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Fish remains from the Neolithic site of El Mirador cave (Atapuerca, Spain): Seasonality and resource management

Restes de poissons du Néolithique de la grotte du Mirador (Atapuerca, Espagne) ; saisonnalité et gestion des ressources

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ABSTRACT

Ichthyoarchaeological analyses of the freshwater fish remains from levels 19 and 20 in El Mirador cave (Atapuerca, Spain) have been conducted. Fish were always present as a source of animal protein, although their importance in the human diet was not fully exploited by people during the Neolithic on the Iberian Peninsula. Two principal goals are treated here: a taxonomic study of the fish remains and a characterization of the exploitation of this resource. The results show that the human community of El Mirador cave practiced fishing, and that fish was part of their diet and social life.

RÉSUMÉ

Des analyses ichthyo-archéologiques de restes de poissons d'eau douce provenant des niveaux 19 et 20 de la grotte du Mirador (Atapuerda, Espagne) ont été réalisées. Les poissons étaient toujours présents en tant que source de protéine animale, bien que leur importance dans l'alimentation humaine n'ait pas été pleinement explorée au cours du Néolithique dans la péninsule Ibérique. Deux objectifs principaux sont abordés : une étude taxonomique des restes de poisson et une caractérisation de l'exploitation de cette ressource. Les résultats montrent que la communauté humaine de la grotte du Mirador pratiquait la pêche et que le poisson faisait partie de son alimentation et de sa vie sociale.

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1. Introduction

El Mirador cave is located within the municipality of Ibeas de Juarros, into the Sierra de Atapuerca karstic System (Burgos, Spain). The site rises to 1033 m above sea level and its geographical coordinates are 42° 20′ 58″ N and 03° 30′ 33″ W (Fig. 1A).

The cave has an impressive Holocene succession, composed of 24 archaeological levels. The MIR4 and MIR 3 levels were deposited during human occupations in the Bronze Age and the remaining layers (MIR6-MIR24), during the Neolithic period (6000–5000 cal BC.), except for MIR5 which represents a time when the cave was not occupied (Martín et al., 2009; Vergès et al., 2002, 2008) (Fig. 1B).

A total of 17 dates using AMS ^{14}C on samples of charred vegetables place occupation during the Neolithic between 3650–3510 cal BC for MIR6 and 5210–5170 cal BC for MIR24 (Vergès et al., 2008) level. Levels MIR19 and 20 date to 5210–4850 cal BC and 5230–4920 cal BC, respectively. These two levels have characteristics very similar to the rest of the Neolithic sequence (Martín et al., 2009). During this time, the cave was employed as a cattle pen. Overlying layers of animal manure and plant debris indicate periodic burning for sanitation (Angelucci et al., 2009).

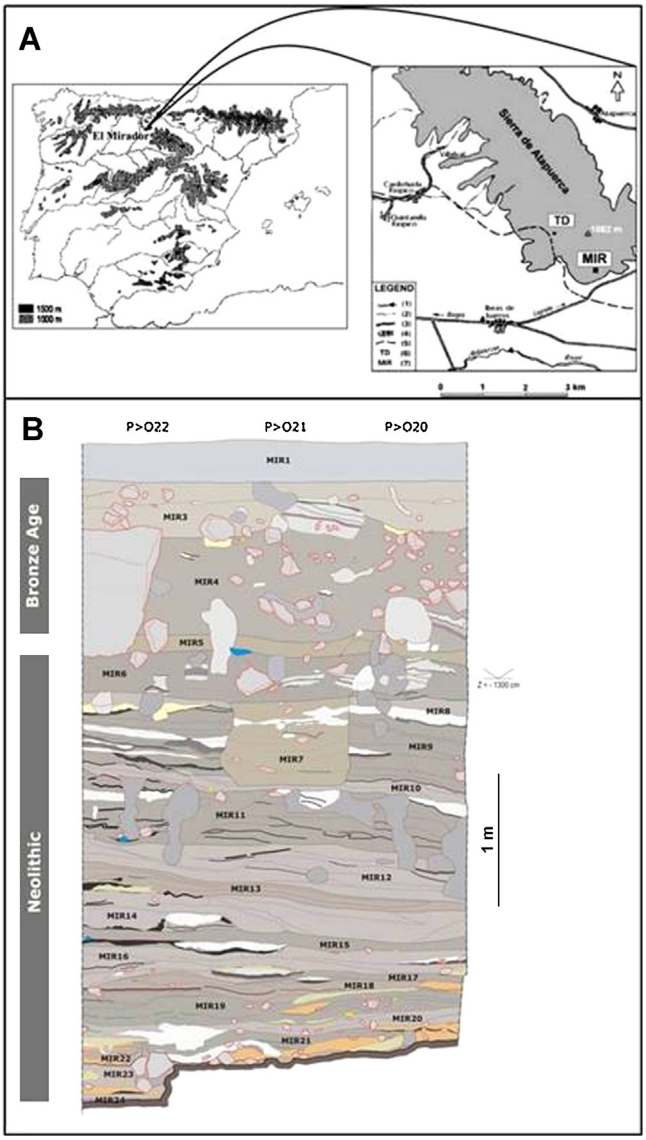

Fig. 1. (A) Location of Sierra de Atapuerca and El Mirador cave (MIR) site (modified from Rodríguez, 2004). (B) Synthetic column of El Mirador stratigraphy showing the different archaeological levels, and specifically levels 19 and 20, from which the fish material haves been analyzed (modified from Angelucci et al., 2009).

Fig. 1. (A) Situation de la Sierra d'Atapuerca et de la grotte du Mirador (MIR) (modifié d'après Rodríguez, 2004). (B) Colonne stratigraphique synthétique du Mirador montrant les différents niveaux archéologiques et plus spécialement les niveaux 19 and 20, dans lesquels les restes de poissons ont été analysés (modifié d'après Angelucci et al., 2009).

From a paleoclimatic point of view, the existence of a temperate dry climate is documented, which presents three different biotopes including landscape mixed forest of oaks, river forest near the Arlanzón river and fields around the cave (Allué and Euba, 2008; Rodríguez and Buxó, 2008). The presence of anthropophilic rodents also reports this human occupation around the cave (López-García et al., 2008).

Although several zooarchaeological studies have been published about faunal remains in Neolithic chronologies on the Iberian Peninsula (Bosch et al., 2000; Castaños, 1991, 2004; Estremera, 2003; Liesau and Montero, 1999; Molist, 2005; Morales and Martín, 1995; Pérez-Ripoll, 1980, 2006; Rojo-Guerra et al., 2006; Saña, 1998; Saña et al., 2014), all of them include analyzed mammal remains and evidence for animal husbandry. However, few specific ichtyoarchaeological studies about those chronologies have been conducted on the Iberian Peninsula (Antolín et al., 2013; Blanco, 2012; Juan-Muns, 2000; Le Gall, 1995; Zapata et al., 2007). Therefore, the principal goal of the present study is to show the fish consumption as part of the human diet during the Neolithic period of the Iberian Peninsula.

2. Materials and methods

A total of 227 samples were collected by screening (mesh sizes of 5 mm, 2 mm and 0.5 mm were used. Most of the remains were extracted from the 2 mm concentrate) during the 2004–2005 excavation campaigns at El Mirador site, 29 fish remains from level 19 and 198 from level 20. During the analysis of this material, a binocular EXACTA OPTECH model LFZ s/n 201030 20 W (IPHES 00013) and entomology tweezers were used. Anatomical and taxonomical classifications were done by comparison method of external characteristics of those remains using a reference collection and an osteological atlas (Conroy et al., 2005; Lepiksaar, 1994; Watt et al., 1997). The taxonomic nomenclature used has been extracted from Cannon (1987). Standard measurements methodology was taken from Morales and Roselund (1979) and Watt et al. (1997).

After taxonomic and anatomical identification, we quantified Minimum Number of Elements (MNE). In addition, and in order to calculate the age and death seasonality of individuals, a quantitative procedure from the measurements of growth rings (annuli) was applied to vertebrae. During winter, fish grow more slowly than in other seasons due to the low temperatures and scarcer food availability; rapid growth implies wider spaces between consecutive marks rather than slow growth. Consequently, winter growth marks are closer to each other than growth annuli formed during the rest of the year, forming a darker region during the winter growth of vertebrae; summer growth appears as wider rings. Therefore, a band consisting of a wider ring and a narrower ring represents one year (Fig. 2B) (Cannon, 1988; Desse & Desse, 1983; Turrero et al., 2013). For this study, those well-preserved vertebrae, with no taphonomical modifications were used.

To infer, average total body length and weight of well-preserved samples and published regressive statistics (Prenda et al., 2002) were used.

The observation and study of concentric rings also help to determine the season during which the fish died and this fact could inform about the time of settlement of archaeological site when cutmarks of preparation for conservation techniques were not observed (Barret, 1997). The position of the last circle of growth in relation to the outer edge of the bone indicates the period of the death of the individual. The application of this method enables us to demonstrate the time when the fishes were caught at sites (Desse and Desse-Berset, 1992).

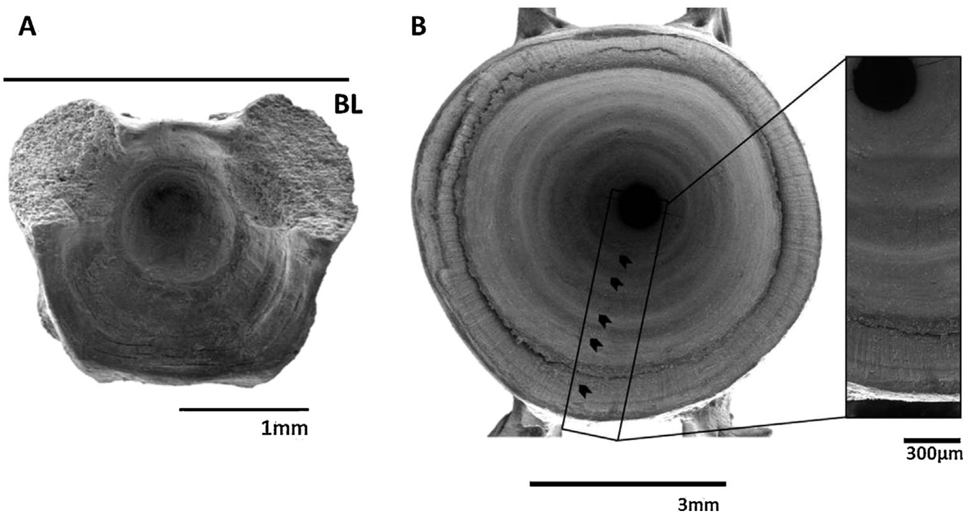

Fig. 2. (A) First thoracic vertebra of *Salmo trutta* from El Mirador (MIR20 Q21). Scale bar 1 mm, BL: total length of the vertebrae (B) *S. trutta* caudal vertebra from El Mirador (MIR20 Q22). Scale bar 3 mm. Arrowheads point to winter marks (age 5 +). Magnification of growth bands is shown on the right. (Scale bar 300 µm) (C) S. truth caudal vertebral (MIR 19Q20 F:V). Scale bar 0,5 mm.

Fig. 2. (A) Première vertèbre thoracique de *Salmo trutta* de El Mirador (MIR20 Q21). Échelle 1 mm, BL : longueur totale de la vertèbre (B) vertèbre caudale de *S. trutta* de la grotte du Mirador (MIR20 Q22). Échelle 3 mm. Les flèches marquent les bandes de croissance d'hiver (âge 5 +). Un grandissement des bandes de croissance est montré à droite (échelle 300 µm). (C) Vertèbre caudale de *S. trutta* (MIR 19 Q20 F:V). Échelle 0,5 mm.

2.1. Taxonomy

Teleostei
Order Salmoniformes Bleeker, 1859
Family Salmonidae Cuvier, 1816
Genus ***Salmo*** Linnaeus, 1758
Salmo trutta Linneus, 1758
Material:
Level 19
6 isolated thoracic vertebrae (P21 F:V–VI 1550/80; P21 F:G 1570/80; Q22 F:V 1580/90; P22 F:G 1580/90; P20 F: VL 1560/70; Q21 F: VL 1570/80)
6 isolated caudal vertebrae (P22 F:V 1580/90; P22 F:VL 1570/80; P22 F:VL 1560/70; Q20 F:V 1560/70; P22 F:B 1580/90; Q22 F:V 1570/80)
Level 20
29 isolated thoracic vertebrae (Q21 F:VL 1570/80; P21 F:A 1580/90 (N:13); Q22 F:A 1590/00 (N:2); P21 F:VI 1580/90; P20 F:VL 1560/70; Q21 F:A 1590/00; Q21 F:A 1590/00; P21 F:VI 1580/90; P20 F:VL 1560/70 (N:2); Q21 F:A 1590/00; Q22 1590/00; Q21 F:VI 1590/00; Q22 F:A 1590/00; Q22 F:A 1590/00; P20 F:VL 1560/70)
15 isolated caudal vertebrae (P21 F:A 1580/90 (N:2); P21 F:VI 1580/90 (N:4); P20 F:A 1570/80; Q20 1570/80; Q22 F:A 1590/00; P21 F:VI 1580/90 (N:2); Q22 1590/00; Q22 F:A 1590/00 (N:3))
N, Number remains (in case that would be more than one)
Description and comparison:
The genus *Salmo* shows a characteristic honeycomb structure of its vertebral centrum. These centrae are circular and taller rather than long, and exhibit a lateral surface with an irregular network of lamellae forming many circular to ovate foramina of various sizes. The largest foramina occur midway along the centrum and may extend nearly half of its length; small foramina are situated along the anterior and posterior margins (Turrero et al., 2013). To distinguish between *S. salar* and *S. trutta*, the unique native species of the Iberian Peninsula (Elvira, 1995; Elvira and Almodóvar, 2001) diagnostic characteristics of size and morphology of atlas have been applied. Trout atlases appear waisted and are relatively tall when compared to the vertebral width. Pores are round (broadly ovate), often large, few in number and cover the complete surface. The processes are angular and flattened and do not protrude as ears (Feltham and Marquiss, 1989).

Brown trout (*S. trutta*) is common in the Iberian Peninsula and Europe. The presence of salmonides is already documented in Pleistocene sites such as Sima de los Huesos (Cuenca-Bescós et al., 1997) and in Gran Dolina (TD) (Sanchíz, 1987) both in Atapuerca. Also several authors (Adán et al., 2009; Turrero et al., 2013) have identified this species in several sites from the North Iberian Peninsula.

3. Results

The study included 227 fish remains (Fig. 3A–B), and most of the sample corresponds to postcranial remains (90% in level 19 and 97% in level 20), of which only complete vertebrae (57 remains) were confidently identified as belonging to the unique species, *S. trutta* (Figs. 2A, 3C) (44 to Level 20; 13 to Level 19). The cranial bones in the sample corresponds to partial neurocranium elements, impossible to determine at species level.

3.1. Osteometric analysis and seasonality

Since the only species represented in the sample is *S. trutta*, we use published regressive statistics (TL = a + bBL) from Prenda et al. (2002) to infer both average total body length (TL), relating the measurements (in mm) of total length of the vertebrae (BL) (Fig. 2A) where a (−10.31) and b (89.76) (r^2 99,4%) are known values for *S. trutta* (Prenda et al., 2002). As the authors indicate, all vertebrae (thoracic and caudal) are useful to estimate the total values of the body length. Here, the measurement process used was the standard in ichtyoarchaeology. As a result, estimated average total body length for *S. trutta* from Level 19 is 248 mm from a sample of 11 well-preserved vertebrae (min/max. 91.12/345.14 mm). For Level 20, we used the same regressive statistics and obtained results for average total body length of 235 mm (min/max. 118.94/380.15 mm) from a sample of 29 well-preserved vertebrae. All the estimated values for both levels are similar to modern brown trout populations of the Iberian Peninsula (Alonso et al., 2012).

From the point of view of seasonality, four vertebrae from Level 19 and six vertebrae from Level 20 clearly showed growth annuli. Following Turrero et al. (2013) all vertebrae indicate the spring-summer period as the time of death of the trout specimens, a fact also described by other authors (Le Gall, 1995) at other archaeological sites. Nowadays, this period (spring-summer) is when trout abundance is greatest (Doadrio et al., 2011).

3.2. Food acquisition and source management. Taphonomic analysis

Analyzing the local geography of El Mirador site, we observe that the nearest river is the Arlanzón, which is located at approximately 1000 m above sea level and a few hundred meters from the site (1033 m) (Vergès et al., 2002), and probably the principal source of fishes for the El Mirador's inhabitants (Fig. 1A).

As we mentioned, one single species, *Salmo trutta*, was identified in the sample. This indicates the selection of a consumed species, and not an accumulation by natural agents. If birds of prey or carnivores were the agents of accumulation, there should be some other indication. For example, if other fish taxa such as the cyprinids, which are very common in other natural contexts (Blanco, 2012; Clavero et al., 2015; Doadrio & Casado, 1989; Pascual, 2000) were present in the sample, both cranial and postcranial elements would be present (Broughton et al., 2006; Butler and Schroeder, 1998; Rodríguez-Santana, 1996; Russ, 2010; Russ and Jones, 2011). Furthermore, the average size of fishes found would be smaller or different sizes were present (Broughton et al., 2006). These authors do not show the values or range from your results but explain that big sizes overrepresented are a clear signal to discard a natural accumulation on their sites. A natural accumulation would show a wide range of sizes. On the other hand, digestion marks would be present, for example, vertebrae

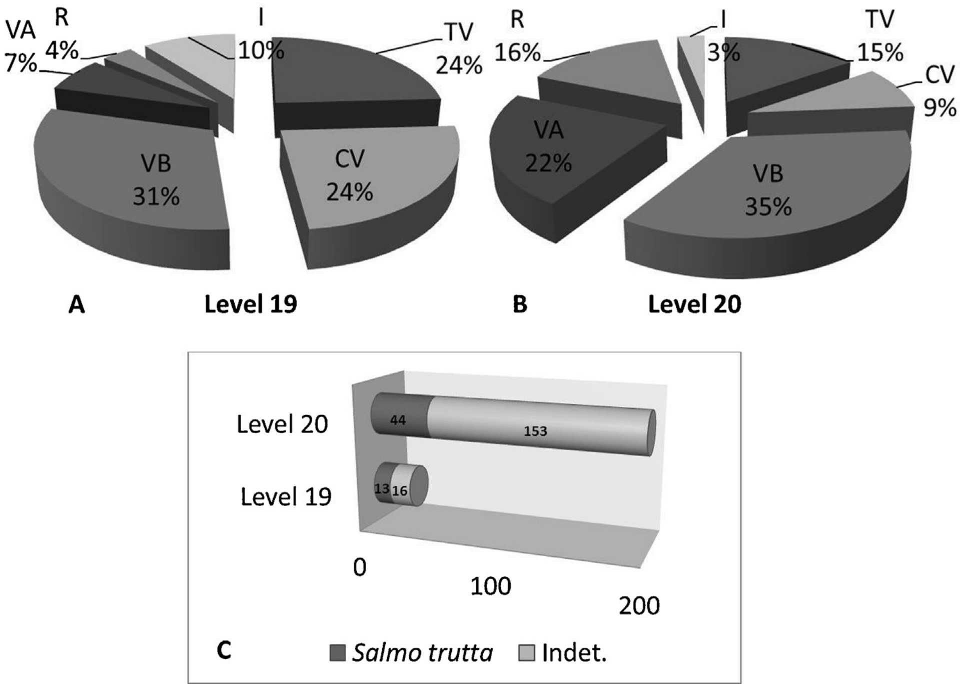

Fig. 3. (A) Anatomical elements from level 19. I: indeterminate remain; R: rib; VA: Vertebral apophysis; VB: Vertebral body; CV: Caudal vertebra; TV: thoracic vertebra. Total remains: 29. (B) Anatomical elements from level 20. I: indeterminate remain; R: rib; VA: Vertebral apophysis; VB: Vertebral body; CV: Caudal vertebra; TV: thoracic vertebra. Total remains: 197. (C) Histogram which shows the minimum number of elements (MNE) of *Salmo trutta* and indeterminate remains in both Level 19 and Level 20. NISP total = 227.

Fig. 3. (A) Éléments anatomiques du niveau 19. I : reste indéterminé; R : côte ; VA : apophyse vertébrale ; VB : corps vertébral ; CV : vertèbre caudale ; TV : vertèbre thoracique. Nombre total de restes : 29. (B) Éléments anatomiques du niveau 20. I : reste indéterminé ; R : côte ; VA : apophyse vertébrale ; VB : corps vertébral ; CV : vertèbre caudale ; TV : vertèbre thoracique. Numéro de restes total : 197. (C) Histogramme montrant le MNE (nombre minimum d'éléments) de *S. trutta* et les restes indéterminés dans les niveaux 19 et 20. MNR total = 227.

with rounded edges and extreme pitting on the surface of bones (Broughton et al., 2006; Butler and Schroeder, 1998).

A common characteristic of the salmonid group is that their vertebrae are not strongly ossified, giving them a rough porous texture and making them particularly prone to digestion and disintegration (Conroy et al., 2005). The almost exclusive presence of postcranial elements (the few cranial remains have not been attributed to any species for their poor state of conservation at the site) could be caused by a taphonomic process, but the presence of the vertebral apophysis, one of the less ossified parts of the fish skeleton (Lubinski, 1996; Rodríguez-Santana, 1996) refutes this hypothesis and indicates that differential skeletal representation in the sample lies in a deliberate accumulation process in which skeletal elements of the skull were removed before being deposited. This fact has already been observed by other authors (Blanco, 2012; Broughton et al., 2006; Morales et al., 2011; Roselló Izquierdo et al., 1994).

From a taphonomic point of view, burnt fish bones were not observed, so we cannot conclude that the fish were subjected to high temperatures during a possible cooking process (Steffen and Mackie, 2005). In addition, if the fishes were processed using tools, during the butchery or preparation process (Zohar and Cooke, 1997), several cut marks could be observed in the skeleton which are called primary, the result of preparing a fish for transport or consumption in general. In this case, cut marks could be observed in upper cleithral halves, transversal fractures of vertebrae or in keratohyal (Roselló Izquierdo et al., 1994). In our case, cutmarks were also not observed, which would indicate that butchery was accomplished without using tools. Thus, whole fish arrived at the site that were beheaded (Blanco, 2012; Roselló Izquierdo et al., 1994; Willis et al., 2008).

4. Discussion and conclusion

Several sites of Neolithic age have been excavated on the Iberian Peninsula, but few have relevant fish bones assemblages similar to that of El Mirador. In addition, Iberian sites with freshwater fish remains are underrepresented compared with marine or coastal sites.

Therefore, we can conduct only a partial analysis for the Neolithic of the Iberian Peninsula due to the small number of sites available for comparison. The low presence of fish remains at Neolithic sites may be due, in some cases, to the recovery methodology, as noted by several authors (Antolín et al., 2013; Blanco, 2012; Rodríguez-Santana, 1996). Usually the recovery was done without the use of sieves of various mesh sizes. Thus, the studied levels 19 and 20 of El Mirador cannot be compared to similar aged sites where fish remains, but no brown trout, were recovered, for example, La Draga (Banyoles, NE Spain) (Blanco, 2012). In any event, we assume that this species was an important food resource because it is still fished commercially on both the Iberian Peninsula and in Europe.

As noted by several authors (Lubinski, 1996; Russ, 2010; Russ and Jones, 2011), it was necessary to do an analysis to test if the fish assemblage of El Mirador resulted from natural or anthropogenic accumulation. In the present case, poor skeletal representation and the taxonomy of the accumulation indicate that the recovered assemblages from the richest levels of El Mirador, levels 19 and 20, correspond to an anthropogenic accumulation. Although the sample size of the trout vertebrae is too small to make further generalizations, the assemblage must be considered as a food resource. The study of fish remains belonging to the rest of El Mirador's levels will improve our knowledge of the fish assemblages of this site. Of course, future study would also be important to improve our knowledge about Neolithic fishing on the North Iberian Peninsula. Few have studied this question which would provide more information about ancient diet during this important period of human prehistory. So far very few fish remains have been documented during the Neolithic and Mesolithic of the Iberian Peninsula at the various studied sites. In some cases, the evidence for fishing as a subsistence activity is indirect, demonstrated by the presence of hooks and other possible tools for fishing (Bernaldo de Quirós and Neira, 2007-08).

Although it is difficult to ascertain the fishing technology used, the Neolithic inhabitants of El Mirador must have had enough tools to catch larger fishes. Furthermore, the Arlanzón River, a few hundred meters from the site, was a good fishing resource for the inhabitants of El Mirador.

In conclusion, the assemblage of fish remains found in levels 19 and 20 of El Mirador (Atapuerca, Spain) indicates that the inhabitants were the most likely accumulator of fish bone. This study shows that fish consumption was common practice during the Neolithic of the *Sierra de Atapuerca*.

Salmo trutta was the only exploited species and is very common nowadays in the region. The accumulation agent was identified by establishing taphonomic signatures, for example, the large size of the trout, skeletal element representation as shown by the presence of only postcranial bones in the sample, and finally the lack of bone surface modifications. We did not find cutmarks or burnt bones which prove that the fish arrived at the site whole, and just beheaded. All vertebrae indicate spring-summer as the period of death. This period is also described by other authors as the time of human occupation at El Mirador (Cabanes et al., 2009; Martín et al., 2009) which are based on the ovicaprids and bovids death age analysis. The presence of several fish bones at this site indicates that fish served simply as food to complement the diet of its inhabitants.

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