empire. When we look, outside Italy, at the archaeozoological record the question of eating horsemeat seems to be more complicated. And also for the Dutch part of the empire and the adjacent 'free' country, the archaeozoological information indicates differences in the use of horses and products of horses (Clason, 1998; Lauwerier & Robeerst, 1998, in press; Rinkes, 1997; Visser, 1995).

The aim of this study, based on the Dutch material, is to get a stronger grip on this issue of meat, and as a result to gain more insight in the role the horse had for the different populations, some of which lived within, and others beyond the borders of the Roman empire (Figure 1). More specifically, we want to have an answer to the following questions: Did the Romans and the native people that lived in the Netherlands in Roman times eat horsemeat? And if they did so, or did not, what was the reason? An underlying methodological goal is to formulate useful criteria to establish whether or not horse is eaten.

MATERIAL AND METHOD

The archaeozoological information used in this study is the result of an inventory of the available published and unpublished documentation (Lau-

werier & Robeerst, 1998, in press). The investigation was limited historically to the Roman period. The geographical demarcation is that of the present Netherlands. Figure 1 shows the location of the sites on both sides of the *limes*, the Roman border. Also indicated on the map is the nature of the various contexts: military, native, *villa* or temple. The 'military settlements' do not only include the strictly military places or *castella*, but also settlements directly related to them, such as the *canabae legiones* of Nijmegen and other military *vici*. The 30 places shown on the map represent 58 archaeozoological complexes with numerical data and 35 with measurement data. This information is summarized in Figures 2 and 3. A more detailed indication of the various complexes, descriptions of the period, the number of identifiable bones of horses and cattle, sheep, goats and pigs, statistical information about withers heights, and references to the literature the data come from is given elsewhere (Lauwerier & Robeerst, 1998, in press).

For the calculation of the height at withers the Vitt factors recommended by von de Driesch & Boessneck (1974) were used; these have been calculated as far as possible according to May's formulas (1985).

DIFFERENT GROUPS, DIFFERENT HORSES, DIFFERENT PURPOSES

The horse served various purposes. Judging by the many literary and often also pictorial sources, horses in Roman times were kept at any rate for transport, as riding or draught animals in the army, circus or in private service (Toynbee, 1973: 167-185). In addition to this practical use, the horse also had a status value in the Germanic context, which, among other things, is apparent in the custom described by Tacitus of using these animals as gifts to chiefs of neighbouring states (Germania 15).

Occasionally the horse served a symbolic or religious purpose. The horse, for instance, was an attribute of the horse-goddess Epona and a symbol of the power of Jupiter.

Judging from the archaeozoological material, after death or slaughter the bones of horses were only very occasionally used for the manufacture of artefacts. In the Netherlands such use is seen in three northern settlements outside the Roman empire, in the territory of the native Frisii. In Kimswerd a metatarsus IV was made into an awl (Milojkovic & Brinkhuizen, 1984); in Sneek a phalanx was decorated on all sides with a point-circle motif (Clason, 1962); and in Schagen-Wittepaal a metapodial was sawn through, also an indication of bone working (Zeiler, 1996). Similar sawn through metapodials have also been found in the military *castra* of Nijmegen (Lauwerier, 1988). It is striking that in native settlements south of the limes bones of horses were not used for this purpose, in spite of the fact that this material was more easily available than in the northern settlements. Skinning for leather appears to have been far more common. For several settlements this was demonstrated by cutmarks related to this activity (Gehasse, 1997; Lauwerier, 1988: 153-155).

Opinions on whether horseflesh was actually used, which seems economically probable in view of the food value, differ for the various sites. That they were not eaten, is concluded of horses from Valkenburg (Clason, 1960), Zwammerdam (Van Wijngaarden-Bakker, 1970) and various settlements from the eastern and central river area (Laarman, 1996a; Lauwerier, 1988), whereas meat from horses at Paddepoel (Knol, 1983), Velsen-Hoogovens and Schagen-Langedijk (Van Wijngaarden-Bakker, 1988) probably was consumed. These observations lead one to suspect that the consumption of horsemeat varied according to the population group. The question of the evidence for these assumptions will be dealt with in some detail later in this paper.

That there are differences concerning horses between different population groups is known from their appearance. Different groups had different horses. For example, Caesar reports that Germanic horses are small and ugly compared to the Roman horses (De Bello Gallico IV 2,2), and Tacitus writes that Germanic horses are not remarkable for either beauty or speed (Germania 6).

The bones found during excavation, however, provide the clearest picture of horses from the Roman period in the Netherlands. From their size we gain an impression of the size of the horses used by various groups in various parts of the country (Figure 2).

It is striking that there is no question of any gradual increase in wither height during the Roman period as has been established for cattle in the Netherlands and elsewhere in the Roman empire (Audoin-Rouzeau, 1991; Lauwerier, 1988: 166-169). There are, however, clear differences between the various groups of settlements.

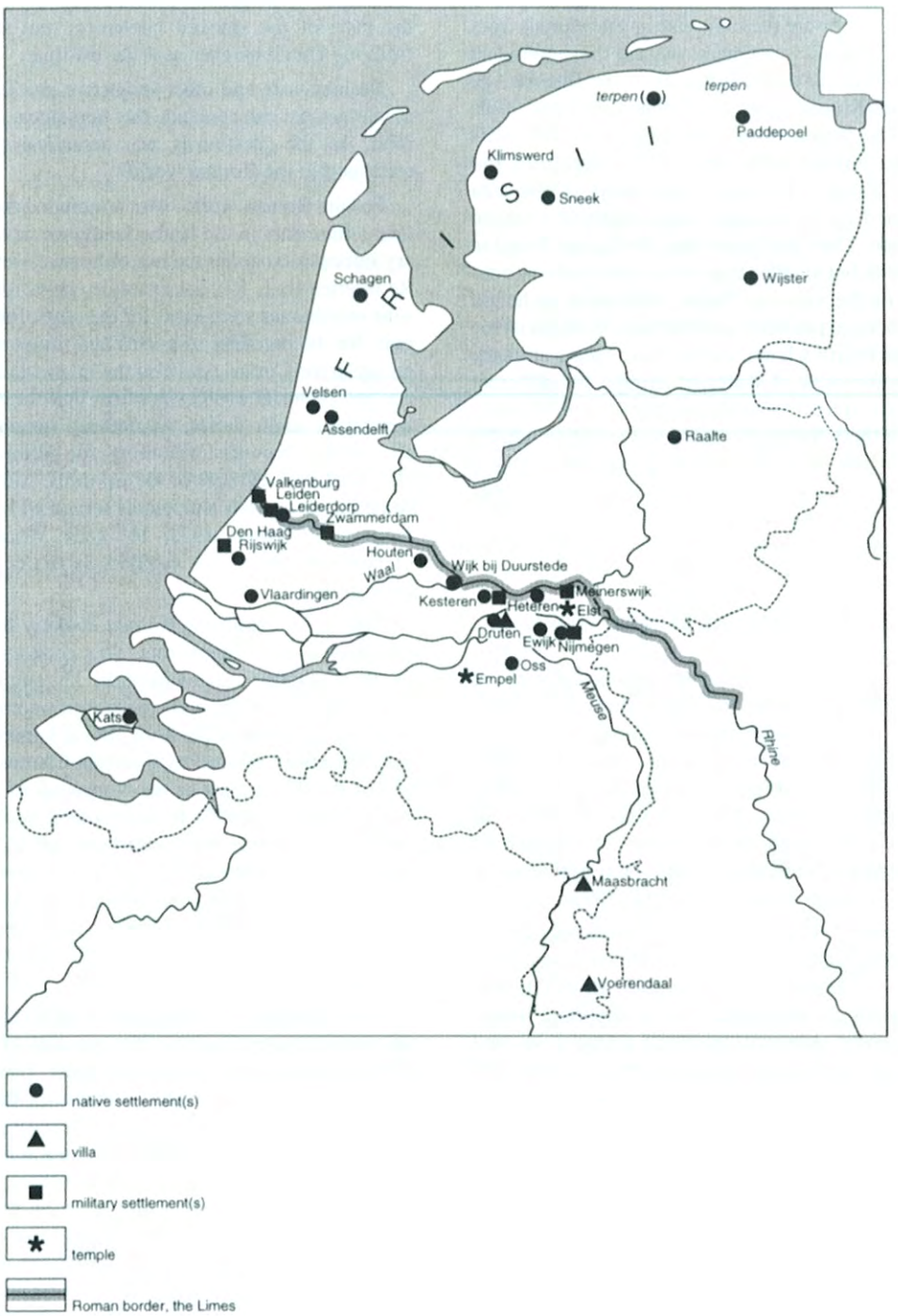

FIGURE 1
Map of the Netherlands with the findspots mentioned in the text. The dotted line indicates the Roman imperial boundary, the *limes*.

The horses in the native settlements north of the *limes* are the smallest, with an average height of 132 cm. They are the same size as the animals from other Germanic settlements outside the empire and scarcely larger than the horses of the Bronze Age and pre-Roman Iron Age (Benecke, 1994: table 24). The largest horses are those from the *villae* and the military settlements with averages of 144 and 142 cm. The native inhabitants of the area occupied by the Romans had animals of a size in between. They are larger than the horses found in the north but smaller than those from military contexts in the vicinity. These differences in height have been explained by differences in origin of the Roman military horse and the local native animals, by preferences of different groups for different types of animals, by strategic reasons for not making southern horses available to the native inhabitants north of the limes, by producer-consumer relations between groups south of the Roman border and by factors like status (Lauwerier & Robeerst, 1998, in press).

HORSEMEAT AND THE ROMAN WORLD

A reason to assume that horsemeat was eaten in the 'Dutch part' of the Roman world is the fact that bones of horses are present among the animal finds in almost all excavations. From the settlements shown on Figure 1, representing 58 different archaeozoological complexes, no bones of horses were found in only three: in the *villa* of Maasbracht, the Roman *castellum* at Meinerswijk and at an early temple (before AD 50) at Elst.

Another reason to expect consumption of horsemeat is because it is economically very profitable in view of its food value. Research into horseflesh has shown that it is an important source of vitamins, minerals, essential amino acids and essential fatty acids (Levine, 1998). In the 19th and 20th century the marketing of horsemeat was made legal in Austria, Germany, Scandinavia, Belgium and the Netherlands because of its nutritious value and this meat was considered as 'normal' food, although often only for the lower social classes (Levine, 1998; Simoons, 1994: 188-191). In another part of the world, in Kazakhstan, people from the forest-steppe regard the flesh of their horses as better food than that of cattle, sheep and goats, animals that they also herd (Levine, 1998). An advantage of horsemeat is that, because of its tenderness, unlike beef, it does not deteriorate with the age of the animal (Gade, 1976: 8). Personally, the author of the present article especially relishes the taste of the smoked horsemeat and sausage from the Dutch butcher near the institute.

Besides taste and other subjective and irrational matters, we can conclude that horsemeat is good food. But the question is, was horseflesh considered food in the Roman world?

For the Roman world, which included the military settlements in the Netherlands, we have literary information about the use of horses. Varro (De Re Rustica II, 7, 15), for example, gives four reasons why horses were kept: for the army, for transport, for the breeding of horses and mules and for racing in the Circus. And also the many other literary and pictorial sources confirm that these tasks were their main duties. Sometimes horses were also used as mounts for hunting, for pulling vehicles, for farm activities or to turn mills. After their death the skins, tails and manes served all kinds of purposes (Toynbee, 1973: 167-185). What these literary sources do not mention, is the eating of horsemeat.

The recipes from the Roman cookery book of Apicius/Caelius support this. This cookery book, *De Re Coquinaria*, dates from the 1st century AD. It was written by the well-to-do gastronome Apicius, but the form of the book that is known to us may have been revised by a certain Caelius at the end of the 4th century or the beginning of the 5th century (Forbes, 1965). In this cookery book there are recipes for over fifteen bird species, for about twenty different species of fish, for several molluscs and for all other kinds of sea-food. A total of twelve different mammal species are mentioned almost 150 times. However, there is not one recipe for the preparation of horsemeat.

Also informative with regard to this subject are the animal bones found as the remains of grave gifts in cemeteries. Sometimes these bones are found on dishes and plates, sometimes they are simply placed in the grave. The interesting thing about this bone material is that it is not refuse but part of the meal itself: a sort of table setting for the dead. Whether the meals were meant as real food or just had a symbolic meaning, will not be discussed here. Generally, we only find the remains of pigs, chicken, sheep or goats and cattle on the plates. Horse is always absent. In an inventory of the occurrence of animal bones in graves from twenty cemeteries within the northwestern part of the Roman empire, horse was only found in one

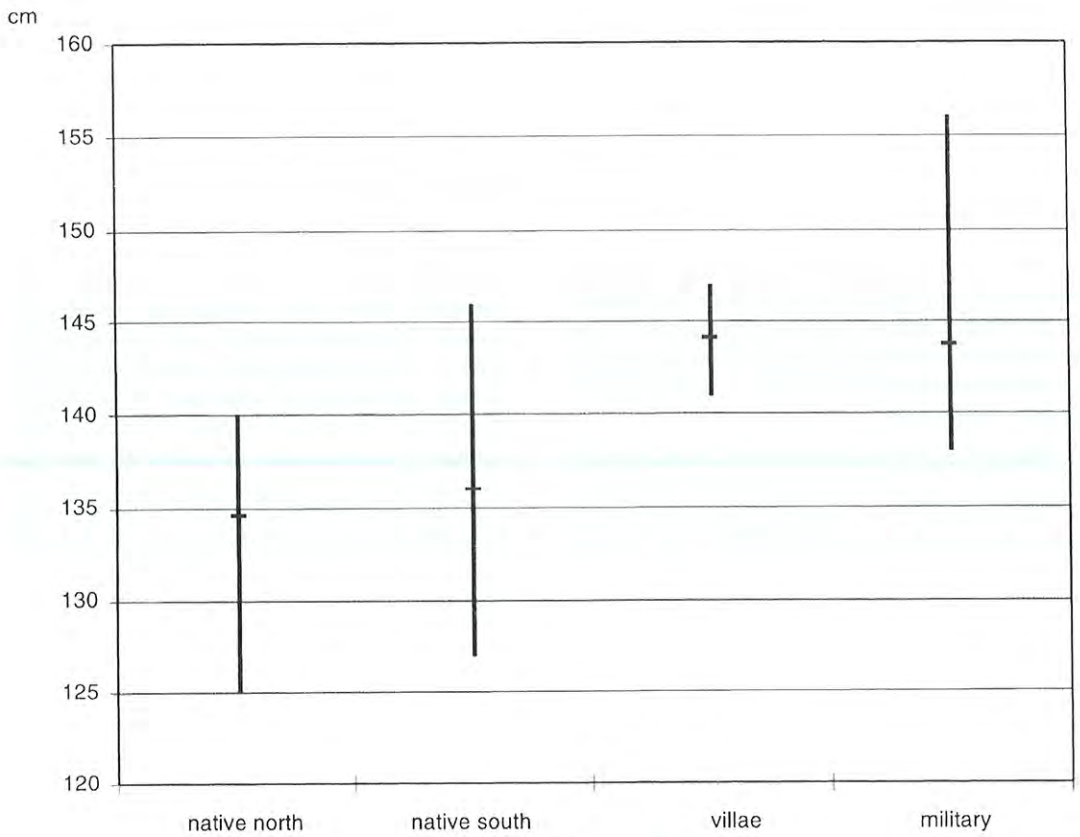

FIGURE 2
Withers heights (cm) of horses from various Roman period contexts in the Netherlands.

case (Lauwerier, 1988: 82-83). The only exception is the Late-Roman cemetery near the *castellum* of Oudenburg (Mertens & Van Impe, 1971). Here in one grave a complete radius was found, in another, a horse scapula. Because these bones were not lying on or near dishes or plates, it is not known if these remains were parts of a meal, and anyhow the radius was complete. Though we have to practise some restraint in drawing conclusions about meat from large animals from the zoological information from graves (Lauwerier, 1993), the data from the cemeteries indicate that horse was not used as food for the deceased.

Significantly the historical sources, where the eating of horsemeat is mentioned, indicate that this was not a normal habit. The Roman writer Tacitus reports that horsemeat was only eaten by the army in emergencies. Thus, thanks to horsemeat, starvation was prevented after the catastrophe to Germanicus' fleet, caused by North Sea storms: *"Some of the ships went down; more were stranded on remote islands; where, in the absence of human life, the troops died of starvation, except for a few who supported themselves on the dead horses washed up on the same beach"* (Annales II, 24; translation Moore & Jackson, 1962).

Also after a defeat by Civilis and forced by famine, horses and other 'unusual' foods were eaten: *" ... their sources of food, both usual and even unusual, failed them, for they had consumed their beasts of burden, their horses, and all other animals, which, even though unclean and disgusting, necessity forced them to use"* (Historiae IV, 60; translation Moore & Jackson, 1962).

From the above, the literary sources, the recipes from the cookery book and the information from cemeteries, we conclude that within the Roman military context, the consumption of horsemeat was generally 'taboo', despite the economic value it might have had as a result of its food value.

Whether this was a taboo in the sense that it had undesirable consequences due to negative magic (Frazer, 1922: 19-20), or was a collective avoidance for other reasons, we will leave aside for the moment.

HORSES IN MILITARY SETTLEMENTS

If we accept that this Roman 'taboo' on eating horsemeat also applied to the military settlements in the Netherlands, we can see what results it had in the archaeozoological dataset of these military sites and subsequently compare it with the other types of settlement.

Figure 3 shows the proportion of horse bones in the material of the various settlements. The percentages of horses are relative compared to the other domesticated food mammals: cattle, sheep, goats and pigs. As with the withers heights, no correlation was found between this proportion and the dates of the settlements. There are, however, considerable differences between the groups of contexts. For example, the average proportion among the native sites north of the *limes* is about seven percent, with most settlements scoring less than five, and only three settlements with more than ten percent horse bone in the find material. On the other hand, the native sites inside the borders of the empire have a high score, most had more than ten percent while the average was sixteen percent. The lowest scores are for temples and military settlements. Inside the temples the proportion of horse is zero. At the military settlements all percentages are below ten, while most of the military sites contain less than five percent horse, with an average of three percent. Of course all these figures are influenced by taphonomic factors; but this does not alter the fact what it is all about. Even if the percentages of military settlements are low, and considerably lower than in other types of settlements, we can state that in almost every military

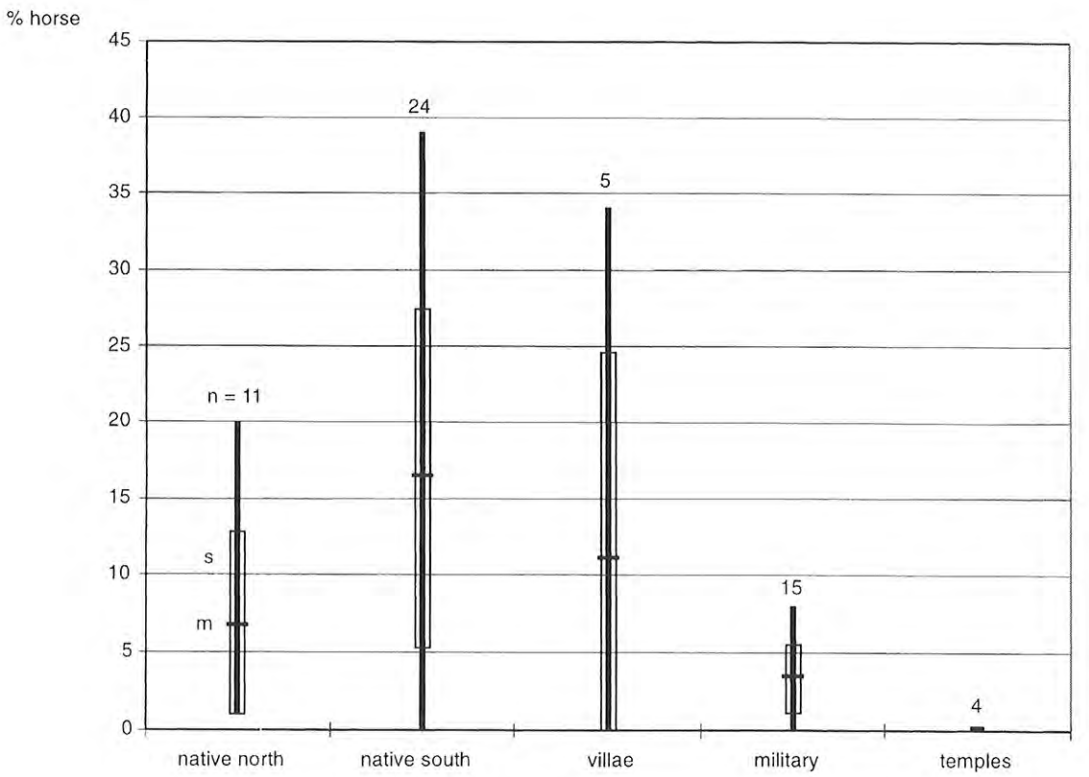

FIGURE 3
Relative frequencies of horses from Roman period sites in the Netherlands. (Relative compared to hand-collected material of cattle, sheep, goats and pigs).

settlement bones of horses are found among the normal settlement refuse.

If the bone material itself is considered, as far as it is described in the publications, three observations can be made: horse bones have few butchering marks compared with cattle bones, the horse bones are often complete or consist of large fragments, and many articulated elements are found.

Early investigation of the material from the *castellum* Valkenburg showed that the horse bones were not broken (Clason, 1960). The more recent excavation of the site around this army camp shows that the horse bones have few butchery marks compared to cattle bones, that there are high percentages of associated elements and that the bones are often complete or consist of large fragments (Gehasse, 1997). An identical pattern can be seen at Leiden-Roomburg: little fragmentation, the absence of chopping marks (except one case that will be discussed later), and the occurrence of associated bones. Little fragmentation and the absence of traces of butchering have also been established in the case of the military settlements at Zwammerdam (Van Wijngaarden-Bakker, 1970) and three military sites at Nijmegen (Ia; castra; canabae legionis) (Lauwerier, 1988: 150-155; table 68).

Although we find bones amongst the normal offal, these features underline the literary evidence that horsemeat was not eaten at military sites, nor at military sites in this northern part of the empire. Since the animals were not butchered and boned, fewer butchery traces are found and the bones are less fragmented. Peters (1994) suggests that the smaller degree of fragmentation may be connected with the decreased flavour of the marrow from horses which were generally older. However, even if marrow extraction is not involved, one would still expect to find just as many butchery marks as for cattle at the points of articulation, due to the disarticulation of parts of the skeleton. This is not usually the case. Of the three bones with traces from the *castra* at Nijmegen, there are two sawn through metatarsi, indicating manufacturing artefacts not butchering. In the *canabae legionis* and Nijmegen Ia no bones with any butchery marks were found at all. In addition to traces indicating the skinning of the animals at the military site Valkenburg-Marktveld, a few traces were also found which could be linked to the disarticulation of the carcass and stripping of flesh. For this reason, Gehasse (1997) does not exclude the sporadic consumption of horsemeat at this site. Sporadic, because the fragmentation is relatively slight and there are many associated bones. Based on these circumstances, the butchery marks could perhaps be better explained as resulting from the rough cutting off of large pieces of meat for the dogs. At Leiden-Roomburg more or less complete horse bones were found with traces of gnawing by dogs.

If horsemeat was not, or only rarely, eaten in military settlements, that implies that after the death of a horse a carcass was left with several hundred kilos of rotting, stinking meat. Within a densely populated settlement such as a fort or *vicus*, this would have been a very unpleasant problem, which would have been solved by removing the horse from the settlement. And that is what we find in the archaeological record. At the fort in Zwammerdam, the dead dogs and horses were thrown into the river Rhine at a location not far from the settlement (Van Wijngaarden-Bakker, 1970). The same was done with a horse discovered during an excavation carried out in 1962 in the immediate surroundings of the *castellum* of Leiden-Roomburg. Cavalry horses from the *castellum* of Kesteren were dumped at the place where a cemetery was later built (Lauwerier & Hessing, 1992). The dead horses from the Nijmegen *castra* were thrown, together with a great deal of other refuse, from a steep hill in the neighbourhood of the east exit of the army camp. Occasionally they were buried outside the army camp (Haalebos, 1993).

All these methods of refuse removal at least partly explain the much lower percentages of horse bone at military sites compared to native settlements. But the finds of skeletons also confirm that horse was not eaten normally in these military settlements. We can also conclude that it is clear that the percentage of horse bones in a settlement context does not actually say much about whether or not horses were eaten, but mainly about how dead or slaughtered animals were dealt with and where they were deposited.

HORSEMEAT AND NATIVE SETTLEMENTS

For a few native sites it has been concluded that, in view of the high degree of fragmentation of the bone and the many butchering marks, horsemeat probably was eaten. Such was the case with the settlement at Paddepoel (Knol, 1983) and the simple agrarian settlement at Houten-Doornkade (Taayke, 1984). At Rijswijk some of the horses

were slaughtered for consumption, others were not (Clason, 1978; Ket, 1987). It is also assumed for Schagen-Langedijk and Velsen-Hoogovens that horsemeat was eaten, but no mention is made of the grounds for this assumption (Van Wijngaarden-Bakker, 1988).

On the basis of the same above-mentioned criteria, it is concluded that horsemeat was not consumed at the native sites of Raalte-Heeten (Lauwerier *et al.*, 1999), Houten-Tiellandt (Laarman, 1996a), Wijk bij Duurstede (Laarman, 1996b), Druten I, Kesteren, Ewijk, Heteren, Nijmegen Ib-c, Nijmegen IV (Lauwerier, 1988: 162-164). Here we find a much lower degree of fragmentation and far fewer butchery marks in comparison with cattle from the same sites. One unusual skeleton from Houten-Tiellandt bearing very clear butchery marks, will be discussed later. According to Zeiler (1996), the butchery marks on the horse bones from Schagen-Wittepaal do not give a definite answer to this question. No statements on consumption have been made for the remaining sites.

All in all, we may conclude on the basis of the degree of fragmentation and the occurrence of butchery marks, that there were considerable differences between the native sites with regard to the consumption of meat. At some native sites horsemeat was probably eaten, but not at others. The consumption of horsemeat appears to have been customary particularly among some Frisian groups north of the *limes*, and in some settlements in the western part of the river area (Figure 1). Horsemeat was seldom or never eaten by the rest of the native population in the southern area. This may perhaps be connected with the prevailing Roman/military 'taboo' in these parts, but it may also have been (partly) an independent custom. Anyway, also in the preceding period, in the Iron Age, horsemeat was apparently only very rarely consumed by population groups that lived in the western Netherlands, Belgium and northern France (Ijzereef, Laarman & Lauwerier, 1992; Gautier, 1990).

It is noteworthy that at many native sites complete or partial articulated skeletons are found. That such skeletons occur at sites where horsemeat probably was not eaten is not surprising. Just as at the military sites, the carcasses were dumped. The difference is that horse carcasses in a military context were dumped outside the site as much as possible, but in the case of the mainly agrarian native settlements they were often dumped inside the settlement.

Whole or partial skeletons of horses, which were therefore not used for consumption, have also been found, however, at sites where horsemeat probably was sometimes eaten. This applies to Rijswijk where, among other things, a pit containing a complete skeleton (Ket, 1987) and one with two forelegs were found (Clason, 1978). At Velsen-Hoogovens two partial skeletons were discovered in a pit; and at Schagen-Langedijk three, all containing lower limbs (Van Wijngaarden-Bakker, 1988). The lower limbs could be primary slaughtering refuse. Whole or partial skeletons found at sites where horsemeat was eaten may generally be explained in two ways. Perhaps horsemeat was not a preferred food, so that meat from these animals, or at any rate parts of them were only eaten in times of famine, and the animals were buried in other circumstances. Another reason might be that the animals, or parts of them, were deposited as a ritual procedure. There is a third explanation in the case of complete skeletons: that animals unfit for consumption due to illness were dumped.

REASON FOR THE 'TABOO'

In the military settlements and most of the native settlements horseflesh was not used for consumption. So, horses in the Roman period were not only of economic and practical value. It is clear that, more than other farm animals, they also had an emotional value. The fact that there was in most cases a 'taboo' on the consumption of horsemeat is an indication that these animals were regarded as more than just meat on the hoof, which could also be used for riding purposes.

We can only speculate as to the reason for this avoidance. It may be based on the aversion to consuming `comrades', which in most of the contemporary western world applies to dogs, cats and usually horses. That this 'taboo' is not absolute and can be disregarded in times of famine, as was the case with the naval disaster and defeat of the Roman army referred to above, is an added argument in favour of such an explanation. It is comparable with the comrade dog, that is also eaten in Europe almost only in times of famine and bad social conditions (Geppert, 1990; Simoons, 1994: 240-241).

Another possibility is that horses were associated with religious or magical matters, and for that reason could not be eaten. Take, for example, the horse as a cult animal or as an attribute or symbol

of some deity or other. The horse, for instance, was an attribute of the Celtic horse-goddess Epona. Tacitus describes white horses which lived in sacred woods and which served as messengers between gods and humans (Germania 10). With this type of source, however, we do not know what the scope was and whether it covered the area discussed in this article.

There is no evidence that the horse served as a sacrificial animal at temple sites in the Netherlands, as was the case at other cult places from the pre-Roman period (Roymans, 1990: 79). Mainly young cattle were ritually slaughtered at the Gallo-Roman temples at Elst. Only one bone from a horse was found there (Lauwerier, 1988: 111-121). At Empel, too, the horse is virtually absent (Seijnen, 1994). The same applies to the Fortuna temple at Nijmegen (Zeiler, 1997). Here, apart from goats, cattle, quail and fish, it was mainly chickens that were burnt as sacrifices. A small quantity of bones were found in the ditches of a sanctuary at Oss-Ussen, which is dated to the Roman period. These are mainly from cattle, pigs, sheep or goats and from a dog. There were no horse bones (Lauwerier & Ijzereef, 1994: 240). From the absence of horse bones we concluded that the horse did not play any part in sacrifices or ritual meals in any of these temple complexes.

At other places there appear to have been ritual dealings involving horses (Lauwerier & Robeerst, 1997, in press). At the rather native *villa* of Druten two horses had been buried at the entrances of two buildings, apparently as building offerings (Hulst, 1978; Lauwerier, 1988: 104-111). And also in a native settlement at Wijster (225-360 AD) horses were probably used as building sacrifices as well as cattle (Clason, 1967; Van Es, 1967: plan V and VI).

At the Germanic settlement of Raalte-Heeten, which specialized in iron production, a total of twenty skeletons of cattle and horses were found, and one of red deer (Lauwerier *et al.*, 1999; Lauwerier & Groenewoudt, in press). Five skeletons of cattle and three of horses from a period from 310/320 to 345 AD at this site were found associated with the fence and entrance building. They might be explained as site offerings with which the settlement area was inaugurated or confirmed, a Germanic counterpart, as it were, of the Roman *suovetaurilia* offering. Moreover, one might also consider a function, such as site offering, for the animal graves from a later period at the above mentioned native site at Wijster, consisting of horses or combinations of horses and cattle and situated against or close to the enclosure (Van Es, 1967: plan VII). At the native settlement of Leidschendam-De Leeuwenbergh there was a single horse burial exactly at the entrance to a farmyard on the inside of the plot boundary (Wiepking, 1997). This horse, dating to between 120 and 180 AD, also qualifies as a site offering. A young horse and two dogs, discovered during the same excavation on the premises of what had possibly been a cult place, could also have ritual significance.

A clear indication of possible ritual use of horses in a military context comes from the *castellum* of Leiden-Roomburg, Roman *Matilo*. In the fill of the Corbulo Canal, *the Fossa Corbulonis*, exceptionally heavily chop marked, but complete bones, partly belonging together, were found on a spot where a bronze mask and several unused coins were also unearthed. It is suggested that these finds may form part of a votive offering (Enckevort & Hazenberg, 1997; Lauwerier & Robeerst, 1998, in press).

The use of horses for such ritual purposes could be the reason for a taboo on eating their flesh. Nevertheless, if we consider that cattle also served this kind of ritual or magic purpose, but that this did not result in a taboo, and the fact that in time of famine the 'taboo' could be broken, the first mentioned explanation, the aversion to consuming 'comrades', would in general seem to be the most likely reason for the avoidance of horsemeat.

A RITUAL HORSE MEAL

Most remarkable is a group of horse bones found in Houten-Tiellandt, a native site south of the *limes* (50-300 AD) (Laarman, 1996a). In a pit there were altogether 87 bones of one approximately five-year-old mare, but they were not in anatomical connection. The other unusual thing about this skeleton is that it shows cutting and chopping marks on all bones (Figure 4). If this animal had been slaughtered for normal human consumption, not all the bones would have remained together, since carcass sections would have been removed, bones and all, as can be seen everywhere else. Laarman (1996a) assumes that the animal died from natural causes and that the flesh was stripped off and fed to dogs. In that case, however, no clear traces of butchering would have remained. Particularly the butchering marks on the vertebrae and the cut through ribs indicate pieces of meat on the

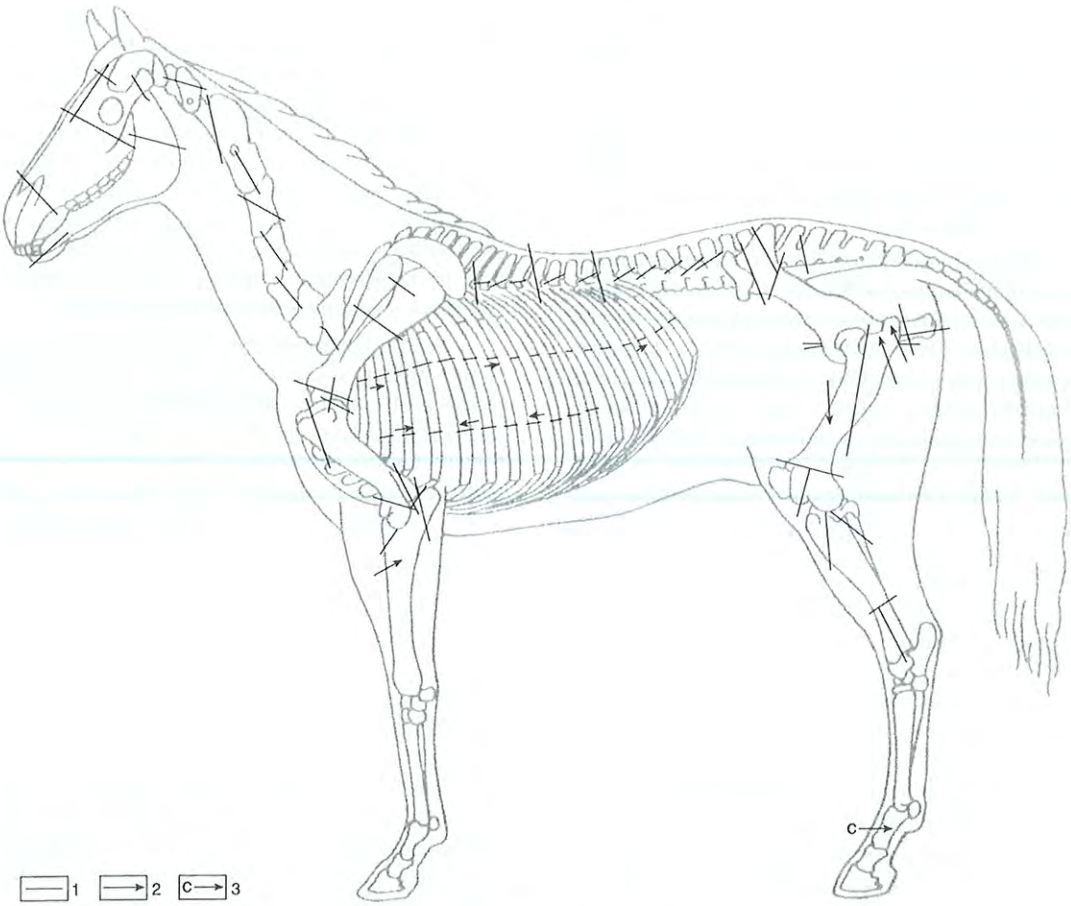

FIGURE 4
Houten-Tiellandt: cutting and chopping marks on the bones of a mare which were not assembled anatomically. Legend: 1 chopped through; 2 chopping mark; 3 cutting mark (after Laarman, 1996a: figure 66).

bone. If these pieces had been fed to the dogs there would certainly have been gnawing marks on them, but they are absent. Moreover the bones would have been scattered by the dogs.

The fragmentation and butchery marks indicate slaughter for consumption. What is striking is that, although the other finds from Houten show that horsemeat was not eaten, this horse had been consumed and yet all the remains stayed together after consumption. This cannot have been a normal pattern of consumption. About two hundred kilograms of horsemeat must have been eaten near the find pit within a short space. This extremely concentrated, probably once-only consumption of such a large quantity of meat from an animal which was not normally eaten makes one suspect that these were the remains of a ritual meal.

One can only speculate as to its significance. The relatively large quantities of bones from apparently uneaten horses elsewhere on the excavation site indicate that the horse must have played an important part in the economy of Houten; Laarman (1996a) suggests the breeding of these animals. The eating of horse may have been part of a ritual in honour of a horse deity connected with such activities. But this is pure speculation.

CONCLUSION

Written as well as archaeological sources indicate that the consumption of horsemeat in the Roman military world was subject to a kind of taboo. This avoidance of horseflesh is reflected in

the archaeozoological record of military settlements in the Netherlands. Although bones of horses are found among the 'normal' offal, the bones are little fragmented, often complete and articulated and frequently found as complete skeletons. The 'taboo' was probably mainly based on the principle that one does not eat one's comrades and in general had no religious or magical background.

The avoidance of eating horse was not general among the native population. At various places north of the *limes*, in the area of the Frisii, and in the western part of the river area, some groups did eat horsemeat. In the rest of the land occupied by the Romans the natives did not eat horse. Possibly this 'taboo' was influenced by Roman presence, but older, native habits are not excluded.

From the foregoing it can be concluded that the fact that eating horsemeat was forbidden in later periods cannot so much be seen as a Christian tradition but primarily an adopted Roman, and partly even native, habit. The few known papal bans on the consumption of horsemeat known from medieval times, at the most indicate that the already existing taboo was christianized.

The Roman army usually dumped their dead, uneaten horses outside the military camps and *vici*; at native settlements the horses were dumped inside the site, more often than in military settlements.

Occasionally the horse served a ritual purpose. Only at various native sites, were horses used as building or site sacrifices, sometimes in combination with other animals. The only possible ritual use identified at a military context is at the military *vicus* at Leiden. These horse bones, together with a mask and unused coins may be part of a votive offering. There are, however, no indications that the flesh of the horses that were ritually used by the natives or by the soldiers, was used for consumption.

A completely different phenomenon linked with ritual use is the complete skeleton of a horse from the native settlement of Houten-Tiellandt, which had clearly been butchered for consumption. It is regarded as the remains of a ritual meal eaten by the inhabitants of a settlement where horsemeat was not normally consumed.

From a methodological point of view we can conclude that, if we want to know whether the flesh of an animal had been eaten, apart from written sources, we have to look at a variety of factors such as nutritional value, fragmentation, articulation, the place and form of chopping and cutting traces, the occurrence of complete or partial skeletons and especially the context in which the animal remains are found. The percentage of the animal remains alone does not say much about this question.

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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. Oberste 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 analyses[1]. 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 alone[2]. 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 settlements[3].

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 models[4].

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 area[5], also in historic sources from Central Europe[6] and in a few ethno-

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

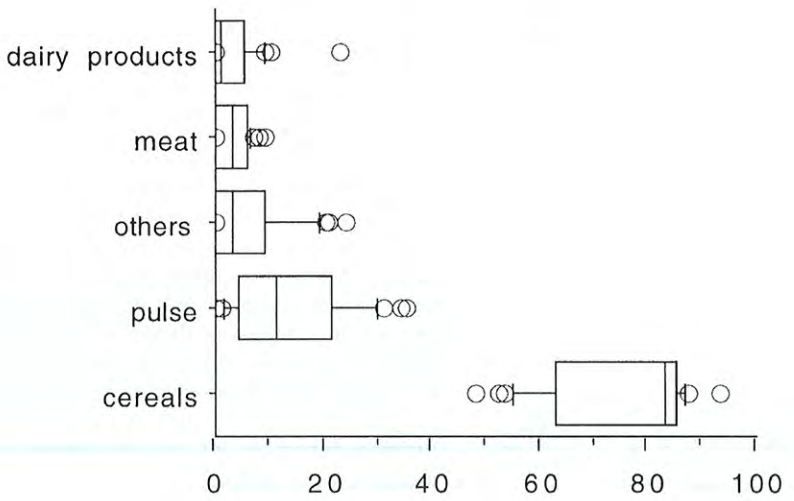
[2] Detailed discussion about problems of quantification can be found in Gross, Jacomet & Schibler (1990).

[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 Himalaya[7]. 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 protein[8].

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 vitamines 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 hemps, 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

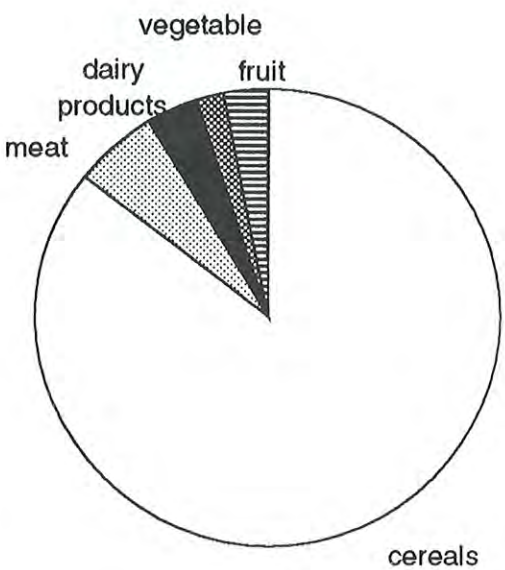


FIGURE 2
Daily calories input per category of food for a village in the Hunza valley, Karakorum (after Kreutzmann, 1989). Basis of calculation: average percent of total calories per person and day.

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

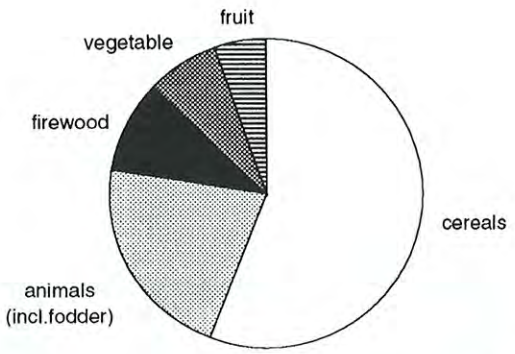


FIGURE 3
Calculated working time per activity expressed as percent of year average for the same village as in Figure 2 (after Kreutzmann, 1989).

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 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.

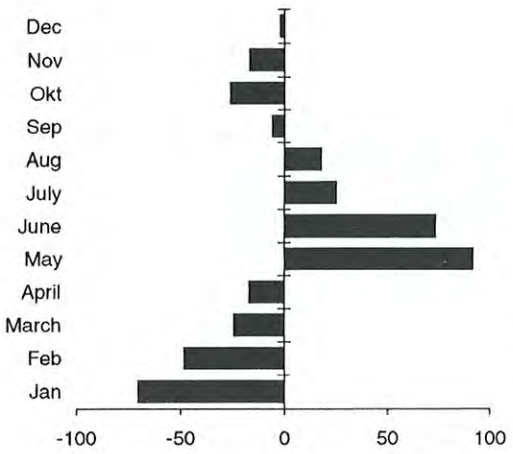


FIGURE 4
Distribution of working hours over the year. Divergence from the year-round-average per month in percent (after Kreutzmann, 1989). Left side (negative values): manpower surplus, right side (positive values): manpower deficit.

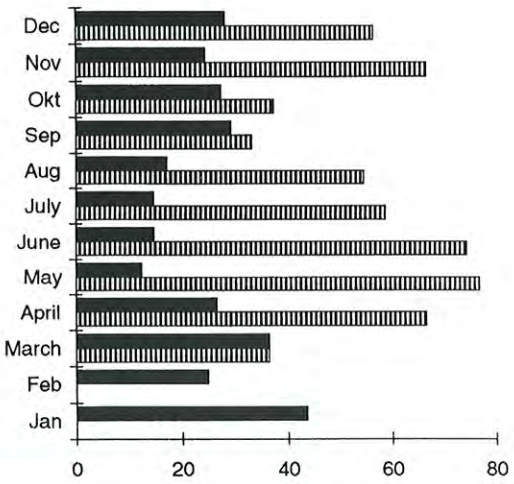


FIGURE 5
Distribution of working hours over the year for two different important activities: producing cereals (striped bars) and cattle breeding (black bars). Basis of the calculation are percent of monthly average (after Kreutzmann, 1989).

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.

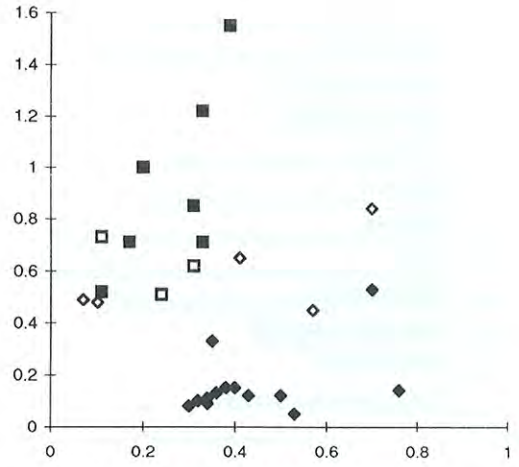


FIGURE 6
Number of cattle per head (y-axis) and hectares of arable land per head (x-axis) for 29 villages. Squares indicate villages practising any forms of transhumance, rhombs indicate villages without transhumance. Open symbols present villages with important ovicaprids breeding (i.e. the number of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

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).

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.

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 unrealistical.

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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1000 years (6th to 16th century) of Economic Life in the Heart of Europe. Common and distinct Trends in Cattle Economy of the Baltic Sea Region and the Swiss Region of the Alpine Forelands

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ABSTRACT: The Middle Ages in Europe are often regarded as "dark centuries" because of famines and pestilence. However, they were also undoubtedly the cradle of modern times. A number of innovations took place leading to a more intensive agriculture. As a result the population increased rapidly during this period. This development should be reflected in the archaeological material. The aim of our investigation was to examine whether sites from such strikingly different regions like the Baltic Sea and the Alpine Forelands fit into a model of supra-regional phenomena. A further question was to examine to what extent local economy and/or ecology influence the frequency of different species and the size of domesticated animals. Our data suggest that we have to reckon with supra-regional phenomena that were strongly influenced by climatic developments. However, it can also be seen that in small regions economic life is strongly correlated with cultural history (e.g. the social status of the consumer), the political environment, and geographic and ecological requirements.

KEYWORDS: MIDDLE AGES, SWITZERLAND, GERMANY, ECONOMY, ECOLOGY, OSTEOMETRY, CATTLE, PIG, SHEEP/GOAT, SOCIAL STATUS, RURAL SETTLEMENT, URBAN SETTLEMENT, CASTLE

RESUMEN: La Edad Media en Europa se considera normalmente como la "edad tenebrosa" debido a las hambrunas y a la peste. Sin embargo, fue también, sin duda, la cuna de los tiempos modernos. Una serie de innovaciones condujeron, entre otros, a una agricultura más intensiva. Como resultado de ello la población aumentó rápidamente durante este periodo. Tal desarrollo debería quedar reflejado en el registro arqueológico. El objetivo de nuestra investigación consistía en comprobar si yacimientos de zonas tan marcadamente distintas como el Mar Báltico y las regiones prealpinas pueden encuadrarse dentro de un modelo de fenómenos supraregionales. Una cuestión adicional consistió en examinar en qué medida la ecología y/o la economía local determina la frecuencia de ciertas especies así como la talla de los animales domésticos. Nuestros datos sugieren que debemos tener en cuenta fenómenos supraregionales que se vieron fuertemente influenciados por parámetros climáticos. No obstante, podemos asimismo comprobar que en zonas restringidas la vida económica se correlaciona en gran medida con la historia cultural (por ejemplo, el estatus social del consumidor), el entorno político así como con peculiaridades geográficas y ecológicas.

PALABRAS CLAVE: EDAD MEDIA, SUIZA, ALEMANIA, ECONOMÍA, ECOLOGÍA, OSTEOMETRÍA, GANADO VACUNO, GANADO PORCINO, OVICAPRINOS, ESTATUS SOCIAL, ASENTAMIENTO RURAL, ASENTAMIENTO URBANO, CASTILLO

[1] Authors in alphabetical order.

INTRODUCTION

The Middle Ages in Europe embrace a period of about 1000 years: from 500 to 1500 AC. This period is characterized by the adherence to old traditions as well as by important technical innovations particularly in the field of agriculture. The introduction of the three-field-system and the one-way-plough for example led to more intensive agriculture. This entailed a rapid population increase in the High Middle Ages (between 1100 and 1300 AC, Grupe, 1990).

The aim of this paper is to find out if sites from different climatic and geographic regions fit into a model of supra-regional trends in medieval cattle economy or if they depend on regional or local developments. For our analysis we chose two regions that lie 1.000 km apart: The Swiss plateau including the Jura mountains and the Rhine valley completed by some sites in Eastern France and Southern Germany and the Baltic Sea Region of Northern Germany.

MATERIAL AND METHODS

The topography, the climate and the cultural and historical development of both of the regions differ greatly. The Alpine Foreland Region in Switzerland is characterized by the hilly landscape of the Swiss plateau, the Jura mountains and a relatively plain area along the Rhine valley. This area has a long historical tradition and was part of the Roman empire for more than 400 years. In contrast, the topography of the Baltic Sea Region is almost completely plain with no elevations over 150 meters. Before becoming a political and economic center of the Danish Viking empire, this region was almost uncolonized. According to the contemporary historian Adam von Bremen, this part of Europe was covered by impenetrable forest before the first settlements were established in the 9th century (after Abel, 1978b). The following analysis is based upon the faunal assemblages of 28 sites with 53 different chronological phases and approximately 250.000 bone fragments (Table 1). From the archaeozoological point of view the most important sites of the Alpine Foreland Region are the town of Basel and the canton and the town of Schaffhausen. The best investigated medieval settlements in northeastern Germany are the port-and trade-towns of Haithabu, Schleswig and Lübeck.

To ensure the comparability of our data we selected only bone assemblages with more than 150 identified bones that were dated within a time span of 200 years or less. We excluded water-sieved material from latrines and special deposits from e.g. tanning or bone workshops.

Unfortunately the different types of settlements like villages, towns and castles are not represented equally through the different phases of the Middle Ages. In the early period from the 6th to the 9th century the farmstead with wooden houses was the normal case of settlement in the Alpine Foreland. From the 11th century on, we are quite well informed about the life in towns but we lack almost every archaeological record of rural settlements. Furthermore, castles are very well represented from the 12th to 15th century in the southern region of the investigated areas. In earlier periods our knowledge of this type of settlement is very poor.

Concerning the archaeozoological research in the Baltic Sea Region mostly urban settlements dating from the 9th to 11th century are well examined.

RESULTS AND DISCUSSION

To show the variation of the bone-frequencies of the domestic animal species cattle, sheep, goat and pig through the centuries we use box-plots in addition to conventional column graphs.

The faunal remains from sites of the Alpine Forelands and the Baltic Sea show a more or less similar composition of animal species (Table 1). Cattle are the most important domestic animal followed by pig and sheep/goat. Game animals like red deer or wild boar played a relatively unimportant role in the economic life of these sites.

In both the northern and the southern sites increasing frequencies of cattle bone can be detected in the course of the Middle Ages (Figure 1 and Figure 2). This trend is more distinct in the Baltic Sea sites. Furthermore, higher variation of cattle frequencies was observed in the Alpine Foreland sites from the 14th to the 16th century. On the other hand, sheep/goat and pig bone frequencies decreased from the 6th to the 16th century in both regions. A possible explanation for these trends is the increase of cleared woodland and the intensification of grain cultivation particularly in the High Middle Ages. This development, for example, is documented very well for the Zurich

Site	Short-cut	Type of settlement	Dating AC	NISP domestic animals	NISP% domestic animals	NISP wild animals	NISP% wild animals	No. wild animal species	NISP% cattle	NISP% sheep/goat	NISP% pig	References
Alpine Forelands:												
Schleitheim-Brüel	Schleit 6./7.	rural	6th/7th cent.	3914	99.1	35	0.9	3	50.5	17.7	29.7	Rehazek in prep. a
Lausen-Bettenach	Lausen 6./7.	r	6th/7th cent.	1183	96.7	40	3.3	15	30.3	18.3	39.7	Hüster-Plogmann & Veszeli unp.
Basel-Reischacherhof, D+E	ReischD/E 7./8.	urban	7th/8th cent.	1041	99.0	10	1.0	5	33.2	19.7	38.2	Morel unp.
Berslingen, Ph2b	Bers2b 8./9.	r	8th/9th cent.	629	93.7	42	6.3	2	39.2	18.8	31.4	Rehazek in press
Basel-Reischacherhof, C	ReischC 9./10.	u	9th/10th cent.	190	98.9	2	1.1	2	32.3	30.7	28.6	Morel unp.
Basel Schneidergasse 1	Schneider1 10.	u	10th cent.	804	99.6	3	0.4	2	18.0	56.0	23.9	Reich 1995
Basel Schneidergasse 4	Schneider4 10./11.	u	10th/11th cent.	646	99.7	2	0.3	1	39.8	34.7	23.0	Reich 1995
Berslingen, Ph3b	Bers3b 10./11.	r	10th/11th cent.	356	99.7	1	0.3	1	48.7	15.4	23.5	Rehazek in press
Basel-Barfüsserkirche, total	BarfüssTot 11.	u	11th cent.	3767	99.7	11	0.3	7	50.3	37.4	9.8	Schibler/Stopp 1987
Basel Schneidergasse 2	Schneider2 11.	u	11th cent.	1483	99.8	3	0.2	2	26.7	47.1	23.1	Reich 1995
Habsburg Splittplanie	Habssplitt 11.	castle	11th cent.	211	88.3	28	11.7	5	13.0	19.2	53.6	Veszeli & Schibler 1998
Habsburg untere Kulturschicht	HabsUK 11.	c	11th cent.	756	95.0	40	5.0	8	20.9	19.8	51.0	Veszeli & Schibler 1998
Berslingen, Ph4	Bers4 11./12.	r	11th/12th cent.	418	98.4	7	1.6	3	28.5	22.6	43.1	Rehazek in press
Basel-Reischacherhof, A+B	ReischA/B 11./12.	u	11th/12th cent.	1916	99.2	15	0.8	6	25.2	32.4	36.9	Morel unp.
Basel Schneidergasse 5	Schneider5 11./12.	u	11th/12th cent.	648	99.8	1	0.2	1	33.2	38.5	28.5	Reich 1995
Eptingen, Riedfluh	Riedfl 11./12.	c	11th/12th cent.	2036	95.3	100	4.7	6	42.6	18.5	28.4	Kaufmann 1988
Salbüel	Salbüel 11./12.	c	11th/12th cent.	716	98.8	9	1.2	5	9.0	29.8	58.6	Morel 1991
Winterthur, Phase II	WinterII 11./12.	u	11th/12th cent.	661	99.6	3	0.5	2	33.9	16.4	44.6	Hartmann-Frick 1994
Basel-Barfüsserkirche, total	BarfüssTot 12.	u	12th cent.	782	99.1	7	0.9	6	20.4	54.5	19.8	Schibler/Stopp 1987
Zürich Münsterhof A	MünsterhA 12.	u	12th cent.	932	95.8	41	4.2	12	12.5	46.1	14.6	Csont 1982
Berslingen, Ph5	Bers5 12.	r	12th cent.	449	97.2	13	2.8	2	54.5	16.5	23.8	Rehazek in press
Winterthur, Phase III	WinterIII 12./13.	u	12th/13th cent.	926	99.1	9	0.9	3	43.7	19.9	33.2	Hartmann-Frick 1994
Zug Kaufhaus, I-III	KaufhI-III 12./13.	u	12th/13th cent.	470	99.4	3	0.6	3	23.7	31.9	41.0	Rehazek in prep. b
Basel Schneidergasse 6	Schneider6 12./13.	u	12th/13th cent.	635	100.0	0		0	31.8	42.2	23.8	Reich 1995
Burg Grenchen	Grench 12./13.	c	12th/13th cent.	1453	96.3	56	3.7	6	44.2	11.5	38.1	Stampfli 1962
Salbüel	Salbüel 12./13.	c	12th/13th cent.	415	99.0	4	1.0	2	31.0	15.0	53.0	Morel 1991
Habsburg obere Kulturschicht	HabsOK 12./13.	c	12th/13th cent.	1350	89.9	151	10.1	21	11.9	8.8	62.0	Veszeli & Schibler 1998
Basel-Augustinergasse, Latr. 1-4	August1-4 13.	u	13th cent.	1260	99.5	6	0.5	3	15.6	26.4	25.3	Schibler 1995
Basel Schneidergasse 3	Schneider3 13.	u	13th cent.	454	99.1	4	0.9	3	18.1	53.7	23.8	Reich 1995
Basel-Barfüsserkirche, total	BarfüssTot 13.	u	13th cent.	3631	99.5	20	0.5	15	27.1	45.9	21.1	Schibler/Stopp 1987
Zürich Münsterhof C	MünsterC 13.	u	13th cent.	887	96.8	29	3.2	7	17.7	52.2	19.9	Csont 1982
Stadtkirche St. Johann G4	JohannG4 13.	u	13th cent.	548	68.1	257	31.9	8	15.9	12.3	15.3	Markert 1990; Markert unp.
Winterthur, Phase V	WinterV 13.	u	13th cent.	425	99.8	1	0.2	1	35.9	28.7	31.0	Hartmann-Frick 1994
Gelterkinden, Scheidegg	Scheidegg 13.	c	13th cent.	269	85.4	46	14.6	6	27.0	3.2	40.0	Kaufmann 1975
Nidau-Schloss U	NidauU 13.	c	13th cent.	4190	95.7	190	4.3	26	9.6	6.3	64.8	Büttiker/Nussbaumer 1990
Nidau-Schloss M	Nidau M 13./14.	c	13th/14th cent.	1123	89.5	134	10.5	17	15.4	11.8	42.0	Büttiker/Nussbaumer 1990
Heitnau	Heitnau 13./14.	c	13th/14th cent.	390	99.0	4	1.0	1	32.2	9.6	50.3	Hartmann-Frick 1957
Gräpplang O	GräppO 14.	c	14th cent.	306	95.9	13	4.1	5	20.7	13.2	27.3	Würgler 1961
Zug Kaufhaus, IVb	KaufIVb 14./15.	u	14th cent.-1430	470	99.6	2	0.4	2	32.0	41.0	14.2	Rehazek in prep. b
Nidau-Schloss O	NidauO 15./16.	c	15th/16th cent.	375	72.8	140	27.2	9	12.0	11.7	35.3	Büttiker/Nussbaumer 1990
Habsburg Graben	HabsGr 16.	c	16th cent.	545	97.1	16	2.9	6	48.8	6.2	39.6	Veszeli & Schibler 1998
Haut Koenigsbourg	Koenig 15./17.	c	1450-1630	3359	97.7	79	2.3	5	73.6	6.9	14.4	Arbogast 1993
Zug Casino	Casino 16./17.	u	16th/17th cent.	181	98.4	3	1.6	2	78.3	4.9	14.1	Rehazek 1998
Baltic Sea:												
Haithabu	Hb1	u	9th cent.						30*	18*	52*	Haithabu div. authors
Haithabu	Hb2	u	10th cent.	224671	98.8	2821	1.2	99	37*	16*	47*	Haithabu div. authors
Haithabu	Hb3	u	10th/11th cent.						40*	15*	45*	Haithabu div. authors
Schleswig-Schild	Sl11.	u	11th cent.						40	35	25	Schleswig div. authors
Schleswig-Schild	Sl12.	u	12th cent.	110799	97.6	2672	2.4	67	46	32	22	Schleswig div. authors
Schleswig-Schild	Sl13.	u	13th cent.						50	25	25	Schleswig div. authors
Schleswig-Schild	Sl14.	u	14th cent.						46	26	29	Schleswig div. authors
Lübeck-Heiliggeist Hospital	HL13-15	u	13th/15 cent.	5793	99.5	26	0.5	5	49*	19*	31*	Pudeck 1980
Lübeck-Königsstrasse	HL15	u	15th cent.	4027	99	40	1	8	65*	15*	20*	Paul 1980
									* estimated values			

TABLE 1
Analyzed faunal assemblages from the different archaeological sites/phases and their datings.

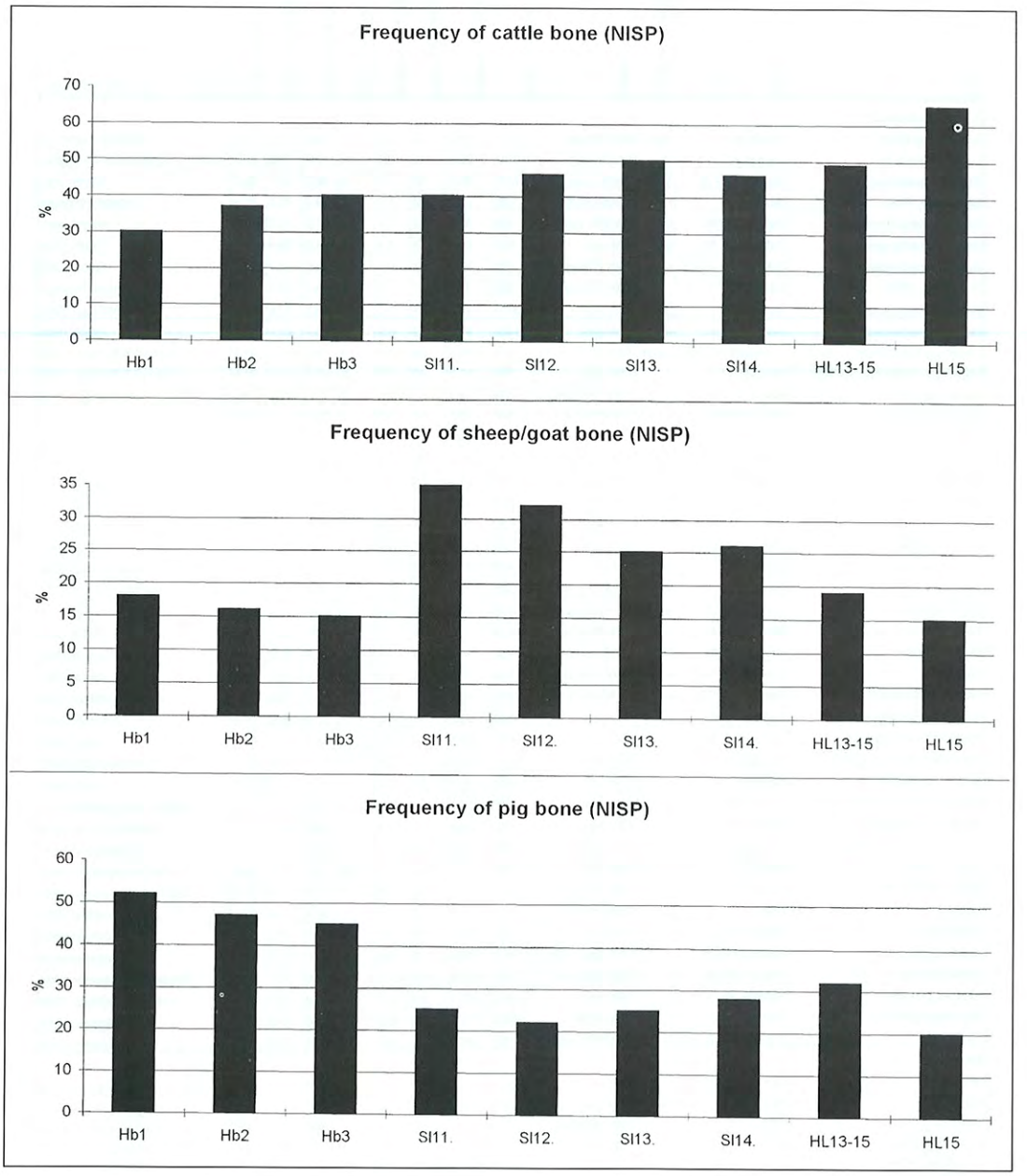
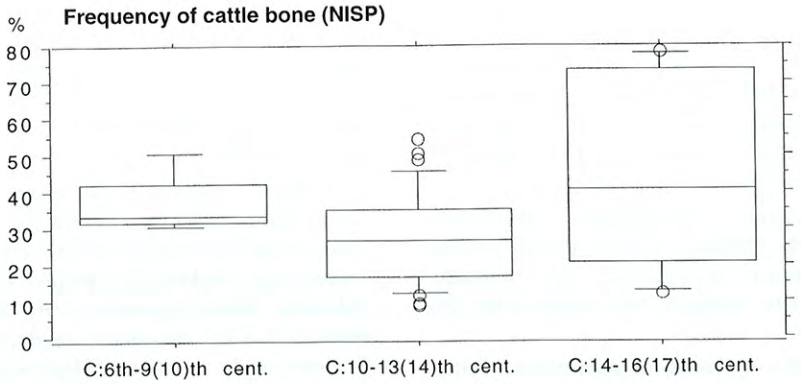
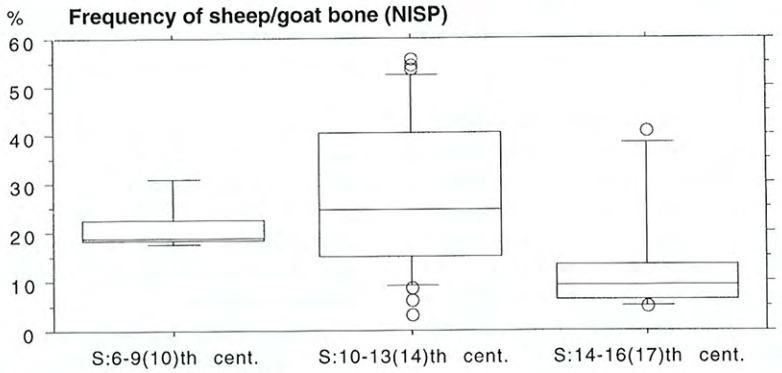


FIGURE 1
Frequency of cattle, sheep/goat, and pig bone (NISP) from the Baltic Sea Region, 9.-15th century.





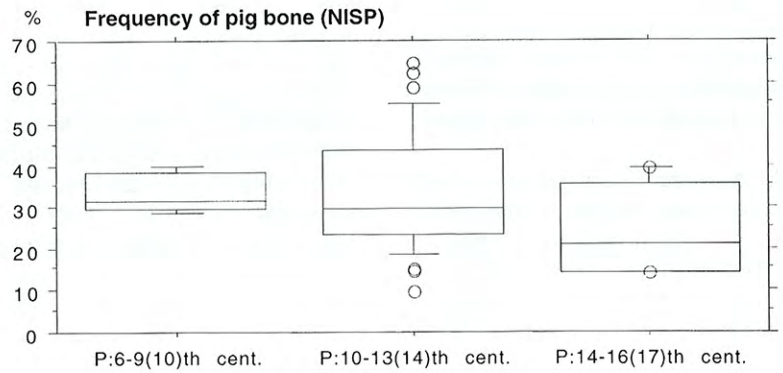


FIGURE 2

Frequency of cattle, sheep/goat, and pig bone (NISP) from sites of the Early, High and Late Middle Ages of the Alpine Forelands. Each box plot is composed of five horizontal lines representing the 10th, 25th, 50th and 75th percentile of a variable, in this case the frequencies of the four different animal species. The values below the 10th and above the 90th percentiles are outliers. Number of analyzed sites: 6th-9th/10th century (n=5), 10th-13th/14th century (n=32), 14th-16th/17th century (n=6).

region (Stromer, 1995) and the area of Schaffhausen, which shows a very one-sided intensification of meadowland (Rehazek, in press). An open landscape (with a high percentage of meadowland) favors the keeping of cattle. In addition, a decrease in woodland entails a diminished food supply for small livestock, particularly for the pigs.

Further questions concerning the consumption and perhaps the breeding of domesticated animals are the differences between the types of settlements like towns, villages, and castles in the different regions.

Cattle seem to be more frequent in rural settlements than in towns or castles in the Alpine Forelands (Figure 3). A comparison between the North and the South shows that the people in the urban sites of both had a very similar amount of cattle.

The situation is different for sheep and goat (Figure 3). Most of the sheep and goat bones were found in the southern towns with large differences from town to town. Again, the amount of sheep or goat bone in rural settlements of the Alpine Forelands and towns of the Baltic Sea is quite similar. However, the percentage of sheep bone in castles is relatively low. Pig bones, together with poultry and wild animals, are found in castles more often than in every other kind of settlement (Figure 3). This is not very surprising, because according to historical records from the Southern feudal lords collected animals like pigs and poultry as taxes from unfree farmers (reference follows). As a consequence, we would expect the consumption of those animals to be relatively low in rural settlements which it turned out to be.

It is not very astonishing that beef was in contrast very common among farmers in the villages. Cattle were needed to do the fieldwork and they produced goods like milk, leather, dung, etc. After they grew old and unproductive they were slaughtered.

In the Middle Ages the citizens of towns had also the right to keep some animals for their own use (Borst, 1983). Many of them were obviously sheep or goat. These so called "cows of the poor men" may have been chosen because of their modest requirements and their ability to produce milk and wool.

The different percentages of domestic animals in towns of the Alpine Forelands and the Baltic Sea region need an explanation. The results show that the kitchen refuse found in northern towns is very similar to that found in rural settlements of the South. We suggest that this is caused by different cultural conditions. As we briefly mentioned above, Scandinavia was disconnected from cultural life in Europe up to the 9th century. The lack of 300 years of agriculture may have resulted in a "rural town life".

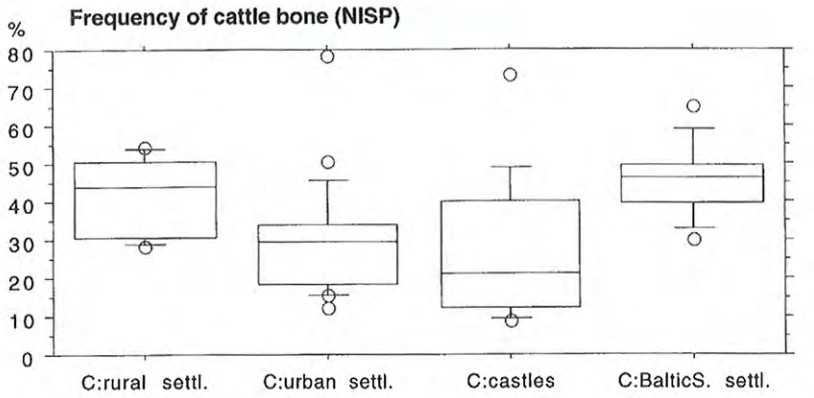
Cattle size, which is related to genetic predisposition, fodder quality, and breeding-know-how, provides further information on the economic circumstances in the Middle Ages. We used the LSI-method (Meadow, 1984; Uerpmann, 1990) with a standard individual of 117 cm withers height. The individual is a cow of the traditional "Hinterwälder" breed of Southern Germany and Northern Switzerland.

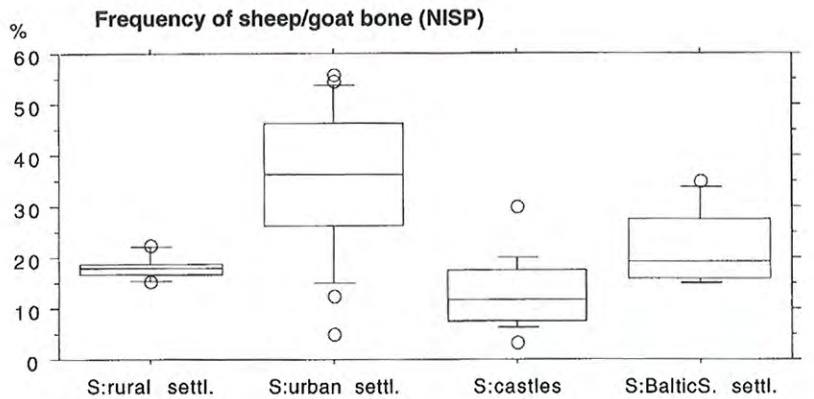
As shown on Figure 4, the size of southern cattle decreased up to the 12th century whereas the size of northern cattle increased (Figure 5).

In our opinion this is a result of agricultural tradition. After the Romans left the Alpine Forelands in the 4th century there was a slow and continuous decrease in cattle size. Perhaps, cattle breeding did not collapse right away because some knowledge and/or Roman tradition was still present and the region was always more or less cultivated (Breuer *et al.*, in press). On the other hand, the settlers in the north first had to convert the primary forest into arable land before they had long-term success in cattle breeding.

However, the look at the box plots shows a further striking feature: In the South, the size of cattle decreased remarkably in the 11th century and in the North in the 13th century. The question is why. This period is known as a climatic optimum with warm summers (Glaser & Schenk, 1995) and was characterized by an increasing human population. To feed the whole population as much grain as possible was cultivated. This meant that cattle was fed on more or less poor land. This is documented by historical records in the 11th century in Switzerland (Stromer, 1995) and, with a delay of almost 200 years, in the 13th century in northern Germany (Abel, 1978b; Kuhlmann, 1958). As a result the animals were smaller than in the preceding periods.

Admittedly, cattle were small in the Middle Ages. However, while there were differences in size up to the 13th century the animals remained remarkably small in both regions from the 13th to the 15th century. Diminished cattle size concurred with the agricultural crisis in the very early 14th century that was accompanied by bad weather conditions, poor harvests, famines and pestilence. But although historical records tell us about the





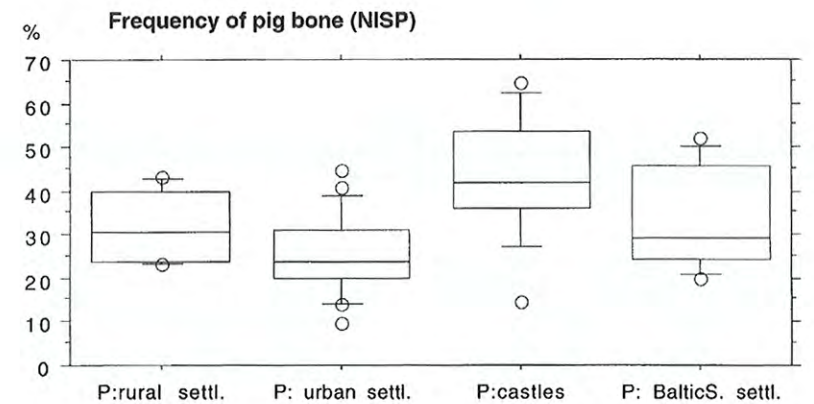


FIGURE 3

Frequency of cattle, sheep/goat and pig bone (NISP) from the different types of settlements (rural, urban, castle). Baltic Sea Region and Alpine Forelands, 6th-16th/17th century. Each box plot is composed of five horizontal lines representing the 10th, 25th, 50th and 75th percentile of a variable, in this case the frequencies of the four different animal species. The values below the 10th and above the 90th percentiles are outliers. Number of analyzed sites: rural settlements (n=22), urban settlements (n=16), castles (n=15), Baltic Sea settlements (n=9).

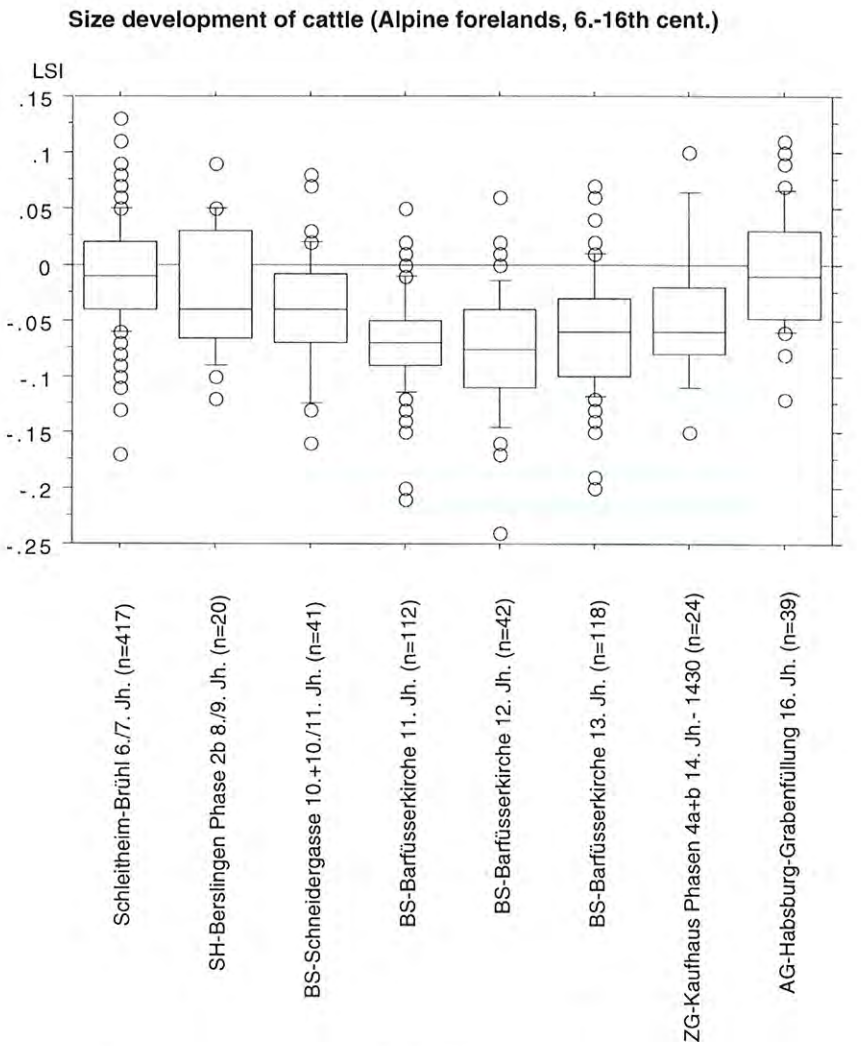


FIGURE 4
Size development of cattle. Alpine Forelands, 6th-16th century. Each box plot is composed of five horizontal lines representing the 10th, 25th, 50th and 75th percentile of a variable, in this case the logarithmic size index LSI.The values below the 10th and above the 90th percentiles are outliers. Zero-line: Standard individual (withers height 117 cm).

intensification of cattle breeding after the "black death" in the middle of the 14th century (Abel, 1978a), cattle size remained low up to the 16th century. From the 16th century onwards cattle size increased and led to our modern cattle breeds.

CONCLUSION

It can be concluded that supra-regional phenomena may have been influenced primarily by climatic developments. However, within small regions, economic life was strongly correlated with cultural history, the political environment and geographic and ecological requirements. Thus our aim must be to compare regional, archeologically classified data first and then look for supra-regional phenomena.

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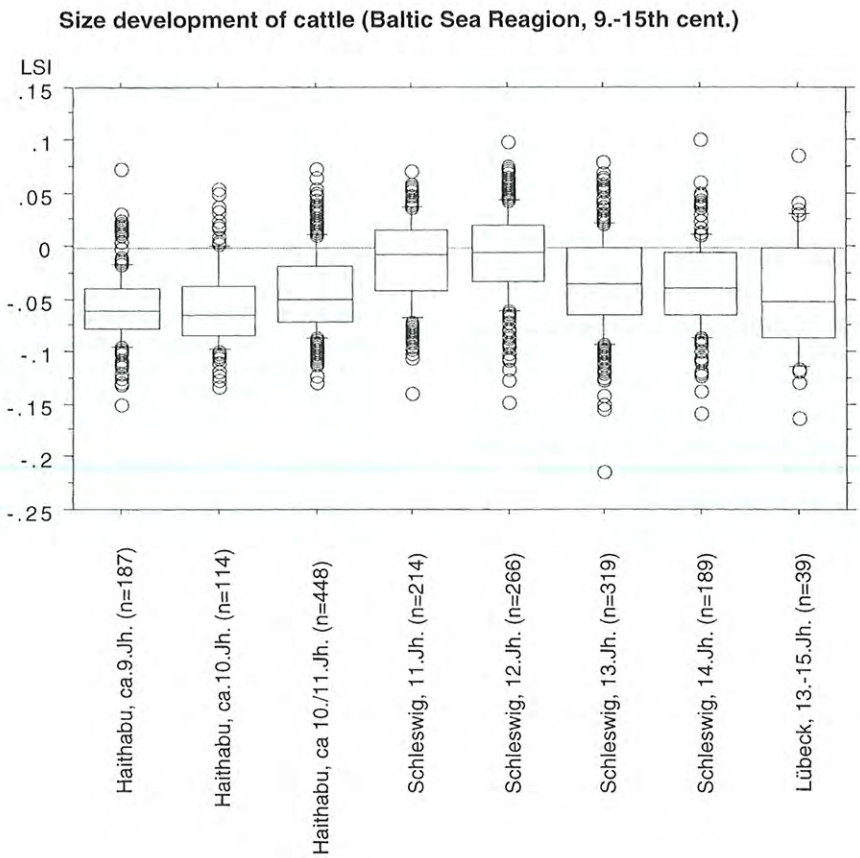

FIGURE 5
Size development of cattle. Baltic Sea Region, 9th-15th century. Each box plot is composed of five horizontal lines representing the 10th, 25th, 50th and 75th percentile of a variable, in this case the logarithmic size index LSI.The values below the 10th and above the 90th percentiles are outliers. Zero-line: Standard individual (withers height 117 cm).

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How to fill a Pit: Examples from the Late Iron Age Settlement of Basel-Gasfabrik (Switzerland)[1]

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ABSTRACT: A comparison is made between the bone material of pits and cultural layers of the late Iron Age settlement of Basel-Gasfabrik (Switzerland). The question of whether the pits contain other bone refuse than the cultural layers is explored by taking a look at the history of deposition by comparing species ratios and bone preservation.

KEYWORDS: LATE IRON AGE, TAPHONOMY, SWITZERLAND, BASEL-GASFABRIK, ARCHAEOZOOLOGY, PITS, FILLING PROCESS

RESUMEN: El trabajo compara los depósitos de osamentas de fondos y niveles culturales en el yacimiento del Hierro final de Basel-Gasfabrik (Suiza). La cuestión de si los desechos óseos entre fondos y niveles difieren apreciablemente se investiga analizando la génesis de los acúmulos a través de una comparación entre proporciones de especies y estado de conservación de los restos.

PALABRAS CLAVE: HIERRO FINAL, TAFONOMÍA, SUIZA, BASEL-GASFABRIK, ARQUEOZOOLOGÍA, FONDOS, COLMATACIÓN

INTRODUCTION

The late Iron Age settlement of Basel-Gasfabrik, which dates from c. 150/140 to 80/70 BC, is located on the left bank of the Rhine, less than 2 km from Basel's modern city center in the northwest of Switzerland. The unfortified settlement occupied an area of about 12 hectares. To date, the settlement is essentially represented by over 300 pits. Other archaeological structures, such as cultural layers, are very rare. The original function of the pits is unknown. Despite their diversity in form and depth, they are all thought to constitute former storage or even workplaces that were then abandoned and refilled. Apart from sediments of different origins, the pits contain kitchen refuse and potsherds, parts of house structures and the remains of craftmen's activities. Although there is a cemetery nearby, some of the pits contain either one to several human skeletons or fragments of human bones.

Under these circumstances the question arises as to what sort of refuse the pits contain. Do we have the bone scraps typical for a settlement, i.e. normal waste from cooking or from the slaughter of animals, or were the pits used to store a special kind of waste? This is a question as old as archaeozoology itself.

One way of answering this question is to compare bone material from the pits with the few resi-

[1] Paper held at the ICAZ-congress 1998 in Victoria B.C.

dues investigated to date from cultural layers found outside the pits.

Since the animal bones have not yet been fully examined, the following remarks should be considered as interim results gathered over the last three years.

MATERIAL AND METHODS

The sedimentological material that composes the cultural layers is termed "dark earth". This sediment consists of former topsoil material that has undergone massive mechanical and chemical changes. Sediment of comparable composition is generally also found in the upper third of the pit fillings. It may therefore be assumed that the sediments formed in a similar manner. The material from the cultural layers was generally relocated several times before its final deposition (Rentzel, 1998).

The lower two thirds of the pits are filled with sediments of widely varied origin that display virtually no chemical or mechanical changes.

The osteological contents of the two sediment groups were compared with one another in order to determine whether the lower portion of the pits contained different animal bone material together with the other types of sediment than did the dark earth layers. Since this is only possible for pits in which the dark earth areas can be reliably differentiated from the remaining areas, only 9 of the hitherto 35 archeozoologically studied pits can be examined in this manner. To these can be added 4 cultural layer complexes that only supply dark earth material. In the following box plot diagrams, the term "pits" is applied to the lower pit fillings whereas the term "dark earth" covers the cultural layer material as well as the upper pit fillings. The fragment ratios are taken as the basis for calculation.

COMPARISON BETWEEN PIT FILLINGS AND CULTURAL LAYERS

Species ratio

The most commonly found bones are those of cattle and pigs, sheep and goat bones being less frequently encountered. The ratios of cattle and of sheep or goat bones are very similar in both sediment groups (Figure 1). In contrast, pig bones seem

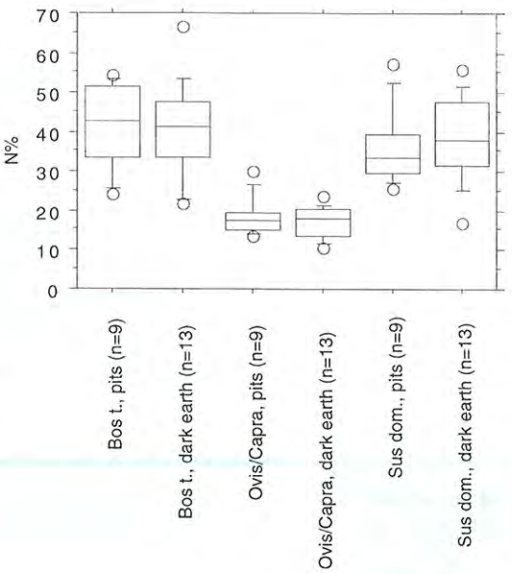

FIGURE 1

Proportion (fragments) of cattle (*Bos taurus*), sheep/goat (*Ovis/Capra*) and pig (*Sus domesticus*) in pits and dark earth material (definition see text) in the late Iron Age settlement of Basel-Gasfabrik.

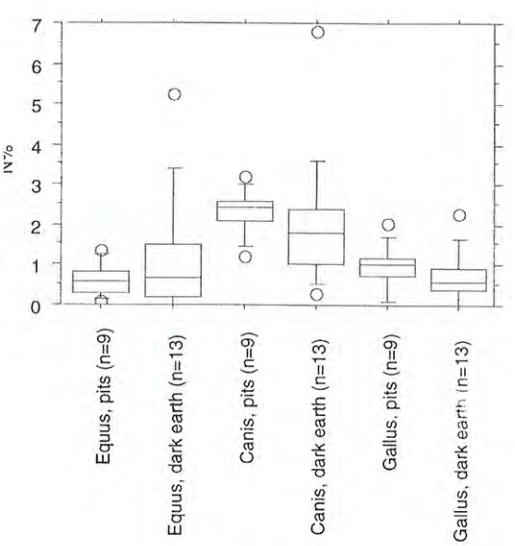

FIGURE 2

Proportion (fragments) of horse (*Equus*), dog (*Canis*) and poultry (*Gallus*) in pits and dark earth material (definition see text) in the late Iron Age settlement of Basel-Gasfabrik.

to be rather more frequently found in the dark earth material. The difference is, however, not significant.

The remaining three species of domestic animals generally only account for a small percentage of the determinable total material. While horse bones appear in similar ratios in both sediment groups (Figure 2), the lower pit fillings tend to contain more dog and chicken bones.

Butchering and fire marks

While bones displaying traces of fire are almost equally common in both sediment groups (Figure 3), bones bearing butchering marks are markedly more frequent in the lower pit fillings. The ratio of traces of cutting to those of hacking is higher in the dark earth areas than in the lower pit fillings.

Viewed as a whole, it can be said that there is considerable similarity in the composition of the two sediment groups: of 8 investigated features, only 3 display differences between the sediment types. These exceptions are dog and chicken bones and bones showing traces of butchering, that could all be shown to be rather more frequent in the lower pit fillings. All in all, this result suggests that little thought was given as to whether - and which - bones should be disposed of in the pits or not.

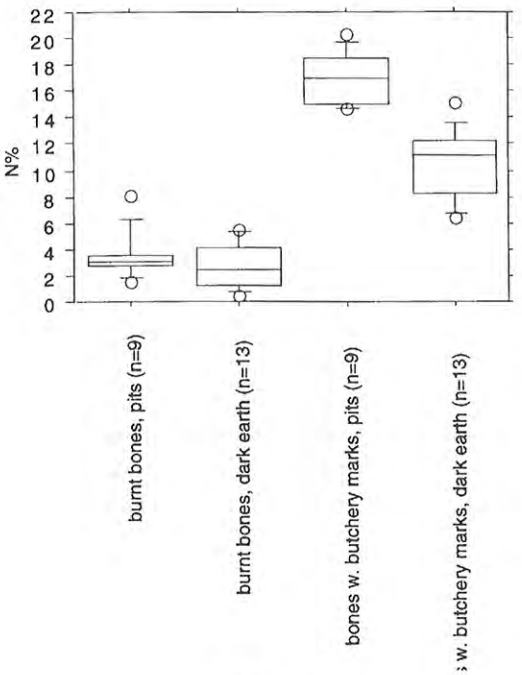

FIGURE 3

Proportion (fragments) of burnt bones and bones with butchery marks in pits and dark earth material (definition see text) in the late Iron Age settlement of Basel-Gasfabrik.

FILLING PROCESS

Based on the results from the sedimentological investigations and also on the generally good preservation of all the archaeological finds in the pits, it must be assumed that they were filled deliberately. Apart from incidental fillings, there was no natural illuviation of surrounding topsoil material.

Two main models can be cited for the filling process:

a) A pit was consistently used as a "waste bin" in normal daily life, with the result that it would probably sometimes have taken months or years to fill it. Besides the eventual dangers implied by a slow process of refilling (some of the pits were quite deep), this model raises the question of what happened to the waste generated each day while the pit was being used in its primary function. If one can exclude the use of a different waste pit, possibilities will have been the river Rhine close by, intermediate dumps/rubbish heaps or the formation of cultural layers (the similarity in the composition of the bone material between dark earth and pits makes this rather likely!).

b) The waste was collected someplace else (intermediate dumps/rubbish heaps) and, as soon as the pit was out of primary use, it was filled up with waste more or less at one go.

Bone preservation

The comparison between the state of preservation of the bones in the dark earth and those in the lower pit material sheds some insight into the filling history of the pits. The similarity or dissimilarity between layer and pit material also tells us something about filling rate.

The proportion of "fatty" bones, i.e. bones with a well-preserved, shiny surface, is markedly higher in the lower pit fillings than in the dark earth material (Figure 4).

In contrast, poorly preserved bones and bones with rounded broken edges are, not unexpectedly, more frequently encountered in the dark earth layers (Figure 5).

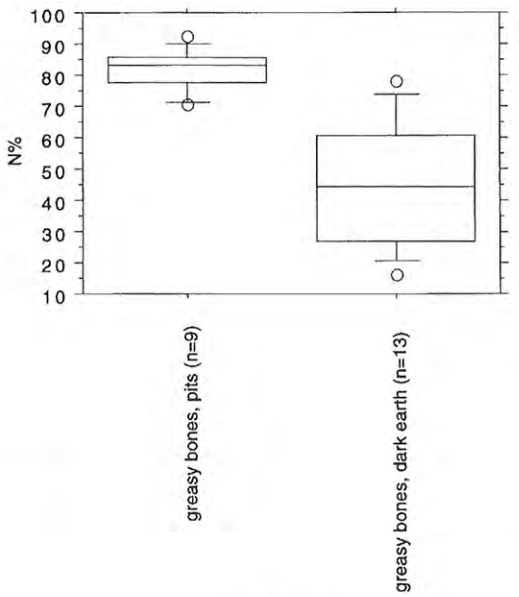

FIGURE 4

Proportion (fragments) of greasy bones in pits and dark earth material (definition see text) in the late Iron Age settlement of Basel-Gasfabrik.

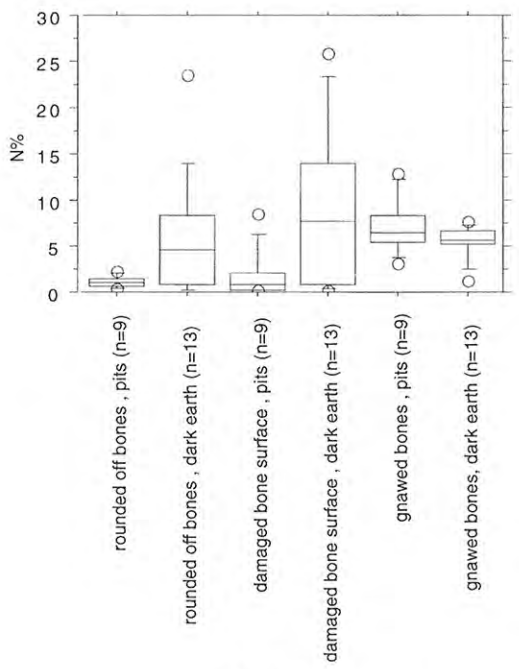

FIGURE 5

Proportion (fragments) of rounded bones, bones with damaged bone surface and gnawed bones in pits and dark earth material (definition see text) in the late Iron Age settlement of Basel-Gasfabrik.

Bones with bite marks appear in equal proportions in the two groups.

In agreement with the sediment material, bones from the dark earth layers have also undergone chemical and mechanical transformation that the bones and sediments of the lower pit fillings largely missed. At present, it is impossible to determine when these changes took place. Whereas the dark earth sediments were already in a weathered state when definitively disposed of, this does not necessarily holds for the bones. Since the dark earth sediments were more water-permeable and better aerated than those in the lower pit fillings, at least a greater leaching out/degradation of the bones could have taken place later on. This is only contradicted by the higher proportion of rounded bones in the dark earth material. Since the sediments of the cultural layers were moved about several times before finally remaining in place, this could account for the more frequently encountered rounding of the bones. The similar and generally low proportion of bite marks and the generally good state of preservation of the bones does at least suggest that not too long a period of time elapsed between generation of the bone waste and its deposition, both in the case of the pit material and in the case of the dark earth material.

CONCLUSION

As a conclusion one can say that, judging from the results accumulated to date, bone material derived from general settlement waste is deposited both in the dark earth layers and in the lower pit fillings. With a few exceptions, it does not seem to have mattered whether the waste finally ended up together with building elements and formerly excavated material in the lower pit fillings or with weathered topsoil material outside the pits. Because of the general intermixing of the animal bones with other filling materials and the small number of matchable bone fragments, one must conclude that the waste was intermediately deposited elsewhere before its final deposition. This at least applies to the content of the lower pit fillings. Since it is difficult at present to judge when the poorer preservation of the animal bone material took place in the dark earth layers, it is impossible to decide whether one must also assume intermediate deposition of the bones in this case, as well. In view of the

small proportion of bitten material in both types of samples and of the generally good state of preservation of the bones, this interim deposition either did not last for a very long time, or else occurred in a location that was protected from dogs, pigs and weathering.

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The Archaeofauna of the late Medieval, Islamic Harbour Town of Saltés (Huelva, Spain)

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ABSTRACT: A preliminary assessment of the food economy in the late medieval Moorish town of Saltes, on the southwestern coast of Spain has been carried out. The study of animal remains indicates that the meat supply to the town was provided by small livestock, cattle, rabbit and domestic fowl. The exploitation of marine resources, however, should have been at least equally important for the food economy. Fishing and the gathering of molluscs mainly took place close to the coast but fishing in the open sea provided an additional yield. Probably, an important part of the catch in the open sea was processed and shipped towards inland consumer sites. Comparison with other medieval Islamic sites from the Iberian Peninsula points to cultural factors as influencing the composition of the daily diet.

KEYWORDS: ISLAMIC SPAIN, ATLANTIC COAST, LATE MEDIEVAL PERIOD, CONSUMPTION PATTERNS, MARINE RESOURCES

RESUMEN: El trabajo lleva a cabo una valoración preliminar acerca de la economía alimentaria en la ciudad musulmana bajo medieval de Saltés en la costa española sudoccidental. El análisis de los restos animales indica que el aporte cárnico a la ciudad estaba preferentemente constituído por ovicaprinos, vacuno, conejos y pollos. Creemos, no obstante, que la explotación de los recursos marinos debió haber sido tan importante para la dieta como los animales terrestres. La pesca y el marisqueo parecen haber sido actividades costeras en su mayor parte si bien existen claras evidencias de una pesquería pelágica. Posiblemente una gran parte de estas capturas eran procesadas y posteriormente comercializadas hacia asentamientos del interior. Las comparaciones con otros yacimientos medievales islámicos de la Península Ibérica indican la existencia de factores culturales como determinantes de la dieta global.

PALABRES CLAVE: ESPAÑA MUSULMANA, COSTA ATLÁNTICA, BAJA EDAD MEDIA, PATRONES DE CONSUMO, RECURSOS MARINOS

SALTÉS: AN INTRODUCTION

The deserted site of Saltés is located on a island with the same name in the estuary of the rivers Odiel and Tinto, close to the town of Huelva, on the southwestern coast of Spain (Figure 1). The island is surrounded by brackish water and consists of three zones of higher elevation, separated by marshland. The occupation of the site dates back to prehistoric times but recent excavations focused on the medieval development of a Moorish harbour town in the northern part of the island. The recent archaeological fieldwork, directed by Mr. A. Bazzana, took place between 1988 and 1997, and showed that the medieval site was characterised by the very intensive urbanisation typical for Moorish towns. Historical sources confirm that the site was conquered by the Christians around

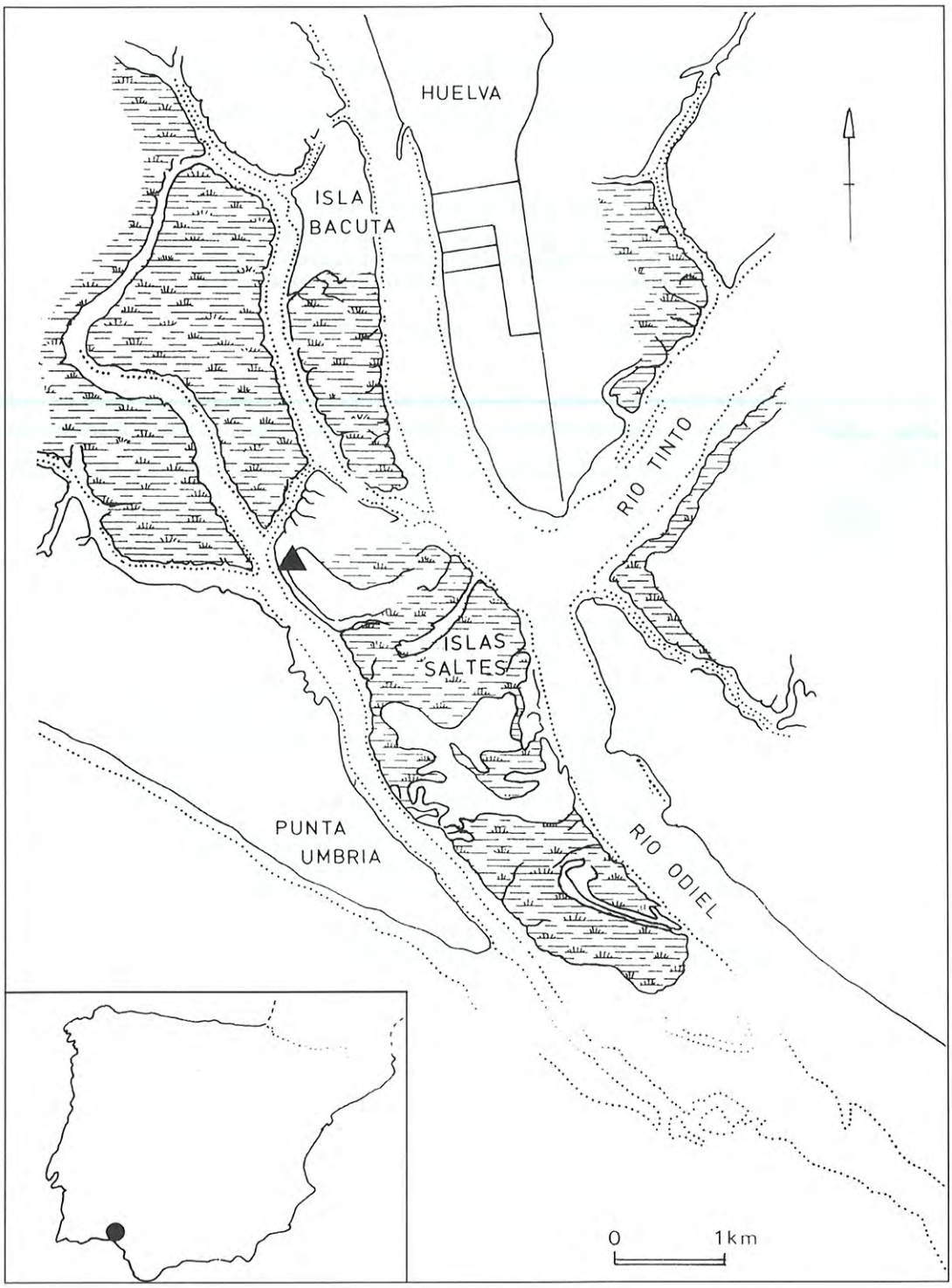

FIGURE 1
Location of the site in the estuary of the rivers Odiel and Tinto.

the middle of the 13th century but was never reoccupied (Bazzana & Cressier, 1989; Bazzana & Bedia García, 1993; Bazzana *et al.*, 1994).

Environmental archaeology, and especially the analysis of organic remains found during excavations, has still not become a full, integrated part of all excavations around the Mediterranean basin (Morales, 1996). One of the reasons is that "classical" archaeology focuses more on the reconstruction of the chronological history of sites than, e.g., on the socio-economic aspects of the daily life that took place in these dwelling places. Another reason is the fact that many excavators are still unacquainted with the possibilities and methodology of environmental research within archaeology. The Saltés excavations illustrate the possibilities of archaeozoology, i.e. the analysis of animal remains, for the reconstruction of the food economy of a medieval urban site from the Almohad period of Muslim Spain. The study collection is limited and biased in many regards, but still delivered essential information. Its publication can be justified by the scarcity of archaeozoological reports from medieval Islamic sites, in particular those from southern Europe, by the historical importance of the site, and by the fact that historical research of the economy of the Almohad period is still not very developed (Viguera, 1988).

A preliminary survey of the fish remains from the 1988 and 1990 campaigns has already been presented at the occasion of the 6th meeting of the ICAZ Fish Remains Working Group (Lentacker, 1994). The same assemblage has subsequently been incorporated in an analysis of fishing and fish trade on Almohad sites on the Iberian peninsula (Morales *et al.*, 1994). The present report deals with all animal remains found during the various excavation campaigns. Amongst this collection, a small number of human remains was found. A chapter will be devoted to their description at the end of the archaeozoological report.

MATERIAL AND METHODS

The present study is based on a collection of animal remains excavated during the campaigns of 1988, 1990 and 1995. Due to differences in sampling and recovery methodology applied from year to year, the archaeozoological collections from these campaigns are considerably heterogeneous. In 1988, no environmental archaeologist took part in the excavation, which partly explains why, during that campaign, animal remains were ocassionally (hand) collected, resulting in a selective and limited sample. In total, 18 contexts yielded animal remains. At that time, this material was stored for future analysis.

The field-work of the 1990 campaign was assisted by the senior author, who introduced the use of sieves, with meshes of 5 and 2 mm, in the excavations. Since no real refuse pits were found during the campaign, all sieved samples had to be collected from drainage channels, latrines, wells and grain storage pits. Other contexts were investigated by handcollecting, be it in a less biased way compared to the previous campaign. In total, 17 stratigraphic units yielded animal remains, although, unfortunately, the density of finds was generally low. As a result, the collection from this campaign is again limited in number but characterised by a high frequency of smaller finds. During the 1990 campaign, most of this material was identified at the site, together with the finds from 1988. For the identification of the mollusc remains, the key of Pérez Quintero (1989) was used. The fish remains were identified using the comparative collections of the Laboratorio de Arqueozoología of the Universidad Autónoma de Madrid, and of the Royal Museum for Central Africa (Tervuren, Belgium). Length estimations of the specimens were made by visual comparison to reference skeletons from these collections.

During the 1995 campaign, both authors visited the site for a short period. That year, sampling was exclusively restricted to a series of stratigraphical layers which contained multiple accumulations of shells (see below). Since no time was devoted to the sampling of other archaeological contexts, the 1995 collection of animal remains is again characterised by a high frequency of large (handcollected) finds. The overall finds number, derived from 46 different contexts, is low. After the field campaign, the collection was shipped to Belgium and analysed using the reference collection of the Royal Museum for Central Africa.

During the field campaign of 1997, no environmental archaeologists were present on the site. Although it was reported that, a.o., a pit was excavated, that contained a large number of oyster shells (Bazzana, pers. comm.), no animal remains from that campaign have been available for study.

In general, the larger animal remains from Saltés are heavily fragmented, hampering the identification of an important part of the bone collec-

tion. For the same reason, given that find numbers are low, a biometrical analysis of the vertebrate remains was not attempted. Although the finds were recovered from different contexts, they are not treated separately within the present report. A comparison of the identification lists per context, which are not published here but remain available from the authors, clearly shows that no meaningful differences in species composition can be detected between the archaeozoological record of individual stratigraphical units. Possible taphonomical and chronological differences between sampling units have therefore also been ignored. Following the information of the excavators, the animal remains, derived from destruction layers and urban refuse contexts, are generally dated to the second half of the 12th and first half of the 13th century, which corresponds to the last occupation phase of the site.

INVENTORY

Molluscs

A few terrestrial gastropods were recovered from a single context during the 1988 campaign and again during the 1995 campaign. Due to sieving, a considerable number was recovered from 5 contexts in 1990 (Table 1). No attempt has been made to identify these remains, all of small size.

The medieval urban refuse contexts from Saltés yielded 15 mollusc taxa that occur in marine or estuarine biotopes. Surprisingly, the sieving campaign of 1990 did not result in a markedly higher number of finds or species within this zoological category. In fact, new contexts excavated in 1990 proved to be poor in marine mollusc remains, compared to the units sampled in 1988 (Table 1). In general, the excavators only collected a set of specimens from each context, that was considered representative for the species composition. Therefore, only presence/absence data and no fragment counts or frequencies are given for this animal group. The abundance of a taxon can only be evaluated by counting the number of contexts where it was collected from (Table 1). This calculation coincides well with a subjective estimation of the species' frequencies, made by the senior author in 1990, by inspecting the remains *in situ*, during several site visits (see 'frequency' in Table 1).

The taxa identified are listed in Table 1. The nomenclature applied follows Poppe & Goto (1991, 1993), which also served as the information

	1988	**1990**	**1995**	**total**	**frequency**
Total number of contexts	18	17	46	81	
Acanthocardia sp.	0	1	0	1	RR
Bolinus brandaris	9	1	3	13	F
Cerastoderma edule	1	2	0	3	R
Cerithium vulgatum	1	1	1	3	R
Chamelea gallina	0	2	0	2	RR
Charonia lampas lampas	1	0	1	2	R
Cymbium olla	3	0	0	3	R
Dentalium sp.	2	0	0	2	R
Glycymeris glycymeris	12	6	5	23	FF
Mytilus edulis	0	1	0	1	RR
Ostrea edulis	13	2	2	17	FF
Pecten maximus	7	2	4	13	F
Sepia officinalis	0	1	1	2	RR
Solen / Ensis sp.	1	3	3	7	R
Tapes decussatus	4	2	2	8	R
Terrestrial gastropods	1	5	1	7	

TABLE 1

Survey of the molluscs found at Saltés. The number of contexts where the species was recovered from, and a subjective estimation of the frequency of the marine species, made during the 1990 campaign are indicated.

source for the ecological characteristics of the species. Most of the species found occur on soft substrates close to the coast:

- *Acanthocardia* sp. on mud bottoms from the intertidal zone to the continental shelf,
- *Bolinus brandaris* on sand and mud bottoms 1 to 200 m deep,
- *Cerastoderma edule* in sand, mud and gravel bottoms from the intertidal zone to a few meters deep,
- *Cerithium vulgatum* in shallow water on sandy and muddy bottoms,
- *Chamelea gallina* on mud and sand bottoms from 5 to 20 m deep,
- *Charonia lampas lampas* on different substrates from the extreme low tide level to 700 m deep,
- *Cymbium olla* in shallow water on sand bottoms,
- *Dentalium* sp. on mud and sandy bottoms between 1 to 50 m deep,
- *Mytilus edulis* on substrates from the intertidal to 40 m deep,
- *Ostrea edulis* on different types of sediments from shallow water down to 90 m deep,
- *Pecten maximus* on sand and gravel bottoms but also on mud, from the extreme low tide level to 250 m deep,
- *Solen/Ensis* sp. in shallow sandy areas,
- *Tapes decussatus* in sand or muddy gravel bottoms, in quiet waters below mid-tide level to a few meters deep.

One bivalve, *Glycymeris glycymeris*, occurs offshore, on sand, mud and gravel bottoms down to 75 m deep. The cuttlefish, *Sepia officinalis*, is the only cephalopod species, represented by fragments of its internal shell. Cuttlefish live in waters above the continental shelf.

Fish

As usual, sieving had a considerable impact on the diversity and amount of fish bones collected. During the excavations of 1988, 10 fish remains from 4 different species were found; these remains are mostly large vertebrae. The 1995 campaign yielded only two fish bones. However, in 1990, sieving produced 1054 remains, amongst which 19 different species could be recognised. Of course, a large part of the collection, i.e. 690 specimens or two thirds of the total, remained unidentified. A list of the fish species found is given in Table 2. Compared to the preliminary list published earlier (Lentacker, 1994), two species have been added, the identifications of two species (*Alosa* sp. and *Solea* sp.) have been described more carefully, and the nomenclature has been updated according to Whitehead *et al.* (1984, 1986a, b). The relevant ecological and economical data for the fishes have been taken from the latter works and from von Brandt (1984).

The Saltés fish assemblage is dominated by marine and estuarine species. That remains of freshwater fishes were absent from the site is not surprising; sea water penetrates far upstream in the Odiel and Tinto rivers, which gives the immediate environment of the site a brackish character. The most important fish present were the seabreams or sparids (Sparidae). Within this family, few remains belonged to the genus *Pagrus*, represented by two species, the common seabream (*Pagrus pagrus*) and the redbanded seabream (*Pagrus auriga*). A single bone came from a gilthead (*Sparus aurata*) but specimens of the genera *Pagellus* and *Diplodus* were the most frequently found within the sparids. The collection contained sufficient numbers from the latter two genera to allow a reconstruction of body length distribution within the populations (Figure 2). Within the *Pagellus*-group the bones of the common pandora (*P. erythrinus*) and the axillary sea-bream (*P. acarne*) were recognised. *Pagellus erythrinus* can attain a total length of 60 cm while the maximum for *P. acarne* is 36 cm. Usually, however, both species attain a length of 20-25 cm. The majority of the Saltés finds represent fishes from only 10 to 20 cm (Figure 2). Hence, most of the sea-breams that were caught at Saltés are rather small and represent young individuals. The young of these fishes live closer to the coast than the adults. Within the genus *Diplodus* only one species was found, i.e. the annular seabream (*Diplodus annularis*). Both juveniles and adults of this species live in the littoral zone. The adults reach to 12-15 cm long, which is a size comparable to that of most of the specimens found at Saltés (Figure 2).

Other in-shore species represented within the fish assemblage are the comber (*Serranus* sp.), the sole (*Solea* sp.) and the meagre (*Argyrosomus regius*). Meagre usually attains 50 cm but some of the specimens from Saltés were even longer than 85 cm. It is known that, from April to August, these large adult fishes enter the coastal lagoons and estuaries to spawn. The cartilaginous fish that

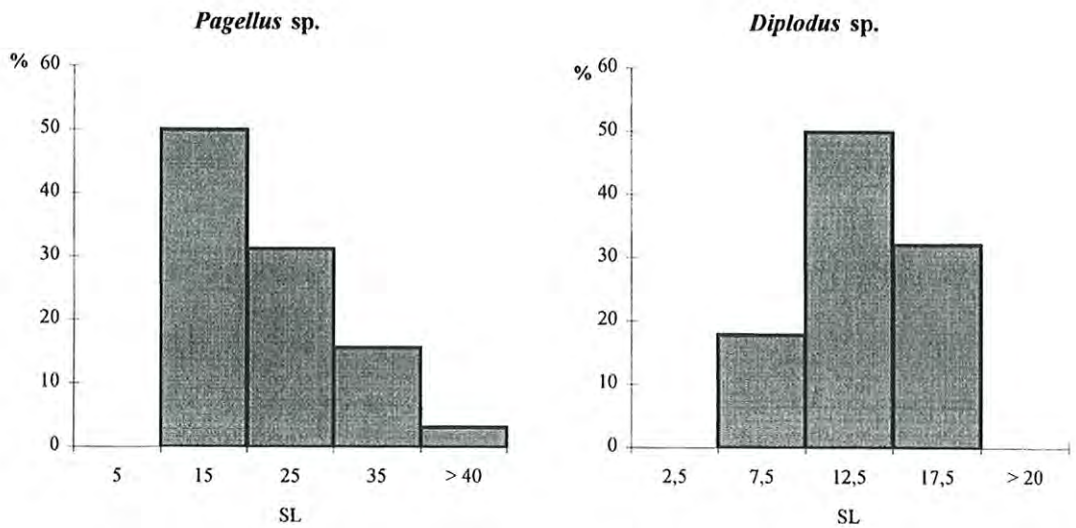

FIGURE 2
Frequency distributions of the estimated body lengths (SL) of fishes within the genus *Pagellus* (n = 64) and the genus *Diplodus* (n = 28).

left remains at Saltés, i.e. the sand tiger shark (*Eugomphodus taurus*), the tope shark (*Galeorhinus galeus*), the smooth-hound (*Mustelus mustelus*) and the ray (*Raja* sp.), also live not far from the coast.

Other fishes found in small quantities in the collection of Saltés are the thicklip grey mullet (*Chelon labrosus*) and the allis or twaite shad (*Alosa* sp.). Both these species enter estuaries and occur close to the coast, together with the species already described. However, some fish represented within the Saltés excavations are to be found off-shore, especially the shoaling fish that live in open waters, such as the mackerels *Scomber japonicus* and *Scomber scombrus*, and the Atlantic blue tuna (*Thunnus thynnus*). The shoaling pilchards (*Sardina pilchardus*), also found at Saltés, live closer to the coast. Within the off-shore group, only the pilchards were found in meaningful numbers.

Birds

Bird remains are scarce within the archaeozoological record of the Saltés excavations (Table 3). One species, the domestic chicken (*Gallus gallus* f. *domestica*) dominates all samples. A few bone fragments prove the presence of both hens and roosters. Generally, the finds are too fragmented and too few to allow for a biometrical analysis. It is possible that chicken was not the only domestic bird species at Saltés but the scarce remains of geese (Anseriformes sp.) do not allow a species identification, let alone subspecific differences as would be the case for the domestic goose (*Anser anser* f. domestica). The same is true for the mallard (*Anas platyrhynchos*) remains. Remaining bird bones certainly come from wild species and prove the presence of red grouse (*Alectoris rufa*), herring gull (*Larus argentatus*), a dove (*Columba* sp.) and a passerine bird (Passeriformes sp.). Except for the geese, that are winter residents, all birds can be found in the area around the site throughout the year.

Mammals

Amongst the mammal remains (Table 3), those of sheep (*Ovis ammon* f. *aries*) and goat (*Capra aegagrus* f. *hircus*) are the most numerous (Figure 3). These two domestic species have been inventoried together, because often their remains can not be discriminated from one another (Boessneck *et al.*, 1964). Only during the analysis of the 1995 material (that could be studied in the lab) special attention was paid to the discrimination of sheep and goat. Within a set of 31 identifiable bones, 29 came from sheep, 2 from goat. This suggests that sheep was far more frequent in the archaeological contexts investigated. Only 6 bones from sheep could be used for a reconstruction of the withers height, yielding results ranging from 53 to 70 cm.

	1988	1990	1995
Sand tiger shark (*Eugomphodus taurus*)	–	1	–
Tope shark (*Galeorhinus galeus*)	–	6	–
Smooth-hound (*Mustelus mustelus*)	4	24	–
Ray (*Raja* sp.?)	–	7	–
Cartilaginous fish (Chondrichthyes)	–	1	–
Axillary seabream (*Pagellus acarne*)	–	24	–
Common pandora (*Pagellus erythrinus*)	2	17	–
Pagellus sp.	–	25	–
Common seabream (*Pagrus pagrus*)	–	2	–
Redbanded seabream (*Pagrus auriga*)	2	1	–
Pagrus sp.	–	6	–
Pagellus sp./*Pagrus* sp.	–	43	–
Gilthead (*Sparus aurata*)	–	1	–
Annular seabream (*Diplodus annularis*)	–	18	–
Diplodus sp.	–	11	–
Sparidae sp.	1	117	–
Meagre (*Argyrosomus regius*)	1	3	1
Sole (*Solea* sp.)	–	2	–
Comber (*Serranus* sp.)	–	1	–
Bluefin tuna (*Thunnus thynnus*)	–	2	1
Chub mackerel (*Scomber japonicus*)	–	2	–
Mackerel (*Scomber scombrus*)	–	2	–
Scomber sp.	–	9	–
Pilchard (*Sardina pilchardus*)	–	34	–
Allis or twaite shad (*Alosa* sp.)	–	4	–
Thick-lipped grey mullet (*Chelon labrosus*)	–	1	–
Total identified fish remains	10	364	2
Unidentified fish remains	0	690	0
Total	10	1.054	2

TABLE 2

Fish remains collected during the excavation campaigns at Saltés.

Estimations of the age at death were difficult to asess for the Saltés sheep and goats, due to the limited number of more or less complete tooth rows in the collection and the heavy fragmentation of the long bones. Nevertheless, an assemblage of 110 sheep and goat remains (from the 1988 and 1990 campaigns) evidenced the presence of 42 specimens (38%) from subadult animals, that had not yet reached the age of 3 to 3.5 years. Amongst those, first, second and third year animals could be found. An important part of the small livestock was thus slaughtered when young. No intra-skeletal selection is evident; all bones seem to be present, except for the smallest ones that have been missed by handcollecting. One context contained the incomplete skeleton of an adult sheep. The bones from this buried carcass have only been counted as one find within the inventory.

Cattle (*Bos primigenius* f. *taurus*) bones were found in lower numbers compared to the sheep and goat remains (Figure 3). It has to be taken into account that handcollecting of animal material normally produces collections that are biased towards the larger finds, such as cattle or horse bones. The low frequency of cattle bones at Saltés is therefore certainly significant. Since no complete adult cattle long bones have been found, withers heights could not be calculated. The frequency of subadult animals (younger than 4 years) could again only be roughly evaluated. In a sample

	1988	1990	1995	Total
Aves				
Geese (Anseriformes sp.)	2	0	0	2
Mallard (*Anas platyrhynchos*)	1	0	1	2
Red grouse (*Alectoris rufa*)	1	6	6	13
Herring gull (*Larus argentatus*)	0	1	0	1
Dove (*Columba* sp.)	1	0	0	1
Passerine bird (Passeriformes sp.)	0	1	0	1
Domestic fowl (*Gallus gallus* f. domestica)	24	6	26	56
Unidentified bird remains	10	17	17	44
Mammalia				
Shrew (Soricidae sp.)	0	1	0	1
Black rat (*Rattus rattus*)	0	11	0	11
Unidentified rodent (Rodentia sp.)	0	0	1	1
Rabbit (*Oryctolagus cuniculus*)	77	54	80	211
Hare (*Lepus capensis*)	3	1	0	4
Roe deer (*Capreolus capreolus*)	4	0	0	4
Red deer (*Cervus elaphus*)	12	0	5	17
Horse (*Equus ferus* f. caballus)	11	0	7	18
Cattle (*Bos primigenius* f. taurus)	45	3	43	91
Sheep (*Ovis ammon* f. aries) / Goat (*Capra aegagrus* f. hircus)	209	28	145	382
Dog (*Canis lupus* f. familiaris)	4	0	0	4
Cat (*Felis silvestris* f. catus)	7	5	16	28
Small vertebrae	3	21	3	27
Medium sized vertebrae	73	0	30	103
Large vertebrae	16	3	3	22
Ribs	158	2	106	266
Unidentified mammal remains	370	184	159	713
Total bird remains	39	31	50	120
Total mammal remains	992	313	598	1.903

TABLE 3

Bird and mammal remains excavated at Saltés.

of 49 finds, only 10 (20%) came from subadult specimens. All parts of the skeleton were present.

Domestic mammals that were found in lower numbers than sheep and cattle, are horse (*Equus ferus* f. *caballus*), dog (*Canis lupus* f. *familiaris*) and cat (*Felis silvestris* f. *catus*). All horse bones seem to derive from adult animals; some were fragmented and showed cutting or chopping traces. The bones from cats and dogs almost certainly come from complete skeletons, although these have been only partially recovered. Amongst the cat remains, a high frequency of bones are from young animals, both juveniles and subadults.

Small wild living mammals are represented at the site by a shrew species (Soricidae sp.), the black rat (*Rattus rattus*) and an unidentified rodent (Rodentia indet.). Without doubt, the black rat lived close to or even in the houses of Saltés, as a commensal animal. This could also be true for the small insectivore and the unidentified rodent. Larger species, that came from the natural surroundings in the region, are the hare (*Lepus capensis*), roe deer (*Capreolus capreolus*) and red deer (*Cervus elaphus*).

A special mention should be made for the remains of rabbit (*Oryctolagus cuniculus*), that were very numerous in the collections from all sea-

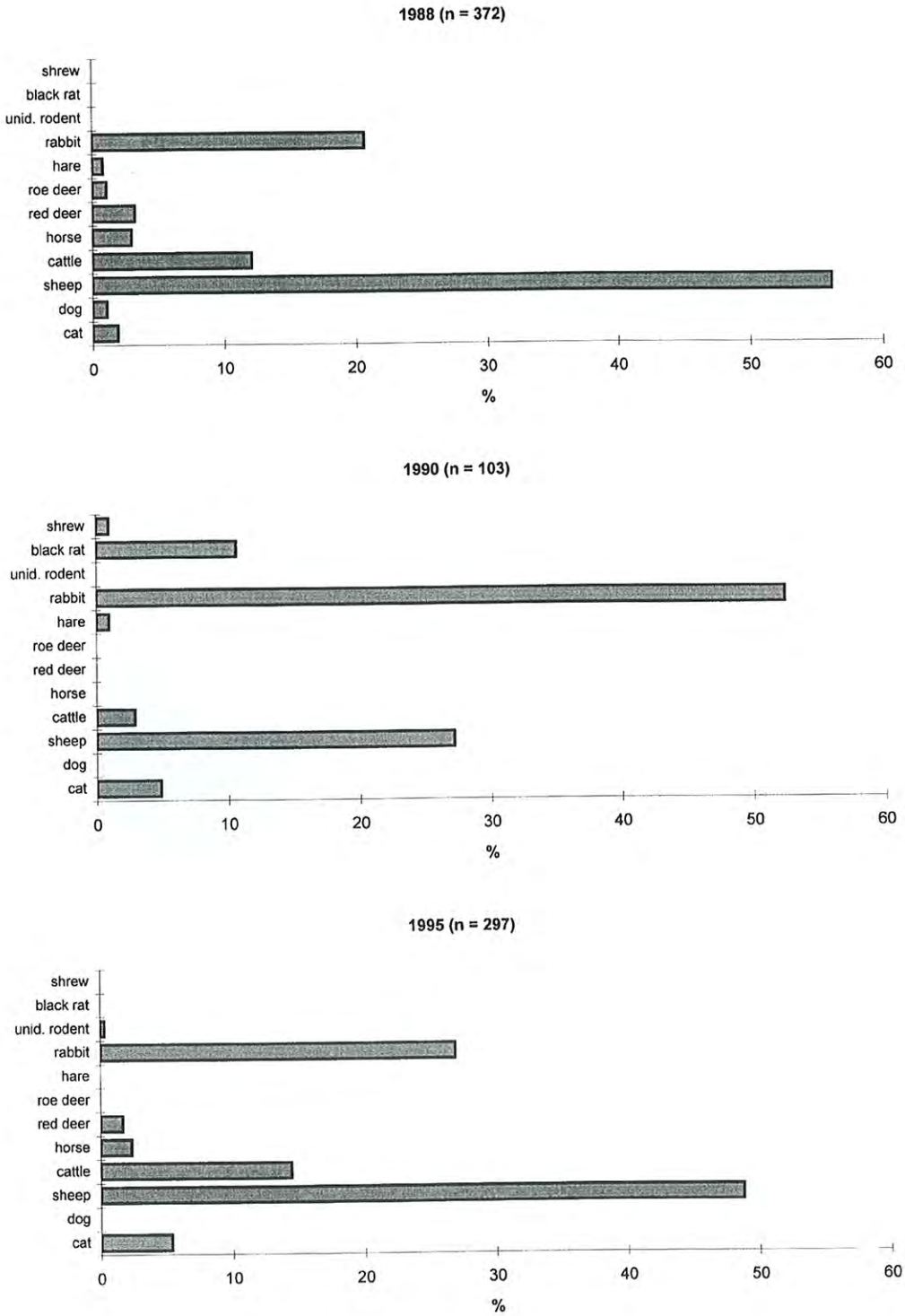

FIGURE 3

Frequency of species within the mammal remains from the different excavation campaigns.

sons (Figure 3). During the 1990 campaign, when most care was taken during collecting, the rabbit was the most common mammal found in the archaeozoological assemblage. Better sampling and recovery was without doubt responsible for a higher frequency of small bones, including those of rabbits. This is also proven by the higher frequency of very small bones amongst the rabbit remains. Rabbit phalanges, e.g., have only been found in 1990. It can be assumed that all types of bones were present at the site but whether the rabbit remains were sometimes found as part of complete skeletons is not documented in the excavation records. Measurements on the bones (not listed in the present report) have been compared to those reported by von den Driesch & Boessneck (1970), and show no significant differences between the Saltés population and other wild rabbits from the Iberian Peninsula. Hence the finds provide no arguments for the existence, within the medieval site, of a domesticated rabbit population characterised by the presence of selectively bred, large individuals. In historical documents from late medieval Andalucia the rabbit is also classified amongst the hunted fauna (García, 1996: 226).

Relative importance of the animal groups

When a global view is given of the animal remains found during each campaign (Figure 4), it becomes apparent that the 1990 campaign, during which sieving was applied, yielded a strikingly different faunal spectrum compared to the handcollected assemblages from 1988 and 1995. On the

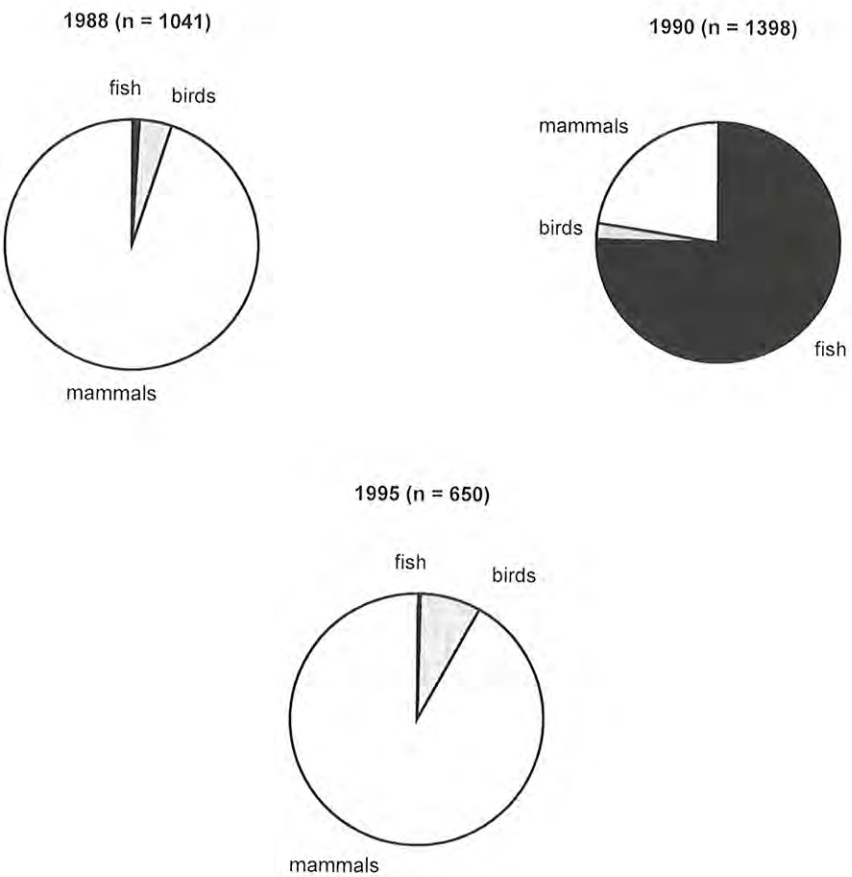

FIGURE 4
Frequency of fish, bird and mammal remains in the different assemblages.

one hand, the importance of fish on the meat-procuring economy would have been completely missed without the 1990 campaign. On the other hand, the frequency of the bird remains only slightly increased because of sieving, suggesting that this group of remains was not severely overlooked by handcollecting. Comparable methodological observations have been documented in the case of other medieval sites (Ervynck, 1993) and must lead to the conclusion that bird bones are indeed rather rare on Saltés, as on many other medieval sites. Since only the presence or absence of the mollusc taxa was recorded per context, no evaluation of their abundance per campaign could be made.

TAPHONOMICAL ASPECTS

With a few exceptions, the shells of marine molluscs found at Saltés are to be regarded as human consumption refuse. The collection mainly consists of uneroded specimens of large, consumable species. Only the "razor blade" shells of the *Solen* and/or *Ensis* specimens were mostly broken but, considering their brittle nature, this can be seen as a normal condition. Two species, *Cerithium vulgatum* and *Dentalium* sp., are small and could therefore represent intrusive finds, not used for human consumption. They could have been brought to the site accidentally, with a load of fish or with other molluscs. This scenario, however, can not be proved and is only based on the assumption that shellfish that yield a limited meat weight are often considered not to be consumable. The only shells that are without doubt intrusive are some of the *Glycymeris glycymeris* that show clear traces of erosion, i.e. a rounded, abraded shell, often with a perforation at the umbo. These shells clearly were not brought to the site as parts of live animals; they more probably were once part of a beach deposit, eroded by the tides, that was used within town, e.g., for levelling or consolidating. Finally, the small shells of terrestrial gastropods are also considered to be intrusive.

All fish and bird remains found must come from animals that have been used for consumption. The only exception could be the herring gull, a bird that is commonly considered to be less suited as a food item in Europe. Within the consumption refuse category are also included the bones of hare, roe deer and red deer that were hunted for their meat, and those of cattle, sheep and goat that were the domestic meat providers. The only exception is the find of an incomplete sheep skeleton. The taphonomic status of most other mammal remains does not pose many problems. The black rat, an unidentified rodent and an insectivore species are without doubt contemporaneous intrusives. Cats and dogs were most probably also not eaten at medieval Saltés; their bones must represent what is left from carcasses that were buried within town. Whether the horse bones come from buried, complete animals or are consumption leftovers, is more difficult to decide. When the first scenario holds, these skeletons must have been disturbed in later times, because complete horses have certainly not been found during the excavations. It is unfortunate that, due to the limited finds of horse bones, an evaluation of the fragmentation and the presence of chopping or cutting traces is difficult. However, some of the bones are indeed broken up and do display the traces mentioned. Therefore, it can not be excluded that part of the horse remains is the result of human consumption.

Part of the rabbit bones found certainly represent kitchen or table refuse. However, since the rabbit is a burrowing animal that still occurs in large numbers in the region of Saltés, it has to be taken into account that, after the site was deserted, animals may have disturbed the medieval deposits. When these rabbits occasionally died within their burrows, their remains could become part of an archaeological context. The only way to distinguish bones that are consumption refuse from those that are part of buried intrusive animals is the recognition of complete skeletons while excavating. However, intrusive skeletons can also be disturbed by later burrowing animals, which further complicates a taphonomic reconstruction. Rabbit bones at Saltés show no differences in colour compared to the other bones excavated at the site. Complete skeletons have also not been recorded by the excavators, although this can be linked to the excavation techniques applied. It will thus be assumed that rabbit bones in the collections mainly represent medieval consumption refuse, although it must not be forgotten that part of the collection has possibly nothing to do with the medieval site.

THE FOOD ECONOMY OF MEDIEVAL SALTÉS

Animal husbandry

Generally, the area around medieval Saltés is described by the contemporary writer al-Himyari

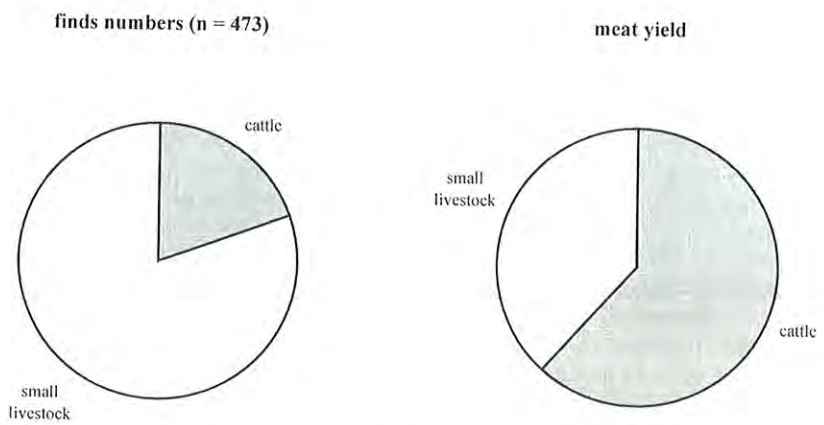

FIGURE 5
Frequency of small livestock versus cattle (all assemblages combined), on the basis of the finds numbers and of the calculated meat yield (see text).

as having good pastures, that were always green and had sufficient fresh water sources (Bazzana & Cressier, 1989: 35). The site thus had ample opportunities to rear livestock. The inventory showed that, in terms of meat consumption, sheep was the most highly priced animal at Saltés; cattle was slaughtered in considerably smaller numbers (Figure 5). Of course, it must be taken into account that each cattle bone stands for a much larger meat weight than each sheep element. If we estimate the meat yield of a medieval sheep at 15 kg and that of medieval cattle at 100 kg (Nobis, 1965), and assume that, for each species, the number of individuals stands in the same relation to the number of bones found, the meat weight of cattle and sheep can be evaluated against each other by simply multiplying the number of bones with the meat yield per individual (Figure 5). Such a calculation shows that, in terms of food intake, cattle was more important than small livestock but this does not say anything about what meat was most in culinary demand. Written sources indicate that the meat of young sheep was most appreciated within the cuisine of Muslim Spain (García, 1996). Find numbers of the Saltés collection are in accordance with this. Moreover, sheep remains also evidenced a high frequency of bones from subadult animals. The frequency of subadult individuals was much lower within the (slaughtered) cattle population.

There still remains a possibility that the low frequency of cattle bones in the excavated contexts is the result of taphonomical processes. Maybe larger bones amongst the kitchen refuse were more easily cleaned away? Or perhaps only few bones of cattle, that were slaughtered outside the main habitation area, were brought to the site, attached to the meat? These arguments can not be ruled out but it needs to be stressed that no intra-skeletal selection was visible within the set of cattle remains. Moreover, a dominance of small livestock has been recorded from many other Iberian Muslim sites, such as Calatrava la Vieja (Morales *et al.*, 1988), Mesas do Castelinho (Portugal: Cardoso, 1993a, b), Silves (Portugal: Antunes, 1991) and Mértola (Portugal: Antunes, 1996; Morales, 1993b).

The absence of pigs (and wild boar) from the consumption refuse must of course be linked with the Muslim taboo on this animal. Muslim sites in Spain sometimes contain some pig remains, perhaps due to the presence of a small nucleus of Christian people within the settlement. Examples are Calatrava la Vieja (Morales *et al.*, 1988), Mértola (Antunes, 1996) and Mesas do Castelinho (Cardoso, 1993b). At Saltés, however, not a single bone was found. This complete absence is striking since the medieval writer al-Himyari mentions the presence of an important number of Christians at Saltés (Bazzana & Cressier, 1989: 35). Perhaps these people had no access to pork or were living in a different part of town, outside the excavation area? An example of another Iberian Muslim site with a complete absence of pig or wild boar bones is Silves (Antunes, 1991).

The presence of horse bones must also be discussed within the context of religiously framed food patterns. The problem, however, is that it

remains uncertain what the taphonomic status of the horse remains was. Was horse occasionally eaten at the site, or do the bones represent parts of buried carcasses? It is not probable that dead horses were buried within the dense habitation zone but perhaps parts of dead animals were fed to the dogs? Written sources certainly do not suggest that horse meat was highly esteemed within the medieval Muslim cuisine (García, 1996). Some horse bones were also found amongst consumption refuse at Islamic Calatrava la Vieja (Morales *et al.*, 1988), Mesas do Castelinho (Cardoso, 1993b) and Mértola (Antunes, 1996; Morales, 1993b), although Morales (1993b: 265) considers them not to be consumption refuse.

As has been discussed, there are no biometric grounds for the presumed presence of domestic rabbits at Saltés. Such possibility, however, can not be excluded. The same is true for the remains of anseriform birds and of mallard. Perhaps chicken was the only domestic bird at the site but, certainly, they must have been common. Domestic animals that were not kept in town to be consumed, are dogs and cats. The latter were presumably useful for the destruction of small commensals, such as the black rat. Dogs served as guards or company.

Hunting

The wild mammals that could be hunted in the area around Saltés include roe deer, red deer, hare and rabbit, when one assumes that not all specimens from the latter species were domesticated. The hunting of wild fowl brought red partridge, dove, and possibly also a small passerine, geese and mallards to the site. Geese were hunted only during winter. With the exception of rabbit, wild animals were only responsible for a minor part of the meat supply. Important find numbers of rabbits are typical of other Islamic sites from the Iberian Peninsula. Examples are Calatrava la Vieja (Morales *et al.*, 1988), Mértola (Antunes, 1996; Morales, 1993b) and Mesas do Castelinho (Cardoso, 1993a). In no case did the study of these sites testify to the presence of domestic rabbits.

Fishing

The importance of fishing with nets at Saltés is reflected by the multiple finds of net weights (Bazzana & Cressier, 1989: 47), and cylindrical terra cottas (Bazzana & Bedia García, 1993: figs. 27 & 28). The species spectrum of the fish and the cuttlefish consumed at Saltés, and the size distribution within the genus *Pagellus*, indicate that coastal fishering was the prevalent way to exploit marine resources. The most important fish caught were the sparids, a pattern that is comparable to most other sites in the area (Morales, 1983; Roselló & Morales, 1987, 1990). Sparids are easily caught, e.g. with trail-nets on the beach. Next to the sparids, cartilaginous fish seem to have been an important yield from the coastal fishery. Rays and sharks were certainly not rejected as food items. Fishing with nets was also practiced at the open sea. In that way, mackerels, pilchards and blue tuna arrived to the site. The faunal spectrum of fish from medieval Saltés is almost identical to that from the nearby protohistoric site of Cabezo de San Pedro (Lepiksaar, 1973).

Compared to the sparids fished close to the coast, the importance of the open sea fishes seems to have been limited. However, it is possible that the tunas were butchered and that most of their bones were removed from the flesh before they were brought into town (Morales, 1993a). This taphonomical pattern would underestimate the importance of that fish sector in the food supply of the site. Another agent responsible for the underestimation of the fish catch in the open sea, involved processing and subsequent transport inland. Fishing with nets could result in a catch which was too large for immediate local consumption. Drying, smoking or pickling could certainly help preserve this surplus.

Some evidence of fish processing was found at Saltés. During previous excavations (Bazzana & Cressier, 1989: 27) two pickle or brine baths were excavated at the edge of the site, near the estuary. Their construction was dated to the Roman period but they could possibly also have been in operation during medieval times. Unfortunately, the archaeologists emptied the brine baths at Saltés to take measurements but did not take any samples of the material filling them. A physico-chemical dating of the contents was therefore impossible. Traditionally, the heydays of the fish salting industry along the southern Spanish coast are thought to be restricted to the Roman period (Ponsich, 1988). Lack of samples from the baths also hampered the possible identification of the species processed. Generally, fish processing produced two types of food items: salted fish (*salsamenta*) and fish sauce (*garum*, *muria* or *allec*) (Morales, 1993a: 136-137). The open sea fishes, i.e. mackerels and pil-

chards, were well suited to be processed into these products. The role of tuna in the process is critically reviewed by Morales (1993a).

Historical sources from Almohad times tell little about the economics of fish selling and trading (Morales *et al.*, 1994). Later texts, however, describe that within the kingdom of Granada, tuna was one of the most highly priced (thus expensive) fishes. Sole also ranked high as a food product. Sparids were much cheaper, perhaps because they were easily caught, in large numbers, perhaps because their meat is full of spines. Cartilaginous fish did not command high prices either, but this could be to the generally low culinary value of their meat (Malpica, 1984).

Gathering of molluscs

The species inventory (Table 1) showed that the consumption of molluscs was not restricted to a few species. Most of the marine shells are from large specimens. Just like the fishing activities, the gathering of benthic molluscs took place mainly close to the coast. Soft substrates were explored in search of shellfish that lived in the sediment, such as, e.g., cockles (*Cerastoderma edule*) or "razor blade" shells (*Solen/Ensis* sp.). Other species were collected on the substrate, especially those occurring in banks, such as oysters (*Ostrea edulis*) and mussels (*Mytilus edulis*). The only molluscs from deeper water are the non-intrusive specimens of *Glycymeris glycymeris*, that were probably side catches of the offshore fishery.

Meat or fish?

The archaeozoological data gathered at Saltés do not allow one to estimate the contribution of the various animal items to the diet of the town's inhabitants. Such an evaluation is always difficult, due to differences in preservation and recovery chances of the animal remains. The fact that not all remains were sampled in a non-selective way during the excavations obviously hampers any straightforward interpretation. Nevertheless, the finds do suggest that marine resources were very important for the settlement. Consumption refuse from fish can be found everywhere and, even though large molluscs are not abundant in all archaeological contexts, this can be due to specific disposal patterns of large refuse items.

Written sources on the cuisine from Andalucia indicate that fish was not highly regarded as a food item for the upper classes. This is reflected by the fact that, in Muslim cookery books, little attention is paid to fish (García, 1996). Other authors, such as Arié, state that '*les Andalous furent de tous temps amateurs de poisson de mer*' (Arié, 1974-75: 304). Generally, the texts indicate that fish was especially popular amongst the people living along the coast and close to rivers. Fish, that was elsewhere seen as an occasional item in the diet, provided an essential part of the food supply for the coastal and riverine Islamic populations (García, 1996).

The economic relation between Saltés and inland sites

It remains to be investigated to what extent the settlement at Saltés must be interpreted as a self-sufficient production unit within medieval Muslim Spain or whether import and export were important aspects of the food economy. Although medieval written sources describe the presence of good pastures around Saltés, it is probable that livestock consumed in town was not all reared in the immediate surroundings of the city and was often imported from other regions. That small livestock was reared in a transhumant system is well documented for medieval Spain (Moreno, 1997) and makes it probable that the city benefited from animal husbandry that took place further inland.

It has been shown that Saltés produced food products that could be of potential trading interest. The commercial function of the town is mentioned by contemporary written sources, such as the geographical works by al-Idrisi and al-Himyari (Bazzana & Cressier, 1989: 33-34). Another contemporary writer, Ibn Said, specifically described Saltés as an important fishing center, where fish was salted before being exported to Sevilla (Bazzana & Cressier, 1989: 34). The author gives no indication about which species were processed and also does not specify in what way was the fish salted. It is possible that the Roman brine baths described earlier have to be linked with this export, but this can not be proven. Most probably, in the case of fish that was of the fatty-meat type, i.e. pilchard, mackerels and tuna, an elaborate processing took place (Morales *et al.*, 1994). From historical sources it is known that at Sevilla fresh fish was also eaten. Coastal towns as Saltés could therefore have been responsible also for the supply of fresh products, that could mainly have consisted of sparids (Morales *et al.*, 1994).

element	remains recovered	greatest length
upper skull	fragments of one specimen	
lower jaw	fragments of one specimen	
vertebrae	1	
ribs	23	
scapula	2 (1 L, 1 R)	
clavicula	3 (2 L, 1 R)	42.6 / 43.2 / 44.1
humerus	3 (2 L, 1 R)	62.1 / 62.4 / 63.0
ulna	2 (1 L, 1 R)	57.6 / 57.7
radius	3 (2 L, 1 R)	50.0 / 50.2 / 50.7
femur	2 (1 L, 1 R)	71.9 / 72.2
tibia	4 (2 L, 2 R)	61.2 / 61.4 / 62.2 / 62.7
fibula	2 (1 L, 1 R)	59.6 / 60.1

TABLE 4

Human remains found in a medieval refuse context at Saltés (L: left, R: right), and measurements of the greatest length of the long bones (in mm).

Archaeozoological evidence for fish trade in Almohad Spain comes from inland sites such as 12th to 13th century Mértola (Portugal), where (a few) bones from pilchards and sparids were found (Antunes, 1996; Roselló, 1993). In an early 13th century archaeological context at Calatrava la Vieja (La Mancha, Spain), pilchards, sardinellas (*Sardinella aurita*) and horse mackerel (*Trachurus trachurus*) were found as imported seafish (Mo-rales *et al.*, 1994). The faunal spectrum of the imported fish indicates a trade with the Atlantic sector of the southern Iberian coast (west of Gibraltar), rather than with the Mediterranean (Morales *et al.*, 1994).

A possible trade of marine molluscs inland can not be proved on account of the written sources but animal remains from inland Muslim sites testify to it. At 9th to 10th century Mesas do Castelinho (Almodovar, Portugal) *Patella* sp., *Glycymeris glycymeris*, *Cerastoderma edule* and *Mytilus* sp. were apparently consumed (Cardoso, 1993a). At Muslim Mértola (Portugal) *Nassarius reticulatus*, *Acanthocardia tuberculata*, *Ostrea edulis*, *Pecten* sp., *Tapes decussatus* and *Cerastoderma edule* were found (Moreno, 1993), and, at another location within the same site a second author reports *Ostrea edulis*, *Mytilus galloprovincialis*, *Pecten maximus*, *Tapes decussatus* and *Cerastoderma edule* (Antunes, 1996).

HUMAN REMAINS

At one location, during the 1988 campaign, a set of small human bones was found. These remains were encountered in a refuse context, together with numerous animal remains, and were therefore not recognised as inhumations. Most probably these bones are contemporaneous with the animal remains. An inventory of the assemblage is given in Table 4, showing that all skeletal elements are present, except small ones such as phalanges, carpals, etc. In several instances left and right bones can be paired, leading to the conclusion that the remains of two individuals were excavated. When the length of the long bones is compared to reference growth curves (Johnston, 1962), one can see that both inhumations are from newborn children. Most probably, two stillborn baby's (twins?) were simply buried in the vicinity of their parents' house. It is known that in the medieval Islamic world very young children were sometimes not buried with the same regards that adults were (Simpson, 1995). The habit of burying stillborn children in the house has been also attested in the Bahia oasis (Egypt) (Fakhry, 1950).

CONCLUSION

The study of the animal remains indicates that the meat supply at Saltés predominantly came from small livestock, cattle, rabbit and domestic fowl. The exploitation of marine resources, however, must have been at least equally important for the food economy of the town. Fishing and the gathering of molluscs took mainly place close to the coast but open sea fishing provided an additional yield. Probably, an important part of the

pelagic catch was processed and traded inland.

The organic material collected at Saltés demonstrates that the site has a high potential for the study of consumption patterns within a medieval Islamic community. Only when future excavations incorporate an extensive sampling program for animal and botanical remains, can this potential be fully exploited. In that way, aspects that were not touched in the present study, such as socio-economic differences between living units, diachronic comparison within the medieval period or patterns of garbage disposal, could also be analysed. The site also offers a unique possibility to study the consumption behaviour of a protohistoric settlement lying below the medieval city.

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Horses from Pleistocene Sites in the Rhineland, Germany

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ABSTRACT: This paper deals with the size variability of caballine horses (*Equus ferus* in a broad sense) from Middle and Upper Pleistocene sites in the Rhineland. Osteometrical (Variability Size Indices) and oxygen isotope ($\delta\ ^{18}O$) data show the variability in the size of *Equus ferus* living under different climatic and environmental conditions: horses of warmer climates were larger than those of colder climates, which is in contradiction to Bergmann's rule.

KEYWORDS: CABALLINE HORSES, CLIMATE, BODY SIZE, SIZE INDEX, OXYGEN ISOTOPES

RESUMEN: Este trabajo se ocupa de la variación en la talla del caballo (*Equus ferus* en el sentido amplio del término) en el área del río Rin durante el Pleistoceno medio y superior. Los datos osteométricos (Variability Size Indices) e isotópicos ($\delta\ ^{18}O$) demuestran el efecto de las condiciones climáticas y ambientales en la variación de *Equus ferus*: caballos de climas más cálidos son de mayor tamaño que aquellos de climas fríos, lo cual contradice la muy citada regla de Bergmann.

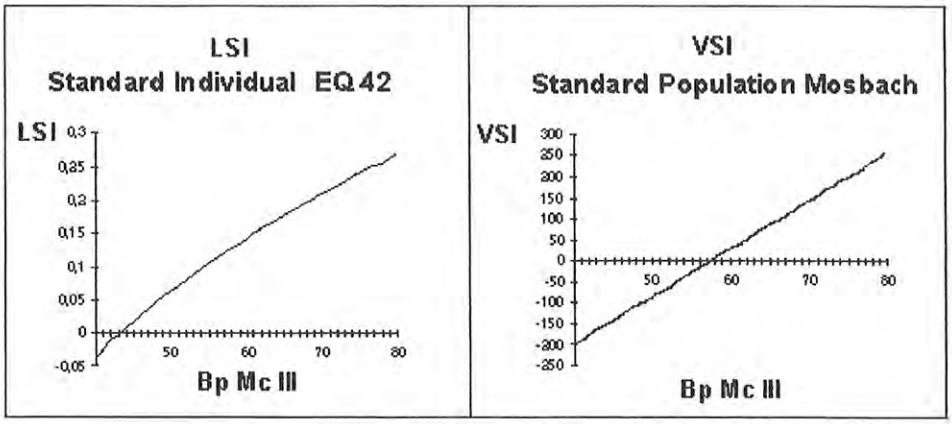
PALABRAS CLAVE: ÉQUIDOS CABALLINOS, CLIMA, TAMAÑO, ÍNDICES DE TALLA, ISÓTOPOS DE OXÍGENO

INTRODUCTION

Osteometrical data from archaeozoological samples are routinely used for a number of different purposes: in investigations of animal domestication (e.g. Davis, 1981; Meadow, 1984; Uerpmann, 1979, 1990), taxonomic determinations (e.g. Eisenmann & Beckouche, 1986; Forsten 1991), or to distinguish between sexes in dimorphic taxa (e.g. Weinstock, 1998). In the present study, osteometric data are used to examine the effects of the climatic changes during the Pleistocene on the morphology of caballine horses and on the isotopic composition of their bone remains[1]. Whereas the relationship of climate and body size is an old topic of discussion, the analysis of isotopes in this context is fairly new.

In this paper, we concentrate on the correlation between the body size changes of caballine horses in the Rhine valley and the climatic changes which took place during the Middle and Upper Pleistocene. The Rhineland was chosen because it is a

[1] The present report is part of a larger project dealing with the effects of climatic change on the morphology and isotopic composition of large mammal remnains. Initial work is limited to two species: *Rangifer tarandus* (Weinstock 1997b, 1998) and *Equus ferus*.



FIGURES 1 & 2
LSI and VSI distribution in correlation to the standard.

relatively small area containing significant collections of well dated *Equus* remains.

MATERIAL AND METHOD

The oxygen isotope ratios in animal bone tissue depend on the global oxygen cycle. The oxygen isotope ratios ($^{18}O/^{16}O$) in the drinking water of mammals change as a function of temperature, humidity, and other related effects. Animals in different habitats have an uptake of drinking water with different oxygen isotope ratios. This ratio is changed by fractionation in the body in a characteristic way for certain species and independent of environmental temperature until the oxygen isotopes are incorporated in the hydroxyapatite of the bones. Investigations of recent animals show a linear relationship between the oxygen isotope ratios of drinking water and bone phosphate (Longinelli, 1984; Luz & Kolodny, 1985). Because of this linear relationship and because of the diagenetic stability of phosphate, the $\delta\ ^{18}O$ values of animal bones reflect the isotopic composition of the drinking water at the time of the formation of the hydroxyapatite. Therefore it is possible to draw conclusions about palaeoenvironments on the basis of the oxygen isotope ratios of bone phosphate (Ayliffe & Chivas, 1990; Luz *et al.*, 1990).

Oxygen isotope compositions were measured exclusively on phosphate of the bone apatite. The sample preparation and analysis followed a modified version of the method described by O'Neil *et al.* (1994) and Stephan (1999). The $^{18}O/^{16}O$ ratios are expressed in the δ-notation relative to USMOW.

It is important to mention that the osteometric studies reported here do not include skulls or teeth, but only postcranial bones. While teeth are certainly useful for taxonomic purposes, their relationship to body size is problematic, since they are part of the nutritional system and much more stable genetically than the postcranial skeleton (Clutton-Brock, 1987).

In this study, body size is used in the sense of "body mass" and not height. Therefore, length measurements of long bones were also excluded. The length of a limb bone represents mostly the height of an animal which depends on other criteria of selection than the whole body mass. The weight of an animal, which directly reflects the body mass, is expressed mainly in breadth and depth measurements of the long bones and all measurements of the small bones in the appendicular skeleton. The measurements were taken to the nearest 0.1 mm generally following the definitions of von den Driesch (1976) and Eisenmann *et al.* (1981).

For the purpose of comparing the size of horses - or any other animals - from different sites and/or periods, it is of great importance that samples be as large as possible. Here, the size index methods are very useful, because through these methods all skeletal elements can be compared simultaneously. Size indices are defined as measures for the deviation of a particular dimension from the respective dimension in a standard. This standard can either be a single individual (Iceland-

ic pony EQ 42, comparative collection, University of Tübingen), if the index is calculated with the Logarithmic Size Index method (LSI; Uerpmann, 1990), or it can be a standard population, when using the Variability Size Index (VSI; Uerpmann, 1982).

The LSI method has the advantage that it is very simple to calculate according to the formula:

$$LSI_{(x)} = \log_x - \log_m$$

where "x" is the dimension of the archaeological specimen while "m" is the corresponding dimension in the standard individual. The disadvantages of this method reside in its exponential nature and therefore the unequal treatment of small and large dimensions (Figure 1).

The VSI has better mathematical properties. It is calculated according to the following formula:

$$VSI = \frac{x\text{-}m}{2 \cdot s_m} \cdot 50$$

where "x" is again the dimension of the archaeological specimen while "m" in this case is the mean of the corresponding dimension in the standard population, and "s_m" is its standard deviation. The standard population should be as homogeneous as possible, because strongly deviating individuals will influence the standard deviation. As can be seen from the formula, the VSI attains a value of ±50 for values of x that are two standard deviations larger or smaller than the mean. It is thus scaled according to the variability of each measurement in the standard population. In mathematical terms it is linear and its increments do not depend on the magnitude of the respective bone dimension (Figure 2). The resulting VSI is positive, if the measured animal was bigger than the mean of the standard population. It will take negative values, if it is smaller. If more than one measurement can be taken on a particular specimen the arithmetic mean is calculated, resulting in a "mean VSI" of the bone. The mean VSI values for all bones of a particular collection form a body of numbers whose statistical parameters characterise the respective sample. The mathematical results can be displayed graphically as "box-and-whisker" plots or as histograms.

Despite the clear advantages of the VSI method over the LSI method, it had not been utilised for horses until now because of a lack of an adequate standard population. The newly available osteometrical data from the site of Mosbach (Brünning, 1978; Koenigswald & Tobien, 1987) allow now the application of the VSI method in the investigation of caballine equids. At the Mosbach site, near Wiesbaden in the Rhine valley, a large number of horse remains were collected over many years. The finds come from fluviatile sands, dating to a temperate phase at the beginning of the Middle Pleistocene, probably Oxygen Isotopic Stage 13 or 15.

The collection is not only rich but also shows a high level of biological homogeneity, which makes it the ideal choice as a standard population. Thus, the size indices used here are based on this horse population. The VSI-distribution of the Mosbach horses approaches a normal distribution, reflecting size homogeneity within the population.

The sites compared to Mosbach in this paper are: Tönchesberg, Wannen, Ariendorf, and Schweinskopf in the Neuwied basin, Wallertheim near Mainz, Mauer near Heidelberg, Achenheim near Strasbourg (France) and - for comparative purposes although not in the Rhine Valley - Vogelherd in the Swabian Alb (see also Table 1).

– Mauer (Beinhauer & Wagner, 1992) - well known because of the *Homo erectus heidelbergensis* - is like Mosbach dated to the Cromerian (OIS 15 (?); Hambach *et al.*, 1992). - Mauer and Mosbach are therefore the only early Middle Pleistocene sites dealt with here. All the others are younger, dating to the end of the Middle Pleistocene and the Upper Pleistocene.

– Neuwied basin: Wannen (Justus, 1987; Turner, 1990), Tönchesberg 1A (Conard, 1992; Turner, 1990), Ariendorf (Turner, 1990), and Schweinskopf (Turner, 1990) are well dated to OIS 6, which is the end of the Middle Pleistocene. From Wannen there is an additional sample of Late Pleistocene bones (Frechen, 1995).

– Wallertheim belongs to OIS 5 (Conard, 1995). For this paper the horse remains from layer F, probably OIS 5c, are analysed.

– Achenheim (Wernert, 1956) has a relatively long sequence, spanning isotopic stages 6 to 2. The results for Achenheim are preliminary, since not all of the material has yet been evaluated. The stratigraphy of this site is complicated and it is not easy to define the transitions between stages.

– Vogelherd (Lehmann, 1954 a+b). Since no adequate sites from the colder parts of the Upper Pleistocene in the Rhineland are at present avail-

Site	Geographical Location	Age	OIS
Mosbach	Wiesbaden	Cromer Complex	13 or 15
Mauer	Heidelberg	Cromer Complex	13 or 15
Toenchesberg IA	Neuwied basin	Younger Riss/Saale	6
Wannen	Neuwied basin	Younger Riss/Saale	6 (+2)
Ariendorf	Neuwied basin	Younger Riss/Saale	6
Schweinskopf	Neuwied basin	Younger Riss/Saale	6
Wallertheim F	Mainz	Early Würm/Weichsel	5c
Achenheim	Strasbourg	Riss to Würm	6-2
Vogelherd	Lonetal, Ulm	Würm	4-3

TABLE 1
List of sites

able to us, this period must be covered by a site in the Swabian Alb. For the purposes of this study, Middle Palaeolithic (Mousterian) material from Layer VII (probably OIS 4) and Upper Palaeolithic (Aurignacian) bones from Layers IV + V (probably OIS 3) of this cave were used.

RESULTS AND DISCUSSION

The main goal of our work is to investigate possible correlations between climatic and environmental changes during the Pleistocene and the body size of *Equus ferus* in Central Europe. Figure 4 shows the VSI values of the measured bone complexes. The black bar in the middle of each plot indicates the mean ± 1 standard deviation. The box contains the middle quartiles and has the median marked at its outside. The two 'whiskers' represent minimum and maximum.

The box-and-whiskers plots show a smaller size decrease from the Cromer Complex - Mosbach and Mauer - to the younger Middle Pleistocene sites, and a stronger decrease towards the end of the Pleistocene. It would seem as if the extreme climatic changes which occurred during the very long time span of the Middle Pleistocene had no significant influence on the body size of horses. However, when considering the isotopic signals of the bones in detail (Table 2), it can be recognised that the available faunal remains do not actually reflect the climatic changes. Obviously, none of the Middle Pleistocene collections included here come from really cold periods of the glacial cycles.

It seems possible that - if horses from cold periods were available - the plot would show stronger fluctuations in the size of Middle and Upper Pleistocene *Equus* instead of a fairly continuous size decrease. This is indicated by the temperature related size decrease during the Upper Pleistocene. There are several sites where the horse remains from overlaying strata are significantly smaller than those from the Middle Pleistocene layers. Histograms of the VSI-distributions of all horse bones from these sites are shown in Figure 5.

For instance, at Mauer two metapodials were found which clearly do not belong to the same population as the rest of the horse bones. Their VSI values are much smaller[2]; stratigraphically, they come from loess deposits belonging to a cold phase, perhaps to the penultimate or - more probably - to the last glaciation.

In Wannen, again, it is obvious that two different size classes of horses are represented. The majority of the bones come from fairly large horses, but 29 specimens point to a similar body size as that of the smaller horses from Mauer. An ESR date for a molar of the small horses from Wannen gives an age of c. 14.5 ka BP, while a ^{14}C-date on a bone gave 22.2 ka BP[3]. Apparently, these bones were deposited during the cold period around the last Glacial Maximum.

[2] VSI-values are calculated independently for the proximal and distal end of complete long bones. Therefore there are four size indeces for two complete metapodials.

[3] Thanks are due to Prof. Dr. A. Mangini and Dr. B. Kromer, Heidelberg, for making these dates available.

Site	Sample N°	VSI	δ ^{18}O(‰)
Mosbach	EQ-MOS 282	8.9	17.3
	EQ-MOS 283	-31.2	16.5
	EQ-MOS 284	12.5	16.7
	EQ-MOS 285	-4.3	16.6
	EQ-MOS 286	-16.9	16.7
	EQ-MOS 287	8.0	16.8
	EQ-MOS 288	-5.5	17.7
	EQ-MOS 289	43.4	17.2
	EQ-MOS 290	-13.7	17.1
	EQ-MOS 291	19.4	17.1
	EQ-MOS 332	-37.3	16.3
	EQ-MOS 333	26.0	18.6
	EQ-MOS 334	41.2	16.8
Mauer, large horses	EQ-MAU 279	-31.2	16.8
	EQ-MAU 280	-12.6	17.4
	EQ-MAU 281	-23.7	16.7
Mauer, small horses	EQ-MAU 277	-92.8	16.0
	EQ-MAU 278	-133.3	16.4
Wannen, large horses	EQ-WAN 339	-8.1	16.3
	EQ-WAN 346	-19.6	16.6
	EQ-WAN 347	-44.0	16.6
Wannen, small horses	EQ-WAN 341	-105.9	16.4
	EQ-WAN 344	-129.0	16.0
	EQ-WAN 345	-84.0	15.0
	EQ-WAN 348	-95.4	14.7
	EQ-WAN 349	-123.3	15.9
Schweinskopf	EQ-SWK 336	-49.6	16.4
	EQ-SWK 337	-45.4	16.9
	EQ-SWK 338	-28.2	17.2
Ariendorf 2	EQ-ARI 335	-46.5	16.9
Toenchesberg I A	EQ-TOE 92	-67.7	15.6
Toenchesberg I B	EQ-TOE 93	-83.7	16.2
Wallertheim, Layer F	EQ-WALF 71	-35.3	17.1
	EQ-WALF 72	-55.9	17.3
	EQ-WALF 73	-47.0	17.7
	EQ-WALF 74	-44.0	17.3
	EQ-WALF 75	-53.3	17.2
	EQ-WALF 76	-53.0	16.6
Wallertheim, Layer A	EQ-WALF 80	-37.5	16.7
Vogelherd IV	EQ-VGH 263	-104.1	15.6
	EQ-VGH 264	-109.4	14.4
	EQ-VGH 265	-141.6	14.8
	EQ-VGH 266	-156.3	14.6
Vogelherd V	EQ-VGH 270	-106.6	15.3
	EQ-VGH 271	-126,0	15.7
Vogelherd VII	EQ-VGH 275	-23.1	15.9
	EQ-VGH 276	-57.1	16.0

TABLE 2

List of bone samples which yielded VSI and δ ^{18}O values

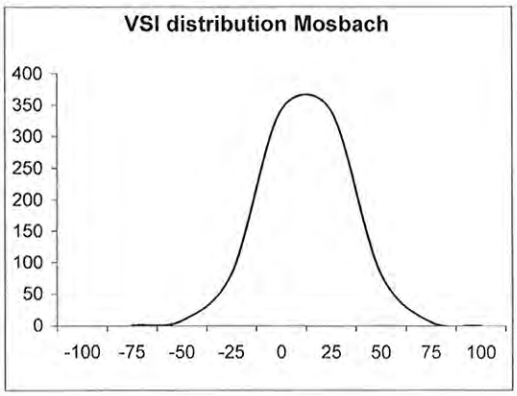


FIGURE 3

VSI distribution of the Mosbach Standard Population. By definition the mean value of the distribution is zero.

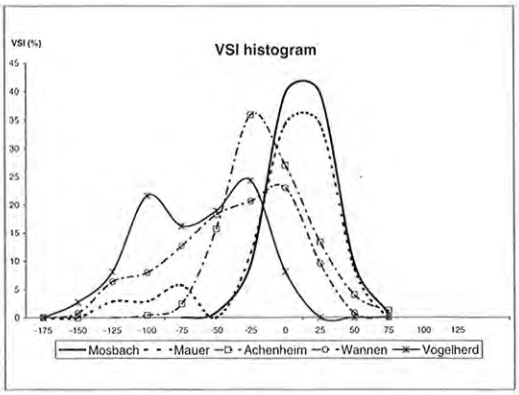


FIGURE 5

VSI distributions for sites with large and small horses in comparison to Mosbach.

The osteometrical evaluation of the horses from Achenheim has not been finished yet. However, it is already clear that beside large individuals there are also some with very small size indices. Unfortunately, no reliable absolute dates for these horses are yet available, and the isotopic analysis of this material is still to be carried out. It seems probable - as was the case in Wannen - that the smaller equids belong to a younger, presumably colder period.

In the case of Vogelherd the two size classes are very well marked in the histogram. The small horses from layers IV+V belong to a colder period of the last glaciation (as indicated by the (δ ^{18}O-values, see below).

The rest of the sites (Wallertheim, Tönchesberg, Schweinskopf, Ariendorf) show a relatively homogeneous population of Equids within the range between the larger Wannen horses and the horses of Vogelherd layer VII.

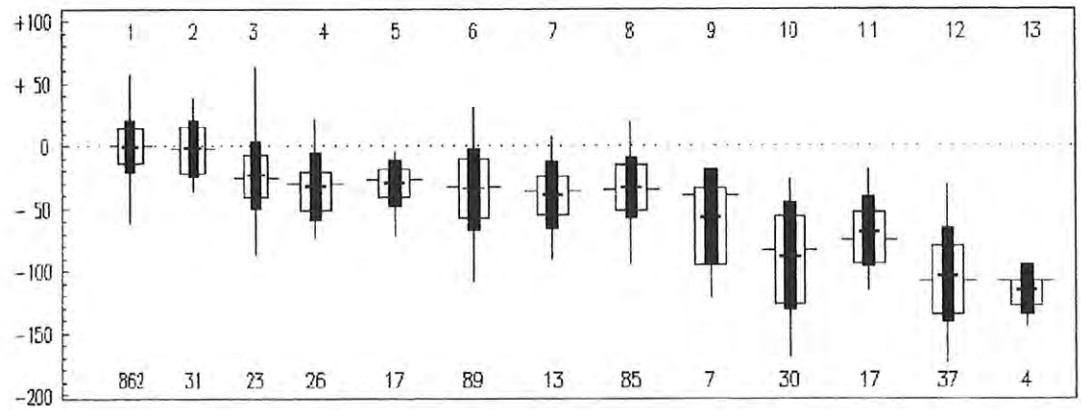


FIGURE 4

VSI-distributions of horses from Middle and Upper Pleistocene. Sites are arranged in chronological order from older (left) to younger (right). The chronological position of the small horses from Mauer is unclear.

1 - Mosbach
2 - Mauer, large
3 - Achenheim, large
4 - Schweinskopf
5 - Ariendorf
6 - Wannen, large
7 - Toenchesberg
8 - Wallertheim
9 - Vogelherd VII
10 - Vogelherd IV/V
11 - Achenheim, small
12 - Wannen, small
13 - Mauer, small

How can the size variability of the horses in the Rhine valley during the Pleistocene be explained? In order to test the hypothesis that the size fluctuations of *Equus ferus* are a response to changes in climatic and environmental conditions, bone samples from the different sites were analysed for their $^{18}O/^{16}O$ ratios.

Figure 6 shows the relation between the VSIs and corresponding $\delta\ ^{18}O$ values for all specimens which yielded a sample for chemical analysis. The individual values are listed in Table 2.

The small horses from Wannen (OIS 2) have definitely lower levels of VSI and $\delta\ ^{18}O$ values than the larger horses of the same site (OIS 6). The same is the case in Vogelherd IV/V in contrast to Vogelherd VII. This result demonstrates that the smaller horses were not contemporaneous to the larger horses and lived under very different environmental conditions.

The relationship between climatic/environmental conditions and body size has been discussed at least since the 19th century (e.g. Bergmann, 1847; Allen, 1877), with the result that a number of so-called "ecogeographical rules" were postulated. One of the best known is Bergmann`s rule, which - as reformulated by Mayr (1970) - states that, in species of warm blooded animals, races from colder climates tend to be larger than races of the same species living under warmer conditions. The basic idea is that with an increase in body mass the surface of the body does not increase at the same rate. Therefore the loss of heat per unit of weight is larger in a small than in a large animal of the same species. Bergmann's rule has been used in a number of studies to explain variations of the body size in different species in the past (e.g. Davis, 1981; Klein, 1964; Klein & Scott,1989).

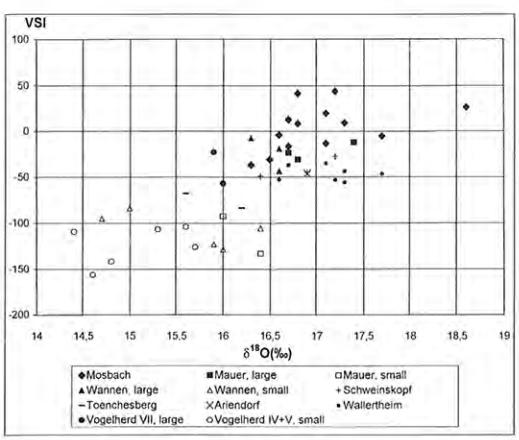


FIGURE 6

VSI versus O (‰) values for Pleistocene horse bones. $\delta^{18}O$ values taken from Stephan (1999).

In recent decades, however, the validity of Bergmann's rule has been questioned by some scholars (e.g. Dayan *et al.*, 1991; Geist, 1987; McNab, 1971; Scholander, 1955, 1956). Geist (1987), for example, argues that the rule would only apply if "all other things are equal". Since thermoregulation in homoiotherm vertebrates is a complex physiological system (e.g. Schmidt-Nielsen, 1975), and since it is but one of many requirements of an individual, it cannot be expected that a single factor - temperature - would determine the correlation between body size and environment. Instead, a number of different factors are involved. On the one hand there are ontogenetical factors such as age and sex (in case of sexually dimorphic species), which can be - up to a point - controlled by the investigator. On the other hand are climatic factors such as temperature and precipitation but also "bio-ecological" ones, like population density and food availability (Weinstock, 1997a, 1998). Of course, climatic and "bio-ecological" factors are interrelated.

The results presented here are in contradiction to Bergmann's rule: Large horses lived during warmer periods and smaller horses during colder ones. As VSI-values are calculated mainly from breadth- and depth-measurements they closely reflect the body weight, which is a direct expression of body mass. Therefore the positive overall correlation between VSI and (^{18}O is clear-cut mathematical evidence against the validity Bergmann's rule in the wild horses which existed in Central Europe during the Middle and Upper Pleistocene. A similar phenomenon was observed for Upper Pleistocene reindeer, *Rangifer tarandus*: the smallest reindeer in the Périgord region (southwestern France) occurred during the glacial maximum, ca. 18 ka BP (Weinstock, 1997a+b).

The isotopic investigations are extremely useful to draw conclusions about the temperature regime - and perhaps the degree of continentality - under which a given population lived, but many other climatic parameters which may influence body size remain unknown. At the moment it is not possible to offer a detailed explanation for the size variations in the caballine horses of the Middle and Upper Pleistocene. Research will be continued

and its geographical frame broadened. In particular it is necessary to measure more bones from contexts belonging to really cold phases of earlier glacial cycles.

The investigations into the development of body size in equids might have repercussions for the taxonomy of this genus. Size has been often used as a criterion to define horse species such as *Equus mosbachensis*, *Equus achenheimensis*, or *Equus solutreensis* (Musil, 1969; Nobis, 1971). Our preliminary results suggest that the size of caballine horses varied repeatedly in response to environmental fluctuations. There seems to be no need to assign horses from different periods at different sites to different species. Instead, it can be postulated that a single species of caballine horse (i.e. *Equus ferus*), with a high degree of phenotypic plasticity, existed during the whole of the Middle and Upper Pleistocene in Central Europe. Statistical parameters for their body size (for instance in the form of VSI distributions) will be more valuable for the geographical and stratigraphical discrimination of populations than any bi- or trinominal taxonomy can ever be.

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Book Reviews

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ANIMALS AND PEOPLE IN THE HOLOCENE OF NORTH AFRICA. *ArchaeoZoologia*. Vol. IX/1.2. ISBN: 285919 1399. 172 pp. 540 FF, airmail, ad 15$. Order/Payment (MasterCard, Visa, Eurocard) Carte number/expiration date. La Pensée Sauvage, Publ. BP 141, T38002 Grenoble, France. *Achilles Gautier (ed.)* 1998.

This volume of *ArchaeoZoologia* is the first issue of the periodical in which the new editorial policy is implemented of publishing it in the form of one or several related papers together with edited collections of papers focussing on the same theme (editorial A. Gautier).

The result is an attractive volume about animal and man in North Africa in a broad sense, comprising ten articles: two about cattle, five faunal reports, one contribution about birds, one about mythical animals and one about the dromedary. They are written in German, English and French. There are twelve authors from Belgium, France, Britain, Egypt, Germany, Italy and Switzerland.

I. Chenal-Vélardé presents an overview of the finds of domestic cattle in the area under discussion. She is of the opinion that more data than currently available will be needed to establish possible cattle-domestication processes in the east of North Africa, in the Western Desert of Egypt in particular, and discusses the much weaker evidence of introduction of domesticated cattle from outside Africa. The table in figure 2 offers a useful overview of sites and ^{14}C dates.

The second article on cattle is by F. Paris, who discusses Neolithic inhumation graves of *Bos* in the south of the Sahara. It would have been practical if this article had followed the article by Chenal-Vélardé because both authors in part discuss the same sites. The evidence from Ardrar Bous and Nabtha is complementary. Chenal-Vélardé discusses the near-complete skeleton of an animal that was naturally buried; Paris mentions the remains of two other animals that were buried by man at the same site. The three animals are thought to have been domesticated.

Faunal assemblages are discussed by C. Corride, A. Gautier & W. van Neer, M. Leguilloux, W. van Neer and A. von den Driesch.

Gautier & Van Neer deal with the faunas of Debbat El Eheima and Debbat Bangdit (1600-1000 BC/400-1000 AD) in the southern Sudan. The sites lie opposite each other on the left and right banks of the White Nile. An interesting finding is that the inhabitants of the older site, Eheima, relied more heavily on hunting than those of the later site Bangdit. Since there is no evidence for a change in the climate, the combined effect of disturbance of wildlife by prolonged settlement and overhunting may explain the observed shift. It may also be that the introduction of zebu cattle, which are well adapted to a tropical climate, intensified Nilotic cattle pastoralism and thus was also a factor in the reduction of game animals.

C. Corride studied the faunal remains from a number of 9th-5th millennium BP sites in the Tradrat Acacus. in the north of Libya. Corride compared his data with those of other archaeozoologists working in the same area. In the older sites, including Uan Muhuggiag US 3/4, there is hunting of Barbary sheep (*Ammotragus Lervia*) and other wild species (second half of the 8th millennium BP). In the younger sites, including those of Uan Muhuggiag Lower and US 1/2 (6th-8th millennium BP) up to Uan Muhuggiag Upper (4th-5th millennium BP), there is a shift to pastoralism with sheep/goat and cattle, while hunting continued to be practised.

K.C. MacDonald for the first time studied the bird remains that were collected during McBurney's excavations in the early fifties in Haua Fteah Cave in the north of Libya. The period spans well over 100,000 years and ends in the Neolithic around 4800 BP. The bird species proved to be of some use in clarifying the environment and chronological sequencing of McBurney's excavations.

A. von den Driesch discusses the late Roman period animal remains from the Kobbat Bent el Rey building in Carthage, on the Mediterranean coast of Tunisia. There were numerous remains belonging to mammals, birds, reptiles, amphibians, fishes and molluscs. The many remains of pig reflect the fact that Romans preferred pork to the meat of other mammals, as was also evident from the Roman sites in the Eastern Egyptian Desert (Lequilloux, Van Neer) The building was in use

from 320/340 to the 7th century AD. The percentages of the vertebrate species remained more or less the same between the beginning and the end of the use of the building. Wild animals were rare.

The contributions of Lequilloux & Van Neer deal with the faunal remains from Roman sites in the Eastern Egyptian Desert. In this case also it would have been appropriate for the one article to have followed the other. Lequilloux in the first place discusses the fauna of Al Zarqa, a military settlement or, according to Van Neer, a desert *hydreuma*. In Al Zarqa pig predominates, followed by dromedary, sheep/goat, horse and chicken. No cattle remains were recovered. Van Neer found this pattern also in Mons Claudianus, dated to the 1st and 2nd centuries AD, but here equids outnumbered pig and dromedary among the mammals. A mere six bones of cattle were also found. In the other settlements, with the exception of 4th-century Abu Sha'ar, where dromedary predominates and pig comes second, sheep and goat predominate among the mammals. Another source of protein was fish, and in the case of 4th- and 5th-century Abu Sha'ar, marine turtles. It could be shown that the inland military posts got their food both from the Nile valley and from the coast. According to Van Neer the fact that pigs were more frequently consumed than the more desert-adapted sheep/goat, underscores the firm dietary preferences of the romanised inhabitants of the desert stations and quarry settlements.

Ostraca found at Mons Claudianus reveal that piglets from the Nile valley were transported alive along the desert roads to be reared at the quarry site. According to Lequilloux, who also cites the ostraca of Mons Claudianus, pork was seldom consumed fresh but was nearly always salted. The pork remains from Abu Sha'ar are thought to confirm this. So here we have two contradictory conceptions of the Roman past in the Eastern Egyptian desert.

From the data of Berenike, studied by Van Neer, it is evident that the number of pig remains steadily dropped in the later periods. This may reflect the food preferences of a population that comprised progressively fewer romanised inviduals, or that pig rearing was abandoned because it was too demanding.

Finally the contribution of M. Manlius & I. Schneider should be mentioned, as well as the article by E.B. Push. The first deals with paintings of mythical creatures dating from the First Intermediate Period to the Middle Period of Ancient Egypt. These mythical beasts to some extent resemble aardvark and warthog. It may be possible that the ancient Egyptians encountered both species in the south of the Fayoum or in the north of the Sudan. Gautier and Van Neer found remains of warthog at Eheima and Bangdit in the middle of Sudan, be it in a later period.

Push describes the incised representation of a dromedary on a disk of local Nile clay from the Bronze Age site of Quantir/Piramess, c. 1300 BC. This picture of a dromedary is the oldest from Egypt and may prove that the dromedary was known at that time in Egypt. According to Boessneck (1988), dromedary remains date to much later periods.

In my opinion it would have been better if the contributions on cattle had followed each other, or indeed if they could have been combined with one map and one list of ^{14}C dates. The same applies to the two contributions on the Roman-period sites in the Eastern Desert of Egypt.

In general, this volume is a clear illustration of the need for far more archaeozoological research in this part of the world. "Animals and People in the Holocene of North Africa" is a useful starting-point for improving our knowledge at the end of the second millennium AD, or indeed the 10th millennium since the first farmers started to farm in the Near East.

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ZOOARCHAEOLOGY. Cambridge Manuals in Archaeology. Cambridge University Press. Cambridge (455 pages, £60 hardback; £22.95 paperback). *Elizabeth J. Reitz & Elizabeth S. Wing* 1999.

The analysis of animal remains from archaeological sites is a rapidly developing discipline as the result of a series of circumstances. Prominent among these are: (1) a growing awareness on the part of the excavators that animals have played a far more important role in shaping human evolution than the traditionally assumed one as providers of food and secondary products, (2) the rapid incorporation of sophisticated techniques, such as molecular biology and stable isotope analysis, that increase the range and scope of the information archaeofaunas are able to yield and (3) the fact that most archaeological faunas provide an intermediate "temporal range" that bridges the gap between zoology (recent) and paleontology (distant past) thus ensuring the possibility of framing current problems, such as the overexploitation of stocks or the depletion of local and global biodiversity, within a larger context than the one either restricted to actualistic or strictly fossil data. Other developments, including improved retrieval techniques or expansion of the taxonomic scope of archaeozoological research, follow from these main issues. As things stand at present, very few of either the biological or the historical sciences have remained alien to the rapid development of archaeozoology/zooarchaeology (choose the name yourself as this is an old and futile debate!) but also many of the physical sciences have similarly played significant roles.

The problem faced by anyone atempting a minimally balanced presentation of such a state of affairs is not what to include but, rather, what to leave out. Well aware of such difficulty, Reitz & Wing stress the criteria for their selection of taxa on the Preface ("*Our emphasis is on animals whose remains inform us about aspects of relationships between humans and their natural and social environment, especially site formation processes, subsistence strategies and palaeoenvironments. Among these... those that offer food, shelter, transport, fuel, tools, ornaments, clothing and social identity receive particular attention*") but not their reasons for leaving behind taxa of equal if not higher relevance for tackling some of these same problems as could be the case of insects and mites. Similarly, one misses an explanation for dealing mainly with skeletal, but not keratinized, tissues and for not devoting sections, even cursory ones, to review paleogenetics, stable isotopes, traces element or any other of the innovative fields of analysis. In fact, one of the criticisms one could invoke for this book is that its "traditional" scope overlaps to a certain extent with other reference manuals in the same series (Claasen, 1998; Hillson, 1986; Lyman, 1994; Wheeler & Jones, 1989).

Having said that, one must appreciate the holistic treatment the authors have tried to apply throughout the text. To start, its geographic range is global and, although this does not mean that an effort has been made to provide regional surveys, the examples shown do give a far more balanced picture of zooarchaeological developments than would have been the case had Reitz & Wing restricted to their fields of interest (quite similar, by the way, on account of their close professional relationship!). Some colleagues complain that, at present, there are two, not one, zooarchaeologies: the American one and the European one. To a certain extent this is true but the differences might not be as much geographical as conceptual. American zooarchaeologists, normally with a strong anthropological/archaeological background, opt for the "topmost-down" approach (i.e., questions first, then data gathering) whereas European zooarchaeologists, with deep roots in the zoological/veterinary sciences, have often chosen the opposite "bottom-up" approach. Again, Reitz & Wing have tried to circumvent to the best of their ability such dichotomy by organizing the volume: "*...in much the same way a faunal study might be*" while adding two chapters on anthropological (number 2) and ecological (number 4) principles to provide the basic background for framing results. One might argue here that both chapters are much too superficial to provide a deep insight into any single question. Still, we feel, from our "continental" perspective, that these two chapters might well be the most informative portions of the manual for practising European zooarchaeologists.

A rather innovative approach used in this text has to do with the creation of a hypothetical collection (Appendix 4) used to illustrate the basics of identification, quantification, meat weight estimation, skeletal distribution, bone modifications, etc... as well as parameters derived from them (e.g., utility indexes). Following a single data set throughout the various chapters provides a sense of continuity to the text which we feel greatly

increases its overall coherence. This same comment applies to Chapter 11 (Conclusions) which constitutes an abridged review of correlations between concepts and data, integrating theory and practice as well as the two conceptual approaches to zooarchaeology just mentioned.

A third of the text has been devoted to the "big questions" of zooarchaeology, namely subsistence (Chapter 8), domestication (Chapter 9) and palaeoenvironmental analysis (Chapter 10). Such treatments must, of necessity, be restricted although we feel that the range of issues covered (nutrition, exchange systems, epiphenomena, etc.) does provide a fairly balanced list of topics on the agenda of any faunal analyst. As it so happens, it is in these chapters that the authors are forced to consider additional sources of evidence such as insects or isotopic analysis although the coverage remains restricted for the most part to case studies.

Several appendixes on taxonomy, anatomy and the management of archaeofaunal/reference collections provide readers with data and practical hints to better follow the narrative. The list of references incorporates papers from all over the world thus providing a rather balanced overview of the current state of affairs.

In perspective, the impression one gets is that zooarchaeology is diversifying at so fast a pace that no single author can probably provide at present a comprehensive review of the discipline. Most of these recent developments arise in sciences alien to the common bioarchaeological background that most specialists have thus being only after many years of practise that the faunal analyst is able to grasp both the mechanics and the possibilities of each one of the different techniques. Notwithstanding, one should now stress that there is no single book like this one on the market at present. Also, when one considers both strengths and weaknesses, the former clearly outweight the latter. If only for these reasons the verdict should be a possitive one. Such verdict is further reinforced when one considers that handbooks are meant as guidelines not as recipe books. We therefore will not hesitate in recommending this book both to students and to professional practitioners alike. There is certainly more to it than just nice illustrations or straightforward procedures on how a faunal analysis can be planned, carried out and presented to the public. Indeed, no easy task!

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DOMESTICATION OF ANIMALS INTERACTIONS BETWEEN VETERINARY AND MEDICAL SCIENCES FREE COMMUNICATIONS. Report of the 30th Congress of the WAHVM and the 6th Conference of the Historical Division of the DVG. 9-12 September 1998 Munich/Germany. *Johann Schäffer (ed.)* 1999.

Der Verlag der Deutschen Veterinärme-dizinischen Gesellschaft hat eine Auswahl von Beiträgen des Veterinärgeschichtskongresses, der im September 1998 in München stattfand, veröffentlicht. Es wurden zwei Themen behandelt: *Domestikation der Tiere* und *Beziehungen zwischen den Tiermedizin- und Medizinwissenschaften.* Als dritter Absatz folgen verschiedene Aufsätze unter dem Titel *Free Communications.*

Wie schon der Leiter der DVG-Fachgruppe Geschichte Univ.-Prof.Dr.Dr.habil. Johann Schäffer im Vorwort darauf hinweist, ist das este Thema aus verschienden Gründen erheblich unterrepresentiert, wobei leider nur zwei Aufsätze vorliegen.

Norbert Benecke stellt den gegenwärtigen Stand der **Domestikation des Pferdes in Europa und Südwestasien** dar. Aufgrund verschiedener archäozoologischen Funde vermutet er eine polytope Entstehung des Hauspferdes mit eigenständigen Domestikationzentren wie Mittel-Südwest und Osteuropa wie auch Mittelasien, bei denen die ältesten Hinweise in den beiden letztgenannten Regionen vom 4. Jahrtausend stammen. Im restlichen Europa kann das Hauspferd erst ein Jahrtausend später nachgewiesen werden und in anderen Gebieten wie z.B. in Ägypten erst ab Mitte des 2. Jahrtausend. Abgesehen von anderen Nutzungen, besteht der Autor auch auf die Rolle des Pferdes als Reittier und viel später, ab dem 2. Jahrtausend mit dem Einsetzen des leichten Wagens, als Zugtier.

C. Cananzi, P.P. Niutta und A. Pugliese liefern einen Beitrag über **die Zähmung des Frettchens in Sizilien**, wo dieses Tier traditionell für die Kaninchenjagd eingesetzt wird. Es werden einige Methoden der Zähmung und der Jagd besprochen, die wahrscheinlich durch die Araber oder sogar früher, zur Römerzeit bekannt waren, da dieses Tier schon in der Antike zur Reduzierng von Kaninchenplagen eingesetzt wurde.

Das zweite Leitthema beginnt mit einem Aufsatz von H. Meyer in dem **die Rolle des Hundes als Modelltier in der Ernährungswissenschaft** hervorgehoben wird, wobei dieses Tier schon seit dem 17 Jahrhundert für verschiedene Experimente angewandt wurde. Die Gründe, den Hund anderen Haustieren vorzuziehen, mag u.a. an seiner einfachen Haltung und Widerstandsfähigkeit bei operativen Eingriffen liegen, bis er im 20 Jh. durch Ratten und andere kleine Versuchstiere ersetzt wurde. Es werden einige Themen zur Erkenntniss der Ernährungswissenschaften wie die Verdaungsphysiologie, Eiweiss- und Energiestoffwechsel sowie einige Mangelkrankheiten erlaeutert.

Peter Koolmees diskutiert über den **Professionalisierungsprozess der Medizinischen Berufe in den Niederlanden von 1840-1940.** Es wird vom soziologischen Standpunkt her die professionalisierung der Medizin und Tiermedizin analysiert, bei denen drei Prozesse sich herauskristalisieren, wie eine Differenzierung, Legitimierung und Institutionalisierung, die mit der Zeit und mit einer gezielten Staatspolitik die Volksheilkundigen und Quaksalber annullieren sollten.

Jan. B. Berns diskutiert über die **Übereinstimmungen und Unterschiede in der Fachsprache der Medizin und Tiermedizin**, deren Ursprung sowohl aus antiken und modernen Sprachen, wie auch aus regionalen und lokalen Dialekten der Bauern und Züchtern abzuleiten ist. Zuletzt wird sie auch von der Stellungnahme des Menschen zum Tier beeinflusst.

In zwei Beiträgen wird die multidisziplinäre Arbeit der Humanmedizin und Tiermedizin an einem klassichen Beispiel erläutert: die Rinderpest. Im ersten Falle bespricht Bob Baljet über **Niederländische Humanmediziner und Tiermedizin im 18 Jh.** Durch die Rinderpest wurden mehrere Humanmediziner der Universität Leiden und Utrecht beaufragt, diese Seuche zu bekämpfen. Klassiche Therapien wie Aderlass, Phytotherapie, Maulwaschungen mit Essig usw. Wurden angewandt und zum Schluss auch von Prof. Camper und Van Doeveren Impfprogramme, - ohne Erfolg-, durchgeführt. Im zweiten Falle, A. Montovani *et al.* stellen dar, wie dank der **Rinderplage in Italien**, eine multidisziplinäre Zusammenarbeit der beiden Wissenschaften dazu führte, diese Seuche zu bekämpfen, aber auch vor allem dazu verhalf, dass in 1769 in Turin die erste tiermedizinische Schule eröffnet wurde.

D. Und H. Seyfarth stellen aus historischer Sicht den Kenntnisstand über **die Ätiopathogenese der Perlsucht (Tuberkulose) des Rindes im 19 Jh.** dar. Von Meinungen des 16 Jh. die diese Kran-

heit als eine Form von Syphilis angesehen wurde, bis zu Behauptungen, dass die Perlsucht diesselbe Kranheit wie die Tuberkulose beim Menschen bedeutet, veranlasste, dass sowohl Humanmediziner wie auch Tiermedinier intensiv an der Forschung dieser Kranheiten teilnahmen.

R. Münch beschreibt **Roberts Koch Expeditionen nach Africa um über verschiedene Mensch-und Tierseuchen zu forschen**. Nicht nur Rinderpest, Texasfieber, Surra und andere Tierkranheiten wurden von ihm untersucht, sondern auch die Epidemiologie der Schlafkrankheit war eines seiner Hauptziele, was zur entgültigen Konsolidierung der Tropenmedizin beigetragen hat.

W. Wittmann und B. Mundt schreiben einen Aufsatz mit dem Titel: **Von Friedrich Loeffler zu Heinz Röhrer- die Riemser Institute für Tierseuchenforschung und Ihre Beziehungen zur humanmedizinischen Virologie.** Friedrich Loeffler, ein Schüler von Robert Koch war seit 1888 in der Greifenwalder Universität tätig, in der er in Zusammenarbeit mit Veterinären verschiedene Tierseuchen untersucht und bekämpft hat, und ein Jahr später mit P. Frosch die Viren entdeckte. Seine Nachfolger, Otto Waldmann und später H. Röhrer forschten an verschiedenen Tierseuchen weiter u.a.Tumore von Nutztieren, Geflügelvirosen, Tollwut, immer in enger Zusammenarbeit mit der Humanmedizin.

Im dritten Absatz sind verschiedene Aufsätze über antike Autoren enthalten, in denen Beobachtungen gemacht wurden, die heutzutage wissenschaftlich belegbar sind. So beschreibt W.Jöchle **Aufzeichnungen von Herodot** die zum Teil falsch übersetzt worden sind oder als Fantasieerzählungen interpretiert wurden wie z.B. dass die Skythen durch vaginale Reizung der Stuten, eine bessere Melkung ermöglichte (erklärbar durch eine Oxytozin- Freisetzung), der Einfluss von Pheromen auf das Verhalten von Hengsten, oder der Vermehrungsprozess bei Fischen.

M.Fritz Brumme schreibt über **Herophilus-*equarius medicus* oder *ocularis medicus?*** eine Figur die in der Medizin-und Verterinärmedizingeschichte vorkommt. Es handelt sich dabei um einen klassischen Fall von der *ständischen* Historiographie. Herophilus als römischer Tierarzt oder Augenarzt ist eine Kunstfigur, bei der die beiden Berufe- abgesehen von verschiedenen Lesensarten der Quellentexte - als solche zur augusteischen Zeit einen sozial sehr abgewerteten Status,- den Sklaven entsprechend- hatten. Auch stellt der Autor den Beruf des Tierarztes zu dieser Zeit in Frage.

K.D. Fischer schreibt über die **griechichen pferdemedizinische Schriften** von Pelagonuis (Mitte des 4 Jh. n.C) und später von Vegetuis 4Jh.n.C., leztere wurde im 9Jh. wiederentdeckt und durch Anweisungen von Karl dem Grossem kopiert, aber erst später ab dem 13 Jh. sowohl in Byzanz wie bei den Arabern praktisch angewandt. Durch Anregung Kaiser Friedrich II entstand eine weitere Arbeit über Pferdekrankheiten, wobei insbesondere in Süditalien und Sizilien verschiedene griechische und arabische Veterinärabhandlungen ins Lateinische übersetzt worden sind.

Der Lebenslauf einer der grössten Persönlichkeiten der europäischen Tiermedizin des 18, Jh. **Ignaz Josef Pešina- ein europäischer Wissenschaftler-**, wird von R. Böhm und J.Šindlá_ beschrieben.

F.R.Doepmann mit dem Titel **Dreck oder Droge- Zur Anwendung von Exkrementen in der Tierheilkunde** erläutert den traditionellen Gebrauch von Fäces und Urin in der Volksmedizin verschiedener Kulturen und Zeitstufen und versucht die pharmakologischen Effekte der Karbonate in der Rinderungasche zur Wundbehandlung im heutigen Sudan zu erklären.

H. Prange beschäftigt sich mit den **Tierseuchen und Tierverluste im Blick des Staatssicherheitsdienstes der DDR** und zitiert das Vorgehen des Apparates der Staatsicherheit an einigen Beispielen wo dann gezielte *Operative Vorgänge* und *Personenkontrollen* verdeckt bearbeitet wurden, um schadenrelevante Ereignisse im organisierten Staatsystem so aufbereitet wie es der Partei und Regierung gelegen kam.

Der letzte Beitrag von Johann Schäffer handelt über die Resultate von mehreren Umfragen in den lezten Jahren über die **Situation der offiziellen Lehrveranstaltungen im Fach Geschichte der Veterinärmedizin.** Es hat sich herausgestellt hat, dass dieses Fach nur in Europa eine traditionell wichtige Bedeutung hat und auch dort sogar nur in 5 Ländern als Pflichtfach gilt.

CORINA LIESAU VON LETTOW-VORBECK: *Departamento de Prehistoria y Arqueología. Universidad Autónoma de Madrid. Cantoblanco 28049 Madrid. España.*

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In memoriam

PHILIPPE MOREL
(9 November 1959-6 June 1999)

The members of the Institute of Prehistory of the University of Basel (Switzerland) mourn for their friend and colleague Phillipe Morel. One of them, Barbara Stopp, tried to remember his years in Basel from the early 80's to the middle of the 90's.

I met Philippe during my first days at the University of Basel in spring 1983. Not only due to the few students in prehistory there was no way to miss his, in the true sense of words, outstanding figure. It was not difficult to become acquainted with him since he dedicated himself to introduce the three freshmen to the top of his interests by inviting them to dinner at his home. It was there that I was first nearly struck by bones. I was, to say the least, quite impressed by his two-room flat, which not only served as his living quarters but also, which was probably much more important to him, store his then already quite impressive comparative collection of animal bones. He proudly showed us the youngest elk bones ever found in Switzerland, now housed in a box under his bed. The climax was the dinner, spaghetti with a tasty tomato sauce, served in his kitchen between glasses of decaying animal bodies in various states. And this was in no way some sort of crucial test, just his normal way of life.

Later, when I started my career as an archaeozoologist, he became one of my teachers. I still remember mine and my colleagues' somewhat nervous anticipation every time he entered our common working-room and came over to our places not only to have a little chat but also to check our work. Friendly, but mercilessly, he found all our "misplaced" bones and corrected us with just a hint of reproach in his eyes.

Philippe was an extremely dedicated collector of animal bones. Already as a teenager he started to collect those he found by chance. Later on it became an important part of his life. It did not matter to which animal class the find belonged, whether the bones were still attached to a more or less decaying body or already clean. He was grateful for nearly everything: from a rabid lynx he himself "imported" from France in his rucksack - by train notabene and yes, the people did smell something

strong - to all sorts of run over animals his many friends collected for him. Most of them never went to the countryside without a plastic bag at hand. One can easily imagine the strange packets he sometimes got. From a former teacher who collected (living) snakes he got some of the dead animals, also exotic and poisonous ones. His second passion became speleology, especially when he detected that caves contain a lot of natural traps for animals. Bats for example, which are quite rare in modern Switzerland, were not so rare in some of the older cave sediments. Probably no speleologist in Switzerland did not know Philippe and his love for bones. He provided them with containers and bags and instructed them on how to collect the bones correctly.

His overall generous and friendly nature, his dedication and interest made it easy for him to gather new friends. When he started to build up a comparative collection for fish in the early 80's he was in no time befriended with a lot of fishermen and anglers of Basel who brought him their unwanted catch. It is quite useless to say that he quickly became a well-known specialist for fish in Basel who also worked together with the officials.

After achieving his degrees in 1985 he decided to leave the Institute of Prehistory at the University and to set up his own institute in Basel. At least he decided this time to separate living quarters and working place. So he rented a flat with three rooms and a kitchen which served him as a preparatory. The contact with him never broke. When there were problems with bones especially hard to determine, he was always happy to help out with his well assorted comparative collection

or with some special literature. By entering his laboratory one immediately stood in a narrow passage filled with bone-boxes to the left and right high up to the ceiling, a familiar odour of decay coming out of his preparatoy which also served as his coffee and tea kitchen. Since he was normally quite pleased with visitors, there was no way to escape an offer of tea/coffee.

Coming from the French speaking part of Switzerland, he returned there in the middle of the 90's where he set up his new office in Neuchâtel.

His scientific career began with his examination work, the analysis of medieval bone material from Basel under the direction of Prof. E. Schmid (University Basel). After having received his master degree he stayed at the Institute and worked on Roman bones from Oberwinterthur (canton Zürich). During this project he got the oportunity to start with the examination of the Palaeolithic site of Champréveyres near Neuchâtel together with Werner Müller also here in Basel. Besides these big research projects he always worked on a lot of smaller archaeozoological projects from different medieval sites in Switzerland excavated by Prof. Werner Meyer and Jakob Obrecht. He participated also at their excavations. The results of his scientific work were presented at the ICAZ-confrences in London, Bordeaux and Konstanz. He was particularly active in the fish-working-group of ICAZ where he attended almost every meeting. These meetings were also an opportunity for him to collect fish bones from all over Europe to complete his collection. Besides his archaeozoological work he was also interested in zooecological projects, specially on fishes and birds of Switzerland. A special topic of his archaeozoological interest was the research on early faunal material. Therefore he began to investigate cavebear bones from various sites in the Swiss Alps. Not only in Europe but also in Syria he was involved in excavations of early Palaeolithic sites. For several years he participated at summer campaigns in El Kowm together with a team of the Institute of Prehistory from the University of Basel under the direction of Prof. J. M. LeTensorer. There he was very enthusiastic to describe new species of the local fauna. For sure this list of his scientific work is incomplete but shows very clearly how broad his interests were and how much important scientific work Philippe had done in his young life.

Philippe died on the 6th of June 1999 during a speleological expedition in the Swiss Alps only 39 years old.

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b) Manuscripts should usually not exceed 20 A4 printed pages (29'5 x 21 cm), including figures and tables. For longer manuscripts, contact the editor. Manuscripts should be submitted on diskette in WordPerfect 5.0 or 5.1, Word 6.0 (for PC). Three paper copies of the manuscripts (for editorial use and review) should be submitted as well. The paper copies should be double-spaced throughout, including tables, figure texts and references.

c) Figures and tables must be of high quality and should be submitted on separate sheets of paper with the number of the figure or table indicated lightly in pencil at the bottom of the page. Figure legends should be numbered with arabic numerals and given on a separate sheet of paper. Figure and table legends should be concise and informative.

d) Papers should be organized as follows: Title, name and mailing address(es) of author(s), Abstract, Keywords, Introduction, Materials and Methods, Results, Discussion, Conclusions, Acknowledgements, References. Results and Discussion may be treated together if this is appropiate. Non-experimental works can be organized in the way which the author(s) think(s) is the most appropiate one.

e) Citations in the text should be with author and date of publication, e.g., (Smith, 1992) or (Smith & Jones, 1992) with comma between author and date; for two-author papers, cite both authors; for papers by three or more authors, use Martín *et al.*, 1993. For two or more papers with the same author(s) and date, use, a, b, c, etc., after the date.

f) References: only papers cited in the text should be included; they should be arranged as indicated in point «f» above.

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