

# Fish remains from three Upper Palaeolithic cave deposits in southern Belgium<sup>1</sup>

Wim VAN NEER, Wim WOUTERS & Mietje GERMONPRÉ

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## Abstract

Fish remains are described that were excavated in the 19th century from Trou de Chaleux, Trou du Frontal and Trou du Sureau, three Upper Palaeolithic cave sites in the Meuse basin, Belgium. After a critical assessment of possible taphonomic agents acting in caves, it is concluded that the material — consisting mainly of medium-sized and large salmonids, burbot and cyprinids — is anthropogenic. Using present-day behavioural information on the identified fish species it is hypothesised that the exploited fish were an abundant and predictable food resource during the spawning season, when they occurred en masse in shallow, marginal waters. Finally the possible fishing techniques and the dietary role of freshwater fish in Palaeolithic times are discussed.

**Keywords:** fishing, Upper Palaeolithic, seasonality, taphonomy, caves.

## Résumé

*Cet article décrit les restes de poissons découverts au XIX<sup>ème</sup> siècle dans le Trou de Chaleux, le Trou du Frontal et le Trou du Sureau, trois sites en grotte dans le bassin mosan datant du Paléolithique supérieur. Après avoir passé en revue les accumulateurs possibles en grottes, il apparaît que l'ichtyofaune, comprenant surtout des salmonidés, des lottes de rivière et des cyprinidés de taille moyenne et grande, est d'origine anthropique. En se basant sur le comportement actuel des espèces identifiées, on peut estimer que ces poissons représentaient une ressource abondante et prévisible pendant la saison de reproduction, saison à laquelle on les retrouvait en masse dans les eaux marginales, peu profondes. Finalement les techniques de pêche possibles et l'importance alimentaire des poissons d'eau douce au Paléolithique font l'objet d'une discussion.*

**Mots-clés :** pêche, Paléolithique supérieur, saisonnalité, taphonomie, grottes.

## 1. INTRODUCTION

The first description of Pleistocene finds from Belgian cave sites dates from the 1830's (Schmerling, 1833). Some thirty years later Edouard Dupont undertook major excavations in numerous prehistoric caves in the south of Belgium. He discovered important bone accumulations dating essentially to the Last Glacial (Dupont, 1873). The material included large quantities of remains from herbivores and carnivores, artefacts, bone tools and ivory ornaments that were stored in the Royal Belgian Institute of Natural Sciences. When E. Dupont became a director of the institute in 1868 (Vivé & Versailles, 1996), he apparently did not have much time to devote to the study of the fossil assemblages he excavated, although the archives of the institute contain many of his unpublished notes dating from 1905-1906. It is only during the last ten years that a new interest in this bone material has

grown, resulting in publications on, among others, the dating and the archaeozoology of Belgian Magdalenian caves (Charles, 1996; Germonpré, 1997; Charles, 1998), systematics and osteometry of foxes (Germonpré & Sablin, 2004), cave bear palaeobiology (Germonpré & Sablin, 2001; Germonpré, 2004) ancient DNA of giant deer (Hughes *et al.*, 2006) and of arctic foxes (Dalen *et al.*, 2007).

The aim of the present contribution is to describe the thus far unstudied fish remains of three Upper Palaeolithic caves that were excavated by E. Dupont in the 1860's (Dupont, 1873). The hand-collected material originates from the caves of Trou de Chaleux, Trou du Frontal (Furfooz) and Trou du Sureau

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<sup>1</sup> The authors would like to dedicate this paper to their colleague Mircea Udrescu at the occasion of his retirement. We thank him for the many years of fine collaboration.

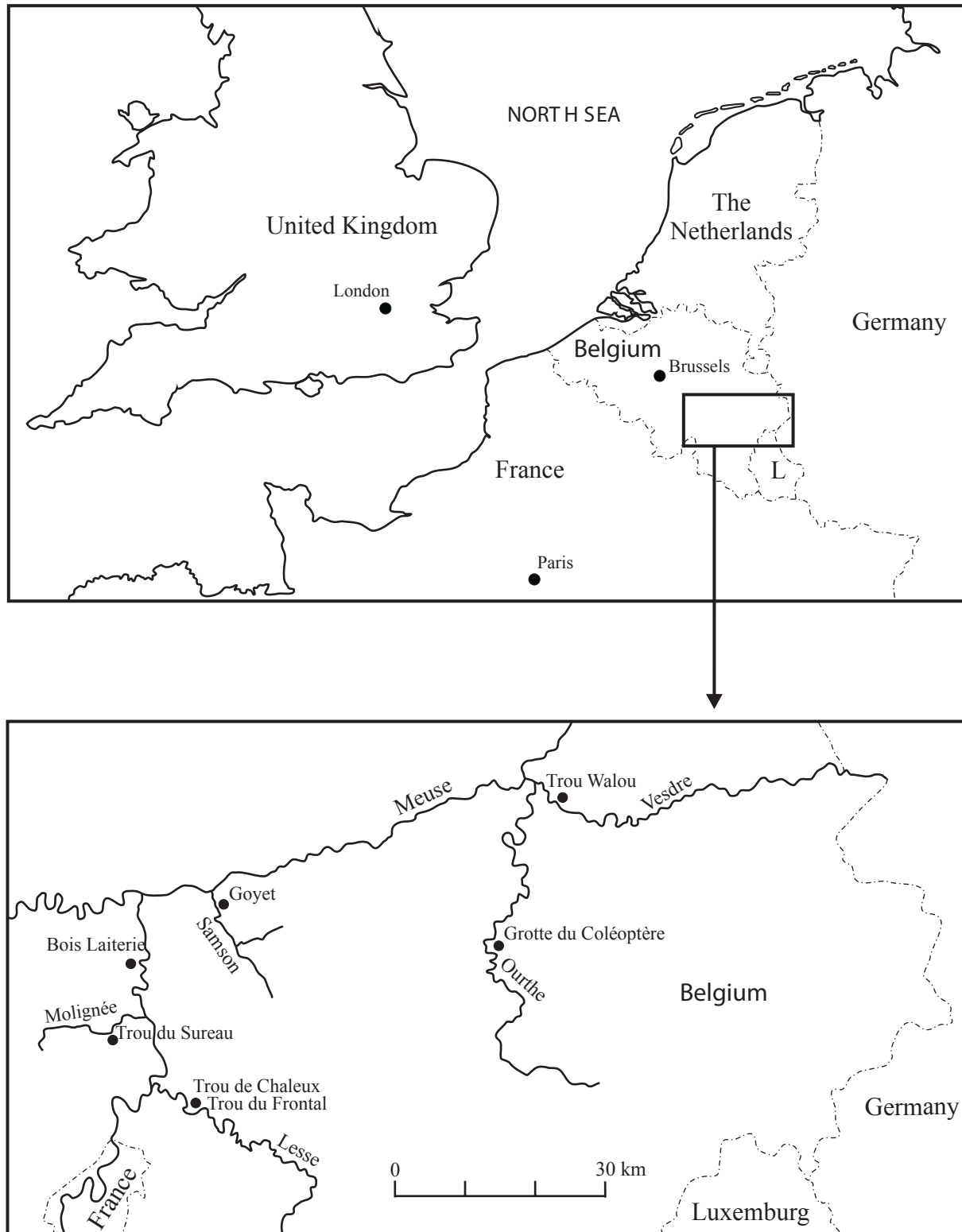


Fig. 1 — Location of the sites mentioned in the text.

(Montaigle) (Fig. 1). The Trou de Chaleux and Trou du Frontal caves are situated, within one km of each other, in Carboniferous limestone cliffs on the right bank of the river Lesse, a tributary of the Meuse.

Trou de Chaleux is located at about 17 m above the Lesse. One major bone horizon containing a wealth of Magdalenian artefacts was discovered. Three AMS dates on two cut-marked horse cuneiforms and one musk ox phalanx yielded ages ranging from 12,790 to 12,880 BP. In addition a fourth AMS date of c. 3000 y BP on a cut-marked pig bone indicates a limited amount of mixing of faunas of very different age, probably spanning both the Lateglacial and at least parts of the Postglacial (Charles, 1996, 1998). Furthermore three conventional radiocarbon dates exist, but most were done on bulk samples composed of unidentified bone splinters. The nature of the contextual relationship between these bone samples and the Magdalenian occupation is unclear; the dates merely give an average age of a mixture of bone fragments of uncertain origin, while the AMS dates on the cut bones can be directly linked with the human activity on the settlement (Charles, 1996, 1998; Germonpré, 1997). The fauna is dominated by horse remains; other herbivores include reindeer and musk ox. The assemblage also contains carnivores such as red fox, arctic fox, large canids, brown bear, wolverine, stoat, weasel, polecat, badger and cat (Dupont, 1873). The same publication mentions 'poissons d'eau douce' which are considered anthropogenic and are reported to pertain mainly to pike and 'trout' (Dupont, 1873: 184).

Trou du Frontal (Furfooz) is located 16 m above the Lesse River. It yielded not only a Magdalenian assemblage, with a cut-marked horse bone giving an AMS date of 12,800 BP, but also a significant proportion of Postglacial material, including a high number of pig and sheep/goat remains. A human tibia was dated to about 4,400 BP (Charles, 1998). The carnivores in the faunal assemblage are composed of red fox, arctic fox, large canids, brown bear, stone marten, stoat, weasel, polecat, badger and

cat (Dupont, unpublished notes). Freshwater fish remains are mentioned, but no species or quantities are indicated.

Trou du Sureau (Montaigle) is situated in a Carboniferous limestone cliff 33 m above the Flavion River. The latter is an arm of the Molinee River, a tributary of the Meuse. Several bone horizons were described by Dupont (1873). Fish remains were found in the second bone horizon, which also contains Upper Palaeolithic artefacts (Otte, 1979). The carnivore material pertains to red fox, large canids, stone marten, stoat, weasel, polecat and badger (Dupont, unpublished notes). No dates are yet available for the second bone horizon, but Dupont (unpublished notes) assigned it to the "Age du Renne". Typical Pleniglacial species such as mammoth, cave bear or cave hyena, found in the deeper horizons of the cave, are lacking in this assemblage (Dupont, unpublished notes). We therefore tentatively attribute the second bone horizon to the Late Glacial. Dupont (1873: 188) mentions an assemblage for this cave that he describes as an unusual accumulation of small mammals, terrestrial birds (575 individuals), anurans, shells and fresh water fish. The remains being so numerous, the material was only partially sampled in a random way. It is unclear, however, if the fish remains that are available for study are derived from this assemblage or if they have been sampled from other parts of the cave.

## 2. DESCRIPTION OF THE MATERIAL

The fish bones were identified with the aid of the skeletal reference collections of modern fish housed at the Royal Belgian Institute of Natural Sciences. The skeletal elements of each taxon were recorded and, whenever possible, the body length of the corresponding fish was reconstructed by direct comparison with modern specimens of known size. These reconstructed sizes are expressed as standard lengths (SL), *i.e.* the distance from the tip of the snout to the base of the tail. An overview of the identified

taxa is given in Table 1. Table 2 lists the skeletal elements by which the various fish are represented and indicates the body size reconstructions. Below the various finds are described in taxonomic order. Unless indicated otherwise, the data that are provided on the distribution and habits of the fish species have been borrowed from Philippart & Vranken (1983a; 1983b), Nijssen & de Groot (1987) and Froese & Pauly (2006).

Remains of eel have only been found at Trou du Frontal, and consist of two dentaries of specimens measuring 60-70 cm SL (Fig. 2a) and of a caudal vertebra of an eel of more than 50 cm SL. Given the small general size of isolated eel bones and the recovery methods used, it is probably no coincidence that remains were found on only one of the investigated sites and that they are from large individuals. Late medieval sites excavated in Belgium during the last two decades clearly show that eel are always heavily underrepresented or absent in hand-collected fractions and that their numbers increase dramatically in the 4 mm and, especially, the 2 mm sieve fractions (Veeckman *et al.*, 2000). Eel spend a large part of their lives

in continental waters before returning to the sea for reproduction. They inhabit all types of freshwater.

Cyprinids represent about one fourth and one third of the identified fish bones at Trou du Frontal and Trou de Chaleux, respectively. At Trou du Sureau only 4% of the remains are from cyprinids. The carp family consists of numerous species with a similar osteomorphology, which hampers identification. Of the 33 cyprinid remains present in the analysed assemblages only one could be brought to species with certainty, namely a pharyngeal plate from Trou de Chaleux belonging to a nase (*Chondrostoma nasus*) of 30-40 cm SL (Fig. 2b). This gregarious species prefers shallow waters with a fast current and occurs in the upper reaches of rivers, i.e. in the grayling and barbel zones of the classification proposed by Huet (1959). During the spawning season, nase migrate upstream and enter small tributaries where they reproduce over gravel in shallow water.

Three cyprinid bones from Trou du Frontal, a quadrate of an individual measuring 30-40 cm

	Trou du Frontal	Trou de Chaleux	Trou du Sureau
<i>Anguilla anguilla</i> (eel)	3	-	-
<i>Chondrostoma nasus</i> (nase)	-	1	-
Cyprinidae, cf. <i>Barbus barbus</i> (cyprinid, cf. barbel)	3	-	-
Cyprinidae cf. <i>Leuciscus</i> (cyprinid, cf. chub/ide/dace)	3	1	-
Cyprinidae indet. (cyprinids)	17	5	3
<i>Esox lucius</i> (pike)	4	1	-
<i>Thymallus thymallus</i> (grayling)	9	7	37
<i>Salmo salar</i> (Atlantic salmon) or <i>Salmo trutta trutta</i> (sea trout)	5	-	-
<i>Salmo trutta fario</i> (brown trout)	9	5	16
Salmonidae indet. (salmonids)	2	-	9
<i>Lota lota</i> (burbot)	37	1	10
total identified fish	92	21	75
unidentified fish	4	-	2

**Tabl. 1** — Fish remains from the studied assemblages. Figures represent number of identified specimens (NISP).

Site	Taxon	Skeletal element	SL in cm
<b>Trou du Frontal</b>			
	<i>Anguilla anguilla</i>	2 dentaries	60-70
		1 caudal vertebra	>50
	Cyprinidae cf. <i>Barbus</i>	1 frontal	40-50
		1 parasphenoid	40-50
		1 quadrate	30-40
	Cyprinidae cf. <i>Leuciscus</i>	1 frontal	30-35
		1 basioccipital	30-40
		1 pharyngeal plate	30-40
	Cyprinidae indet.	1 basioccipital	-
		1 neurocranium fragment	-
		1 preopercular	40-50
		2 preoperculars	50-60
		2 pharyngeal plates	-
		1 ceratohyal	40-50
		1 basipterygium	30-50
		5 precaudal vertebrae	40-50
		2 caudal vertebrae	40-50
		1 soft fin ray	-
	<i>Esox lucius</i>	1 dentary	-
		1 maxilla	40-50
		1 palatine	40-50
		1 opercular	40-50
	<i>Thymallus thymallus</i>	5 precaudal vertebrae	30-40
		2 caudal vertebrae	20-30
		2 caudal vertebrae	30-40
	<i>Salmo salar</i> / <i>Salmo trutta trutta</i>	1 precaudal vertebra	70-80
		4 caudal vertebrae	70-80
	<i>Salmo trutta fario</i>	1 precaudal vertebra	20-30
		3 precaudal vertebrae	30-40
		5 caudal vertebrae	30-40
	Salmonidae indet.	1 precaudal vertebra	30-40
		1 vertebra fragment	30-40
	<i>Lota lota</i>	1 quadrate	50-60
		1 cleithrum	50-60
		1 basioccipital	50-60
		4 precaudal vertebrae	35-40
		14 precaudal vertebrae	50-60
		16 caudal vertebrae	50-60

<b>Trou de Chaleux</b>			
	<i>Chondrostoma nasus</i>	1 pharyngeal plate	30-40
	Cyprinidae cf. <i>Leuciscus</i>	1 pharyngeal plate	40-50
	Cyprinidae indet.	2 precaudal vertebrae	40-50
		1 caudal vertebra	20-30
		1 caudal vertebra	30-40
		1 caudal vertebra	40-50
	<i>Esox lucius</i>	1 precaudal vertebra	50-60
	<i>Thymallus thymallus</i>	2 precaudal vertebrae	35-40
		4 caudal vertebrae	35-40
		1 caudal vertebra	40-50
	<i>Salmo trutta fario</i>	2 precaudal vertebrae	40-50
		3 caudal vertebrae	40-50
	<i>Lota lota</i>	1 precaudal vertebra	40-50
<b>Trou du Sureau</b>			
	Cyprinidae indet.	1 basioccipital	15-20
		1 preopercular	-
		1 supracleithrum	-
	<i>Thymallus thymallus</i>	1 opercular	30-40
		3 precaudal vertebrae	25-30
		11 precaudal vertebrae	30-40
		5 caudal vertebrae	25-30
		17 caudal vertebrae	30-40
	<i>Salmo trutta fario</i>	1 dentary	40-50
		1 precaudal vertebra	20-30
		3 precaudal vertebrae	30-40
		11 caudal vertebrae	30-40
	Salmonidae indet.	6 precaudal vertebrae	20-30
		1 precaudal vertebra	30-40
		2 caudal vertebra fragments	-
	<i>Lota lota</i>	1 cleithrum	30-40
		4 precaudal vertebrae	30-40
		2 precaudal vertebrae	50-60
		3 caudal vertebrae	50-60

**Tabl. 2** – Detailed inventory of the fish remains with indication of the skeletal elements found and of the reconstructed sizes.

**Legend of Fig. 2** (to the right)

**a:** Dentary of eel from Trou du Frontal; **b:** Pharyngeal plate of nase from Trou de Chaleux; **c:** Palatine of pike from Trou du Frontal; **d:** Right lateral view of caudal vertebra of grayling from Trou du Sureau; **e:** Caudal vertebra of Atlantic salmon or sea trout from Trou du Frontal. Right lateral and posterior view; **f:** Right lateral view of caudal vertebra of brown trout from Trou du Sureau; **g:** Basioccipital of burbot from Trou du Frontal. Scale bars are 1 cm.



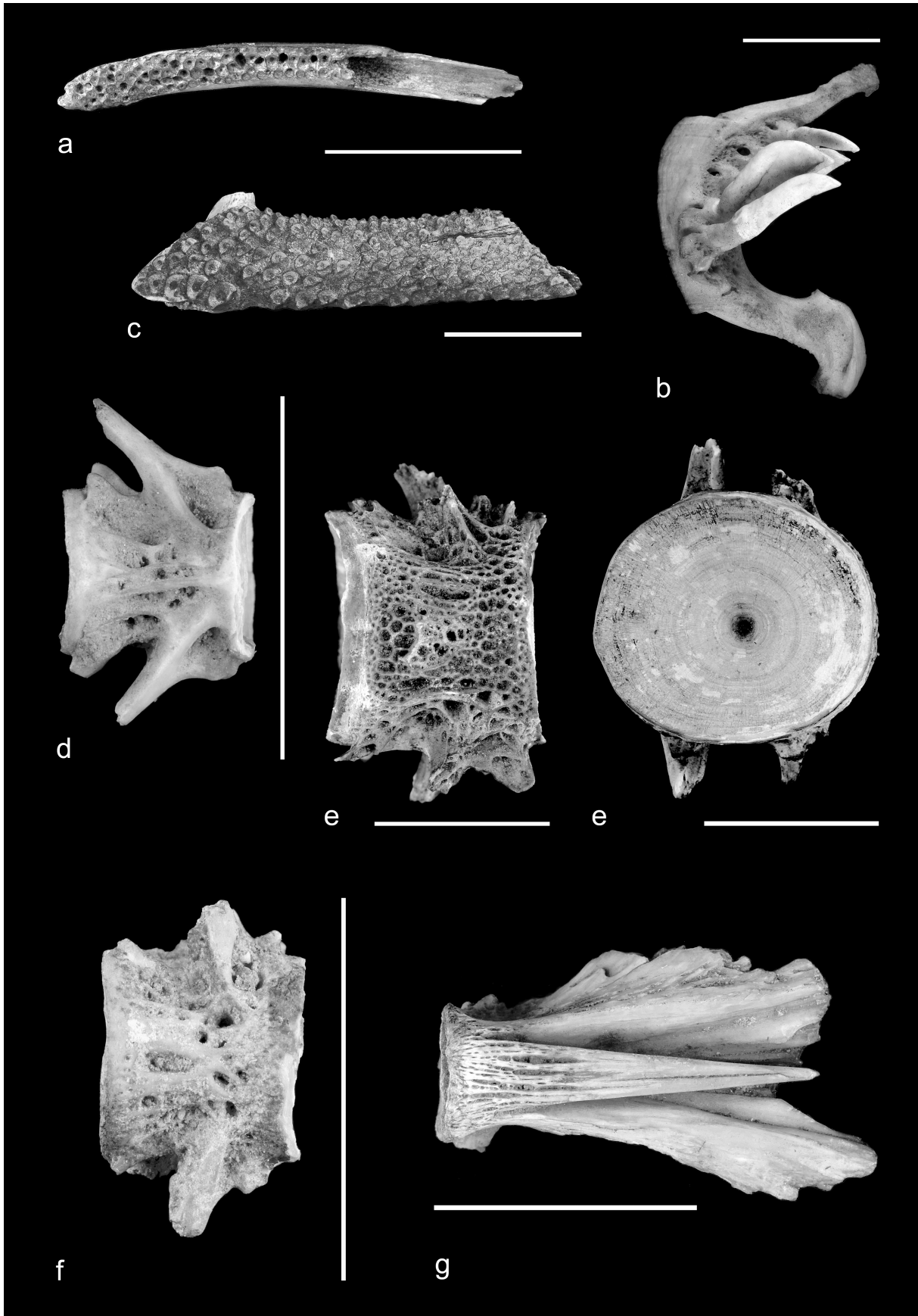


Fig. 2 — Some diagnostic elements of the major fish taxa.

SL and a frontal and a parasphenoid of fish of about 40-50 cm SL, show close similarities to barbel (*Barbus barbus*), but due to the rather poor state of preservation of the elements it was decided to classify this identification as tentative. Four elements have been attributed with the same reservation to the genus *Leuciscus*, a taxon that is represented nowadays in the Meuse basin by dace (*Leuciscus leuciscus*), ide (*Leuciscus idus*) and chub (*Leuciscus cephalus*) (Philippart & Vranken, 1983a). At Trou de Chaleux a pharyngeal plate is preserved of a *Leuciscus* measuring 40-50 cm. A similar bone, but of an individual of 30-40 cm SL, was found at Trou du Frontal where a basioccipital and a frontal were also identified of fish in the same size range. If it is accepted that the three *Leuciscus* species attained the same sizes in Upper Palaeolithic times as today, the Trou de Chaleux specimen with its reconstructed standard length of 40-50 cm can be classified as being either ide or chub. The latter two species grow larger than dace, of which the maximum reported total length is 40 cm (Froese & Pauly, 2006), which corresponds to 33.4 cm SL (using the equation provided by the same source). Although none of the aforementioned identifications are straightforward, all taxa are typical for the upper reaches of rivers. Barbel, chub and dace mainly live in the grayling and barbel zone, whereas ide is typical of the barbel and bream zone.

Pike is represented at Trou de Chaleux by a single precaudal vertebra of a fish measuring 50-60 cm SL. At Trou du Frontal four cranial elements, a dentary, a maxilla, a palatine (Fig. 2c) and an opercular were found. The three bones that allowed a size reconstruction are from individuals of 40-50 cm SL. Pike have a wide ecological tolerance and can be found in almost every type of running or stagnant water.

Salmonids are well represented at all sites considered here, particularly at Trou de Chaleux and Trou du Sureau where they represent 57 and 83% respectively of all identified fish bones. At Trou du Frontal about one fourth of the fish bones are from salmonids. About 90%

of the remains from this family could be identified to species. The majority of the salmonid remains consists of vertebrae, a phenomenon that does not need to result from phenomena of processing or differential disposal, but that is most probably due to differential preservation (Lubinski, 1996). Some of these vertebrae are poorly preserved and only allowed identification as 'Salmonidae', but the rest could be further identified. Grayling (*Thymallus thymallus*) could be recognized mainly on the basis of the typical lateral ornamentation of the vertebral centra (Fig. 2d), which differs from that seen in the genus *Salmo* (Le Gall, 1984). Distinguishing vertebrae of *Salmo salar* (Atlantic salmon) from those of *Salmo trutta* (brown trout or sea trout) should be possible on osteomorphological grounds according to Le Gall (1984), a view that is in contradiction with Desse and Desse (1976) who underline that a great deal of intraspecific variation exists and thus overlap amongst species. It was possible, however, to specifically identify most of the *Salmo* vertebrae by combining the reconstructed body lengths and the number of growth bands on the centra. One precaudal and four caudal vertebrae (Fig. 2e) from Trou du Frontal belonging to fish measuring 70-80 cm SL can be identified as Atlantic salmon (*Salmo salar*) or sea trout (migratory brown trout, *Salmo trutta trutta*) because they have only four growth zones (4+ in ichthyological jargon). Non-migratory brown trout (*Salmo trutta fario*) of that age would only measure about 30 to 40 cm maximally (Seifert & Kölbinger, 1989: 32). The majority of the *Salmo* vertebrae are from smaller fish (Fig. 2f): most of them must have measured between 30 and 40 cm SL and there are only a few specimens of 20-30 and 40-50 cm SL (see Tabl. 2). Some of the specimens are rather poorly preserved, with their edges damaged and the growth increments not clearly legible. However, those that allowed a reading of the growth increments had 3 or 4 growth bands, showing that they belong to the slower growing non-migratory *Salmo trutta fario*.

The grayling and brown trout occur in the cool, oxygen rich waters of the upper reaches



of rivers. Grayling are sedentary, gregarious fish that prefer gravelly or sandy bottoms; they occur in the lower part of the trout zone and the upper part of the barbel zone, but their main niche is the intermediate, grayling, zone that is named after the species. The brown trout is a solitary and sedentary species that can be found in a wide range of waters. Juvenile *Salmo trutta fario* live in shallow waters, whereas the larger fish prefer deeper waters and are therefore not found in the trout zone, but rather in the grayling and barbel zone (Seifert & Kölbing, 1989). Brown trout leave their territory only for reproduction, which takes place in small tributaries with fast running water over gravelly bottoms. Spawning usually occurs in 15-30 cm deep water. Grayling use spawning grounds similar to those of brown trout, but reproduction happens later in spring when river temperatures are rising (Philippart & Vranken, 1983a; Maitland & Campbell, 1992: 161). The Atlantic salmon and the sea trout are marine taxa that enter river to reproduce in the trout zone. During their spawning run and the actual reproduction they are very vulnerable to predation.

Remains of burbot (*Lota lota*) have been found at all sites in varying proportions: 40% of all identified fish remains at Trou du Frontal, 13% at Trou du Sureau and 5% at Trou de Chaleux. The majority of the bones are vertebrae (Tabl. 2) and it is believed that the low number of other skeletal elements (Fig. 2g) is due to their fragility and the effect this has on their preservation. At Trou du Frontal the majority of the remains correspond to individuals of 50-60 cm SL, only a few specimens measure 35-40 cm SL (Tabl. 2). At Trou du Sureau half of the burbot are between 50-60 cm SL, the others measure 30-40 cm SL. The single bone found at Trou de Chaleux is from a fish of 40-50 cm SL. Burbot prefer the deeper parts of large lakes and rivers, but move inshore for feeding. Larger individuals, such as the ones found at the studied sites, feed mainly on fish. The burbot is reputed to damage salmonid spawning grounds, feeding on the eggs and fry (Seifert & Kölbing, 1989).

### 3. DISCUSSION

#### 3.1. Taphonomy

Although certain mammal and bird species are known to eat fish, it appears very unlikely that any of them has contributed to the fish faunas described above. As will be argued below, it is likely that most of the fish encountered at the sites are derived from shallow, inshore waters over gravelly bottoms where these taxa abound during the annual reproduction. Fish are very numerous during the spawning season, but at the same time they are very vulnerable to predation by both man and animals. Nevertheless, it is believed that the majority of the fish remains, if not all, must be considered anthropogenic.

As mentioned in the introduction, all the caves are located at a high elevation compared to the present-day rivers along which they are lying. This large distance to the river banks eliminates the possibility that the fish remains represent a natural death assemblage or an accumulation by otters (*Lutra lutra*), the only piscivorous mammal that can be expected in the Upper Palaeolithic. Otter spraints, which contain a high number of fish bones, are typically left along the river margins (Ewer, 1973: 266). No remains of otter have been reported from any of the caves, and even if they had been present, they would not offer a good explanation for the presence of the fish remains found. If an otter were to die naturally in the cave, or if such an animal had been hunted by man and brought to the cave for processing, a deposition could occur of fish bone from the otter's stomach contents. The reconstructed sizes of the fish contradict such a scenario. Studies on otter spraints have shown that they only contain bones of fish of rather small size, which are eaten whole. Larger fish are normally represented only by scales and by little or no bone at all (Brinkhuizen, 1994). A study of the stomach contents of modern *Lutra canadensis*, a related species, showed that the trout had an average size of 11.5 cm total length (TL) and that the largest individual measured 23 cm TL (Harris, 1968: 76). The maximum

length reported for cyprinids was 13 cm TL. For pike an average total length was mentioned of 25 cm, but no maximum was given. An analysis of spraints from *Lutra lutra* showed fish lengths of 9.5-17 cm for salmonids, 22-42 cm for eel and 13-21 cm for pike (Jenkins *et al.*, 1979). It is hence obvious from the reconstructed sizes (Tabl. 2 and Fig. 3) that the majority of the fish in the analysed caves are from larger fish than those usually captured by otter.

The carnivores that have been positively identified from the caves are red fox (*Vulpes vulpes*), arctic fox (*Alopex lagopus*), large canids (unclear if they are from wolf or dog), brown bear (*Ursus arctos*), wolverine (*Gulo gulo*), stoat (*Mustela erminea*), weasel (*Mustela nivalis*), stone marten (*Martes foina*), polecat (*Mustela putorius*), badger (*Meles meles*) and cat (*Felis silvestris*). It is known that brown bear actively prey on migrating or spawning salmonids, but the other species mentioned above only very occasionally capture fish. Some rare records of such behaviour exist for both species of fox, for wolf, stoat, polecat, badger and cat (Lyneborg & den Hoed, 1972; Ewer, 1973; Broekhuizen *et al.*, 1992). Dead fish are occasionally scavenged by foxes, wolf, and badger (Lyneborg & den Hoed,

1972; Neal, 1986). Again it is highly unlikely that these species have contributed to the fish assemblages found at the sites. None of these mammals are cave dwelling species and since they only rarely eat fish – except the brown bear – the probability is very low that stomach contents of hunted animals, butchered on site, can explain the presence of fish remains.

A deposition of fish remains by birds also seems very unlikely. At Trou du Frontal the ornithofauna, mentioned by Dupont (1873), consists of 14 species, among which are an unidentified falcon and the eagle owl (*Bubo bubo*). The raptors reported from Trou de Chaleux include white-tailed eagle (*Haliaeetus albicilla*), an unidentified owl species, and kestrel (*Falco tinnunculus*). The owl may have been an inhabitant of the cave, whereas the kestrel and eagle owl prefer to nest on rocky outcrops, sometimes at the entrance of a cave, but never inside. The diet of owls and kestrel does not include fish, but the white-tailed eagle is a typical piscivorous species. However, this eagle nests in large trees, not in caves. The same is true for the only other truly piscivorous raptor living in Western Europe, namely the osprey (*Pandion haliaetus*). The chances of undigested food of these

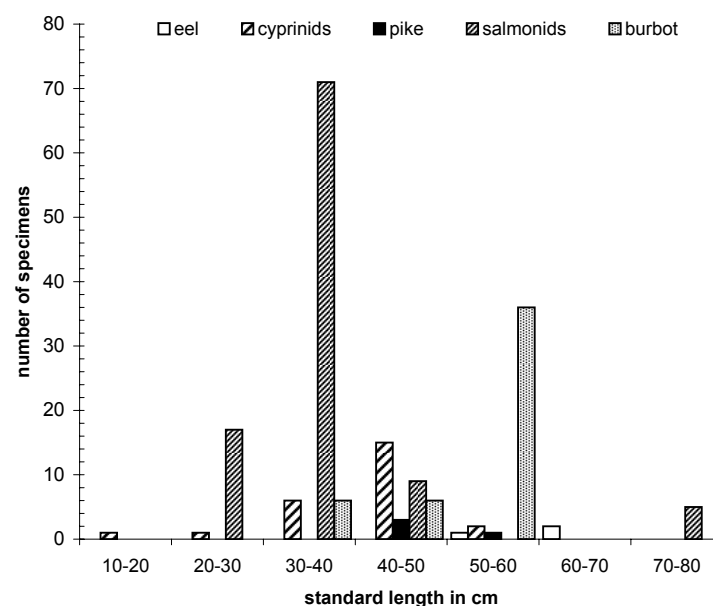


Fig. 3 — Reconstructed body lengths of the fish. The data from all sites were lumped.

fish-eating raptors accumulating in caves are therefore very low. In addition, it appears that the reconstructed sizes of the fish found at the studied sites are not in good agreement with an involvement of white-tailed eagle or osprey. Green (1976: 481) reports that the pike and brown trout captured by ospreys in Scotland measure between 10 and 60 cm TL, with a mean of 31 cm. A coastal population, studied in Corsica, consumed mainly mullets (*Mugilidae*) of between 26 and 33.5 cm TL, with a mean total length of 30 cm (Francour & Thibault, 1996). The bream (*Diplodus*) consumed in the same area had a similar average length. For white-tailed eagle no data on fish lengths were found, but observations of prey fishes brought to nest-places in Norway suggested estimated weights between 100 g and 6-8 kg, with most specimens between 0.5 and 3 kg (Willgohs, 1961). The same author also believes that the importance of fish to the diet of white-tailed eagle, as inferred from pellets, is underestimated because their bones are to a large extent digested and therefore only rarely found in pellets. The latter statement suggests that this raptor, although it apparently takes larger fish than the osprey, would play only a minor role in the deposition of fish remains.

### 3.2. Season and place of capture

The biology of the fish – in particular their spawning behaviour – suggests when fishing may have been easiest and most productive. Most of the species identified at our Upper Palaeolithic sites reproduce in shallow inshore waters, making them an easily accessible and predictable source of food. Salmon, sea trout and brown trout reproduce in winter, in shallow waters over gravelly bottoms. The spawning grounds are usually between 15-30 cm deep and located in small tributaries rather than in main rivers. The same areas are used by grayling, but their reproduction season starts later in spring when river temperatures start to rise. All these salmonids suffer from predation by several bird species and mammals such as brown bear (Quinn & Kinnison, 1999), otter and

foxes (Maitland & Campbell, 1992: 126) at the spawning grounds, but also at other shallow parts of the river where migrating fish pass. Of course, prehistoric man must also have used these opportunities to capture migrating or spawning salmonids. The only positively identified cyprinid species, the nase, reproduces nowadays in early spring (March-April) and has the same preference for fast-running water of shallow depth (maximum 30 cm) over gravelly (or rocky) substrate. The other cyprinid species barbel, dace/ide/chub, of which the identification was only tentative, also spawn in spring and again over gravelly bottoms. Burbot on the contrary spawn in deeper waters and their abundance at the Upper Palaeolithic sites can therefore not be explained as a result of higher vulnerability during their reproduction. However, the species actively searches for spawning grounds of salmonids to feed on the eggs and larvae. Because of the severe damage that burbot cause it has even been suggested in some of the fishery literature that the species should be eradicated in the nursery reaches of salmonid waters (Maitland & Campbell, 1992: 264). It is clear that burbot also become vulnerable to predation because of these movements to feeding grounds in shallow water. The same scenario could explain the capture of eel near Trou du Frontal, a species that reproduces in the Sargasso Sea. Eel are also reputed to be detrimental to salmonid fry (Deelder, 1973: 3-6).

Numerous remains of vertebrae have been found at the sites, but it appears impossible to use them for the establishment of seasonality because the increments at their edges are poorly legible. Furthermore, chances that relevant information can be derived from fish bones and otoliths may be less than generally assumed because of the large individual variation that is observed in the timing of the onset the growth season (Van Neer, 1993; Van Neer *et al.*, 2004). The length of the growth period, and hence the width of the growth bands, is also very variable, which hampers the establishment of the widths that are to be expected for various seasons of capture. In fact, only elements that have a very narrow growth band

at their edges can be confidently used for a seasonality estimate, and can in that case be attributed to fish that are caught at the beginning of their new growth season. This shortcoming is illustrated by the vertebrae found in the Late Magdalenian levels at Bois Laiterie where marginal increments could not confirm or reject the hypothesized fishing season, despite the fact that they were better preserved (Van Neer, 1997).

If it is accepted that the inhabitants of the studied caves were opportunistic fishers, exploiting the aquatic resources in the neighbourhood at the time that they were most easily accessible, a hypothesis can be formulated regarding the length of time that fishing was practised throughout the year. The months of the year that the exploited species mentioned in the foregoing paragraphs spawn today in the Meuse basin, probably do not exactly correspond to those of the Upper Palaeolithic, due to the lower temperatures at the time. The start of the reproduction may have been somewhat delayed, until the necessary minimum temperatures of the water were reached. Figure 4 gives a schematic overview of the present-day spawning seasons of the species in the Meuse basin (Philippart & Vranken, 1983a; 1983b). It is obvious, however, that regardless of the exact onset of the respective spawning seasons, exploitation of fish may have continued for several months.

Information on the seasonal exploitation of the birds and mammals for the sites considered here is scanty thus far. At Trou de Chaleux and Bois Laiterie cementum lines of ungulate teeth were studied to establish the season of death (Stutz, 1997), but the number of analysed specimens was small and only few of them yielded clearly legible growth zones. The estimated season of death of two reindeer specimens from Bois Laiterie is summer-late autumn (June – December) and growth increment data from Trou de Chaleux are limited to one caprid that would have died during winter-early spring (January – April) (Stutz, 1997). Additional information for the latter site is provided by the fox remains, which are believed to be anthropogenic rather than the remnants of individuals that dened and died naturally in the cave. The majority of the bones are from adult individuals showing that foxes did not use the cave as a den. Cut marks and impact notches on the long bones indicate meat removal and marrow procurement (Charles, 1998; Germonpré & Sablin, 2004). Head elements and phalanges are underrepresented, suggesting that they were removed with the skins. A few mandibles from young arctic foxes are – based on the eruption state of the first lower carnassial (Habermehl, 1961) – from about four months old individuals that must have died in autumn (Germonpré, unpublished data). This could indicate that the

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
salmon			±5°C									
sea trout		±6°C										
brown trout			below 6-7°C									
grayling							8-9°C					
nase							±10°C					
barbel									±15°C			
ide												

Fig. 4 – Present-day spawning seasons in the Meuse basin of the identified fish, with indication of the water temperature needed for the onset of reproduction (based on Philippart & Vranken, 1983a). Light gray areas indicate variation seen in function of yearly oscillations in water temperature.



foxes were trapped during this season and that the Magdalenians therefore also used Trou de Chaleux cave in autumn. At Trou du Frontal the skeletal element distribution and the presence of a juvenile of about 2-3 months old could indicate that this cave was used as a den site by the foxes (Charles, 1998; Germonpré, unpublished data). At Bois Laiterie, several remains from juvenile foxes similarly imply that these carnivores denned in the cave (Gautier, 1997). Additional data will be needed to establish more accurately the length of occupation throughout the year of these cave sites and to reconstruct in more detail the Magdalenian resource scheduling.

### 3.3. The exploited species spectrum and the fishing techniques

Upper Palaeolithic fishing in the considered sites concentrated on salmonids, burbot and cyprinids and it is likely that the former may have been the major exploited taxon. It has been noted that remains of salmon have a relatively low survival rate because their bones are not only relatively porous, but also have a high fat content making them more vulnerable to dissolution by the fatty acids that are produced when the tissues decompose (Lepiksaar & Heinrich, 1977). It should be underlined that the sampling did not involve the use of sieves, which can

explain the observed absence of smaller taxa and the bias towards the recovery of the largest species and specimens. However, it is unlikely that such smaller fish had a great dietary importance. The fish fauna retrieved through sieving at the Upper Magdalenian site of Bois Laiterie includes only remains of brown trout, grayling and burbot, and which mainly belong to large specimens. Except for a brown trout of 10-20 cm SL and another individual of 20-30 cm SL, all the fish are larger than 30 cm SL (Van Neer, 1997: 208). At Walou cave, where Upper Palaeolithic and, mainly, Middle Palaeolithic fish remains were collected through sieving (Van Neer & Wouters, in press a and b), salmonids and burbot occur that are similar in size to those from the sites described here. However, in addition there is a substantial number of small salmonids measuring between 5 and 15 cm SL. Cyprinids are mainly represented by small individuals (most of them between 3 and 5 cm SL) and also small stone loaches *Barbatula barbatula* (all between 3 and 8 cm SL) and bullhead *Cottus gobio* (all between 5 and 10 cm SL) occur. For Walou it was hypothesized that those small specimens do not represent fish that were intentionally captured by people, but that they rather represent stomach contents of burbot, which feeds preferentially on the small fish found.

Table 3 shows the percentage contribution of the various taxa in the three Upper Palaeolithic

	Trou du Frontal (n=92)	Trou de Chaleux (n=21)	Trou du Sureau (n=75)	Bois Laiterie (n=60)
eel	3.3	0.0	0.0	0.0
nase	0.0	4.8	0.0	0.0
cf. barbel	3.3	0.0	0.0	0.0
cf. chub/ide/dace	3.3	4.8	0.0	0.0
unidentified cyprinid	18.5	23.8	4.0	0.0
pike	4.3	4.8	0.0	0.0
salmon/sea trout	5.4	0.0	0.0	0.0
brown trout	9.8	23.8	21.3	61.7
grayling	9.8	33.3	49.3	5.0
unidentified salmonid	2.2	0.0	12.0	0.0
burbot	40.2	4.8	13.3	33.3

Tabl. 3 — Percentage contributions of the various fish taxa in the studied assemblages, compared to those of Bois Laiterie.



assemblages and compares this to the species proportions in the Upper Magdalenian cave of Bois Laiterie. On figure 5 the data are presented in an alternative way, with the members of the cyprinid and salmonid families combined. There is considerable variation in the contributions of cyprinids, salmonids and burbot that cannot easily be explained. Since all the assemblages are of rather small size the interpretation below should be considered as tentative. Possibly, the absence of cyprinids in Bois Laiterie – where sieving was carried out (and thus a wider range of species could be expected) – reflects a shorter fishing season compared to the other sites. As shown above, most cyprinids spawn later in the year than the salmonids. The fact that grayling are relatively rare among the salmonids of Bois Laiterie, compared to the earlier spawning brown trout, also suggests that fishing activities were more restricted in time. The differences observed in the other ichthyofaunas may also be related to the length of the fishing seasons, but other factors may have played a role, such as differential preservation or selective sampling. It is not excluded either that the larger range of species at Trou de Chaleux and Trou du Frontal may be related to the fact that these assemblages are of questionable chronological unity (*cf.* presence of domestic pig bones).

As already mentioned, an emphasis on fishing of salmonids, burbot and, to some

extent cyprinids, has also been noted in the Middle Palaeolithic levels of Walou cave, similarly located along a small river with cold, oxygen rich water (Van Neer & Wouters, in press a and b). The exploited species spectrum apparently did not change significantly through time, but it is hard to reconstruct the diachronic importance of fish in the food provisioning. The proportion of fish versus other vertebrate remains is a possible measure, but due to problems related to differential preservation and sampling, it is difficult to quantify the importance of the various resources in nutritional terms. It is generally believed that fishing in Middle Palaeolithic times was a minor activity (Le Gall, 1992), carried out in an opportunistic way (Bar-Yosef, 2004). Isotopic analyses of human bone seem to indicate that freshwater fish contributed only to a small extent to the diet of Middle Palaeolithic people (Balter *et al.*, 2001; Bocherens *et al.*, 2001). Similar isotopic research shows that an increased use of aquatic resources (fish, molluscs, and/or birds) only began from mid-Upper Palaeolithic times (Richards *et al.*, 2001). Le Gall (1992) concluded, after a survey of about 30 Early, Middle and Late Magdalenian ichthyofaunas in France, that fishing only intensified in Late Magdalenian times, a phenomenon that he relates to the changing climatic conditions. The resulting gradual disappearance of reindeer and wild horse, the favourite game

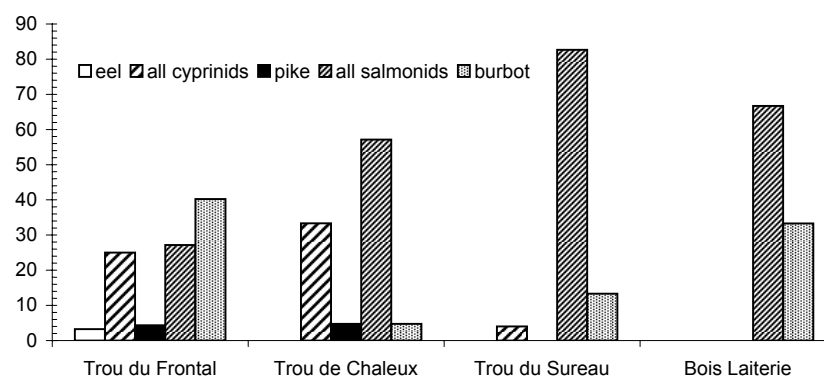


Fig. 5 — Proportions of the major fish groups at Trou du Frontal, Trou de Chaleux, Trou du Sureau and Bois Laiterie.

species of the Magdalenians, combined with reforestation would have affected the mode of exploitation of the environment and may have led to more intensive fishing activities. The numerous Upper Palaeolithic artistic representations related to fishing also seem indicative of a more frequent exploitation of freshwaters (Cleyet-Merle, 1990). Atlantic salmon and brown trout are the most frequently depicted fish in French Upper Palaeolithic art, and the importance of salmonids is also illustrated in Belgium by a representation of brown trout on a Magdalenian *bâton de commandement* found in Goyet, at about 5 km southeast of Namur (Twisselmann, 1951).

Upper Palaeolithic artefacts that can be confidently identified as fishing gear are rare. Harpoons made of bone or reindeer antler and 'leister' elements are regularly found at Magdalenian sites, but it is not certain that these were used for fishing (Cleyet-Merle, 1990). Examples of such harpoons in Belgium are known from Goyet (Dupont, 1873) and grotte du Coléoptère (Dewez, 1975). In France, gorges made of bone have been found, and possibly small bipointed stone tools made suitable gorges as well (Cleyet-Merle, 1990). However, since the fishing activities probably concentrated on fish that were occurring in large numbers in shallow, inshore waters, it is not necessary to invoke the use of elaborate gear. Grasping by hand and also the use of any type of wounding or striking gear, such as clubs or spears, may have been effective in the wadeable areas of the small rivers where fish came to spawn. Such gear, made of wood, or various types of baskets made of plant fibre, obviously has only a rare chance of being preserved in the archaeological record.

#### 4. CONCLUSIONS

In summary, the Middle and Upper Palaeolithic sites discussed here seem to indicate that the targeted fish species, the place and the season of fishing did not change through time in the upper reaches of the Meuse basin.

People must have been well aware of the life cycle of the fishes and took advantage of their abundance in shallow water during the yearly recurring, predictable, spawning season. There may have been some variation in the length of the fishing season, but it is unclear if human strategies or fish behaviour at the different localities were the main determining factor. The available data for the region considered here are still too limited to confirm the intensification of freshwater fish exploitation suggested by isotopic analyses of human bone (Richards *et al.*, 2001) and by the increasing proportions of fish remains in archaeofaunas elsewhere in Europe (Le Gall, 1992).

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#### References

- BALTER V., PERSON A., LABOURDETTE N., DRUCKER D., RENARD M. & VANDERMEERSCH, B., 2001. Les Néandertaliens étaient-ils essentiellement carnivores ? Résultats préliminaires sur les teneurs en Sr et en Ba de la paléobiocénose mammalienne de Saint-Césaire. *Comptes Rendus de l'Académie des Sciences Paris, Sciences de la Terre et des Planètes*, **332** : 59-65.
- BAR-YOSEF O., 2004. Eat what is there: hunting and gathering in the world of Neanderthals and their neighbours. *International Journal of Osteoarchaeology*, **14** : 333-342.
- BOCHERENS H., BILLIOU D., MARIOTTI A., TOUSSAINT M., PATOU-MATHIS M., BONJEAN D. & OTTE M., 2001. New isotopic evidence for dietary habits of Neandertals from Belgium. *Journal of Human Evolution*, **40** : 497-505.

- BRINKHUIZEN D. C., 1994. Het dieet van de otter (*Lutra lutra*) in twee voormalige ottergebieden in Friesland. *Paleo-aktueel*, **5** : 143-147.
- BROEKHUIZEN S., HOEKSTRA B., VAN LAAR V., SMEENK C. & THISSEN J. B. M. (éd.), 1992. *Atlas van de Nederlandse zoogdieren*. Utrecht, Stichting Uitgeverij Koninklijke Nederlandse Natuurhistorische Vereniging.
- CHARLES R., 1996. Back into the north: the radiocarbon evidence for the human re-colonisation of the north-western Ardennes after the Last Glacial Maximum. *Proceedings of the Prehistoric Society*, **62** : 1-17.
- CHARLES R., 1998. Late Magdalenian chronology and faunal exploitation in the North-Western Ardennes. *British Archaeological Reports International Series* **737**. Oxford, 245 p.
- CLEYET-MERLE J.-J., 1990. *La préhistoire de la pêche*. Paris, Errance, 195 p.
- DALÉN L., NYSTRÖM V., VALDIOSERA C., GERMONPRÉ M., SABLIN M., TURNER E., ANGERBJÖRN A., ARSUAGA J. L. & GÖTHERSTRÖM A., 2007. Ancient DNA reveals lack of postglacial habitat tracking in the arctic fox. *Proceedings of the National Academy of Sciences*, **104** : 6726-6729.
- DEELDER C. L., 1973. Exposé synoptique des données biologiques sur l'anguille, *Anguilla anguilla* (Linnaeus, 1758). Synopsis FAO sur les pêches. Rome, FAO, **80** : pag. var.
- DESSE G. & DESSE J., 1976. *Diagnostic des pièces rachidiennes des Téléostéens et des Chondrichtyens. III. Téléostéens d'eau douce*. Paris, Expansion Scientifique, 108 p.
- DEWEZ, M. 1975. Nouvelles recherches à la grotte du Coléoptère à Bomal-sur-Ourthe (Province de Luxembourg). Rapport provisoire de la première campagne de fouilles. *Helinium*, **15** : 105-133.
- DUPONT E., 1873. *L'homme pendant les âges de la pierre dans les environs de Dinant-sur-Meuse*. Bruxelles, C. Muquardt, 250 p.
- EWER R. F., 1973. *The carnivores*. London, Weidenfeld & Nicholson, 494 p.
- FRANCOUR P. & THIBAUT J.-C., 1996. The diet of breeding Osprey *Pandion haliaetus* on Corsica: exploitation of a coastal marine environment. *Bird Study*, **43** : 129-133.
- FROESE R. & PAULY D. (éd.), 2006. *FishBase*. World Wide Web electronic publication. www.fishbase.org, version (10/2006).
- GAUTIER, A. 1997. The macromammal remains of la Grotte du Bois Laiterie. In : M. OTTE & L. G. STRAUS (éd.), *La grotte du Bois Laiterie (Namur): La recolonisation magdalénienne de la Belgique*. Liège, Études et Recherches Archéologiques de l'Université de Liège (ÉRAUL), **80** : 177-196.
- GERMONPRÉ M., 1997. The Magdalenian upper horizon of Goyet and the late Upper Palaeolithic recolonisation of the Belgian Ardennes. *Bulletin de l'Institut royal des Sciences naturelles de Belgique, Série Sciences de la Terre*, **67** : 167-182.
- GERMONPRÉ M., 2004. Influence of climate on sexual segregation and cub mortality in Pleniglacial cave bear. In : R. C. G. M. LAUWERIER & I. PLUG (éd.), *The future from the past: Archaeozoology in wildlife conservation and heritage management*. Proceedings of the 9th congress of the International Council of Archaeozoology, Oxford, Oxbow Books: 51-63.
- GERMONPRÉ M. & SABLIN M. V., 2001. The cave bear (*Ursus spelaeus*) from Goyet, Belgium. The bear den in Chamber B (bone horizon 4). *Bulletin de l'Institut royal des Sciences Naturelles de Belgique, Série Sciences de la Terre*, **71** : 209-233.
- GERMONPRÉ M. & SABLIN M. V., 2004. Systematics and osteometry of Late Glacial foxes from Belgium. *Bulletin de l'Institut royal des Sciences naturelles de Belgique, Série Sciences de la Terre*, **74** : 175-188.

- GREEN R., 1976. Breeding behaviour of Ospreys *Pandion haliaetus* in Scotland. *Ibis*, **118** : 475-490.
- HABERMEHL K. H., 1961. *Altersbestimmung bei Haustieren, Pelztieren und beim jagdbaren Wild*. Berlin, Verlag Paul Parey, 223 p.
- HARRIS C. J., 1968. Otters. *A study of the recent Lutrinae*. London, Weidenfeld & Nicholson, 397 p.
- HUET M., 1959. Profiles and biology of Western European streams as related to fish management. *Transactions of the American Fisheries Society*, **88** (3) : 155-163.
- HUGHES S., HAYDEN T. J., DOUADY J. C., TOUGARD C., GERMONPRÉ M., STUART A., LBOVA L., CARDEN R. F., HÄNNI C. & LUDOVIC S. L., 2006. Molecular phylogeny of the extinct Giant Deer, *Megaloceros giganteus*. *Molecular Phylogenetics and Evolution*, **40** : 285-291.
- JENKINS D., WALKER J. G. K. & MCGOWAN D., 1979. Analyses of otter (*Lutra lutra*) faeces from Deeside, N.E. Scotland. *Journal of the Zoological Society*, **187** : 235-244.
- LE GALL O., 1984. *L'ichtyofaune d'eau douce dans les sites préhistoriques. Ostéologie-Paléoécologie-Paléothnologie*. Cahiers du Quaternaire, **8**. Paris, CNRS, 196 p.
- LE GALL O., 1992. Poissons et pêches au Paléolithique (Quelques données de l'Europe occidentale). *L'Anthropologie (Paris)*, **96** : 121-134.
- LEPIKSAAR J. & HEINRICH D., 1977. *Untersuchungen and den Fischresten aus der frühmittelalterlichen Siedlung Haithabu*. Berichte über die Ausgrabungen in Haithabu. Neumünster, Wachholtz, **10**, 140 p.
- LYNEBORG L. & DEN HOED G., 1972. *Wilde zoogdieren in Europa*. Amsterdam, Mous-sault, 256 p.
- LUBINSKI P. M., 1996. Fish heads, fish heads: an experiment on differential preservation in a salmonid fish. *Journal of Archaeological Science*, **23** : 175-181.
- MAITLAND P. S. & CAMPBELL R. N., 1992. *Freshwater fishes*. London, Harper Collins, 368 p.
- NEAL E., 1986. *The natural history of badgers*. Facts on File Publications, New York, 256 p.
- NIJSSSEN H. & DE GROOT S. J., 1987. *De vissen van Nederland*. Utrecht, Stichting Uitgeverij van de Koninklijke Nederlandse Natuurhistorische Vereniging, 224 p.
- OTTE M., 1979. Le paléolithique supérieur ancien en Belgique. *Monographies d'Archéologie Nationale*, **5** : 1-684.
- PHILIPPART J.-C. & VRANKEN M., 1983a. *Atlas des poissons de Wallonie*. Liège, Cahiers d'Éthologie Appliquée, Service d'Éthologie et de Psychologie animale de l'Institut de Zoologie de l'Université de Liège, **3** (suppl. 1-2), 395 p.
- PHILIPPART J.-C. & VRANKEN M., 1983b. *Animaux menacés en Wallonie. Protégeons nos poissons*. Jambes, Région Wallonne & Paris-Gembloux, Éditions J. Duculot, 206 p.
- QUINN T. P. & KINNISON M. T., 1999. Size-selective and sex-selective predation by brown bears on sockeye salmon. *Oecologia*, **121** : 273-282.
- RICHARDS M. P., PETTITT P. B., STINER M. C. & TRINKAUS E., 2001. Stable isotope evidence for increasing dietary breadth in the European mid-Upper Paleolithic. *Proceedings of the National Academy of Sciences of the United States of America*, **98** (11) : 6528-6532.
- SCHMERLING P. C., 1833. *Recherches sur les ossements fossiles découverts dans les cavernes de la province de Liège*. Liège, Collardin, Volume I, 167 p. & Volume II, 195 p.
- SEIFERT K. & KÖLBING A., 1989. *So macht Angeln Spass*. München, BLV, 309 p.
- STUTZ A. J., 1997. Seasonality of Magdalenian cave occupations in the Mosan basin: cementum increment data from Bois Laiterie, Chaleux and Trou da Somme.



- In : M. OTTE & L. G. STRAUS (éd.), *La grotte du Bois Laiterie (Namur): La recolonisation magdalénienne de la Belgique*. Études et Recherches Archéologiques de l'Université de Liège (ÉRAUL). Liège, **80** : 197-204.
- TWIESELMANN F., 1951. *Les représentations de l'homme et des animaux quaternaires découvertes en Belgique*. Mémoires de l'Institut royal des Sciences naturelles de Belgique **113**. Bruxelles, 28 p.
- VAN NEER W., 1993. Limits of incremental growth in seasonality studies: the example of the clariid pectoral spines from the byzantino-islamic site of Apamea (Syria, 6th-7th century A.D.). *International Journal of Osteoarchaeology*, **3** : 119-127.
- VAN NEER W., 1997. Fish remains from the Upper Magdalenian in the Grotte du Bois Laiterie. In : M. OTTE & L. G. STRAUS (éd.), *La grotte du Bois Laiterie (Namur) : La recolonisation magdalénienne de la Belgique*. Études et Recherches Archéologiques de l'Université de Liège (ÉRAUL). Liège, **80** : 205-213.
- VAN NEER W., ERVYNCK A., BOLLE L. J. & MILLNER R. S., 2004. Seasonality only works in certain parts of the year. The reconstruction of fishing seasons through otolith analysis. *International Journal of Osteoarchaeology*, **14** : 457-474.
- VAN NEER W. & WOUTERS W. (in press a) Les restes de poissons des niveaux paléolithique moyen et supérieur. In : DRAILY C. (éd.) *La grotte Walou à Trooz (Belgique)*. Bilan des recherches 1996 à 2004. Études et Documents, Archéologie. Namur.
- VAN NEER W. & WOUTERS W. (in press b) Trooz/Forêt : La pêche attestée au Paléolithique moyen et supérieur dans la grotte Walou. *Chronique de l'Archéologie Wallonne*, **14**.
- VEECKMAN J., VAN HOOFF W., COOREMANS B., ERVYNCK A. & VAN NEER W., 2000. De inhoud van de afvalput van de Grootte Schalien Loove: speuren naar de 17de eeuwse bewoners. *Brabom (Berichten en Rapporten over het Antwerps Bodemonderzoek en Monumentenzorg)*, **4** : 115-190.
- VIVÉ A. & VERSAILLES A., 1996. *Du Musée à l'Institut : 150 ans de sciences naturelles*. Bruxelles, Institut royal des Sciences Naturelles de Belgique. 112 p.
- WILLGOHS J. F., 1961. The white-tailed eagle (*Haliaeetus albicilla*) in Norway. *Universitetet i Bergen Arbok. Matematisk-Naturvitenskapelig Serie*, **12** : 1-212.

## Authors' Address

Wim VAN NEER  
Koninklijk Belgisch Instituut voor  
Natuurwetenschappen  
Afdeling Anthropologie en Prehistorie  
Vautierstraat 29  
B-1000 BRUSSEL (België)  
wvanneer@naturalsciences.be

and

Katholieke Universiteit Leuven  
Laboratorium voor Diversiteit en Systematiek  
der Dieren  
Charles de Bériotstraat 32  
B-3000 LEUVEN (België)

Wim WOUTERS  
Koninklijk Belgisch Instituut voor  
Natuurwetenschappen  
Afdeling Anthropologie en Prehistorie  
Vautierstraat 29  
B-1000 BRUSSEL (België)  
wim.wouters@naturalsciences.be

Mietje GERMONPRÉ  
Koninklijk Belgisch Instituut voor  
Natuurwetenschappen  
Afdeling Fossiele Vertebraten  
Vautierstraat 29  
B-1000 BRUSSEL (België)  
mietje.germonpre@naturalsciences.be