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Faunal Remains from Archaeological Sites Document Human Impact on the Terrestrial and Aquatic Environment: examples from the last thousand years in Belgium

Bea De Cupere and Wim Van Neer

The aim of this article is to demonstrate how animal remains from archaeological sites can contribute to a better understanding of human impact on the terrestrial and aquatic environment over time. A number of case studies, mainly from Belgium, illustrate the possible effects of deforestation, overhunting, overfishing and water pollution on wildlife. Species extinctions and introductions from the last millennium are also discussed. It is shown how relevant these results are and how they can be communicated to the general public, the wider scientific community and stakeholders.

1. Introduction

As the human population has continued to grow, so has the impact of our species on the environment and even on the global climate. Because of this large impact, it has been proposed to name the current geological epoch as the Anthropocene. There is still much debate about the need for such an era and also about when its start date should be set. Some scientists propose that the Anthropocene coincides with the Holocene (Smith and Zeder 2013), as this is when human societies first began to play a significant role in shaping the Earth's ecosystems. In this article, we consider some examples of the impact that humans have had on the environment, concentrating on the fauna of the last thousand years in Belgium. This is done through the analysis of faunal remains found during archaeological excavations, as these can provide information about periods for which no historical sources are available that would allow us to document the past fauna and the changes it may have undergone. We describe the different types of human influences that can be observed in the Belgian archaeological data and then we discuss how this information can be disseminated to the wider public and to the scientific community and stakeholders responsible for nature restoration.

2. Types of Human Impact

2.1. Effect of deforestation, human disturbance and overhunting

Since the Neolithic, forests have been cleared when people became sedentary and started to use trees as raw material for construction and as fuel. Faunal remains left behind on sites inhabited by these early settlers are already dominated by domestic species (cattle, sheep, goat, pig). Although these species are not very precise indicators of the habitat, potentially they can illustrate deforestation.

At archaeological sites that extend over a long period of time, a decrease in the number of pigs - traditionally herded in forests - is often observed, thus illustrating a degradation of the landscape. The stress that pigs undergo as a result of deforestation can also be documented through an increase in the incidence of linear enamel hypoplasia (LEH), a deformation visible in the tooth crowns related, among other things, to food stress (Dobney and Ervynck 2000). In Neolithic faunas, the wild mammal element usually forms only a small part of the total assemblage, but over time a decrease in the amount of forest species such as wild boar, red deer or brown bear can often be observed. Deforestation, combined with human disturbance and overhunting, may in the long run even cause the total extinction of species in certain regions. In Flanders, the northern part of Belgium, including Brussels, brown bear and wolf are typical examples of species that totally disappear (Figure 1 and Figure 2). Archaeozoological data show that brown bear was still a rare occurrence during the 9th-12th centuries AD in Flanders (Ervynck 1993). The last known archaeozoological evidence for the wolf in Flanders is provided by a foot that was once nailed to the gate of the Castle of Counts (Gravensteen) in Ghent, the seat of the court of the Oudburg castellanum in the post-medieval period (Ervynck *et al*. 2014).

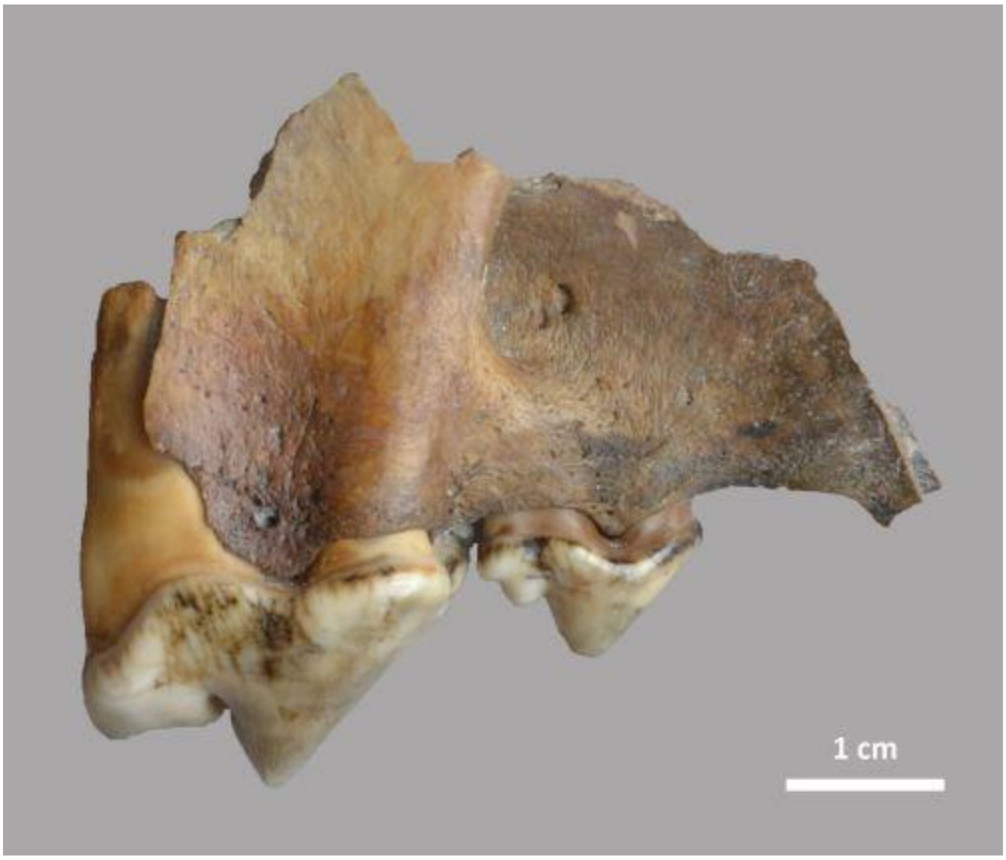

Figure 1: Side view of a right maxilla fragment of wolf (*Canis lupus*), with third and fourth premolar, found in the historical centre of Brussels (second half 13th to first half 14th century AD - site of Parking 58). It is the only known wolf find for medieval Brussels and, by extension, Flanders

Figure 2: Cranial view of a right humerus of brown bear (*Ursus arctos*), from a young individual, found in the historical centre of Brussels (10th century AD - site of Parking 58)

2.2. Overfishing

Besides impacting the terrestrial environment, people have also affected the aquatic environment of both the continental and offshore waters. There are at least three major factors that impact pristine fish populations, i.e. overfishing, pollution of surface waters, and introductions (Van Neer and Ervynck 2010). Archaeozoological data can be used to document past fish species diversity and to reconstruct size spectra and relative population densities of different species over time. The information provided by faunal remains sometimes complements historical data. However, written sources are relatively rare, do not exist for older periods and if they are available, they are often not accurate enough.

Anadromous fish, i.e. species that spend most of their lives at sea and that enter rivers for spawning, are extremely vulnerable to overfishing as they occur in large numbers at particular points of the year. This predictability allows them to be fished, often in large numbers, before they reach the spawning grounds, which is obviously detrimental to the survival of the species. Examples are sturgeons (in our region both *Acipenser sturio* and *A. oxyrinchus*; Figure 3), Atlantic salmon (*Salmo salar*), but also less spectacular species such as allis shad (*Alosa alosa*), twaite shad (*Alosa fallax*) and smelt (*Osmerus eperlanus*). The decline of sturgeons in the North Sea and adjacent areas can be followed archaeologically (Thieren *et al*. 2016), and a case study in the Netherlands shows the negative effect of overfishing combined with construction works (in particular water mills) on Atlantic salmon (Lenders *et al*. 2016). Similar diachronic data are not available for allis shad and smelt, but the regular presence of these species in past faunal assemblages of our study region contrasts sharply with the poor status of these fish nowadays and the occurrences mentioned in fishery literature of the 19th and early 20th centuries (Vrielynck *et al*. 2003). Besides overfishing, the poor quality of the waters may have been an additional factor in the decline of the latter species. This is suggested by the relatively recent catches of smelt and shad, which, according to fisheries biologists, are related to the improved water quality resulting from the treatment of wastewater from larger inland towns.

Figure 3: Dorsal plate of an Atlantic sturgeon (*Acipenser oxyrinchus*), from an individual of approximately 2.8m long, found in the historical centre of Brussels (end 13th to beginning 14th century AD - site of Parking 58)

2.3. Pollution of surface waters

With increasing urbanisation since the Middle Ages, pollution of inland waters has become a growing problem. The numerous medieval ordinances regarding the disposal of organic waste are indicative of the negative effect this must have had on the quality of the surface waters. Waste from slaughterhouses, breweries and tanneries were a major problem, but also household waste must have contributed to the poor state of the waters (Thomas 1994; Deligne 2003; 2005). It is likely that occasionally mass mortality of fish occurred, but a longer-term effect was probably the eutrophication of the rivers resulting from the constant supply of organic waste.

An analogy with historically documented changes in the species spectrum, e.g. in the city of Berlin (Wolter *et al*. 2000), can help to explain shifts in the fish fauna over time. Shifts in the proportion of 'sensitive' versus 'tolerant' species are a possible way of documenting ancient pollution from archaeozoological material. An increase through time of certain cyprinids, such as roach (*Rutilus rutilus*) or bream (*Abramis brama*), may be indicative of eutrophication. Another possible good indicator of poor water quality is the proportion of eel (*Anguilla anguilla*), a species that is highly resistant to both organic and inorganic pollution. An alternative, more direct, way of documenting organic pollution in freshwater is the analysis of nitrogen stable isotope ratios in archaeological fish bone. Thus far this type of research has only been carried out successfully in Switzerland, for a number of sites along the Rhine river dating from the 11th century onwards (Häberle *et al*. 2016). The nitrogen stable isotope ratios, which reflect the ecological water conditions and the input of contaminants, show an increase through time, indicating the eutrophication of the water.

2.4. Introductions

As a result of climate change, the natural range of fish species can shift. For instance, in recent years, 'warmer' species (e.g., grey gurnard *Eutrigla gurnardus*, and poor cod *Trisopterus minutus*) are more regularly observed in the southern North Sea, while others like cod (*Gadus morhua*) become rarer in that region (Hedger *et al*. 2004). These natural expansions, contractions or distribution shifts in marine species are also occasionally seen in the archaeological record. For instance, a few indicators of warmer conditions (e.g. *Spondyliosoma cantharus*) are known from 13th century Ypres/Ieper (Ervynck *et al*. 1990), although it is not excluded that they reflect a seasonal occurrence. More convincing evidence has been found further north in Denmark for the Atlantic period (Enghoff *et al*. 2007), with 'warm species' such as anchovy (*Engraulis encrasicolus*), smoothhound (*Mustelus* sp.), common stingray (*Dasyatis pastinaca*), European sea bass (*Dicentrarchus labrax*), black sea bream (*Spondyliosoma cantharus*) and swordfish (*Xiphias gladius*).

Climate may influence the occurrences of species in continental waters as well, albeit that during the last few centuries introductions have played a greater role. In most instances, there is sufficient historical evidence for the introduction of freshwater fish. Examples of species introduced in Belgium, and elsewhere in western Europe, for the purpose of fish farming but which subsequently escaped and successfully populated the local waters include the pikeperch (*Sander lucioperca*) and the American catfish (*Ameiurus nebulosus*), both brought in during the 19th century (Vrielynck *et al*. 2003). A much older introduction is the carp (*Cyprinus carpio*), which was brought into western Europe around the 12th century. Archaeozoological data complete the picture as historical information is not available for all regions and periods (Hoffman 1994). In Flanders, by AD 1300 escaped carp had already formed populations in the rivers, as shown by archaeological finds (Van Neer and Ervynck 2004). Similarly, the rabbit was introduced in Belgium during the 13th century from southern Europe, and first kept in domestic warrens from where they escaped and settled in the environment (Ervynck 2003). The breeding of rabbits in cages did not take place until the post-medieval period.

The merit of archaeozoological finds of fish, and other species, is that the former occurrences give an indication of the status of the animals, i.e. it helps to establish whether the species found nowadays in a particular region are native or allochthonous. In the current Belgian fish fauna, there are two cases where faunal remains have rather unexpectedly determined whether the species was indigenous or not. The European bitterling (*Rhodeus amarus*), a small cyprinid, has usually been considered an autochthonous species in the ichthyological literature (Vrielynck *et* *al*. 2003). Thus far only one record is known from a 13th to 14th century site in the Meuse basin (Vanpoucke 1992). This low incidence was believed to be a result of the small size of the species (maximum total length 11cm; common length 5cm), combined with the difficulty of discriminating bone finds from the numerous species within the cyprinid family. However, historical information combined with biogeographical arguments show that the bitterling is an invasive species that arrived only in late medieval times in Western Europe together with the carp that was imported from the east (Van Damme *et al*. 2007).

A completely opposite case is that of the European catfish (*Silurus glanis*), which fisheries biologists traditionally assume is not indigenous to Belgian waters, as there is convincing evidence that it was imported from Central Europe in the late 19th century (Gens 1891; Vrielynck *et al*. 2003). However, it appears that the species also occurred previously in both the Scheldt and the Meuse basin until at least late medieval times (Van Neer and Ervynck 2009). No historical references or depictions exist of the fish, but archaeological finds show the rare occurrence of the animal in what was the westernmost extension of its native range. The last certain evidence for catfish in the Scheldt river basin dates from the 12th century AD, and in the Meuse river basin, further south, the last occurrence is dated to the 15th century. The European catfish is a slow growing species that is therefore very sensitive to anthropogenic and climatic influences. Moreover, the rivers of the Scheldt and Meuse basins are in the marginal area of the species' geographic distribution where population densities were always rather low. In addition to fishing pressure, the species had difficulties in surviving because access to spawning grounds was hampered by damming and the construction of sluices. The Little Ice Age also may have played a role: the lower summer temperatures made reproduction more difficult for the catfish, which need water temperatures of at least 18-20°C for spawning to start (Mohr 1957). All this may have led to the total disappearance of the catfish from Belgian rivers in late medieval times.

3. Bringing Messages to a Wider Audience

3.1. General public

Nowadays, the impact of climate change in the form of exceptional droughts, excessive storms or rains, and forest fires, is regularly covered through various media. During the last few decades, we have seen that the results obtained by climatologists gradually made their way to the broader scientific community and finally also to the wider general audience. This has happened despite the criticism of a small proportion of non-believers that continue to link the observed changes to natural variability.

The merit of archaeozoological (and archaeobotanical) research is that it has the potential to demonstrate that not only climate but also human interference have impacted the environment. This message can be brought to the general public in various ways. Larger exhibits, but also smaller ones when, for instance, recent excavations have been carried out in a particular town quarter or village have the potential of reaching a very local audience that will feel strongly connected to the information provided. Showcases from such exhibitions generally bring a selection of remarkable artefacts, but also animal and plant remains are often on display nowadays (Figure 4). In some cases, websites are dedicated to such public events that increase the visibility and help to spread the message.

The reconstruction of daily life in the past with the aid of archaeological information inevitably focuses on subsistence, but in many cases it is possible to also highlight paleo-ecological aspects. Landscape reconstructions give the audience an idea of the former environment and of how it may have differed from the present-day situation (Figure 5). In many cases, deforestation through time can be made clear and, at the same time, faunal shifts can be illustrated. Typical showpieces that attract attention are skulls of large predators such as wolf or brown bear that allow the effect of deforestation and overhunting to be addressed. The history of the local extinction of species is sometimes covered in the media, for instance on the occasion of the gradual return of the wolf in Belgium (https://welkomwolf.be/), with sightings regularly mentioned on radio and television. These news facts are a good opportunity to discuss the former occurrence of the species and allow the potential contribution of archaeozoology to the general debate to be demonstrated. This is not only the case for the wolf or large aquatic species such as the sturgeon, but also for less iconic species such as smelt or shad that return when water quality improves. Perhaps archaeozoologists could do some self-promotion across media platforms such as Facebook, Twitter, or through interviews on radio and television?

Examples have been given on how archaeozoology documents phenomena such as deforestation, overhunting, overfishing, pollution and species introductions. The attention of the general public can be drawn to the information potential of archaeozoology on the occasion of the sighting or capture of a rare species, but for instance also when there is mass mortality of fish owing to pollution. Adverse conditions of freshwaters have been documented in the past as noted earlier, and go back to medieval times when urban populations grew and both domestic refuse and artisanal waste (from slaughterhouses, breweries, wool and metal working, etc.) caused severe pollution. Numerous ordinances illustrate the problem, and the effect can be seen in an impoverished fish fauna. By placing this problem in a broader, historical context, one can become more aware of the harmful effect that humans can have on their environment and hopefully encourage people to do better than our predecessors.

Figure 4: Finds from the archaeological excavations at the late medieval port of Brussels were shown to the public through an exhibit. One of the finds presented in the display cabinet is a bone of the great bustard (*Otis tarda*), attesting the rare occurrence of this species during past times in Belgium

Figure 5: Reconstruction of the Roman landscape at Brussels, based on the archaeozoological and archaeobotanical data (De Cupere *et al*. 2017)

3.2. Scientists and stakeholders

Reaching scientists and stakeholders is another challenge. We have given some examples that we think are relevant from a historical ecological point of view and worth sharing and discussing with ecologists and conservation stakeholders. The archaeozoological data allow reconstruction of former baselines against which the present-day situation can be compared and that ideally could serve to make recommendations for future actions in the field of nature development.

Such archaeozoological information needs to reach the ecologists, and from our experience it appears that the most successful way of doing this is by contacting the scientists directly and sending them publications. This is necessary as the outcome of archaeozoological analyses usually appear in arts and humanities publications. However, there are some exceptions with summaries of archaeozoological (and historical) data relevant from an ecological or zoogeographical point of view that have been published in biological journals (e.g., Van Damme *et al*. 2007; Van Neer and Ervynck 2009; Thieren *et al*. 2016; Barrett 2019). In the case of the Belgian freshwater fish fauna, archaeozoological data have been taken into account to some extent when discussing the autochthonous or allochthonous nature of species (Vrielynck *et al*. 2003). Efforts to obtain funding were unsuccessful for an interdisciplinary research project to further document the historical changes to the Belgian fish fauna and to use these as a means of complying with European guidelines for restoration of the Scheldt river. However, the ideas developed in that project proposal found their way to an article (Van Neer and Ervynck 2010) explaining the benefits of a collaboration between fishery specialists, historians and archaeozoologists. A creditable attempt was made to illustrate the potential of archaeozoological (Galik *et al*. 2015) and historical data (Haidvogel *et al*. 2015) in order to understand the evolution of the fish fauna of large central European rivers such as the Danube. Recently, joint efforts for such multidisciplinary research have been rewarded by funding agencies such as the DFG, showing that there is gradually a growing awareness of the power of a common approach (Werther *et al*. 2021). Hopefully, similar initiatives will become even more numerous in the future and help in the definition of baselines, the development of management plans for habitat restoration and conservation. It is well known that baselines have shifted through time and that a return to an original, 'pristine' condition is impossible. For that reason, reference conditions are often defined in a way that restoration projects can try to pursue taking into account available financial means and practical limitations.

It remains to be seen, however, where the discussion between scientists from different disciplines will lead. As a number of case studies below show, confronting historical ecological data and the current environment of a given region will not necessarily always yield unambiguous answers to certain questions.

In Flanders, efforts are being made to help the survival of the European hamster (*Cricetus cricetus*), a species that has almost become extinct in recent decades as a result of intensive farming and habitat destruction (Agentschap Natuur en Bos 2015). This species is only known from prehistoric archaeological sites and has not been documented in any Roman, medieval or post-medieval sites in Belgium. It appears that the European hamster was recorded for the first time at the end of the 19th century and that its population density was always extremely low. In fact, this is a typical Central European species that struggles to survive at the western edge of its range. The attention given to this species may to some extent also be related to its pettability, a factor that probably will not help the restoration of the European catfish (*Silurus glanis*) that equally is a species with a distribution centred in Eastern Europe.

Confrontation of the archaeozoological, and often also historical, data with the modern freshwater fish fauna of Belgium shows that several species are not native. In the case of recent invasive species such as the topmouth gudgeon (*Pseudorasbora parva*), sometimes measures for eradication, or more sensibly, for the limitation of their expansion, have been tried (Lemmens *et al*. 2015). However, a number of species exists that nowadays are no longer considered as being invasive and that are seen as part of the 'normal' fish fauna. That is the case for fish such as pike-perch (*Sander lucioperca*), the bitterling (*Rhodeus amarus*) and carp (*Cyprinus carpio*) that have been living here for centuries. This means *a priori* that a return to the pristine condition will never be possible.

Due to the improvement of water quality, certain species recolonise Belgian rivers once more and it may be tempting to stock certain fish again. Purists may object to such efforts because of the genetic pollution that can occur. In some cases, it may also be debatable exactly which species should be used for reintroduction. In the case of sturgeon, efforts in Western Europe have focused in recent years on *Acipenser sturio*. However, archaeozoological work has shown that an additional species (*A. oxyrinchus*) occurred in Western Europe and that it was even more abundant in the North Sea (Thieren *et al*. 2016). It is only now that this archaeozoological information, combined with genetic studies on sturgeons from natural history museum collections, is being used in the discussion of reintroductions (Brevé *et al*. 2022a). There is some concern that hybridisation would jeopardise the introduction of *A. sturio*, but besides interbreeding, which likely also occurred naturally in the past, there is also a risk of hybridisation with acipenserids that are not native at all (Brevé *et al*. 2022b). Species that were introduced for fishery purposes (and which have escaped) include Siberian sturgeon (*A. baerii*), Russian sturgeon (*A. gueldenstaedtii*) and sterlet (*A. ruthenus*).

4. Conclusion

Archaeozoology has the potential to provide unique information on the former occurrence of species and to some extent also on the proportions in which they lived in a certain geographical area. This allows policy makers to evaluate the present-day fauna in a particular region and to establish which species are native and which ones can be considered as invasive. For several species and time periods, historical data are available, but the further one goes back in time, the more archaeological data become relevant. Archaeozoologists cannot as such participate in the practical development of management plans, but they have a role to play in informing ecologists and policymakers about the pristine fauna and about the effects that humans have had through time. It is the task of the policymakers to investigate to what extent the different baselines can be of use in the establishment of nature restoration plans. When it comes to communication with the general public, however, a joint role can be played by both parties.

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