

POSSIBILITIES AND LIMITATIONS OF THE USE OF ARCHAEOZOOLOGICAL DATA IN BIOGEOGRAPHICAL ANALYSIS: A REVIEW WITH EXAMPLES FROM THE BENELUX REGION

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Abstract. Archaeozoology is the study of interactions between man and other animals through time, by the analysis of animal remains and traces found during archaeological excavations. Gradually, it has also been recognised by the « mainstream » zoological world that archaeozoological data can provide insight into the evolution or regional variation of the Late Pleistocene and Holocene faunas of the Low Countries, just as palaeontological research does for older periods. The wide scope of recent archaeozoological research is, however, often not fully recognised, not only in terms of taxonomic diversity, but also with regard to the detail of information gathered. This review highlights these interpretative possibilities, but also outlines the possible limitations of archaeozoological datasets. These limitations are linked with the characteristics of the sites investigated, *i.e.* the conditions affecting preservation, the formation processes, the cultural framework, or the origin of the deposits. The dataset is also biased by archaeological methodology, particularly in relation to the sampling and recovery of organic remains. Furthermore, the information gathered will differ strongly between taxa, according to their taphonomic status, their place within different human cultures, the chances of fossilisation of their remains, and eventual identification problems. When the limiting factors described are not known or not well understood, the use of archaeozoological data in faunal reconstructions may lead to false conclusions.

Key words: archaeozoology, biogeography, biodiversity, introduction, extinction.

INTRODUCTION: THE BIODIVERSITY OF THE PAST

The past is an important dimension to an holistic approach to the environment (MACINNES & WICKHAM-JONES, 1992). It is indeed impossible to understand and discuss the composition of the fauna in a certain geographical area without any data on its evolution. A diachronic dimension is even more important when faunas are managed, *e.g.*, when the reintroduction of wild species is considered or when management strategies for natural reserves are discussed, involving the herding of domestic grazers in semi-confinement. When, for example, a discussion arose in the Netherlands about the introduction of « wild sheep » into the wild fauna of some natural reserves, supporters of this idea put forward the argument that this would only be a reintroduction, because « wild sheep » had occurred

in Europe during the Pleistocene and some populations were still surviving on Corsica and Sardinia. The subsequent proposal was to introduce animals from this Mediterranean stock into the Low Countries. Thanks to research on the evolution of wild and domestic sheep, critics of the idea could, however, explain that the Pleistocene sheep of Europe was in fact a different species (*Ovis savinii*) than the one still surviving on Corsica and Sardinia (*Ovis ammon*). Moreover, the Mediterranean «wild sheep» represent no more than feral populations of domestic sheep (*Ovis ammon* f. *aries*) that were introduced to the islands, from the Near East, in Neolithic times (VAN WIJNGAARDEN-BAKKER, 1991).

Data on the composition of former faunas can be gathered in many ways. Most well known is the contribution of palaeontology, generally involving the study of fossil remains and traces of former organisms. In principle, palaeontology studies material from all time periods, from the Precambrian to recent times. However, in the mind of the general public (and of scientists not familiar with the field), palaeontology often deals only with «old» material, dating from the Pleistocene or before, and is therefore considered to be of little importance for the study of recent faunal evolution. This common misunderstanding mostly originates because «younger» (*i.e.*, Holocene) sites are generally excavated by archaeologists and not by palaeontologists. Consequently, the study of organic remains from these sites is not labeled «palaeontology» but «archaeozoology», or «archaeobotany». Both archaeozoology and archaeobotany are, however, no more than palaeontological disciplines with a specific character, because humans were the conscious or unconscious taphonomic agents responsible for the accumulation of the organic remains found at excavated sites.

During the last decades, it has gradually been recognised by the «mainstream» zoological world that archaeozoology – here defined as the investigation, through the analysis of animal remains and traces found at archaeological excavations, of the interaction between man and animal through time – can provide insight into the evolution or regional variation of our recent faunas (see BENECKE, in press, for a recent review for European faunas). This paper presents a survey of the difficulties that can arise when archaeozoological data are used without caution. A student of biogeography cannot safely incorporate archaeozoology into any considerations without knowing the possibilities and limitations of the field.

POSSIBILITIES OF ARCHAEOZOOLOGICAL ANALYSIS

In its pioneering years, archaeozoology mainly focused upon the history of large mammals. Most of the material recovered from archaeological excavations came indeed from large domestic animals (cattle, sheep, pigs) in the case of Neolithic or younger sites, or from large game in the case of Palaeolithic or Mesolithic sites. Gradually, however, the remains of smaller animals, including invertebrates, were incorporated into archaeozoological analyses. This evolution became possible by the use of refined sampling and recovery methods on sites, and by the gradual accumulation of experience with the treatment, identification and interpretation of small archaeological organic remains. Nowadays, archaeozoological research covers a wide scope of organisms, of

which the presence or absence at archaeological sites can be evaluated. Remains of invertebrates from the famous early medieval Coppergate site at York (UK) included specimens belonging to sponges, nematodes, annelids, molluscs, echinoderms, crustaceans, chilopods, diplopods, and a wide variety of insect orders (KENWARD & HALL, 1995). During the last decade, mites (Acari) have also become increasingly popular as ecological indicators for archaeological sites (SCHELVIS, 1992) (Fig. 1). Recently, it has been demonstrated that even the remains of testate amoebae can be found in archaeological contexts (BOBROV, 1998).

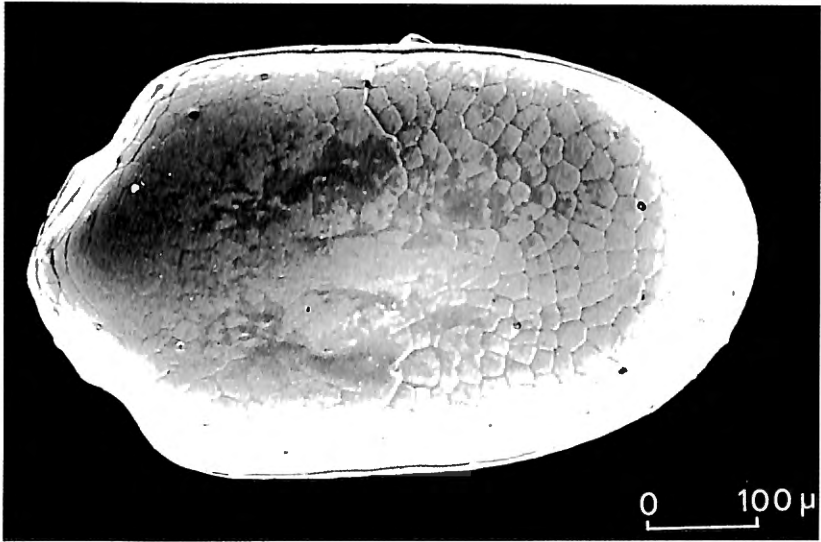


Fig. 1. – Exoskeleton of a mite belonging to the Gamasida, recovered from a medieval site at Oudenburg (B.) (from SCHELVIS & ERVYNCK, 1993).

The species lists from archaeozoological contexts give information about the composition of former faunas. The assemblages studied are dated by the analysis of archaeological artefacts found in the same contexts, their stratigraphic provenance, historical information, and, occasionally, by physico-chemical methods. The use of the latter technology is often not needed, especially when, as is the case for the Roman period, it is often possible to date faunal collections within a time interval of 20 to 25 years, on the basis of their archaeological context alone (*e.g.*, ERVYNCK & VANDERHOEVEN, 1997). In most cases, archaeozoological collections can also be placed into a taphonomic context, meaning that it is often clear why remains ended up at a human dwelling place, and what agents were responsible for their accumulation and preservation. From the associated archaeological and historical data, archaeozoological finds can be placed in a socio-economic context, revealing, for example, whether the material was deposited in a rich site with many long-distance contacts, or in a poor, rural household depending upon a subsistence economy. Finally, pedological, geomorphological and climatological information, together with associated plant remains, allow situating the animal remains in their former environment.

It would be a mistake to assume that archaeozoological information about past faunas is only needed for periods or cultures without written archives. Generally, historians (and biologists working with historical data) underestimate the potential of information that can be extracted from archaeological research and how fruitful can be the critical confrontation between written and excavated sources. As to the consumption of animal food products, for example, it has been amply demonstrated that, even for a period with a rich historical documentation such as the Late Middle Ages, written records alone are not sufficient to allow a more or less reliable reconstruction (ERVYNCK *et al.*, 1996; ERVYNCK & VAN NEER, 1998). When reviewing the historical records for faunal biogeographical information, it becomes clear that archaeozoology is the only reliable source of information about past faunas for most of the period that we call «history». For his history of birds in Belgium, the oldest reliable scientific source that DESMET (1987) could use was the 19th century «Faune belge» by DE SELYS-LONGCHAMPS (1842), whilst archaeological records of birds cover the whole of the Holocene. The danger exists that, when only 19th and 20th century scientific data are used in historical biogeography, the impression arises that our 19th century fauna represents the original or 'natural' one, except for some extinctions of larger species, which are usually situated in early prehistory. It is therefore often surprising for students of the fauna of the Low Countries to learn from archaeozoological analyses that Dalmatian pelican (*Pelecanus crispus*) was still present around 2400 BC (CLASON *et al.*, 1979), that aurochs (*Bos primigenius*), black vulture (*Aegypius monachus*) and great auk (*Pinguinus impennis*) survived into Roman times (DE GRAEVE, pers. comm.; VERHAGEN, 1991; VAN WIJNGAARDEN-BAKKER, 1978), and that brown bear (*Ursus arctos*) only became extinct after the 12th century AD (ERVYNCK, 1993a). In contrast, archaeozoology has proven that animal groups such as our freshwater fish fauna, of which the decline (and extinction) is commonly thought to have begun during the Industrial Period, already suffered significant diminishing population numbers during the Middle Ages (VAN NEER & ERVYNCK, 1993; 1994; in press). Finally, even for the biogeography of the most recent periods, for which real scientific data is supposedly available, archaeozoological data can be extremely meaningful. For example, the often quoted theory that the post-medieval decline of the black rat (*Rattus rattus*) in Northwestern Europe is the result of competition with the brown rat (*Rattus norvegicus*), which was introduced in the 18th century, is contradicted by the archaeological finds of late 19th to 20th century black rat nests in the center of Gent (ERVYNCK, 1990; ERVYNCK & BASTIAENS, in press).

On a global scale, archaeozoological analysis has already accumulated a vast *corpus* of information, since its beginnings in the 19th century. One major advantage lies in the virtually infinite amount of new material that is still hidden on archaeological sites and which may be available for study in the future. Moreover, previously studied collections always yield new information through methodological developments, and represent an archive of which the potential has not yet been fully explored. Archaeozoology has not only constantly made progress in terms of the taxonomic diversity of the material studied, but has also revealed ever-more-detailed information, gathered from excavated remains. Archaeozoological research yields more than mere species lists. It is now possible, from the skeletal elements of vertebrates, to deduce morphological characteristics such as body size or the domestication status of former animals, their growth rate, the distribution of age at death of past populations, their sex ratio, prevailing pathologies, aspects of feeding con-

ditions, etc. (see DAVIS, 1987 or CHAIX & MENIEL, 1996 for a general review). One of the most important recent innovations is the extraction of biomolecular information from ancient bone, but methodological problems still occur (GÖTHERSTRÖM & LIDEN, 1998).

LIMITATIONS IN THE USE OF ARCHAEOZOOLOGICAL DATA

When archaeozoological data are used in biogeographical studies, the simplest question asked is often whether the species list from a site provides information about the presence or absence of a certain animal species in a certain period, in the area around the site. When dealing with this question, many of the limitations of the archaeozoological dataset become apparent. They can be discussed in a logical order, following the chain of events from the presence of an animal at a former human dwelling place to the analysis of its remains by an archaeozoologist (Fig. 2).

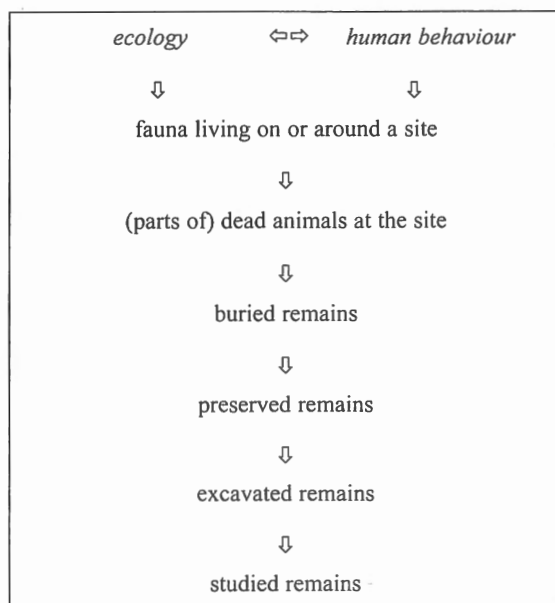


Fig. 2. – Schematic diagram illustrating the events from the death of an animal and the archaeozoological analysis of its remains (modified after DAVIS, 1987).

Nature of the sites investigated

The composition of the wild fauna that lived in the natural and cultural environment of a former site and its surroundings is the result of ecological conditions and human behaviour (land use, creation of artificial environments, hunting pressure, introduction of domesticates, etc.). Through the analysis of the archaeozoological finds from a site, it is

possible to reconstruct the past fauna, but what is often not fully recognised is the extent to which an archaeozoological study collection represents but a heavily biased sample from the former fauna. First of all, human behaviour has dictated what animals were originally brought to the site, whilst the structure of the site itself influenced which commensal species or parasites could live in or around it. Therefore, even contemporaneous sites located within the same landscape can sometimes yield very different faunas. The commensal fauna of a food storage site will be different from that of a ceremonial place. Within a cultural period characterised by socio-economic differentiation, certain animal species are more likely to be found at high status sites compared to low status ones. The privileges of the feudal nobility on game species such as red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*) and brown bear (*Ursus arctos*) (SMIT, 1911) are responsible for the fact that medieval remains of these species are only found at castles and not at rural sites (ERVYNCK, 1992). Since, in late medieval abbeys, a larger quantity and a wider variety of fish were consumed compared to contemporaneous urban households (ERVYNCK, 1997), the investigation of the first group of sites is more appropriate in revealing changes in the freshwater fauna.

Taphonomic groups

One further reason that archaeozoological collections are not a random sample of a former fauna relates to why animals were killed and why their carcasses (or parts of them) were brought to a site. Animals could be killed because they served as food, because a primary material suitable for artefact production (antler, horn, fur, *etc.*) could be gained from them, because of ritual motives, or because they were considered a nuisance and were therefore destroyed. These different reasons for killing define different taphonomic groups (GAUTIER, 1987) and inevitably influenced the presence of animal remains on a site and their preservation. The remains of animals that were eaten by humans usually ended up in the consumption refuse contexts that are frequently excavated at archaeological sites. The remains of species that were only killed, or of animals of which only certain body parts were brought to a site as primary material, have a reduced chance of being found during excavation. This pattern explains the dearth of archaeological data hampering a documentation of the population histories of such species as beaver (*Castor fiber*) and wolf (*Canis lupus*), species which disappeared from the Belgian fauna only in post-medieval times (FRECHKOP, 1958; TACK *et al.*, 1993; CRIEL, 1994). For the same reasons, there are also insufficient archaeozoological data to describe the demographic evolution of, *e.g.*, wild cat (*Felis silvestris*), badger (*Meles meles*), fox (*Vulpes vulpes*), and the smaller carnivores, which still survive in Belgium. In medieval times, these species were exterminated, or killed for their fur, but their carcasses were not often brought to a site for consumption. This explains the scarcity of their remains from archaeological sites of that period. In contrast, brown bear (*Ursus arctos*) was eaten after being hunted (ERVYNCK, 1993a), and therefore the history of this mammal is much better documented.

Animals of which the remains can be found at archaeological sites, but that ended up there without the knowledge or intent of man, are termed «intrusives» (GAUTIER, 1987). Mostly, this taphonomic group consists of small species belonging to the commensal or parasitic fauna present at a site, or to the wild fauna living close to it. These animals (gas-

tropods, insects, arthropods, amphibians, reptiles, small mammals) are mostly found in special contexts that acted as pitfalls, such as wells and cesspits, or at places where prey remains have accumulated through the actions of non-human taphonomic agents such as owls. Such contexts, however, are not present at all sites, have not yet been excavated in sufficient numbers and have often been inadequately sampled (see further). For these reasons, few archaeozoological data have yet been gathered on the natural history of the intrusive fauna.

Preservation

After animal remains arrive at a site, it is necessary for their preservation that they rapidly become incorporated into an archaeological context. Animal skeletal elements that are deposited on the surface are easily destroyed by activities of scavengers, trampling, weathering, etc. The structures present at a site, used for the deposition of consumption refuse, thus partly determine the chances of preservation for animal remains. This explains why in Belgium, animal bones are rare at Iron Age sites (ERVYNCK, 1994) but are very frequent at Roman sites. The latter group is generally characterised by complex buildings and large infrastructures (sewers, cesspits, etc.), whilst the Iron Age sites are less complex and more rural in nature. Without doubt, the systems of garbage disposal will have been totally different between both types of habitation.

The taphonomic characteristics of groups of archaeozoological material are also of major importance for their preservation. Consumption refuse will generally consist of isolated skeletal elements that are often severely fragmented. Conversely, animals that have not been eaten may leave complete skeletons to be found, with individual elements still in anatomical position. The same is sometimes true for intrusives that have been caught in a pitfall, although the small intrusive animals that have been consumed by a predator living in or close to a human dwelling place are often only represented by disarticulated, fragmented and poorly preserved skeletal elements.

Besides the taphonomic characteristics of the contexts and material investigated, other, general factors also influence the preservation of animal remains. Certain soil types are disadvantageous for the preservation of chitin, shell and bone. The sandy soils of parts of Flanders and of the Campine area are well-drained, causing an alternation of wet and dry conditions that is destructive for buried animal remains. Local factors damaging for potential archaeozoological finds are bioturbation, soil erosion, and a wide range of human interventions. Lowering of the ground water table, for example, has been proven to be harmful for the preservation of the buried organic archaeological heritage.

Of course, the characteristics of the animal remains themselves are largely responsible for their preservation or destruction. As a general rule, the larger skeletal elements (of large species) always have a better chance to survive destruction than the smaller skeletal elements (of small species) (see LYMAN, 1994 for a review). Regardless of size, however, the structure of the animal remains is also determinative. Within the fishes, for example, remains of species with cartilaginous skeletons have significantly less chance of being found at archaeological sites than species with bony skeletons. Even within the latter group, however, some species such as mackerel (*Scomber scombrus*) or salmonids (*Salmo*

sp.) store lipids in cavities within their skeletal elements (Fig. 3), a factor that determines the poor survival of remains of these fish at archaeological sites. It is believed that in the soil the lipids turn into lipid acids, which dissolve the mineral fraction of the surrounding bone and influence the denaturation of collagen (MÉZES & BARTOSIEWICZ, 1994).

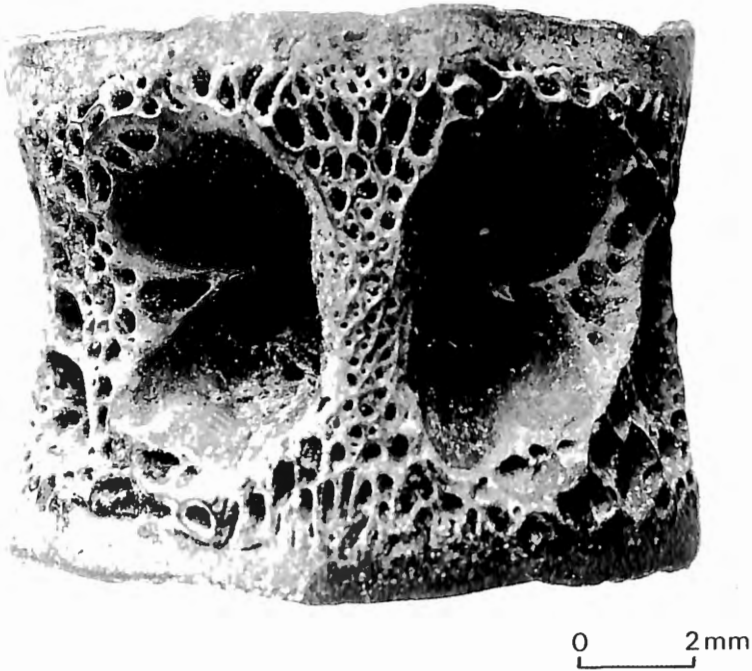


Fig. 3. – Vertebra of a salmon (*Salmo salar*), showing the porous structure where the storage of lipids is located (from VAN NEER & ERVYNCK, 1993).

Finally, it is sometimes hard to distinguish whether certain groups of animal remains are rare because of preservation conditions or of other causes. In medieval sites from the Low Countries, *e.g.*, bird remains are always rather scarce but it is often not clear whether this pattern is the result of the poor preservation chances of friable bird bones, or because birds were expensive food items during the period considered (ERVYNCK, 1993b).

Sampling and recovery

An archaeozoological dataset is always biased by archaeological methodology, especially when considering the sampling and recovery of organic remains. During excavations, most animal remains are simply handcollected, although it has long been proven that this method is an inadequate way to recover the remains of many small species (most invertebrates, smaller fish, amphibians, reptiles). Moreover, within the group of species recovered, handcollecting favours the recovery of the largest elements. More refined sampling methods are therefore needed to

adjust for this bias. During excavations by the Institute for the Archaeological Heritage of the Flemish Community, suitable contexts are sampled (at least 10 l of sediment) and sieved on a 0.5 mm mesh, which is sufficient to recover most molluscs, carabid beetles, fish and other small vertebrates. Moreover, the contents of deposits containing interesting archaeozoological assemblages are sometimes completely sieved. Additionally, smaller samples are taken that can be floated in order to recover microscopic remains such as parasite eggs or exoskeletons of mites (see SCHELVIS & ERVYNCK, 1992). When reviewing older excavation reports, however, one must bear in mind that the refined sampling and recovery of animal remains only became a standard procedure at Flemish sites after 1985.

Analysis of the remains

Once animal remains are recovered from an archaeological site, they must be analysed, a process where identification is the first step. However, the identification of archaeological animal remains differs significantly from the identification of recent animals. Most identification keys for recent specimens are not applicable to archaeozoological material, and it is therefore not surprising that identification to species level is not always possible. In some cases, identification problems hamper the study of a whole animal group (e.g., land slugs, small passerines). In other cases only the discrimination between a small number of species poses problems (e.g., sheep and goat, flatfish species within the Pleuronectidae). Moreover, these identification problems differ between skeletal elements (for the vertebrates) and depend upon the preservation condition or the taphonomic status of the collection.

Identification possibilities of course depend upon specialist experience and the availability of reference collections. Moreover, there exists a marked discrepancy between the number of species within each animal phylum and the number of archaeozoologists working on these groups (Fig. 4) (SCHELVIS, 1993). Therefore, in many countries, several cate-

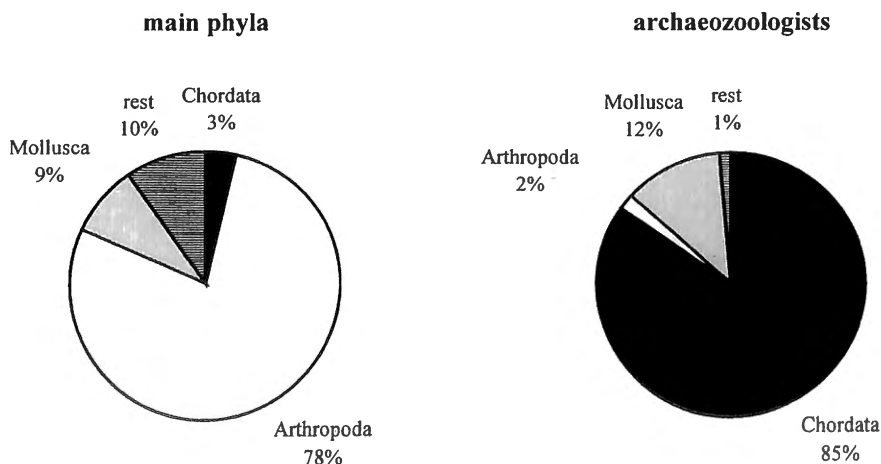


Fig. 4. – Discrepancy between the number of species within each phylum of the animal kingdom and the number of archaeozoologists working on these groups (after SCHELVIS, 1993).

gories of archaeozoological remains are simply not studied because of a lack of expertise. Moreover, the impetus to work on certain animal groups is influenced by the cultural questions asked. Groups important for human food economy have consequently gained more attention than groups that can only be used as ecological indicators. Furthermore, even within the group of ecological indicators, the characteristics of some groups (*e.g.*, carabid beetles, see ERVYNCK *et al.*, 1994) make them more reliable for interpretative purposes, which explains why they are preferentially studied.

Absence and presence

The arguments listed demonstrate that the absence of a particular species from the archaeozoological inventory of a site must always be evaluated against information on the nature of that site, the cultural period studied, the taphonomic status of the material, the preservation conditions at the site and of the species considered, the sampling and recovery methodology applied, and the specialist expertise available. All this explains why the absence of a particular species from an archaeozoological inventory does not necessarily imply that the species was absent from a former fauna.

When the presence of a species' remains is established by archaeozoological analysis, this is also not always straightforward proof of the former occurrence of the organism around the site studied. Animal remains can belong to the taphonomic groups of the so-called «reworked» and «late» intrusives, meaning that they originate from deposits that are older than the context in which they eventually ended up, or that they only became part of an archaeological context some time after that context was deposited. An example of the latter group are the remains of burrowing animals, that, after their death, became incorporated in the older archaeological layers or deposits which they were disturbing.

An additional problem is presented when animals or parts of animals are transported over long distances, in which case the presence of their remains in an archaeozoological inventory is misleading. Generally, it is thought that elk (*Alces alces*) disappeared from the Low Countries before the Late Middle Ages (ERVYNCK *et al.*, in press). Therefore, the fragments of elk antler which were found in a late medieval context from the center of Bruges (ERVYNCK & HILLEWAERT, unpubl. data) presumably only represent primary material for artefact production which was imported from more northern regions. In fact, all Roman and medieval finds of elk consist of antler fragments. A long bone of elk described from a medieval context in Liège (B.) (GAUTIER & HOFFSUMMER, 1988) almost certainly represents a reworked, intrusive element, originating from Neolithic layers that are present beneath the medieval deposits.

CONCLUSION

When the possibilities and limitations of archaeozoology are not known or understood, there is an inherent danger in the use of archaeozoological finds in biogeographical reconstructions. The possibility to follow a species' history through archaeozoological research differs markedly according to its status in former times (*e.g.*, protected game versus species on the extermination list), the taphonomic context in which the remains can be

found (*e.g.*, consumption refuse versus intrusive remains), and the socio-economic context of the sites investigated (*e.g.*, high status versus low status sites).

The previous discussion has illustrated what conditions must be met before archaeozoological data on the presence or absence of species can be safely interpreted. However, the archaeological context in which animal remains are found is always the most critical parameter for the significance of a faunal assemblage. Archaeozoology studies the interaction between man and animals, and not only the presence or absence of species, and is therefore a truly interdisciplinary field of science. When biogeography uses archaeozoological data, it should therefore take the same approach. The history of our fauna can only be understood when, more than extinction or introduction, processes such as pollution, destruction of habitats, synanthropisation of animals, domestication or scientific manipulation of organisms are studied (SIMMONS, 1979). Such analyses, however, are only possible when data from history, archaeology and ecology are fully integrated.

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REFERENCES

- BENECKE, N. (Ed.) (in press) – *The Holocene History of the European Vertebrate fauna*. Modern Aspects of Research. Berlin.
- BOBROV, A.A. (1998) – Testate amoebae (Protozoa: Testacea) as an indicator of environmental conditions in archaeozoology. In: *8th International Congress of the International Council for Archaeozoology. Abstracts*. Victoria (Canada): 58.
- CHAIX, L. & P. MENIEL (1996) – *Éléments d'archéozoologie*. Editions Errance, Paris: 112 pp.
- CLASON, A.T., W. PRUMMEL & D.C. BRINKHUIZEN (1979) – Vogelen en vissen. Een glimp van de Nederlandse vogel- en viswereld uit het verleden. *Westerheem*, 28: 9-23.
- CRUEL, D. (1994) – *Rode lijst van de zoogdieren in Vlaanderen*. Administratie Milieu, Natuur en Landinrichting, Brussel: 79 pp.
- DAVIS, S.J.M. (1987) – *The archaeology of animals*. B.T. Batsford, London: 224 pp.
- DE SELYS-LONGCHAMPS, E. (1842) – *Faune belge*. H. Dessain, Liège: 310 pp.
- DESMET, J. (1987) – *Vogels. Hun levensloop in België, hun wedervaren met de mens*. Van de Wiele, Brugge: 207 pp.
- ERVYNCK, A. (1990) – Zwarte ratten bevolkten eens het Patershol. De mummies uit Rodekoningstraat 5. *Stadsarcheologie. Bodem en Monument in Gent*, 14 (2): 32-37.
- ERVYNCK, A. (1992) – Medieval castles as top-predators of the feudal system: an archaeozoological approach. *Château Gaillard. Etudes de Castellologie médiévale*, 15: 151-159.
- ERVYNCK, A. (1993a) – In memoriam: De bruine beer der Benelux. *Zoogdier*, 4 (3): 4-11.
- ERVYNCK, A. (1993b) – The role of birds in the economy of medieval and post-medieval Flanders: a diversity of interpretation problems. *Archaeofauna*, 2: 107-119.
- ERVYNCK, A. (1994) – L'archéozoologie de l'âge du Fer: un bilan pour la Belgique. *Lunula. Archaeologia protohistorica*, II: 38-41.

- ERVYNCK, A. (1997) – Following the Rule? Fish and Meat consumption in Monastic Communities in Flanders (Belgium). In: *Environment and Subsistence in Medieval Europe. Papers of the «Medieval Europe Brugge 1997» Conference Volume 9*. DE BOE, G. & F. VERHAEGHE (Eds). Instituut voor het Archeologisch Patrimonium, Zellik: 67-81.
- ERVYNCK, A. & J. BASTIAENS (in press) – Twee knaagdiernesten uit het huis «De Spiegel». *Stadsarcheologie. Bodem en Monument in Gent*.
- ERVYNCK, A., K. DESENDER, M. PIETERS, & J. BUNGENEERS (1994) – Carabid beetles as palaeo-ecological indicators in archaeology. In: *Carabid beetles: ecology and evolution*. DESENDER, K. *et al.* (Eds). Kluwer Academic Press, Dordrecht: 261-266.
- ERVYNCK, A., W. HUPPERETZ & J.M. VAN WINTER (1996) – Papier, botten of pitten? De kansen en problemen van een geïntegreerde aanpak van het thema middeleeuwse voeding. In: *Dagelijks leven op Limburgse kastelen (1350-1600): voedsel en voedselbereiding*. HUPPERETZ, W. & J.M. VAN WINTER (Eds). Limburgs Museum, Venlo: 6-23.
- ERVYNCK, A. & A. VANDERHOEVEN (1997) – Tongeren (Belgium): changing patterns of meat consumption in a roman *civitas* capital. *Anthropozoologica*, **25-26**: 457-464.
- ERVYNCK, A. & W. VAN NEER (1998) – Het archeologisch onderzoek van de voedsleconomie van laatmiddeleeuwse steden. Mogelijkheden en eerste resultaten voor Leuven. In: *Leven te Leuven in de late Middeleeuwen*. BESSEMANS, L. *et al.* (Eds). Peeters, Leuven: 79-94.
- ERVYNCK, A., W. VAN NEER & A. LENTACKER (in press) – Introduction and extinction of wild animal species in historical times: the evidence from Belgium. In: *The Holocene History of the European Vertebrate fauna – Modern Aspects of Research*. BENECKE, N. (ed.). Berlin.
- FRECHKOP, S. (1958) – *Faune de Belgique. Mammifères*. Institut Royal des Sciences naturelles de Belgique, Bruxelles: 545 pp.
- GAUTIER, A. (1987) – Taphonomic groups: How and Why? *ArchaeoZoologia*, **1** (2): 45-52.
- GAUTIER, A. & P. HOFFSUMMER (1988) – Les restes d'animaux de la zone septentrionale. In: *Les fouilles de la place Saint-Lambert à Liège, 2. Le vieux marché. Etudes et Recherches Archéologiques de l'Université de Liège* 23. OTTE, M. (Ed.). Université de Liège, Liège: 227-232.
- GÖTHERSTRÖM A. & K. LIDEN (1998) – Guidelines for work with ancient DNA developed at the Archaeological Research Laboratory. *Laborativ Arkeologi. Journal of Nordic Archaeological Science*, 10-11, 55-57.
- KENWARD H.K. & A.R. HALL (1995) – *Biological evidence from 16-22 Coppergate. The Archaeology of York. The Environment 14/7*. Council for British Archaeology, York: 797 pp.
- LYMAN, R.L. (1994) – *Vertebrate taphonomy*. Cambridge University Press, Cambridge: 524 pp.
- MACINNES, L. & C.R. WICKHAM-JONES (1992) – Time-depth in the countryside: archaeology and the environment. In: *All natural things: archaeology and the green debate. Oxbow Monograph 21*. MACINNES, L. & C.R. WICKHAM-JONES (Eds). Oxbow, Oxford: 1-13.
- MÉZES, M. & L. BARTOSIEWICZ (1994) – Fish bone preservation and fat content. *Offa*, **51**: 361-364.
- SCHELVIS, J. (1992) – Mites and Archaeozoology. General methods; applications to Dutch sites. Ph.D thesis University of Groningen, Groningen: 116 pp.
- SCHELVIS, J. (1993) – The birds and the bees. *Archaeofauna*, **2**: 163-167.
- SCHELVIS, J. & A. ERVYNCK (1992) – Mijten (Acari) als ecologische indicatoren in de archeologie. Onderzoek op de Romeins vindplaats Oudenburg (prov. West-Vlaanderen). *Archeologie in Vlaanderen*, **II**: 175-189.
- SCHELVIS, J. & A. ERVYNCK (1993) – Mijten (Acari) uit middeleeuws Oudenburg (prov. West-Vlaanderen): een reconstructie van het landschap. *Archeologie in Vlaanderen*, **III**: 233-242.
- SIMMONS, I.G. (1979) – *Biogeography: Natural and cultural*. London: Edward Arnold: 400 pp.

- SMIT, J.P.W.A. (1911) – *Het Brabantse jachtrecht vóór de regering van Karel den Stouten*. Amsterdam : van Langenhuysen, pp. 116.
- TACK, G., P. VAN DEN BREMT & M. HERMY (1993) – *Bossen van Vlaanderen, een historische ecologie*. Leuven : Davidsfonds, pp. 320.
- VAN NEER, W. & A. ERVYNCK (1993) – *Archeologie en vis. Herlevend verleden 1*. Instituut voor het Archeologisch Patrimonium, Zellik, pp. 96.
- VAN NEER, W. & A. ERVYNCK (1994) – New data on fish remains from Belgian archaeological sites. In: *Fish exploitation in the past. Proceedings of the 7th Meeting of the ICAZ Fish Remains Working Group. Annalen van het Koninklijk Museum voor Midden-Afrika, Tervuren, België. Zoologische Wetenschappen 274*. VAN NEER, W. (Ed.). Koninklijk Museum voor Midden-Afrika, Tervuren : 217-229.
- VAN NEER, W. & A. ERVYNCK (in press) – Apport de l'archéozoologie à la connaissance de l'exploitation de l'eau douce au Moyen Age en Belgique. In: *La pêche en eau douce au Moyen Age et à l'époque moderne*. (BENOIT, P., ed.) Liessies.
- VAN WIJNGAARDEN-BAKKER, L.H. (1978) – A subfossil Great Auk – *Pinguinus impennis* (L.) from the Netherlands. *Ardea*, **66** : 57-61.
- VAN WIJNGAARDEN-BAKKER, L.H. (1991) – De Europese moeflon : wild of verwilderd. *Zoogdier*, **2** (2) : 3-5.
- VERHAGEN, M. (1991) – A Black Vulture *Aegypius monachus* from Roman valkenburg, the Netherlands. *Ardea*, **79** : 439-442.