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The Ertebølle 'køkkenmødding' and the Marine Development of the Limfjord, with Particular Reference to the Molluscan Fauna

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INTRODUCTION

The western part of the Limfjord today forms a sound connected to the Kattegat in the east by the narrow Langerak, and to the North Sea in the west by the break through the beach ridges at the Agger spit (fig. 1). This has been the prevailing situation since the Agger spit was breached in 1825. At a stroke, this opening to the west changed the whole fishery in the fjord, from a well-established freshwater fishery to that of the present time with saltwater vertebrates and marine molluscs – although the molluscan fauna is very rich, its 85 species of shell bearing molluscs being among the richest in Danish waters. In particular, the Limfjord has a natural population of oysters, because temperature and salinity in the fjord are sufficient to allow a natural turnover. These conditions have become established since 1825, the marine molluscs being present as a result of immigration since the breach at Agger.

The preceding period, with fresh and brackish species, has left little trace on the deposits of the region. We know of the conditions almost exclusively from historical sources – Pontoppidan's *Danske Atlas* and *Schade's Beskrivelse til Øen Mors* [Description of the Island of Mors] (Pontoppidan 1769, Schade 1811). In particular it is the Limfjord fishery, which was of great importance before 1825, that is described (Rasmussen 1969).

THE EARLIER DEVELOPMENT OF THE LIMFJORD

Investigations at Agger (Petersen 1985a) of the marine deposit under the dunes show that the formation of beach ridges began during the Iron Age *at the earliest.* Throughout the long period from the Early Atlantic into the Subboreal period, there is continuous marine sedimentation. This means that the Limfjord was saline throughout this period, a fact also shown in several places by the dated raised marine deposits which are common in the interior Limfjord area, including the coastal cliffs off Ertebølle.

This development, with its continuous marine deposits, can also be seen in the northern part of the western Limfjord area; in the Vester Hanherred region these deposits can be as much as 30 m thick (Petersen 1981). This great thickness of deposit, which was also the case at Agger, can be explained by the history of the early formation of the Limfjord.

During the final phases of the Weichselian glaciation the melt water had run-off channels towards the northwest, and the sediment deposited by this melt water – the so-called terrace surfaces – is found in the Karup Å river system and in the Falborg valley. The Falborg valley comprises the area south of Viborg, and a stretch to the northwest across the present drainage areas of the Jordbro and Fiskbæk Rivers south of Lovns Bredning (Rasmussen and Petersen in prep.). We can place the formation of these terrace surfaces at around 16,000 before present, and these areas were subject to erosion from then until the Early Atlantic Transgression, as the sea level was very low during the Continental period (defined as beginning at the end of the Allerød, lasting into the Holocene around 7500 bp, cf. Petersen 1985b) – most of the North Sea was dry land. It was the powerful erosion taking place in this period that cut deep channels in the Limfjord region. In these were subsequently deposited the marine sediments of the universally rising seas during the Boreal and Early Atlantic. This eustatic sea level change might be linked to the melting of the North American ice shield – the Scandinavian one had melted earlier.

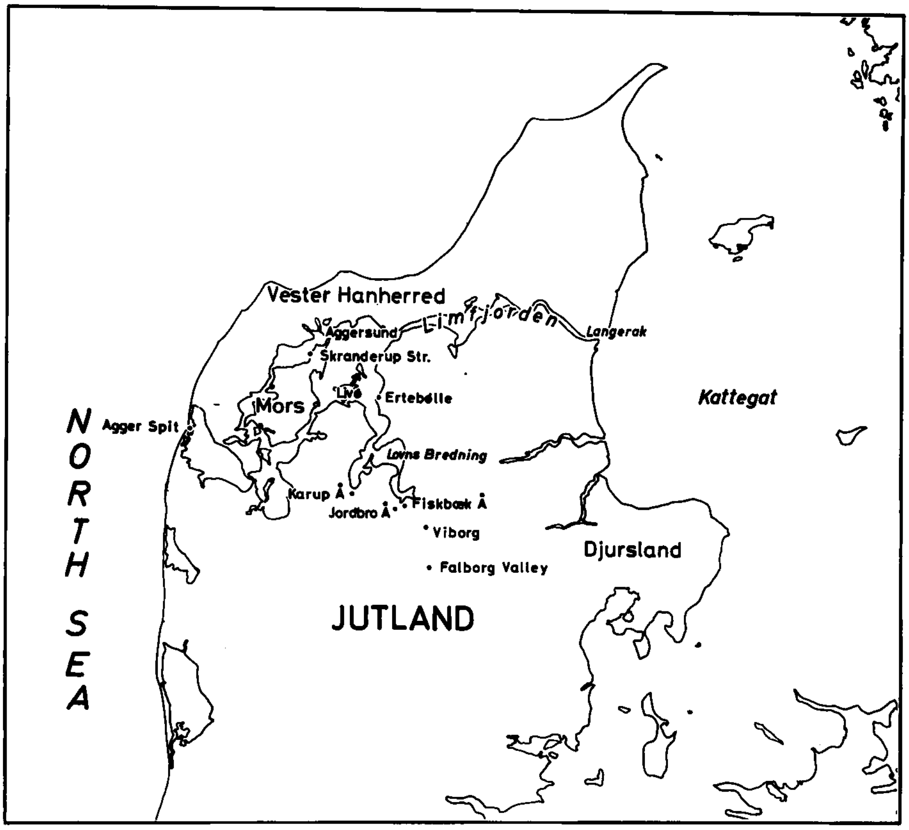


Fig. 1. Location map.

THE HOLOCENE FAUNA OF THE LIMFJORD

The fauna of the early transgressional phase was rich – and most of the species which would characterize the subsequent part of the Holocene were already present, such as the *Tapes* species and the oyster (Petersen 1985b p. 15). In all, 139 species of shell-bearing marine molluscs have been described/identified from the *Tapes* Sea. The many shell-bearing molluscs associate in various seabed communities, and not all can of course be found everywhere. Changes through time can be clearly seen in cores through the thick layers of marine sediments (Petersen 1981). The fauna may be dependent on depth of water or speed of sedimentation. The littoral-coastal fauna was, however, also very rich in the Limfjord area in earlier periods. This was one thing that V. Nordmann, who mapped parts of northern Jutland, called attention to (Jessen 1905, p. 151 ff.). On the basis of the highest marine limit he was able to show that many molluscan species lived in what was for them very shallow water. The same observation can be made along the coasts today, with for example horse mussels, *Modiola*, being washed up on the beach – this species normally lives outside the Limfjord, in deeper water. This situation is clearly important for our evaluation of the possibilities open to people in the Ertebølle period for collecting molluscs in the littoral zone.

Another situation of great importance is the appearance of shellfish as elements of either *infauna* or *epifauna*. To the former belongs first and foremost the cockle, *Cardium edule*, as an element of the latter can be mentioned the mussel, *Mytilus edulis*. As far as seabed types are concerned, the Limfjord has both areas of hard bottom – e.g. the mo-clay formation – and extensive areas of sand and gyttja.

THE AREA AROUND THE ERTEBØLLE *KØKKENMØDDING*

In the Ertebølle area, the seabed at Ertebølle Hoved is hard mo-clay, while to the south there are extensive areas of sand where hard mo-clay only appears sporadi-

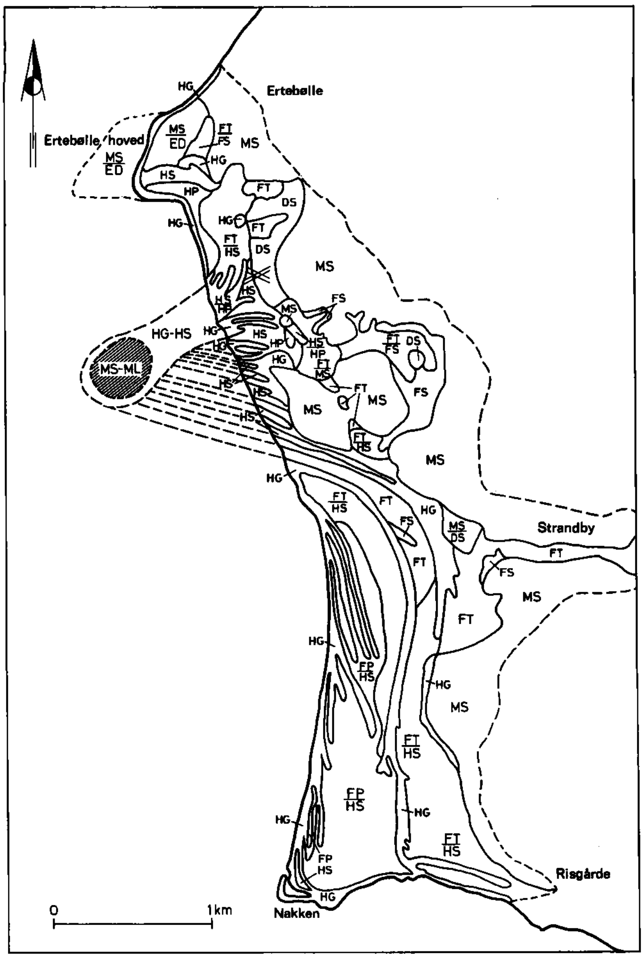


Fig. 2. Geological map of the area round the Ertebølle midden, which is marked with a cross. The letters stand for:

FT	= freshwater peat	HG	= marine gravel
FP	= freshwater gyttja	DS	= meltwater sand
FS	= freshwater sand	ML	= till, clayey
HP	= marine gyttja	MS	= till, sandy
HS	= marine sand	ED	= mo-clay

cally. Substratum conditions have changed through time since the Early Atlantic marine transgression, as a geological map of the area makes clear (fig. 2).

The slope under which the midden lies is regarded as having been cut by the Early Atlantic transgression. It is thought that, at this time (c. 8000 bp), the promontory of Ertebølle Hoved projected further towards the southwest, and that an island of glacial origin lay a short distance out in the Limfjord. Supported by this island complex, a system of raised beaches was formed, of which traces are visible today off the *køkkenmødding* and further south.

Very large raised beaches were laid down in near the settlement, and also further south off the narrow exit from the lowlying area near Strandby. The cliffs behind this raised beach complex were formed in the Early Atlantic, similar to those near the settlement.

Cores have been taken to establish whether marine sediments of this early phase were deposited in the lowlying area east of Strandby. An examination of the possibility that the area east of Strandby was inundated during the early phase of the Limfjord's marine stage (the Early Atlantic) was attempted, by seeking for macro- and microfossils such as molluscs and foraminifera/diatoms in the sediments in the lowlying area. The investigation gave a negative result, in that no fossils were found, so that the development of the basin cannot be elucidated.

The sequence of layers, with peat/gyttja resting on glacial sediments in all three cores, may, however, indicate that the area east of Strandby was a shallow freshwater basin throughout much of the Holocene.

The raised beach complex can be followed as far south as Risgårde, as shown in fig. 2. A more recent complex is being formed off the Nakken promontory. It is the current straightening of the coast which has cut through the older raised beach area, and led to the disappearance of the "island" and the raised beaches running out to it. A residual of erratic boulders is, however, found on the beach south of the settlement, and testifies to the highlying moraine upon which the raised beaches were originally formed.

THE RELATIONSHIP BETWEEN MIDDEN AND FAUNA

On the north side of the raised beaches off the settlement at the present coastline, *in situ* faunal elements approximately on the + 1 m contour have been dated: *Tapes*, *Ostrea* and *Cardium* 6000±100 bp; *Ostrea* 5840±95 bp; and *Mytilus* 5790±95 bp (K-4340, K-4341 and K-4342 respectively, all uncalibrated dates).

Sand-filled hollows between the ridges of the raised beaches have, from a slightly higher level (+ 1.5 m) produced a pure *Cardium* fauna dated to 5280±90 bp (K-3680). On the beach in the bay south of Ertebølle Hoved are *Cardium* dated to 3690±80 bp (K-3679) – in other words from long after the formation of the *køkkenmødding*, which stopped at around 5000 bp after starting about 6000 bp (Andersen and Johansen 1986).

SHELLFISH

Ostrea edulis (Linné)
Cerastoderma edule (Linné)
Mytilus edulis (Linné)
Venerupis decussata (Linné)
Venerupis pullastra (Montagu)
*Venerupis aurea (Gmelin)
Littorina littorea (Linné)
Littorina saxatilis rudis (Maton)
Littorina obtusata littoralis (Linné)
Hinia reticulata (Linné)

ACCESSORY MARINE MOLLUSCS

Bittium reticulatum (Da Costa)
Peringia ulvae (Pennant)
Macoma balthica (Linné)
Parvicardium exiguum (Gmelin)
Timoclea ovata (Pennant)
Hiatella arctica arctica (Linné)
Gibbula cineraria (Linné)
Cingula semicostata semicostata (Montagu)
Triphora perversa adversa (Montagu)
Lacuna vincta (Montagu)
Rissoa albella (Lovén)
Rissoa lilacina (Recluz)
Odostomia unidentata (Montagu)
Buccinum undatum (Linné)
Acmaea virginea (Müller)

TERRESTRIAL GASTROPODS

*Vallonia costata (Müller)
Vallonia pulchella (Müller)
Pyramidula rotundata (Müller)
Hyalinia pura (Alder)
Clausilia bidentata (Strøm)
*Vitrea crystallina (Müller)
*Eulota fruticum (Müller)
*Helix hortensis (Müller)
*Carychium minimum (Müller)
*Cochlicopa lubrica (Müller)
*Vertigo angustior (Jeffreys)

Table 1. All the species of molluscs found in the Ertebølle *køkkenmødding*. An * indicates species only found in the earlier examination (Madsen et al. 1900).

It has earlier been suggested (Petersen 1986) that an examination of the dated *in situ* fauna off the midden, compared with the molluscan composition of the dated midden itself, would give a good chance of examining the Ertebølle choice of diet. It emerges that the oyster was the preferred shellfish in the early phase of the midden (op. cit. table 2).

Two column samples (J and N), taken from the midden for the purpose of examining the shellfish, have now been studied. They reiterate that the oyster was the predominant shellfish (figs. 3 and 4). However, in a level of column sample N (N 17 and 15–11), dated to around 5460 bp, the curve of the *Cardium* peak begins; this is close to the date (5280 bp) of the formation of shallow sand flats after the raised beach formation – when *Cardium* becomes the completely dominant faunal element off the settlement. In column sample J, a lesser marked *Cardium* peak is correspondingly dated to begin around 5430 bp, and thus might reflect the initial formation of shallow sand flats off the settlement.

The main elements in the shellfish of the midden are *Ostrea*, *Cardium* and *Mytilus*, but *Tapes*, *Littorina* and *Nassa* are also present – athough, as shown in both figures 3 and 4, they could at no time have formed an important part of the diet.

For column sample N, accessory marine and terrestrial small molluscs are also listed. Among the marine, *Bittium reticulatum* is particularly predominant – although in no layer does it appear in sufficient quantities to justify the conclusion that individual layers represent *in situ* marine deposits. In support of this is the ubiquitous appearance of small terrestrial snails – particularly *Vallonia pulchella*. These are regarded as having lived on the midden during its formation.

Table 1 lists all the species found in the midden, without taking into account the numbers in which they appear. There are 25 marine species, of which only a few formed part of the diet, while the rest must be regarded as carried into the midden by chance, "accessory marine molluscs".

SEA LEVEL CHANGES AND THE ACCUMULATION OF THE MIDDEN

As mentioned in the section on the area around the midden, the slope below which the midden lies is regarded as cut by the Early Atlantic transgression. The basis for this is that, in the Vester Hanherred region north of Ertebølle, deposits of shells, *Ostrea/Cardium*, at + 3.5 m are dated to around 7000 bp on abraded surfaces off slopes like that behind the Ertebølle *køkkenmødding*.

On the nearby island of Livø, and on Skranderup beach on northwestern Mors, there is evidence of a regression around 6000 bp (Petersen 1976). Formation of the midden began in this period, as mentioned in the section on the relationships between midden and fauna.

As shown by the examination of the two column samples (J and N), there is nothing that can be interpreted as an autochthonous marine layer, so there are thus no reasons to assume that the midden was inundated by the sea for any length of time during the millennium of its accumulation.

Experience of a multi-lobed body of water like the Limfjord, however, makes it not unlikely that wind action or shorter periods of high water level could have *redeposited* parts of the midden. Allochthonous shell midden material cannot be recognized by means of methods used in this study, however, but should rather be visible in the appearance of the artifacts (Andersen and Johansen 1986).

The dating of a definite shallow water fauna, the Cardiidae of the shallow sand flats, to around 5280 bp, at a higher level than the earlier faunal elements dated off the settlement, testifies to a rising sea level towards the latest phase of the midden.

The final flooding of the midden can be demonstrated archaeologically by water-rolled flints. This can be referred to the Early Subboreal, when the highest marine limit is attained in this area. High-lying raised beaches at Aggersund at + 6 m are dated to around 4990 bp (Petersen 1976).

THE SPECIES COMPOSITION OF THE *KØKKENMØDDING*

Table 1 also lists species identified in the shell midden during the early excavations (Madsen et al. 1900). Within marine molluscs this only adds *Venerupis aurea.*

The situation is different regarding the 11 species of terrestrial gastropods, however, of which 7 were identified by the earlier work of J. Collin Jr. (op. cit. p. 81).

The predominant shellfish in the midden, *Ostrea edulis, can* be found dispersed on the soft seabed, but is most frequently found in banks – and this is the way they were found by the Ertebølle people. This is shown by a umber of the other species found in the midden, such as *Venerupis* spp, *Bittium reticulatum, Parvicardium exiguum, Hiatella arctica, Gibbula cineraria, Triphora perversa, Odostomia unidentata, Buccinum undatum* and *Acmaea.* These are most commonly described together from subfossil oyster banks and, as is characteristic of the Limfjord, also from shallow areas.

The other, briefly predominant element in the midden comes from deposits in fjords and sounds with soft seabed (cf Nordmann (Jessen 1905)). This is *Cerastoderma edule* with species like *Littorina* spp., *Macoma balthica, Rissoa* spp., but also *Bittium reticulatum* and *Parvicardium exiguum* which are also known from the oyster banks.

A large concentration of Cardiidae is found in lagoon formations, to which the sand flats off the midden can be referred.

All the various environments mentioned are highly saline. A few species, *Venerupis decussata* and *Venerupis aurea*, are no longer found in the region. Furthermore, from the size of the subfossil oyster banks and the high species variety in the midden it must be assumed that the natural renewal of the oyster population was greater than it is today. This suggests higher temperatures and greater salinity in the Atlantic sea than is the case at the present time.

According to statements by Steenberg (1911) concerning the habitats of land snails in Denmark, woodland appears to have been predominant among the species found in the Ertebølle *køkkenmødding. Vertigo angustior* and *Cochlicopa lubrica* are, however, exceptions, listed as coming from open and dry areas. It is, however, significant that this must be somewhat revised according to Kerney and Cameron (1979), who specifically state that the most common landsnail in the Ertebølle midden, *Vallonia pulchella*, is *not* found in woodland, but in open calcareous environments. It is not specifically stated that *Vallonia costata* is not found in woodland, but it is also found in open calcareous environments. Evans (1972) mentions *Vallonia costata* as one of the first species to colonize England after the Weichselian, and states that it is a species "of open habitats, rarely entering woods". It must be mentioned that many of the landsnails found in the Ertebølle midden are also known from other middens in Jutland – for example Meilgaard on the Djursland peninsula, Eastern Jutland. As regards the landsnails, there is therefore (concurring with the authors in Madsen et al. 1900) no reason "to doubt that they also derive from the Stone Age, but full certainty cannot be reached". However, with regard to degree of certainty that the snails do

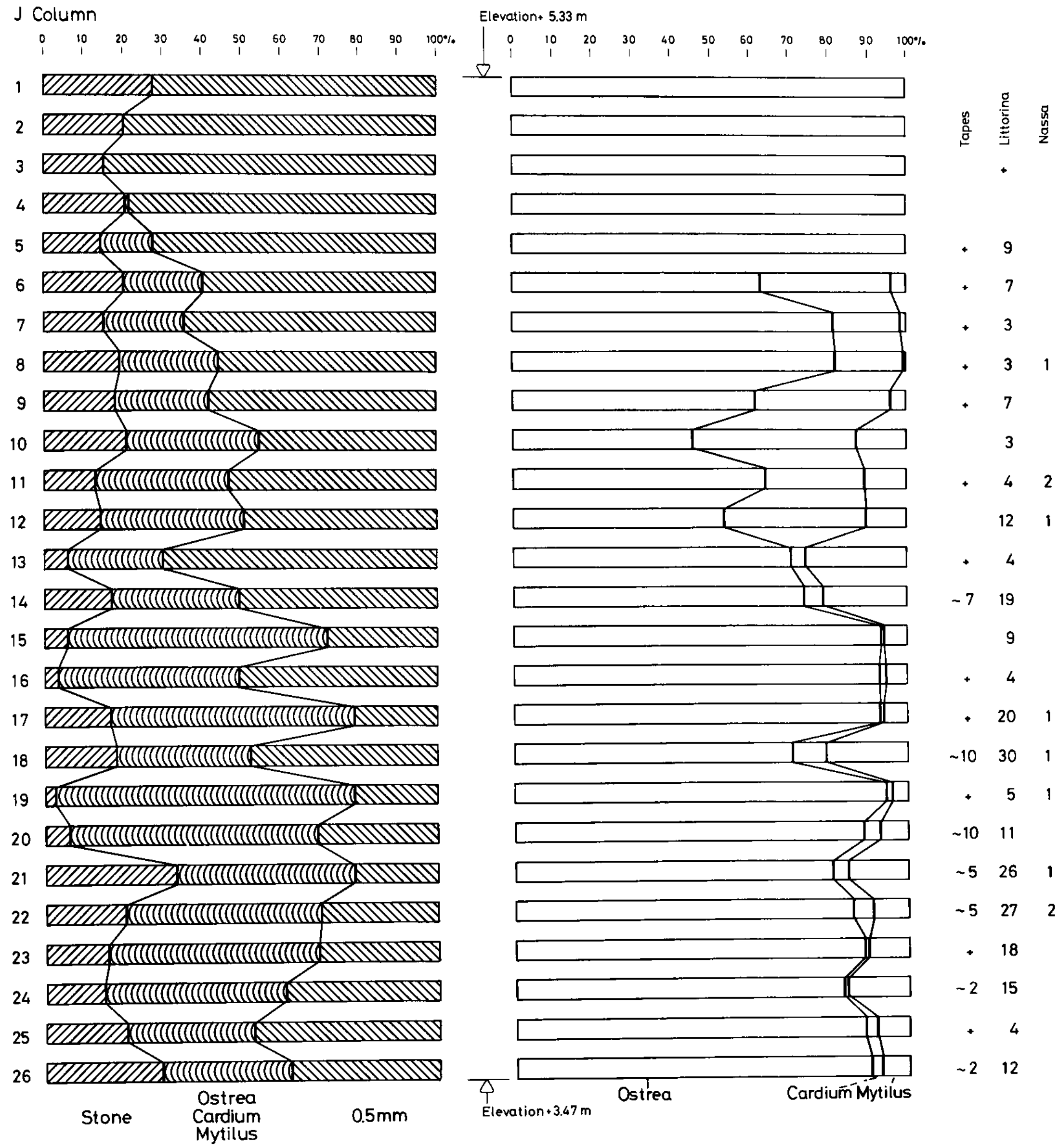
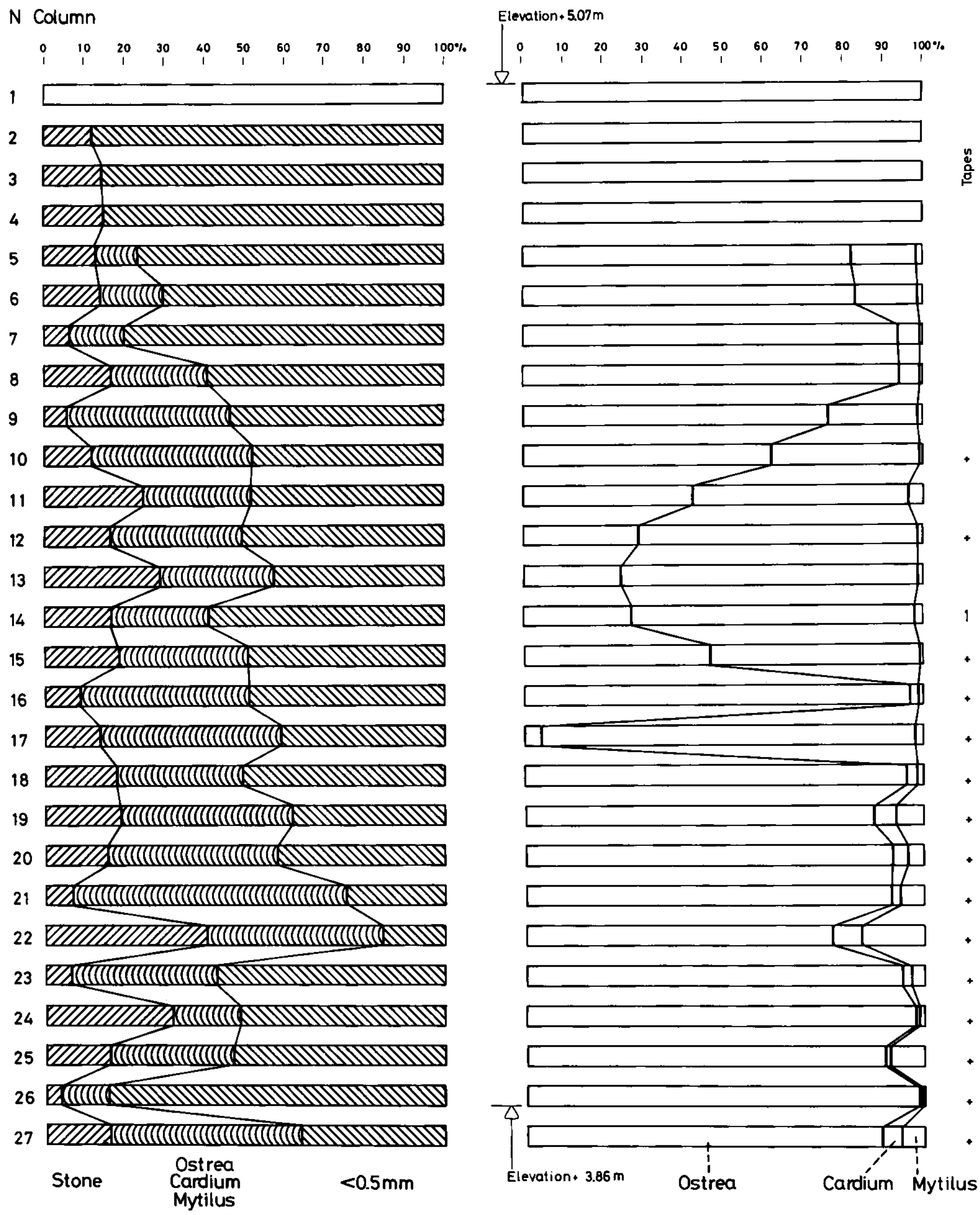


Fig. 3. Column sample J. Percentage by weight in the samples of up to 2000 g of stones, shell material (*Ostrea/Cardium/Mutilus*), and material under 0.5 mm. The division by weight of the species *Ostrea edulis*, *Cardium edule* and *Mytilus edulis* is given. Potential dietary elements are given in number of individuals.

derive from the period of midden formation, their presence *throughout* column sample N seems to demonstrate contemporaneity.

On the basis of the data from column sample N (fig. 4), one could suspect that the appearance of "many" *Bittium* shells could be linked with the *Cardium* maximum, as small snails can easily be included during the digging of Cardiidae – an element of the infauna. The many remains of fish in column sample N were also found in the *Cardium* level; these are examined by Inge Enghoff (1986). Whether there is any dietary connection with cooking – there are fireplaces at the level of the *Cardium* maximum – is something I will not discuss, and I will now let the tables speak for themselves without involving myself in further speculation.



	Tapes	Littorina	Nassa	Marine	Terrestrial
1					
2					
3					
4		1		5	1
5		1		4	3
6				3	7
7		3		9	3
8				3	
9		3		9	6
10	+	1		15	6
11		7		65	3
12	+	10	1	15	2
13		22		11	1
14	1	4		55	5
15	+	9	1	31	
16	+	4	2	28	1
17	+	4		12	2
18	+	1		12	3
19	+	7		5	3
20	+	8		13	2
21	+	7		3	4
22	+	25		7	3
23	+	1		27	1
24	+			8	1
25	+	7			
26	+			9	
27	+	4		3	2

Fig. 4. Column sample N. Percentage by weight in the samples of up to 2000 g of stones, shell material (*Ostrea/Cardium Mytilus*) and material under 0.5 mm. The division by weight of the species *Ostrea edulis, Cardium edule* and *Mytilus edulis* is given. Potential dietary elements are given in number of individuals. Accessory elements of small marine snails and mussels and terrestrial gastropods are found throughout this column sample.

CONCLUSION

In the above the development of the western part of the Limfjord is briefly presented, and the marine molluscan fauna of the area's early stage – the Atlantic – discussed on the basis of earlier works. It emerges that the Atlantic molluscan fauna was rich in species, and studies of areas close to the midden show that the Ertebølle people had rich biotopes to collect in.

Comparing this with the examination of the two column samples (J and N) from the midden, it appears that the oyster (*Ostrea edulis*) was the preferred shellfish.

The cockle (*Cardium edule*) is predominant only in a few layers of the midden. Experience shows that the shells of the mussel (*Mytilus edulis*) survive less well, but as this study is based on weight even small fragments have been included in the data base. It is thus possible to state that the mussel was less sought after as a dietary item.

Besides the division into percentages of the weights of the three species mentioned above, individuals were counted of *Tapes* (*Venerupis* spp.), *Littorina* (*Littorina* spp.) and *Nassa* (*Hinia reticulata*). These are all potential food species, but never achieved any importance. With regard to size, individuals of particularly *Littorina saxatilis rudis* and *L. obtusata littoralis* are present which are so small that they must be ruled out as a food source.

The accessory marine molluscs listed in table 1 are only a small part of the Atlantic fauna of small snails and mussels, and they are regarded as having been carried into the midden by chance. Attention is drawn in this connection to the presence of stones throughout both column samples. As the figures 3 and 4 are based on percentages, a correction factor must be applied as the density of stone is 2.7 while that of shell is about 1. Despite this, there is still so much that the stones must have been brought into the midden via the collected shell material, and perhaps also attached to strands of seaweed.

Regarding the appearance of terrestrial gastropods, one must particularly note that they appear throughout the whole of column sample N. The most common, the *Vallonia* species, are characteristic of open, calcareous environments – and a *køkkenmødding* must be described as exactly that.

Translated by Peter Rowley-Conwy

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REFERENCES

ANDERSEN, S. & JOHANSEN, E. 1986: Ertebølle Revisited. *Journal of Danish Archaeology* 5.

ENGHOFF, I.B. 1986: Freshwater Fishing from a Sea-Coast Settlement – the Ertebølle *locus classicus* Revisited. *Journal of Danish Archaeology* 5.

EVANS, J.G. 1972: *Land Snails in Archaeology.* 436 p. Seminar Press, London.

JESSEN, A. 1905: Beskrivelse til Geologisk kort over Danmark. Kortbladene Aalborg og Nibe. *Danm. geol. Unders.* I. Rk. nr. 10, 193 p. Copenhagen.

KERNEY, M.P. & CAMERON, R.A.D. 1979: *A Field Guide to the Land Snails of Britain and North-west Europe.* 288 p. Collins, London.

MADSEN, A.P., MÜLLER, S., NEERGAARD, C., PETERSEN, C.G. JOH., ROSTRUP, E., STEENSTRUP, K.J.V. & WINGE, H. 1900: *Affaldsdynger fra Stenalderen i Danmark.* 196 p. København.

PETERSEN, K. STRAND 1976: Om Limfjordens postglaciale marine udvikling og niveauforhold belyst ved molluskfaunaen og C-14 dateringer. *Danm. geol. Unders. Årbog 1977*, pp. 39–52. Copenhagen.

– 1981: The Holocene marine transgression and its molluscan fauna in the Skagerrak-Limfjord region, Denmark. *Spec. Publs.int. Ass. Sedimentol.* 5, pp. 497–503.

– 1985a: Late Weichselian and Holocene Marine transgressions in Northern Jutland, Denmark. *Eiszeitalter und Gegenwart* 35, pp. 1–8.

– 1985b: The Late Quaternary History of Denmark. The Weichselian Icesheets and Land/Sea Configuration in the Late Pleistocene and Holocene. *Journal of Danish Archaeology* 4, pp. 7–22.

– 1986: Holocene marine Molluscan Faunas and Shellfish from *Køkkenmøddinger* in the Limfjord Region, Northern Jutland, Denmark. In L.-K. KÖNIGSSON, ed.: *Nordic Late Quaternary Biology and Ecology.* Striae 24.

PONTOPPIDAN, E. 1769: *Den Danske Atlas*, Tomus V. 1104 p. Copenhagen.

RASMUSSEN, H. 1968: *Limfjordsfiskeriet før 1825.* Folkelivs studier 2. Nationalmuseet, Copenhagen. 517 p.

RASMUSSEN, L. AABO & PETERSEN, K. STRAND (in prep.): Geologisk kort over Danmark. Kortbladet Viborg. *Danm. geol. Unders. Serie A*, Nr. 5.

STEENBERG, C.M. 1911: *Landsnegle (Bløddyr I.).* Danmarks Fauna 10. Naturhistorisk Forening. Gads Forlag, Copenhagen. 221 p.

SCHADE, C. 1811: *Beskrivelse over Øen Mors.* Aalborg.