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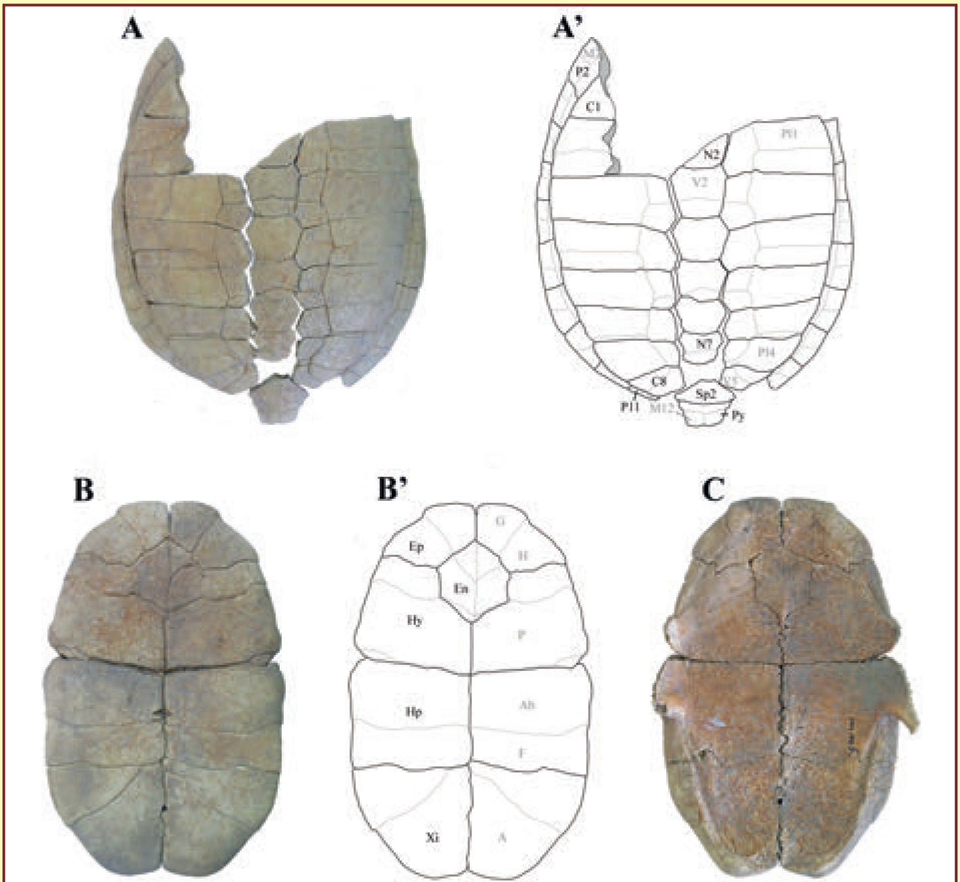

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IN MEMORIAN

ANA FABIOLA GUZMÁN CAMACHO (1967–2022)

Mª Teresa Olivera, Joaquín Arroy-Cabrales, Norma Valentín & Fabiola M. Morales


Ana Fabiola Guzmán Camacho

Nació en la Ciudad de México el 3 de diciembre de 1967 e inició su nuevo camino el 8 de julio de 2022. Desde sus primeros pasos escolares se distinguió como una alumna sobresaliente, estudió la carrera de Biología en la Escuela Nacional de Ciencias Biológicas (ENCB) del Instituto Politécnico Nacional, en donde también obtuvo el grado de Maestra en Ciencias con especialidad en Biología. Realizó estudios de Doctorado con especialidad en Biología Evolutiva y Biodiversidad por la Facultad de Ciencias de la Universidad Autónoma de Madrid, obteniendo "Sobresaliente *Cum Laude*".

Comenzó a colaborar como estudiante en 1988 en los trabajos que se desarrollaban en el entonces Laboratorio de Paleozoología, ahora Laboratorio de Arqueozoología "M. en C. Ticul Álvarez Solórzano" de la Subdirección de Laboratorios y Apoyo Académico del Instituto Nacional de Antropología e Historia, siempre bajo la guía y supervisión del Profr. Oscar J. Polaco Ramos†. En el Laboratorio, además de colaboradora, fue estudiante, servidora social, tesista, técnico especializado, investigadora, coordinadora del laboratorio y curadora de la Colecciones Osteológica de Referencia y Arqueozoológica, recorrido que le dio una sólida preparación. Fue jefe del laboratorio de 2011 a 2016 y curadora de las colecciones de referencia y arqueozoológica a partir de 2004.

Sus estudios se enfocaron en los vertebrados en lo general (recientes, arqueológicos y fósiles) y a los peces en lo particular, con énfasis en la arqueoictiología, lo que no impidió que también hiciera investigación sobre la megafauna fósil del cuaternario.

Su actividad profesional siempre estuvo dividida entre la investigación y la docencia, ya que impartió 63 cursos de 10 asignaturas en la ENCB, su alma mater, desde 1992 como profesora de medio tiempo en la carrera de Biología (Geología Histórica, Paleontología, Geología General, Zoología de Cordados, Etnobiología, Anatomía de Vertebrados, Comunicación Científica, Invertebrados no Artrópodos, Técnicas Museográficas, Manejo de colecciones biológicas) aunque también dio Biología Básica en la carrera de Químico Farmacéutico Industrial y Geología e Hidrología en la carrera de Ingeniería en Sistemas Ambientales. Como docente también ofreció la materia optativa de Paleontología e Introducción a la Paleontología, ambas con teoría y laboratorio para la carrera de Arqueólogo y Antropólogo en la Escuela Nacional de Antropología e Historia y dictó la materia de Manejo de colecciones biológicas, con énfasis en la preparación de esqueleto, para los alumnos de la carrera de Arqueología de la Universidad Autónoma de San Luis Potosí. El ser docente facilitó que siempre hubiera jóvenes interesados en colaborar en sus trabajos y ser asesorados por la Dra. Guzmán en sus trabajos de tesis, formando nuevos investigadores con la disciplina y cuidado que ella les inculcó. Dirigió 10 tesis de licenciatura y participó como sinodal en exámenes profesionales, de grado y de oposición abierto.

También colaboró en la reestructuración de los programas de estudio de algunas asignaturas como Paleontología, Técnicas Museográficas, Comunicación Científica y Manejo de Colecciones. Trabajó arduamente con la Colección Ictiológica del Laboratorio de Ecología del Departamento de Zoología de la ENCB de la que publicó el catálogo de los ejemplares tipo que aloja.

Realizó continuamente trabajo de campo, ya sea para colecta de vertebrados actuales en general y de peces en particular, incluyendo la identificación y todo el proceso para la preparación del material y obtención del esqueleto, tarea que continuaba con su catalogación, etiquetado e integración del mismo a la colección, primero como colaboradora y después como curadora.

El término del siglo XX y principios el XXI han sido prolíficos en la creación de nueva tecnología y el avance informático, por lo que Oscar y Ana Fabiola, además de elaborar el catálogo tradicional, se dieron a la tarea de capturar los datos de todos los ejemplares de vertebrados y moluscos de la colección en sus respectivas bases de datos y lo mismo con el material arqueológico obtenido de los distintos proyectos en los que los integrantes del laboratorio participan para su estudio, lo que facilita enormemente su consulta.

La mayor parte de su trabajo de investigación y publicado está dedicado al estudio de los peces encontrados en contexto arqueológico, de diferentes localidades prehispánicas del país, entre las que están Chalco, Tempo Mayor, Teotihuacán, Villa Ahumada, región Tepehuanes, Ajolotero, Indeco y Cañada de la Virgen, así como restos provenientes de contextos coloniales encontrados en El Coroco, Justo Sierra y el mercado de Monterrey. También contribuyó al estudio de las especies de peces mexicanos de agua dulce actuales, marinos y fósiles.

Su producción también incluye publicaciones sobre otros grupos de vertebrados entre los que hay aves, reptiles y mamíferos, actuales y arqueológicos, así como sobre dinosaurios y megafauna del Cuaternario. Elaboró 85 informes técnicos y presentó 33 conferencias y 68 ponencias, la publicación de cinco libros y 72 trabajos en revistas nacionales e internacionales, así como capítulos de libros.

Se caracterizó por ser una persona reservada, modesta, sumamente trabajadora y responsable, cuya labor a sus 54 años, queda de manifiesto en su producción profesional, en las personas que formó e iniciaron su especialización, en las colecciones que ayudó a crecer y mejorar, de las que fue su curadora. Sus compañeros y amigos guardamos su recuerdo y veremos de enaltecer la gran labor que realizó.

M.ª Teresa OLIVERA CARRASCO
Joaquín ARROYO-CABRALES
Norma VALENTÍN MALDONADO
Fabiola Montserrat MORALES MEJÍA

Laboratorio de Arqueozoología "M. en C. Ticul Álvarez Solórzano"
Subdirección de Laboratorios y Apoyo Académico
Instituto Nacional de Antropología e Historia

It is with enormous sorrow that we received the news of Ana Fabiola Guzman Camacho's untimely death on July 9th, 2022.

Ana Fabiola was an outstanding researcher, a devoted instructor, and a reference New World archaeozoologist with ethnozoology and fish as her two main subjects of interest. She became an active member of the Fish Remains Working Group (FRWG) in 1993 and has since helped foster our discipline through multifarious activities including the organization of scientific events such as the 2005 FRWG meeting in Guadalajara (Mexico) and the 2006 ICAZ Conference that took place in Mexico City.

A student of the late Prof. Dr. Oscar Polaco, Ana Fabiola often conveyed the impression of being the person lying behind the screen of this prominent scholar and pioneer of archaeozoology in Mexico. Through the years we came to realize that there was much more than met the eye to this soft-spoken and kind woman, who listened to people in a polite and inquisitive silence. And those of us who were fortunate enough to discover her intimate side, were surprised to find a cheerful and talkative personality, always ready for a good laugh, and with that subtle kind of irony that is iconic of so many Mexicans. Dozens of wonderful anecdotes have accumulated over the years that we will somehow try to keep vivid and share with others as a tribute to this beautifully enigmatic friend and incredible colleague.

May she rest in peace.

Eufrasia ROSELLÓ IZQUIERDO
Irit ZOHAR
Arturo MORALES MUÑIZ

Ana Fabiola, Oscar, Ruby y Arturo en Paihia (New Zealand). Cortesía de Ruby Cerón-Carrasco & Irit Zohar.

"No os contentéis con demostrar amistad sólo con palabras, dejad que vuestro corazón
se encienda con amorosa bondad hacia todos los que se crucen en vuestro camino"

Abdu'l-Bahá (*La Sabiduría de Abdu'l-Bahá*)

Archaeofauna 31 (2022): 11-56

Freshwater and Marine eels in the Pacific and New Zealand: Food Avoidance Behaviour and Prohibitions

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ABSTRACT: Eels are ubiquitous throughout the Pacific and New Zealand, and offer a rich source of protein and fat. However, bones of eels are rare in archaeological sites. This contrast has been noted several times in archaeological literature, not just in the Pacific, but also in Europe. Explanations for the dearth of bones range from taphonomic processes, the bones are too small, or too fragile, or they preferentially self-destruct because they are rich with oil. We show that each of these reasons is false. We review the presence and absence of eel bones in 144 archaeological sites in the Pacific region, finding only 1,151 eel bones of a total NISP of 188,351 (0.61%). Allometric equations are established for estimating live length and weight from cranial bone measurements of freshwater eels. Prehistoric catches were mostly in the range of 430 to 500 mm, length with only 5 greater than 800 mm, with no sign of the huge eels about 1800 mm long recorded in historic episodes of mass harvesting by Māori. A review of myths and oral traditions in the Pacific about eels revealed some common themes. Eels represent the incarnation of a male deity, symbolising the penis, and that the personified eel tempts and defiles a woman sexually. A male, often an heroic ancestral figure, punishes the eel by cutting him up into pieces. We found that there is often a strong association of eels with danger, and that eels are either venerated or feared, but seldom considered food. In some Pacific societies, the arrival of Europeans resulted in the lifting of the prohibition of eels as food. We also found two historic instances in among Māori that eels were *tapu*, requiring an elaborate *tapu* removal ceremony before they could be eaten by people who were starving. We conclude that mass harvesting of eels in New Zealand, so evident in the historic era, was a post-European development with important implications for Māori settlement patterns, making it possible to establish permanent villages in the interior of major river systems in Central New Zealand.

KEYWORDS: EELS, PACIFIC ARCHAEOLOGY, ALLOMETRY, FOOD TABOOS, MYTHOLOGY

RESUMEN: Las anguilas se encuentran distribuidas por todo el Pacífico y Nueva Zelanda constituyendo una rica fuente de grasa y proteína. Sus huesos, curiosamente, son infrecuentes en depósitos arqueológicos. Tal contraste ha sido repetidamente referido en la literatura arqueológica no sólo en el Pacífico, sino también en Europa. Las razones que explicarían tal escasez de restos son variadas e incluirían procesos tafonómicos, el hecho de que los huesos son muy pequeños, o muy frágiles, o que se autodestruirían debido a su alto contenido de aceites. En este trabajo mostramos que todas estas explicaciones son equivocadas. Para ello, repasamos la presencia de anguilas en 144 yacimientos arqueológicos del Pacífico, donde registramos 1.151 elementos sobre un total de 188.351 (0,61%). Al tiempo, elaboramos, a partir de medidas tomadas en distintos huesos craneales de anguilas dulceacuícolas, ecuaciones alométricas que permiten estimar la longitud en vida y el peso de los ejemplares. Constatamos que las capturas prehistóricas oscilaron entre los 430-500 mm de longitud total, con sólo 5 ejemplares por encima de los 800 mm, sin evidencia alguna de las enormes anguilas de 1800 mm que citan los registros históricos en episo-

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dios de pesca masiva realizada por los maoríes. Una revisión de los mitos y tradiciones orales referidos a las anguilas en el Pacífico evidenció una serie de temas recurrentes. Así, las anguilas representan la encarnación de una deidad masculina, simbolizando el pene, y el hecho que la anguila personificada tienta y profana sexualmente a la mujer. Un hombre, con frecuencia un personaje ancestral y heroico, castiga a esta anguila cortándola en partes. Constatamos igualmente una fuerte asociación de la anguila con el peligro, y que estos peces se veneran o se temen pero rara vez se consumen. Registramos dos casos históricos que mencionan la condición *tapu* de la anguila entre los maoríes lo cual requería una elaborada ceremonia para eliminar dicha condición antes de poder ser consumidas en momentos de hambruna. En algunas sociedades del Pacífico, la llegada de los europeos acabó con la prohibición de consumir anguila. Por todo esto, se concluye que las capturas masivas de anguilas en Nueva Zelanda, bien documentadas en épocas históricas, son un fenómeno ocurrido sólo tras la colonización europea que tuvo gran repercusión en los patrones de asentamiento de los maoríes, posibilitando el establecimiento de poblados permanentes en el interior de los grandes ríos de la Nueva Zelanda central.

PALABRAS CLAVE: ANGUILAS, ARQUEOLOGÍA DEL PACÍFICO, ALOMETRÍA, TABÚES ALIMIENTARIOS, MITOLOGÍA

INTRODUCTION

Dr Samuel Johnson made the perceptive comments below in 1773 during his visit with James Boswell to the Hebrides islands of Scotland:

> “Of their eels I can give no account, having never tafted them; for I believe they are not confidered as wholefome food. It is not very eafy to fix the principles upon which mankind have agreed to eat fome animals, and reject others; and as the principle is not evident, it is not uniform. That which is felected as delicate in one country, is by its neighbours abhorred as loathfome. The Neapolitans lately refufed to eat potatoes in a famine. An Englifhman is not eafily perfuaded to dine on fnails with an Italian, on frogs with a Frenchman, or on horfe-flefh with a Tartar. The vulgar inhabitants of Skye, I know not whether of the other islands, have not only eels but pork and bacon in abhorrence; and accordingly I never saw a hog in the Hebrides, except one at Dunvegan” (Hill, 1773: 135-136).

This passage neatly captures the essence of an issue that has taxed archaeologists in several parts of the world: *since eels are common throughout the world, and easily caught, why are their bones so infrequently found in archaeological sites?* The more general issue of whether the apparent absence of some species of fauna in archaeological sites is due to the failure actually to find it because it was simply not present for capture, or because it was not found for some other reason, such as failure to identify it, is not a new one in literature on archaeofauna (Lyman, 1995). For example, the fish species *Anoplopoma fimbria* is scarce or absent in many archaeological sites along the northwestern shores of the United States, yet this species is large, abundant and nutritious. In seeking to explain such patchy occurrences Nims and Butler examined such factors as post-depositional destruction, inadequate sieve mesh sizes, or sample size, or inaccurate identifications (Nims & Butler, 2019). In this paper we aim to reconcile the ethno-historic importance of the eel fishery in protohistoric New Zealand with the dearth of eel bones in archaeological sites. A similar disjunction is found in the wider Pacific, and evidence in this area is also reviewed. Our working hypothesis is that in cases where humans considered eels acceptable as food, their bones will be found in archaeological sites. Conversely, in cases where people abhorred the idea of eating eels, their bones will be rare in archaeological sites. In addition, we should not expect that likes and dislikes of eels as food would be constant in any one human culture over a period of time. Food avoidance behaviour is a complex and changing human phenomenon, as any parent of young children knows. In times of plenty there is ample opportunity for food fads to take root. In hard times, people will eat almost anything.

EELS AND MĀORI CULTURE IN 19TH CENTURY NEW ZEALAND

Elsdon Best, who spent a lot of his life studying the customs and habits of Māori, asserted “the eel

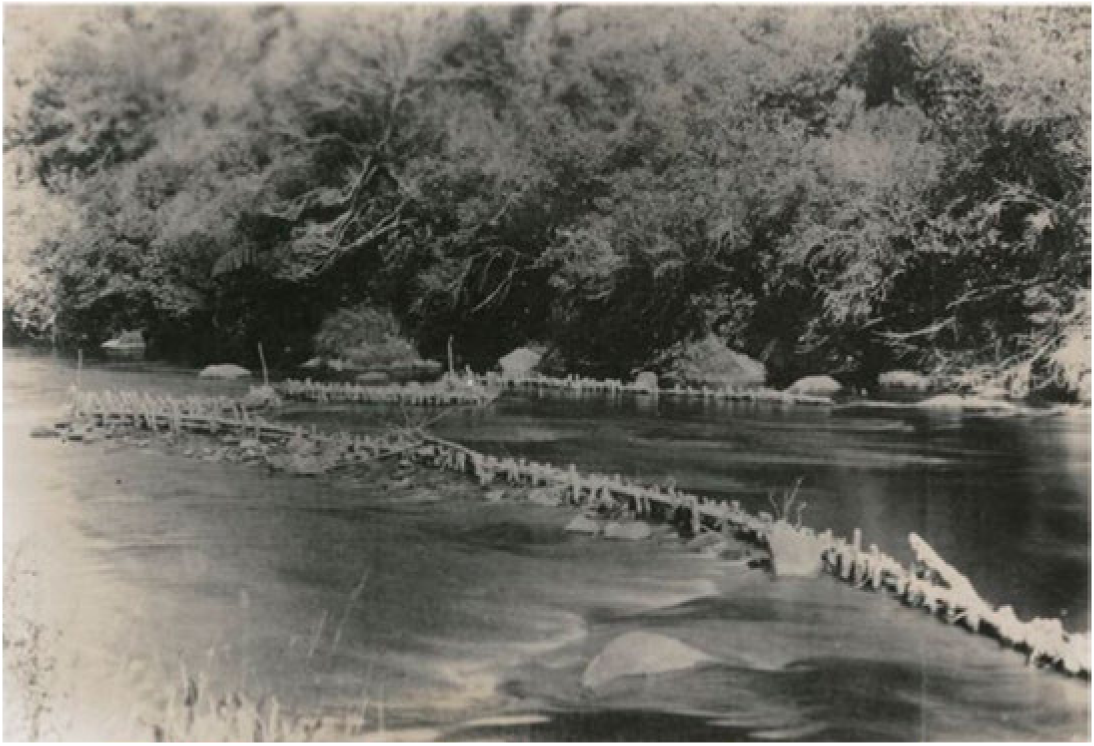

FIGURE 1

An eel weir on the Waingongoro River in Taranaki. Photo by J. Faris in 1888, printed by J. K. Hammonds, chemist, Inglewood. Courtesy Alexander Turnbull Library, Catalogue No: PAColl-4356.

furnished by far the most important food-supply" (Best, 1952: 275). Best published many books and articles in his lifetime, and the catching and processing of eels by Māori features prominently in many of these. Large scale weirs were constructed for their capture. Figure 1 shows a typical example. Eels are directed into a narrow area, where basket traps with a funnel entrance capture them (Figure 2). Construction and maintenance of these eel weirs represented a considerable investment of energy, which is further evidence of the importance of eels for 19th century Māori.

At certain times of year there are mass migrations of eels in New Zealand as they move out of streams, rivers and lakes and take to the sea for breeding. It is not known for certain where New Zealand eels spawn, but a study by Jellyman hints at the south Fiji basin (Jellyman, 2014: 143). In one area of New Zealand, at Lake Onoke in the Wairarapa, there is a 7 km long sand bar between the sea and the lake. Occasionally, the entrance in the sand bar closes after a storm, and rising freshwater level triggers the migration of eels to the sea between February and March each year. Wairarapa Māori in the 19th and early 20th century dug channels into the sand bar and placed basket traps (Figure 2) along the side of these to capture eels as they tried to get to the sea. An important Māori Village called Okorewa was established at the entrance to the sea (Downes, 1918: 305). The annual eel harvest at Okorewa has been described by Saunders (1965), and details are still remembered by residents today. Wairarapa Māori recognised four types of eel (*tuna*), the *hao*, also referred to as the King eels by local Māori, the *riko*, the *paranui*, and the *kokopu tuna* (Saunders, 1965: 37). Saunders described the process as follows: The first to appear in these migrations are the *hao*. They have a silver belly and are about 30 cm long. They are hung out for a while to dry and then grilled over a fire, and then dried in the sun. When the *riko* arrive they have a green back and are 90 to 120 cm long. They are split open and the backbone is removed. Saunders commented that this backbone is very good eating. They are dipped in salted water and then dried in the sun. The *paranui* arrive next. They are dark and thick

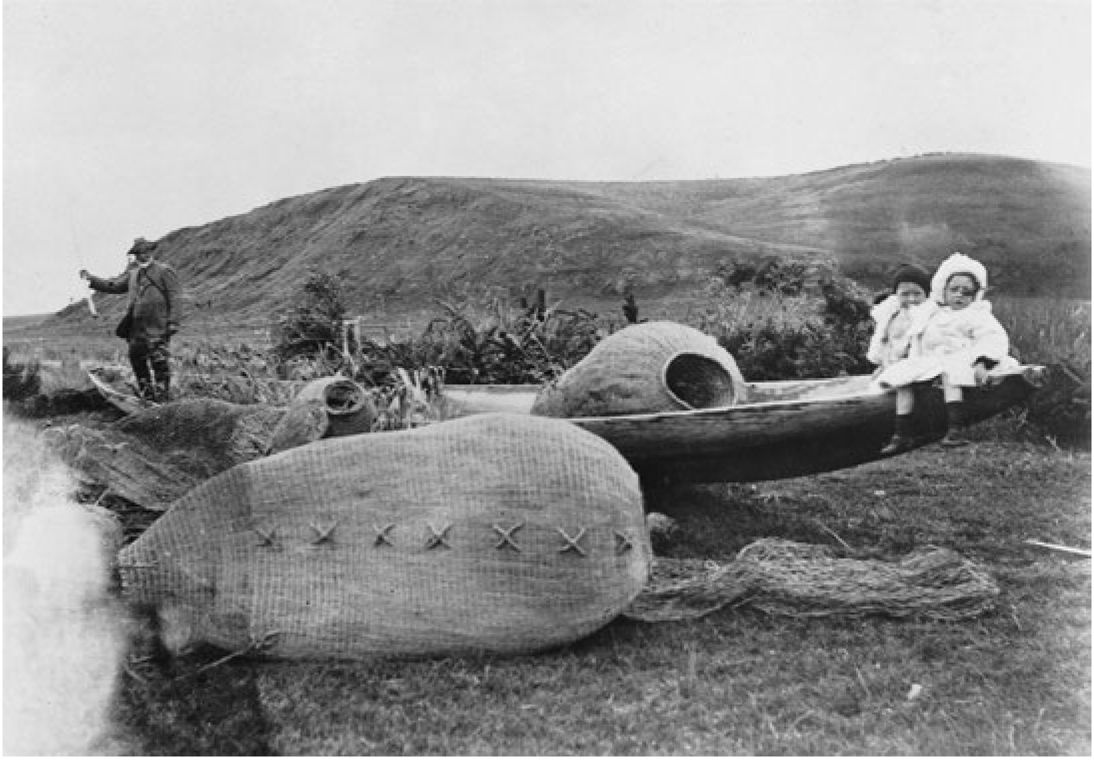

FIGURE 2

Several Māori basket traps, *hinaki*, for capturing eels at Lake Onoke, during a visit to the area by the Scenery Preservation Committee in 1904. Major Tunuiarang Brown stands in the stern of the canoe (*waka*). Photo courtesy National Museum of New Zealand Te Papa Tongarewa.

skinned, and slightly smaller than *riko*. They are treated in the same way as *riko*, and are the longest lasting of the eels when sun dried. The last to arrive at Okorewa are the *kokopu tuna*, they are about 180 cm long and can weigh as much as 27 kg (Figure 4). When split open, they can be 60 cm wide, and are salted and smoked. The *kokopu tuna* are bound to be the long-finned eels, *Anguilla dieffenbachii*, which tend to migrate further inland by rivers and streams, and would arrive at Okorewa later. The short-finned eels, *Anguilla australis*, are commonest in coastal ponds, lakes and swamps (Paul, 2000: 43). A 91 years old Māori elder gave a vivid description at the eel harvesting at Okorewa in 1946:

> "I was standing in the shallow fresh water beside the sand bar when a wave from the sea crashed over the sand bar. In an instant the water all around me boiled with thousands of eels trying to find their way to the sea. I couldn't walk through the mass of eels thrashing about all around me" (Nelson Rangi Te Kai Waho to the author BFL, pers. comm., 2020).

Once the eels are split open they are dried in the sun on special wooden racks (*whata*). These dried eels were traded far afield for other products.

> "These fish are obtainable all the year round in the lake, and in the lagoons and streams along the margin; but the main fishery is in April and May, along the sandspit at the mouth of the lower lake, and where the lake is closed. At this season eels, in a good year, are captured by hundreds of tons and dried in great quantities and distributed throughout the entire North Island, the silver and other descriptions of eels being famed throughout the length and breadth of the Island" (Mackay, 1891: 12).

There are many photos of these eel drying racks in New Zealand photographic archives. An example is given here, Figure 3. Close examination of such photos reveals that there are no heads on the drying eels, which means that when the eels are eventually consumed well away from the place of their capture and processing areas they will end up in archaeological sites without any cranial bones. We have

FIGURE 3

Eels drying on racks (*pataka-tuna*), at Raukawa marae, Ōtaki, New Zealand, during the opening ceremony of Raukawa meeting house. Note there are no heads present. Photograph taken on 14 March 1936 by George Leslie Adkin. Courtesy of Alexander Turnbull Library, Catalogue No: PA1-f-005-386.

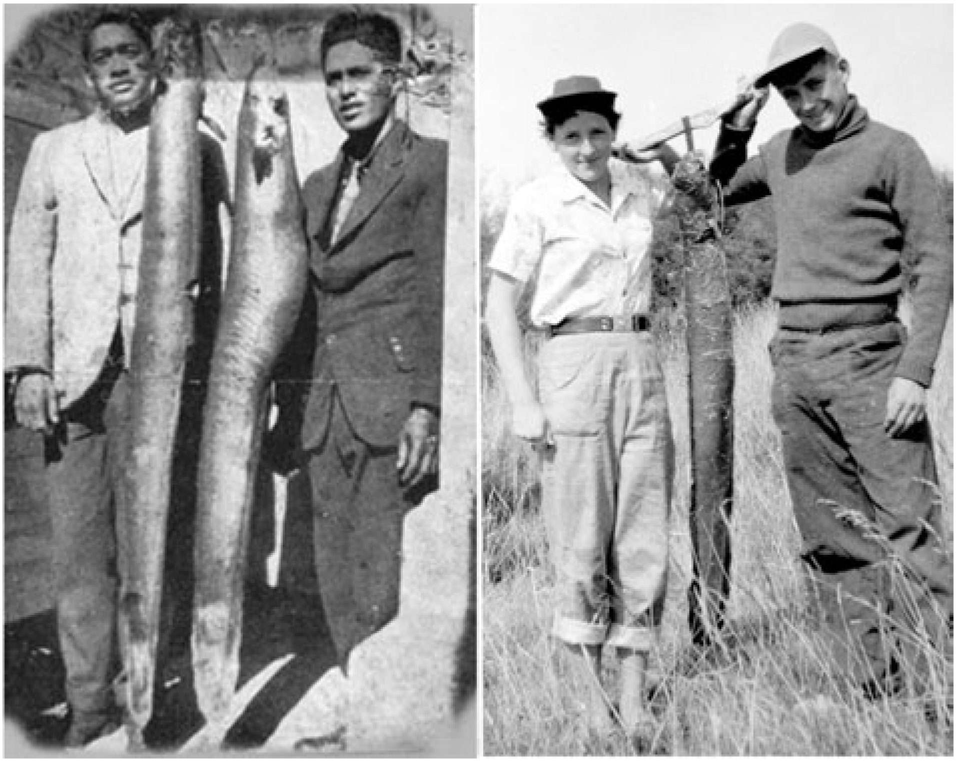

FIGURE 4

Left: These two eels were caught at Bell Block and Okato, Taranaki, weighing 25 and 25.5 lb. Evening Post Newspaper 21 April 1928, page 17. Right: The author, BFL aged 17, and his sister Josephine, with an eel caught in a flounder net in Lake Wairarapa 1960, length c.1,370 mm.

not come across any detailed description of what Māori did with the heads at these mass harvesting and processing sites; however, there are three very interesting photos taken in 1988 at Waiwera (Lake Forsyth) in the South Island of New Zealand (Te Papa #MA1076381-2). These show more details of the processing work. The dead eels are strung up along a fence line with their heads still attached. They are shown at an angle to the main part of the body hanging down. Our interpretation is that the eels were opened up and the entrails removed, and cut behind the operculum so that the head could be placed over the wire and allow the body to hang down. This would explain why the heads appear at an angle to the body on the fence in the photo. The bodies of the eels still appear as round shapes, and therefore have not been split open at this stage as they hang on the fence. About 20 metres from the end of this fence is the drying rack where the split eels are placed over wooden rails. Heads are no longer present, and the bodies are opened up with two flat sides.

The purpose of this two stage process is not clear, but has important taphonomic implications. One possibility of their being placed nearly intact along the fence line would be to allow the skin to partly dry. Freshly caught eels are very slimy and difficult to handle. Splitting them open with a metal knife, let alone with a small sharp flake of chert or obsidian, is not easy when they are wet and slimy. Having the bodies hanging vertically to stiffen and dry would be an advantage.

What happened to the heads during this processing has not been recorded, but is an important point. Māori would not waste the food content in the heads, because there is a lot of food energy there. In some fish species, such as blue cod, the head actually contains more protein food than the fillet (Leach, 2006: 245). Best records that during mass harvesting of barracouta in the South Island the heads were cut off and discarded (Best, 1923: 54–55). In this species, the head contains much less food (ibid.). Whatever is the case, at any of these processing sites where eels were split and dried, we should expect large numbers of head bones and, perhaps, very few vertebrae.

So far, consideration has been focused on mass harvesting of eels. This was generally a seasonal event in New Zealand to take advantage of mass migrations. During the rest of the year processing and its taphonomic implications would be different. In New Zealand eels are very numerous and easily caught by spear or net at any time of year and many would be eaten fresh. They would be taken back to the village and eaten there. We should therefore expect the whole range of bones to be present at village sites.

The foregoing brief review of ethnographic descriptions of eel capture among 19th century Māori society is heavily biased towards the spectacular mass harvesting of eels. As so often happens with historical descriptions, the more mundane everyday events do not get the same coverage. Archaeological sites, on the other hand, are all about the mundane. Middens tell us what people actually ate on a day to day basis. If one day the site at Okorewa is excavated, the midden there may be informative on every day life as well as the spectacular annual event when eels migrated out to sea in that vicinity. Eels represent two economic advantages over other sources of food – first, mass harvesting provides a surplus that can be traded for other commodities and, secondly, eels provide an all important rich source of oil, that helps to offset seasonal shortages of carbohydrate food.

THE EEL PROBLEM IN NEW ZEALAND

The question which now arises is whether these 19th century descriptions of eel harvesting applied in earlier times? New Zealand has a very short prehistoric period of 1,000 years at most (Higham & Hogg, 1997: 149; Hogg *et al.*, 2002: 116; Wilmshurst *et al.* 2008: 7676), and archaeological research has revealed very few eel bones in middens until recently, and then only in very small numbers. This has puzzled archaeologists and culture-historians (Marshall, 1987). In her book on New Zealand prehistory, Davidson comments “there is as yet very little indication that eels were a major food resource, except in the protohistoric period” (Davidson, 1984: 146-147). Sutton, commenting on this problem, describes “eel head parts as small and fragile” (Sutton, 1986: 310), and offers taphonomic reasons why they are not being found by archaeologists, and suggests a change of focus on to the more distinctive and robust vertebrae. This is a good point and since eel vertebrae are quite distinctive should be quantified in future studies.

The rise of economic prehistory and environmental archaeology at Cambridge University had a profound effect on archaeology in New Zealand,

and as a result we now know a great deal more about the numerical abundance of all types of fishes that were caught and eaten by Māori in the pre-European era. A review of 126 such sites from all regions and periods (Leach, 2006: 345-346) shows that the most important fish species was barracouta with a total MNI (minimum number of individuals) for all sites combined of 10,075. The total for all species was 40,433. So barracouta contributed an average of just on 25% of the New Zealand wide catch. By contrast, conger eels are represented by less than 0.5%, and freshwater eels by a mere 0.3%) This shows that as far as food is concerned, during the pre-European era, Māori consumed very few eels at all. Contrary to the large Māori nomenclature relating to eels, Strickland's list of Māori fish names has only three words for barracouta: maka, makā, and mangā, which are arguably all the same word. The numerical abundance of eels in archaeological sites will be thoroughly reviewed below.

This curious contrast between the cultural importance of eels (as described in 19th century ethnographic literature) and their apparent economic unimportance is not limited to New Zealand, but is found in the wider Pacific as well. This apparent gulf is the main focus of this paper.

Some scholars have gone to extraordinary lengths to suggest that the dearth of eel bones in archaeological sites means there is something wrong with the archaeological evidence. Various suggestions have been advanced, such as that the bones are too small, or too fragile, or they preferentially self-destruct because they are rich with oil. There seems to be a reluctance to accept anything except that which is staring us all in the face – that recorded behaviour from the early historic period does not document behaviour which prevailed during the pre-historic period. This problem of failing to accept that the past was not the same as the present was once widespread among Pacific and New Zealand scholars, and was clearly described by Daniellson when reviewing the career of Kenneth Emory.

> "The answer to this well-justified question is that no archaeological excavations were ever undertaken in Polynesia prior to 1950, simply because everybody knew for certain that it was absolutely meaningless and useless to do so… All I can do here, however, is to specify the premises on which this strange dogma was founded. These were the four more or less explicitly stated contentions that it was not worth while understating any archaeological excavations in Polynesia: (1): because the arrival of man was so recent that no stratified layers could have had time to form; (2) Because the frequent hurricanes and tidal waves constantly overturned and scraped the soil bare, and would have destroyed anything left by earlier inhabitants; (3) Because no artefacts could have been preserved in the damp corrosive climate except those of stone – of which there already existed rich collections in the museums, and (4) Because pottery, the key artefact that the archaeologists relied on elsewhere in the world for constructing their chronological sequences, was totally absent from all the islands" (Danielsson, 1967: 33).

Danielsson points out that such a blinkered viewpoint was finally challenged by Emory's excavation of the Kuliouou cave shelter on Oahu in 1950, where he found well defined strata containing artefacts not known in ethnographic collections. In short, as a great deal of subsequent archaeological research has shown, the Pacific does indeed have a past that is different from what historical ethnographic observations portray. Nevertheless, Pacific ethnography has a residual tyranny over archaeology, in the form of the *Direct Historical Approach*. Contrary to this, archaeology surely is all about finding out new things about the past, not simply affirming what we think we already know from observations made during the historic period.

THEORIES WHY EEL BONES ARE RARE

The most recently stated explanation for why eel bones appear to be less frequent in New Zealand archaeological sites than expected was made from DNA identification from 38 bulk bone powder samples, 21 of which were from middens. This 15 author paper, published in the prestigious journal of the National Academy of Sciences, has this to say:

> "Because of taphonomy and difficulties in identifying eel remains, it has long been hypothesized that these animals were of greater importance than their bone remains in midden assemblages reflect [The authors cite Marshall 1987 here]. Our data demonstrate that we can detect previously identified species (Anguilla and Conger) and new species (Gnathophis), using DNA. Still, we do not detect eel frequently. This suggests that in the sites sampled, eel were likely an important seasonal supplement to Māori diet, but not a primary food source" (Seersholm *et al.*, 2018: 4).

The two reasons they mention are the most common advanced world wide to explain the discrepancy between expectation and observation of eel remains in archaeological sites. The first – taphonomy – what exactly does this mean? It refers to the entire history of an item from first encounter with a human to its final resting place in the ground. This can be quite complex. In the case of an eel caught, say, with a fish hook, the person catching it might cut the head off and throw it overboard. As anyone experienced in catching eels knows, their teeth have a nasty habit of latching on and can then be difficult to remove, not to say painful. Clearly, if a head was discarded at sea or river, the cranial bones are not going to end up in a midden site. Cranial bones are the usual anatomical element that archaeologists identify in New Zealand. An alternative version of this is that the heads were cut off and given to dogs to eat and any eel bone fragments would be difficult to identify from coprolites, let alone quantify. Contrary to this, otoliths would survive intact and are simple to quantify. Another taphonomic scenario might be that the eels were split down the middle, dried in the sun, and then transported miles way to be eaten much later. No eels bones would then appear in a site close to where the eels were caught and processed. On the contrary, the ethnographic description outlined above suggests that such sites would be replete with cranial bones and practically no vertebrae. In a limiting case, where no bones, otoliths or any other hard parts remain at some site where eels were processed, there could still be residual evidence. Fankhauser has reported that the lipid profile, distinctive of eels, can be detected from archaeological sediments where eels were processed, regardless of whether there are any bones present (Fankhauser, 2002; Builth, 2014).

The second reason, cited above, is that eel bones are difficult to identify compared with other bones. This is asinine, and scarcely deserves comment. Anyone can be trained in five minutes to distinguish the main cranial bones of eel from other fishes. They are highly distinctive.

One more point arises from the bulk bone DNA study. Eel DNA was infrequent among the 436 taxa identified at family level. This result is similar to those found from regular osteological research on middens, reviewed below.

This issue of a surprising lack of eel bones in middens is not confined to New Zealand, and has been noticed in Europe. Eel bones were expected but hardly represented in early medieval sites in the southern Baltic area. Lepiksaar & Heinrich (1977: 113-114) and Benecke (1983: 284-285) argue that eel bones were under-represented and suggest it is the result of autolysis of eel bones by the fatty acids released from the fat in the bones. Prummel, reviewing this matter (1986), notes that such a problem should occur with all fat-rich fishes such as herring, eel, mackerel, and salmods, and goes on to describe his own analysis of a series of sites near Oldenburg in Schleswig-Holstein dating from AD 650 to 1260, where bones from freshwater eels are abundant. Moreover, herrings were by far the most common fish in the medieval sites in the southern Baltic and these should also have been affected by the same autolysis suggested for eels. The Oldenburg site had 1,040 eel bones. Other common fish species were herring (1,159 bones), pike (476 bones, and flat-fish (392 bones). In all, bones from 26 fish taxa were recovered (Prummel, 1994: 317). In short, Prummel argues that autolysis of eel bones is a modern-day myth. He also considers the environmental setting of each site, such as water salinity, the functional status of each site (trade centres and religious sites), and the ethnicity of the regions where they are based (Slavonic or Viking). None of these three factors explains the relative abundance of eel bones in different sites to his satisfaction.

On the same issue of preferential survival, Kettle comments "fish with a high fat content – like eel, salmon, or tuna – have the potential to acidify the soil matrix in which the remains are found leading to preferential autolysis or dissolution of the bone remains … Although this potential bias is often quoted for salmon, it is not regarded as a potential source of under-representation for eel remains from archaeological sites [citing Enghoff, 1986: 67]" (Kettle *et al*., 2008: 1313). In a thorough review of bone degradation processes in archaeological sites, Nicholson comments on the matter of fish with high oil content thus: "Until the widespread adoption of soil sampling and sieving, an absence of herring bones in archaeology was attributed to the autolysis of bones from fatty fish in aerobic conditions [citing Lepiksar & Heinrich, 1977], a hypothesis which can no longer be sustained" (Nicholson, 1996: 526).

With better recovery methods now being employed, eel bones are more commonly being identified in European archaeological sites. A typical example is at the type site of Ertebølle in northern

Jutland where 18 fish taxa were identified (total NISP[1] = 16,159). Cyprinids were the most abundant, and freshwater eel second (17.3%). The most common cranial bones of eel were dentale, keratohyale, and premaxillare[2] (Enghoff, 1986: 66). Eel had the same relative abundance among post-cranial bones identified. Of these, vertebrae were the most common bone identified (eel NISP = 1,494). Similarly, the Havnø site in Denmark, which spans the Late Mesolithic Ertebølle and the Early Neolithic Funnel Beaker cultures from about 5000–3500 B.C., of the 12 taxa of fish identified with a NISP of 306, freshwater eel dominate, comprising 71% of the collection (Robson *et al*., 2013: 172).

In conclusion, surely now we can finally lay to rest the suggestions that eel bones are not found in archaeological sites because they are too small and fragile to survive, and/or that they are too difficult to identify, and/or that they contain so much oil that they preferentially decay in soil and therefore do not survive. All these things are simply incorrect.

SOME BIOLOGICAL CONSIDERATIONS

A few basic details of eel biology need outlining before considering the presence of eels in archaeological sites. There are many species of eel in the Pacific region (Table 1). Those which have potential economic importance to prehistoric people belong to three families: Anguillidae, Muranidae and Congridae. The latter two are more numerous, have wider distributions, and feature more prominently in archaeological sites. Both Muraenidae and Anguillidae are mainly nocturnal in habits. That is, they are far more active at night. However, from personal experience, both can easily be caught during daylight hours, and are instantly attracted to any bait in their vicinity. Conger eels also are easily taken on hook and line during daylight hours. The annual migration of freshwater eels from New Zealand to the Pacific made mass harvesting possible. This has been described earlier.

Anguilla australis	New Zealand, Auckland islands
Anguilla bicolour	Papua New Guinea
Anguilla celebensis	Western Papua New Guinea
Anguilla dieffenbachii	New Zealand, Auckland Islands
Anguilla marmorata	Most oceanic islands north to the Marianas, and south to Papua New Guinea, New Caledonia, and Society Islands.
Anguilla mauritana	Central Pacific
Anguilla megastomata	New Caledonia, Solomon Islands, eastern Pacific, Fiji, Tonga, Samoa, Marquesas, Tuamotu, Tahiti
Anguilla obscura	Papua New Guinea, East Polynesia, Tonga, Samoa, Marquesas, Tuamotu, Tahiti
Anguilla pacifica	East Pacific
Anguilla reinhardi	New Caledonia

TABLE 1

Distribution of species of the genus *Anguilla* in the Pacific islands. From Lane (1978), following Eales (1968). See also Nandlal (2005).

The security of the taxonomy of different species is constantly under review. One study comparing morphology with M-DNA suggested a concordance of about 80% (Aoyama *et al*., 1999: 196).

Concerning the distribution of eels in the Pacific, the Hawaiian islands are a somewhat unusual case.

According to Titcombe there are numerous types of eels in Hawaii and she documents six congers, one snipe eel, eight snake eels, and 35 morays (Titcomb, 1951: 136), and many details of catching, preparation and consumption. She states "Salt water eels were eaten, but freshwater eels were used only ceremonially. Of details of this use there is no available record" (ibid.: 124). Although there is some suggestion that Chinese immigrants may have introduced a species of freshwater eel in historic times that are now found in streams, James and Suzumoto's careful review of all evidence concludes:

> "Until now Anguilla have not been reported from any Hawaiian stream. Although larvae of freshwater Anguilla species are distributed by oceanic currents, it is unlikely that [an] individual found on Maui arrived without human intervention. … the non-occurrence of Anguillidae in the Hawaiian Islands is some-what surprising given its widespread nature elsewhere in the western Pacific. The isolation of the Hawaiian Islands, both geographically and in terms of oceanic current flow, plus factors of deep-ocean salinity, have

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[1] Number of Identified Specimens

[2] Enghoff is mistaken here. *Anguilla* spp. do not posses a premaxilla (discussed below); the bone he identified was most probably the maxilla.

> been, and continue to be, sufficient barriers preventing this family from reaching the Hawaiian Islands" (James & Suzumoto, 2006: 57).

In many Pacific islands, wetland taro (*Colocasia* sp. and *Alocasia* sp.) are often cultivated in prepared swamps. These locations should be excellent habitats for freshwater eels, but there are few records of this. However, Anderson records that in 2002, large freshwater eels were abundant in taro ponds on Rapa (Anderson, 2012: 42). More generally, only in islands that are large enough to have suitable habitats can we expect to find significant populations of freshwater eels.

FRESHWATER EELS AND NUTRITION

One especially important nutritional feature of eels is the abundant oil[3] they carry. It would not be surprising to find that a community under stress for adequate food might easily forego their horror of eating eels, precisely because of the rich oil reserves they have. Best appreciated this issue when he commented "The Maori is much given to the use of fat foods, and hence a dish of eels is greatly appreciated by him" (Best, 1922: 109). This same sentiment is expanded upon by Johnstone.

> "In Maori economy, the eel played a most important part. More than every other kind of food it represented fat, the nutriment which man, whether savage or civilized, universally craves. The beauty of Bel-gravia, and the Brahmin of Benares, would alike waste and pine were they deprived of milk and butter, pastry and sweetmeats. They must both eat fat in some shape or other. In Maori there were no animals deserving the name of quadrupeds. Man was therefore forced to gratify his craving for fat at the expense of a lower order of creation. Fish was his staple article of diet, and of all fish the eel was to him of the greatest importance" (Johnstone, 1874: 98).

Augustus Hamilton also fully understood how important a source of oil was to the economy of Māori, and in his influential book on *Fishing and Sea-foods of the Ancient Maori*, copied the first part of this passage verbatim from Johnstone's book, without acknowledgement (Hamilton, 1908: 67). Only in the northern half of the North Island of New Zealand was there a reliable source of carbohydrate food, in the form of kumara (*Ipomoea batatas*). Carbohydrate offsets the nutritional craving for fat in human nutrition. In the southern parts of the North Island, the cultivation of kumara was marginal, and there was a 'hungry gap' between the last reserves of stored kumara (August to October) from the previous harvest, and supplies from the next harvest in April. This period of 6–8 months, when there was no carbohydrate from kumara, the main sources of food available were protein-rich sea foods and forest birds, neither of which possess much fat[4]. The problem of a protein-rich diet, depleted of either carbohydrate or fat, is known as 'rabbit starvation' (Speth, 1983, 2020; Speth & Spielman, 1983; Noli & Avery, 1988; Cordain *et al*., 2000), and is graphically described by Stefansson in his *Arctic Manual* :

> "If you are transferred suddenly from a diet normal in fat to one consisting wholly of rabbit you eat bigger and bigger meals for the first few days until at the end of about a week you are eating in pounds three or four times as much as you were at the beginning of the week. By that time you are showing both signs of starvation and of protein poisoning. You eat numerous meals; you feel hungry at the end of each; you are in discomfort through distention of the stomach with so much food and you begin to feel a vague restlessness. Diarrhoea will start in from a week to 10 days and will not be relieved unless you secure fat. Death will result after several weeks" (Stefansson, 1957: 234).

The problem of how to obtain adequate supplies of either carbohydrate or fat to offset starvation from a protein-rich diet among pre-European Māori is described in detail by Leach (2006: 232-273). There are many historical records of half starved Māori relishing rotting shark for the oil, rancid seal blubber, train oil, lamp oil, and even the oil-soaked cotton and wick from lamps, and females giving sexual favours for these morsels (ibid.: 250). With such a background, is it easy to

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[3] Some authors refer to the lipids in eels as fat and others as oil. Fats have high levels of saturated fatty acids, while oils are mainly composed of unsaturated fatty acids. Fats are normally solid at room temperature, and oils liquid. Eel lipids are about 25% saturated fatty acids, and 75% unsaturated (Lovern, 1938: 1217), so strictly speaking the term oil should be used.

[4] Fern root (*Pteridium aquilinum var. esculentum*) provides a modest amount of starch, and was highly prized by Māori, but its quantitative role in the economy could only be minor – basically a famine food. In addition, fern root has highly toxic compounds in addition to starch; these cause cancer of the stomach and other organs.

see how important oil-rich eels could be to people living in areas where kumara cultivation was marginal or impossible. As will be seen below, an episode of starvation during the Brunner expedition in the South Island provided the circumstance for a *tapu* removal ceremony so that eels could be eaten by the Māori guides. Did episodic semi-starvation in some districts provide the impetus for abandoning an ancestral *tapu* on eels altogether, at some stage in the pre-European period? Archaeological evidence should be able to show this, by a sudden appearance of quantities of eel bones in middens, hitherto only rare.

The USDA Nutrition database provides average nutritional values across mixed species of raw eel as follows: protein 18.4, lipid 11.66, carbohydrate 0.0, ash 1.41, all g/100g, and gross energy as 184 kcal/100g. Around these figures there is considerable variation as shown by the research carried out by Shortland & Russell (1948) for the two New Zealand freshwater species. They show that for immature[5] eels, the total oil content varied from 7-23% for *Anguilla australis*, and 8-18% for *A. dieffenbachii,* and that in general oil content increases with the length of the eel (ibid.: 164). This is illustrated in Figure 5. It is important to note that there is considerable variation from one species to another, from one season of the year to another, and also the animal's condition during maturation. Oil content was highest in the skin, lower in the tail portion, and still lower in the head and trunk (ibid.: 169). It will be noted in Figure 5 that the two New Zealand species generally have less oil than the European eel, *Anguilla vulgaris [anguilla]*, and also the Japanese eel, *Anguilla japonica* (Sumner & Hopkirk, 1976: 933). Fatty acid profiles (Shortland & Russell, 1948: 167, and Sumner & Hopkirk, 1976). These show marine profiles for eels living in estuarine environments.

When we consider the value of eels for human nutrition, at the most basic level such raw figures need to be converted to caloric energy using the normally recognised figures of 4, 9 and 4 kcal/g for protein, fat and carbohydrate respectively (Davidson *et al*., 1972: 10). For example, the USDA figures cited above convert to 74, 105, and 179 kcal/100g for protein, oil, and total respectively (zero carbohydrate). When converted to proportions, these are 41.3% energy from protein, and 58.7% from oil. Note that this calculated value of total caloric energy of 179 is slightly less than the value of 184 reported by USDS.

However, it is equally important to note that there is an upper limit to how much protein the hu-

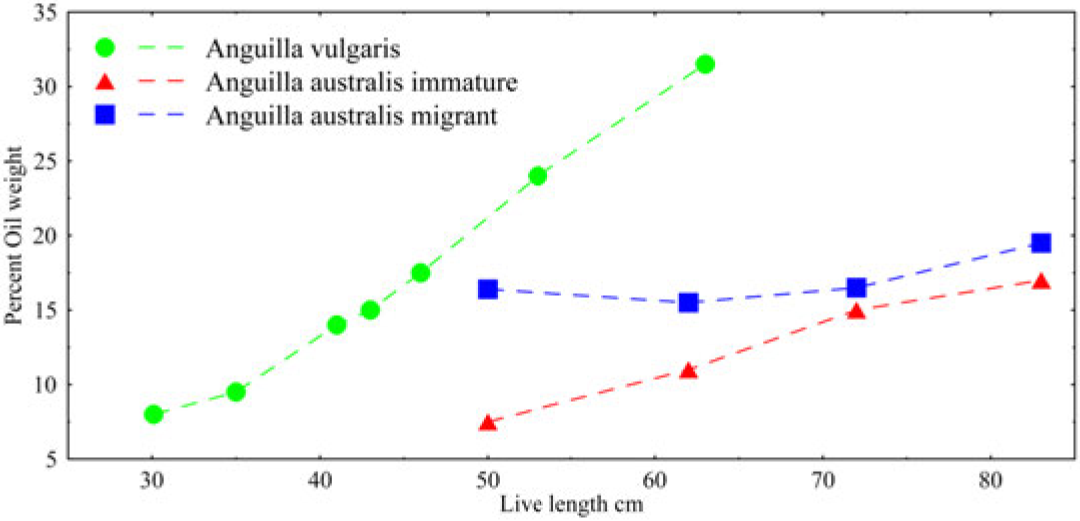

FIGURE 5

Three examples showing how oil content rises as body length increases. *Anguilla vulgaris* (syn. *Anguilla anguilla*) data from Lovern (1938: 1217), and *Anguilla australis* from Shortland & Russell (1948: 178).

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[5] The authors distinguish three categories of eel for purposes of nutrient analysis: Immature; Adult, as the first appearance of sex organ or when gonads commence maturation; and Migrant when sex organs have reached maximum development (Shortland & Russell, 1948: 166).

man body can cope with. The eel value of 41.3% is very high, and would be dangerous unless accompanied by additional sources of fat or carbohydrate. According to Speth, an extreme upper limit that can be consumed safely on a sustained basis is approximately 300 g per day. This figure represents a protein intake of roughly 50% of total daily caloric intake under normal, non-stressful conditions (Speth, 1990: 155). A more realistic maximum daily protein intake may represent 20-30% of daily caloric intake, and would be in the region of 120-180 g of protein per day. Draper (1977: 311) has reported a protein intake of 200 g per day for pre-modern Arctic Inuit, an intake which represented 32% of their daily caloric intake. So a general guideline for the upper limit of energy from protein sources is suggested as 30%.

The study by Shortland & Russell (1948) shows that for two New Zealand species, the proportion of energy from oil ranges from 53-72%, and from protein 27-47%, depending on length (Figure 6). All but two of the specimens studied by Shortland and Russell are above the 30% threshold of energy from protein. The main point to remember from these simple calculations is that eels represent a bountiful supply of oil, outstripping anything else available to Māori in their environment except marine mammals. For example, no shellfish

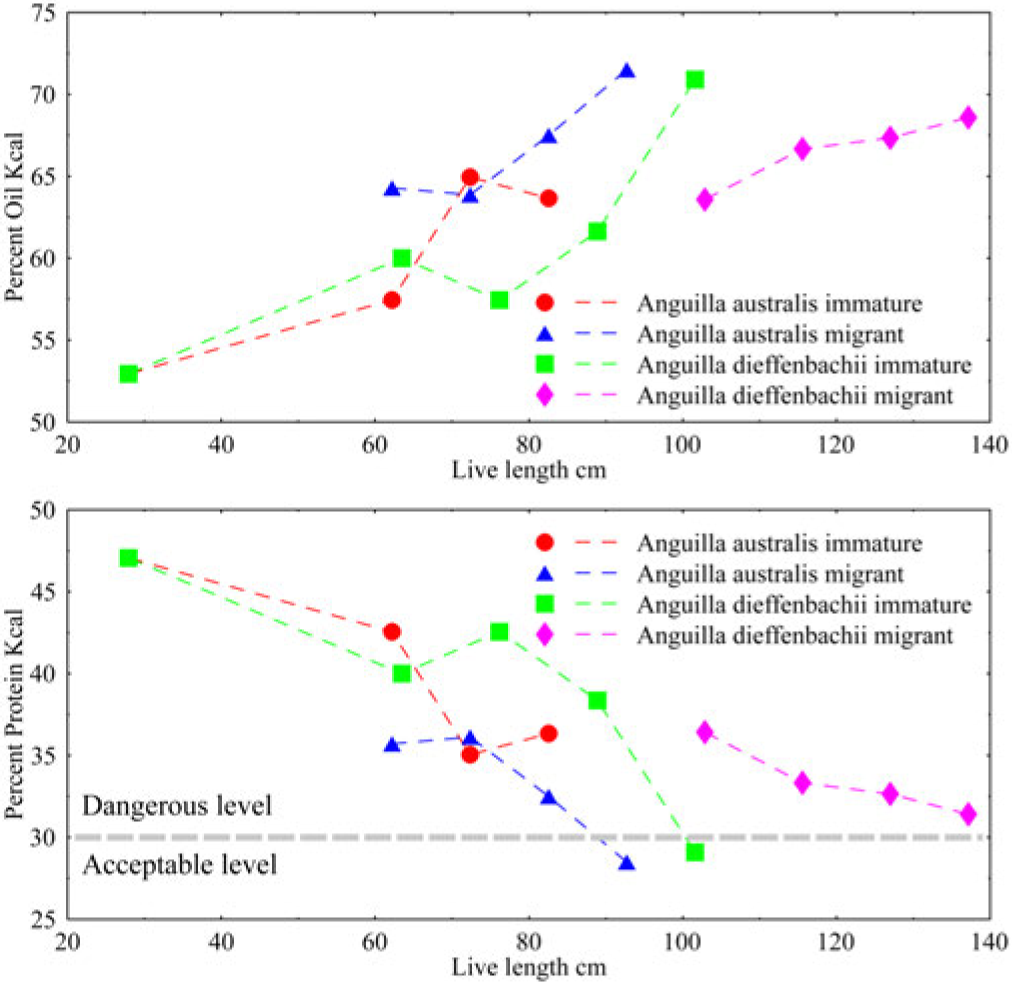

FIGURE 6

Nutritional value of oil and protein in New Zealand eels from proximate analysis. Calculated from graphical data in Shortland & Russell (1948: 182). As a sole food source, protein caloric energy should be less than 30% of daily consumption.

available in New Zealand has as much oil+carbohydrate as eel (Leach, 2006: 239, table 8.4). Only marine mammals would be a superior source of fat for Māori. As Smith has shown, marine mammals had a wide distribution when Polynesians first arrived in New Zealand, but by AD 1500 there were only rare seasonal occurrences in the North Island (Smith, 1989: 92). They continued to have an important economic role in the pre-European Māori economy in the South Island.

From the foregoing it can be seen that eels represented a significant source of oil for pre-European Māori in New Zealand. For people living in warm coastal environments where kumara could be cultivated a balanced diet was possible with carbohydrate from kumara and an inexhaustible supply of protein from fish in the sea. In more southern coastal areas south of about latitude 44°S, a 'hungry gap' was an annual event, and 'Harris lines' are observed in long bones in some communities (Sutton, 1979: 197). Starvation could have been avoided by eating the oil rich skin and tail of eels, but as will be seen below archaeological evidence suggests that the Polynesian immigrants to New Zealand did not consider eels as suitable food, except in the historic period.

Unless prehistoric people chose to take advantage of the abundant oil in eels to augment a protein rich diet it would be impossible to live for any length of time in the interior parts of southern New Zealand, as there are only limited sources of carbohydrate and/or fat available. Any attempt at permanent settlement in large inland river systems in the North Island, such as Wanganui, Manawatu, and Ruamahanga, would be inviting 'rabbit starvation', unless eels were consumed. We have seen above that mass harvesting of eels was undertaken in precisely these areas in the 19th century. The question which must be answered, however, is whether eels were harvested in this way in the prehistoric period. Only archaeological research can answer this.

EELS AND LANGUAGE

In a useful review of the lexemes relating to New Zealand fishes, Strickland lists 198 separate words in the Māori language which, when translated to English, would appear simply as 'eel' (both conger and freshwater species). These words are used to describe numerous different types or qualities of eel that are separately recognised by Māori. For example, the word *putaiore* is used for a type of eel that is blue-black with blue eyes, and has large pectoral fins (Strickland, 1990: 34-37).

Having such a large number of words referring to some single feature of the environment is usually taken to indicate the special importance of it to the group of people whose language it is. An oft- quoted example of this, much disputed, is that among the Eskimo-Aleut languages there are a large number of words that are used to refer to snow (Krupnik & Müller-Wille, 2010). Similarly, the Sami people have 175-180 words related to snow and ice (Magga, 2006: 34). Incredibly, they have around 1,000 words for reindeer (ibid.: 31).

The observation therefore, that there are 198 words in the Māori language referring to eel, seems a fair indication that eels are or were important in Māori society. However, whether this is true for Māori in all regions, indeed, for all periods during their occupation of New Zealand, are questions to be answered. Moreover, it would be wrong simply to assume that this linguistic importance relates equally to their role in Māori diet, as it does in mythology, for example.

Although there are many separate words in the Polynesian languages that refer to various types of eel found in the environment, two words stand out which are almost universal: *Pusi,* referring to seawater eels, and *tuna*, referring to freshwater eels. The various cognates of these two words are listed in Tables 2 and 3, and are derived from Biggs's comparative Polynesian Lexicon Project (POLLEX, Walsh & Biggs, 1966). The words were extracted from the 1996 version (Biggs & Clark, 1966).

It is interesting that in spite of the rarity of moray eels in New Zealand, the name *Puhi-rokoroko* is applied to a type of yellow saltwater eel, and also to the lamprey. Williams records *Puhi* as a very large variety of eel, and *Puhikorokoro* as *Gymnothorax prasinus*, a yellow moray eel which is found between North Cape and Mahia Peninsula (Williams, 1971: 304-305).

The most common form of seawater eel in New Zealand is the conger eel, *Conger verreauxi.* Strickland records several words for this type of eel: *koiero, kōiro, kōriro, ngoiro, ngoingoi; ngoio; ngōiro* (Strickland, 1990). Members of the Congridae family are rare in the Pacific, but are present in Hawaii, for example.

> "*tuna (freshwater eel) is a very ancient term. It is reconstructible to PPn (Proto-Polynesian) and also to Proto Oceanic, and, as *tuNa, to Proto Austronesian. *pusi (sea eel, Gymnothorax spp.) is widely reflected in Nuclear Polynesian languages. It is absent in the Tongic languages (Tongan and Niuean) but is recorded (as pusi) in a Lau dialect of Fijian so can be attributed to PPn. A bunch of somewhat similar terms, with irregular sound correspondences, occur in other Oceanic subgroups" (Pawley, pers. comm. to BFL, 2019)

What this shows, is that no matter where Polynesians voyaged across the Pacific ocean, they took with them their knowledge of their ancestral environment and applied existing language to familiar things when they settled in new lands. We should also expect that common customs relating to eels would also be transferred to newly settled lands.

Tuvalu	Pusi	Saltwater eel
East Futuna	Pusi	Moray eels
East Uvea	Pusi	Saltwater eel
Hawaii	Puuhi	Eel
Emae	Pusi	Parasitic worm
Maori	Puhi	Large eel variety
Maori	Puhi-rokoroko	Yellow Saltwater Eel, Lamprey
Mele-Fila	Pusi	Sea eel
Marquesas	Puhi	Anguille
Penrhyn	Pusi	Fish sp.
Pukapuka	Pui	Small sp. of eel
Rarotonga	Pu`i	Large black, sea-eel, not Moray
Rennell	Pusi	Starry or clouded moray eel
Rotuma	Tepuhi	A sea-snake with transverse stripes
Samoa	Pusi	Moray Eel
Sikiana	Pusi	Eel spp.
Tahiti	Puhi	General name for moray eels
Tokelau	Pusi	Moray eel
Tuamotu	Puhi	Eel
West Uvea	Pusi	Sorte d'anguille de mer
Sikiana	Pusilokiloki	Eel *sp*.

TABLE 2
Polynesian cognates of *Pusi*, from Biggs & Clark (1996).

Anuta	Tuna	Freshwater eel, said to be extinct.
Tuvalu	Tuna	Eel, freshwater crayfish.
East Futuna	Tuna	Freshwater eel.
East Uvea	Tuna	Eel of brackish or fresh water
Fiji	Duna	Freshwater eel
Hawaii	Kuna	Eel freshwater *spp*.
Maori	Tuna	Freshwater eel
Niue	Tuna	Eel, freshwater *spp*.
Nukuoro	Duna	Larvae of mosquito
Penrhyn	Tuna	Eel
Pukapuka	Tuna	Striped lagoon eel
Rarotonga	Tuna	Eel, freshwater *spp*.
Rennell	Tuna	Kind of lake eel
Rotuma	Funa	Freshwater eel
Samoa	Tuna	Eel, freshwater *spp*.
Takuu	Tuna	Moray eel
Tikopia	Tuna	Eels, especially lake eels
Tonga	Tuna	tahi, vai. Eel *spp*.
Tuamotu	Tuna	Eel
West Futuna	Tuna	Freshwater eel
Waya	Tuna	Freshwater eels, Anguillidae

TABLE 3
Polynesian cognates of *Tuna*, from Biggs & Clark (1996).

MYTHS AND TRADITIONS ABOUT EELS

In the introduction to this paper, Samuel Johnson's observation about the Scottish abhorrence of eels and pork as food was cited, and that the opposite was the case in England. In considering the presence or absence of eels in the archaeological record, we clearly need to bear in mind the cultural attitudes that people in different societies have towards eels, and whether these may have changed over time.

The important role that eels played as food throughout English history has been reviewed by Righton & Roberts (2014), and archaeological evidence suggests that this attitude towards eels, contrasting with the Scots, has some antiquity. A site in Southampton, for example showed that bones of freshwater eels were consistently very common for five separate periods from AD 900 to 1750 (Nicholson, 2011: table 1). However, there is some evidence that in other sites in England the herring fishery increased in importance and that eel declined in late Saxon times (Holmes, 2017: 39). The town known as Ely is named after the eel, and there is an annual festival devoted to eels with parades and food stalls (Svanberg & Locker, 2020: 19). The Scottish prohibition on eating eels may not have much time depth as Neolithic, Bronze age, Mediaeval, and Viking archaeological sites certainly contain eel bones (Barrett *et al*., 1999: 366, 380, 382, 384).

Donald Mackenzie, a Scottish historian argued that the prohibition of eating eels and pork meat among the Scots could be traced back to a centuries old religious cult derived from Mosaic law. The origin of this is in the third book of Moses, called Leviticus, in which is found:

> "And all that have not fins and scales in the seas, and in the rivers, of all that move in the waters, and of any living thing which is in the waters, they shall be an abomination unto you: They shall be even an abomination unto you; ye shall not eat of their flesh, but ye shall have their carcasses in abomination" (Leviticus 11:10-11).

The main culprit here is the humble eel. Although moray eels do not have scales, freshwater eels certainly do, although they are small and embedded in the skin. An especially interesting version of this myth is discussed by Ingvar Svanberg, as follows:

> "The Estonian and Swedish speaking settlers of the island of Wormsö did not eat it [eel]. There is a folk legend recorded from that area that tries to explain why eels should not be eaten. The legend tells how kinship between the eel and the snake began. It is said that the snake had seduced the first parents in paradise and thereby raised the wrath of God. Jesus then took a stick and cut the snake into two pieces. The part with the head fell on the dry land, while the tail part fell into the water. A new snake grew from the former part, while the eel emerged from the latter" (Svanburg, 1999: 132 [citing Russwurm, 1855: 189]).

One interpretation of the snake in the garden of Eden is that it symbolises the penis, and that eating from the forbidden fruit is a metaphor for sex. These two ingredients, the penis and sex, are common in myths about eels throughout Melanesia and Polynesia. The second part of the Wormsö myth, concerning cutting up the snake into pieces is not, to our knowledge, derived from biblical sources but, as will be seen below, has clear parallels with Pacific mythology[6].

Throughout the Pacific, from the tropics to temperate New Zealand, myths and traditions about eels abound. Although these vary a great deal, there are also common threads. A small selection of excerpts from Pacific ethnographic literature relating to eels is provided in Appendix 1. A few are presented here to illustrate these common themes.

Tikopia is a Polynesian outlier in the Solomon Islands, inhabited for about 3,000 years. The people on the island today consider that eels are disgusting and would never consider eating them. Some types of eels are totemic, representing ancestral figures for clans. Of particular interest is the central position of eels in origin mythology on this island. Both freshwater and marine eels are strongly repulsive to Tikopians [see Appendix 1 for excerpts from Firth (1981) and Park (1973)]. The eel god Tangata-katoa (meaning all men) is the original generative deity of Tikopia and symbolically identified with the penis. Various types of eel are formed by chopping up the elongated penis of the deity. Firth notes that by 1973 some Tikopians were then eating eels, putting them in soup, even though others disapproved and were still afraid of eels (Firth, 1981: 219).

This origin myth, present here in a Polynesian society, is also found in non-Polynesian societies further west in Melanesia. For example, Malinowski described the legend of a mythical demigod called Inuvayla'u who had a very long penis and was inclined to wriggle along the ground like a snake and impregnate women when they were alone or vulnerable. His brothers were furious with the foul pranks of Inuvayla'u, so they cut the penis up into small pieces with an axe. Each piece turned into stone. One piece was placed in front of the headman's house in the village of Kwabulo, another piece where the men moor their canoes. Finally, the testicles were cut off and turned into two large white coral boulders in a creek. The elements of this myth are present in Māori society (see below, Best, 1923: 56).

Ethnographic literature documents numerous examples of the very special place which eels have in the magico-religious systems of people from Papua New Guinea to Easter Island. The involvement of eels in the totemic behaviour on Tikopia, cited above, is a typical example. The Reverend Gill made the following observation about eels in the Pacific islands[7]:

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[6] Best comments on this as follows: "As in other lands, the eel enters into the myths of our Maori folk, and in the myth concerning the first woman it takes the place of the snake in the Biblical story" (Best, 1929: 73).

[7] It is not explicitly stated in this passage which island he is referring to. Mangaia in the Cook Islands is suspected, since he spent 20 years living there, from 1852-1872.

> "Fear is the ruling motive of heathen worship; and it is interesting to observe that this feeling has led to the worship of the serpent wherever that reptile is known. May not this species of idolatry have been connected with the memory of the arch serpent that deceived Eve? ... In all these eastern islands, where the serpent is unknown, the salt and fresh water eel (Muraenidae) takes its place in the superstitious veneration of the natives, both being regarded as incarnations of deity. Until Christianity came, it was unlawful for women to taste eels, on the alleged ground that in the olden time a divinity assumed the form of a great eel in order to approach an unsuspecting woman while bathing. To this day nothing can exceed the disgust most of the native women feel at eels, which they refuse even to touch. A woman once secretly ate the sea-eel. On discovering the sacrilege, the husband fled from her in horror, and never lived with her again, regarding her as possessed of an evil spirit which would be sure to kill and devour him on some future occasion" (Gill, 1876: 278-279).

Gill goes on to relate examples of severe reactions for eating eels. In 1863 about 80 people in the Tokelau islands were expelled for eating a sea eel that was considered sacred. On another occasion an islander inadvertently ate part of a sea eel, and when he was made aware of it, immediately vomited and exclaimed in horror "Aue tâu[8] Atua e ! (Alas for my God !)" (Gill, 1876: 279).

One of the greatest of all heroic figures in Polynesian mythology is a man called Maui, sometimes called *Maui of a thousand tricks*. Many fabulous tales are recorded of this man. One involves his introduction of coconuts to the world:

> "Throughout Polynesia, a coconut tree is said to have sprung from the severed head of Tuna, a giant eel who courted Hina. Certain variants state that Tuna is killed by Maui, who is jealous of his wife's attentions to Tuna, or that he kills Tuna when Hina, a stranger to him, asks Maui to save her from the eel. The coconut did not grow in New Zealand, but the Maori who had brought the myth of Tuna with them from central Polynesia, state that after Maui kills Tuna, various species of fresh and salt water eels grow from parts of Tuna's body" (Luomala, 1949: 120).

"At Mangaia, Tuna makes love to Hina with curious results, as Hina is the moon" (Best, 1923: 58).

There are numerous variations of the myth concerning the origin of coconuts and how the eel is involved in this. In Samoa, for example, there are variations of the same story, relating to the violation with his tail of a girl by the god Pili, regarded as being an eel; and, according to one version, this was followed by the death of the eel and the growth of a coconut, evidently supposed to have been the first coconut, out of the dead eel's head. Both these ideas of an eel copulating with a woman by its tail and of the growth of the coconut out of an eel's head are found in other islands (Williamson, 1924, III(2): 233).

In Samoa, the story of Sina and her pet eel is a complex love story in which the eel pursues Sina no matter how far away from her village she tries to escape. In some variants her lover switches back and forth from human to eel form. In other variants it is Sina who pursues the eel. However, in all variations the eel must eventually die. He makes one final wish to Sina – that when he is dead she should cut off his head and bury it near her house, and from this a very special tree will grow. This of course is the coconut tree, all parts of which are of great value to Oceanic peoples.

It is little wonder that in many parts of the Pacific, people would never dream of eating eels. This would be sacrilege. As with so many aspects of spiritual values, the spread of Christianity had the effect of changing this deeply entrenched attitude towards eels in the Pacific.

On Mangareva, Peter Buck recorded that people in the past would not think of eating marine eels, but that this repugnance has disappeared: "Formerly the sea eel was not eaten, as it was said to be a man named Te Marautoro, who entered the woman Meto and became smeared with the vaginal secretion (*pakaokao*). With the change in ideas, the repugnance to eating sea eel vanished" (Hiroa, 1938: 197). As we will see below, there is archaeological evidence of changes in human behaviour towards eel on Mangaia . Of freshwater eels on Mangareva, Buck recorded this:

> "When Te-aio was killed, his blood flowed into a stream and was drunk by an eel. The spirit of Te-aio entered the eel, which after Te-aio was deified, became his incarnation. The eel went out to sea, came in contact with a shark, and the spirit of Te-aio passed over to the shark. The shark also became an incarnation. This is the mechanism found in New Zealand, where any fish, reptile, bird, or animal which touches or drinks the blood of an ancestor may become the incarnation of that deified ancestor" (ibid.: 171).

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[8] Tâu here is Gill's way of rendering a glottal stop for a missing consonant, which in this case is k, so the original word is taku meaning my.

Of the Cook Islands in General, Hiroa comments "Fresh-water eels seem to be considered unimportant, except in Mitiaro where they are obtained in large quantities from an inland lagoon" (Hiroa, 1944: 245); and, on the small island of Mitiaro, northeast of Rarotonga "in the middle is a small area of good volcanic soil surrounded by swampy land. A fair sized lake and the swamps supply the *itiki* eel peculiar to Mitiaro" (Hiroa, 1944: 6). There is further information on this below.

In New Zealand itself, the earliest historical records date to the 18th century but, unfortunately, there are few relevant details. For example, there is no mention of eels in the first and second voyages in the journals of Cook, Banks, or Forster; however, there is a short note by the Scotsman Anderson that some large conger eels were supplied by Māori in Queen Charlotte Sound (Cook, 1967, III(2): 807). There is far more useful information in the 19th century.

> "Consider the story of the creation of eels, told to Wohlers in the 1840s. It also concerns the famous Maui and his wife Raukura. Raukura complained that she had been attacked by a person named Long Tuna [Tuna is the common Māori word for freshwater eel] who had dragged her into the water of the river and raped her. Maui went down to the river, lured Long Tuna ashore and chopped him up. He threw the head into the sea where it became the conger eel and body he threw into the river where it became a freshwater eel, a *tuna*" (Biggs, 1993).

Best described a wide range of versions of the story about how the personified eel defiled a woman and was cut into pieces in 19th century Māori mythology. Here are three recorded by Elsdon Best, the latter two citing White (1887: 69, 76).

> "#1: Maui of immortal fame, discovered that Hine-nui-te-Po, the goddess of Hades, was carrying on something more than a flirtation with Tuna, the eel-god. Maui, being attentive to the morals of other persons, proposed to put a stop to the above state of things. He did so by destroying Tuna. This was one of Maui's acts which eventually caused his death, for Hine was not taking interference quietly, and so, by dread arts of magic, caused the death of Maui…#2: Maui married Hine, a daughter of Tuna and Repo, and that he slew Tuna for interfering with Hine. When slain the head of Tuna fled to the fresh water, and that is the origin of fresh water eels; while the tail of Tuna fled to the ocean and became the conger eel…#3: a Ngati Hau legend states that Hine was a sister of Irawaru, and Tuna a son of Manga-wai-roa. Also that Tuna concealed himself in a pool named Muriwai-o-Hata…where he was slain by Maui" (Best, 1902: 65).

Yet another version of this myth was recorded by Best from the Taranaki region of New Zealand.

> "Then one day when the woman was bathing, an eel came round her body, and, with his tail, so excited the woman that there was awakened in her the sexual desire. She then went to seek Tiki, and succeeded in exciting him to an equal extent, thence there came to them the Knowledge [upper case by Best]. This act was viewed a most serious *hara* (misdemeanour, sin), hence Tiki, knowing that the eel had caused the woman to lead him astray, resolved to take vengeance. He therefore slew the eel, and cut him into six pieces. From these six pieces sprang the six varieties of eels known to man" (Best, 1923: 56).

Polach who travelled widely in the North Island in the 1830s noted that in the vicinity of Tauranga, "eel was viewed as an *atua* [a God] by the local natives. Eels are said to have been *tapu*[9] to those folk, hence they could not eat them, and a saying concerning them was, *He uri no Puhi kaore e kai I te tuna* (The offspring of Puhi do not eat eels). Puhi and Tuna are both terms used to denote the tutelary being of eels, or the personified form of such" (Best, 1929: 73).

The *tapu* status of eels, referred to in this passage, is further touched upon by another historical record which deserves special attention. This relates to a sojourn on the West Coast of the South Island by Thomas Brunner in 1846-8. At a time when the party were starving for food he found that his Māori guides caught some eels to eat, but before doing so took part in an elaborate form of spiritual cleansing . This suggests that they considered them potentially dangerous to handle. Perhaps we have here an example of a custom making an historical transition from the sacred to the profane, in the Māori language from *tapu* to *noa* [harmless]. The passage in Brunner's journal is instructive.

> "There is a particular tapu existing among the natives relating to the eel. You must wash your hands before going to catch them, and also on returning, and the bait must be prepared some distance from the house. There must be a distinct fire for cooking the eel, for which you must have a special tinder-box; your

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[9] The Māori word *tapu* has a very similar meaning as the English word taboo.

> hands and mouth must be washed both before and after partaking of them, and should it be necessary to drink from the same stream from which the eels are caught, you must have two vessels of water, the one to drink from, the other to dip from the stream. Whether this relates to particular places or not, I am not able to say, but I found it strictly adhered to at Okitika and Okarita and at the former place I had to walk half a mile for water, with a stream running within a few yards of our station" (Taylor, 1959: 274–275).

Taylor, who edited Brunner's journal for publication, observed in a footnote at this point: "Hokitika and Okarito, which he had not visited at this stage. In the *Nelson Examiner and New Zealand Chronicle*[10] this *eel-tapu* passage is placed much later, on 12 February 1848, when returning up the Grey River" (Taylor, 1959: 275). Brunner must have thought this matter of some importance when he found the custom to be more widespread, after he had travelled further south, and inserted the passage in the entry for the 19th April 1847, where he had first come across the behaviour among Māori.

Elsdon Best was obviously puzzled about this *tapu* cleansing behaviour amongst Māori, for he remarked:

> "A peculiar note comes from a South Island source [not identified by Best] to the effect that when about to set an eel-pot a Maori would wash his hands. 'If this act be neglected', says our informant, 'then no eels will enter the pot'. This may be so, but I cannot say that such a precaution ever came under my own observation. These punctilious eel-trappers must have died out before my time, or possibly the usage did not extend to the North Island... When exploring Westland in 1847, Brunner noted this superstitious practice among eel-fishers [citing Hamilton (1908: 69) as his source of information] (Best, 1977: 188–189).

Hamilton did not specify which manuscript he consulted for Brunner's observation, when he recounted these same details in his own publication (cited above). Unfortunately, we are now so far removed from the primary historical observations that we may never fully understand what was happening to Māori customs relating to eels after the first encounter with Captain Cook in 1769. However, there are indications in these stories which present an intriguing possibility – that in earlier times in New Zealand eels were *tapu*, and not considered as food (like to many places in tropical Polynesia), but for some reason this *tapu* was set aside, and eels became one of the most important sources of food for Māori, as was certainly the case in Tuhoeland, Wanganui, Taranaki, and Wairarapa in the 19th century.

Summary Observations on Eel Myths and Traditions

This review of myths and traditions concerning eels among the Austronesian peoples in the wider Pacific, from Melanesia, Micronesia, and Polynesia, reveal a number of common themes.

#1: The eel, either marine or freshwater, is the incarnation of a male deity and symbolises the penis.

#2: The personified eel tempts and defiles a woman sexually.

#3: A male, often an heroic ancestral figure, punishes the eel by cutting him up into pieces.

#4: There is a strong association of eels with danger.

#5: The eel is either venerated or feared and is certainly not considered food.

#6: In some societies, the arrival of Europeans resulted in the lifting of the taboo of eels as food.

It is hardly surprising that the Polynesians from the tropical Pacific who discovered and settled New Zealand in the last 1,000 years brought with them a raft of existing myths, customs, and cultural attitudes towards catching and eating freshwater and seawater eels. It is reasonable to conclude that the earliest immigrants to New Zealand brought with them an over-arching theme that eels were associated with divine beings, danger and fear, and not considered food. In the course of time in different areas, the oral traditions and myths diverged to varying degrees, so that many versions were recorded in the 19th and 20th centuries. In two recorded cases in the early historic period, one near Tauranga, and the other in Westland, eels were certainly considered *tapu* and not food. During the Brunner expedition, both the explorers and their Māori guides were starving and resorted to eating eels only after an elaborate *tapu* removing ceremony. However, for many parts of New Zealand eels

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[10] *Nelson Examiner and New Zealand Chronicle*, 14 October 1848, Page 3.

came to be a very important source of food. We suggest that at some stage in the cultural transformation of the New Zealand settlers from Polynesian to Māori eels changed from divine to ordinary, from *tapu* to *noa*, from non-food to food. Our view on how and when this transformation happened is discussed below.

THE CRANIAL OSTEOLOGY OF EELS

Identifiable Anatomy

For reasons described elsewhere (Leach, 1997), the bones most commonly chosen for systematic identification of fish from archaeological sites in New Zealand and the Pacific are five paired cranial bones and certain 'special' bones which are particularly characteristic of some species. The five cranial bones are: dentary, premaxilla, articular, maxilla, and quadrate, in order of their ease of identification to species[11]. The main osteological focus of this paper is the bones of the common species of eels that are found in New Zealand, rather than the wider Pacific, and tropical marine eels are not considered in this section except in passing. These are the two species of freshwater eel, and the marine conger eel (*Conger verreauxi*) in New Zealand. These bones are illustrated in Figure 7.

The bones of conger eel are very different from those of freshwater eels and present little difficulty of identification. However, the two species of freshwater eel are much more difficult to distinguish. The long finned eel, *Anguilla dieffenbachii*, grows to a much larger size than the short finned eel, *Anguilla australis*. So, assuming one can estimate the live fish size from bones using a suitable allometric equation, a specimen more than about 100 cm fork length is probably a long finned eel. However, there is an additional problem here, because the linear equations linking bone size and fork length appear to be different for the two species (discussed below).

Fortunately, there is another cranial bone with features by which each species may reliably be identified. This is the vomer. The distribution of teeth on this bone is quite different for the two species. Referring to Figure 7, it may be observed that in the case of the long finned eel the teeth continue posteriorally along the mid-line, tailing off to a narrow point. By contrast, in the short finned eel, these teeth are truncated anteriorally, and are rounded off, rather than narrowing towards the mid-line (See Figure 9).

It may be noticed in Figure 7 that the premaxilla is not illustrated. The reason for this is that eels do not have a separate premaxilla, and, unlike in many

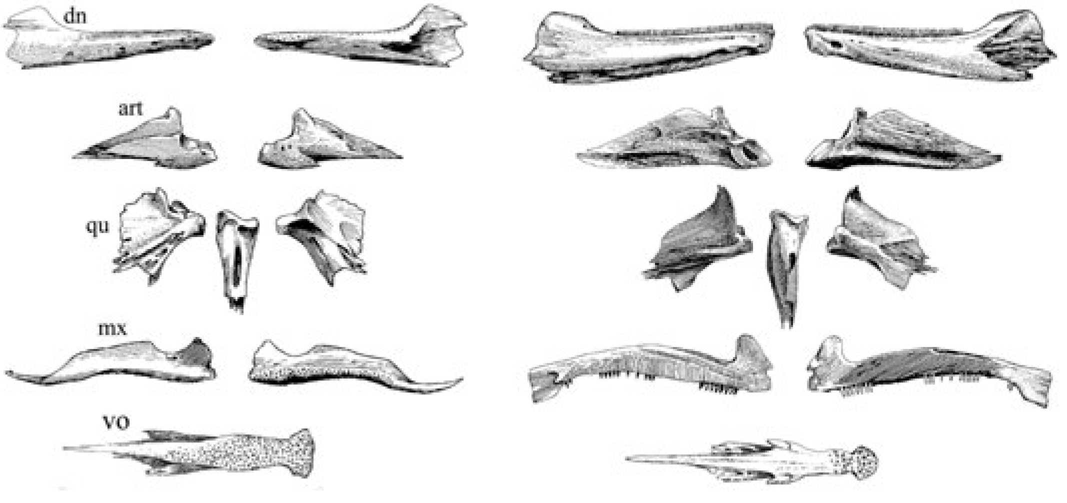

FIGURE 7

Commonly identified cranial bones of eels. Left: the long finned eel, *Anguilla dieffenbachii*. Right, conger eel, *Conger verreauxi* (abbreviations are listed at the end of this paper). Right elements are shown.

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[11] As Ford showed in 1937, eel vertebrae are very distinctive from other fish species, having an unusual housing for the spinal cord and lateral spines (Ford, 1937: 10, 51-52).

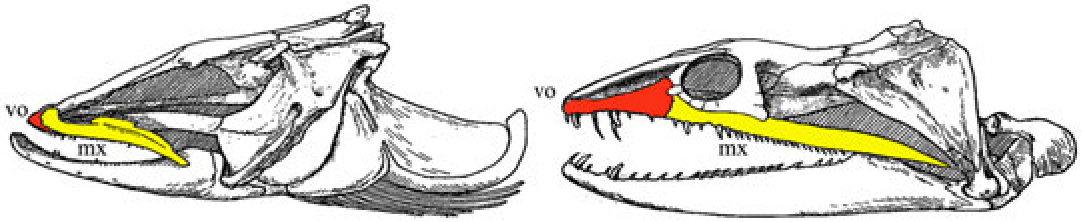

FIGURE 8

Cranial bones of a freshwater eel, Anguilla rostrata (left), and a marine moray eel, *Lycodontis funebris*, syn. *Gymnothorax funebris*, highlighting the vomer and maxilla bones, adapted from Gregory (1959: 202).

other fish species, the upper teeth are situated on the maxillary. This is clearly illustrated in Figure 8. In a detailed study of the development of the chondocranium of the freshwater eel *Anguilla vulgaris*, Norman (1926) described how the premaxillaries, the mesthmoid, and the vomer became fused to form a single bone in embrios:

> "No premaxillary bones are present in a specimen of 31 mm, but in larvae of 40 to 78 mm the rudiments of these bones are apparent. They lie above the rostrum, and have the form of incomplete bony tubes, each of which surrounds a sensory canal; these tubes unite posteriorly just in front of the mesethmoid bones" (Norman, 1926: 398).

The comparative cranial anatomy of the Order Apodes was studied in detail by Regan in his seminal paper in 1912. he defines the main cranial features of the entire order at the outset, before discussing each family in turn. He states:

> "Praemaxillaries not developed as distinct elements... praemaxillaries, mesethmoid, and lateral ethmoids represented by a single dentigerous bone", and "It can hardly be doubted that the dentigerous bone in front of the vomer and between the maxillaries represents the premaxillaries ankylosed to the mesethmod" (Regan, 1912: 378).

Regan added a footnote referring to Boulenger's contribution to *The Cambridge History* volume for additional information on the issue. Boulenger, in discussing the premaxilla in the Order Apodes states:

> "There has been much difference of opinion in the determination of the bones of the upper jaw in these fishes. Cuvier regarded the lateral bones of the upper jaw as praemaillaries, Owen and Richardson as palatines (at least in the Muraenas), whilst ...most recent authors have identified them throughout as maxillaries" (Boulenger, 1904: 599-600).

Boulenger, also footnotes this comment, referring to Jacoby's discussion on Moray eels. Jacoby describes the premaxillary to be "entirely wanting" in Muraenidae (Jacoby, 1867: 261). The only non 19th century comment we found on this isssue is that "the prexmaillary-ethmoid fusion is conventional for anguilliformes" (Robbins & Robbins, 1971:135).

Allometric Analysis

A sample of 99 modern eels was collected, 49 of the long finned eel and 50 of the short finned eel. Each was boiled down, the five cranial bones already described were extracted, and cleaned, and 20 measurements were made with calipers (Teal, 1974). The methods of measurement and metrical analysis follow a series of earlier publications on snapper, *Pagrus auratus* (Leach & Boocock, 1995), kahawai, *Arripis trutta* (Leach *et al*., 1996), barracouta, *Thyrsites atun* (Leach *et al*., 1999), blue cod, *Parapercis colias* (Leach *et al*., 2000). Labridae (Leach & Davidson, 2001), and red cod, *Pseudophycis bachus* (Leach *et al*., 2001), and need not be described further here. In the case of eels, the live total length and weight were measured, and then two measurements were taken on each of the four main cranial bones; one of the maximum length, which can be taken on whole specimens, and another appropriate to a fragment of the bone. Finally, two measurements were taken of the vomer. Thus there are two live measurements, two measurements on each of five bones, both left and right, totalling 22 data for each specimen. The anatomical landmarks used for the measurements are illustrated in Figure 9.

There was considerable difficulty in obtaining large specimens of the short-finned species, and

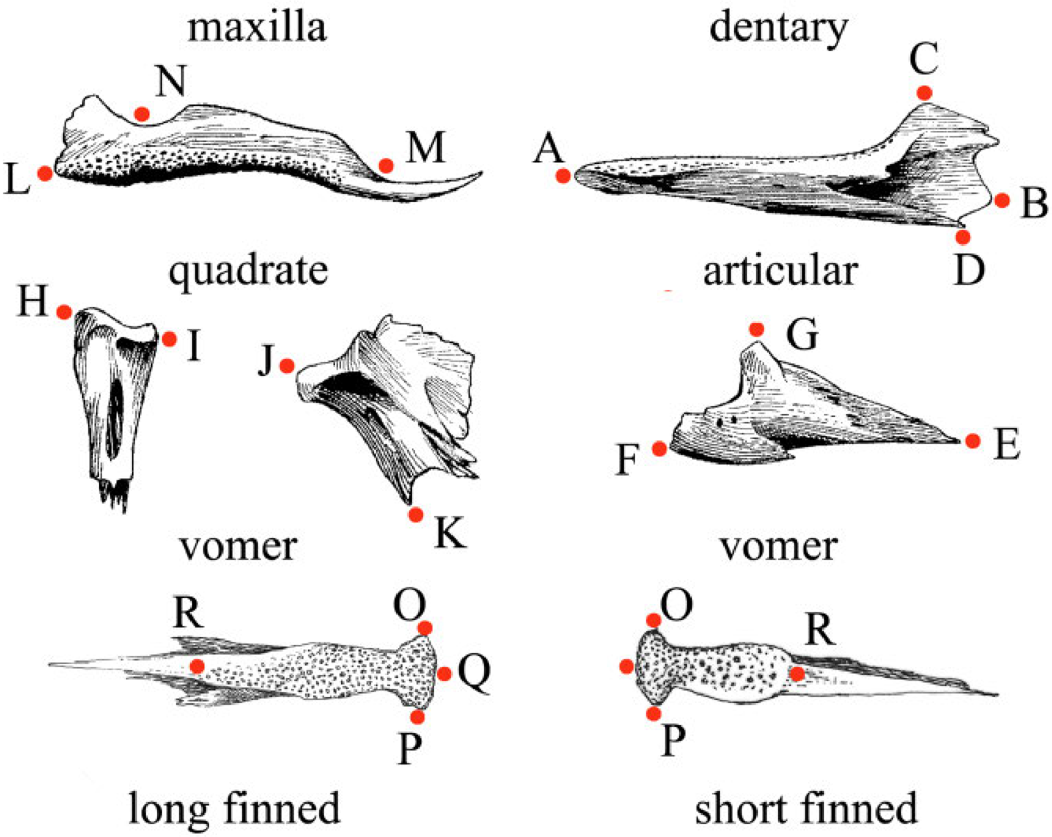

FIGURE 9

Landmarks for measurements on eel cranial bones. For the vomer, both species are illustrated. The remainder are the right elements of the long finned eel which is all but indistinguishable from the short finned eel. RD1=A-B, RD2=C-D, RA1=E-F, RA2=F-G, RQ1=H-I, RQ2=J-K, RM1=L-M, RM2=L-N, VO1=P-O, VO2=R-Q.

only one specimen greater than 600 mm was captured (847 mm).

The bone metrical data were subjected to statistical analysis, to determine the best allometric relationship between bone size and live fish length and weight. Least squares regression analysis was carried out on the measurements, using several models for best fit (linear, exponential, logarithmic, power curve fit, and cubic fit). We initially considered the two species separately, but found very little difference between them. In any event, with the exception of the vomer, the two species are virtually impossible to differentiate from bone anatomy. There was no choice but to combine the two sets of data during statistical analysis.

Deciding which model best fits the modern data could take into account one or more of three things: #1: the standard errors of the estimate for each model, #2: analysis of residuals for each, and #3: visual analysis of how well the various curves fit the modern data when plotted together. The third suggestion is particularly important, and should never be overlooked in this type of study. In this respect, it is useful to generate the line of best fit, and the two lines which show the boundaries of the standard errors of the line. When the modern data are plotted on a graph with these three lines, the success or otherwise of the model is usually much clearer than by simply examining the standard error or residuals.

In the case of reconstructing fork length from a bone dimension, there is good reason to think that a linear equation would be the best fit. However, when the modern data are unevenly spread through the size range, and dominated by smaller specimens, it has frequently been found in practice that some form of non linear curve captures the data better. In most of the previous studies of fish osteology cited earlier, a power curve was found to best capture the modern data. However, in the case of the eels, so few very large eels were able to be caught and measured that the accumulated data were very patchy across the size range. Neither linear nor power curve fit captured the distribution adequately, but an exponential fit did.

In the case of reconstructing live weight from a bone dimension there are good reasons for choosing a cubic function but, as with the above case, several models should be attempted, to make sure unequally distributed sized fish are all reasonably well captured. Once again, in previous studies, the power curve fit has been the most common model accepted after careful examination. However, in the case of eel bones, after examining both the statistics (standard errors and residuals), and a careful study of the graphs for each model, it was decided that the best fits were all cubic equations.

An example of the curves of best fit are plotted out in Figure 10 for the LD1 bone measurement, and the various constants for each bone measurement are provided in Table 4, together with the standard errors of the estimates. For example, the live length of an eel can be estimated from the left dentary maximum length measurement as follows:

$$\text{Live length} = 307.207 * \exp(0.0223*\text{LD1}) \pm 68.2$$

Similarly, the live weight can be estimated from the same bone measurement as:

$$\text{Live weight} = 0.029 * \text{LD1}^3 \pm 277.8$$

	Live Length			Live Weight	
Measurement	**Const A**	**Const B**	**SEE**	**Const C**	**SEE**
LD1	307.207	0.0223	68.2	0.029	277.8
LD2	324.969	0.0736	76.2	1.131	439.2
LA1	293.054	0.0358	65.8	0.108	278.8
LA2	314.366	0.0668	70.6	0.817	372.4
LQ1	354.666	0.1464	92.2	10.961	886.8
LQ2	293.670	0.0810	91.0	1.259	569.4
LM1	326.100	0.0313	74.8	0.084	626.3
LM2	305.459	0.1248	65.6	4.640	310.0
RD1	307.420	0.0223	69.0	0.029	297.6
RD2	330.552	0.0707	73.5	1.047	385.2
RA1	296.997	0.0349	66.0	0.104	268.6
RA2	313.568	0.0668	72.8	0.840	360.2
RQ1	353.225	0.1472	93.8	11.433	794.9
RQ2	295.235	0.0790	88.0	1.174	634.3
RM1	324.016	0.0313	75.2	0.082	638.7
RM2	303.621	0.1259	69.4	4.764	344.7
VO1	346.490	0.1022	110.2	4.333	999.7
VO2	351.533	0.0351	75.7	0.165	510.1

TABLE 4

Equations for estimating live length and weight from bone measurements of both species of eel.

As an example of the utility of these estimates, the LD1 measurement for a mid range specimen

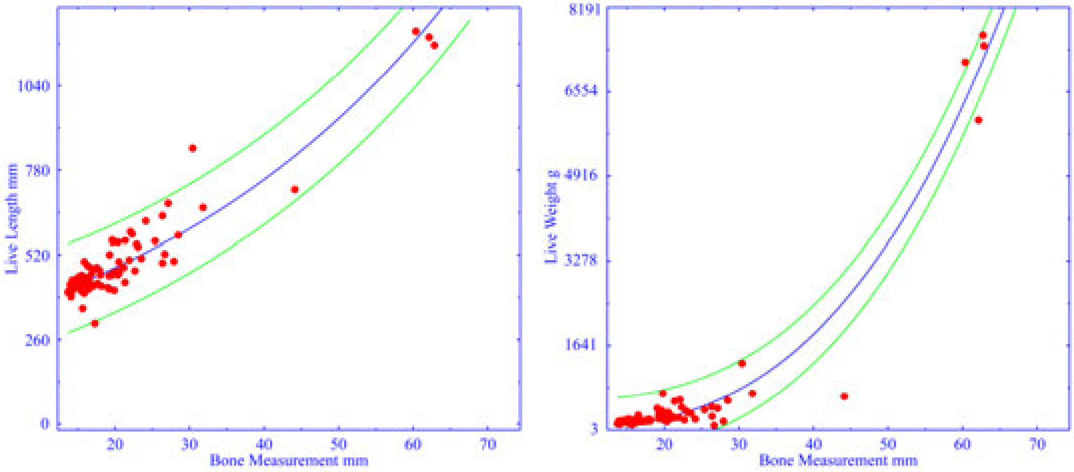

FIGURE 10

Scatterplot showing the typical relationship between the LD1 bone size and live fish size for the two species of eels combined. Left live length, right live weight. The line of best fit is the blue line, and the green lines show the standard error of the estimate across the size range.

(catalogue number FA539) measures 28.50 mm. It had a live length of 580 mm and the live weight was 578 g. Using the constants listed in Table 4, the estimated length and weight for this specimen can be calculated as 580.03 mm and 671.32 mm respectively. The difference between real and calculated length is minimal, and for weight 93g.

Although these are very satisfactory results for an individual specimen, the scatterplot shown in Figure 10 suggests that not all eel specimens will conform as well as this. In particular, live weight will depend a great deal on the condition of specimens, since eels can accumulate considerable oil reserves when food is abundant. In addition, there are likely to be differences between male and female specimens that cannot be determined from bone anatomy. These differences are reflected in large standard errors of the estimates for weight in Table 4, which averages about 500 g, and is as much as 1000 g in the case of vomer measurements.

It has to be accepted that estimating live body weight of eels directly from bone measurement is not easily accomplished. This is most unfortunate, because calculating the caloric contribution to palaeo-diet from faunal remains is an important objective in economic archaeology.

Excavation	**Anguilliformes**	**Muraenidae**	**Anguillidae**	**Subtotal**	**Total**
Kapingamarangi	2	194	-	196	4260
Palau	-	94	-	94	7605
Nan Madol, Ponape	-	50	-	50	3182
Kaloko, Hawaii	-	-	32	32	262
Fais, Caroline Is	-	-	21	21	5183
Ngaaitutaki, Mangaia	-	-	20	20	236
Tiouande Site 5, New Cal	-	10	7	17	631
Fa'ahia Sinoto excavation	-	7	5	12	1708
Vaito'otia	-	7	4	11	1639
Fa'ahia Navorro excavation	-	1	8	9	2277
Rota	-	8	-	8	519
Tiouande Site 14, New Cal	3	4	-	7	110
Motupore	-	5	-	5	2305
Hane, Ua Huka, Marquesas	-	2	2	4	1246
Taumako	1	2	-	3	327
Tiwi Cave, New Caledonia	-	1	2	3	852
Motupore, PNG (Groube)	-	-	3	3	2880
Tepaopao, Mangaia	-	-	2	2	7
Dongan, PNG	-	-	2	2	207
Cikobia, Site 037, Fiji	-	-	2	2	36
Anaio, Ma'uke, Cook Is	-	-	2	2	266
Yalu, Malekula, Vanuatu	-	-	1	1	2
Ponamla, Erromanga, Vanuatu	-	-	1	1	141
Mangaas, Efate, Vanuatu	-	-	1	1	259
Lapita, New Cal, Sand	-	1	-	1	651
Erua, Mangaia, Cook Is	-	-	1	1	25
Nukuoro	-	-	1	1	1599
Totals	**6**	**386**	**117**	**509**	**38,415**

TABLE 5

Twenty-seven archaeological sites in the tropical Pacific region containing eel bones at various taxonomic levels of identification. NISP values.

From the foregoing, the method outlined above for estimating live weight from bone dimensions is a one step process, where the equations are established from the available osteological comparative collection (N=99 specimens). An alternative would be to use a two step process, estimating live length from bone dimension and then using well established formulae for estimating eel weight from live length, which are based on much larger samples. For example, Jellyman *et al.* (2013: 453, 455) presents the equation:

$$W = A*L^B$$

Where W = weight in g, and L = length in mm, and the constants A and B are 4.905 x $10^{-7}$and 3.224 for the short finned eel, and 3.624 x 10^{-7} and 3.307 for the long finned eel respectively. These

Excavation	***Anguilla* spp.**	***Conger* spp.**	**Sub-total**	**Total**
Mana Island North	0	118	118	3949
Washpool Site	55	6	61	1562
Foxton	66	-	66	5504
Parewanui Midden	55	0	55	211
Black Rocks BR4	0	20	20	1678
Te Ika a Maru, Flat	0	16	16	531
Chalky Is	0	13	13	158
Breaksea Sound 1	0	11	11	5795
Paremata	0	9	9	569
Southport 1	0	8	8	1050
Southport 4, Cave	0	7	7	205
Long Island, Dusky	0	7	7	440
Cascade Cove, Dusky	0	7	7	230
Southport 6	0	6	6	470
Makara Beach Midden	0	5	5	82
Titirangi Sandhills,	0	4	4	87
Te Ika a Maru, East Flat	0	4	4	201
Southport 7	0	4	4	218
Black Rocks BR3	0	4	4	353
Black Rocks BR2	0	4	4	275
Wakapatu	1	2	3	289
Mana Island South	0	3	3	2431
Hot Water Beach	3	0	3	915
Southport 5, Cave	0	2	2	250
Shag River Mouth	2	0	2	8004
Tiwai Point	0	1	1	226
Titirangi Cattleyard	0	1	1	33
Sandhill Point 1	0	1	1	954
Makotukutuku M3	0	1	1	39
Coopers Island	0	1	1	481
Totals	**116**	**265**	**381**	**37,190**

TABLE 6

Twenty-nine archaeological sites from New Zealand containing bones of either freshwater eels or marine conger eels. NISP values. NB: The total NISP for Foxton was published as 4,109 in Davidson *et al.* (2000: 79). Since then, additional analyses were made, increasing the total to 5,504.

constants were established from huge samples of the two species (N=34,891 and 41,070). Unfortunately, no similar equation is available for the two species combined.

The two-step option is certainly the best option, however, with the exception of the vomer bone, the two New Zealand species cannot be differentiated from their cranial anatomy. Therefore, with the exception of the vomer, each bone measurement yields two estimates of the live weight, appropriate to each species.

On the whole, this metrical study of the bones of a comparative collection of modern eels has not been as definitive as past studies of other species of New Zealand fish. It proved very difficult to obtain large specimens of both species, and almost impossible for short finned eels. As can be seen from Figure 10, there are large gaps in the size range, which is anything but evenly distributed. However, this study represents a starting point that hopefully can be built upon in future.

The procedure outlined above was used to study archaeological collections from New Zealand and the Chatham Islands that have yielded eel bones, and results are discussed below.

EEL BONES IN PACIFIC AND NEW ZEALAND ARCHAEOLOGICAL SITES

Over a period of years from 1987 to 2001 a small staff of researchers at the Archaeozoology Laboratory at the Museum of New Zealand Te Papa Tongarewa identified (and in some cases re-identified) the fish remains from a large number of archaeological sites from the tropical Pacific, the Chatham Islands, and New Zealand. The precise locations of sites mentioned here are provided in an appendix in Leach (2006: 331 ff). Extensive comparative material was available on specially prepared boards organised anatomically for ease of identification. The methods of analysis and identification were carefully controlled and are described in detail elsewhere Leach (1986). As pointed out earlier, there are two species of freshwater eel in New Zealand. With the exception of the vomer, the cranial anatomy of these two species are difficult to distinguish. During analysis of archaeological collections careful attention was paid to vomers for this reason. In most cases, fragmentation made species determination impossible, but at Foxton five could be identified – four were *Anguilla dieffenbachii*, and one was *A. australis*. At the Waihora site in the Chatham Islands, 16 vomers were *A. australis,* and one was probably *A. dieffenbachii*.

The NISP values for these three groups of excavations are provided in Tables 5, 6, and 7. The total number of identifications in these tables and the sites without eel bones is 188, 351.

Excavation	***Anguilla* spp.**	***Conger* spp.**	**Sub-total**	**Total**
Waihora	54	88	142	22249
Kahiti South	84	18	102	503
Kahiti North	8	1	9	268
CHB	2	4	6	31704
Ohinemamao	2	-	2	27
CHA	-	-	0	3819
CHC	-	-	0	5
Te Ngaio	-	-	0	5
Pokiakio	-	-	0	8
Totals	**150**	**111**	**261**	**58,588**

TABLE 7

Archaeological sites from the Chatham Islands containing bones of either freshwater eels or marine conger eels. NISP values.

EELS IN ARCHAEOLOGICAL SITES IN THE TROPICAL PACIFIC

In the Pacific region there are many species belonging to the Order Anguilliformes, and comparative material is limited. Some specimens were unable to be identified with certainly as Muraenidae and are listed as Anguilliformes. However, both moray eels (Muraenidae) and freshwater eels (Anguillidae) are reasonably easy to distinguish, and are differentiated in Table 5. It is important to note that moray eels are implicated in numerous modern examples of ciguatera poisoning, and the threat is considered serious enough for the general warning "the public should be repeatedly warned to avoid eating moray eels" (Chan, 2017: 1). Although the head, skin and viscera (especially the liver) are considered the most dangerous parts of the animal, eating the flesh can also be fatal (Chan, 2016: 708). Disturbance of coral reefs during stormy weather is known to increase the toxicity of species susceptible to accumulating ciguatera in their tissues (ibid.).

In spite of the dangers of eating moray eels, they are highly nutritious. One nutrient analysis shows 57.8% by weight crude protein, and 14.1% fat (Goodman-Lowe *et al*., 1999: 139).

The following 37 Pacific excavations produced no eel bones at any level of taxon. The total NISP of identified fish bones in each collection is given in parentheses. The **NISP Grand Total = 6,630**.

Tinian (1,038), Mouli B, Loyalty Is (962), Hnajoisisi, Hna Cave, Loyalty Is (954), Cikobia, Site 006, Fiji (711), Kosrae (404), Rurutu (354), Mouli A, Loyalty Is (270), Rota-SIU (261), Hnajoisisi, Loyalty Is (257), Guam (254), Ponape (247), Vatcha Site Ch1 New Caledonia (183), Cikobia, Site 001, Fiji (154), Nikunau Island, Kiribati (135), Arapus, Efate, Vanuatu (86), Hnenigec, Loyalty Is (57), Cikobia, Site 005, Fiji (47), Navatu, Fiji (46), Pwekina, New Caledonia (45), Peete, Loyalty Is (40), Ifo, Erromango, Vanuatu (31), Vatcha Site Ch2 New Caledonia (20), Kurin, Loyalty Is (19), Woplamplam, Malekula, Vanuatu (13), Navaprah, Malekula, Vanuatu (11), Vatcha Sondage A New Caledonia (7), Malua Bay, Malekula, Vanuatu (6), Cikobia, Site 04, Fiji (4), Vatcha Sondage C New Caledonia (3), Vatcha Sondage B New Caledonia (2), Nonime, Loyalty Islands (2), Keny, Loyalty Islands (2), Wambraf, Malekula, Vanuatu (1), Ndavru, Malekula, Vanuatu (1), Cikobia, Site 090, Fiji (1), Cikobia, Site 087, Fiji (1), Cikobia, Site 047, Fiji (1).

EELS IN ARCHAEOLOGICAL SITES IN NEW ZEALAND

The most common species of freshwater eel in New Zealand and the nearby Chatham Islands is the short finned eel, *Anguilla australis*. The long-finned eel, *Anguilla dieffenbachii*, attains a much greater length and tends to be further inland. There are more than 20 species of seawater eels in New Zealand coastal waters, most are deep in northern warmer waters, and have yet to be identified from archaeological sites. The most common seawater eel is *Conger verreauxi*, and this is found in many sites.

Also significant, the following 42 New Zealand excavations produced no eel bones at any level of taxon. The total NISP of identified fish bones in each collection is given in parentheses. The NISP grand total = 47,528.

Long Beach (34,035), Kokohuia (2,578), Sandhill Point 3 (2,341), Cross Creek (1,980), Fox River (695), Sunde Site (610), The Glen (580), Station Bay Pa (532), Omihi (508), Midden 8, Matakana (485), Port Craig Cave (445), Takahanga Post (417), Ross's Rocks (403), Sandhill Point (286), Harataonga Bay (214), Te Kiri Kiri (209), Taiaroa Head (170), Peketa Pa (136), Tumbledown Bay (119), Panau (113), Port Jackson (108), Hudson's Site (94), Black Rocks Fan (81), Davidson Undefended (79), Papatowai (70), Port Craig (54), Makara Terrace (44), Lee Island (31), Leahy Undefended (29), Milford (19), Parangiaio (17), Southport 8 (13), Harataonga Bay Pa (9), Makotukutuku M1 (5), Sandhill Point 2 (4), Goose Bay Midden (4), Titirangi Pa (3), Southport 9 (2), Port Craig1 (2), Port Craig2 (2), Garden Island (1), Breaksea Sound (1).

EELS IN ARCHAEOLOGICAL SITES IN THE CHATHAM ISLANDS

Information on fish catches from nine excavations are in the database at present. The archaeological sites are Waihora (Sutton, 1989); CHA, CHB and CHC (Smith, 1985); Kahiti North, Kahiti South, Te Ngaio, Ohinemamao, and Pokiakio (McIlwraith, 1976). The NISP values are given in Table 7. Four sites which did not contain any eel bones are included in the table.

It is abundantly clear from these tabulated results that eels were only rarely caught by pre-European people in the Pacific and New Zealand. The total number of freshwater eel bones identified was 383, which is a mere 0.2% of the total NISP (188, 351). Marine eels are about twice as abundant with a total NISP of 768, or 0.4% of the total. Even so, this is a very small number.

Only two archaeological sites stand out as having more than average eel bones. These are Kapingamarangi, with 4.6% marine eels, and the Parewanui site which has 26.1% freshwater eels. The alternative measure of abundance of Minimum Number of Individuals (MNI) gives a value of 5.4% for Kapingamarangi, and 53.7% for Parewanui (Leach, 2006: 189). Regardless of which measure is used, these two sites stand well out from others in having far greater relative abundance than any other sites. The Parewanui site is close to historically recorded eel channels and was radiocarbon dated to <250 years (NZ7354, Cassels *et al*., 1988: 120).

LENGTH AND WEIGHT ESTIMATES OF EELS FROM BONES

Measurements were made on as many as possible of the bones of freshwater eel in the sites listed above, and using the allometric equations discussed earlier (constants in Table 4), estimates were made of the corresponding length and weight of each fish represented in these sites. The total number of measurements able to be made was 169 (Washpool 49, Parewanui 42, Foxton 37, Kahiti South 32, Kahiti North 7, and Wakapatu 2). It may be noticed that these numbers are a little lower than the NISP values given in Tables 6 and 7. This is because some bone fragments, although identifiable to genus, did not possess the anatomical landmarks necessary for measurements to be made.

The length and weight ranges of these eels is given in Figure 11. The most abundant eels are in the size range of 430 to 500 mm, which is quite small. The largest eel is estimated to have been 1323 mm, and to have weighed c. 8251 g. The weight of this large eel may also be estimated using Jellyman's formulae for each of the two species, cited earlier. Thus, the specimen with length of 1323 mm would have been either circa 5684 or 7624 g using their two formulae. Our value of 8251 is either 2.5 kg or 0.6 kg too heavy depending on whether the bone belonged to short or long finned species. Clearly for large eels, there can be significant errors in estimating live body weight from archaeological bones, largely because of our inability to determine which species is present.

SPECIFIC SITES FROM THE TROPICAL PACIFIC

The results above from 144 sites scattered through the Pacific and New Zealand were all studied in the Archaeozoology Laboratory at the Museum of New Zealand using strictly comparable methods.

A few of these stand out for additional comments below (Tikopia, Nukuoro and Kapingamarangi), but before doing so there are a few additional studies in the Pacific that deserve mention, even though in some cases the methods of analysis are not quite the same as those summarised above. The sites in question produced significant numbers of eel bones.

Rapanui and Rapaiti

These two islands are well below the tropics[12], Rapanui (Easter Island) lying at 27°10'S and Rapaiti at 27° 35'S. As such, their marine fauna are con-

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[12] The southern border of the tropics is considered to be 23° 26'S.

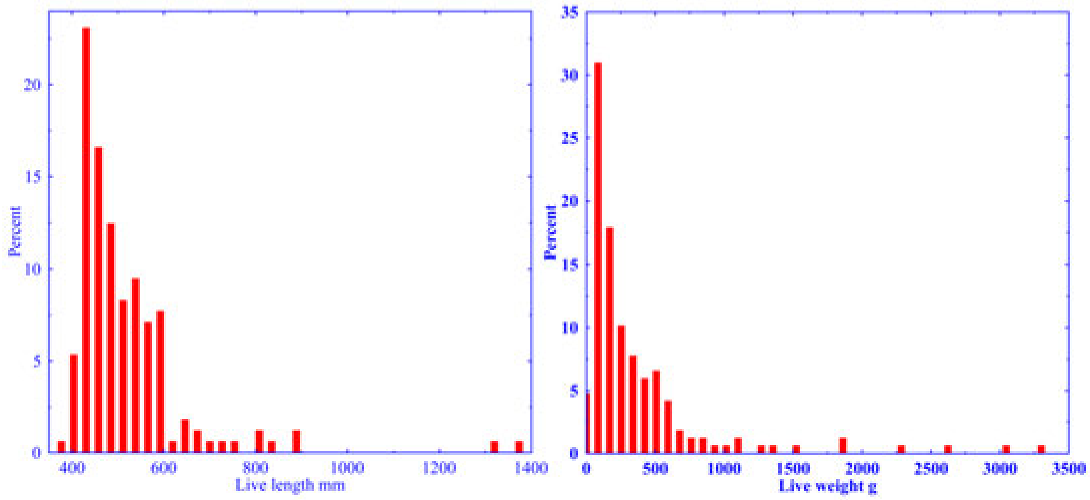

FIGURE 11

Size-frequency distribution of catches of eels present in New Zealand and Chatham Island archaeological sites (N-169). The right hand graph is truncated at 3.5 kg (see text).

siderably different to those of the islands considered above. Neither island has a fringing reef, so there are more limited opportunities for inshore fishing than around islands in the tropics.

Ayres documents eels in considerable numbers in his excavations on Rapanui. He combines the abundance figures for three families of eels together (Muraenidae, Congridae, and Brotulidae[13]) in his tabulation as 28.6%, 26.2%, and 23.2% of the total fish catches by MNI, for sites Runga Va'e (12-1), Papa te Kena (34-2) and Anakena (35-7) respectively (Ayres, 1985: 123). The total MNI for these three sites was 76, 626, and 194). He also did some measurements on dentaries (type of eel not specified), and obtained mean values of 24.7, 25.2, and 24.5 mm for the same three sites (N=15, 90, and 30, ibid.: 112). Without knowing what type of eel these measurements refer to, the live fish length cannot be estimated. By way of comparison, the average dentary length for the New Zealand ling is about 70 mm. In spite of the preliminary nature of Ayres' study, these records from Easter Island are very significant, and certainly show that the people living there in the past targeted marine eels in their fishing activities.

Recent research at two moai in Rano Raraku on Rapanui also produced bones of marine eels. Muraenidae were 6.9% of a total NISP of 434 Teleostei bones in the pre-contact era, and 10.3% of a total NISP of 408 bones in the post-contact period. One bone of Congridae was also present in both time periods (Wake, 2021, and Wake, 2021 pers. comm.). Although these more recent results are derived from much smaller samples than Ayres' study, and come from quite different cultural contexts, they certainly show that marine eels were a significant food source for prehistoric people on Rapanui. Freshwater is strictly limited on the island, so a population of freshwater eels would not be sustainable.

Much more information about ancient fishing is available from Rapaiti (commonly known as Rapa).

Anderson, in his paper on the ethnohistory of Rapa, has several useful observations on eels. In a passage referring to Stokes' unpublished manuscript (Stokes, n.d.) he states:

> "Freshwater eel occurred commonly but was not eaten. In 2002, large freshwater eels were abundant in the streams and taro ponds and still were not eaten. Local people have a legend about a guardian spirit in the form of a blonde-haired woman who changes into an eel, which accounts for it not being killed or eaten... Marine eels were snared in the coral-reef shallows by women. They used two sticks, one of which held a bait, and the other a slip noose" (Anderson, 2012: 42).

Moray eels can be quite dangerous, and this proposed method of capture would not be without risk. Again citing Stokes' unpublished manuscript: "Following snaring, the eel was dashed against the rocks to kill it" (Szabo *et al.*, 2012: 153).

We can't help wondering if this woman who changes into an eel is a somewhat distorted 'folk memory' of the story of Hina and the eel, so widespread throughout Polynesia. A version of this myth even occurs on Rapanui where, unlike Rapaiti, freshwater eels are not present. Métraux notes that *tuna* is considered to be a man on Rapanui.

> "Of extreme importance is the mention of Riri-tuna-rai as the female being who, with Atua-metua, conceives the coconut (niu). Here is a faint suggestion of the wide-spread Polynesian myth of the origin of the coconut which grew from the head of an eel (tuna), the lover of Hina. A version of this myth is present in Mangareva, but as fresh-water eels do not exist in these islands, Tuna is considered there as Man. On Easter Island there are no fresh-water eels or coconuts, and the name niu is given to the fruit of the *Thespesia populnea*, but the chant has retained the traditional association of the eel with the coconut" (Métraux, 1940: 323).

While the archaeological sites on Rapaiti produced no bones of freshwater eels so far, those of marine eels are present in considerable number. As Vogel observed:

> "The large number of marine eels present in the Rapan assemblages, particularly those from Tangarutu, is also somewhat anomalous. This is unlikely to be due to methodology, as MNIs for these were based on the five paired mouth parts for both Congridae and Muraenidae. Rather, it seems likely that the environmental conditions on Rapa resulted in eels being more easily accessible, or perhaps more plentiful, than those families usually more favoured by Polynesians" (Vogel, 2005: 93).

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[13] Brotulidae is classed as a sub-family of Ophidiidae (cusk eels) by Nelson (1994: 225). The New Zealand ling (*Genypterus blacodes*) is an example of a cusk eel and features as a minor component in prehistoric fish catches there (Leach, 2006: 62).

She also notes a significant change in the relative abundance of Muraenidae eels over time at the Tangarutu site. This is clearly seen when either the MNI or NISP values are tabulated (Vogel, 2005: 80-85, and Vogel, 2012: 118-123). From her MNI and NISP values, possible changes through time can be plotted out with appropriate standard errors (discussed earlier) in Figure 13. The Tangarutu site has a time depth of c. 500 years (Vogel, 2012: 126). Vogel offers a number of hypotheses for these observed changes through time.

Rapaiti is an interesting case, where there is a clear differentiation between freshwater and marine eels – one being avoided (*tapu*) and the other being acceptable as food (*noa*).

Aitutaki, Cook Islands

Some very interesting results have been obtained from four excavations on this island. The Ureia site produced 52 bones of Muraenidae from a total NISP of 2930 (1.8%), the Hosea site, 48 from 931 (5.2%), the Aretai site, 9 from 319 (2.8%), and 1275 from 11,183 (11.4%) from the Moturakau site (Allen, 1992: 546-550). The first three sites are situated on open air living spaces, while the latter is a rock shelter on an outlying islet. The high proportion of moray eels from the rockshelter, contrasting with the open sites, raises an issue of site functionality. The main source of food energy in the Cook islands is carbohydrate from taro. This is not available on the islet of Moturakau, so an alternative calorie-rich source of food had to be found for anyone living on this islet for any length of time. The fat-rich reserves in moray eels would help to provide this.

Mangaia, Cook Islands

The Tangatatau rock-shelter on Mangaia was studied by Butler (2017). Although Butler's methods are not exactly the same as those at the Museum of New Zealand, they are close enough for direct comparison with the above site data. One small point relating to methodology is her comment that the eel "premaxilla is extremely reduced in size and lacks distinctive features; none were identified from the site" (Butler, 2017: 104). As described earlier, eels do not develop a separate premaxilla during the embryonic stage of development. This is the reason none were found at Tangatatau. The Tangatatau site consisted of 19 stratigraphic zones. Sixty ^{14}C dates establish a chronology from the earliest zone 1 to the latest zone 17, from circa 1,000 AD to the historic period (Weisler *et al*., 2016: 8151). Mangaia

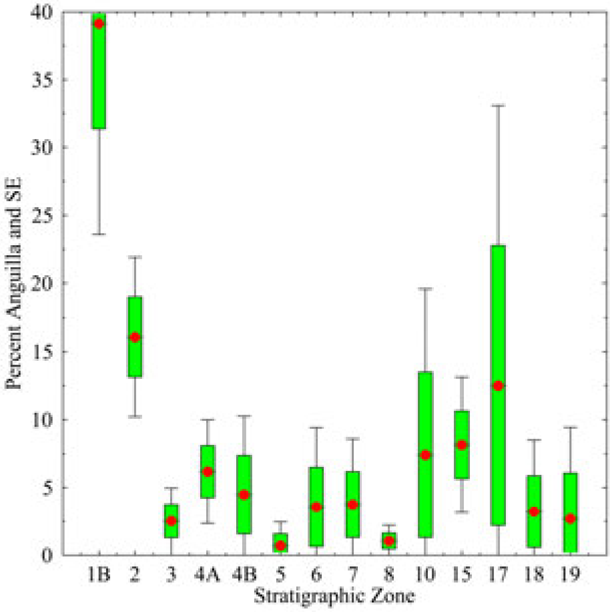

FIGURE 12

Relative abundance of freshwater eels at the Tangatatau site on Mangaia (NISP) over time. Zone 1 is c. AD 1000, through to Zone 19 in the historic period. The standard error is also shown.

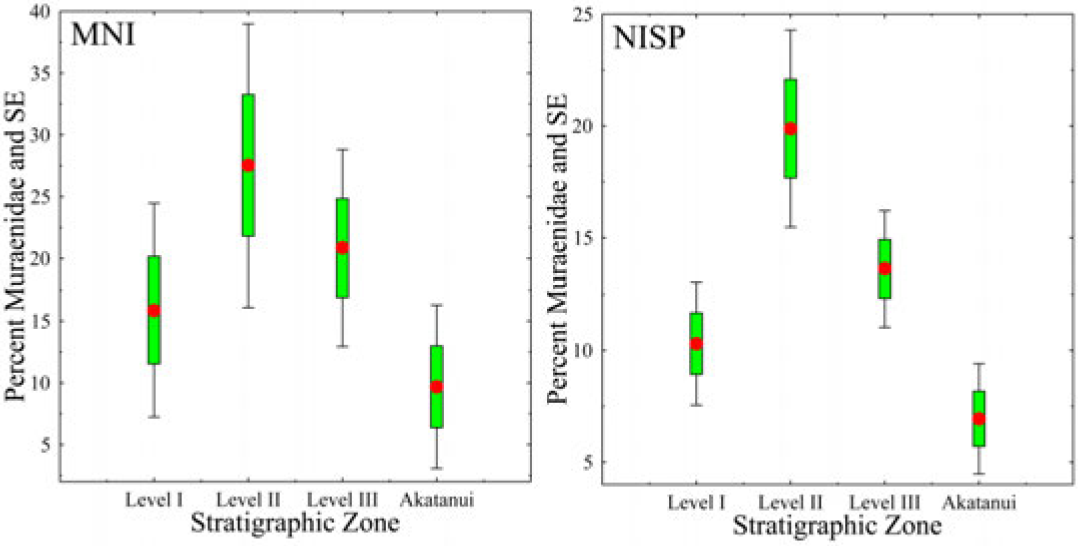

FIGURE 13

The relative abundance (with standard error bars) of Muraenidae through the stratigraphic sequence at the Tangarutu site, followed by the Akatanui site.

is a volcanic island with an elevated limestone reef around it (makatea[14]). Between the makatea and the rocky island there are many swamps; these are very suitable habitats for freshwater eels.

Butler identified 92 bones of freshwater eel. The total NISP of all fish species was 1649, so eels represent 5.6% overall. The most common bones were dentaries (47). The frequency through the history of the site is illustrated in Figure 12, using data from Butler (2017: 118-199). The error bars are 68 and 95% confidence limits of a proportion (also known as the standard error of a proportion), and follows Snedecor & Cochran (1967: 210–211; also see Leach & de Souza, 1979: 32).

Butler observed no appreciable change in size throughout the 1,000 year long sequence (Butler, 2017: 132, figure 7.12 upper), and she did not pay much attention to the possibility of change through time of eel capture, but our graph (Figure 12) does suggest the possibility that eels were more favoured than other fish earlier in the sequence and declined towards the historic period [see also Butler (2017: 127, figure 7.9 upper)]. Bones from sea-eels (Muraenidae) number 59 NISP (c. 3.6%), and were clearly less important.

Of interest is Butler's observation that the eels caught by the prehistoric people on Mangaia were very small specimens. She notes that a modern specimen almost 500 mm long had a dentary height measurement of 3.1 mm. The mean dentary height of the archaeological specimens was less than half of this modern specimen at 1.37 mm, and the largest dentary height was 2.01 mm. Butler notes that on the nearby makatea island of Mitiaro the modern eels are of comparable size to those on Mangaia. According to Jellyman the species on Mitiaro is *Anguilla obscura*. He caught 264 eels from the inland lake there. The smallest was 337 mm and the largest 780 mm, average 538 mm (Jellyman, 1991: 366). In our own comparative collection of 99 specimens, described above, the smallest dentary height measurement was 3.87 mm, corresponding to a live eel measuring 430 mm long. So, the Tangatatau archaeological eels are certainly very small indeed.

Butler suggests two possibilities for their small size – that the eel population had been depleted by earlier occupants on Mangaia, resulting in smaller size. Alternatively, that hillside erosion resulting from intensive horticulture had reduced the aquatic habitat, preventing eels from reaching their full potential size (Butler, 2017: 131, see also Kirch *et al*., 1995: 56). To these can be added another possibility, that small eels were considered food, but large ones were treated as *atua* by the prehistoric Mangaian people.

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[14] The makatea is attributed to a fall in sea level in the late Holocene, circa 3400 yres BP (Yonekura, *et al*., 1988).

Tikopia in the Solomon Islands

Another important archaeological find of eels in the Pacific was on the island of Tikopia. In this case of sea-eels, not freshwater eels. It will be recalled from the discussion of myths and oral traditions on Tikopia that the idea of eating both kinds of eel was considered disgusting, because of a strong association of eel with a deity representing the penis. Archaeological excavations, however, revealed bones of marine eels in the early part of the archaeological sequence, but not later. Kirch and Yen document 133 Muraenidae identifications from of a total NISP for marine fish bones of 5,788, or 2.3% overall (Kirch & Yen, 1982: 286). The provenance of these bones is confined to the Sinapu and Tuakamali phases, between 900 BC and before about AD 1700 (ibid.: 286, 292), and they are certainly not present in the more recent provenances. The same pattern occurs with the porcupine fish, *Diodon hystrix*, which, like marine eels, modern Tokipians refuse to eat. Kirch and Yen provide a compelling argument that the strong *tapu* against eels which Firth describes in detail during the historic period was not in place in earlier times on Tikopia. Kirch and Yen speculate that the *tapu* may have been imposed because of an outbreak of ciguatera poisoning on the island, something that can effect a number of fish types including morays and porcupine fishes. It is important to note that Kirch and Yen consider that the cultural facies they attribute as ‘Polynesian’ begins during the Tuakamali phase, at a time when eels and porcupine fishes were still considered food. The prohibition appears late in the Tuakamali phase.

We should note in passing that these archaeological findings are confined to marine creatures (moray eels and porcupine fish), and not freshwater eels. There are plenty of freshwater eels on Tikopia, but they were not found archaeologically. Raymond Firth’s comments about the Tikopian’s horror of eels was directed at both freshwater and marine eels. The absence of freshwater eels in the archaeological sites on Tikopia suggests that the people differentiated between marine and freshwater eels in the past – one was food and the other was not.

What is singularly important in this example from Tikopia, covering a period of 3,000 years, is that food prohibitions and taboos are cultural norms that can abruptly change, and, with careful analysis, can be documented archaeologically.

Nukuoro and Kapingamarangi in the Caroline Islands

The eel remains on these two Polynesian outliers deserve additional attention. Kapingamarangi is one of the most isolated islands in the Pacific, just north of the equator, and Nukuoro is its nearest neighbor, 215 km distant.

Although the languages on both islands are Polynesian they are rather dissimilar (Leach & Ward, 1981: 86). Both have similar time depth of human occupation, around 700-1,000 years. Both being atolls, there is very limited habitat for freshwater eels, although both have significant areas devoted to swamp taro, so it is possible *Anguilla* spp. could take up residence in these. The marine lagoon on Nukuoro is considerably deeper than on Kapingamarangi, but other than that the marine environments and fishing opportunities are very similar. Archaeological excavations on Nukuoro reached a maximum depth of 2.9m, and 4.1m on Kapingamarangi. Only one Anguilliforme[15] bone was found in the excavations on Nukuoro in a total fishbone NISP of 1,599 (0.06%). On Kapingamarangi, however, 196 Anguilliforme bones from a total fishbone NISP of 4,260 (4.6%) were recovered (Table 5). The sites on both islands are very similar, coral gravel house floors built up over centuries, as people refurbished their floors with clean gravel brought in baskets from surrounding islets at low tide.

During historic times, the people on Kapingamarangi specifically targeted marine eels, and made elaborate traps for catching them. During his research on the island, Peter Buck commented of fishing in general “The best for eating is said to be the sea eel, and to judge by the number of sea-eel traps seen in the canoe sheds, this must be true” (Hiroa, 1950: 48). He describes the manufacture of these eel traps in considerable detail (ibid.: 255-256, 265). No such behavior has been observed on Nukuoro in the historic period.

Such an enormous difference between two such similar islands, so close together, both occupied by

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[15] The reason why this high level taxon is used here is that identifications of fish remains on these two islands involved different taxonomic levels. The one bone on Nukuro was *Anguilla* sp.; whereas on Kapingamarangi, most bones were from Muraenidae, while two bones belonged to two different unidentified Anguilliforme families.

Polynesians for a similar length of time, can only have one explanation – that the cultural attitude towards eels was totally different between the two islands. It must surely put to rest once and for all that the absence of eel bones in archaeological sites in areas where they are locally available reflects one and only one reason – that the people did not consider eels as food.

The fish remains from Kapingamarangi were recovered from four sites, and the stratigraphy in each was divided into four periods: Level I 1000–700 BP, Level II 700–300 BP, Level III 300–100 BP, and Level IV 100–present (Leach & Ward, 1981: 52, figure 35). The proportion of eels in each period are graphed in Figure 14. In Level I the total MNI is only 39, so the standard error is huge and not graphed. The average percent of MNI for the other three periods is 10.0%. No obvious change through time is indicated. Note that in Table 5 NISP figures are given, and the overall percent of eels by this method is 4.6%.

SPECIFIC NEW ZEALAND SITES

Turning now to a final few New Zealand archaeological examples relating to eels – Fox and Cassels reported an MNI of one freshwater eel from their excavation at the Aotea site, Waikato, alongside 10 snapper (Fox & Cassels 1983: 102). The site dates to about 400 B.P.

Pricket comments about his excavation at Raupa in the Firth of Thames: "In the midst of a very large area of swamp and waterways eel was almost certainly of importance, as would have been snapper and other fish of the Hauraki Gulf (Prickett, 1990: 145). Unfortunately, the excavation produced rather few remains of fish, but there was one possible identification of eel in Area V (ibid.). This site is late pre-European in age, and it is a great pity that more fish remains were not recovered to shed light on the relative abundance of eel remains.

One archaeological site where eel bones could be expected to have been abundant is the swamp pa called Kohika, in the Bay of Plenty, occupied between AD 1610 and 1810 [95% confidence limits, see Irwin & Jones (2004: 80)]. As Irwin points out:

> "Though finds of eel bones in New Zealand sites are rare, it might have been expected that Kohika, surrounded by streams and lakes, would produce some. This has proved not to be the case, however, and close examination of the material reveals no trace of their very distinctive bones. Clearly, eels were available locally and survival conditions for their bones were excellent had they been eaten and their bones disposed of in the same way as other fish" (Irwin, 2004: 206).

Like Kohika, another site where eel bones would be expected to be present in large number

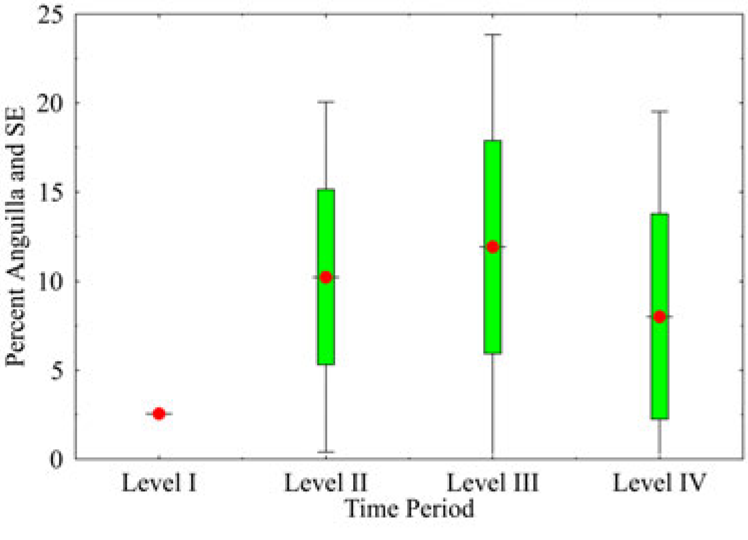

FIGURE 14

Relative abundance of marine eels on Kapingamarangi (MNI) arranged in chronological periods. Level I is c. 1000 BP, and Level IV is historic period. The standard errors are also shown.

considering its location on a sandy knoll amongst a series of swamps and lagoons is the site of Foxton. The site contained considerable evidence of moa-hunting, and was occupied for a long period. Of the 5,504 fish bones identified only 66 were of freshwater eel, occurring in both early and late contexts (Davidson *et al.*, 2000: 79, 81). Clearly, eels contributed only a tiny fraction of fish caught and eaten by the people at Foxton (1.2%), and therefore cannot be considered a major target species as was observed among a number of 19th century Māori communities nearby (Curtis, 1964).

One archaeological site which seemed likely to contain abundant eel remains was a midden in the close vicinity of a fortified Pā site at Parewanui where there are artificial eel channels in the surrounding swampy lands. The Pā is known to have been occupied in the early 19th century. The eel channels are similar to those seen on the Horowhenua flood plane and Manawatu river, described in the early 1900s (Cassels *et al.*, 1988: 110). Historical records in the 1940s of Māori communities living at Parewanui attest to dried eels being prominent (ibid.: 111). The midden was therefore expected to have eel bones in it, and indeed it did. It was radiocarbon dated to <250 years (ibid.: 120). Although only a small sample with a total MNI of 54 across 5 taxa, eel contributed 29 individuals, representing 53.7% of the catch (NB: eel NISP = 55, of total NISP of 211 = 26.1%). The authors of the publication reported that the eel bones were:

> “all from small specimens. This contrasts with what might be expected from nineteenth century Maori eeling practice as it is generally understood. This involves the mass seaward migration of adult eels for spawning and suggests that there is no functional relationship between the midden and the eel-trapping channels” (Cassells *et al.*, 1988: 123).

They further comment as follows:

> “the remains are probably those of young elvers migrating into the lakes and swamps rather than mature eels taken during their migration to the sea. The latter were the focus of eel fishing according to historical records. The possibility that large scale eel fishing was a development of the contact period is not ruled out by the results of this excavation” (ibid. 125).

There is a minor confusion here. The juvenile transparent forms, known as glass eels, return from breeding grounds in the sea. When they migrate into freshwater they turn black, and are then known as elvers (5-7 cm long), and travel upstream. It is adults that are found in swamps. Moreover, no details are provided by the authors as to what they mean by ‘small specimens’. As will be seen below the eels in this site, while not enormous, were not very small at all.

TIME-TREND ANALYSIS OF EELS IN NEW ZEALAND

In an earlier study of fish remains in New Zealand and the Chatham Islands, an attempt was made to pool data on fish remains into three periods, to see if time-trends could be observed in fish catches (Leach, 2006: 189-191). This earlier study strongly confirmed the conclusions which have been arrived at in this present paper – that pre-European Māori caught very few eels until after Europeans arrived (see Table 8). In a short chronology of only c.1,000 years, this time-trend study is not without problems, and details can be disputed. In addition, such a study ignores the fact that far more sites have no eel bones, in spite of the fact that eels are close at hand in almost all environments. The absence of eel bones is also evidence that they were being ignored by people.

EEL LIVE LENGTH ESTIMATES FROM SPECIFIC SITES

Measurements were taken from as many bones as possible from archaeological collections from New Zealand sites known as Foxton, Parewanui, Waihora, Wakapatu, and Washpool; and from Chatham Islands sites known as Kahiti north, Kahiti south, and Waihora. Rather than illustrate these catches as simple histograms it was decided to present the length data cumulative graphs, or sigmoid curves. This makes it possible to see at a glance the cumulative contribution of different sized fish to the overall catch (Figure 15). For example, At Parewanui, 75% of the eel catch were less than 540 mm long. Such curves provide a simple snapshot of the catch composition.

The sigmoid curves for these sites are quite similar in the case of Parewanui, Kahiti South, and Waihora, but the catches at the Washpool and Foxton stand out from these three (Figure 15). Most of the catch at the Washpool were very small eels,

	Eel MNI	**Total MNI**	**%**	**±**	**SE%**	**Archaeological Site**
Protohistoric Period (eels present in 1 of 8 sites)						
	29	54	53.7	±	14.5	Parewanui Midden, Bulls, Manawatu
Simple Mean			**53.7**	**±**	**14.5**	
Late Prehistoric (eels present in 10 of 63 sites)						
	1	5	20.0	±	53.8	Northland Harbour Board, Whangarei
	24	159	15.1	±	5.9	Kahiti South, Hansons Bay, Chatham Is
	6	95	6.3	±	5.5	Kahiti North, Hansons Bay, Chatham Is
	1	17	5.9	±	14.9	Ohinemamao, Petre Bay, Chatham Is
	1	25	4.0	±	10.1	Raupa N53/37, T13/13, Hauraki Plains
	1	35	2.9	±	7.1	Aotea N64/25, North Island west coast
	14	4197	0.33	±	0.19	Waihora, Chatham Islands
	2	1206	0.17	±	0.27	Mana Island North Settlement R26/141
	1	884	0.11	±	0.28	CHA, Chatham Islands
	4	4978	0.08	±	0.09	CHB, Chatham Islands
Simple Mean			**5.5**			
Weighted Mean			**0.47**	**±**	**0.13**	
Early Prehistoric (eels present in 9 or 55 sites)						
	1	14	7.1	±	18.2	Riverton, Southland
	37	771	4.8	±	1.6	Washpool Site, Palliser Bay
	3	278	1.1	±	1.4	Hot Water Beach, Coromandel
	1	94	1.1	±	2.6	Wakapatu, Western Southland
	1	401	0.25	±	0.61	Sunde Site soft shore midden, Motutapu
	1	585	0.17	±	0.42	Rotokura, Tasman Bay
	1	584	0.17	±	0.42	Sunde Site Oyster lens, Motutapu
	1	2134	0.05	±	0.12	Shag River Mouth, Otago
	1	2425	0.04	±	0.10	Houhora, Northland
Simple Mean			**1.6**			
Weighted Mean			**0.65**	**±**	**0.19**	

TABLE 8

Time Trends in the presence of eel bones in New Zealand and Chatham Islands archaeological sites, after Leach (2006: 189). The weighted mean takes into account different sample sizes (Snedecor & Cochran, 1967: 521), and the standard error of proportion is described by Snedecor & Cochran (ibid.: 210).

while at Foxton they were much larger eels. The Foxton curve has a long tail to the right; with the largest eel estimated as 1320 mm in length. Only Foxton has eels greater than 677 mm live length (eight specimens). As will be seen from Figure 15, 75% of the eel catch was less than 450 mm long at the Washpool site, 540 mm long at both Parewanui and Waihora, 570 mm at Kahiti south, and 590 mm at Foxton. These are considerably different catch compositions and presumably reflect local availability and whether catches were during eel migration behaviour. There are no swamps in the vicinity of the Washpool, so larger eels may not be so abundant. The opposite is the case at Foxton, where there are large areas of swampy ground. Parewanui has a similar environment to Foxton so it is surprising that so few large eels were caught. The two sites at Kahiti are both on sand dunes which are backed by swampy land, so larger eels would be present there. Waihora is somewhat unusual, displaying similar catch characteristics to Kahiti South, but the Waihora site is close to a rocky

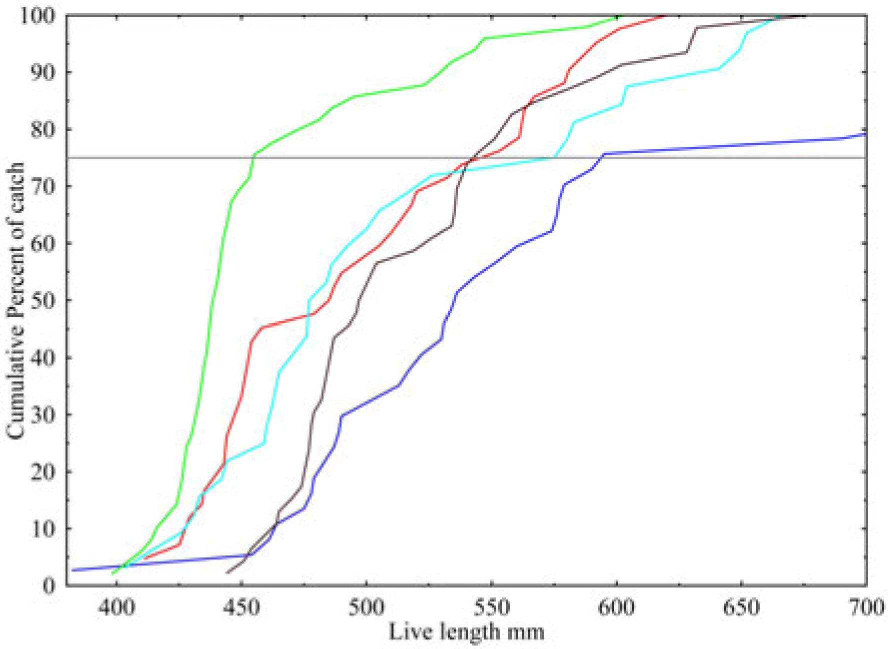

FIGURE 15

Sigmoid curve of eel catches for four New Zealand sites, to illustrate the size of eels that form 75% of the fish caught. Washpool green, Parewanui red, Katiti South cyan, Waihora brown, and Foxton blue.

shore environment with no swamplands in the near vicinity, although there are streams running into the interior of the island. A few measurements are available on eel bones from two more sites: Wakapatu (N=2) and Kahiti North (N=7). These yield live length ranges of 527-684 mm, and 447-542 mm respectively. There is no sign of large eels in these sites.

These eel catches for which we have been able to make estimates of live length are pitifully small samples. With the possible exception of Parewanui, none could be considered as representative of the massive eel harvests so vividly described in 19th century ethnographic literature of Māori communities. We have no doubt that excavations in the future of 19th century villages in areas where these mass harvests were made will reveal substantial deposits of eel bones, including of large females. However, the foregoing has shown that eels were only rarely caught by pre-European Māori. Of the 80 archaeological sites reviewed from New Zealand and nearby Chatham Islands, only 226 eel bones were identified of a total NISP of 143,306 (0.19%).

A single site at Parewanui stand out above all others as having enough eel bones to suggest that eels were an important food for the people who lived there. The site was close to landscape features interpreted as eel channels, precisely for harvesting eels, described in the historic period. It is very difficult to come to any other conclusion than that mass eel harvests in New Zealand only began either very late in the prehistoric period or after European contact.

SUMMARY OBSERVATIONS ON EELS IN ARCHAEOLOGICAL SITES FROM THE PACIFIC AND NEW ZEALAND

The foregoing analyses have shown that with very few (but notable) exceptions, eel bones are infrequently found in archaeological sites in the Pacific and New Zealand. The numerical abundance data are summarised in Table 9. The total number of fish bones identified in this review is 188,351 from 144 sites. Only 1,151 eel bones were identified in these sites, 0.61% overall.

In the tropical Pacific, eels, mainly marine species, account for about 1.1% of fish catches, compared with only 0.5% in New Zealand. However,

	No Sites Without	Sub-Total NISP	No Sites With	Sub-Total NISP	Eel NISP	Total NISP	Eel Percent
Pacific	37	6,630	27	38,415	509	45,045	1.13%
New Zealand	42	47,528	29	37,190	381	84,718	0.45%
Chatham Is	4	3,837	5	54,751	261	58,588	0.45%
Totals	83	57,995	61	130,356	1,151	188,351	0.61%

TABLE 9

Summary presence and absence of eel bones in Pacific and New Zealand archaeological sites.

such overall averages can be very misleading. In the Pacific 89% of all eel bones come from only nine of the 64 sites. This variation does not reflect variable natural local abundance, but deep rooted cultural beliefs about what is and what is not acceptable as food.

Two atolls in the Caroline islands with basically the same climate and soil conditions and length of human occupation present contrasting fish catches in the archaeological sites. The sites on Kapingamarangi have abundant marine eel remains throughout the time sequence; whereas those on Nukuoro have none. Surprisingly, sites on both islands have one or two freshwater eels in them (Table 5). Ethnographic records in the historic period confirm the importance of eels to the people on Kapingamarangi. The idea that eel bones are rare in archaeological sites because they decay easily from the high fat content is therefore rejected by the analysis presented here.

Another Polynesian outlier, Tikopia, in the Solomon Islands, presents an intriguing possibility that eels were once considered food, but that in the course of time a prohibition emerged. Moray eel bones are common from 900 BC to AD 1700, but are absent in later layers in the historic period. Historic ethnographic records show that both freshwater and marine eels are considered disgusting to eat. Although freshwater eels occur on the island, none were found in the archaeological sites.

At the Tangatatau site on Mangaia in the Cook Islands the opposite picture emerges – marine eels are rare, and freshwater eels are common. There is a hint from the abundance figures through time that eels were much more common in the earliest part of the sequence and declined to low levels thereafter, following a similar pattern to Tikopia. Ethnographic records on this island, once again, show that eating eels was considered disgusting. Observations of the bone size of the archaeological eels suggest that only tiny eels were caught and eaten in the past, even though much larger eels are present on more than one island in the Cook Islands. The absence of large eels in the site raises the possibility that they were considered different in the folk taxonomy relating to eels.

Analysis of a sample of 169 eel bones from archaeological sites in New Zealand and the Chatham Islands revealed that almost all fish were less than 600 mm live fish size. This suggests that the bulk of fish caught were probably *Anguilla australis*. The larger species, *A. dieffenbachii*, is the last to migrate from the upper waterways in New Zealand to the sea, when they then travel to the south Fiji basin for breeding. The mass harvesting of eels that was observed among many Māori communities living close to the sea would certainly have these large fish in their catch. The dearth of them in the archaeological record suggests that none of the 80 sites investigated were involved in such mass harvesting. The low numbers of eel bones in all these sites supports the same conclusion. Smaller numbers of *A. dieffenbachii* are certainly found in lakes and swampy areas close to the sea, and could have been caught at times other than during mass migrations. The rarity of large eels in New Zealand sites is in concert with the finds at Tangatatau on Mangaia.

Three archaeological sites that are situated in environments which have abundant eels available year-round, all had careful attention paid to fish remains, and produced contrasting results. At the Foxton site, eels contributed only 1.2% ± 0.3 of the fish catch. Most of them are from the early part of the site, circa 700 years BP. For the people living at this site, eels were a trivial component of diet. Parewanui is an early historic period site, and eels contributed 26.1% ± 6.2 of the fish catch. The site is close to artificial water channels thought to be for harvesting eels. This site is consistent with ethnographic reports of mass harvesting of eels. Finally, the Kohika site, occupied between AD 1610 and 1810, has no eel bones at all, and could well be an example of food avoidance behaviour, eels being prohibited. These three sites display characteristics which are in concert with historic observations about the variable role of eels in Māori culture, cited earlier. On one hand we have Polach's observation that eels were *tapu* and could not be eaten by people living in the vicinity of Tauranga in the 1830s, and Brunner's observation of a cleansing ceremony to lift the *tapu* on eels so they could be eaten by Māori along the West Coast of the South Island during an episode of starvation. On the other hand, we have many records of mass harvesting of eels for food among Māori resident in three major river systems in the North Island: Wanganui, Manawatu and Ruamahanga.

CONCLUSIONS

Marine eels are ubiquitous throughout the Pacific region, and freshwater eels are found in islands large enough to have abundant sources of freshwater. Contrary to expectation, both marine and freshwater eels are surprisingly rare in archaeological sites in the Pacific and New Zealand, considering their natural abundance and ease of capture, although there are some notable exceptions. This is something that has also been observed in European archaeology, and has commonly been attributed to taphonomic effects, or that the bones are small and difficult to identify, or that they break down in soil by autolysis because they are rich in oil. In this paper we show that each of these reasons is false. The mere fact that in some modern societies, where eels are considered desirable as food and abundant eel bones are found in their ancestral archaeological sites, repudiates most of these suggestions.

Eels are very easy to catch and provide a rich source of protein and fat. The amount of fat increases with age of animal and typically an eel can provide 74, 105, and 179 kcal/100g for protein, oil, and total respectively. This represents nearly 59% caloric energy from fat. Humans require more than 70% of their caloric energy from non protein sources, either from carbohydrate or fat. For societies where carbohydrate foods are in limited supply, eels can provide the difference between survival and starvation. Finding this nutritional balance is not a problem in tropical and sub-tropical Pacific communities, because carbohydrate rich foods are easily cultivated.

New Zealand ranges from subtropical in the north to subantarctic in the south. Tropical tubers introduced from the Pacific in prehistoric times formed the basis of a secure carbohydrate economy in the north, but was progressively less favourable for successful gardening southwards. In the far south, the economy was firmly hunter-gatherer in character, with sources of fat assuming far greater importance in the diet than in the north. Maintaining a horticultural economy in the intermediate area, between 40°-43°S was very difficult, and major river valleys in the central area, where tubers could not be grown and stored, prohibited permanent settlements being established. During the 19th century, following colonisation by Europeans, there are many records of Māori in this central region taking part in mass harvesting of freshwater eels with their abundant fat reserves. Prehistoric archaeological sites in the same region have very few eel bones.

We review aspects of the cranial osteology of eels, and the most commonly found bones in archaeological sites. Allometric analysis was carried out to establish equations for estimating live length and weight from bone measurements. A total of 1,151 eel bones have been found among 188,351 fish bones from 144 archaeological sites in the Pacific (64), New Zealand (71), and the Chatham Islands (9), representing an overall abundance of just 0.61%. Of these, only 383 bones were from freshwater eels (0.2%). We were able to take measurements on 169 of these 383 bones and use the allometric equations to estimate live length and weight. The analysis showed that the most abundant eels were in the range of 430 to 500 mm length, with only 5 greater than 800 mm. There are vivid ethnographic descriptions of mass harvesting by 19th century Māori, describing the migration of eels to the sea. The second variety to arrive, called *riko*, were from 900-1200 mm long, followed by the *kokopu tuna*, about 1800 mm long. Only two archaeological eel bones belong to eels over 900 mm.

Three of the 144 tropical Pacific sites are of special interest: The people on Kapingamarangi atoll in the historic period made special traps to catch marine eels, and during the prehistoric period marine eels were about 10% of all fish caught. A site known as Tangatatau, on the island of Mangaia, had significant freshwater eels in the deposits, averaging 5-10% of the catch. Finally, on Tikopia marine eel bones are about 2.3% of fish caught, but are only found from about 900 BC to AD 1700. In the historic period, both marine and freshwater eels were considered disgusting to eat. This one example shows that social attitudes towards eels can change over time in any one society.

In the tropical Pacific, eels represented the incarnation of a male deity, symbolising the penis, and the personified eel tempts and defiles a woman sexually. A male, often an heroic ancestral figure, punishes the eel by cutting him up into pieces. We found that there is often a strong association of eels with danger, and that the eel is either venerated or feared, and is certainly not considered food. In some Pacific societies, the arrival of Europeans resulted in the lifting of the *tapu* of eels as food.

We argue that the Polynesians who settled New Zealand from the tropical Pacific brought with them a fear and loathing of eels embedded in their mythology and oral history, and this is the reason for the dearth of eel bones in archaeological sites – that is, the people who settled New Zealand came from a part of the Pacific where eels were considered *tapu*, and not eaten. We document two examples in 19th century ethnographic records where Māori considered eels to be *tapu*, and in one case of starvation, could only be eaten after an elaborate *tapu* removal ceremony. In short, the transition of eels from sacred to profane, from *tapu* to *noa*, took place during the tumult of the clash of cultures in the post-European era. Such a dramatic change had several unanticipated advantages – the fat reserves that eels possess made it possible for major river valleys in the central area to be populated with permanent settlements for the first time. These protohistoric communities also benefited from the introduction of potato and feral pigs.

ACKNOWLEDGEMENTS

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APPENDIX 1: ADDITIONAL ETHNOGRAPHIC RECORDS RELATING TO EELS

The following extracts are listed in alphabetical order by island name.

Hawaii: Titcomb (1982) has many useful observations about the role of eels (*puhi*) in Hawaiian society. “Salt water eels were eaten, but freshwater eels were used ceremonially only. Of details of this use there is no available record” (Titcomb, 1982: 124).

Kapingamarangi and Nukuoro: The Samoan story about Sina and the eel is not present on Kapingamarangi or Nukuoro. However, Sina or Hina is a common female name in many parts of Polynesia, celebrated in myths and stories, including Kapingamarangi (Elbert, 1949: 243). As Fischer has shown, Hina is also cognate with the Nukuoro story of Sinonukataha (Fischer, 1958: 12). Since freshwater eels are not present on atolls, it is not surprising that the Samoan eel myth is absent on these two atolls. The myth could not be applied to seawater eels, because, unlike freshwater eels, they are dangerous to humans, and not personified as a penis. It is interesting that the common Polynesian names of *pusi* for saltwater eels and *tuna* for freshwater eels, are not found on either of these atolls. Carroll provides the word *labodo*, meaning snake, also eel, water snake, etc. for Nukuoro (Carroll, 1965: 470). This cognates with *labodu* for marine eels on Kapingamarangi, and perhaps *laboto* among the Raluana people (Tolai or Kuanua language) of New Britain (Brown, 1981: 98). On this issue Ross Clark reports as follows: “the labodo/u word came up in my 1994 paper on language contact at the Polynesian Outliers [Clark, 1994: 122]. I found Woleaian labut(o) ‘snake, worm, eel’ and Ponapean lapwed ‘salt water eel (generic)’. Bender *et al.* give a Proto Central Micronesian *lapw(ou) so ‘moray eel’, with several more cognates [Bender *et al*., 2003]. Going back further, Ross, Pawley & Osmond have Proto-Oceanic *[la]bwa(s,j)i 'moray eel' [Ross *et al*., 2011: 44]. This means that the NKO word, though clearly borrowed from a Micronesian source, may be a distant cognate of Polynesian *pusi. In that paper I found that NKO and KAP were among those Outliers least linguistically influenced by their non-Polynesian neighbours" (Clark to BFL pers. comm. 2020).

Kosrae: Rochers (citing Sarfert, 1919) comments: "Although eel [*semis* is the Kosrae name referring to salt water eel] is presently a fairly common food in Kosrae, it was once considered tabu and not eaten. Formerly, it was believed that if one killed an eel it would come and sleep with the person and cause illness and eventually death" (Rochers, 1992: 16).

Mangaia: "When Te-aio was killed, his blood flowed into a stream and was drunk by an eel. The spirit of Te-aio entered the eel, which after Te-aio was deified, became his incarnation. The eel went out to sea, came in contact with a shark, and the spirit of Ta-aio passed over the shark. The shark also became an incarnation. This is the mechanism followed in New Zealand, where any fish, bird, or animal which touches or drinks the blood of an ancestor may become the incarnation of that deified ancestor" (Hiroa, 1934: 171).

New Zealand: Discussed in the main text.

Ponape: "There is one species of fish universally held sacred by the islanders, a species of eel, inhabiting the fresh water… to our enquiries why this fish enjoyed such a peculiar and universal exemption, the only answer had been *Majorhowi*!" (O'Connell, 1972: 137). In a footnote there is reference to the logbook of a Sydney vessel, The *Gypsy*, at Ponape in 1841, which states "the river eels are worshipped by the natives, and in such veneration are they held, that should they be caught and cooked on board ship and the natives got knowledge of it, every soul would directly abandon her with the greatest abhorrence. The taboo against consuming the fresh water eel persists today." (ibid.: 138).

Taumako: This is a Polynesian outlier in the outer eastern Solomon Islands, close to Tikopia. Freshwater eels are found in the inland swampy areas of river valleys. They are referred to as *te atu*, which is an abbreviation of *te atua* (Leach & Davidson, 1978: 47). Atua is a Polynesian word referring to a deity or supernatural being. In spite of this, the Taumako people today consider both moray eels and freshwater eels to be good food (ibid.: 65, 67).

Tikopia: "Most marked among taxa in this field [totemism] were eels. All kinds of eels have been looked upon by Tikopia both traditionally and in modern times as very unpleasant creatures, and normally no Tikopian would eat an eel. Traditionally such an attitude could be related to the mythical origin of eels from the phallus of a primal deity, but whether this is now current or not, even the sight of an eel may bring a strong demonstration of repugnance. Two types, the eel of the lake (*Anguilla* sp.), and the grey-brown reef eel (*Gymnothorax* sp.) continue to be regarded as especially repulsive creatures in themselves, and as *atua*, to be symbolic of spirit powers embodying a great deal of evil, representing male lust and responsible for bodily affliction of the digestive organs" (Firth, 1981: 222).

Firth provides further details on this notion "including an origin myth in which the various types of eels were created by successive truncations of the elongated phallus of a generative deity. Linked with this was the notion that eels in their spirit form were essentially concupiscent; conceived as always male, they were therefore very dangerous to women. More generally, the eel gods were conceived as suspicious, jealous, personifications of punishment for offenders" (Firth, 1967: 556).

"In 1973 I was told (rather unwillingly) that a few Tikopia in the new colonies had even eaten eels, putting them in soup, in a new food style and in breach of custom. This was strongly disapproved by many Tikopia, who were still afraid of eels. I have now learned from Judith Macdonald, recently returned (1980) from a very fruitful research expedition to Tikopia, that she found in the island community the same expressions of disgust and fear about eels, and saw the same behaviour, as I recorded" (Firth, 1967: 219, footnote).

Trobriand Islands: Malinowski describes the legend of Inuvayla'u thus: "In the village of Kwabulo there lived Inuvayla'u the head of his clan, the Lukuba clan; the head of his village. He copulated with the wives of his younger brothers, of his maternal nephews.

When the men went out fishing, he would stand outside a house, and make a hole in the thatch; he then thrust his penis through the thatch and fornicated. His penis was very long; his penis was like a long snake. He would go into the garden when the women made koumwala (clearing the ground from debris preparatory to planting); or when they pwakova (weeded the ground). He would stand right away behind the fence, he stood in the uncut bush and his penis wriggled on the ground like a snake. The penis crept along all the way. The penis would approach a woman from behind as she was bending down to her task. It would strike her hard till she fell, and on all fours she would be fornicated with as the penis entered the vulva.

Or when women went to bathe in the lagoon, the penis would go under the water like an eel and enter the vulva. Or when they went to collect shells, as women do on the western shore (pl. 80), wading and feeling for them with the toes in the mud of the lagoon, Inuvayla'u would fornicate with them. When the women went to the water-hole, he would smash their coco-nut shell bottles and fornicate with them. The men were then very angry for they had no water to drink. They would abuse the women. The women would be too ashamed to speak, for their bottles had been broken. One day the men ordered, telling their wives: 'Cook fish, cook *taytu,* make pudding of taro, so that our revered old man eats his fill.' 'No', answered the women, 'we shall not do it; this man does wrong by us; when you go to fish, and we remain in the village, when we work in the garden, by the water-hole, in the lagoon, he does violence to us'.

Then the men watched him. They said they were going to fish. They hid in the *weyka* (the thick scrub surrounding the village), they saw: Inuvayla'u stood outside a hut, he made a hole in the thatch; his penis sneaked on the ground, it crept through the hole, it came in: he wronged the wife of his younger brother. The men went to the garden… (here the various conditions under which the hero plays his foul pranks on the women are again enumerated, in almost exactly the same words as before).

When his younger brothers, his maternal nephews, saw this, they grew very angry. Next morning they ducked him; they ducked him in the head pool of the tidal creek, which comes up to the village of Kwabulo (pl. 81).

He came out of the water. He returned to his house, his mind was full of shame and of sorrow. He spoke to his mother Lidoya: 'Bake some *taytu* and fish. Bake it in the ground. Pack all our belongings and the food in your big basket; lift it and put it on your head; we shall go, we shall leave this place'.

When all was ready, he came out of his house, which stood on the *baku* (central place of the village). He wailed aloud, facing the *baku*. He took his *kema* (axe), he cut at his penis. First he wailed and wailed over it, holding it in his hands. Then he cut off the point of his penis ; it came off on the *baku* in front of his house ; it was turned into stone. The stone is still there, on the *baku* of Kwabulo in front of the headman's house. He cried and wailed and went on. He stood outside the outer ring of houses, he looked back, he took his penis and wept over it. He struck again with his axe. The second bit fell off and was turned into stone. It can be seen still outside the village in Kwabulo. He cried and wailed and went on. Half-way between the village and the tidal pool of the creek he stopped. He looked back towards the houses. He took his penis into the palms of his hands, he wept over it and cut off another bit. It turned into stone, and can be seen there not far from Kwabulo. He came to the canoes ; he looked back towards the village, he wept over his genitals. He took the axe and cut off the remaining stump of his penis. It was turned into stone, and it lies now near where the Kwabulo men moor their canoes. He entered his canoe and punted along. Half-way down the creek he wept once more. He gripped his axe and cut off his testicles. Large white coral boulders (*vatu*) lie in the creek. They are the token : they show where Inuvayla'u cut off his testicles" (Malinowski, 1932: 348-350.

Tubuai: "Eels (*puhi*) although abundant in fresh water, are not eaten, and the salt-water eel, which attains considerable size, is regarded as poisonous" (Aitken, 1971: 37).

Tuamotu Islands: "The moray eel harvest was quite important on 'Anaa because in addition to the food it supplied, congers' jaws (*niho kamia*) were used as the part of warriors' attire designed to shred the skin of their adversaries during combat... or as a kind of saw called kamia or oreore" (Torrente, 2015: 19). Emory provided illustrations of these unusual toothed knives (Emory, 1975: 133).

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Subsistence strategies in the Inner Congo Basin since the 14th century AD: the faunal remains from Nkile and Bolondo (DR Congo)

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ABSTRACT: The faunal remains are described from Nkile and Bolondo, two archaeological sites in the equatorial rainforest of the Democratic Republic of Congo. Both river-side settlements, located in the Ruki-Tshuapa basin and dating to between the 14th century to the second half of the 20th century, show a heavy reliance on aquatic food resources. The animal remains show that fishing was a major subsistence activity, whereas hunting, slaughtering of domestic stock and harvesting of molluscs were less frequent activities. The contribution to the diet of the different animal taxa suggested by the zooarchaeological data is in line with recently published stable isotope results obtained on humans and animals from Bolondo. The type of fish, and in particular their reconstructed sizes, show that the major exploited fishing grounds were shallow waters that became accessible during the low water seasons (nowadays July-August and a minor season in March at both sites). The proportions of the exploited fish taxa are comparable to those marketed nowadays in larger urban centres. Juvenile fish, and to some extent, small crocodiles, were heavily exploited but it is argued that at the time this was still a sustainable activity that did not deplete the fauna as much as today since human populations were smaller and the fishing gear less effective.

KEYWORDS: RAINFOREST, SUBSISTENCE, FISHING, AFRICA, ZOOARCHAEOLOGY

RESUMEN: Se describen aquí los restos de fauna de Nkile y Bolondo, dos yacimientos arqueológicos en la selva tropical de la República Democrática del Congo. Asentamientos fluviales en la cuenca del Ruki-Tshuapa que datan entre el siglo XIV hasta la segunda mitad del siglo XX, evidencian una dependencia intensa sobre los recursos acuáticos. Los restos demuestran que la pesca fue una actividad de subsistencia preferente mientras que tanto la caza como el sacrificio de animales domésticos y la recolección de moluscos eran actividades menos frecuentes. La contribución a la dieta de los distintos taxones animales que la evidencia zooarqueológica pone de relieve, concuerda con los resultados de isótopos estables recientemente publicados sobre los restos humanos y de fauna de Bolondo. Los tipos de peces, y particularmente las tallas que inferimos de los mismos, demuestran que las zonas principales de pesca fueron siempre aguas someras que serían accesibles durante la estación seca (actualmente entre julio y agosto con un

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pico secundario en el mes de marzo en ambos sitios). Las proporciones de los taxones ictiológicos explotados resultan comparables con las actualmente comercializadas en los grandes centros urbanos. Los peces juveniles, así como los pequeños cocodrilos, eran explotados de modo sistemático si bien concluimos que en aquellos momentos ello constituía una actividad sostenible que no mermaba la fauna como hoy lo hace al ser las poblaciones humanas mucho más restringidas que las actuales y los aparejos de pesca menos efectivos.

PALABRAS CLAVE: SELVA TROPICAL, SUBSISTENCIA, PESCA, AFRICA, ZOOARQUEOLOGÍA

INTRODUCTION

The Congo Basin, in particular its central part, is one of the least known regions in Africa from an archaeological and bioarchaeological point of view. This is partly due to the environmental characteristics of the region, i.e. a dense tropical rainforest with large floodplains where archaeological prospection is hampered by the lack of ground visibility. Moreover, for practical reasons, archaeological surveys have this far been carried out along rivers leaving the archaeological map blank of interfluvial sites (Eggert, 2014; Cornelissen, 2015). Most of the field work has been done by two teams in this region that was mainly archaeological *terra incognita* before the second half of the 1970s (Smith *et al*., 2017: 1). Within the framework of the *River Reconnaissance Project* directed by Manfred Eggert (then University of Hamburg), excavations took place in the western and central part of the Congo Basin where both Nkile and Bolondo – the sites dealt with in this paper – are located (Eggert, 1983; Wotzka, 1995). The eastern part of the Congo Basin has been surveyed between 2010 and 2013 by the missions of the Royal Museum of Central Africa, Tervuren (Smith *et al*., 2017). These efforts led to the establishment of a relative chronology for the last two and a half thousand years based on ceramic styles combined with radiocarbon dates anchoring it in time (Wotzka, 2006; Eggert, 2014; Smith *et al*., 2017). Fauna is poorly or not preserved at all on the sites in the study region (Van Neer, 1990), making the assemblages from Bolondo and Nkile quite unique (Figure 1). After a taphonomical evaluation, the faunal remains described below are interpreted from a palaeo-economical point of view with a particular emphasis on the fishing practices.

MATERIAL

The first excavations at Bolondo took place in 1983 during the *River Reconnaissance Project* while the most recent fieldwork, led by Hans-Peter Wotzka, was conducted in 2016 (Bleasdale *et al*., 2020). Bolondo is a fishing camp, a so-called *longanda* (plur. *nganda*), located on the right bank of the Tshuapa River, that is inhabited up to the present day. The occupation of *nganda* is typically seasonal, but nowadays Bolondo has sufficiently risen above the river to be out of reach of the water permitting the place to be occupied all year round. This location of the site in the floodplain, directly adjacent to the riverbank, combined with the house construction techniques – light structures on artificial mounds – has led to a waterlogging phenomenon. Layers of white river clay, used as flooring, alternate with layers of archaeological material allowing the organic material, both faunal and botanical, to be much better preserved than on higher ground sites (Bleasdale *et al*., 2020).

The faunal remains from Bolondo are from two human graves and from several trenches corresponding to settlement contexts. About two thirds of the hand-collected bones (around 200 remains) are from the 1983 excavation campaign during which also several human burials were uncovered (Wotzka, 1995). Five individuals from these graves were radiocarbon dated, placing the burial period between the 15th and 20th centuries AD (Bleasdale *et al*., 2020). Thanks to fine sieving during the 2016 campaign, numerous faunal remains were retrieved from the residues that served initially for archaeobotanical analysis. Samples were taken from each archaeological layer in two pre-excavated 1x1m trenches (Trench 1 and Trench 5), each of which was extended by 0.25 m^2 for this purpose. Wherever possible 10 litres of sediment were taken (2 l for the thinnest layers) for a total of 160 litres that

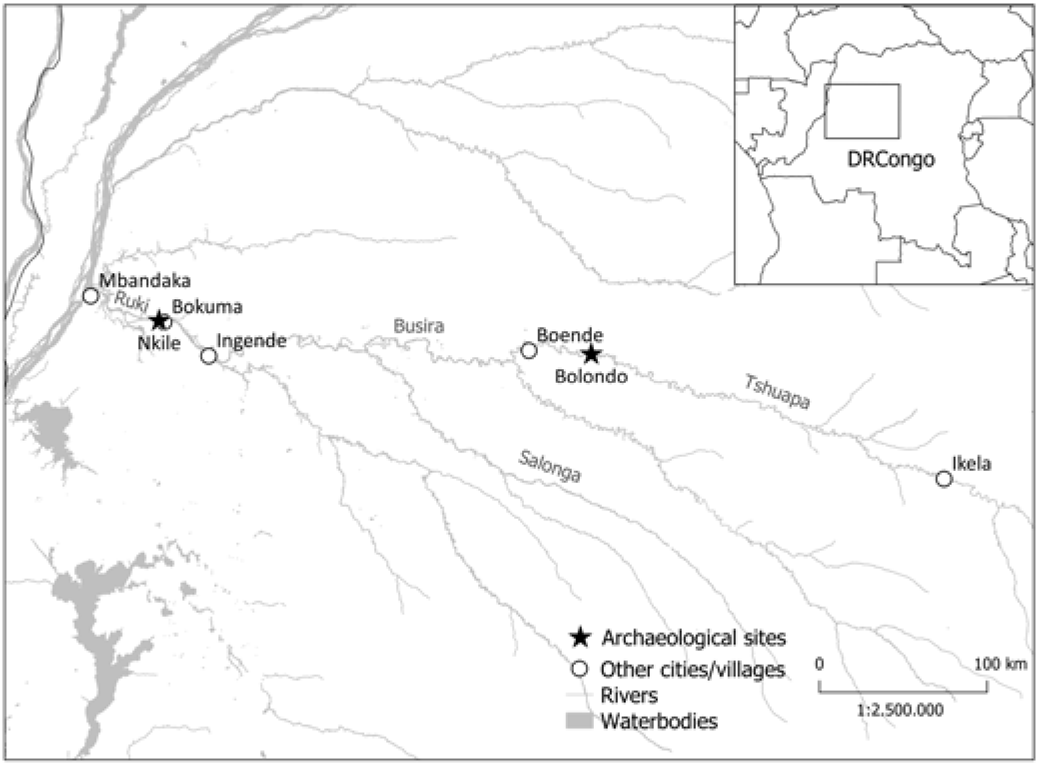

FIGURE 1
Map of Central Africa indicating the major watercourses and the localities mentioned in the text.

were first flotated and then tower sieved through 2.5 mm and 1 mm meshes (Bleasdale *et al.*, 2020). Through this process, more than 7000 faunal remains (mainly fish) were retrieved. For the purpose of this paper, the material coming from the 2016 campaign has been grouped into phases based on the ceramic finds. Trench 1, that yielded only a small part of the entire faunal assemblage, was divided into three phases, all of them associated with the so-called Bolondo Group. The first phase, comprising the upper layer, was associated with both the Bolondo Group and the Ilemba-Bokonda Group, the latter being chronologically situated in the 20th century. The second phase was mainly associated with the Bolondo Group, radiocarbon dated to around AD 1400-1600. The third and oldest phase was associated with the Bolondo Group and the Bosanga Group, dated between the 14th and 15th centuries AD. Most of the faunal material comes from Trench 5 that has a longer stratigraphy and that yielded a more varied set of ceramic groups. The first and most recent phase of Trench 5 is associated with Ilemba-Bokonda ceramics. The most recent finds of these upper layers date to the second half of the 20th century. The second phase that is associated mainly to the Bokone Group, also yielded a few Bolondo and Wema sherds, dating this phase approximately to the 19th century and somewhat before. The third phase is associated mainly with the Bolondo Group with a few sherds of the Bosanga, Wema and Inkaka Groups. In addition to the relative chronology, a few radiocarbon dates are available that place this occupation in the 16th century AD. The fourth phase, finally, is associated to ceramics of the Wema Group and has been radiocarbon dated to the 14th and 15th centuries AD (Wotzka, 1995; Neumann *et al.*, 2022).

An assemblage of around 200 hand-collected remains is available from Nkile, a site along the Ruki river that was excavated during the 1977-78 field season (Eggert, 1983; Wotzka, 1995). This village, located about 3 km downstream of Bokuma, was abandoned around AD 1915. Immediately adjacent to the river shore, three trenches were excavated with the following dimensions: NKI 2: 150 x 350 cm; NKI 3: 100 x 200 cm and NKI 6: 150

x ca. 250 cm. Another trench, NKI 4, excavated about 30 m farther inland and measuring 100 x 100 cm, yielded only one animal bone. The excavations were carried out in artificial spits but for the present faunal analyses, all the animal remains have been lumped as the archaeological material was strikingly homogenous throughout the different levels. The ceramics found in the Trenches 2, 3 and 6 overwhelmingly belong to the Botendo Group. The start of this ceramic group is unclear, but the material no doubt comprises the entire 19th century. The deposits of which the fauna are studied correspond to the youngest occupation phase of the village, until it was given up at the beginning of the 20th century. The sole animal bone from NKI 4, which yielded a more mixed assemblage in its lower layers, possibly belongs to an older phase than the material from the other trenches.

METHODS

The faunal remains were identified with the aid of the comparative collections housed at the Royal Belgian Institute of Natural Sciences. For each taxon the skeletal elements were noted and in the case of fish a size reconstruction was carried out on the basis of sufficiently well preserved bones. Each bone was directly compared to modern specimens of known length and the size estimations were expressed in centimeters standard length (SL), i.e. the length of the fish from the tip of the snout to the base of the tail. For the quantification, number of identified specimens (NISP) were noted and the minimum number of individuals (MNI) was established. It should be underlined that the modern fish skeletons available for comparison are mainly from specimens acquired from the Egyptian and Sudanese Nile, the Niger and the Senegal rivers and with only few fish from more southerly basins. The present-day ichthyofauna of the study region, although still poorly known (Monsembula Iyaba & Stiassny, 2013; Sonet *et al*., 2019), comprises numerous taxa that are not available in our reference collection. An impression of the wealth of species present in the Ruki basin is given in the checklist of FishBase (https://www.fishbase.de/trophiceco/FishEcoList.php?ve_code=815, accessed 16th April 2021). Information on the occurrence of species and their ecology mentioned in the descriptions below was taken from FishBase, unless stated otherwise. Because of the species richness of the ichthyofauna, identifications of the archaeological material often did not go beyond family level. In a few instances measurements could be taken of the mammal remains and this was done according to the guidelines of Driesch (1976).

THE FAUNAL REMAINS

Bolondo

Besides the abundant faunal remains found in the settlement (Table 1), Bolondo also yielded a smaller amount of hand-collected finds associated to two human burials. The sole faunal element found in the grave of Individual 2, was a maxillary tooth of a small antelope. This tooth was probably not intentionally placed in the burial and may be considered as background fauna that was already present in the sediment when the grave was dug. In the burial of Individual 1, a small crocodile humerus occurs which can probably also be considered as an intrusive element. However, the 27 teeth, mainly canines with their roots artificially pierced, are clearly grave goods and presumably were part of a necklace. Sixteen of these teeth are from a canid, most probably dog since there are no wild canids living in forested areas. Ten other specimens resemble felids, the size of a domesticated cat, but a precise identification is difficult. One other tooth may be an incisor of a monkey (Cercopithecidae).

The hand-collected faunal remains from the settlement contexts of Bolondo consist of only 76 fragments whereas the total NISP from the sieved fractions is almost 2600. Of the 75 mollusc remains found in the settlement only two were sufficiently preserved to permit an identification as *Limicolaria*. One specimen allowed measuring its height (34 mm) and the other one still had its colours preserved, suggesting that it is a rather recent shell. Among the unidentifiable molluscs are both gastropods and bivalves.

The fauna from Bolondo, like that of Nkile, is dominated by fish remains. The identification was not only hampered by the limited reference material, but also by the small average size of the fish recovered from the sieved samples which made manipulation of the remains and observation of their morphological characteristics difficult. In the case of the vertebrae, identification appeared in addition extremely difficult as we were often dealing with young individuals in which diagnostic characters were not always clearly developed. This explains why the majority of the unidentified fish in Table 1 are vertebrae. Of the 15 fish taxa that are found in the sieved samples there are only seven occurring in the hand-collected material. It is clear that the most abundant fish taxa in the hand-collected fauna are the same as those that are frequent in the

	Total HC	**Trench 1**			**Trench 5**				**Total sieved**
		Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3	Phase 4	
Limicolaria sp. (garden snail)	**2/2**	-	-	-	-	-	-	-	**-**
Protopterus cf. *dolloi* (lungfish)	**7/4**	-	-	-	1/1	-	4/3	-	**5/4**
Polypterus sp. (bichir)	**2/2**	-	19/3	3/1	320/2	160/3	497/10	66/3	**1065/22**
Heterotis niloticus (African bonytongue)	**-**	-	-	-	3/1	-	-	-	**3/1**
Mormyridae (elephantfish)	**-**	-	1/1	1/1	13/2	3/2	9/4	17/2	**44/12**
Cyprinidae (minnows)	**-**	-	-	-	1/1	-	4/2	7/1	**12/4**
Distichodus sp. (distichodus)	**-**	-	-	-	1/1	-	-	1/1	**2/2**
Distichodus sp./*Citharinus* sp. (distichodus/moon fish)	**-**	-	-	-	4/1	4/1	1/1	-	**9/3**
Hydrocynus sp. (tiger fish)	**-**	-	-	-	-	1/1	-	-	**1/1**
Alestidae (African tetras)	**-**	-	-	-	23/2	1/1	3/3	2/2	**29/8**
Chrysichthys sp. (claroteid catfish)	**-**	-	-	-	-	2/2	-	-	**2/2**
Clariidae (clariid catfishes)	**10/9**	-	4/4	10/4	67/22	10/7	66/34	50/25	**207/96**
Synodontis sp. (squeaker catfish)	**4/3**	-	1/1	-	15/2	5/1	41/16	44/13	**106/33**
Schilbeidae (schilbeid catfishes)	**-**	-	-	-	3/1	-	-	-	**3/1**
Siluriformes (catfish)	**7/4**	4/1	50/15	35/8	185/14	106/11	279/30	221/30	**880/109**
Cichlidae (cichlids)	**6/2**	-	4/4	1/1	38/8	20/5	52/16	29/7	**144/41**
Lates sp. (lates perches)	**1/1**	-	-	-	1/1	-	-	-	**1/1**
Parachanna sp. (snakehead)	**9/5**	-	-	-	12/3	1/1	-	7/5	**20/9**
Serpentes (snakes)	**-**	-	-	-	18/1	4/1	7/1	6/1	**35/4**
Crocodylidae (crocodile)	**8/4**	-	-	-	-	2/2	7/1	-	**9/3**
Testudines (turtle)	**1/1**	-	-	-	-	-	-	-	**-**
Rodentia (rodent)	**-**	-	2/1	3/1	-	-	3/1	2/1	**10/4**
Cercopithecidae (monkey)	**1/1**	-	-	-	-	-	-	-	**-**
Canis lupus f. familiaris (dog)	**1/1**	-	-	-	-	-	-	-	**-**
Carnivore, fox size	**2/2**	-	-	-	-	-	-	-	**-**
Carnivore, dog size	**1/1**	-	-	-	-	-	-	-	**-**
Suid	**1/1**	-	-	-	-	-	-	-	**-**
Suid?	**1/-**	-	-	-	-	-	-	-	**-**
Cephalophus nigrifrons (black-fronted duiker)	**1/1**	-	-	-	-	-	-	-	**-**
small antelope	**3/3**	-	-	-	-	-	-	-	**-**
Tragelaphus spekii (sitatunga)	**1/1**	-	-	-	-	-	-	-	**-**
medium-sized antelope	**1/1**	-	-	-	-	-	-	-	**-**
Capra aegagrus f. hircus (goat)	**2/2**	-	-	-	-	-	-	-	**-**
small bovid	**3/-**	-	-	-	-	-	-	-	**-**
large bovid	**1/1**	-	-	-	-	-	-	-	**-**
total identified	**76/52**	4/1	81/29	53/16	705/63	319/38	973/122	452/91	**2587/360**
unidentified molluscs	**10**	2	2	9	56	9	-	-	**78**
unidentified fish	**62**	1	15	9	206	122	291	138	**782**
unidentified mammal	**35**	-	1	-	6	1	2	2	**12**
unidentifiable (mainly fish)	**15**	27	299	95	536	543	1800	657	**3957**
total unidentified	**122**	30	317	113	804	675	2093	797	**4829**

TABLE 1

Species list of the settlement contexts from Bolondo, indicating the Number of Identified Specimens (NISP) and the Minimum Number of Individuals (MNI) in the hand-collected (HC) and sieved material. The figures in the columns are NISP/MNI. For Trenches 1 and 5, the sieved finds are shown by phase.

sieved material, namely catfish (with Clariidae and *Synodontis*), *Parachanna* and Cichlidae. Remains of lungfish (*Protopterus*) are relatively frequent compared to their numbers in the sieved material and are from somewhat larger specimens.

The skeletal elements by which the lungfish are represented in both the hand-collected and sieved material are the typical upper and lower jaws with their heavy toothed surface. In addition, a ceratohyal and two parasphenoids were found. Few elements allowed a size reconstruction, but it appears that very small to medium-sized individuals were present. The following estimated lengths were obtained: two fish of 5 to 10 cm SL, two individuals of 15 to 20 cm SL, and one fish of each of the length classes 30-50 cm SL, 40-50 cm SL and 50-60 cm SL. In the Ruki river basin only *Polypterus dolloi* occurs. Lungfish can use atmospheric oxygen and therefore easily survive in shallow, oxygen-poor environments. They have the ability to dig into the mud to survive the dry season in a cocoon, but this is not seen in the study region as the floodplains never dry out completely.

In terms of number of remains, *Polypterus* is the most abundant fish taxon in the sieved samples, but this is a result of the numerous scales (Figure 2) that represent 95% of the skeletal elements of these fish. The rhomboid scales are well ossified and typically covered with ganoine that gives them a shiny external aspect. Many scales show traces of burning. In some of the smaller samples of which the ratio of burned scales was quantified it appears that up to one third of the specimens had been exposed to fire. Other skeletal elements of bichir that were easily recognisable are the vertebrae (29 specimens), the bifurcated dorsal spines (8 specimens), skull roof and other cranial fragments characterised by a fine granular surface (9 specimens). The reconstructed sizes that could be obtained on nine of these remains vary between 15 to 30 cm SL. For the estimation of the body size we also used the scales, which showed that there was a wider range in lengths among the bichirs. In Figure 3 the variation of the scale width is shown in a sieved, random sample. Using measurements taken on three modern specimens of 13.5, 17 and 29 cm SL the reconstructed sizes in the archaeological sample appear to vary between about 8 and 48 cm SL, with the majority of the obtained estimations between 15 and about 25 cm SL. In

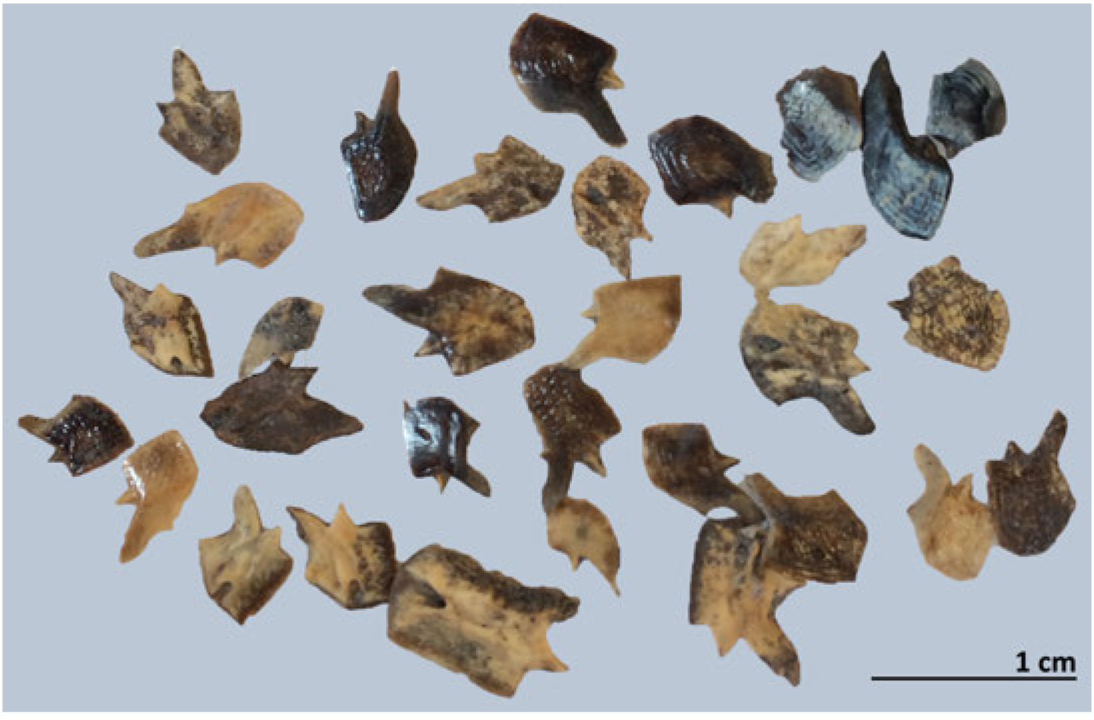

FIGURE 2

Polypterus scales showing the effect of various degrees of exposure to fire.

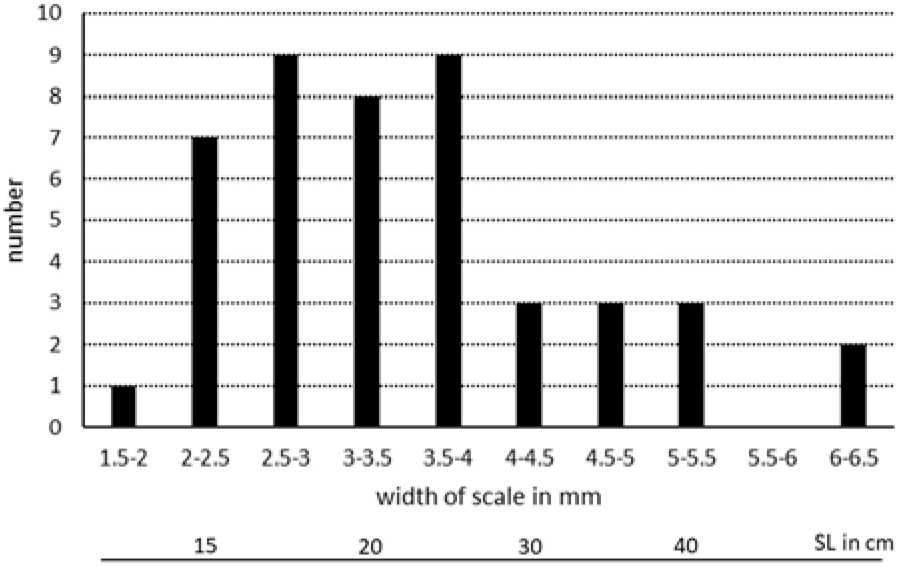

FIGURE 3

Greatest width of *Polypterus* scales in a random sample of 45 specimens. The approximate corresponding standard lengths (SL) are indicated at the bottom of the graph.

the other material, a comparable size range and the same abundance of small scales are seen with only occasional larger outliers of up to 65-70 cm SL. Six bichir species have been reported for the Ruki basin and they are all typical of swamps and shallow parts of the river.

At Bolondo a few remains of African bonytongue (*Heterotis niloticus*) were found, a species that is lacking at Nkile. In the surface layer of Trench 5, three fragments occur of the typical scales of this species, that cannot be mistaken for those of any other African taxon. Cockerell (1910) describes them as 'large oval scales with the exposed portion thick and corrugated, with a more or less vermiform sculpture'. The presence of this species at Bolondo is somewhat surprising as it is not listed among the native taxa of the Ruki basin. It has been introduced in the Ubangi River in 1960 and was already common in the area of Mbandaka in the 1980s (Vanden Bossche & Bernacsek, 1990). The presence of this fish is attested in Trench 5 in the uppermost level which is in line with the very recent date of these layers. Young *Heterotis* live in shallow waters with abundant aquatic vegetation and the adults are reputed for their floating nests, made of plant matter, in which they deposit their eggs.

The presence of Mormyridae was attested in almost every layer by vertebral centra that have a very typical, reticulated lateral side. Twenty-eight species belonging to 11 genera of this family have been reported from the Salonga region (Monsembula Iyaba & Stiassny, 2013) and for the entire Ruki basin no less than 44 species in 12 genera are listed in FishBase (https://www.fishbase.de/trophiceco/FishEcoList.php?ve_code=815, accessed 16th April 2021).

Six vertebral centra that were measurable have been compared to modern specimens and it appears that the mormyrids from Bolondo were between 5 and 10 cm SL (3 specimens) and 10-15 cm (3 specimens). Also the Cyprinidae remains, precaudal vertebrae and a single dentary, are from small fish that could not be identified beyond family level. The closely related genera *Distichodus* and *Citharinus*, belonging to the suborder of the Citharinoidei, share many osteological characteristics hampering a precise identification of isolated bones. Two skeletal elements, a quadrate and an opercular, were identifiable as *Distichodus*, but the nine vertebrae had to be classified as representing the *Distichodus*/*Citharinus* group. The reconstructed sizes of these fish range between less than 5 and 7 cm SL. Thirty remains of Alestidae have been identified of which one opercular could be attributed to a tiger fish (*Hydrocynus* sp.) of about 5 cm SL. The identification of four other cranial bones and 25 vertebrae had to remain at family level.

Catfishes are the most common fish found at Bolondo, both in terms of NISPs and of MNIs. Of the 1200 siluriform remains almost 75% could not be identified any further. These unidentified catfish bones are mainly fragments of the skull roof, the pectoral girdle, and pectoral and dorsal spines of which the articular facets were lacking. Among the identified taxa, the Clariidae family is the most abundant. The articular facet of 78 of the pectoral spines match very well with *Clarias*, and four dentaries could be attributed to *Channallabes*. No evidence for *Heterobranchus* was found, whereas the possible presence of *Clariallabes* could not be verified due to the lack of comparative specimens. The reconstructed sizes show that the clariids were relatively small with most fish measuring between less than 10 cm and 30 cm SL (Figure 4). Some specimens in the smallest length class (<10 cm SL) appear to be even below 5 cm SL, but an accurate estimation was not possible due to lack of very small comparative specimens. Clariidae are typical floodplain dwellers that can survive extreme conditions thanks to their accessory breathing organs allowing the uptake of oxygen from the air.

The numerically second most important catfish taxon is *Synodontis,* a genus that could easily be identified on the basis of its pectoral and dorsal spines, its cleithrum and, when sufficiently preserved, its skull roof. The size reconstructions show a heavy preponderance of small fish: more than 70% of the individuals are less than 10 cm SL and even one third are smaller than 5 cm SL (Figure 4).

The presence of *Chrysichthys* is attested by two cleithra belonging to fish measuring 8-9 cm SL and 15-18 cm SL and also for the schilbeid catfish the osteological evidence is scant. Three vertebrae of this catfish family belonging to two small individuals were found.

Among the percomorph fish, Cichlidae are the most frequent taxon at Bolondo. Identified skeletal elements include various cranial and pectoral girdle elements, dorsal and anal spines and pterygophores as well as a few vertebrae. The average small size of the cichlids is clear from the length reconstructions, showing that about half of the fish were smaller than 10 cm SL (Figure 4).

The presence of *Lates* is indicated in the hand-collected material by a second precaudal vertebra of a fish measuring 30-40 cm SL and in the sieved samples by a cleithrum of an individual of the same size. The genus was not noticed during a survey in the Salonga National Park (Monsembula Iyaba & Stiassny, 2013) and it is not mentioned either in the checklist of FishBase for the Ruki river; (https://www.fishbase.de/trophiceco/FishEcoList.php?ve_code=815, accessed 16th April 2021). However, the rare occurrence of *Lates niloticus* is mentioned for the region of Ikela on the Tshuapa river (Matthes, 1964), one of the Ruki headwaters.

Parachanna finally is represented at Bolondo by remains of dentary, maxilla, premaxilla and opercular that correspond mainly to individuals of 20-25 cm SL (MNI=6) and somewhat larger fish (MNI=4). One individual is less than 20 cm SL. Two species (*P. obscura* and *P. insignis*) have been reported from the region. Snakeheads typically inhabit floodplains with abundant aquatic vegetation.

Three reptile taxa were found but their identification was not very precise, due to the lack of adequate reference material (in the case of the snakes) or the absence of diagnostic characters in the case of the turtle and the crocodile remains. The presence of snakes is attested by vertebrae and ribs which, judging from their sizes and the occurrence of traces of burning, may represent human food waste. The unidentified turtle bone was a plastron fragment, whereas the crocodile remains consist of two ribs, a vertebra, a lower jaw fragment, a tibia, a femur and 11 dermal scutes. In our study region three species occur, i.e. African slender-snouted crocodile (*Crocodylus cataphractus*), Nile crocodile (*Crocodylus niloticus*) and dwarf crocodile (*Osteolaemus osborni*). Given the environment of the site, it is likely that the remains are from dwarf crocodile that typically occupy dense swamps and flooded forests (Eaton, 2010). It is also the species that is nowadays most frequently marketed at Mbandaka (Figure 5). The two long bones were compared to a modern specimen of *Osteolaemus* with a total length of about one meter. It appears that the femur is of a similar sized specimen and that the tibia belonged to an individual that was about one third larger. In the sieved samples only small scutes were found that belonged to young crocodiles but of which the exact length could not be established.

Remains of mammals, both wild and domesticated are rare at Bolondo. In the sieved material only remains of isolated molars and incisors of small rodents were found, animals that lack in

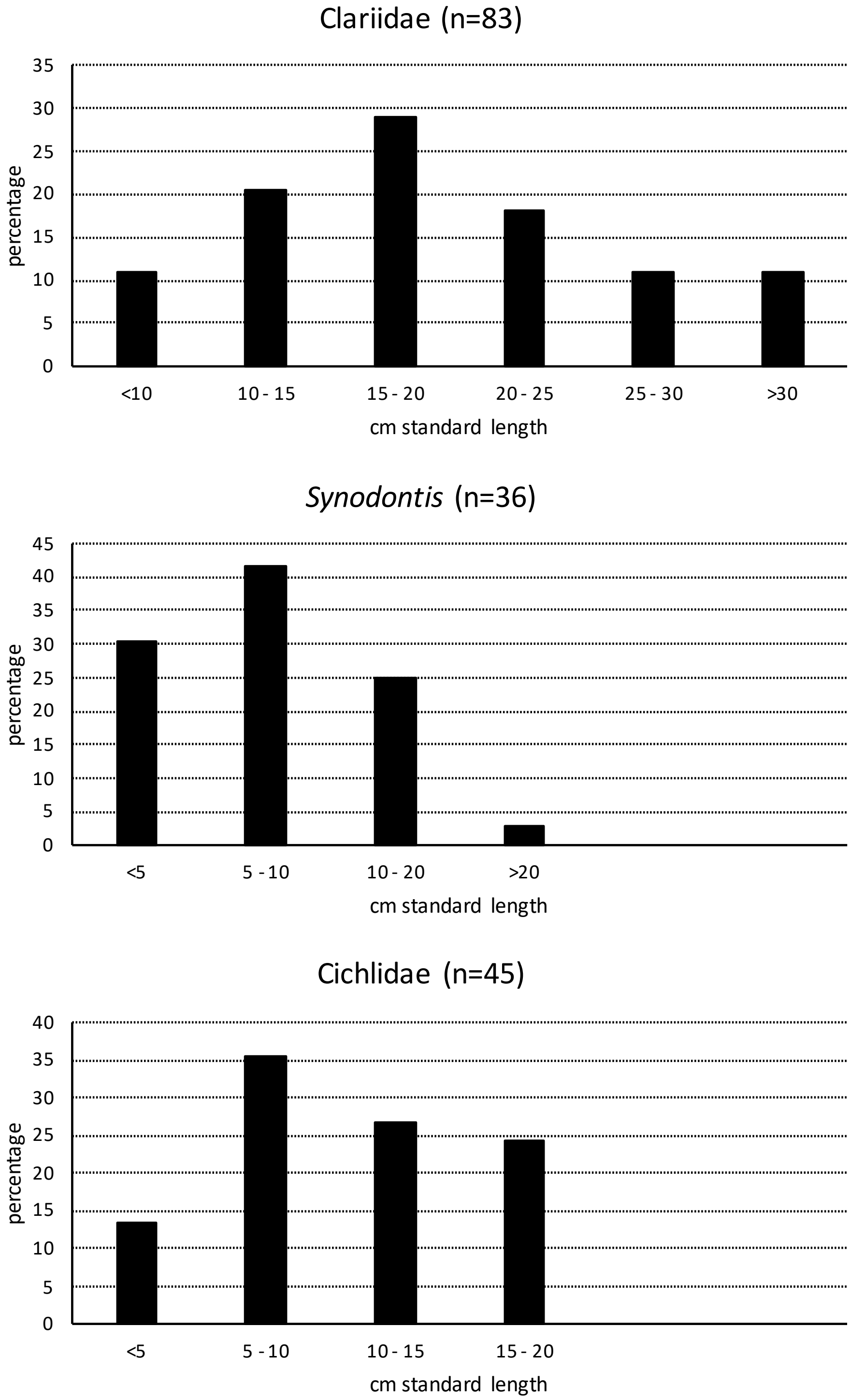

FIGURE 4

Proportions of the various length classes in the clariid catfish, the *Synodontis* and the Cichlidae of the sieved samples from Bolondo. The MNI on which the estimations were carried out are indicated (n).

FIGURE 5

Dwarf crocodiles for sale at a market in Mbandaka in December 2016 [© Théodore Trefon (2017)].

the hand-collected fraction. The sole evidence for a cercopithecid monkey at Bolondo is a jaw fragment. Six antelope remains were found of which two could be identified to species. The presence of sitatunga (*Tragelaphus spekii*) is indicated by a third phalanx (DLS: 55; Ld: 50) with its characteristic elongated shape, an adaptation to life on muddy substrate. A complete metacarpal (GL: 113; Bp: 16.3; SD: 10.7; Bd: 16.9) fits perfectly with black-fronted duiker (*Cephalophus nigrifrons*). The presence of domestic goat is indicated by a scapula (SLC: 17.7; GLP: 29.2; LG: 24.5; BG: 19.9) and a mandible with the third and fourth premolars and the first and second molars still in place. The scapula was identified on the basis of the criteria mentioned in Boessneck *et al*. (1964) and the mandible corresponded to goat judging from the morphology of the premolars (cf. Zeder & Pilaar, 2010). These goat remains have been radiocarbon dated to 450 ± 30 BP (Poz-98263) for the mandible and 460 ± 30 BP (Poz-98264) for the scapula. The corresponding calibrated calendar dates (95% probability) are AD 1413-1480 and AD 1412-1471 respectively. This firmly places the goat bones in the 15th century AD which is, to our knowledge, the earliest presently known evidence for domestic livestock in the Congo Basin. In addition to the antelope and goat remains mentioned above there are still three other bovid bones that could not be identified any further. Other poorly identified remains from the hand-collected assemblage of the settlement are two suid fragments that could either be a wild species or domestic pig. The presence of domestic dog is attested by a mandible (alv. L. M1: 17.6 mm) with cut marks on the ventral side near the angular process and on the buccal side, below the second molar. Two of the three other, unidentified, carnivore remains are in the size range of domestic dog and the third bone is from a somewhat smaller, presumably wild carnivore.

Nkile

The faunal assemblage from Nkile, like that of Bolondo, consists mainly of fish remains (Table 2). All three snail genera, *Homorus*, *Limicolaria* and *Subulina*, belong to the Achatinidae, a family

	NKI 2	NKI 3	NKI 6	Total
Homorus sp.	1/1	-	1/1	2/2
Limicolaria sp. (garden snail)	-	-	1/1	1/1
Subulina cf. *avakubiensis* (awlsnail)	-	-	1/1	1/1
Protopterus sp. (lungfish)	-	-	1/1	1/1
Protopterus cf. *dolloi* (lungfish)	-	-	8/2	8/2
Mormyrops sp. (elephantfish)	-	1/1	4/3	5/4
Cyprinidae (minnows)	-	-	1/1	1/1
Bagridae (bagrid catfishes)	2/1	1/1	2/1	5/3
Clariidae (clariid catfishes)	8/2	1/1	11/8	20/11
Synodontis sp. (squeaker catfish)	1/1	-	2/2	3/3
Cichlidae (cichlids)	6/3	-	1/1	7/4
Ctenopoma sp. (climbing perch)	1/1	-	-	1/1
Parachanna sp. (snakehead)	11/3	3/2	35/6	49/11
Crocodylidae (crocodile)	-	-	2/1	2/1
Cercopithecidae (monkey)	-	-	1/1	1/1
Genetta sp. (genet)	-	1/1	-	1/1
Philantomba monticola (blue duiker)	-	1/1	1/1	2/2
Canis lupus f. familiaris (dog)	-	-	1/1	1/1
Ovis ammon f. aries / *Capra aegagrus* f. hircus (sheep/goat)	-	-	2/1	2/1
small bovid (sheep/goat size)	3/1	1/1	1/1	5/3
total identified	33/13	9/8	76/34	118/55
unidentified gastropods	1	-	1	2
unidentified fish	20	-	60	80
unidentified mammals	9	1	12	22
total unidentified	30	1	73	104

TABLE 2

Species list of Nkile, indicating the Number of Identified Specimens (NISP) and the Minimum Number of Individuals (MNI) in the three trenches adjacent to the river Ruki.

of terrestrial pulmonate gastropods. They are typical of well vegetated environments, and because of their small size it is unlikely that they represent human food waste. Among the 97 fish remains, 10 different taxa were identified. In four cases, identifications had to remain on family level for the reasons mentioned above. Half of the identified fish remains (NISPs) belong to *Parachanna*. The majority of the snakeheads from Nkile are in the size class 30-40 cm SL (MNI=5), but there are also smaller specimens of 20-30 cm SL (MNI=2) and larger ones of 40-50 cm SL (MNI=2) and even 50-60 cm SL (MNI=2). The clariid catfish are the second most important taxon in terms of NISPs. Two pectoral spines match well with *Clarias*, whereas the sole dentary found differs from both *Clarias* and *Heterobranchus*. Clariids smaller than 20 cm SL are lacking at Nkile, possibly due to the lack of sieving during the excavations, but apart from that there is a lot of variation in size. The majority of the fish are medium-sized, measuring 20-30 cm SL (MNI=3), 30-40 cm SL (MNI=3) and 40-50 cm SL (MNI=2). In addition there are larger animals of 50-60 cm SL, 60-70 cm SL and 80-90 cm SL (one individual of each). The *Polypterus* finds consist of one typical ganoid scale, an opercular, a posttemporal and five skull roof fragments with the fine granular typical of this genus. The opercular and the posttemporal belong to an individual of 40-50 cm SL. All the other fish taxa are represented by few remains. The sole *Protopterus* bone is a lower jaw of an animal of around 60 cm SL. The finds of *Mormyrops* consist of a basioccipital, a quadrate and an articular, and two precaudal vertebrae. The material represents at least four individuals measuring 50-60 cm SL (2 individuals) and 70-80 cm SL (2 individuals). The sole cyprinid bone is a mesethmoid of a large fish, measuring between 70 and 80 cm SL, that could not be identified beyond family level due to the lack of adequate comparative material. Five remains could be attributed to the bagrid catfish family, i.e. two hyoid fragments, a cleithrum, a precaudal vertebra and a piece of the Weberian apparatus. The reconstructed sizes of these bagrids are 40-45 cm SL, ca. 60 cm SL (MNI=2) and 80-90 cm SL. Another catfish, besides the already mentioned clariids, is *Synodontis*. The three bones, each corresponding to a different individual, are a humeral process (10-15 cm SL), a frontal bone (10-15 cm SL) and an unidentifiable skull roof fragment of a somewhat larger individual (ca. 20 cm SL). Seven bones belong to the Cichlidae, a family that counts numerous species in Central Africa. The identified material consists only of cranial remains, i.e. three operculars, two interoperculars, one lacrimal and one premaxilla. The reconstructed sizes are 15-20 cm SL, 20-25 cm SL (2 individuals) and 25-30 cm SL. *Ctenopoma* finally, is represented by an opercular of a fish measuring 10-15 cm SL.

Two dermal scutes indicate the presence of crocodile, and in one case a cutmark is visible on the external surface. Compared to the fish, mammal remains are also rare, both the identified and unidentifiable fragments. The sole primate bone is a proximal fragment of a second phalanx from a cercopithecid that could not be identified more precisely. The fronto-parietal part of a skull demonstrates the presence of genet and two antelope remains could also be identified. These specimens, a jugal fragment and a caudal vertebra, could easily be assigned to blue duiker (*Philantomba monticola*), which is the smallest species living in the region. An upper molar and a first phalanx compare morphologically to sheep and goat. In addition, there are five remains that can be either ovicaprid or an antelope of similar size, and that are listed as small bovids. Finally, there is an ulna fragment of dog of which the olecranon is missing as a result of carnivore gnawing. This piece also shows traces of human working: at the medial side several parallel cut marks are visible below the proximal articular surface.

Besides the aforementioned remains that were found in Trenches NKI 2, NKI 3 and NKI 6, there is still a single find from NKI 4. That trench is located more inland and yielded the lower jaw of a suid with the first molar fully developed and functional, and with the third and fourth permanent premolars piercing. On the basis of size and the enamel pattern of the teeth, an identification as warthog (*Phacochoerus*) or giant forest hog (*Hylochoerus meinertzhageni*) can be excluded. The gross morphology of the molar compares to that of both the bush pig (*Potamochoerus porcus*) and the domestic pig (*Sus scrofa* f. *domestica*), but using the diagnostic criteria described by Cooke & Wilkinson (1978: 439-440) the jaw can be attributed to domestic pig.

TAPHONOMY

Apart from the animal remains associated with the human skeletons at Bolondo, that are mainly funerary gifts, the majority of the faunal remains found at Nkile and Bolondo can be considered food remains. Exceptions are the small snails, i.e. *Homorus* sp. and *Subulina* sp. found at Nkile, that can be considered penecontemporaneous intrusives (*sensu* Gautier, 1987). Possibly the *Limicolaria* sp. found at both sites also fall in this category although these achatinids are edible and often exploited as food (Felagha *et al*., 2020). The two specimens from the hand-collected sample of Bolondo are large and may represent snails that were harvested for food. Among the unidentified molluscs from Bolondo shell fragments of both gastropods and bivalves were found few of which seem to be of large individuals that could represent food waste. They probably are from individuals that died naturally on the spot or from molluscs that were eaten by some of the fish species, in which case they would be stomach content. Molluscs are part of the diet of several catfish taxa (Clariidae, Bagridae, *Synodontis* etc.) and large cyprinids (Sandon & Tayib, 1953). Other animals that possibly were not consumed by humans are the small rodents found in the sieved material from Bolondo that may be from intrusive animals that had died naturally. All the other vertebrate remains, including those of dog, are considered human food waste. As mentioned above, the dog ulna found at Nkile and the mandible from Bolondo showed cut marks.

The large amount of small-sized fish seen at Bolondo are believed to represent food waste as well. Theoretically, some of the smaller fish could be stomach content of the few large piscivorous fish encountered at the site, i.e. *Lates* or *Hydrocynus,* however no evidence of etching due to digestion was found. Accumulations of large numbers of small fish have been reported from a modern rivershore locality in Senegal, representing fish disposed off by fishermen while cleaning their nets (Van Neer & Morales-Muñiz, 1992), but the assemblage from Bolondo is clearly different. The association with archaeological and archaeobotanical remains makes this alternative explanation

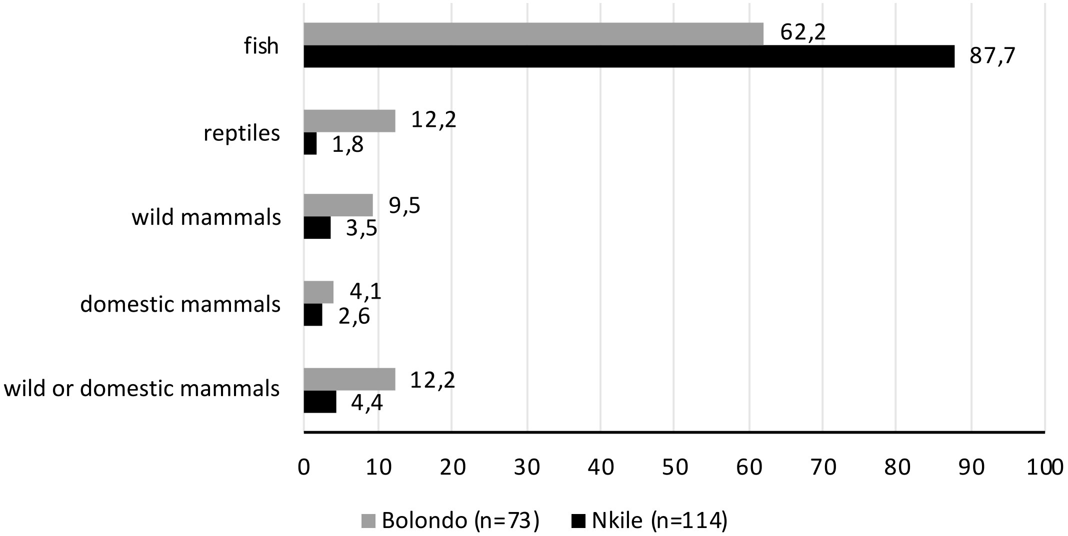

FIGURE 6

Proportion of the fish, reptiles, wild and domestic mammals in the hand-collected samples from at Nkile and Bolondo. The percentages are based on the NISPs.

highly unlikely and, in addition, there are numerous fish bones with burning marks. These were observed not only on the *Polypterus* scales mentioned above but also on many catfish and cichlid bones. The observed colours vary from black to grey-white showing that sometimes the fish were exposed to high temperatures. It is likely that the traces of burning are partly accidental, due to the fact that food remains ended up in hearths. Nevertheless, some of them can be considered as a result of intentional exposure to fire. A traditional way of preparing bichirs is to throw the fish into the fire and to peel off the hard scales once the fish are cooked (WVN, personal observation, Uganda, Lake Albert, December 1989).

SUBSISTENCE

No matter whether the NISPs or the MNIs are considered, it is clear that the most commonly practised subsistence activity was fishing. The evidence for possible harvesting of molluscs is meagre, but it cannot be excluded that some large achitinids or even freshwater bivalves were used for human consumption. Hunting is indicated by the presence of cercopithecid monkeys at both Nkile and Bolondo, and there are antelopes at both settlements as well. These include typical forest species, i.e. blue and black-fronted duiker and in addition there is the sitatunga, a larger antelope that typically occurs in marshy, forested areas. Carnivores were also occasionally hunted, as shown by the bone of a genet and a few remains of unidentifiable similar-sized carnivores. Evidence for the keeping of domestic animals is present but it appears that these species were not often used as food. As the presence of tsétsé flies hampers cattle raising in the equatorial forest, livestock production in this region nowadays focuses on small ruminants, poultry and pigs. In the villages, chicken and goats, sometimes sheep or some pigs are kept in small numbers, mainly for own use (Tollens, 2010). Both at Nkile and Bolondo a few ovicaprid remains occur among which only goat could be positively identified at Bolondo. The bones were not suitable for an evaluation of the stature or the type of breed they may have belonged to, but given the type of environment the site is located in, it is likely a dwarf goat typical of the region (Weaver, 2020). The suid remains found at Bolondo, do not permit a distinction between the domestic form and the wild species occurring in the region, i.e. giant forest hog and bush pig. However, the first molar found at Nkile is from domestic pig which is the sole evidence for this animal thus far in Central Africa (Van Neer, 2000). As no bird remains were found at all, it could not be verified if poultry was kept. Cut marks show that dog was consumed at both sites, a practice that is well documented for West Africa and the Congo Basin (Frank, 1965).

The importance of fishing is clearly shown when comparing the amount of fish bones to that of reptiles, wild mammals and domestic mammals. In Figure 6 the relative importance is indicated of the various animal groups for the hand-collected assemblages of Nkile and Bolondo. A category of wild/domestic mammals was also retained to include the bones on which the distinction could not be made. In the sieved material from Bolondo, 97% of the remains are from fish, the other bones are from crocodile and snakes. Small crocodiles and water cobra (*Boulengerina annulata*) are nowadays regular bycatches during fishing (Pagezy, 1992; Dounias, 2011). The poor contribution of non-fish is obvious and the same pattern is seen when the unidentified fish are compared to the other unidentified vertebrates (Table 1).

Thanks to a recent stable isotope study carried out on the humans and fauna from Bolondo (Bleasdale *et al*., 2020) dietary information obtained from zooarchaeological and isotopic analyses can be confronted. Usable carbon and nitrogen stable isotopic data were obtained from the bone collagen of 11 humans and a series of animal bones, including two goats, a duiker (re-identified in our present faunal report as *Cephalophus nigrifrons*), an unidentified antelope, a dog, an unidentified fox-sized carnivore, two crocodiles, a clariid catfish and a bichir. Oxygen and carbon isotopes from tooth enamel from humans and a smaller faunal sample were also investigated. The isotopic data show that people relied not only on terrestrial, domestic fauna but also on aquatic resources although the latter signal is not always clear. Fish may have contributed less to the overall diet than mammals because of their relatively low meat weight and since fishing was a seasonal activity. Also interesting about the isotopic results is that the dog has carbon and nitrogen ratios comparable to those of the humans, indicating that it fed on the leftovers of human meals. The fact that the unidentified fox-sized carnivore has similar isotopic values suggests that this bone was also from a dog that was somewhat smaller than the specimen positively identified as dog. The two goats are clearly separated isotopically from the antelopes: they have a higher δ^{15}N ratio and their δ^{13}C is less depleted. This indicates that these animals were kept and fed in a more open environment.

FISH EXPLOITATION

A comparison of the fish faunas exploited at both sites is hampered by the fact that only for Bolondo sieved samples are available. When considering the hand-collected fish bones (Table 3), it appears that the spectrum at both sites is largely comparable with *Parachanna* and catfish, in particular Clariidae, as major taxa. Other shallow water fish such as lungfish and bichir are also well represented and Cichlidae occur in fair amounts.

	Nkile (n=98)	Bolondo (n=46)
Parachanna sp. (snakehead)	50	20
Clariidae (clariid catfishes)	21	22
Synodontis sp. (squeaker catfish)	1	9
Bagridae (bagrid catfishes)	5	-
Siluriformes (catfish)	-	15
Protopterus sp. (lungfish)	1	15
Polypterus sp. (bichir)	8	4
Cichlidae (cichlids)	7	13
Lates sp. (lates perches)	-	2
Ctenopoma sp. (climbing perch)	1	-
Mormyrops sp.	5	-
Cyprinidae (minnows)	1	-

TABLE 3

Proportions of the various fish taxa in the hand-collected samples from Nkile and Bolondo. Percentages are calculated on the basis of the number of identified specimens (n).

The sieved samples from Trench 1 and Trench 5 of Bolondo consist of 111 and 1403 fish bones respectively. The material from Trench 1 is dominated by siluriforms that make up 94% of the identified remains. Mormyrids and cichlids are represented by a few bones only, and among the catfish all but one of the identified remains are from clariids. In addition to these four taxa also the presence of *Polypterus* should be mentioned which is only attested by scales.

The much larger sample from Trench 5 yielded 14 fish taxa, but the most abundant fish are also here the catfishes. They represent 78% of the NISP and among the bones identified to family, it appears there are about twice as many Clariidae as *Synodontis*. Cichlidae account for about 10% of the number of identified bones. The sample sizes in the different phases of Trench 5 are large enough to permit a diachronic comparison of the fish taxa (Table 4).

The figures in Table 4 suggest an increase through time in the amount of exploited catfish and a possible decrease in the cichlids. When only the proportions of Clariidae, *Synodontis* and Cichlidae are considered, the number of observations in Phase 2 are rather limited and chance fluctuations may have affected the proportions. Nevertheless, it seems that, in general, the amount of clariids decreases through time and that of *Synodontis* increases (Figure 7). It is unclear if this shift is due to a change in the abundance of the fish through time or if it is related to the employed fishing gear. The number of observations on the fish lengths per phase is too small to verify if a decrease in size and thus possible overfishing may have been involved.

	Phase 1 (n=384)	Phase 2 (n=162)	Phase 3 (n=477)	Phase 4 (n=380)	Total sieved (n=1403)
all Siluriformes	70,3	75,9	80,9	82,9	78
Cichlidae	9,9	12,3	10,9	7,6	9,9
Polypterus	4,4	5,6	3,8	0,5	3,3
Mormyridae	3,4	1,9	1,9	4,5	3
Alestidae	6	1,2	0,6	0,5	2,1
Parachanna	3,1	0,6	-	1,8	1,4
others	2,9	2,5	1,9	2,1	2,3

TABLE 4

Proportions through time of the major fish taxa in the sieved samples from Trench 5 at Bolondo. Percentages are calculated on the basis of the number of identified specimens (n).

Even if the sites are located in the equatorial African rainforest, there is seasonal variation in the waterlevels that has an influence on the accessibility of the fish populations. The lowest water levels in the Ruki are in July and August (Devroey, 1957: 283), based on observations over about two decades (1933-1955) at Ingende, which is near Nkile. Also in the month of March there is a drop in the water levels at that locality. At Boende, on the Tshuapa river, closer to Bolondo, a similar pattern was observed between 1916 and 1955 (Devroey, 1957: 289). These dry seasons are ideal for fishing as the lowering of the waters results in the formation of ponds and small lakes, both of natural and anthropic origin (Inogwabini, 2005; Comptour *et al.*, 2016). It is obvious from the species composition and the preponderance of shallow water fish taxa at Bolondo and Nkile that these are the aquatic environments that were preferably exploited for the fish they contained. During the season that the waters lowered and became wadable, it must have been possible to capture fish with a variety of methods adapted to shallow environments. The fishing gear used in such waters of the Congo Basin, although not preserved as archaeological artefacts, is known both by museum collections, and by a set of photographs and written documents present in archives since the end of the 19th century, notably at the RMCA (Royal Museum for Central Africa, Tervuren, Belgium). Some of the fishing devices are still in use today (Bahuchet & Rameau, 2016) and include, amongst others, fish weirs, finely woven baskets as well as nets used to scoop water (and fish) out of the ponds (Dounias, 2011). Very often the

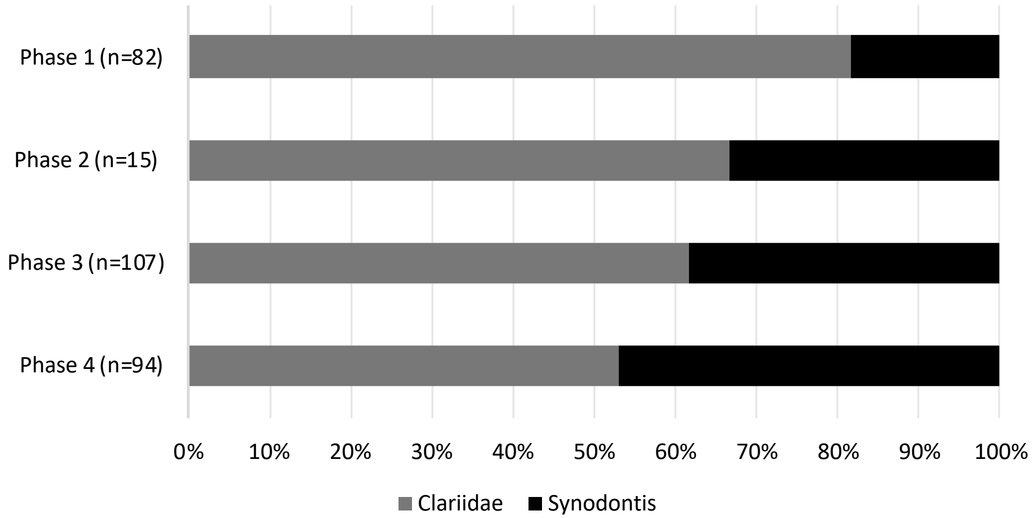

FIGURE 7

Proportions through time of the Clariidae and *Synodontis* in the sieved samples from Trench 5 at Bolondo. n = the number of specimens on which percentages are calculated.

latter type of fishing was practised as a communal activity that took place during the low water season and that aimed at catching a great number of fish of all sizes in a single event (Figure 8). These practices often involved a large number of participants and are known to have been widespread in the past (Van Leynseele, 1979; Comptour *et al*., 2016). Another category of fishing gear frequently used in the shallow water environments of the region are stationary traps that exist in many forms and sizes adapted to the type of fish and water level. The average small size of the fish captured at Bolondo and Nkile suggest that the fishing gear used at these sites must have been finely meshed and these may have been baskets and traps of the kind mentioned above. Whether ichthyotoxic plants were used by fisherfolk in the past is hard to prove and the sole zooarchaeological evidence for such a practice is known from a coastal site in Ecuador (Béarez, 1998). With the possible exception of the small size of the fish, we have no indications for fish poisoning at the studied sites, but the practice is mentioned in the literature for pre-colonial and colonial times (Boulenger, 1901; Malaisse, 1968; Eggert, 1987) and attested by both documents and photographs in the aforementioned archives of the colonial period. For the sake of completeness, it should be mentioned that at Bolondo a pierced cylindrical ceramic artefact, reminiscent of present-day net weights used on the Congo river, was found although contemporary weights observed at Bolondo are made of laterite.

The species spectrum and the relative importance of the various fish taxa seen at both sites compare rather well to those seen in present markets of urban centres such as Mbandaka to which fisherfolk bring their catch for sale (Vanden Bossche & Bernacsek, 1990: table 11). The species list in the latter FAO-report also mentions that fingerlings account for about 4% of the fish offered for sale. Nowadays, there are concerns about the over-exploitation of fish populations due to the use of modern fine-meshed nets (1-2 cm) and chemical poisoning of ponds during the low water season

FIGURE 8

Women scooping water out of a pond closed by an artificial dam; region of Lake Mai-Ndombe. AP.0.0.9449, © RMCA Tervuren; photo L. Van den Broeck, 1899-1914.

(Inogwabini, 2005). However, when traditional techniques are applied in traditional ways, the quantities of fish extracted do not compare to those obtained by modern gear (Inogwabini, 2014). Still today floodplain fisheries can be very productive without signs of biological overfishing, although more quantitative information about small-scale fisheries is needed to evaluate the selectivity of the fishing gears and their impact on the ecosystem (Misund *et al.*, 1999). As mentioned above, it is unclear if ichthyotoxic plants were used at Bolondo or Nkile, but it is obvious that the fisherfolk were capable of capturing numerous small-sized fish. Our zooarchaeological data show that this practice seems to have been ongoing already for centuries, apparently without having a negative effect on the fish populations. Possibly the removal of small fish had no adverse effect on the ichthyofauna as the human populations were smaller in the past and fishing pressure was therefore still sustainable.

It has been argued that heavy exploitation of fish populations can still be sustainable when it is not carried out all year long, nor everywhere, as observed at least among the Libinza of the Ngiri river not far from our research zone (Van Leynseele, 1981). The ponds and fishing grounds in that region have owners that still practise a certain degree of control when the stocks seem to decline.

A few documents from the *Fonds Affaires Indigènes et Mains-d'oeuvre*, available for consultation in the RMCA archives, are part of a survey carried out at the end of the 1940s on the initiative of the Belgian colonial administration about fishing practices and customary law. It appears that this type of customary or ownership control was widespread in the past but that it was discouraged by the colonial authorities in order to assert their ownership of the land. Among those forms of fish population control carried out by the fisherfolk, temporary fishing bans could be imposed to allow fish stocks to recover (De Noyette, 1948).

During the large part of the high water season, the sites are surrounded by water and this period is unfavourable for fishing as fish are very dispersed and access to the waters is difficult. This period of the year is typically devoted to hunting, in particular of duiker (Pagezy, 1986), a species also present in the faunal assemblages. It should be underlined, however, that based on historical documents and ethnographic data available for the region, it appears that sites like Bolondo and Nkile are traditionally not occupied by the entirety of its population throughout the year but are instead part of a larger web of semi-permanent functional encampments linked to an inland village (Eggert, 1987; Dounias & Bahuchet, 2000).

CONCLUSIONS

The faunal remains from Bolondo and Nkile, two riverside settlements located along the Ruki-Tshuapa basin, described in the present paper are the sole assemblages known thus far for the Inner Congo basin. The excellent preservation of the bones is due to the exceptional waterlogged conditions and probably also to the rather recent nature of the deposits that correspond to human occupation spanning the 14th to 20th centuries AD. At both sites, subsistence has predominantly been based on the exploitation of the aquatic environment, i.e. fishing and the capture of reptiles (crocodiles and possibly water cobra). These activities mainly took place during the low water season when pools and small ponds that formed in the floodplain became wadable and therefore could easily be exploited with the aid of fine-meshed fishing gear such as scoop baskets and nets. Also stationary traps and ichthyotoxic plants may have been used, as was done until very recent times. Throughout a sequence of about 600 years at Bolondo no shift is seen in the species spectrum or in the sizes of the fish that would be indicative of over-exploitation. It appears that the fish were exploited over the centuries in a sustainable way, probably because fishing was only practised seasonally and rather locally. Among the rare terrestrial resources used at both sites are some wild animals, i.e. cercopithecids, some carnivores and antelopes, mainly duikers. Domestic animals are also rare and include goat, pig and dog that all served as food.

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Zooarqueología de todo un valle: cambios en el consumo de animales en los últimos 3.400 años en El Valle de Mauro, Norte Semiárido de Chile (31°s)

All valley´s zooarchaeology: changes in the consumption of animals in the last 3,400 years in El Mauro Valley, Semiarid North of Chile (31°s)

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RESUMEN. Se presentan y discuten los resultados del análisis zooarqueológico de 37 sitios arqueológicos del Valle de Mauro (31º57`S-71º01`O, ~900 msnm), emplazado en la franja meridional del Norte Semiárido del actual territorio chileno. Estos sitios abarcan una secuencia cronológica y cultural que va desde el Arcaico Tardío (*ca*. 3.400 años cal AP en adelante) hasta ocupaciones históricas, enfatizando la secuencia prehispánica asociada a eventos del Período Alfarero Temprano (*El Molle*), Intermedio Tardío (*Diaguita*) y Periodo Tardío (*Inca*). Nuestros resultados indican un consumo intensivo de camélidos (*Lama guanicoe*) durante el Arcaico que desciende drásticamente en sincronía con la aparición de la cerámica y prácticas hortícolas en el valle. Hacia momentos *Diaguita* y con prácticas agrícolas consolidadas junto a la aparición de camélidos domésticos (*Lama glama*), proponemos la necesidad de repensar a estos grupos con prácticas pastoriles trashumantes condicionadas por los ciclos de pasturas en el Semiárido, tal como se observa para momentos históricos.

PALABRAS CLAVE: ZOOARQUEOLOGÍA, VALLE DE MAURO, NORTE SEMIÁRIDO, CAMÉLIDOS, DOMESTICACIÓN

ABSTRACT: We present and discuss results of the zooarchaeological analysis of 37 archaeological sites in *El Mauro* Valley (31°57'S-71°01'O, ~900 masl), located on the southern border of the Semiarid North of Chile. These sites cover a chronological and cultural sequence ranging from the Late Archaic (*ca*. 3,400 cal years BP onwards) to historical occupations, emphasizing the pre-Hispanic sequence associated to Early Ceramic Period (*El Molle*), Late Intermediate Period (*Diaguita*) and Late Period (*Inka*). By integrating all recovered taxa, new consume patterns emerge through the sequence. Or results indicate intensive consumption of camelids (*Lama guanicoe*) during the Archaic period, that descends drastically in sync with the appearance of ceramics and horticultural practices in the valley. With the consolidation of agricultural practices and the introduction of camelid herding (*Lama glama*) towards the *Diaguita* period, we propose the need to rethink these groups with transhumant pastoral practices conditioned by the pasture cycles in the Semiarid, as observed for historical moments.

KEYWORDS: ZOOARCHAEOLOGY, *EL MAURO* VALLEY, SEMIARID NORTH, SOUTH AMERICAN CAMELIDS, DOMESTICATION

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INTRODUCCIÓN

Los valles, como ecosistemas, aportan a las poblaciones humanas una gran variedad de recursos bióticos (plantas y animales) y abióticos (materias primas en general). Además, los valles conforman paisajes culturales, en donde el entorno de los asentamientos humanos cumple un rol activo en la organización social de los grupos, el cual se va modelando a partir de cambios detonados por factores internos y externos. Para el caso del Norte Semiárido chileno (NSA en adelante), franja que abarca desde el río Copiapó (27°S) en su extremo norte hasta el río Aconcagua por el sur (32°S) y con cuencas centro-meridionales como la del Elqui (29°S), Limarí (30°S) y Choapa (31°S), sus valles fueron áreas claves para el asentamiento humano sobre todo para grupos horticultores, agrícolas y ganaderos. Estas tres cuencas (Elqui, Limarí y Choapa), poseen distintas influencias culturales tanto de la vertiente oriental de los Andes, como de las cuencas del Huasco-Copiapó para el caso del Elqui y de Chile central para el Choapa. Esta última cuenca, es una de las más estudiadas a nivel arqueológico especialmente en la costa y a lo largo de toda su secuencia cultural, con énfasis en continuidades y discontinuidades en la ocupación del espacio, la influencia de cambios climáticos en la disponibilidad de los recursos –con hincapié en el registro malacológico y en la recolección–, y sus relaciones culturales con áreas vecinas, entre otras temáticas (ver Méndez & Jackson, 2006).

Entre las preguntas zooarqueológicas que caben por abordar en la franja meridional del NSA, es sí las variaciones ecológicas y sociales habrían implicado diferentes restricciones y demandas sobre las opciones económicas y los recursos animales, lo que requiere un enfoque detallado y una mejor síntesis de los datos zooarqueológicos. Para el caso del Valle de Mauro, trabajos previos han considerado parcialmente las evidencias arqueofaunísticas, enfatizando el estudio y la evaluación de la domesticación de camélidos como un proceso local autónomo o bien introducido, el análisis funcional y morfológico de la tecnología ósea y algunos trabajos centrados a problemas de sitios específicos (López *et al*., 2015; Santander & López, 2016). No obstante, se hace necesaria una visión global, considerando las variaciones en el uso de la fauna a lo largo de toda la secuencia, con el fin de discutir dichas variaciones en función de los cambios socioeconómicos y culturales discutidos en el NSA desde fines del Arcaico (*ca*. 4.000 años cal AP) hasta momentos históricos. En particular, los objetivos de este trabajo son explorar la variabilidad del registro arqueofaunístico asociado al tránsito de economías basadas en la caza-recolección, caza-recolección-horticultura, caza-agricultura, domesticación de camélidos y, dentro de estos marcos, los notables cambios en el registro a lo largo del Período Alfarero Temprano (1.900-750 años cal AP) y la posible introducción de camélidos domésticos durante el Periodo Intermedio Tardío (950-520 años cal AP).

En este sentido, la posibilidad de estudiar un valle completo permite una mayor resolución de distintos fenómenos o conceptos a abordar en el presente trabajo como la intensificación, detonada posiblemente por un aumento demográfico hacia fines del Arcaico. Esta intensificación, en especies claves como los camélidos dentro de ambientes áridos y semiáridos, puede causar una reducción en la disponibilidad de este recurso y una diversificación en la dieta, la cual conduce a un aumento en el uso de recursos con bajas tasas de retorno (Neme *et al*., 2012). Para momentos históricos, sobre todo en un ambiente rural como Mauro, es relevante evaluar las causas de las similitudes y diferencias en la crianza de caprinos en comparación al pastoreo de camélidos para momentos prehispánicos.

ANTECEDENTES DEL VALLE DE MAURO

El Valle de Mauro: características generales

El Valle de Mauro (31º57-S-71º01'O, ~900 msnm) corresponde a una cuenca preandina formativa del estero Pupío, el cual desemboca en el océano Pacífico a unos 40 km al poniente y que se inserta en un área dominada por un clima de estepa templado (Figura 1). Esta área refleja condiciones climáticas transicionales entre el desierto absoluto del Norte Árido y los ambientes mediterráneos de la zona central (Veit, 1996). Dentro de la secuencia estudiada en el presente trabajo, que abarca desde los *ca*. 3.400 años cal AP hasta tiempos históricos, el ambiente ha transitado por una serie de fluctuaciones. Hacia los 4.200 años cal. AP se produce una expansión de la vegetación de humedales y en los 3.200 años cal. AP la contracción del bosque. Entre los 1.800 y 1.300 años cal AP se expande la vegetación arbustiva, mientras que hacia los 1.300

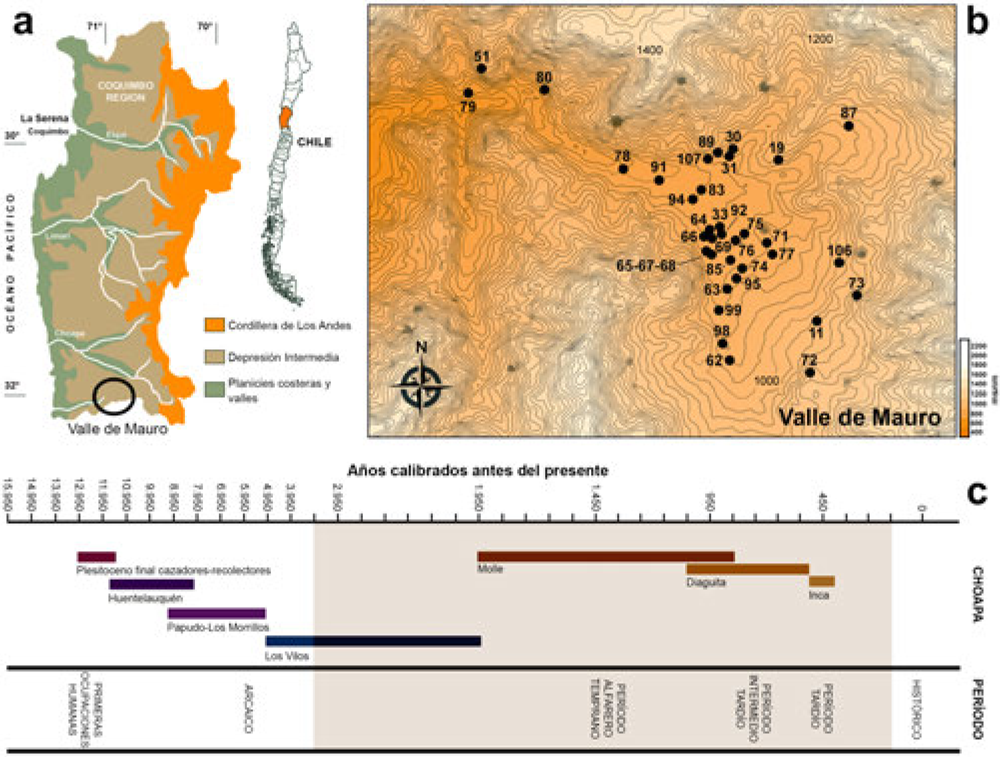

FIGURA 1

(a) Ubicación del Valle de Mauro y sitios estudiados, **(b)** ubicación de sitios estudiados con sus respectivos números de identificación, y (c) Marco cronológico para la cuenca del Choapa señalando los períodos estudiados (Figura 1c tomada y modificada de Falabella *et al*., 2016).

años cal. AP se estabilizan las condiciones actuales (Maldonado & Villagrán, 2006). La zona costera está influenciada por las variaciones asociadas a *El Niño-Southern Oscilation* (ENSO), causada por cambios latitudinales estacionales que producen alta variabilidad y precipitaciones en latitudes medias del actual territorio chileno (Muñoz *et al*., 2018). Análisis sedimentológicos en los sectores de Guanaqueros y Tongoy (30°S) indican una fase seca de alta productividad primaria que alcanzó un *peak* cerca de los 6.500 años cal AP seguido por un aumento continuo en condiciones húmedas y baja productividad primaria sobre todo en los últimos 2.000 años (Muñoz *et al*., 2018).

Arqueología del Valle

Las primeras ocupaciones humanas se registraron en el sitio MAU033, con 2 muestras óseas humanas datadas en 8.267 y 6.219 años cal AP (Gómez & Pacheco, 2016), aunque no asociadas a eventos ocupacionales domésticos. Se identificó una casi total ausencia de sitios del Arcaico Medio en El Mauro, a diferencia de lo observado en la costa (Méndez & Jackson, 2006). En este sentido, para poblaciones acerámicas las fechas se concentran en el Arcaico Tardío (AT) en el sitio MAU085, el cual corresponde a una extensa área de procesamiento de guanacos, retoque de artefactos líticos y recambios de puntas de proyectil desde los astiles (López *et al*., 2015, 2016. Ver Figura 2). Otras evidencias sincrónicas se observan en MAU033 y en el contexto funerario MAU091. Con la aparición de la cerámica durante el Periodo Alfarero Temprano (PAT), los sitios se distribuyen en gran parte de la cuenca, emplazados desde los 600 hasta los 1.055 msnm, aunque con una mayor concentración a lo largo del estero Pupío, quebradas y en las llanuras de baja pendiente del sector centro-norte. La cerámica está representada por vasijas pequeñas

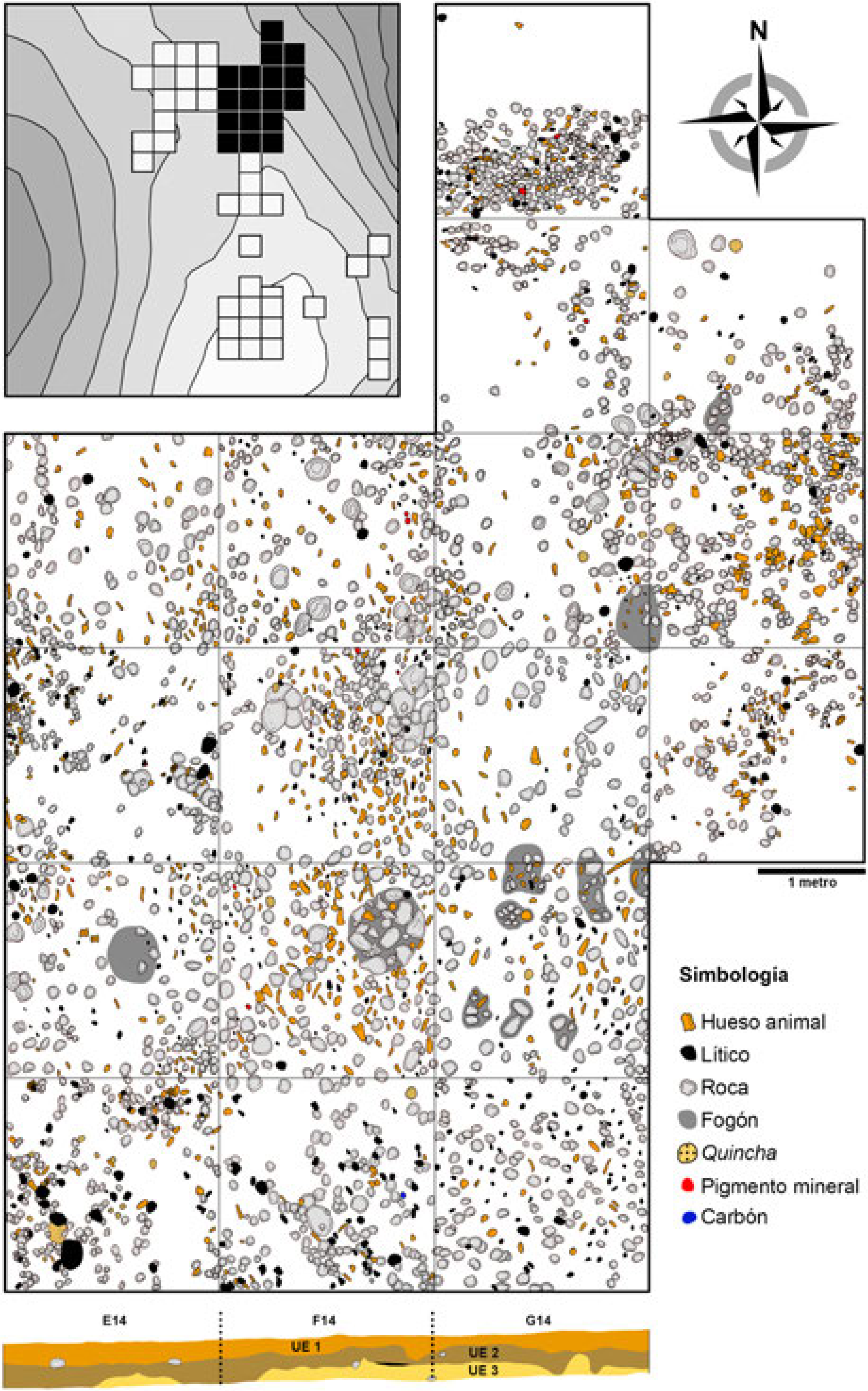

FIGURA 2
Vista de planta del componente Arcaico Tardío o AT (Unidad Estratigráfica 2) del sitio MAU085. Abreviaturas: UE. Unidad estratigráfica.

y medianas, de formas restringidas y usadas para el consumo de agua o alimentos líquidos. Dentro del registro arqueobotánico destacan especies endémicas y cultivadas como quinoa (*Chenopodium quinoa*), madi (*Madia sativa*) y maíz (*Zea mays*) (López *et al*., 2017). En sitios como MAU085 se observa una reocupación PAT sobre la extensa ocupación de fines del Arcaico (Figura 3).

A partir de las dataciones absolutas se identificó una supervivencia entre grupos locales de modos de vida PAT durante inicios del Período Intermedio Tardío (PIT) definido por la cultura *Diaguita* asentada en la zona con posterioridad a los *ca*. 750 años AP. Los sitios con ocupaciones PIT y del Periodo Tardío (PT) –este último correspondiente al momento de la influencia incaica en la zona–, se concentran en el sector norcentral del valle, en cotas de altitud que van entre los 800 y 900 msnm. Dentro de los datos cronológicos obtenidos, existe un grupo asignable con certeza al PIT y otro al PIT-PT (Figura 4). Para el caso del PIT es evidente el carácter sedentario y orientado a la producción de alimentos, aunque con un despliegue más acotado que los sitios incas explicable por unidades domésticas de gran autonomía productiva en base a la recolección y cultivos (quinoa y maíz). Durante el PT, estas unidades domésticas sufren cambios drásticos, incrementándose la variedad y cantidad de recursos utilizados relacionado a una amplia red de intercambio y traslado de recursos, aumentando también las especies vegetales domésticas como el madi, poroto (Fabaceae), pallar (*Phaseolus lunatus*) y zapallo (Cucurbitaceae).

El conjunto zooarqueológico: acercamiento metodológico

Se analizaron un total de 300.814 especímenes óseos (Tablas 1 y 2). Este registro ha sido publicado parcialmente en estudios previos (ver López *et al*., 2012, 2015, 2016; Santander & López, 2016), siendo este el primer trabajo que sintetiza toda la información de Mauro.

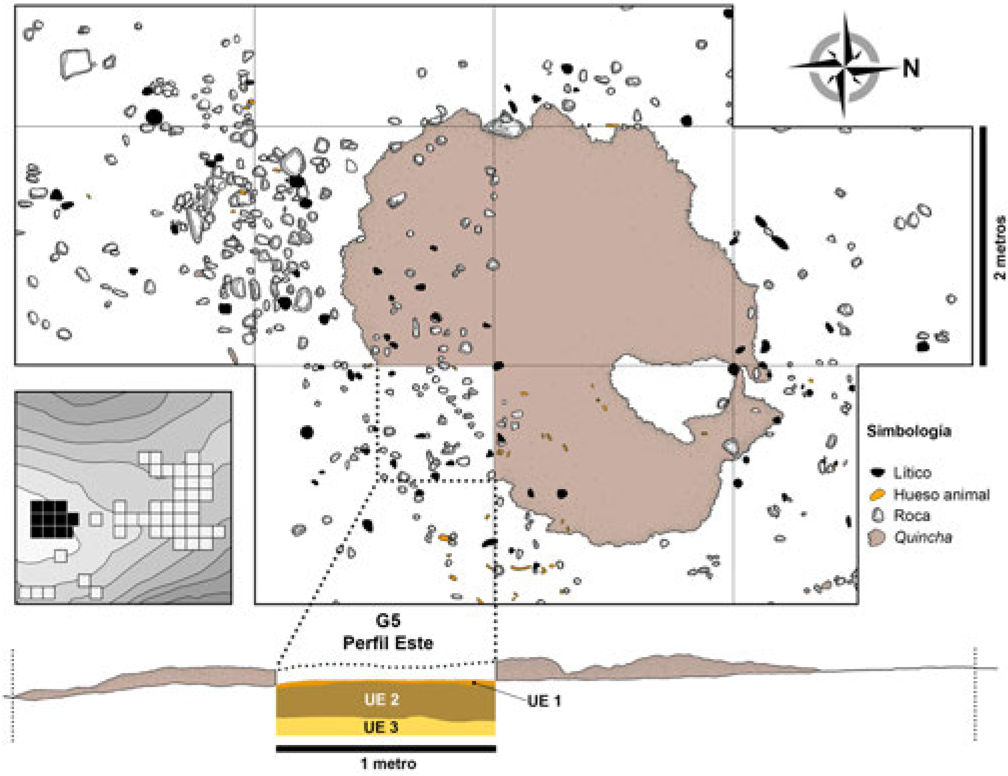

FIGURA 3

Vista de planta del componente Alfarero Temprano o PAT (Unidad Estratigráfica 1) del sitio MAU085. Abreviatura: UE. Unidad estratigráfica.

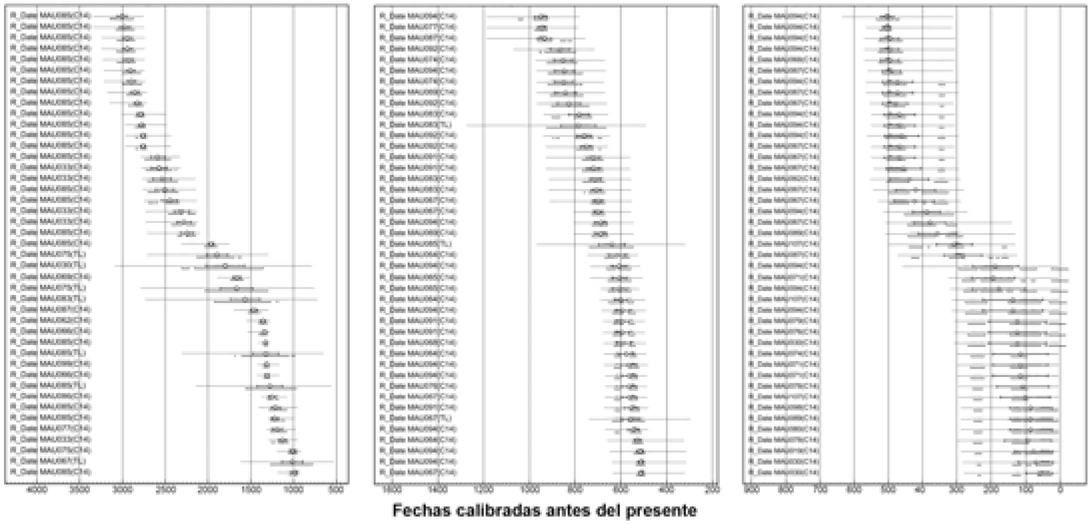

FIGURA 4

Dataciones ^{14}C calibradas de los sitios estudiados. Fechas tomadas de López *et al*. (2012, 2015) y Gómez & Pacheco (2016). Calibración realizada mediante OxCal 4.4.4 (Bronk Ramsey, 2021), usando la curva SHCal20 (Hogg *et al*., 2020).

Cuantificación y análisis

La cuantificación se realizó mediante el NISP (*Number of Identified Specimens*) y %NISP. Para el análisis de abundancia taxonómica se calculó el MNI (*Minimum Number of Individuals*) mediante un cruce de datos como la mayor representación de huesos del esqueleto apendicular, la edad de los individuos y el tamaño de unidades anatómicas. En cuanto a la edad de los camélidos, se utilizaron 4 categorías asociadas a la edad: **(a)** nonato, **(b)** no fusionado, **(c)** semi-fusionado y **(d)** fusionado, utilizando rangos etarios definidos por Kaufmann (2009). Para facilitar el proceso de cuantificación, los datos son presentados mediante 2 grandes categorías: **(a)** adultos y **(b)** subadultos (nonatos, no fusionados y semi-fusionados), sumándose a los restos de adultos especímenes cuyos centros de fusión estaban ausentes, pero que presentaban un desarrollo óseo afín a animales adultos. Las medidas de frecuencia de unidades anatómicas utilizadas correspondieron al MNE (*Minimum Number of Skeletal Elements*) junto al MAU (*Minimum Number of Animal Units*) y el %MAU.

Con el objetivo de mitigar el sesgo de los procesos tafonómicos sobre la destrucción ósea, se correlacionaron (r_s) los valores de densidad mineral ósea de guanacos calculados por Stahl (1999) y el %MAU para cada sitio. Este mismo ejercicio se realizó con el Índice de Utilidad para el guanaco de Borrero (1990) y modificado por Lyman (1994, 1998). Además, se evaluaron el Índice de Médula Ósea para la llama (Mengoni-Goñalons, 1988, 1996) y el Índice de Secado de Carne (De Nigris & Mengoni-Goñalons, 2004). Para ponderar las estrategias de uso de los animales se calcularon los índices de Riqueza, Diversidad y Equitatividad con el fin de comparar los distintos sitios y componentes culturales del valle. Los índices en cuestión fueron calculados de la siguiente forma: **(a)** Índice de Riqueza, el que se expresa como NTaxa, y refleja la cantidad de taxones utilizados en un sitio. Corresponde a la sumatoria de todas las categorías taxonómicas no traslapadas. **(b)** Índice de Diversidad (H'), el cual mide la importancia relativa de las especies registradas y la variedad de animales explotados para cada periodo. Para su cálculo se utilizó el Índice de Shannon y se expresa mediante la fórmula $H' = - \sum (pi) (\ln pi)$; en donde *pi* es el número de especímenes de la categoría *i* dividido por el tamaño de la muestra. Por último, **(c)** el Índice de Equitatividad (J'), mide la distribución de la abundancia de los individuos a lo largo de una secuencia y la variedad de especies usadas en los sitios en base al uso igual/desigual de especies y el grado de dependencia de los recursos explotados. Comprende valores que van de 0 a 1, en donde el más cercano o igual a 1 implica que los taxones tienden a ser igualmente abundantes. Para el cálculo de este Índice se utilizó la fórmula $J' = H' / \ln S$, en donde H' es el índice de Shannon y

Sitio	Tipo de sitio	Componente 1	Componente 2	Componente 3	NISP
MAU011	Indeterminado	Histórico	-	-	12
MAU019	Doméstico/Funerario/ Arte rupestre	Histórico	Período Alfarero Temprano	-	61
MAU030	Doméstico/Arte rupestre	Período Alfarero Temprano	Histórico	-	450
MAU031	Indeterminado	Histórico	-	-	1
MAU033	Doméstico/Funerario/ Arte rupestre	Arcaico Medio y Tardío	Período Alfarero Temprano	-	8.135
MAU051	Doméstico	Período Alfarero Temprano	Histórico	-	106
MAU062	Doméstico/Funerario	Período Alfarero Temprano	Histórico	-	1.235
MAU063	Doméstico	Período Alfarero Temprano	-	-	75
MAU064	Doméstico	Período Intermedio Tardío	Período Alfarero Temprano	-	1.083
MAU065	Doméstico	Período Intermedio Tardío	Período Alfarero Temprano	-	31
MAU066	Doméstico	Período Alfarero Temprano	Período Intermedio Tardío/Tardío	-	107
MAU067	Doméstico/Funerario	Período Intermedio Tardío/ Tardío	Período Alfarero Temprano	-	20.218
MAU068	Doméstico	Período Intermedio Tardío/ Tardío	Período Alfarero Temprano	-	54
MAU069	Doméstico	Período Alfarero Temprano	Período Intermedio Tardío/Tardío	-	42
MAU071	Doméstico	Histórico	Período Alfarero Temprano	-	129
MAU072	Doméstico	Período Alfarero Temprano	-	-	1
MAU073	Doméstico	Período Alfarero Temprano	Histórico	-	1
MAU074	Doméstico	Período Alfarero Temprano	-	-	62
MAU075	Doméstico/Funerario/ Arte rupestre	Período Alfarero Temprano	-	-	500
MAU076	Doméstico	Período Alfarero Temprano	Período Tardío	Histórico	13
MAU077	Doméstico/Funerario	Período Alfarero Temprano	-	-	125
MAU078	Doméstico	Histórico	-	-	21
MAU079	Doméstico	Período Alfarero Temprano	Histórico	-	269
MAU080	Doméstico	Período Alfarero Temprano	-	-	9
MAU083	Doméstico	Período Intermedio Tardío	Período Alfarero Temprano	Histórico	2.093
MAU085	Doméstico/Funerario	Arcaico Tardío	Período Alfarero Temprano	-	217.871
MAU086	Doméstico	Período Alfarero Temprano	Histórico	Período Intermedio Tardío/Tardío	16
MAU087	Doméstico/Funerario	Período Alfarero Temprano	Histórico	-	383
MAU089	Doméstico	Histórico	Período Alfarero Temprano	-	2.742
MAU091	Doméstico/Funerario	Período Intermedio Tardío	Período Alfarero Temprano	-	7.473
MAU092	Doméstico	Período Alfarero Temprano	Período Intermedio Tardío	Histórico	1.086
MAU094	Doméstico/Funerario	Período Intermedio Tardío/ Tardío	Histórico	Período Alfarero Temprano	34.626
MAU095	Doméstico	Histórico	-	-	9
MAU098	Doméstico	Período Alfarero Temprano	Histórico	-	528
MAU099	Doméstico	Período Alfarero Temprano	-	-	12
MAU106	Doméstico	Histórico	-	-	142
MAU158	Doméstico	Período Alfarero Temprano	-	-	86
Total					**300.814**

TABLA 1

Sitios estudiados y NISP total estudiado de cada contexto arqueológico.

Taxa	NISP Total	AT		PAT		PIT		PIT/PT		H		Peso	AT	PAT	PIT	PIT/PT	H
		NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI		Peso total	Peso total	Peso total	Peso total	Peso total
Mammalia	282553	167614	-	58729	-	10891	-	43872	-	1447	-	-	-	-	-	-	-
Artiodactyla	135	0	-	64	-	29	-	16	-	26	-	-	-	-	-	-	-
Camelidae*	10894	4227	26	1113	27	565	12	4989	50	0	0	95	2470	2565	1140	4750	-
Caprinae	228	0	0	0	0	0	0	0	0	228	21	65	-	-	-	-	1365
Capra hircus	20	0	0	0	0	0	0	0	0	20	7	75	-	-	-	-	525
Bos taurus	104	0	0	0	0	0	0	0	0	104	16	750	-	-	-	-	12000
Sus s. domestica	2	0	0	0	0	0	0	0	0	2	2	250	-	-	-	-	500
Carnivora	16	4	-	0	-	0	-	12	-	0	-	-	-	-	-	-	-
Canidae	40	13	2	13	8	7	3	4	3	3	2	6	12	48	18	18	12
Lycalopex culpaeus	5	2	1	3	3	0	0	0	0	0	0	6	6	18	-	0	-
Lycalopex griseus	12	8	1	1	1	1	1	2	1	0	0	5	5	5	5	5	-
Lycalopex sp.	2	0	0	0	0	0	0	2	1	0	0	5,5	-	-	-	5,5	-
Puma concolor	2	1	1	1	1	0	0	0	0	0	0	77	77	77	-	-	-
Mustelidae	8	1	1	0	0	0	0	7	1	0	0	0,29	0,29	-	-	0,29	-
Thylamys elegans	2	0	0	0	0	1	1	1	1	0	0	0,29	-	-	0,29	0,29	-
Equidae	4	0	0	0	0	0	0	0	0	4	4	700	-	-	-	-	2800
Equus f. caballus	14	0	0	0	0	0	0	0	0	14	6	700	-	-	-	-	4200
Rodentia	3872	645	-	178	-	235	-	2802	-	12	-	-	-	-	-	-	-
Abrocoma sp.	790	118	32	51	24	24	11	596	171	1	1	0,2	6,4	4,8	2,2	34,2	0,2
Octodon sp.	1568	427	34	136	20	56	15	949	226	0	0	0,3	10,2	6	4,5	67,8	-
Spalacopus cyanus	89	19	5	18	14	8	4	37	10	7	4	0,95	4,75	13,3	3,8	9,5	3,8
Lagidium viscacia	103	68	8	18	6	12	5	5	2	0	0	0,5	4	3	2,5	1	-
Cricetidae	27	10	5	4	2	13	4	0	0	0	0	0,02	0,1	0,04	0,08	-	-
Akodon sp.	2	2	1	0	0	0	0	0	0	0	0	0,02	0,02	-	-	-	-
Phyllotis sp.	10	0	0	0	0	0	0	10	3	0	0	0,02	-	-	-	0,06	-
Myocastor coypus	3	0	0	0	0	0	0	3	1	0	0	6,5	-	-	-	6,5	-
Oryctolagus cuniculus	18	0	0	0	0	0	0	0	0	18	7	2	-	-	-	-	14
Ave	420	10	-	11	-	14	-	382	-	3	-	-	-	-	-	-	-
Cathartidae	3	0	0	0	0	0	0	3	1	0	0	1,5	-	-	-	1,5	-
Falconidae	8	5	1	0	0	0	0	3	1	0	0	0,65	0,65	-	-	0,65	-
Passeriforme	78	1	1	0	0	0	0	77	7	0	0	0,08	0,08	-	-	0,56	-
Fringillidae	1	0	0	0	0	0	0	1	1	0	0	0,08	-	-	-	0,08	-
Sturnella loyca	6	0	0	0	0	0	0	6	2	0	0	0,08	-	-	-	0,16	-
Mimus thenca	19	0	0	0	0	0	0	19	2	0	0	0,08	-	-	-	0,16	-
Phrygilus sp.	2	0	0	0	0	0	0	2	1	0	0	0,05	-	-	-	0,05	-
Nothoprocta sp.	133	0	0	0	0	0	0	133	28	0	0	0,42	-	-	-	11,76	-
Zenaida auriculata	14	0	0	0	0	0	0	14	5	0	0	0,18	-	-	-	0,9	-
Gallus gallus	2	0	0	0	0	0	0	0	0	2	2	0,7	-	-	-	-	1,4
Vultur gryphus	2	0	0	0	0	0	0	2	2	0	0	11,5	-	-	-	23	-
Reptilia	1	1	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Callopistes sp.	74	6	2	2	2	1	1	65	5	0	0	0,37	0,74	0,74	0,37	1,85	-
Liolaemus sp.	5	1	1	0	0	0	0	4	2	0	0	0,15	0,15	-	-	0,3	-
Anura	29	0	-	29	-	0	-	0	-	0	-	-	-	-	-	-	-
Rhinella sp.	5	0	0	0	0	0	0	5	2	0	0	0,85	-	-	-	1,7	-
Osteichthyes	1	0	-	0	-	1	-	0	-	0	-	-	-	-	-	-	-
Indeterminado	14	7	-	4	-	3	-	0	-	0	-	-	-	-	-	-	-
Peso total													2597,38	2740,88	1176,74	4940,81	21421,4
Totan NISP		173189		60375		11861		54023		1891							
NTaxa			16		11		10		25		11						
Diversidad *(H')*													0,268	0,338	0,188	0,243	1,275
Equitatividad *(J')*													0,097	0,141	0,082	0,075	0,532

TABLA 2

NISP total estudiado, NISP-MNI por periodo y peso por taxa. Se agregan además los valores de NTaxa y de Diversidad *(H')* y Equitatividad *(J')* para cada periodo. Abreviaturas: PIT. Período Intermedio Tardío, PT. Período Tardío, PAT. Período Alfarero Temprano, AT. Arcaico Tardío, y H. Período Histórico. *La categoría Camelidae grande engloba a *Lama guanicoe*, *Lama glama* y *Lama* sp.

S es la cantidad de taxones (NTaxa). Para calcular los últimos dos índices se multiplicó el MNI por el peso promedio de cada taxa en vida (Del Papa *et al*., 2011). Esto permite estimar la biomasa obtenida a partir de los recursos animales. Las categorías taxonómicas de Mammalia, Artiodactyla, Carnivora, Rodentia, Ave, Reptilia, Osteichthyes y taxones indeterminados fueron eliminadas del cálculo debido a los problemas que presenta la cuantificación de fragmentos que involucran a especies de distintos tamaños. Animales introducidos post-contacto con el europeo fueron obviados en los gráficos producto a que especies como el vacuno superan notablemente el peso de los mamíferos nativos. Por último, para evaluar los cambios en la explotación de camélidos, se midió el $\text{NISP}_{\text{Camelidae}}$/NTaxa, junto a la distribución de los MNI para cada período y eliminar –en parte– el sesgo producido por conjuntos muy fragmentados.

RESULTADOS

Estudios previos sobre las evidencias zooarqueológicas de El Mauro, enfatizaron el análisis osteométrico e isotópico para identificar el momento cronológico en el cual aparecieron los camélidos domésticos. Los resultados de estas investigaciones señalan una escasa variación de tamaños y valores isotópicos de C y N de los camélidos durante el AT y PAT, los cuales se diversifican para el PIT, fenómeno explicado por la aparición de camélidos de pequeña talla clasificados preliminarmente como domésticos (*Lama glama*) (López *et al*., 2015; Figuras 5a, 5b y 6). La introducción de llamas especializadas como animales de carga es clara con la llegada del *Inca* durante el PT (López *et al*., 2015). Ahora bien, en la Tabla 2 y Figura 7 se detalla el registro zooarqueológico total para cada sitio. Considerando el MNI como índice para estimar la abundancia taxonómica, las 5 especies más representadas en el valle de mayor a menor corresponden a *Octodon* sp., *Abrocoma* sp., Camelidae grande, *Spalacopus cyanus* y *Nothoprocta* sp.

Para el AT los 3 taxa con mayor frecuencia de individuos corresponden a *Octodon* sp. (MNI= 34), *Abrocoma* sp. (MNI= 32) y Camelidae grande (*Lama guanicoe*, MNI= 26). Hacia el PAT, el registro es similar al Arcaico, aunque el orden cambia por cuanto el taxa más representado corresponde a Camelidae grande (MNI= 27). Durante momentos PIT, *Octodon* sp. es el taxa más representado (MNI= 15), seguido por los camélidos (MNI= 12). Los mismos taxones representan la mayor frecuencia de individuos para el PIT-PT, es decir, *Octodon* sp. (MNI= 226), *Abrocoma* sp. (MNI= 171) y Camelidae (MNI= 50). Para momentos históricos los restos de Caprinae (MNI=21) son los más abundantes,, seguido por *Bos taurus* (MNI= 16), *Capra aegagrus hircus* y *Oryctolagus cuniculus* (MNI= 7).

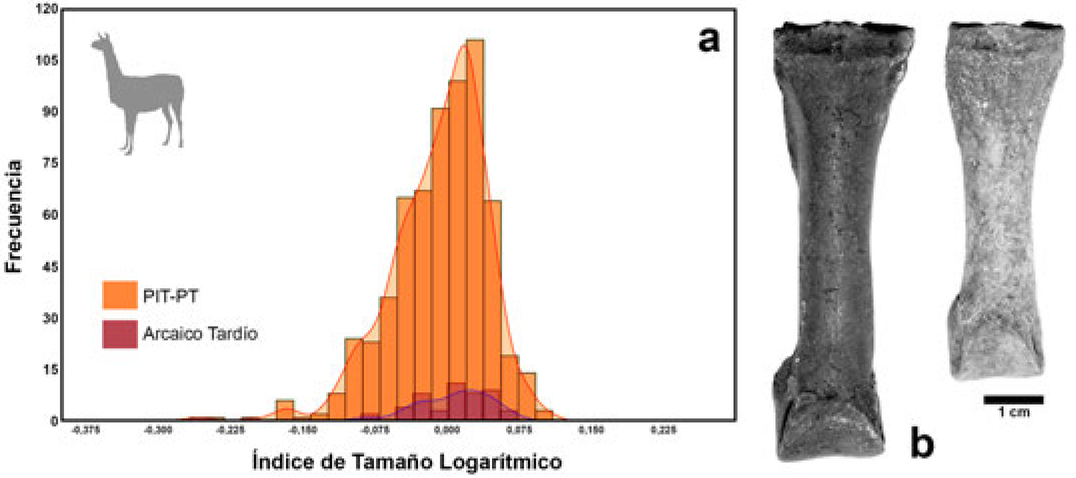

FIGURA 5

(a) Histograma del Índice de Tamaño Logarítmico (LSI) y estimación de Densidad de Kernel para los restos de camélidos arqueológicos del Arcaico Tardío y el Período Intermedio Tardío (PIT)-Período Tardío (PT) del Valle de Mauro; y **(b)** Diferencias de tamaños entre primeras falanges anteriores del sitio MAU094 (PIT-PT). El camélido de referencia para el cálculo del LSI corresponde a un guanaco (*Lama guanicoe*) del sector cordillerano de Chile Central (33° S). Datos tomados y modificados de López *et al.* (2015).

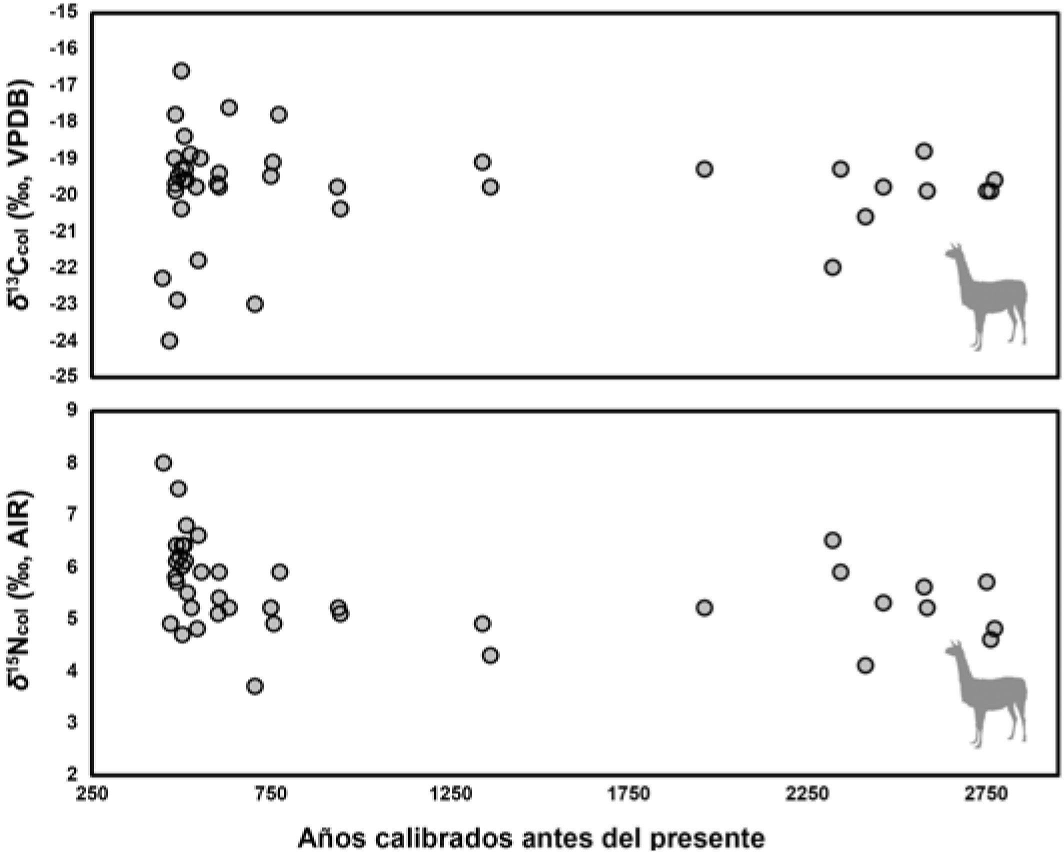

FIGURA 6

Datos isotópicos (C y N) de camélidos del Valle de Mauro comparadas con sus respectivas dataciones ^{14}C. Datos tomados y modificados de López *et al*. (2015).

La alta frecuencia de roedores no es ajena al registro arqueológico para el Semiárido o Zona Central. La información etnohistórica entregada por De Ovalle (1974 [1646]), describe una forma de captura para *Octodon*, en donde se inundaban sus galerías subterráneas para luego atraparlos mientras escapaban. Las pieles de roedores como *Abrocoma* eran muy valoradas entre *aymaras* y *quechuas* de Chile, Argentina y Bolivia (Mann, 1978). Debido a su tamaño, las técnicas de consumo y preparación no son complejas y contemplaron la disposición de roedores completos sobre las brasas y cenizas e incluso eran consumidos crudos (Andrade & Boschín, 2015; Fernández *et al*., 2017). Por su parte, los cánidos son especies que aparecen en bajo número y corresponden a animales silvestres (*Lycalopex culpaeus* y *Lycalopex griseus*). No es claro el registro en Mauro de cánidos domésticos, aunque estudios recientes en el sitio El Olivar en la cuenca del Elqui (29°S) indican el registro de *Canis familiaris* para momentos PIT; cuyos rasgos, formas y tamaños son similares a ejemplares prehispánicos del actual Noroeste argentino y poseen un tamaño mediano comparable al actual *terrier* irlandés (Lucio González & Francisco Prevosti, comunicación personal).

Para el caso de la muestra de El Mauro, el NTaxa (como Índice de Riqueza) más alto se da durante el PIT-PT, valor que se diferencia notablemente del resto de los periodos que mantienen un NTaxa relativamente homogéneo asociado al consumo de camélidos y roedores principalmente, con un valor más alto para el AT. En cuanto a los valores del Índice de Diversidad (*H'*), para momentos prehispánicos es mayor para el PAT y el PIT es el periodo con el valor más bajo. Por su parte, el Índice de Equitatividad (*J'*) y para momentos prehispánicos, el periodo con un valor más alto se da durante el

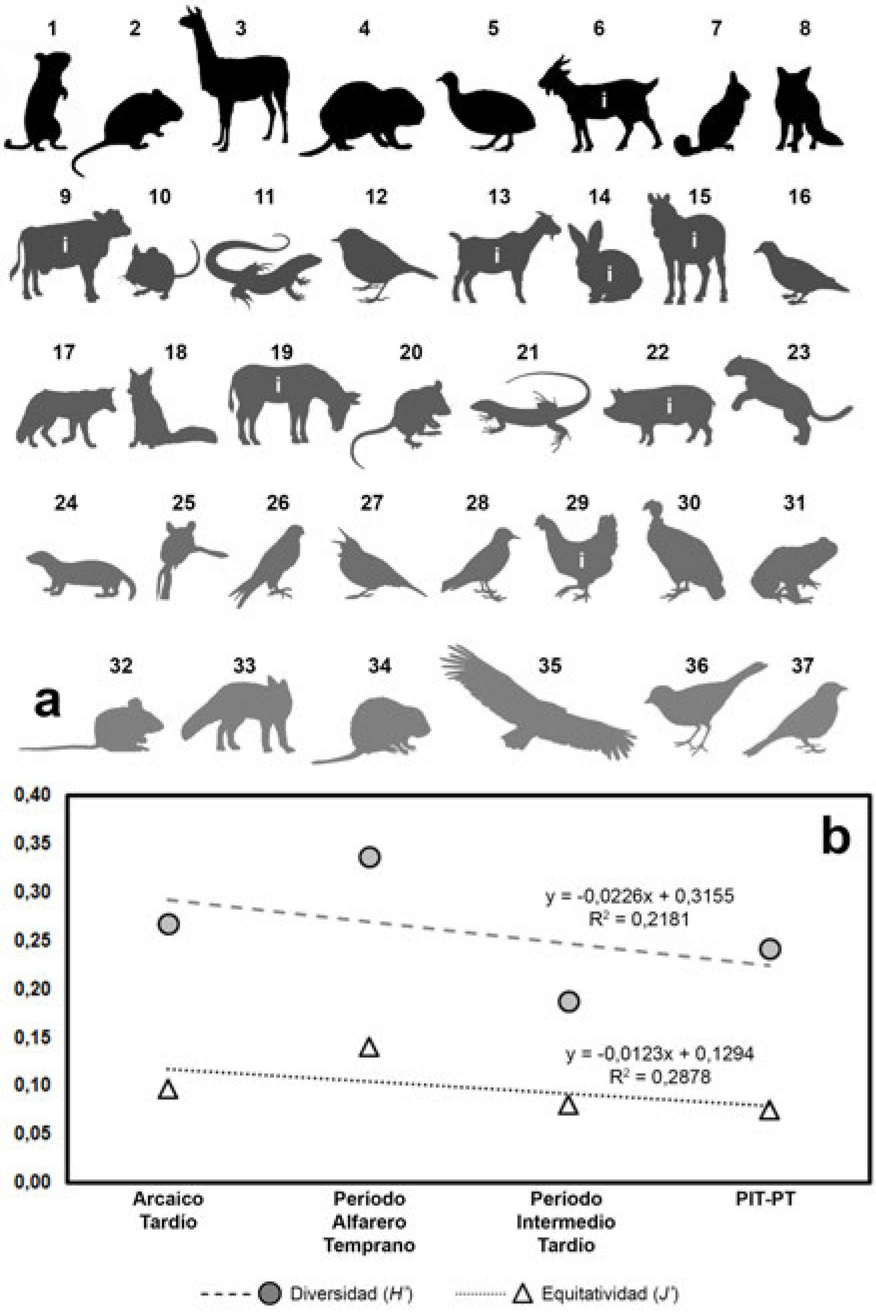

FIGURA 7

(a) Especies representadas en el Valle de Mauro enumeradas con un MNI de mayor a menor: 1. *Octodon* sp.= 295, 2. *Abrocoma* sp. 239, 3. Camelidae= 115, 4. *Spalacopus cyanus*= 37, 5. *Nothoprocta* sp.= 28, 6. Caprinae= 21, 7. *Lagidium viscacia*= 21, 8. Canidae= 18, 9. *Bos taurus*= 16, 10. Cricetidae= 11, 11. *Callopistes* sp.= 10, 12. Passeriforme= 8, 13. *Capra hircus*= 7, 14. *Oryctolagus cuniculus*= 7, 15. *Equus ferus caballus*= 6, 16. *Zenaida auriculata*= 5, 17. *Lycalopex culpaeus*= 4, 18. *Lycalopex griseus*= 4, 19. Equidae= 4, 20. *Phyllotis* sp.= 3, 21. *Liolaemus* sp.= 3, 22. *Sus scrofa domestica*= 2, 23. *Puma concolor*= 2, 24. Mustelidae= 2, 25. *Thylamys elegans*= 2, 26. Falconidae= 2, 27. *Sturnella loyca*= 2, 28. *Mimus thenca*= 2, 29. *Gallus gallus*= 2, 30. *Vultur gryphus*= 2, 31. *Rhinella* sp.= 2, 32. *Akodon* sp.= 1, 33. *Lycalopex* sp.= 1, 34. *Myocastor coypus*= 1, 35. Cathartidae= 1, 36. Fringillidae, y 37. *Phrygilus* sp.= 1. Las i minúsculas marcan los animales introducidos post-contacto con el europeo. **(b)** Representación gráfica de los Índices de Diversidad y Equitatividad para los periodos prehispánicos.

PAT y el valor más bajo se encuentra para el PIT-PT. No obstante, el *J'* tiene su valor más alto para el Periodo Histórico al igual que el Índice de *H'*. Para este último caso, el valor se explica por la sobredimensión de animales que superan los 50 kg a partir de la multiplicación entre el MNI por el peso promedio de cada especie en vida (Del Papa *et al.*, 2011). Para momentos históricos son introducidos animales que superan este peso, los que exceden ampliamente el número de especies que alcanzan estas dimensiones en momentos prehispánicos. Para la totalidad de los periodos prehispánicos los camélidos son los principales animales consumidos, seguidos por roedores y carnívoros, con una frecuencia relativamente similar entre el AT y el PAT. La incidencia de roedores y carnívoros aumenta durante el PIT, mientras que para el PIT-PT se acrecienta considerablemente el consumo de roedores y disminuye el de carnívoros (Tabla 3).

Orden	**AT** (%)	**PAT** (%)	**PIT** (%)	**PIT-PT** (%)	**H** (%)
Artiodactyla	95,096	93,583	96,878	96,138	67,176
Rodentia	0,981	0,990	1,112	2,410	0,019
Carnivora	3,861	5,400	1,955	0,583	0,056
Cathartiformes	-	-	-	0,496	-
Tinamiformes	-	-	-	0,238	-
Squamata	0,034	0,027	0,031	0,044	-
Anura	-	-	-	0,034	-
Passeriformes	0,003	-	-	0,020	-
Columbiformes	-	-	-	0,018	-
Falconiformes	0,025	-	-	0,013	-
Didelphimorphia	-	-	0,025	0,006	-
Perissodactyla	-	-	-	-	32,678
Lagomorpha	-	-	-	-	0,065
Galliformes	-	-	-	-	0,007

TABLA 3

Representación expresada por los Órdenes taxonómicos para cada periodo. El porcentaje representa el MNI x peso promedio del taxón en vida dividido por el peso total de todas las especies. Abreviaturas: PIT. Período Intermedio Tardío, PT. Período Tardío, PAT. Período Alfarero Temprano, AT. Arcaico Tardío y H. Período Histórico.

DISCUSIÓN

El caso de los camélidos

En todo el conjunto analizado no se reconocen restos de vicuñas (*Vicugna vicugna*). Esto se debe a que el valle se encuentra a muy baja altitud y fuera de los límites de distribución sur de esta especie dentro de la franja del Norte Árido-Semiárido del actual territorio chileno (Vilina *et al.*, 2015). Como se mencionó en los antecedentes, los estudios previos indican que la llama aparece en primera instancia durante el PIT (Cartajena *et al.*, 2014; López *et al.*, 2015). En base a este escenario, el consumo de camélidos transita para el Choapa desde grupos cazadores-recolectores arcaicos con movilidad residencial a grupos alfareros iniciales con prácticas hortícolas, pero también con una alta movilidad residencial y una baja notable en la caza de guanacos. Para momentos *Diaguita* (PIT), con evidencias que sustentan el registro de camélidos domésticos, se observa un patrón de asentamiento disperso, en especial en terrazas fluviales producto de un mayor desarrollo agrícola y en donde la caza de guanacos fue una práctica central en su economía. Durante la influencia incaica (PT), estas prácticas se mantienen y es el período en donde ingresan llamas de gran tamaño afines a animales de carga, manteniéndose también, formas pequeñas de esta especie. En este período, además, surgen otras lógicas de producción como la *mit`a*, que fue el principal tributo ofrecido por las poblaciones anexadas al incanato, mediante la entrega de mano de obra para la realización de actividades específicas orientadas a la obtención de recursos que circularon en la economía estatal (Troncoso *et al.*, 2009). Las evidencias arqueofaunísticas, en particular aquellas que provienen de los restos de camélidos, apoyan estas labores específicas (artefactos para la confección de textiles) y los medios necesarios (llamas) para la circulación constante de bienes (Troncoso *et al.*, 2009; López *et al.*, 2012).

El consumo de camélidos debió diferir para todos los periodos. Para cazadores arcaicos tardíos nuestras expectativas apuntaban a que este consumo representó una mayor intensificación en la explotación debido a factores como el aumento demográfico. Nos referimos a intensificación como un aumento en la producción de uno o más recursos por unidad de tierra y, además, a las interacciones locales o regionales entre la gente y sus hábitats (ver Otaola, 2014). Sobre esto, la mayor visibilidad de los asentamientos hacia el AT se ha relacionado con una mayor intensidad en la ocupación regional, posiblemente asociada a un aumento demográfico en coordinación con una monumentalización del paisaje (Méndez & Jackson, 2004; Troncoso *et al.*, 2016a). Por esto, las expectativas se ajustan a sitios de caza y procesamiento inicial articulados con otros de consumo final para bandas de cazadores dispersas, pero con una alta densidad ocupacional en el valle y en donde la fusión de grupos para cazas grupales pudo ser una estrategia utilizada como forma de afianzar alianzas.

La aparición de la cerámica no marcó una ruptura con los modos de vida arcaica y tampoco hay indicios de que vaya de la mano con la domesticación animal. En este sentido, nuestras inferencias para sitios habitacionales y de caza-procesamiento inicial no deberían diferir de los sitios arcaicos, aunque se debe considerar la baja ostensible del registro de camélidos para el Alfarero Temprano. Si la intensificación en la caza fue uno de los factores detonantes en la baja de camélidos se espera un aprovechamiento intensivo de las carcasas, con altos niveles de fragmentación de huesos largos. Con una mayor sedentarización durante el PIT y asentamientos más autónomos junto a una crianza efectiva de camélidos, se espera un consumo constante de estos animales por medio de la caza evitando el sacrificio de animales de rebaños. Los sitios analizados corresponden a áreas habitacionales por lo que es esperable unidades de alto rendimiento y un número reducido de individuos debido al énfasis en una dieta basada en el aporte de los cultivos (Becker *et al*., 2015). Con la influencia incaica en la zona se mantuvieron ciertas prácticas *Diaguitas*, pero redefinidas dentro de una lógica propia del *Inca*. Nuestras expectativas en base a la *mit'a* como uno de los principales tributos ofrecidos por las poblaciones anexadas al incanato, apuntan a una intensificación en la explotación de los distintos ambientes y en la distribución de recursos a asentamientos articulados por el imperio (Troncoso *et al*., 2009). Así mismo, es esperable un aumento en la explotación de recursos como los camélidos para la mantención de manos de obra para la realización de actividades específicas dentro de la economía estatal y una diversificación de especies para distintos usos económicos, rituales

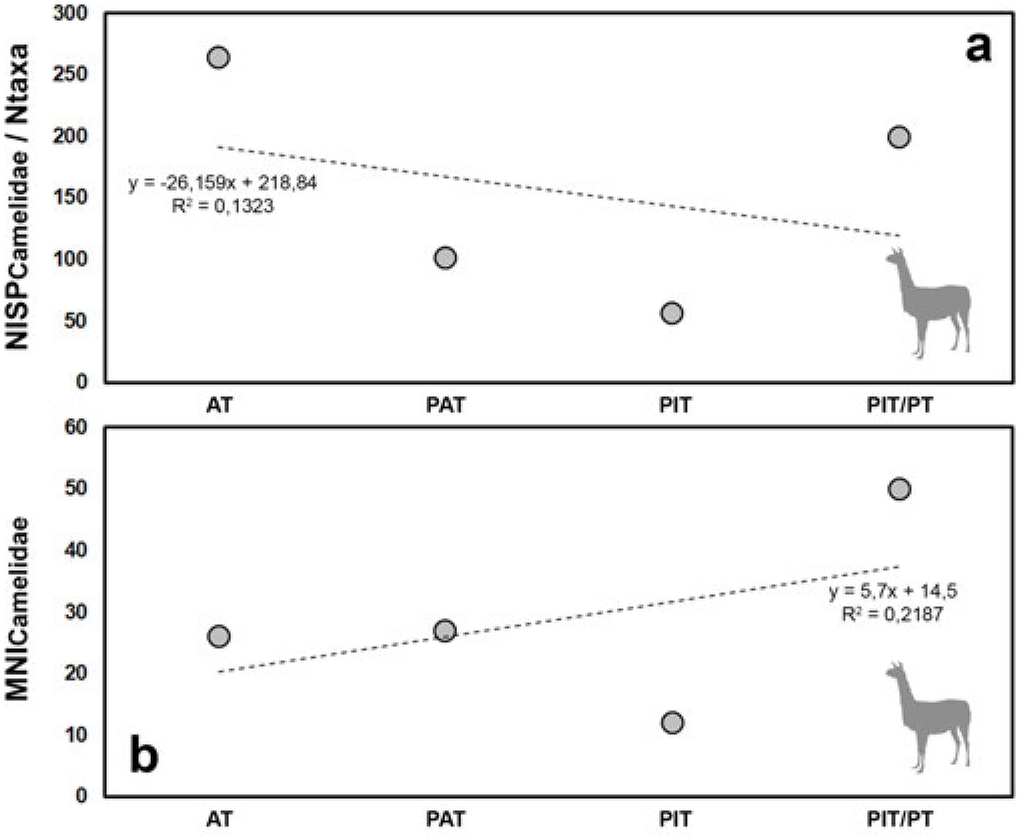

FIGURA 8

(a) Representación gráfica del NISP$_{\text{Camelidae}}$ dividido por el Ntaxa. (**b**) MNI$_{\text{Camelidae}}$ a lo largo de la secuencia prehispánica. Abreviaturas: AT. Arcaico Tardío, PAT. Período Alfarero Temprano, PIT. Período Intermedio Tardío, PT. Período Tardío.

y medicinales, junto a la prolongación de la vida útil de recursos cárnicos a través del secado u otras prácticas afines (López *et al*., 2012).

En base a las expectativas, la relación entre el $\text{NISP}_{\text{Camelidae}}$ y Ntaxa indica una mayor frecuencia de camélidos (guanacos) para el AT y una menor para el PIT y que vuelve a aumentar hacia el PIT-PT (Figura 8a). Sin embargo, al considerar únicamente el MNI de los camélidos la frecuencia de guanacos baja para el AT, debido a que los escasos sitios de este periodo presentan una alta fragmentación, aunque con una mayor identificabilidad (Figura 8b). En base al $\text{MNI}_{\text{Camelidae}}$, aumenta considerablemente el número de estos animales para el PIT-PT. Cabe destacar que la mayor parte de los guanacos del AT provienen mayoritariamente del sitio MAU085 y secundariamente de MAU033. Las muestras de guanacos del PAT provienen de 19 sitios con un promedio de 1,42 individuos para cada contexto, muy por debajo de los 21 guanacos calculados sólo para el sitio MAU085. Esto se explica porque MAU085 no corresponde a un sitio de consumo final, sino que representa actividades de procesamiento primario de cazas colectivas durante 2.100 años continuos, siendo reutilizado luego como un área habitacional PAT con un MNI de 7 guanacos. Para el AT, ningún índice económico y de densidad presenta resultados significativos (Tabla 4), y una comparación entre los eventos arcaicos y alfareros de MAU085 no reflejan diferencias significativas en el caso del Índice de Utilidad sugiriendo cierta continuidad en las prácticas de selección de unidades anatómicas. Para el PAT es donde se dan los valores más significativos del Índice de Médula Ósea indicando una selección de huesos largos con alto contenido en médula, y en el caso del sitio MAU091 un valor significativo pero negativo para el Índice de Secado que refleja unidades anatómicas de alto valor para el secado ausentes en el sitio.

Para el PIT ningún índice aportó datos significativos. Lo último se observa también para el PIT-PT, con un valor significativo y negativo para la cavidad medular en el sitio MAU094, asentamiento altamente complejo con una gran frecuencia de camélidos (MNI= 32), pero también con una alta diversidad de aves, cánidos, roedores y reptiles, por lo que suponemos un enclave importante en la producción incaica. Durante el PIT las nuevas prácticas de producción animal tiene un correlato con un nuevo conjunto de tecnologías óseas como torteras, lanzaderas y agujas relacionadas a una mayor producción textil (Santander & López, 2016).

¿Intensificación en la caza de camélidos durante el arcaico?

Hacia el PAT es notoria la baja de restos óseos, con escasos especímenes de guanacos, lo cual también es coherente con los datos isotópicos en restos

Sitio arqueológico	**Índice de Utilidad**		**Densidad ósea**		**Índice de Secado de Carne**		**Índice de Médula Ósea**	
	r_s	**P**	r_s	**P**	r_s	**P**	r_s	**P**
MAU033 (AT)	0,042	> 0,05	0,063	> 0,05	-0,018	> 0,05	-0,185	> 0,05
MAU085 (AT)	-0,015	> 0,05	-0,148	> 0,05	-0,078	> 0,05	-0,052	> 0,05
MAU062 (PAT)	0,311	> 0,05	-0,638	< 0,05	-0,315	> 0,05	0,746	> 0,05
MAU067 (PAT)	-0,009	> 0,05	0,033	> 0,05	-0,284	> 0,05	0,476	> 0,05
MAU083 (PAT)	-0,214	> 0,05	-0,002	> 0,05	-0,479	> 0,05	0,905	< 0,05
MAU085 (PAT)	-0,185	> 0,05	-0,134	> 0,05	-0,055	> 0,05	-0,279	> 0,05
MAU091 (PAT)	-0,457	> 0,05	0,065	> 0,05	-0,843	< 0,05	0,822	> 0,05
MAU064 (PIT)	0,315	> 0,05	-0,351	> 0,05	-0,082	> 0,05	0,292	> 0,05
MAU083 (PIT)	0,196	> 0,05	-0,028	> 0,05	-0,098	> 0,05	0,583	< 0,05
MAU091 (PIT)	-0,033	> 0,05	0,013	> 0,05	-0,147	> 0,05	0,097	> 0,05
MAU092 (PIT)	0,223	> 0,05	0,250	> 0,05	-0,014	> 0,05	-	-
MAU067 (PIT-PT)	-0,387	< 0,05	0,249	> 0,05	-0,094	> 0,05	-0,303	> 0,05
MAU094 (PIT-PT)	-0,356	< 0,05	0,207	> 0,05	-0,016	> 0,05	-0,564	< 0,05

TABLA 4

Resultados de las correlaciones de Spearman entre el %MAU y los valores de Índice de Utilidad, Densidad ósea, Índice de Secado de Carne e Índice de Médula Ósea en restos de camélidos. En negro se marcan los valores estadísticamente significativos. Abreviaturas: PIT. Período Intermedio Tardío, PT. Período Tardío, PAT. Período Alfarero Temprano, y AT. Arcaico Tardío.

humanos en donde se observó un bajo consumo de proteína animal (Gómez & Pacheco, 2016). La disminución del guanaco como recurso fue propuesta para el registro arqueológico del Holoceno tardío en el sur de Mendoza (32°S, Provincia de Argentina) como efecto de un proceso de intensificación regional reflejada –en parte– en la declinación de los artiodáctilos en favor de especies de menor tamaño y la introducción de plantas domésticas alrededor de los 2.000 años AP (Neme *et al*., 2012). A partir de la aplicación del *Ungulate Prey Depression Model* (UPDM) para el caso de Mendoza se plantea que, frente al aumento de la presión de caza, la densidad de población de ungulados se mantendrá por debajo de la capacidad de sustentación del ambiente y por tanto habrá más alimento disponible por espécimen. Lo anterior derivará en el mantenimiento de las tasas de crecimiento, individuos corporalmente más grandes y una sobrerrepresentación dentro de individuos juveniles respecto a los adultos (Neme *et al*., 2012).

En base a esta propuesta, efectivamente en el Valle de Mauro se ha observado para el AT y PAT una talla de guanacos mayor incluso al de llamas cargueras actuales del Norte Árido, aunque al no tener muestras del Arcaico Medio, no es posible determinar si dicha talla excede a sus precedentes. Para evaluar este punto se correlacionaron los fechados del AT y PAT obtenidos directamente sobre muestras óseas y su respectivo valor del Índice de Tamaño Logarítmico (LSI) considerando las medidas del guanaco de Chile central como estándar utilizado en estudios previos (ver López *et al*., 2015). La línea de tendencia refleja una baja en las tallas de los guanacos desde los *ca*. 2.700 años calibrados AP hasta las fechas más tardías de eventos PAT (r= 0,3146, p = 0,319), lo que se contrapone a la expectativa de individuos corporalmente más grandes frente al aumento de la presión de caza (Figura 9). Lo mismo se aplica para la edad, ya que la tendencia general es una mayor representación de individuos adultos con una relación de 65% de animales de este rango etario *versus* el 35% para animales juveniles del AT y 70 y 30% para el PAT (ver Tabla 5).

¿Hubo continuidad o una ruptura pastoril para momentos históricos?

La retracción de los camélidos hacia zonas cordilleranas durante momentos históricos tempranos fue fomentada por la necesidad de tierras para el cultivo y la introducción de nuevas especies como las cabras, vacunos y equinos. La "Ordenanza de 1557", prohibió el pastoreo en terrenos bajos de sembradío, implicando el traslado del ganado a las montañas y motivando la trashumancia hacia esas zonas

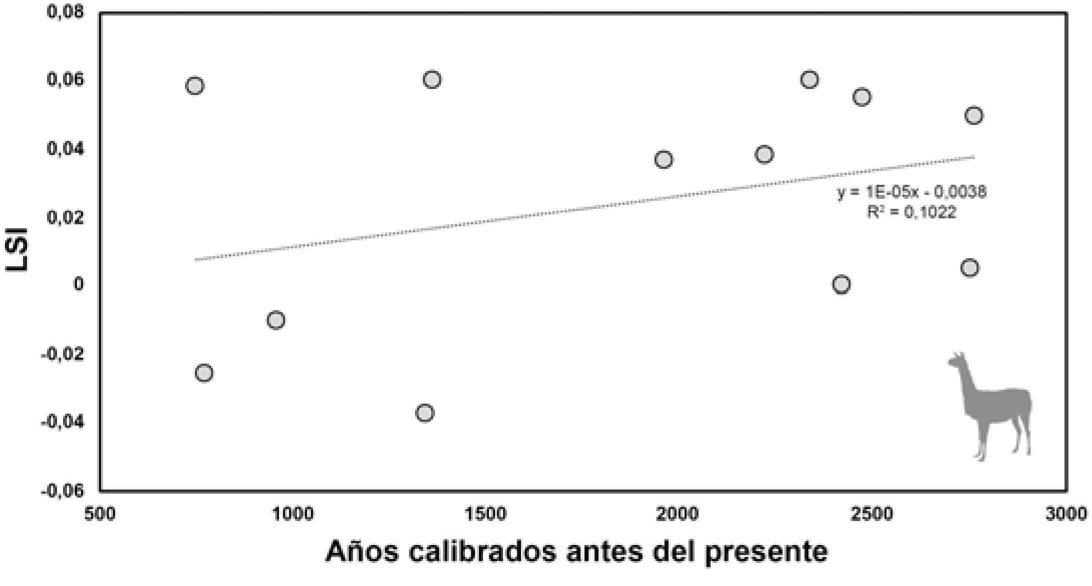

FIGURA 9

Correlación entre el Índice de Tamaño Logarítmico (LSI) de camélidos adultos del AT y PAT de los conjuntos analizados y su antigüedad.

Sitio arqueológico	**$MNI_{Adultos}$**	**$MNI_{Subadultos}$**	**$\%MNI_{Adultos}$**	**$\%MNI_{Subadultos}$**
MAU085 (AT)	14	7	67	33
MAU033 (AT)	3	2	60	40
Subtotal (AT)	17	9	65	35
MAU051 (PAT)	1	0	100	0
MAU062 (PAT)	1	1	50	50
MAU065 (PAT)	1	0	100	0
MAU066 (PAT)	1	0	100	0
MAU067 (PAT)	2	1	67	33
MAU069 (PAT)	1	0	100	0
MAU075 (PAT)	1	0	100	0
MAU077 (PAT)	0	1	0	100
MAU083 (PAT)	1	1	50	50
MAU085(PAT)	5	2	71	29
MAU087 (PAT)	1	1	50	50
MAU089 (PAT)	1	0	100	0
MAU091 (PAT)	1	1	50	50
MAU098 (PAT)	1	0	100	0
MAU158 (PAT)	1	0	100	0
Subtotal (PAT)	19	8	70	30
Total AT + PAT	36	17	68	32

TABLA 5

Frecuencia relativa y absoluta de los MNI de adultos y subadultos de los sitios del AT y PAT del Valle de Mauro. Abreviaturas: PIT. Período Intermedio Tardío, PT. Período Tardío, PAT. Período Alfarero Temprano, y AT. Arcaico Tardío.

(Castillo, 2003). No obstante, esta trashumancia en el NSA para tiempos históricos está en concordancia con los ciclos de productividad natural del medio ambiente Semiárido (Erazo & Garay-Fluhmann, 2011). Estos ciclos se refieren a que mientras los pastos se van secando en la costa, más arriba están creciendo; en el área precordillerana, los pastos maduran o alcanzan su pleno desarrollo en octubre, mientras que en la cordillera se da una mejor época durante diciembre-enero (Castillo, 2003).

El pastoralismo y la trashumancia en el Semiárido tiene una base en la existencia de estancias y comunidades. La ganadería caprina se ha organizado como una empresa familiar, que es la estructura básica que organiza la producción y que se han movilizado tradicionalmente por un territorio comunitario sustentada por la figura de la "Comunidad Agrícola" (Erazo & Garay-Fluhmann, 2011). Aranda (1971) definió al movimiento pastoril en algunos valles de NSA como una trashumancia de tipo "ascendente" o "normal", en donde los crianceros suben sus ganados temporalmente en verano, en un movimiento este-oeste. Este sistema de pastoreo destaca por la inexistencia de pueblos en las inmediaciones de las veranadas debido a las inclemencias geográficas y climáticas. De acuerdo con Opazo (1917) a partir de observaciones realizadas sobre cabreros de la primera mitad del siglo XX en la Región de Coquimbo (29°54'28''S-71°15'15''O) señala que: *Todos los años en el mes de noviembre i diciembre se hace la aparta de la engorda que se va a llevar a la cordillera a las veranadas… También van a la engorda los guatones o cabros capados de un año de edad … En la cordillera se mantiene la engorda hasta el mes de marzo trayéndola nuevamente a la majada para hacer la matanza i preparar el charqui.*

Este manejo trashumante del ganado caprino tiene un interesante correlato arqueológico a partir de dos aspectos. El primero, se refiera a la necesidad de realizar movimientos este-oeste frente a los ciclos de productividad natural de los ambientes semiáridos y, en segunda instancia, a los patrones de asentamiento sobre todo para momentos *Diaguitas*, período en el cual el registro de camélidos domésticos es efectivo, a decir por los datos osteométricos. Las características del medio ambiente Semiárido motivan a pensar en movimientos trashumantes ganaderos durante este periodo coordinados con asentamientos dispersos con una alta autonomía. Pese a esta autonomía productiva a nivel agrícola, no se debe descartar que desde momentos *Diaguita* se haya aplicado un sistema de comunidad agrícola cuyos orígenes se han relacionado a la fragmentación de la propiedad de la tierra (herencia, venta), antiguos asientos mineros, reagrupamiento indígena durante la colonia e importación del modelo comunitario peninsular (Erazo & Garay-Fluhmann, 2011). Las unidades familiares crianceras históricamente han sido la estructura organizativa (productiva) básica de la comunidad y que se movilizan por territorios comunitarios e instalando asentamientos provisorios. Dentro de los reglamentos de la comunidad, la trashumancia es considerada un imperativo vinculado a un manejo eficiente de los campos comunitarios para que todos los comuneros puedan tener acceso continuo al forraje (Castillo, 2003).

Volviendo a momentos prehispánicos, grandes áreas funerarias *Diaguitas* en la cuenca del Elqui como El Olivar, Plaza de Coquimbo y Plaza de La Serena (Falabella *et al*., 2016; Troncoso *et al*., 2016b), sugieren actividades colectivas bajo un eje político-religioso común y espacios de agregación para la reproducción social de estas comunidades. Así mismo, en zonas como la cuenca del Limarí el patrón de asentamiento *Diaguita* coincide con el de las actuales comunidades campesinas de la zona, señalando Troncoso *et al*. (2016a: 215) que: "*La consolidación del proceso de sedentarización y constitución de comunidades agrarias en esta región, por tanto, cristalizaría con la Cultura Diaguita*". El arte rupestre también aporta a un posible antecedente a favor de la trashumancia ganadera por cuanto su emplazamiento coincide con rutas naturales de tránsito que son utilizadas hasta la actualidad (Troncoso *et al*. 2016a). En zonas cordilleranas de la misma cuenca se da una alta intensidad en el arte rupestre distribuidos en puntos sensibles del paisaje y en donde se cruzan varias rutas de movilidad interregional, junto a una búsqueda de reafirmación de la afiliación grupal al compartir un lenguaje visual en estos espacios alejados (Troncoso *et al*. 2016a).

CONCLUSIONES

El presente análisis, que consistió en discutir las evidencias zooarqueológicas de todo un valle tenía como objetivo principal el identificar diferencias y similitudes en el manejo de faunas desde los primeros eventos ocupacionales hasta momentos históricos en un valle interior de la cuenca del Choapa. A lo largo de toda la secuencia estudiada, los camélidos son los animales más representados. Hacia el Arcaico Tardío las evidencias de Mauro se concentran casi exclusivamente en un sitio, MAU085. El registro se condice con una explotación intensiva de guanacos, aunque por las características de los sitios del mismo periodo en distintas cuencas de los valles interiores del Choapa -campamentos que ocupan quebradas tributarias y reparos rocosos con alta visibilidad del espacio circundante-, MAU085 posee características de cazas colectivas y/o fusión de bandas en un sector estratégicamente localizado y que no tiene a la fecha un correlato arqueológico de similares características en el Choapa. Estas cazas colectivas sobre guanacos adultos las consideramos como parte de una intensificación en la explotación de estos animales explicable por el aumento demográfico identificado a nivel regional. No es del todo claro que esta intensificación haya sido un factor clave en la baja ostensible de camélidos para el Período Alfarero Temprano a partir de expectativas de modelos como el *Ungulate Prey Depression Model*. La aparición de la cerámica y las prácticas hortícolas no fueron factores que motivaron una mayor sedentarización, puesto que las evidencias arqueológicas sugieren poblaciones altamente móviles. No obstante, queda abierta la pregunta sobre las causas de la menor ingesta de proteína animal a inicios de las ocupaciones alfareras: ¿se debió a una baja ostensible de camélidos por factores ambientales, intensificación de la caza y/o un mayor acercamiento a prácticas hortícolas y un énfasis en la recolección?

A decir por estudios previos en el mismo valle, hasta inicios del Período Intermedio Tardío no hay indicios de camélidos domésticos, los que aparecen para momentos *Diaguita* en la cuenca del Choapa. Los datos osteométricos no sustentan que dicha aparición se deba a un proceso autónomo de domesticación, siendo más afín a una introducción de llamas desde áreas vecinas (López *et al*., 2015), aunque es un escenario que no podemos aseverar debido a la escasa evidencia osteológica de camélidos para el Alfarero Temprano. Así, una temática novedosa que surge de nuestro análisis es redefinir a las comunidades *Diaguitas* como ganaderas y no únicamente agrícolas. Esta última práctica, si bien ha sido sugerida en estudios previos, sus alcances no se han discutido en la conformación de un paisaje de pastoreo. Parte de nuestras expectativas se sustentan en la continuidad de una trashumancia pastoril hasta momentos históricos, explicable por los ciclos estacionales de los pastos de las distintas ecozonas de la región. Tendencias en el registro arqueológico *Diaguita* en todas las cuencas del Semiárido, tales como un patrón de asentamiento nucleado-disperso, caseríos autónomos pero con espacios “construidos” para fomentar la agregación y reproducción social, movimientos trashumantes hacia la cordillera, una importante presencia de camélidos en contextos funerarios y a nivel iconográfico, así como un profuso trabajo textil que surge en este periodo, deben evaluarse a partir de una sociedad ganadera y que en el incanato adquiere otro cariz, manteniendo y fomentando algunas prácticas propias del *Diaguita*.

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European Pond Turtle (*Emys orbicularis*) remains in Iron Age contexts of the Spanish Northem Iberian Peninsula

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ABSTRACT: The aim of this paper is to present some new data concerning the systematic identifications of several terrapin findings documented in three Iberian Iron Age sites from the Northern Meseta and Basque-Cantabrian Basin: El Soto de Medinilla (Valladolid), La Mota (Valladolid) and La Hoya (Álava). New interpretations concerning the first-hand study of these remains are presented. With the aim of comprehending the interaction of humans with these reptiles, we consider that they were mainly captured as a food resource. The previous identification of *Emys orbicularis* (i.e., the European Pond Turtle) in El Soto de Medinilla and La Mota is confirmed and justified. The identification of the same taxon in La Hoya constitutes the youngest archaeological reference of its presence in the Basque-Cantabrian Basin.

KEYWORDS: TURTLE, ARCHAEOZOOLOGY, TAPHONOMY, FIRST MILLENNIUM BC, NORTHERN MESETA, BASQUE-CANTABRIAN BASIN

RESUMEN: En este trabajo se presentan nuevos datos e interpretaciones fruto del estudio de primera mano de varios hallazgos de galápagos recuperados en tres yacimientos ibéricos de la Edad del Hierro procedentes de la Meseta Norte y de la Cuenca Vasco-Cantábrica: El Soto de Medinilla (Valladolid), La Mota (Valladolid) y La Hoya (Álava). Con el fin de comprender la interacción humana con estos reptiles, se realiza un estudio tafonómico y arqueozoológico de los restos que se considera que fueron capturados principalmente como recurso alimentario. Asimismo, se aporta la justificación sistemática de la previa identificación de *Emys orbicularis* (el galápago europeo) en los yacimientos de Soto de Medinilla y La Mota. La identificación del mismo taxón en el yacimiento de La Hoya constituye la referencia arqueológica más reciente de su presencia en la Cuenca Vasco-Cantábrica.

PALABRAS CLAVE: TORTUGA, ARQUEOZOOLOGÍA, TAFONOMÍA, PRIMER MILENIO A.C., MESETA NORTE, CUENCA VASCO-CANTÁBRICA

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INTRODUCTION

During the final moments of the Bronze Age, the archaeological record of the Northern Iberian Peninsula shows that an important amount of settlements were abandoned, remaining few sites with population continuity (Blanco-González, 2010: 368-372). Throughout the First Iron Age (9th–5th centuries BC) in the Northern Meseta, some of the new occupied settlements grew in population and economy, compared to the previous stages. In the Duero Basin, these communities exploited fertile plainlands, with a specialised agriculture based on wheat, barley and oats crops, surrounded by oak and holm oak forests full of prey [e.g. Red Deer (*Cervus elaphus*), Roe Deer (*Capreolus capreolus*) and Wild Boar (*Sus scrofa*)]. This agricultural economy echoes in the material culture with big pottery containers for cereal storage, plain pottery and Atlantic influenced metallurgy (Ruiz Zapatero & Álvarez-Sanchís, 2015: 213-214). The material culture of the Basque-Cantabrian Basin communities shows an Urnfield Culture influence since the Late Bronze Age (Arnáiz Alonso & Montero Gutiérrez, 2004). During the First Iron Age, the Greek and Phoenician colonies demanded raw materials that transformed the central Iberian Peninsula economy, developing a profuse commercial network in the 6th century BC. This exchange networks, and the subsequent initial Iron industry stimulated the development of the indigenous communities changing the habitat from small villages to fortified settlements (Ruiz Zapatero & Álvarez-Sanchís, 2015: 215-216). During the Second Iron Age this tendency accelerated until the Roman conquest, with the appearance of large oppida (Ruiz Zapatero & Álvarez-Sanchís, 2015: 222).

Quaternary freshwater terrapins (i.e., *Mauremys leprosa* and *Emys orbicularis*) and tortoises (i.e., *Chersine hermanni* sensu Bour & Ohler (2008), traditionally described as *Testudo hermanni*; and, possibly, *Testudo graeca*) remains are identified in several Iberian archaeological sites (e. g. Félix *et al.*, 2006; Blasco, 2008; Nabais, 2012; Sanchis *et al.*, 2015). Within the framework of a doctoral thesis currently in process, and several research projects performed by the authors, most Iberian turtle archaeological remains have been studied through a wide chronological range, pursuing the aim of valuing the impact of these reptiles in the different sites where these animals are known (Boneta *et al.*, 2015a, b, 2017). The difficulties regarding the study of these faunal remains derive mainly from its general low frequency within archaezoological assemblages, due to multiple factors regarding preservation conditions, correct identification, recovery techniques or cultural issues. In many sites, the extremely few findings provide limited information and prevent accurate archaeozoological approaches. Consequently, scarce specific studies are generally carried out for this clade of reptiles (in contrast with other faunal groups such as mammals, birds and fishes), preventing the execution of synthesis works and the achievement of general conclusions (Morales & Sanchís, 2009; Boneta *et al.*, 2015b). In addition, no systematic approach are generally conducted for most chelonian remains, few detailed attributions having been justified, and scarce specimens having been figured. Despite this limited information, the consumption of turtles has been reported in the Northern Iberian Peninsula since the Lower Pleistocene of Atapuerca (Burgos) (Blasco *et al.*, 2011).

Aside from El Soto de Medinilla (Valladolid) and La Mota (Medina del Campo, Valladolid) terrapin remains (Liesau, 1994, 1998; Morales & Liesau, 1995), in the Duero Basin, other published references for the European Pond Turtle in the Northern Iberian Peninsula come from the Basque-Cantabrian Basin (Figure 1). The oldest notices are the Mesolithic levels of Atxoste (Virgala, Álava) rock shelter. With an archaeological record that starts in the Upper Palaeolithic and lasts up until Bronze Age (*ca.* 12000 - 3360 BP), Atxoste record provided a significant faunal assemblage, product of human hunting (Alday Ruiz *et al.*, 2011). Within this osseous accumulation, one hundred and three remains of *Emys orbicularis* were identified in the Mesolithic levels V and VI (Pérez-García *et al.*, 2015). An additional reference of the European Pond Turtle from the Basque-Cantabrian Basin is available, although problematic. Altuna (1978) published the presence of an *Emys orbicularis* humerus in the Iron Age site of Castro de Berbeia (Barrio, Álava), from levels dated between 490 - 400 BC. Pérez-García *et al.* (2015) reported that the cited specimen is currently lost, so its record could not be revised by us.

The aim of this paper is to update and discuss the data concerning the systematic identifications and the interpretations in their archaeological context of the European Pond Turtle (i.e. *Emys orbicularis*) findings from three Northern Spanish

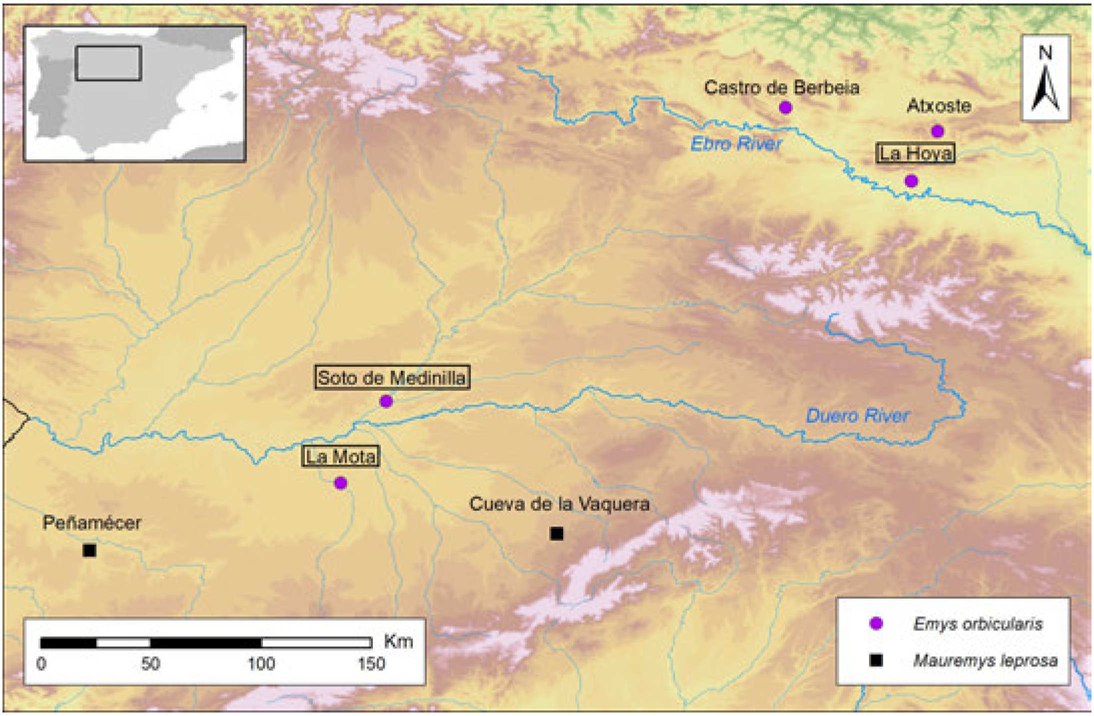

FIGURE 1

Location of all referred sites in the text. Presence of the European Pond Turtle (*Emys orbicularis*) and Spanish Terrapin (*Mauremys leprosa*) in the Northern Meseta and Basque-Cantabrian Basin from the Tenth to the First millennium BC.

Iron Age sites: El Soto de Medinilla (Valladolid), La Mota (Medina del Campo, Valladolid) and La Hoya (Laguardia, Álava).

ARCHAEOLOGICAL CONTEXTS

In this context, the site of El Soto de Medinilla (Valladolid) is a fortified settlement that defines the First Iron Age in the area. It is strategically located in a meander of the Pisuerga River. This river forms a Quaternary multiple terrace valley that comprises quartz and quartzite gravels, with silt and limestone pebbles, and loam matrix, with siliceous pebbles. The climatology is shaped by the high altitude of the area and the surrounding mountain ranges that favour a cold-mediterranean climate with long winters, scarce rainfalls and summer aridity (Liesau, 1998: 63-71). With an occupation that spans through 8th-3rd centuries, levels Soto I and Soto II stand out, corresponding with the late First Iron Age and a transition period to the Second Iron Age (Hierro I, 8th to initial 3rd centuries BC.). The Second Iron Age belongs to the so called "Vaccean occupation" (Soto III) (Hierro II, initial 3rd -2nd centuries BC) (Delibes *et al.*, 1995). The faunal assemblage shows that the main consumed stock changed dramatically depending on the stages and the applied archaeozoological parameters (NISP or weight W). In Soto I and II ovicaprines (NISP 37%, W 12%) are the most common faunal remains, but the cattle (NISP 19%; W 39%) and horses (NISP 9%; W 25%) are the most consumed species. The suids (NISP 9%, W 5%) are less relevant than the hunting of wild species (NISP 25%, W 19%). For Soto III an intensification of the main stock is noted, as cattle numbers increase (NISP 36,7%, W 64%), as well as suids (NISP 14%, W 9%). Ovicaprines (NISP 35,7%, W 14%) remain stable, this communities consumed less than NISP 12% and W 7% wild species (Liesau, 1994, 1998: 164, figure 83). The context of the terrapin finding in El Soto de Medinilla was documented inside a round hut made with mudbricks and with an inner circular bank and a central fireplace, dated to 670 a.C. (Delibes *et al.*, 1995: 162). An almost 200 bones assemblage corresponding to the main domestic animals, several wild mammals, birds and fish bones were identified inside the hut, hence one of the most singular faunal findings of the site (Morales & Liesau, 1995: 498; Liesau, 1998: 76, figure 33).

La Mota (Medina del Campo, Valladolid) is a naturally protected village strategically located on a terrace between the Zapardiel River and the Adajuela Stream. Surrounded by endorheic ponds and fertile meadows, the landscape is composed by sandy clays, Miocene and Quaternary sand deposits (Seco Villar & Treceño Losada, 1995: 220). With an occupation that lasts through the Iron Age, the levels between the First and Second Iron Age (7th – 4th centuries BC) stand out for its characteristic Celtiberian domestic architecture with rectangular houses (Arnáiz Alonso, 2017). The faunal assemblage recovered from these transitional stages (Hierro I/II) was studied by Morales & Liesau (1995). The results indicate an important predominance of two ruminants, the cattle (NISP 20%, W 47%) and the ovicaprines (NISP 63%, W 30%), and a relatively low frequency of suids (NISP 8%, W 6,3%) and wild species (NISP 8%, W 7,4%) (Morales & Liesau, 1995: table 4). The terrapin finding context from La Mota (Nivel II, Cuadro 9-A9) is a ‘sedimentation stratum with no remarkable elements’ (Seco Villar & Treceño Losada, 1995: 237) (Table 1).

With an occupation that starts in the Middle Bronze Age and continues till the Final Iron Age, the fortified village of La Hoya (Laguardia, Álava) is a plain settlement in a well communicated landscape known as ‘La Rioja Alavesa’ in the Basque-Cantabrian Basin, 6 km distance from the Ebro River. With a mediterranean climatology, the pollen analysis results show a pine tree and holm oak predominance in a heavily anthropized scenery (Pérez Díaz & López Sáez, 2012: 165-166). Its most significant remnants are dated in the Second Iron Age (Celtiberian stage), with an outstanding urban planning (Llanos, 2005). The faunal remains from the site were studied by Altuna (1980). During the Celtiberian stage, the cattle is the main consumed stock (NISP 43%) and in this site the porcine (NISP 21%) is almost as well represented as the ovicaprines (NISP 28%). The consumed wild ungulates are scarce (5%) (Altuna, 1980: table 13). The terrapin remains from La Hoya were recovered in Sector I (*Nivel* A2, *Cuadro* C17), the village central area, inside a domestic context characterized by the presence of waste and faunal remains (Llanos, 2005).

MATERIAL AND METHODS

The European Pond Turtle (*Emys orbicularis*) is a middle size freshwater turtle form that reaches a maximum carapace length of 20 cm. In Southern Iberian Peninsula populations, its mean length is 13’8 cm for males and 14’2 cm for females (Ayres, 2015). It inhabits diverse freshwater and low brackish ecosystems, such as permanent and temporary ponds, ditches and reservoirs, from sea level to altitudes up to 1050 m. Generally, it occupies lentic environments, showing preference for abundant aquatic vegetal areas. In the West Iberian

SITE	CHRONOLOGY	TAXA	NISP	MNI	REFERENCES
El Soto de Medinilla (Valladolid)	Iron Age I-II (9th-2nd centuries BC)	*Emys orbicularis*	49	1	Morales & Liesau (1995)
La Mota (Medina del Campo, Valladolid)	Transition Iron Age I to II (7th-4th centuries BC)	*Emys orbicularis*	2	1	Morales & Liesau (1995)
La Hoya (Laguardia, Álava)	Iron Age (5th-4th centuries BC)	*Emys orbicularis*	4	1	Unpublished
Castro de Berbeia (Barrio, Álava)	Iron Age (490-400 BC)	*Emys orbicularis*	1	1	Altuna (1978)
Atxoste (Vírgala Mayor, Álava)	Mesolithic (9100-8510 cal BP (Level V) 9940-9450 cal BP (Level VI)	*Emys orbicularis*	103	6	Pérez-García *et al*. (2015)
Peñamécer (Espino de los Doctores, Salamanca)	Early Bronze Age (3800-4000 BP)	Mauremys leprosa	-	-	Jiménez-Fuentes & Pollos (1995)
Cueva de la Vaquera (Torreiglesias, Segovia)	Neolithic (5500-3600 BC)	*Mauremys leprosa* (*Mauremys caspica* sensu Morales & Martín (2003)	-	-	Morales & Martín (2003)

TABLE 1

Data of the referred sites in the text with European Pond Turtle (*Emys orbicularis*) and Spanish Terrapin (*Mauremys leprosa*) remains. Location, chronology, recognized taxa, NISP, MNI and references are provided. “-” quantity not specified in the publication.

Peninsula, it mainly occupies rivers and streams, in coppice and oak grove areas, while in the East it lives predominantly in marshes (Ayres, 2015). The annual activity of the species is bimodal with two peaks, after and before hibernation. Inactivity periods are marked by the high and low temperatures of summer and winter seasons (Ayres, 2015). The water temperature seems to be a turning point; the species starts its activity above 9ºC (Ramos *et al*, 2002).

The European Pond Turtle osseous remains studied here correspond to carapace elements, as in most archaeological contexts. El Soto de Medinilla and La Mota faunal remains are deposited in the Archaeozoology Laboratory (L.A.Z.), in the Biology Department of the Universidad Autónoma de Madrid (Madrid). The faunal remains from La Hoya are deposited in the BIBAT Arkeologia Fournier de Naipes Museoa, in Vitoria-Gazteiz (Basque Country). European Pond Turtle remains first-hand study, considering both the anatomy and the inter- and intraspecific variability and specific characterization, was carried out. The applied criteria for the species systematic identification are the ones proposed by authors such as McDowell (1964), Jiménez Fuentes (1980), Hervet (2000, 2004), Chesi *et al.* (2009) and Bailón (2010).

The remains studied here were photographed (with a Canon Ixus 107 photo camera), measured (with a calliper), graphically represented (using CorelDRAW 9) and examined in order to search for any human action trace (with a 10x, 15x and 20x magnification hand loupe). Detail photographs were taken with a Zeiss Stemi DV4 binocular loupe with an attached camera and software *Infinity 1*. Remains quantification is limited to the Number of Identified Specimens (NISP) per taxon, following Grayson (1984: 16) definition of specimen as "*a bone or tooth, or fragment thereof*"; and Minimum Number of Individuals (MNI) following Clason (1972), considering only the remains identified at species level, being the most abundant element for each species (considering laterality of shell and appendicular elements) the one that determines the MNI, including criteria related to size, age and sex. Fragmentation and bone surface modification were considered for the taphonomic analysis, identifying the type of fracture and visible processing marks (Lyman, 1994; Liesau, 1998). All the remains were previously identified by other specialists and deposited in public institutions.

RESULTS AND DISCUSSION

An almost complete shell was recovered in El Soto de Medinilla, corresponding to the carapace and plastron of a single individual (Figure 2) from stage Soto II (8th-6th centuries BC) (Cata A, Hut VII). The plastron is complete. The carapace preserves the lateral areas of the first and second left costals; the complete third to eighth left costals, second to eleventh left peripherals, second to eighth right costals, fourth to tenth right peripherals; a fragment of the posterior half of the second neural; and the complete third to seventh neurals, pygal and second suprapygal. Consequently, the NISP for El Soto de Medinilla is 49 (NISP = 49). The remains from La Mota are a single plastron fragment, corresponding to the articulated partial right hypoplastron and right xiphiplastron, recovered from Nivel II, Cuadro 9-A9 (7th-4th century BC) (NISP = 2) (Figure 3). A relatively complete but fragmented plastron posterior lobe was recovered in La Hoya site, inside a habitational area (Nivel A2, Cuadro C17) (Llanos, verb. com.) from the Celtiberian period (5th-4th centuries BC). Four plates (NISP = 4) are preserved (Figure 4), corresponding to the articulated hypoplastra and xiphiplastra. Only the right xiphiplastron is complete. The shell recovered in El Soto de Medinilla (Figure 2), the single plastron fragment recovered in La Mota (Figure 3) and the posterior plastral lobe recovered in La Hoya (Figure 4), shows that the identified MNI in each of these sites is 1.

Characters such as the absence of intergular and inframarginal scutes, the posterior reduction of the epiplastra and the presence of a little bulgy oval carapace allow their attribution to Testudinoidea (Hervet, 2004; Chesi *et al.*, 2009). This taxon differs from Testudinidae, clade that includes terrestrial forms (e.g., *Chersine hermanni* and *Testudo graeca*), in characters such as, smooth external bone surface, absence of medially short and laterally long costals (alternated with medially long and laterally short costals), absence of overlap between the pleuro-marginal sulci and the costo-peripheral sutures, medially poorly-developed epiplastral lip, and hexagonal second to, at least, sixth neurals, with the short margins latero-anteriorly located. This character combination is shared by the members of Emydidae (e.g., *Emys orbicularis*) and Geoemydidae (e.g., *Mauremys leprosa*) (Hervet, 2000; Bailón, 2010). The individual of El Soto de Medinilla (Figure 2) can be attributed to the Euro-

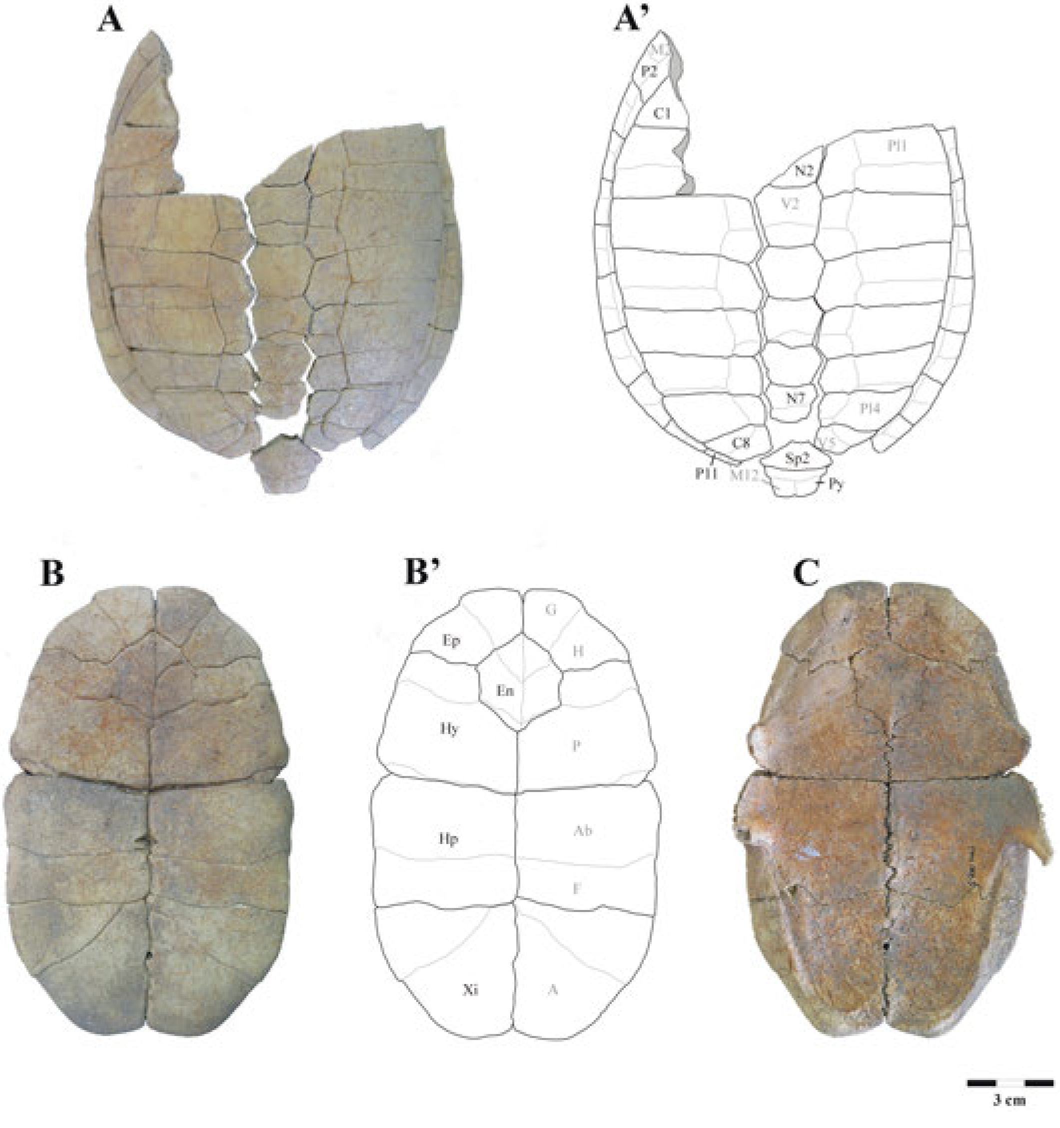

FIGURE 2

Deposited in L.A.Z. - Emy Orb 3, shell of *Emys orbicularis* from the Iron Age site of Soto de Medinilla (Valladolid, Spain). A, carapace, in dorsal view. B-C, plastron, in ventral (B) and dorsal (C) views. The scutes sulci are represented in grey, and the plates in black. The plates borders are drawn with continuous lines. Discontinuous lines are used for the broken borders. Abbreviations for plates: C1-C8, first to eighth costal; En, entoplastron; Ep, epiplastron; Hp, hypoplastron; Hy, hyoplastron; N2-N7, second to seventh neural; P2-P11, second to eleventh peripheral; Py, pygal; Sp2, suprapygal 2; Xi, xiphiplastron. Abbreviations for scutes: A, anal; Ab, abdominal; F, femoral; G, gular; H, humeral; M2-M12, second to twelfth marginal; P, pectoral; Pl1-Pl4, first to fourth pleural; V2-V5, second to fifth vertebral.

pean *Emys orbicularis* and not to *Mauremys leprosa* by the following criteria: absence of a medial keel on the pygal plate; pygal not remarkably wider than long; fifth vertebral scute overlapping on the anterior half of the pygal and the last pair of peripherals; sulcus between the pleural and the marginal scutes always distant from the suture between the costal and the peripheral plates; markedly anteriorly directed lateral end of the sulci which delimit the marginals; plastral bridge shorter than the anterior and posterior lobes; absence of an osseous connection between the plastron and the carapace; subrounded anterior margins of the epiplastra; relatively low epiplastral lips; subhexagonal entoplastron, with the greatest width situated in the anterior half; presence of a hinge between the hyoplastra and the hypoplastra; low and short plastral buttresses; wider than long hypoplastra; rounded lateral margins of the posterior plastral lobe; wide and very shallow anal notch; gular scutes overlapping the anterior half of the entoplastron; humero-pectoral sulci located on the posterior edge of the entoplastron, near posterior margin; pectoro-abdominal sulci located on the most posterior region of the hyoplastra; short abdominal scutes relative to the anals; absence of axillary and inguinal scutes (Hervet, 2000). Considering this character combination, the specimen recovered in El Soto de Medinilla (Figure 2) can be attributed to the emydid *Emys orbicularis*, as it was previously proposed by Morales & Liesau (1995). Considering both the length of the shell (ca. >15 cm.) and the plastron flatness, it is interpreted as an adult female. The remains from La Mota (Figure 3) also shows and exclusive combination that allows its attribution to *Emys orbicularis* but not to *Mauremys leprosa*, including: smooth external bone surface, rounded lateral margins of the posterior plastral lobe. The

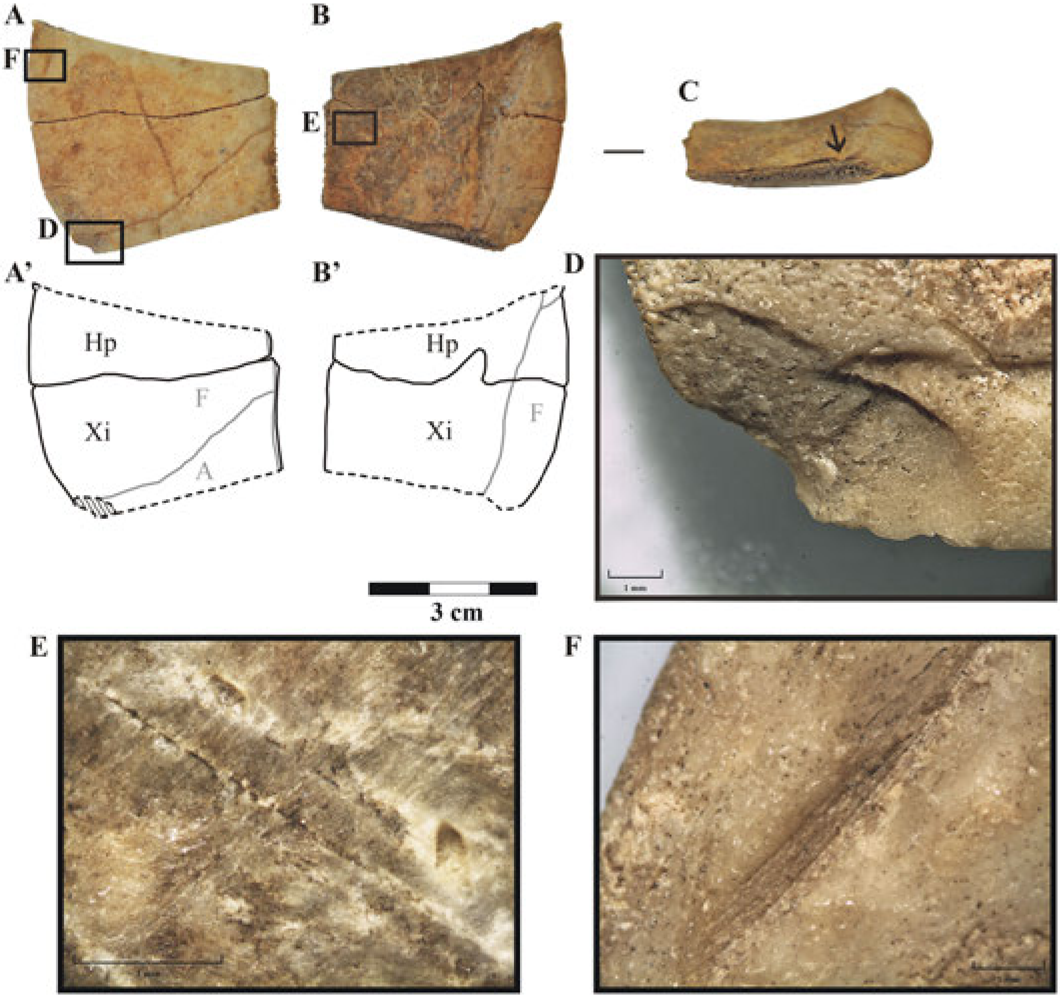

FIGURE 3

Deposited in L.A.Z., fragmented right hypoplastron and xiphiplastron of *Emys orbicularis*, plates from Iron Age site of La Mota (Medina del Campo, Spain), in ventral (A and A') and dorsal views (B and B'). Posterior edge detail (C), the arrow shows a sharpened straight profile in the cortical layer. Percussion flake detail (D), cutmarks detail (E) and scratch detail (F). The scutes sulci are represented in grey, and the plates in black. The plates borders are drawn with continuous lines. Discontinuous lines are used for the broken borders. Abbreviations for plates: Hp, hypoplastron; Xi, xiphiplastron. Abbreviations for scutes: A, anal; F, femoral.

remains from La Hoya (Figure 4) share all these characters, in addition to others unknown for the La Mota specimen (i.e., absence of carapace-plastron osseous contact; presence of a hinge between the hyoplastra and the hypoplastra; wider than long hypoplastra; abdominal scutes shorter than the anals; wide and very shallow anal notch), also allowing its attribution to *Emys orbicularis*.

The presence of *Emys orbicularis* in El Soto de Medinilla and in La Mota were previously briefly discussed but without quantitative data nor figuration. The authors interpreted them, been recovered in habitational contexts, as related to human consumption, based on that these animals have been consumed until recent times (Morales & Liesau, 1995: 497). Due to the lack of any disarticulation marks, we cannot specifically confirm human consumption of the Soto de Medinilla individual. However, the absence of fractures or processing marks does not necessarily reject human consumption as other cooking techniques that prevent such evidence could have been employed, such as, boiling. Given the singular archaeological context of the finding, regarding the whole faunal assemblage, with more than 200 faunal remains corresponding to the main domestic animals (at least

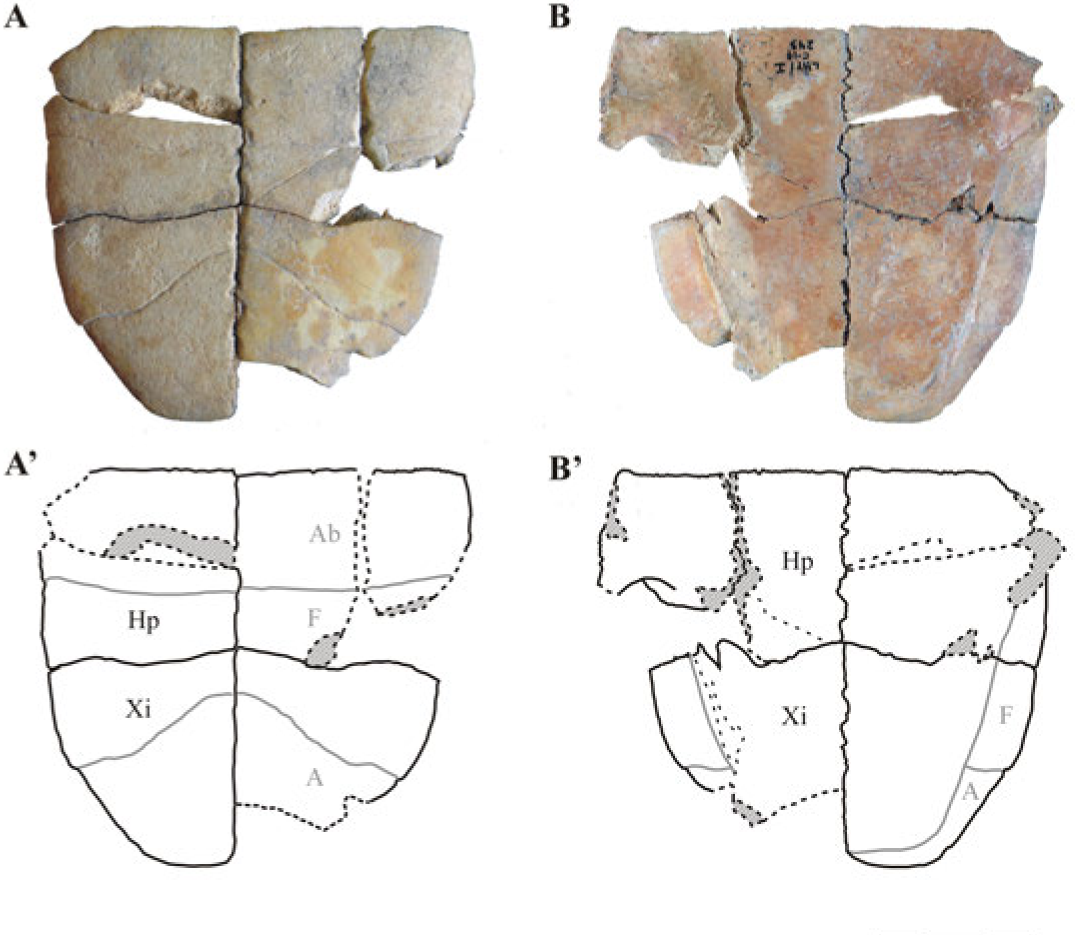

FIGURE 4

Deposited in BIBAT - LHY.1975.243, posterior half of a plastron of *Emys orbicularis*, plates from Iron Age site of La Hoya (Laguardia, Spain), in ventral (A and A') and dorsal (B and B') views. The scutes sulci are represented in grey, and the plates in black. The plates borders are drawn with continuous lines, discontinuous lines are used for the broken borders. Abbreviations for plates: Hp, hypoplastron; Xi, xiphiplastron. Abbreviations for scutes: A, anal, Ab, abdominal; F, femoral.

two horses, two bovines, a sheep and a young male goat), several wild mammals (at least two rabbits, a hare and a lynx), birds and fish (Liesau & Morales, 1995: 498; Liesau, 1998: 90-91), another use may be taken into consideration. The shell could have been used as raw material for a functional purpose, such as, a musical instrument or a rattle. However, this use is normally associated with distinct shell modifications (Gillreath-Brown & Peres, 2017).

Although little revealing in quantitative terms (Figure 3), La Mota remains from this site provide interesting taphonomic evidences. Both, the hypoplastron anterior edge and the xiphiplastron posterior edge show a sharp profile that may indicate some anthropical marks. The xiphiplastron presents a sectioned bone surface, done by percussion, probably with a metal tool. This mark seems to have been done in fresh as the ventral posterior edge shows a sharpened straight profile in the cortical layer (Figure 3 C); in the dorsal lateral edge there is a double flaked surface, probably due to the impact of the percussion act (Figure 3 A). Two slight parallel incisions are documented dorsally (Figure 3 B). In the hypoplastron ventral lateral edge a scratch is documented (Figure 3 C). All these evidences may perhaps indicate a butchering and dismembering of the terrapin as food resource, although the context does not provide more information in the archaeological record.

The high specimen fragmentation of La Hoya remains (Figure 4) may also indicate a consumption refuse origin. The right hypoplastron osseous inguinal bridge presents an old fracture, therefore this could indicate a processing manipulation to open the shell. However, no clear anthropical fractures or butchery marks could be identified, perhaps masked by the application of a consolidating product.

The current common presence of the European Pond Turtle (i. e. *Emys orbicularis*) in Northern Iberian Peninsula in contrast with the slight presence of the Spanish terrapin (*Mauremys leprosa*) is generally justified by the thermophilic character of this last species (Díaz-Paniagua *et al.*, 2015). Although very adaptable to inauspicious environments, it is currently rare in the north area of the Duero River, and in the west region of the upper half of the Ebro Basin (Díaz-Paniagua *et al.*, 2015: 13). In the Iberian archaeological record (Figure 1), there are no published references of *Mauremys leprosa* remains for the Iron Age, although this taxon has been cited in the Early Bronze of Peñamécer (Espino de los Doctores, Salamanca) (Jiménez Fuentes & Pollos, 1995) and in the Neolithic of Cueva de la Vaquera (Torreiglesias, Segovia) (Morales & Martín, 2003).

As previously noted, the low frequency of chelonian remains in the three sites studied prevent from developing an accurate archaeozoological analysis and provide scarce information about the interaction of the humans with these reptiles in each context. All the sites have optimal surrounding environment for chelonian capture due to its close location to river courses. Consequently, considering the taphonomic data and the archaeological contextual and environmental information, the most viable scenario for the presence of *Emys orbicularis* in La Hoya and, especially, in La Mota is to consider them as a food resource. This hypothesis could indicate an opportunistic and occasional capture better than a sporadic use, notably considering the huge faunal assemblages recovered in these sites with thousands animal bones. On the other hand, Soto de Medinilla remains point to alternative hypothesis still to be explored.

CONCLUSIONS

The study and review of the terrapin remains from El Soto de Medinilla (Valladolid), La Mota (Medina del Campo, Valladolid) and La Hoya (Álava) sites allows an overview of the occurrence of this group of reptiles for the Iron Age record in the Northern Iberian Peninsula. The identification of *Emys orbicularis* in El Soto de Medinilla and La Mota is confirmed and figured for the first time. Otherwise, the finding from La Hoya (Álava) constitute up to now the youngest archaeological justified reference of this taxon in the Basque-Cantabrian Basin. These results provide new information about the chronological and geographical distribution of this taxon in the Northern Iberian Peninsula.

Taphonomic evidences, such as processing marks (i.e., percussions, incisions and fractures) in addition to the archaeological context (mainly habitational) and the proximity of susceptible capture locations, lead us to propose that the remains of La Mota (Medina del Campo, Valladolid) and La Hoya (Laguardia, Álava) were transported to the sites by its inhabitants, consumed and then disposed as refuse mixed with other animal bones. However other hypothesis may be considered for Soto de Medinilla (Medina del Campo, Valladolid), such as its use as raw material for the elaboration of unknown artifacts (i.e., rattles), given the good state of the shell and the unique faunal assemblage recovered in the hut. Nevertheless, their exceptional record during the Iron Age in the Northern Iberian Peninsula seems to reflect only an opportunistic and occasional capture as a food resource.

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Gestión ganadera durante la Edad del Bronce Medio y Final en Mallorca (Islas Baleares). El caso del poblado de *Els Closos de Ca'n Gaià*

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RESUMEN: En las últimas décadas ha habido un aumento exponencial de los métodos analíticos aplicados en arqueozoología. En este trabajo se presentan los resultados del estudio faunístico realizado en el poblado de la Edad del Bronce Balear o Bronce Naviforme (ca. 1600-850 BC) de Els Closos de Ca'n Gaià (Felanitx, Mallorca), donde se han analizado los restos procedentes de dos estructuras con funcionalidades distintas. El objetivo principal de este estudio es aportar información sobre la ganadería y la explotación de los recursos animales de la sociedad naviforme. Para ello, se ha llevado a cabo un análisis *multiproxy* de los restos de fauna, combinando el estudio arqueozoológico "tradicional" con el estudio de la dieta de los caprinos domésticos a través del microdesgaste dental y las áreas de captación del ganado a través de los isótopos de estroncio ($^{87}Sr/^{86}Sr$). Este análisis *multiproxy* sugiere la existencia de diferencias significativas en la composición de la cabaña ganadera en las dos estructuras analizadas, donde el consumo doméstico estaría centrado en la ingesta de ovejas y cabras jóvenes. Por otra parte, la combinación de los resultados del estudio de la dieta y las áreas de captación del ganado caprino junto con otros datos bioarqueológicos disponibles sugiere que el ganado consumido era mayoritariamente de origen local, y que se alimentaría de la vegetación disponible en zonas cercanas al yacimiento.

PALABRAS CLAVE: ARQUEOLOGÍA DEL MEDITERRÁNEO, EDAD DEL BRONCE, MALLORCA, ISLAS BALEARES, CONSUMO DOMÉSTICO, GESTIÓN GANADERA, ISÓTOPOS DE ESTRONCIO, MICRODESGASTE DENTAL, DIETA, MOVILIDAD

ABSTRACT: In the last decades there has been an exponential increase in analytical methods applied in zooarchaeology. This work presents the results of the zooarchaeological study carried out in the Bronze Age village (ca. 1600-850 BC) of Els Closos de Ca'n Gaià (Felanitx, Mallorca), where the faunal remains from two structures with different functionalities have been analyzed. The main objective of this study is to provide information on livestock and the exploitation of the animal resources of the naviform society. For this, a multiproxy analysis of the faunal remains has been carried out, combining the "traditional" zooarchaeological study with the study of caprine diet through dental microwear and livestock catchment areas through strontium isotopes

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($^{87}Sr/^{86}Sr$). This multiproxy analysis suggests the existence of significant differences in the composition of the livestock herd in the two structures analyzed, where domestic consumption would be centered on the intake of young sheep and goats. On the other hand, the combination of the results of the study of the diet and the caprine catchment areas, together with other available bioarchaeological data, suggest that animals consumed were mostly of local origin, and that they probably fed on the vegetation available in nearby areas.

KEY WORDS: MEDITERRANEAN ARCHAEOLOGY, BRONZE AGE, MALLORCA ISLAND, BALEARIC ISLANDS, HOUSEHOLD CONSUMPTION, LIVESTOCK MANAGEMENT, STRONTIUM ISOTOPES, DENTAL MICROWEAR, DIET, MOBILITY.

INTRODUCCIÓN

El presente artículo surge de los datos obtenidos en el marco de una tesis doctoral basada en la arqueozoología de la Edad del Bronce balear (Valenzuela-Suau, 2020). Concretamente, se presentan los resultados del estudio faunístico realizado en el poblado de Els Closos de Ca'n Gaià (Felanitx, Mallorca) donde se han analizado dos estructuras con funcionalidades distintas (el Navetiforme I y la estructura IIA) con una metodología *multiproxy* (Figuras 1 y 2).

A partir del ca. 1600 BC la población balear empieza a construir los poblados de navetiformes dispersos por todo el archipiélago, evidenciando una intensificación en el uso del territorio. Así pues, durante la Edad del Bronce en las Islas Baleares surge el período conocido como el Bronce Naviforme (ca. 1600-850 BC) que se caracteriza por la aparición de estos poblados de navetiformes (Lull *et al.*, 1999; Oliver, 2005; Guerrero *et al.*, 2007; Salvà, 2013; Oliver *et al.*, 2018). Esta etapa cronológica recibe el nombre de la estructura arquitectónica más emblemática –los navetiformes– que se agrupan en poblados generalmente abiertos. Se trata de edificios de planta alargada en forma de herradura, con un ábside más o menos apuntado en el lado opuesto al acceso. Las medidas oscilan entre 16-21 m de largo y unos 5-6 de ancho, con una altura que posiblemente alcanzaba entre los 3 y 4 m (Lull *et al.*, 1999; Guerrero *et al.*, 2007) (Figura 2B).

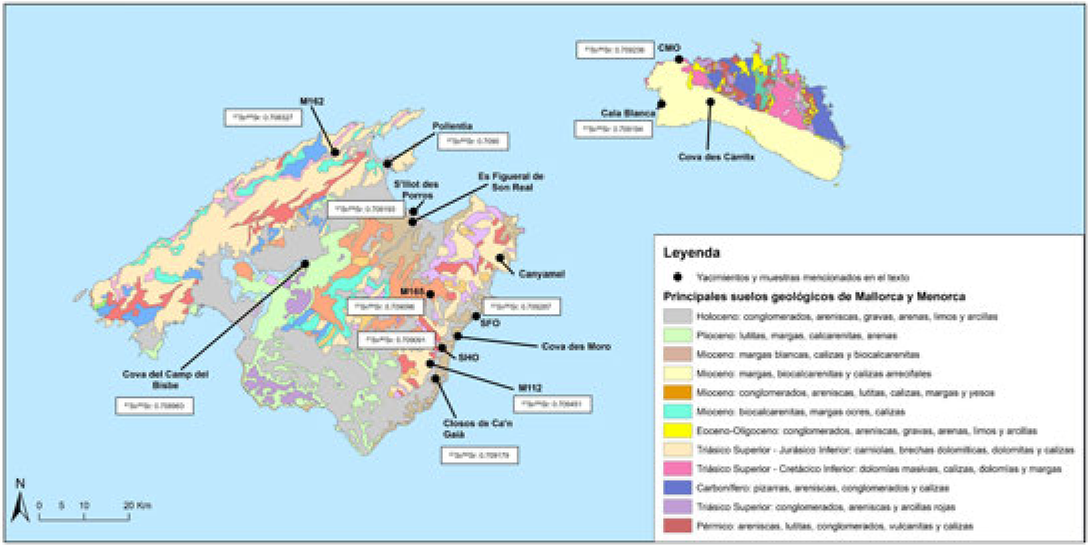

FIGURA 1

Mapa geológico de Mallorca y Menorca (Islas Baleares, España) (mapa extraído de IGME GEODE 50 y modificado para este artículo). Se pueden observar las señales isotópicas estimadas para cada capa geológica analizada, así como los yacimientos arqueológicos citados en el texto.

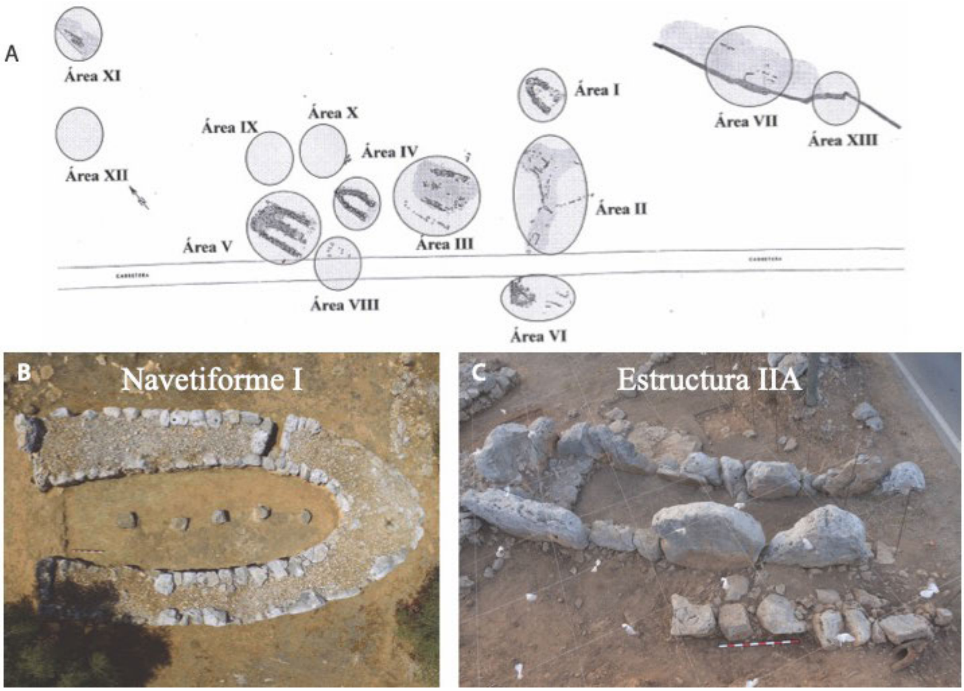

FIGURA 2
Plano del poblado de Els Closos de Ca'n Gaià (Felanitx, Mallorca) (2A) y las dos estructuras analizadas -el Navetiforme I (2B) y la IIA- (2C).

A nivel socioeconómico, se ha documentado la existencia de una agricultura intensiva y diversificada y una ganadería basada en la explotación de la tríada doméstica, que sugieren que estas poblaciones tenían una economía mixta (Ramis, 2006; Salvà & Hernández-Gasch *et al*., 2009; Valenzuela-Suau *et al*., 2017, 2018; Valenzuela-Suau, 2020). La llegada de productos exógenos no presentes en las Islas Baleares, como el marfil o el estaño, evidencia la presencia de contactos más o menos fluidos con otras poblaciones (p.ej. Escanilla *et al*., 2017; Llull *et al*., 2022). En cuanto a las relaciones entre las islas y los poblados del archipiélago balear, se constata la existencia de un *habitus* común donde habría una afluencia que debió abarcar todos los ámbitos de la vida, tanto a nivel técnico como socio-económico (Albero *et al*., 2011; Ramis & Salas, 2011, 2014; Salvà, 2013).

En torno al 1200/1000 BC (en este artículo Bronce Final) se evidencia un cambio social y estructural a través de la transformación arquitectónica. Aunque algunos poblados de navetiformes seguirán ocupados, se empezaron a construir asentamientos con un esquema diferente. También en este momento se llevaron a cabo reformas en los poblados de navetiformes, como ocurre, por ejemplo, en Els Closos de Ca'n Gaià, donde se redujo el acceso de entrada a estas estructuras (Fornés *et al*., 2009; Javaloyas *et al*., 2011).

ELS CLOSOS DE CA'N GAIÀ (FELANITX, MALLORCA)

Los trabajos arqueológicos en este poblado se llevan realizando ininterrumpidamente desde el año 1996 hasta la actualidad. Este yacimiento arqueológico está compuesto por ocho conjuntos arquitectónicos de los cuales se ha excavado aproximadamente el 10% de la superficie total (Figura 2A) (Javaloyas *et al*., 2007; Fornés *et al*., 2009; Salvà, 2013). Concretamente, se ha excavado íntegramente una estructura de hábitat –el Navetiforme I (Figura 2B), Área I (Figura 2C)– junto con el exterior más inmediato y un conjunto de estructuras conocidas como Área II que se adosan a otro navetiforme individual, el Navetiforme II.

Hasta el momento se han podido estudiar dos conjuntos faunísticos correspondientes al Navetiforme I y a la estructura IIA, integrada en la citada Área II (Figura 2). El primero de estos edificios es un navetiforme de 16 m de longitud y 7 m de anchura máxima. Los muros son de triple paramento y tienen entre 2 y 3 m de grosor, levantados directamente sobre el suelo, sin cimientos y con pequeñas cuñas que les dan solidez. Aunque este navetiforme funcionó como espacio doméstico al menos durante cinco siglos, se han registrado ciertas remodelaciones a lo largo de toda su historia que permiten documentar las siguientes fases (Calvo & Salvà, 1999; Hernández *et al*., 2004; Javaloyas *et al*., 2007; Fornés *et al*., 2009):

– Fase I. Entre el 1700 y el 1500 BC se constata un uso anterior a la construcción del edificio (UE 95 y 96). Estas unidades estratigráficas se constituyen por un sedimento arcilloso con restos arqueológicos no demasiado abundantes (fauna, cerámica y carbones) y con un alto grado de rodamiento. Las evidencias de esta primera etapa se documentan también en otras zonas del poblado a través de dataciones relativas y absolutas claramente asociadas al Bronce Antiguo (Salvà, 2013).

– Fase II. Este momento corresponde a la primera fase de ocupación del navetiforme (en este artículo Bronce Medio) y se inicia con la construcción de la estructura en torno al 1500 BC. Esta fase dura aproximadamente hasta el cambio de milenio y está constituida por limos y arcillas de unos 50 cm de potencia (UE 36). Los restos arqueológicos no son demasiado abundantes, y la fauna y cerámica se disponen de forma mayoritaria en los lados del edificio o en torno a las bases de las columnas, posiblemente por efecto de sucesivas limpiezas del espacio. A nivel estructural, el interior del edificio viene marcado por la presencia de cuatro bases de columna de piedra situadas en el eje longitudinal y dos enlosados: uno que ocupa prácticamente la mitad este y otro, de grandes piedras, que delimita la entrada.

– Fase III. Se trata de la segunda ocupación de la estructura (Bronce Final) y se desarrolla entre 1100 y el 850 B.C. aproximadamente (UE 9 y 35). De este momento se puede destacar la incorporación de nuevos elementos estructurales, como la losa donde se llevarían a cabo trabajos domésticos, como la preparación de piezas cárnicas para su posterior cocinado (Salvà *et al*., 2002; Fornés *et al*., 2009). En este momento el enlosado de la entrada se cubrió y sobre él se construyó una pared que redujo la entrada más de la mitad, fenómeno que parece ser general en la mayoría de navetiformes mallorquines (Javaloyas *et al*., 2007; Salvà & Hernández-Gasch, 2009; Fornés *et al*., 2009). El material arqueológico se encontró *in situ* y se deduce que la mayoría de los restos de fauna corresponden al momento de abandono de la estructura.

No se ha conservado ningún hogar en ninguna de las fases de ocupación del Navetiforme I, aunque según el estudio micromorfológico, en el nivel de la segunda fase de ocupación (Fase III) *"aparecen muchos restos vegetales con trazas de combustión propio de un nivel de hábitat. Representaría una zona cercana a un área de combustión con una actividad de tipo culinaria. Por las alteraciones de los componentes, este hogar habría alcanzado una temperatura superior a los 500ºC. En este nivel las condiciones serían las mismas que el nivel anterior"* (Bergadà, 2003: 3). Además, en el exterior del navetiforme, según la misma autora, hay "una mayor presencia de carbonatos y fosfatos que podría ser debida a la presencia de calcita la cual es el componente mayoritario en los restos de combustión" (Albert, 2003: 8). Por ello proponemos que, posiblemente, en esta época las actividades relacionadas con el fuego se realizaron tanto en el interior como en el exterior del navetiforme.

– Fase IV. Esta etapa viene marcada por el abandono de la estructura, derrumbándose el techo al cabo de poco tiempo. Los materiales de esta fase corresponden a las reparaciones del techo, por lo que la tipología cerámica refleja un palimpsesto de todas las épocas anteriores, contemporáneas y posteriores al uso de la naveta como lugar de habitación (Bronce Antiguo, Bronce Naviforme, Talayótico, Bizantino, Islámico y de época Moderna y Contemporánea).

Situada en el Área II se encuentra la otra estructura analizada en este trabajo, la IIA (Figura 2C). Por el momento no se han encontrado paralelos a esta estructura en otros poblados y el resto de los materiales está pendiente de estudio, por lo que su funcionalidad es incierta. La hipótesis de partida es que el Área II no tendría una funcionalidad de hábitat, sino que es la presencia de morteros y molinos de mano, así como otros objetos que parecen indicar que allí se llevarían a cabo trabajos comunitarios y/o supradomésticos. La estructura IIA presenta una planta rectangular, está construida con grandes losas que la delimitan, colocadas directamente sobre el suelo y ajustadas con cuñas, sobre un nivel de preparación previa del terreno (UE 75). No se conserva en su totalidad, ya que la carretera que atraviesa el yacimiento la destruyó en los años

50 del siglo XX. Las dataciones que se han realizado sugieren que su construcción posiblemente debió acontecer hacia 1400 BC. Posteriormente a la construcción se detecta claramente un largo momento de uso en pleno Bronce Naviforme, desde 1400 hasta 1100 BC. aproximadamente (UE 74, 26, 32, y 86/89). Posiblemente se produce un último momento de utilización de la estructura hacia 800/700 BC, después de un periodo de abandono.

Así pues, el análisis arqueozoológico que aquí se presenta pretende ofrecer nuevos datos para la comprensión de la gestión ganadera y la explotación de los recursos animales que se llevaban a cabo en este poblado. Por una parte, a partir de la comparación de las dos estructuras, se podrá observar si había diferencias entre las tareas realizadas en cada lugar, contribuyendo a aumentar el conocimiento sobre la gestión del poblado. Además, en el caso del Navetiforme I también se podrá ver si hubo cambios diacrónicos gracias a la comparación del registro arqueológico de las dos fases de ocupación. Por último, el estudio de la dieta de los caprinos domésticos y las áreas de captación del ganado junto con el resto de información disponible permitirá aportar información sobre la explotación del territorio a través de las prácticas ganaderas contribuyendo así a la comprensión de la sociedad naviforme en general.

MÉTODOS

El estudio arqueozoológico incluye la determinación taxonómica y anatómica de los restos faunísticos recuperados, así como el registro de los principales agentes tafonómicos que han afectado al conjunto. Para la determinación de especies y elementos anatómicos se ha utilizado la colección de referencia del Grupo ArqueoUIB de la Universidad de las Islas Baleares, así como los atlas de Schmid (1972) y Barone (1976). El cálculo del número mínimo de individuos (NMI) ha sido realizado a partir del cálculo propuesto por White (1953; NMI simple). El estudio tafonómico presentado en este trabajo se basa en la identificación de los agentes que han afectado a los restos siguiendo los trabajos de Vigne (1988), Gardeisen (1997) y Bosch *et al*. (2011), y, a partir de la coloración de los huesos se han podido calcular los grados de alteración térmica siguiendo la escala propuesta por Etxeberria (1994).

La edad de sacrificio de los animales ha sido determinada a partir de la combinación del grado de fusión de los huesos y de la erupción y desgaste de las piezas dentales siguiendo los criterios de Bull & Payne (1982), Grant (1982) y Gardeisen (1997), junto con la clasificación de Payne (1973). A partir de los datos registrados, los perfiles de sacrificio han sido representados siguiendo la propuesta de Valenzuela-Lamas (2008) en la que se combina la información sobre la edad de muerte obtenida a partir de las mandíbulas y los huesos largos, y se calcula el perfil de sacrificio que tiene mayor probabilidad de corresponder a los datos de mortalidad a partir de la estadística bayesiana. Para la interpretación de los resultados de los perfiles de sacrificio se ha seguido el trabajo de Varrón (2010, *De Rerum Rusticarum, libri III*). La interpretación de las marcas antrópicas de carnicería ha sido realizada a partir de la descripción y localización siguiendo el trabajo de Vigne (1988). Finalmente, el registro biométrico se ha realizado en base a los trabajos de Driesch (1976) complementado con Davis (1996). En cuanto al cálculo de alzada de la cruz, esta tan sólo ha podido realizarse en ovejas y ha sido calculada a partir de Teichert (1975).

Juntamente con la determinación taxonómica y tafonómica hemos realizado estudios de dieta y de movilidad con el fin de comprender mejor la gestión ganadera en el asentamiento. En particular, estos análisis se han centrado en las ovejas y cabras –el taxón más representado en este período, y el único que permitía un tamaño significativo de la muestra– y, en los casos que ha sido posible, sobre el mismo individuo para poder tener los dos indicadores (dieta y movilidad).

El estudio de la dieta se ha realizado a través del análisis del microdesgaste dental en el *Institut Català de Paleoecologia Humana i Evolució Social* (IPHES) (Tarragona, España). Este análisis permite caracterizar la dieta que tuvieron estos animales los días previos a su sacrificio y, por tanto, refleja el tipo de vegetación existente en los alrededores del lugar donde se sacrificó el animal (Grine, 1986). En este caso, se ha priorizado el análisis de las segundas y terceras molares inferiores, de las que se ha observado el protocónido. En el caso en que ha sido necesario seleccionar molares superiores, se ha analizado el paracono. Las piezas dentales se han limpiado con acetona y luego con etanol al 96%, eliminando así la suciedad y los posibles consolidantes. Una vez preparada la muestra, se ha realizado una reproducción de alta resolución de la superficie aplicando silicona dental (Provil Novo Light CD2 regular). A continuación, se ha creado un molde con Turboflex Putty Soft que ha sido rellenado con resina epoxi transparente (Epoxy 1060/1585) para crear el positivo. Una vez obtenidos los positivos, se han analizado diferentes parámetros con un estereomicroscopio a 35x siguiendo el trabajo de Solounias & Semprebon (2002). Para ello, se han analizado dos submuestras de 0.16 mm^2 cuantificando el número de puntuaciones (*pits*) y estrías (*scratches*), y haciendo una media de las dos superficies analizadas.

El total de parámetros recogidos nos ha permitido diferenciar entre tres grupos generales según su dieta. Por una parte, los pastadores (*grazers*) se caracterizan por una presencia mayor de 17 estrías y menos puntuaciones, dado que su dieta se basa en consumir plantas gramíneas, con una concentración de fitolitos mayor. En segundo lugar, se encuentran los ramoneadores (*browsers*), que ingieren más herbáceas no gramíneas y arbustos, y se distinguen por un menor número de estrías que los pastadores y más puntuaciones. Por último, existe el grupo dietario más oportunista con una dieta más diversificada, los de dieta mixta (*mixed feeders*), que se encuentran entre los dos grupos anteriores. Estos grupos han sido representados con un diagrama de puntos generado a partir del código de Rivals (2019) del lenguaje R-Project. En cuanto a los parámetros cualitativos, se han analizado la presencia o ausencia de hendiduras (*gouges*), el grueso de las estrías, su orientación y la presencia o ausencia de puntuaciones grandes (*large pits*). Gracias a este análisis se ha podido inferir si las ovejas y las cabras comían hojas o ramas de arbustos, o si comían vegetación corta, cercana al suelo.

El estudio de las áreas de captación del ganado caprino doméstico se ha realizado a través de los análisis de isótopos de estroncio (^{87}Sr/^{86}Sr). Las formaciones geológicas contienen ratios isotópicas de estroncio diferentes dependiendo de su edad de formación y sus características félsicas, que se reflejan en las plantas y, a su vez, en los animales cuando beben agua o ingieren plantas de una zona concreta (Bentley, 2006). Debido a que el estroncio puede substituir al calcio, los animales y las personas lo van incorporando a su organismo durante el proceso de formación de los huesos y dientes sin apenas fraccionamiento isotópico (Comar *et al*., 1957; Toots & Voorhies, 1965). El esmalte dental permite caracterizar las áreas geológicas de captación / pastoreo del ganado ya que, dada su alta cristalinidad, preserva la ratio isotópica de la zona de pasto y no se contamina al quedar enterrado. La dentina y los huesos, mucho más porosos, absorben la ratio isotópica de la matriz sedimentaria que los rodea, por lo que permiten conocer la ratio isotópica del lugar donde se encuentran (Bentley, 2006).

La extracción y preparación de las muestras –una para cada individuo– se realizó en el laboratorio del CSIC-*Institució Milà i Fontanals* (Barcelona, España). Se priorizaron las terceras molares inferiores bien mineralizadas para asegurar que se muestreaban diferentes individuos (Tabla 2). En

	Navetiforme I Bronce Medio				**Navetiforme I Bronce Final**				**Estructura IIA Bronce Medio y Final**			
Taxón	**NR**	**%NR**	**%NRD**	**NMI**	**NR**	**%NR**	**%NRD**	**NMI**	**NR**	**%NR**	**%NRD**	**NMI**
Bos taurus	36	4,1	13,8	2	29	4,4	11,4	1	100	9,3	32,8	4
Sus domesticus	15	1,7	5,7	2	21	3,2	8,3	2	19	1,8	6,2	1
Caprinos no determinados	193	22,3	73,9	8	184	28,1	72,4	11	158	14,7	51,8	8
Ovis aries	8	0,9	3,1	1	9	1,4	3,5	2	5	0,5	1,6	1
Capra hircus	7	0,8	2,7	1	7	1,1	2,8	1	3	0,3	1	1
Felis catus	1	0,1	0,4	1	0	0	0	0	0	0	0	0
Oryctolagus cuniculus & Lepus	1	0,1	0,4	1	4	0,6	1,6	1	20	1,9	6,6	1
NRD	**261**	**30,1**	**100**	**18**	**254**	**38,8**	**100**	**17**	**305**	**28,5**	**100**	**26**
Avifauna	0	0,0	-	0	2	0,3	-	1	6	0,6	-	1
Roedores	3	0,3	-	1	3	0,5	-	1	52	4,9	-	9
Macro	34	3,9	-	-	40	6,1	-	-	68	6,3	-	-
Meso	239	27,7	-	-	188	28,7	-	-	301	28,1	-	-
Indeterminados	328	38,0	-	-	168	25,6	-	-	340	31,7	-	-
Total NR	**865**	**100**	**-**	**-**	**655**	**100**	**-**	**-**	**1072**	**100**	**-**	**-**

TABLA 1

Relación de las distintas categorías taxonómicas registradas en los tres conjuntos analizados (NR= número de restos; NRD= número de restos determinados), sus porcentajes de representación (%NR y %NRD) y el número mínimo de individuos en cada caso (NMI).

Código muestra	UE	Diente	Especie	Desgaste (Payne, 1987)	87Sr/86Sr	± (2sigma)
CG1	18	M3 inf	*Ovis aries*	11G	0.708830	0.000007
CG2	36	M3 inf	*Ovis aries*	8G	0.709242	0.000004
CG3	86/89	M3 inf	Caprino no determinado	5A	0.709051	0.000004
CG4	9	M3 inf	*Ovis aries*	11G	0.709187	0.000006
CG5	36	M3 inf	*Ovis aries*	11G	0.709137	0.000003
CG6	36	M2 inf	Caprino no determinado	9A	0.709056	0.000005
CG8	9	M3 inf	Caprino no determinado	11G	0.708934	0.000003

TABLA 2

Información básica de las muestras de Els Closos de Ca'n Gaià y la ratio isotópica ($^{87}Sr/^{86}Sr$) obtenida.

primer lugar, se eliminó mecánicamente el sarro y la suciedad de la zona seleccionada con un micromotor dental. Posteriormente, se realizó un corte transversal en la zona del protocónido de cada diente con disco de diamante a 1 mm encima de la raíz para poder comparar un momento de vida similar en los animales. Finalmente, se eliminó toda la dentina para evitar contaminaciones.

Así mismo, se muestreó vegetación actual y material arqueológico (hueso y dentina) para caracterizar las ratios isotópicas de estroncio en diferentes capas geológicas de las Islas Baleares (Valenzuela-Suau, 2020). Los datos obtenidos se compararon también con la información disponible para zonas continentales cercanas (Voerkelius *et al*., 2010; Willmes *et al*., 2014; Valenzuela-Lamas *et al*., 2018).

El análisis químico de las muestras se realizó en el *Géosciences Montpellier Laboratory* (*Université de Montpellier–CNRS, France*), siguiendo los procedimientos habituales (Pin *et al*., 1994; Valenzuela-Lamas *et al*., 2018, ver descripción detallada en Valenzuela-Suau, 2020). Las ratios isotópicas se obtuvieron con un *Neptune+ Thermo Scientific Multi-Collector Inductively-Coupled-Plasma Mass Spectrometer* (MC-ICP-MS) del *AETE-ISO platform* (OSU OREME).

RESULTADOS

El conjunto de huesos: el Navetiforme I y la estructura IIA

El registro arqueozoológico analizado se compone de un total de 2583 huesos de animales correspondientes a dos estructuras de un mismo poblado: el Navetiforme I y la estructura IIA. Del Navetiforme I se han registrado 865 restos de la primera fase de ocupación (1500-1100/1000 cal. BC), y 655 de la segunda fase (1100/1000-850 cal. BC). La estructura IIA ha sido analizada en conjunto (1400-850 cal. BC) debido a que, actualmente, las dificultades estratigráficas no permiten ahondar más en su subdivisión. De esta estructura se recuperó un total de 1072 restos de fauna.

En general, el grado de fragmentación es elevado, hecho que ha permitido determinar a nivel de especie menos de la mitad de los restos (ca. 28-38%). La tríada doméstica (bovinos, ovejas/cabras, suidos), supone la inmensa mayoría de los taxones representados en las dos fases y las dos estructuras analizadas de este poblado (Tabla 1). La representación de especies salvajes es testimonial, y no parece que formasen parte de la dieta de los humanos. Destaca la ausencia total de animales de origen marino exceptuando algunos restos malacológicos que se han analizado en otros trabajos (Vicens, 2019). Las ovejas y las cabras (OC) son siempre el taxón mayoritario seguidas por los suidos y, por último, los bovinos. En la estructura habitacional (Navetiforme I) se observa una gran diferencia de representación de las ovejas y las cabras en comparación con los otros dos taxones de la tríada doméstica (Figura 3).

La frecuencia relativa de las principales especies domésticas es similar en las dos fases de ocupación. El test estadístico del Chi cuadrado confirma que no hay diferencias significativas a nivel estadístico entre las dos fases (χ^2=1,75; *p*= 0,41). En cambio, la estructura IIA presenta unos valores más equilibrados entre las especies de la tríada doméstica, y son significativamente distintos en comparación con las dos fases del Navetiforme I (χ^2=34,1; *p*= 0,00 IIA *vs* Bronce Medio Navetiforme I); χ^2=40,2; *p*= 0,00 (IIA vs Bronce Final Navetiforme I). Este dato podría estar relacionado con un tipo de depósito diferenciado, dado que se trata de dos estructuras con funcionalidades distin-

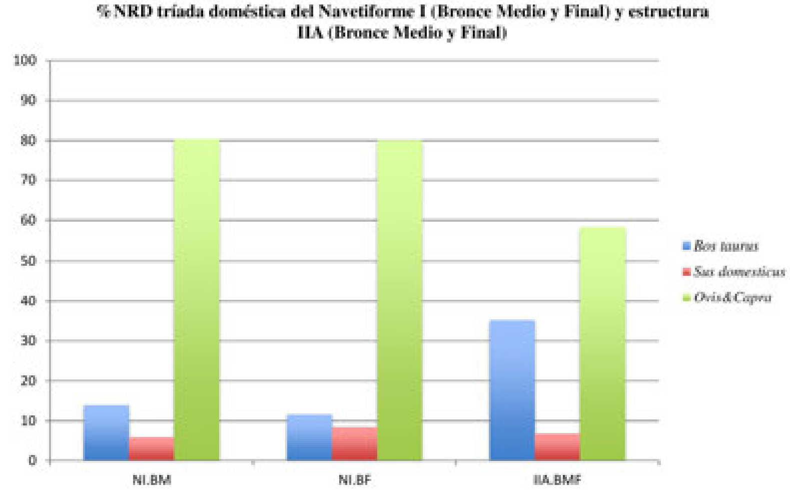

FIGURA 3

Porcentajes de representación específica de la tríada doméstica en cada uno de los conjuntos analizados de Els Closos de Ca'n Gaià (NI. BM y NI.BF= Navetiforme I Bronce Medio y Final; IIA BMF= estructura IIA Bronce Medio y Final).

tas, pero no se puede descartar que se trate de una cuestión de conservación de los restos.

Los agentes tafonómicos que han alterado los tres conjuntos analizados son mayoritariamente las raíces, que se sitúan entorno al 99% de los restos en todos los casos, y el óxido de manganeso (BM Nav. I: NR 603, 28,1%; BF Nav. I: NR= 463, 70,7%; estructura IIA: NR= 2, 1,8%), mientras que el resto de agentes se sitúan por debajo del 20% de afectación (mat. supl. 1). Así pues, los restos han sufrido cambios relacionados con aspectos naturales como el agua y la vegetación. En cuanto a la acción antrópica, el fuego y los huesos probablemente hervidos (Bosch *et al*., 2011) están presentes en los tres conjuntos y –exceptuando el MBA del Navetiforme I (NR= 186, 21,5%)– en general tiene una incidencia parecida, situándose por debajo del 10% (BF Nav. I: NR= 32, 4,9%; estructura IIA: NR= 46, 4,3%). Destaca la presencia de mordeduras, así como dos huesos procedentes de la estructura IIA que habrían estado en contacto con mineral de cobre, ya sea solo o como parte de una pieza de bronce (mat. supl. 1).

Dada la importancia que tiene esta cuestión a la hora de discutir la funcionalidad de los conjuntos, es necesario analizarlo con más detalle. Se han documentado algunos huesos (NR= 10) con marcas puntuales de fuego, que podrían responder a restos que han sido cocinados. Así mismo, otros restos presentan alteraciones térmicas compatibles con temperaturas elevadas [>500 ºC según la escala de Etxeberría (1996)], lo que sugiere la cremación de algunos desechos alimenticios (mat. supl. 2).

La representación esquelética de los animales recuperados en el interior del Navetiforme I muestra la presencia de casi todos los elementos anatómicos en las dos fases analizadas (mat. supl. 3a, 3b y 3c). En el caso de las ovejas y las cabras, se evidencia claramente que llegarían enteras al interior de la estructura (Figura 4) –teniendo en cuenta que hay una proporción parecida entre los distintos elementos anatómicos de este taxón–, mientras que en el caso de los bovinos y los suidos se registra una mayor presencia de las partes del cuerpo que aportan más carne en comparación con el resto de los elementos anatómicos (p.ej. tibias, fémures, radios). De los caprinos domésticos de la estructura IIA llegan sobre todo los metatarsos, seguidos por cráneos y mandíbulas, mientras que el resto de partes anatómicas se sitúan por debajo de 50% de representación, incluyendo los elementos que aportan más carne. Los huesos que se descartan durante el primer despiece del animal están poco presentes también (p.ej. huesos del carpo o falanges).

Los huesos de ovejas y cabras procedentes del Navetiforme I sugieren que se habrían llevado a cabo todos los estadios de procesamiento dentro de la casa – tal vez desde el sacrificio del animal, y con mayor probabilidad su despiece y cocinado – tanto durante la primera como la segunda ocupación. La presencia de cortes en la cara ventral

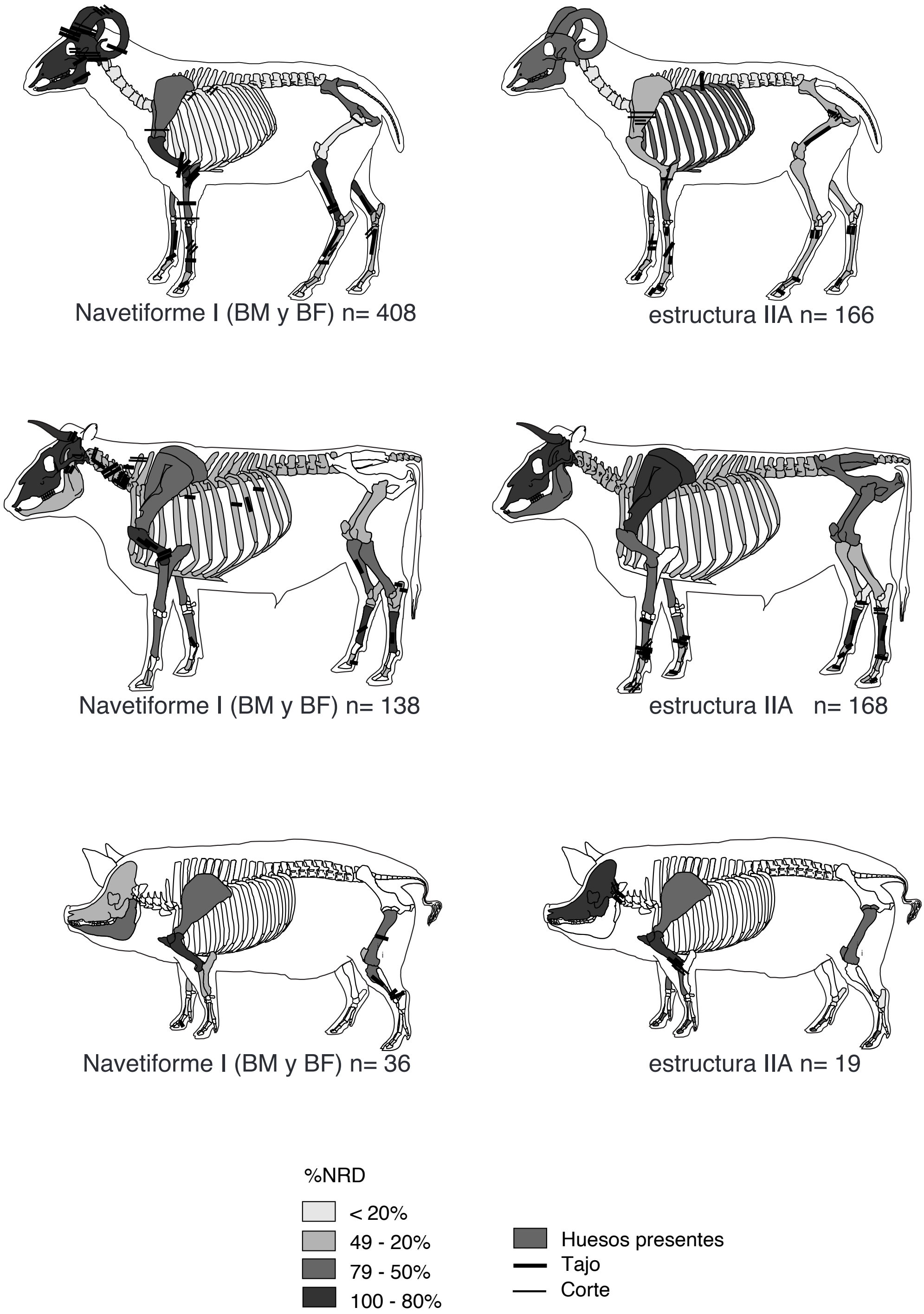

FIGURA 4

Representación esquelética y marcas antrópicas de carnicería de la tríada doméstica del Navetiforme I durante la Edad del Bronce Medio y Final (BMF) y la estructura IIA basados en los porcentajes de representación anatómica (ver mat. supl. 2a, 2b y 2c).

de un atlas podría corresponder al momento de sacrificio o tal vez al primer despiece (separación de la cabeza). Otros cortes y tajos en diferentes puntos probablemente corresponden al desollado, desarticulación y despiece de diferentes partes del cuerpo (Figura 4). En la estructura IIA, los caprinos domésticos muestran marcas de carnicería en 16 huesos, sobre todo desarticulación, el primer y el despiece secundario.

Las marcas antrópicas localizadas en los huesos de bovino del Navetiforme I indican también el procesamiento y el consumo de esta especie, aunque hay que destacar que, durante la segunda ocupación, la mayoría de las marcas corresponden al despiece secundario del animal. Una de las vértebras y una de las costillas seccionadas presenta, además, marcas por alteración térmica, indicando su posible cocinado posterior. Se ha registrado un axis con dos cortes profundos que podrían ser de desarticulación o primer despiece, y el fragmento también presentaba mordeduras[1]. También se observa un calcáneo cuya sección podría atribuirse a el primer despiece o al despiece secundario. Este resto, además, presenta mordeduras. En cuanto a los bovinos de la estructura IIA, se han registrado 28 fragmentos de hueso con marcas antrópicas asociadas a su aprovechamiento cárnico. Están representados el primer y segundo despiece, pero también la desarticulación de húmeros, el descarnado de huesos largos, las marcas de carnívoro y hervidos, e incluso la evisceración a partir de los cortes en costillas.

Los restos de cerdo son escasos y, por ende, el número de huesos con marcas antrópicas también. Se ha registrado el despiece secundario del animal a partir de un fémur y una tibia distal seccionados. Éste último hueso muestra también signos de haber sido hervido. También se ha registrado una tibia seccionada en la zona distal por lo que podría corresponder al primer despiece. En el caso de los cerdos de la estructura IIA, se observa un cráneo que habría sido seccionado durante el primer despiece del animal y que, además presenta también cortes quizás por extracción de la piel, así como un húmero con signos de haber sido desarticulado, seccionado durante el segundo despiece y descarnado.

Edad de sacrificio de los animales

El escaso número de huesos con los que poder aproximar la edad de sacrificio de los animales en bovinos y suidos no permite realizar los perfiles de mortalidad en la mayoría de los casos, a diferencia de lo que ocurre con las ovejas y las cabras –el taxón más representado[2]. Si se comparan las dos fases de ocupación del Navetiforme I, se observa un cambio en las estrategias ganaderas al menos en el caso de las ovejas y las cabras: durante la primera fase se estarían consumiendo animales principalmente jóvenes, mientras que durante la segunda ocupación éstos se sacrifican más viejos, tal vez con un mayor aprovechamiento de los productos secundarios (como la lana o la leche) y manteniendo a los mejores reproductores. La alta presencia de ovejas y cabras menores de 6 meses sugiere el nacimiento de los animales en el yacimiento o cerca de éste (Hamilton, 2000). La estructura IIA muestra un sacrificio más gradual, en que en torno al 60% de las ovejas y las cabras se consumieron antes de los dos años de edad (Figura 5). En el caso de los bovinos, tan sólo se ha podido realizar el perfil de mortalidad para la estructura IIA y éste muestra un patrón de sacrificio gradual. Aún así, existe cierta tendencia a sacrificar los bovinos en óptimo de carne y animales adultos no seniles.

La dieta de las ovejas y las cabras a través del análisis del microdesgaste dentario

El estudio del microdesgaste dentario se ha realizado sobre un total de ocho dientes procedentes de las dos estructuras analizadas y que corresponden a los niveles de la Edad del Bronce. Concretamente, se trata de segundos y terceros molares inferiores de oveja (NR= 3) y de caprinos domésticos que no han podido ser discriminados a nivel de especie (NR= 5). El esmalte de los dientes presentaba alteraciones producidas por raíces y por la acidez del suelo. De las muestras seleccionadas (NR= 8), dos dientes no conservaban microdesgaste dentario y tuvieron que ser descartadas. El resto de los dientes (NR= 6) tiene un patrón de microdesgaste con pocas estrías y un número intermedio de puntuaciones (Figura 6). Eso sugiere que los animales

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[1] No se ha diferenciado entre humano o animal.

[2] Las tablas de estimación de edad de sacrificio de bovinos y suidos se presentan como materiales anexos (mat. supl. 4).

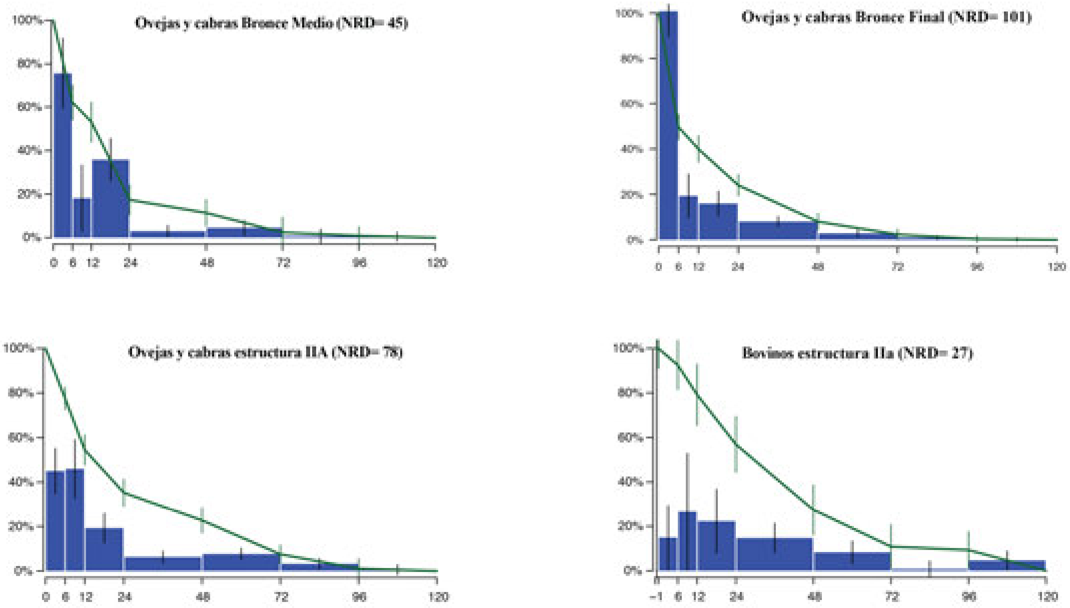

FIGURA 5

Perfiles de mortalidad de las ovejas y cabras del Navetiforme I durante el Bronce Medio (BM) y Final (BF) y la estructura IIA, y los bovinos de la IIA. Los ejes horizontales inferiores expresan la edad de sacrificio en meses. Las líneas verticales indican la horquilla de variación de los valores obtenidos (coeficiente de variación).

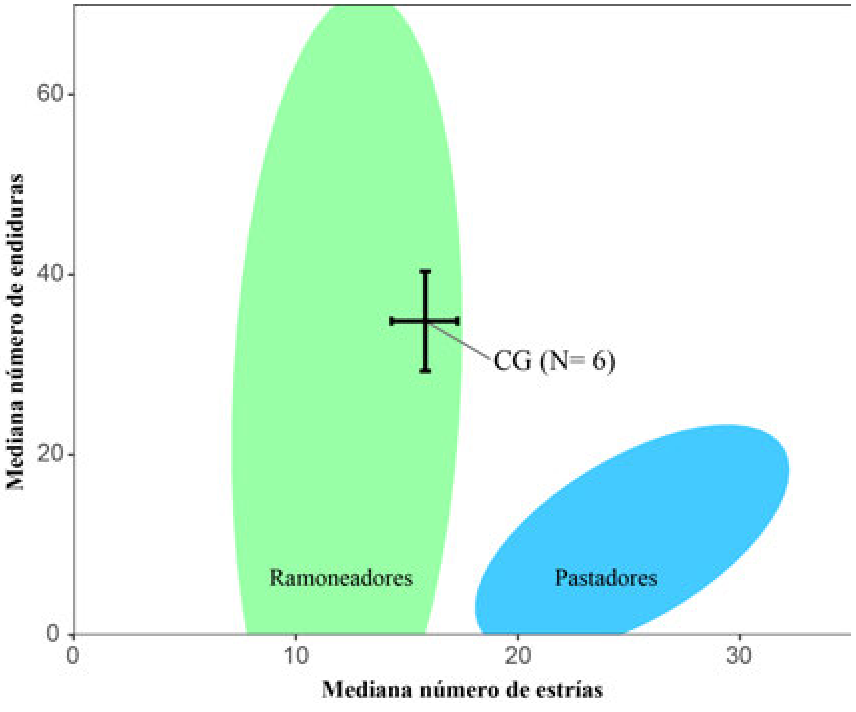

FIGURA 6

Gráfico bivariado con la media del número de endiduras (*pits*) y estrías (*scratches*) de los dientes de caprinos domésticos analizados de Els Closos de Ca'n Gaià (n= 6). [Creado a partir del código de R-Project de Rivals (2019)].

tenían una dieta predominantemente de tipo ramoneador, por lo que este ganado se alimentaría principalmente de herbáceas y hojas, aunque el número de estrías sugiere que también tendrían un aporte de pasto.

El resto de variables analizadas serían el resultado de una alimentación cercana al suelo. Este dato viene determinado por una significativa presencia de *large pits* (66,6%), un 100% en la presencia de *gouges* y una media de 1 en una escala del 0-2 en el grueso de las estrías. Todo ello puede ser consecuencia de que las hojas tenían polvo en superficie como por ingerir partículas minerales por la cercanía de las plantas con el suelo. Así pues, aunque el número de dientes no es muy alto, los datos de microdesgaste sugieren que las ovejas y las cabras de Els Closos de Ca'n Gaià durante la Edad del Bronce ramonean en zonas con matorral y herbáceas, en un paisaje bastante abierto.

Las áreas de captación del ganado: los isótopos de estroncio

El yacimiento analizado se sitúa en una zona geológica formada durante el Holoceno compuesta por conglomerados, areniscas, arenas, limos y arcillas[3]. La ratio isotópica local se ha estimado a partir de la dentina de uno de los individuos analizados y proporciona un valor de $^{87}Sr/^{86}Sr$ de 0.7091 (Error $2\sigma = 0.0000011$). En otros trabajos se ha registrado una señal similar en dos yacimientos situados en otras zonas Holocenas de Mallorca: $^{87}Sr/^{86}Sr$ 0.7090 en S'Illot des Porros (Valenzuela-Suau *et al*., 2021) y un $^{87}Sr/^{86}Sr$ de 0.7090 en Pollentia (Valenzuela-Oliver *et al*., 2016).

Para el análisis de movilidad del ganado se seleccionaron 7 dientes de caprino correspondientes a individuos diferentes (Tabla 2). Estos dientes presentan ratios isotópicas de estroncio $^{87}Sr/^{86}Sr$ comprendidas entre 0.7088 y 0.7092 siendo valores cercanos a la ratio isotópica local (0.7091) y similares a otras zonas de Mallorca (Valenzuela-Suau *et al*., 2021). Esto sugiere que los animales podrían haber pastado en las cercanías del yacimiento, así como proceder de otras localidades con una geología similar. En cualquier caso, no se han detectado animales con ratios isotópicas no presentes en Mallorca.

DISCUSIÓN

En este estudio se han analizado tres conjuntos de fauna procedentes de dos estructuras distintas de Closos de Ca'n Gaià, con dos subfases de ocupación de la Edad del Bronce (ca.1400-1100 and 1100/1000-850 cal BC). Los animales presentes en los tres conjuntos corresponden principalmente a la tríada doméstica, y los agentes de alteración tafonómica que han afectado los restos son principalmente de tipo diagenético (vegetación y agua). En cuanto a las marcas de alteración térmica, la acción del fuego ha dejado marcas en menos del 20% de los restos, y los grados de alteración térmica son compatibles con procesos de cocinado, aunque también se constata la presencia de calcinación en algunos casos. También se han registrado huesos que podrían haber sido hervidos y/o con marcas de alteración térmica en huesos que presentan marcas antrópicas de carnicería (mat. supl. 1). Se ha podido observar que existen diferencias en la temperatura a la que han estado expuestos los huesos, sobre todo en el caso del Bronce Final (BF a partir de ahora y en tablas y figuras) del Navetiforme I (mat. supl. 2).

La tríada doméstica está representada sobre todo por ovejas y cabras, especialmente en el caso del Navetiforme I, seguidos por los bovinos (ca. 10%) y los suidos. Los datos presentados sugieren que en el espacio doméstico (Navetiforme I), la aportación cárnica se centraría en ovejas y cabras de corta edad, que pueden consumirse en una o dos ingestas por los miembros del núcleo doméstico. Esta dieta se complementaría con piezas de bovinos y suidos, más difíciles de conservar, ya que cuando se sacrifican proporcionan un elevado volumen de carne. Si se comparan los porcentajes de representación anatómica por especie y estructura (Figura 4, mat. supl. 3a, 3b y 3c) se observa que las ovejas y las cabras llegarían enteras al interior del Navetiforme I. Para poder determinar la significancia de estas diferencias, se ha aplicado la prueba del X^2 agrupando los huesos del cuerpo de cada especie por segmentos anatómicos más generales: cráneo, tronco, parte superior de la extremidad anterior, parte inferior de la extremidad anterior, parte superior de la extremidad posterior y parte inferior

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[3] La información geológica de este artículo ha sido extraída del mapa del Instituto Geológico y Minero de España (IGME) del 2015.

de la extremidad superior. Los resultados obtenidos indican que no existen diferencias significativas entre las partes del cuerpo de caprinos y bovinos en las dos estructuras[4] (ovejas y cabras Navetiforme I *vs* estructura IIA X^2: 0.19775); bovinos Navetiforme I *vs* estructura IIA X^2: 0.74042). Así pues, aunque sí que se registran diferencias significativas en la presencia relativa de la tríada doméstica entre las dos estructuras, así como la tafonomía que ha alterado los huesos, en el caso de los elementos anatómicos no se ha podido determinar.

A partir de la comparación de los resultados obtenidos para el Navetiforme I con el resto de los datos disponibles en yacimientos contemporáneos, se observa que la proporción de ovejas y cabras de la estructura doméstica de Closos de Ca'n Gaià es mayor en comparación a otros yacimientos (Figura 7). Este dato ya había sido detectado en anteriores trabajos y se puso de manifiesto que las proporciones del ganado se asemejaban más a los yacimientos de fases anteriores (Bronce Inicial) que a los del Bronce Medio y Final (ver Valenzuela-Suau, 2013; Valenzuela-Suau & Valenzuela-Lamas, 2013). En este sentido, el hecho de haber revisado todo el material faunístico de esta estructura (Navetiforme I), eliminando las UE estructurales (UE 7, 8, 15, 28 en el caso del Navetiforme I y 17, 20 y 21 de la estructura IIA), no ha supuesto una gran diferencia en cuanto a los porcentajes de la tríada doméstica, aunque sí ha desaparecido casi por completo la presencia de especies salvajes (p.ej. conejos) sobre todo en el Navetiforme I. En cambio, el hecho de añadir una estructura más –la IIA–, sí que supone un avance en la interpretación socioeconómica del poblado.

Los resultados de la prueba del chi-cuadrado (mat. supl. 5) indican que existen diferencias significativas en la representación relativa de las especies que conforman la tríada doméstica entre la mayoría de los yacimientos arqueológicos disponibles (Figura 7). Se trata de un dato novedoso que nos permite proponer que, dentro del patrón general en el que el consumo de carne está centrado sobre ovejas y cabras, seguidas bovinos y suidos, se registran pequeñas diferencias entre yacimientos que, en su mayoría, resultan estadísticamente significativas (mat. supl. 5). Estas diferencias podrían estar relacionadas con la existencia de una economía local, en la que cada población se adapta a su entorno más inmediato. En este sentido, otros

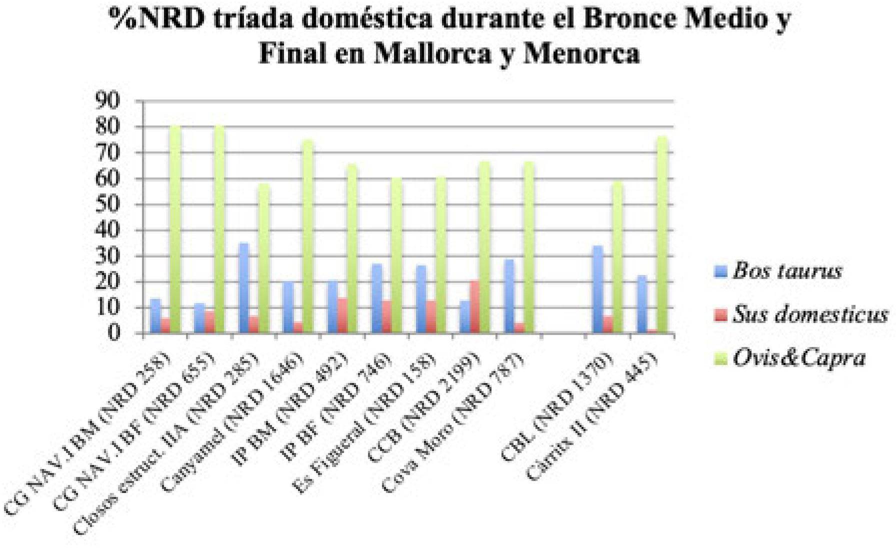

FIGURA 7

Porcentajes de representación de la tríada doméstica de yacimientos de la Edad del Bronce de Mallorca (izquierda) y Menorca (derecha). Canyamel (Capdepera) (Ramis 2011); IP BM y BF= S'Illot des Porros Bronce Medio y Final (Santa Margalida, Mallorca) (Valenzuela-Suau et al., accepted); Es Figueral de Son Real (Santa Margalida, Mallorca) y Cova des Moro (Manacor, Mallorca) (Ramis 2006); CCB= Cova del Camp del Bisbe (Sencelles, Mallorca) (Valenzuela-Suau 2020); Càrritx II (Menorca) (Montero 1999); CBL= Cala Blanca (Ciutadella, Menorca) (Ramis & Anglada, 2012).

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[4] Este test no se ha realizado con los huesos de cerdo dados los pocos restos registrados.

estudios (Picornell & Servera-Vives, 2017) y los resultados del microdesgaste dental y ratios isotópicas de estroncio son coherentes con una gestión ganadera centrada en la explotación del entorno inmediato de los yacimientos (Figura 6, Tabla 2 y Valenzuela-Suau *et al*., 2021). Es necesario seguir aumentando el número de yacimientos para poder avanzar en esta discusión ya que estas diferencias entre yacimientos podrían estar relacionadas con la funcionalidad de cada yacimiento.

Si se analizan con más detalle los datos obtenidos a lo largo del estudio arqueozoológico (sobre todo los perfiles de mortalidad y los porcentajes de representación anatómica) hay ciertos aspectos que merecen una atención especial. Por una parte, en el espacio doméstico (el Navetiforme I) se estarían consumiendo principalmente ovejas y cabras jóvenes –sobre todo durante la primera fase de ocupación– y los elementos anatómicos presentes indican que probablemente estos individuos llegaban enteros o casi enteros al interior la estructura, tal y como ya se ha observado en otros estudios de navetiformes previos (Ramis, 2006, 2011; Ramis & Anglada, 2012). Por otro lado, hay una menor presencia de bovinos y de suidos respecto a la estructura IIA, que tiene un carácter comunitario. Esta práctica podría estar relacionada con el hecho de que las ovejas y cabras de menor edad se pueden consumir en una o dos veces – por tanto, un consumo adaptado a una escala doméstica – y se estaría complementando esta dieta con una ingesta más esporádica de carne de animales de mayor tamaño (bovinos y suidos). Hay que tener en cuenta que sacrificar una vaca o un cerdo supone generar un volumen alto de carne y que en muchas ocasiones son animales considerados de consumo comunitario, que suponen una mayor inversión a la hora de conservar la carne y que, cuando se sacrifican, se pueden compartir entre diferentes núcleos domésticos (Halstead, 1992).

El registro arqueobotánico también aporta información relevante para comprender cómo se organizaban estos grupos durante la Edad del Bronce balear. La vegetación usada como combustible responde a una selección que también respondería a las actividades domésticas que gestionaría este núcleo doméstico de forma independiente, tal y como parece que ocurre con la fauna (Picornell, 2012; Picornell-Gelabert & Servera-Vives, 2017). El tipo de paisaje inferido a través de los estudios paleoambientales del poblado también sería compatible con la dieta registrada a través del microdesgaste dental. En efecto, los estudios de polen y carbones indican que se trataría de un paisaje mosaico de tipo arbustivo caracterizado por el acebuche y con presencia de gramíneas (Picornell-Gelabert & Servera-Vives, 2017). Hemos visto que el estudio de la dieta de las ovejas y las cabras muestra una dieta principalmente arbustiva pero oportunista (alimentación mixta con tendencia hacia el modelo ramoneador), que sería perfectamente consistente con los datos paleobotánicos procedentes de la misma estructura.

Por último, las ratios isotópicas de estroncio sugieren que las ovejas y cabras ramoneaban en zonas próximas al yacimiento, sin descartar una cierta movilidad con otras zonas de geología similar o incluso las montañas cercanas al yacimiento (Salvà, 2001). Ninguno de los dientes analizados presenta una ratio isotópica de estroncio superior a 0.710 por lo que, por el momento, no se observa la presencia de animales procedentes de zonas con una ratio isotópica más radiogénica (p.ej. Córcega, Cerdeña, costa norte de Barcelona).

Así pues, por ahora todos los datos obtenidos a partir del estudio arqueozoológico (NRD, perfiles de mortalidad, porcentajes de representación anatómica, marcas antrópicas de carnicería, microdesgaste dental y áreas de captación del ganado) apuntan hacia la existencia de una ganadería de tipo local y una explotación de los recursos correspondiente al entorno más inmediato y, probablemente, adaptado para cada lugar, dentro de un patrón general centrado en el consumo de ovejas y cabras.

CONCLUSIONES

En este estudio se han analizado los restos faunísticos correspondientes a la Edad del Bronce Medio y Final procedentes de dos estructuras del poblado de navetiformes de Els Closos de Ca'n Gaià (Felanitx, Mallorca) para aportar nueva información sobre la gestión ganadera y la explotación de los recursos durante este período. Para ello, se ha utilizado una metodología *multiproxy* donde al estudio arqueozoológico de los huesos se ha añadido el de la dieta de los caprinos domésticos a partir del microdesgaste dental y las áreas de captación del ganado con los isótopos de estroncio ($^{87}Sr/^{86}Sr$).

Los datos proporcionados respecto al procesado y consumo de alimentos de origen cárnico corroboran los ya obtenidos en anteriores estudios sobre el Bronce naviforme (Medio y Final), que apuntan hacia un consumo doméstico donde se llevaría a cabo todo o casi todo el proceso de sacrificio y despiece del animal en el interior de las estructuras navetiformes, que también serían posteriormente cocinadas y consumidas en estos edificios (Ramis, 2006; Ramis & Anglada, 2012, Valenzuela-Suau & Valenzuela-Lamas, 2013). Aún así, es necesario seguir aportando nuevos datos. En este estudio se amplía la información disponible con la incorporación de una estructura no doméstica (la IIA) y la comparación de los dos conjuntos entre ellos y con el resto de datos publicados.

Además, a lo largo de este artículo se ha podido comprobar que el consumo doméstico del Navetiforme I se basaría principalmente en la ingesta de ovejas y cabras, sobre todo jóvenes, complementado con una menor ingesta de carne de bovino y suido. Esta proporción de especies difiere tanto con la estructura IIA como con el resto de poblados y sitios arqueológicos disponibles del mismo período. La comparativa de la representación de la tríada doméstica en todos los yacimientos publicados del Bronce Medio y Final muestra la existencia de diferencias significativas en la composición de la cabaña ganadera en cada sitio, hecho que sería indicativo de una explotación de los recursos adaptada a cada entorno. Los resultados del microdesgaste dental así lo corroboran, demostrándose un tipo de dieta de las ovejas y las cabras basada en la vegetación disponible en el poblado como indican los estudios paleobotánicos. Finalmente, el resultado del análisis de los isótopos de estroncio muestra un área de captación del ganado mayoritariamente local, con algunos individuos que podrían haber pastado en zonas un poco más lejanas al yacimiento.

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MATERIAL SUPLEMENTARIO

	raíces	**%raíces**	**carnívoro**	**%carnívoro**	**descamación**	**%descamación**	**fisuras**	**%fisuras**	**fuego**	**%fuego**
Nav. I BM (NR= 865)	856	98,96	6	0,7	109	5,1	75	3,5	186	21,5
Nav. I BF (NR= 655)	646	98,6	16	2,4	120	18,3	57	8,7	32	4,9
Estr. IIA (NR= 1072)	1063	99,2	17	1,6	128	11,9	119	11,1	46	4,3
	hervidos	**%hervidos**	**concr.calc.**	**%concr.calc.**	**rodados**	**%rodados**	**óxido mang.**	**%óxido mang.**	**disolución**	**%disolución**
Nav. I BM (NR= 865)	72	8,3	236	11	5	0,6	603	28,1	1	0,1
Nav. I BF (NR= 655)	59	9	80	12,2	3	0,5	463	70,7	2	0,3
Estr. IIA (NR= 1072)	89	8,3	234	21,8	608	56,7	2	1,8	2	1,8

MAT. SUPL. 1

Agentes de alteración tafonómica registrados en los tres conjuntos analizados (Nav. BM= Navetiforme I Bronce Medio; Nav. I BF= Navetiforme I Bronce Final; Estr. IIA BMF (estructura IIA Bronce Medio y Final) y los porcentajes de incidencia de cada uno de ellos.

		Nav. I BM (NR= 176)		**Nav. I BF (NR= 25)**	**estructura IIA (NR= 40)**
Coloración (Etxeberría 1994)	**Distribución en ºC**	**NR**	**%NR**	**NR**	**NR**
Ocre con diversas tonalidades	200-250ºC	4	2,3	0	0
Marrón con diversas tonalidades	250-300ºC	72	40,9	11	7
Negro con diversas tonalidades	300-350ºC	70	39,7	1	20
Negro empezando carbonización	400-500ºC	0	0	5	0
Gris empezando a agrietarse	500-600ºC	25	14,2	7	9
Blanco	>650ºC	5	2,8	1	4
Total		**176**	**100**	**25**	**40**

MAT. SUPL. 2

Desglose de huesos con alteración térmica para cada conjunto analizado. En la primera columna, se detallan las coloraciones correspondientes a cada categoría y, a continuación, el intervalo de grados centígrados estimado en cada caso a partir del trabajo de Etxeberría (1994).

Elem. Anat.	**OC NAV. I**	**OC IIA**	**NRi 1 indv**	**NRi est. OC NAV. I**	**NRi est. OC IIA**	**PR OC NAV. I**	**PR OC IIA**
cráneo	54	4	1	9	8	600	50
mandíbula	37	12	2	18	16	205,6	75
dientes	118	60	30	270	240	43,7	25
costillas	7	0	29	261	232	2,7	0
vértebras	7	4	26	234	208	3	1,9
escápula	14	3	2	18	16	77,8	18,8
húmero	16	4	2	18	16	88,9	25
radio	14	8	2	18	16	77,8	50
ulna	10	4	2	18	16	55,6	25
carpo	5	6	10	90	80	5,6	8
metacarpo	21	7	2	18	16	116,7	43,8
coxal	4	5	1	18	16	22,2	31
sacro	2	0	1	9	8	22,2	0
fémur	18	7	2	18	16	11,1	44
tíbia	17	4	2	18	16	100	25
tarso	7	2	4	36	32	47,2	6,3
metatarso	34	16	2	18	16	38,9	100
patela	0	0	2	18	20	0	0
1falanage	9	7	8	72	64	47,2	10,9
2falange	4	9	8	72	64	12,5	14,1
3falange	2	3	8	72	64	5,6	4,7
metápodo	7	1	-	-	-	-	-
hueso largo	1	0	-	-	-	-	-
hueso plano	0	0	-	-	-	-	-
TOTAL	**408**	**166**	-	-	-	-	-
NMI	**9**	**8**	-	-	-	-	-

MAT. SUPL. 3a

Tabla con el desglose anatómico y los porcentajes de representación anatómica (PR) de los caprinos domésticos recuperados en el Navetiforme I (OC NAV. I) y en la estructura IIA (OC IIA). En negrita se han señalado los elementos anatómicos utilizados para calcular el número mínimo de individuos (NMI). En las siguientes columnas se presentan los datos utilizados para calcular el porcentaje de representación anatómica: el número de elementos que tiene un individuo (Nri 1 indiv.), el número de elementos estimados en cada caso calculado a partir del NMI (Nri est. OC NAV. I y OC IIA) y el cálculo de los porcentajes de representación anatómica para cada estructura (PR OC NAV. I y PR OC IIA).

Elem. Anat.	**BOS NAV. I**	**BOS IIA**	**NRi 1 indv**	**NRi est. BOS NAV. I**	**NRi est. BOS IIA**	**PR BOSNAV. I**	**PR BOS IIA**
cráneo	12	8	1	2	4	600	200
mandíbula	1	3	2	4	8	25	37,5
dientes	8	17	30	60	120	13,3	14,2
costillas	8	14	29	58	116	13,8	12,1
vértebras	12	18	26	52	104	23,1	17,3
escápula	2	15	2	4	8	50	187,5
húmero	4	2	2	4	8	100	25
radio	3	2	2	4	8	75	25
ulna	2	0	2	4	8	50	0
carpo	0	0	10	20	40	0	0
metacarpo	3	7	2	4	8	75	87,5
coxal	0	2	1	2	4	0	50
sacro	0	0	2	2	4	0	0
fémur	1	2	2	4	8	25	25
tíbia	2	1	4	4	8	50	12,5
tarso	1	1	4	8	16	12,5	6,3
metatarso	4	8	2	4	8	100	100
patela	0	0	2	4	8	0	0
1falanage	0	4	8	16	32	0	12,5
2falange	2	1	8	16	32	12,5	3,1
3falange	0	5	8	16	32	0	15,6
metápodo	2	2	-	-	-	-	-
hueso largo	25	21	-	-	-	-	-
hueso plano	32	24	-	-	-	-	-
Indet.	14	11	-	-	-	-	-
TOTAL	**138**	**168**	-	-	-	-	-
NMI	**2**	**4**	-	-	-	-	-

MAT. SUPL. 3b

Tabla con el desglose anatómico y los porcentajes de representación anatómica (PR) de los bovinos recuperados en el Navetiforme I (BOS NAV. I) y en la estructura IIA (BOS IIA). Dado que no se han registrado otras especies de tamaño grande, los elementos correspondientes a la categoria de mamífero de talla grande han sido añadidos. En negrita se han señalado los elementos anatómicos utilizados para calcular el número mínimo de individuos (NMI). En las siguientes columnas se presentan los datos utilizados para calcular el porcentaje de representación anatómica: el número de elementos que tiene un individuo (Nri 1 indiv.), el número de elementos estimados en cada caso calculado a partir del NMI (Nri est. BOS NAV. I y BOS IIA) y el cálculo de los porcentajes de representación anatómica para cada estructura (PR BOS NAV. I y PR BOS IIA).

Elem. Anat.	**SUS NAV. I**	**SUS IIA**
cráneo	1	4
mandíbula	4	0
dientes	1	5
costillas	0	0
vértebras	0	0
escápula	3	1
húmero	6	1
radio	1	1
ulna	1	0
carpo	0	0
metacarpo	2	0
coxal	0	0
sacro	0	0
fémur	4	1
tíbia	3	0
tarso	0	2
metatarso	0	0
patela	2	0
fíbula	0	0
1falanage	0	1
2falange	4	0
3falange	1	2
metápodo	1	0
hueso largo	0	0
hueso plano	0	0
Indet.	0	0
TOTAL	**36**	**19**
NMI	**3**	**1**

MAT. SUPL. 3c

Tabla con el desglose anatómico de los suidos recuperados en el Navetiforme I (SUS NAV. I) y en la estructura IIA (SUS IIA). En negrita se han señalado los elementos anatómicos utilizados para calcular el número mínimo de individuos (NMI). Dado el bajo número de restos, no se realiza el cálculo de los porcentajes de representación anatómica.

Contexto	Especie	Hueso	Edad Mínima	Edad Máxima
Navetiforme I Bronce Medio	*Bos taurus*	metacarpo	6	24
Navetiforme I Bronce Medio	*Bos taurus*	segunda falange	15	18
Navetiforme I Bronce Medio	*Bos taurus*	segunda falange	18	120
Navetiforme I Bronce Medio	*Sus domesticus*	3r molar de leche inferior	1	6
Navetiforme I Bronce Medio	*Sus domesticus*	3a falange	2	6
Navetiforme I Bronce Medio	*Sus domesticus*	tíbia	6	24
Navetiforme I Bronce Medio	*Sus domesticus*	tíbia	6	24
Navetiforme I Bronce Final	*Bos taurus*	occipital	1	12
Navetiforme I Bronce Final	*Bos taurus*	atlas	3	24
Navetiforme I Bronce Final	*Bos taurus*	calcáneo	6	36
Navetiforme I Bronce Final	*Bos taurus*	fémur	6	42
Navetiforme I Bronce Final	*Bos taurus*	3r molar de leche superior	12	24
Navetiforme I Bronce Final	*Bos taurus*	vértebra	12	54
Navetiforme I Bronce Final	*Sus domesticus*	3rd lower deciduous premolar	0	2
Navetiforme I Bronce Final	*Sus domesticus*	3r molar de leche inferior	13	14
Navetiforme I Bronce Final	*Sus domesticus*	ulna	36	60
Navetiforme I Bronce Final	*Sus domesticus*	2a falange	12	60
Navetiforme I Bronce Final	*Sus domesticus*	5º metacarpo	3	24
Navetiforme I Bronce Final	*Sus domesticus*	2a falange	12	60
Navetiforme I Bronce Final	*Sus domesticus*	escápula	1	12
Estructura IIA	*Sus domesticus*	incisivo	1	9
Estructura IIA	*Sus domesticus*	calcáneo	3	24
Estructura IIA	*Sus domesticus*	cráneo	6	15
Estructura IIA	*Sus domesticus*	metápodo	6	24
Estructura IIA	*Sus domesticus*	calcáneo	6	24
Estructura IIA	*Sus domesticus*	incisivo	11	15
Estructura IIA	*Sus domesticus*	3r molar inferior	14	20
Estructura IIA	*Sus domesticus*	4º premolar inferior	15	18
Estructura IIA	*Sus domesticus*	húmero	15	120

MAT. SUPL. 4

Tabla con el desglose anatómico de los suidos recuperados en el Navetiforme I (SUS NAV. I) y en la estructura IIA (SUS IIA). En negrita se han señalado los elementos anatómicos utilizados para calcular el número mínimo de individuos (NMI). Dado el bajo número de restos, no se realiza el cálculo de los porcentajes de representación anatómica.

Sitio	CG NAV I BM	CG NAV I BF	CG IIA	Canyamel	IP BM	IP BF	Es Figueral	CCB	Cova Moro	CBL	Càrritx II	NRD
CG NAV I BM	1	N	***	*	***	***	***	***	***	***	***	259
CG NAV I BF	0,432134113	1	***	***	***	***	***	***	***	***	***	250
CG IIA	9,65E-08	5,98E-09	1	***	***	**	*	***	*	N	***	285
Canyamel	0,041161197	0,000300304	4,26E-08	1	***	***	***	***	***	***	*	1645
IP BM	9,56E-06	4,07E-05	3,60E-05	4,24E-14	1	N	N	***	***	***	***	353
IP BF	9,67E-08	1,28E-07	0,004319495	9,30E-17	0,120052991	1	N	***	***	***	***	746
Es Figueral	0,000100592	9,93E-05	0,041648101	3,07E-06	0,432134113	0,991863212	1	***	***	**	***	158
CCB	1,77E-07	1,94E-05	1,96E-23	1,64E-47	2,28E-05	1,70E-19	4,12E-06	1	***	***	***	2080
Cova Moro	1,19E-05	7,75E-08	0,021063503	2,34E-05	1,71E-10	2,57E-08	0,000120511	1,92E-39	1	***	***	787
CBL	7,95E-10	4,59E-11	0,966724538	4,05E-19	4,02E-09	1,68E-06	0,008965999	1,16E-62	0,000898448	1	***	1370
Càrritx II	0,000269514	4,69E-07	1,08E-07	0,012593546	1,36E-12	3,05E-12	6,57E-09	7,93E-23	0,000492137	9,09E-11	1	448

MAT. SUPL. 5

Resultados del test del chi-cuadrado (X^2) donde se compara el NRD de diferentes yacimientos arqueológicos correspondientes al Bronce Medio y Final de Mallorca y Menorca. CG NAV I BM, BF y IIA= Closos de Ca'n Gaià Navetiforme I Bronce Medio, Bronce Final y estructura IIA; IP BM y BF= S'Illot des Porros Bronce Medio y Final; CCB= Cova del Camp del Bisbe; CBL= Cala Blanca.

Cronología	Especie	Hueso	Medidas en milímetros					Alzada de la cruz en cm (Teichert, 1975)
ca. 1500-850 cal. BC	Caprino no determinado	escápula	SLC 15,8	GLP 24,8	BG 16,9			
ca. 1500-1100/1000 cal. BC	*Ovis aries*	escápula	SLC 14,7	GLP 24	BG 13,8			
ca. 1100/1000-850 cal. BC	*Ovis aries*	húmero	Bd 23,78	BT 22,78	HTC 11,68			
ca. 1100/1000-850 cal. BC	*Ovis aries*	talus	GLl 25,89	GLm 240,5	Dl 13,85	Dm 14,2	Bd 16,62	58,51
ca. 1100/1000-850 cal. BC	*Ovis aries*	talus	GLl 23,3	GLm 21,7	Dl 13	Dm 12,9	Bd 14,65	52,84
ca. 1100/1000-850 cal. BC	Caprino no determinado	ulna	BPC 13,9					
ca. 1500-850 cal. BC	Caprino no determinado	pelvis	LA 24,65	SB 7,5				
ca. 1500-850 cal. BC	Caprino no determinado	escápula	SLC 15,5					
ca. 1500-850 cal. BC	*Bos taurus*	metacarpo	WCM 25,04	DEM 19,7	DVM 27,91	DIM 24,88		
ca. 1500-850 cal. BC	*Bos taurus*	metápodo	WCM 21,94	DEM 18,25	DVM 27,23	DIM 24,11		
ca. 1500-850 cal. BC	*Bos taurus*	metatarso	WCM 21,16	DEM 18,49	DVM 26,63	DIM 23,73		

MAT. SUPL. 6

Biometría.

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Archaeozoological studies: new database and method based on alphanumeric codes

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ABSTRACT: The database is an important tool to collect all the necessary information by any archaeozoologist. However, the specialists do not use a recurring methodology to describe the bone remains, and that complicates the possibility to compare the results from different sites. For these reasons, first, it is necessary to provide a complete and versatile database structure and secondly, employ a fast and objective methodology. In this case, we propose simplified method based on alphanumeric codes.

We have designed four databases in FileMaker©, all of them interrelated and focused on a part of an archaeozoological study: 1) site data, taxonomy; 2) taphonomy modifications; 3) osteometry; 4) teeth analysis. Besides, for taphonomic modifications we have created a compilation of alphanumeric codes that simplified and sum up the description of bone morphology, the origin and morphotypes of fractures and the localization of the taphonomic modifications. This new methodology has been applied to different samples. Some of them have an anthropic origin, others are natural accumulations, and even mixed ones. In all cases we have aimed to contrast the results in an objective way, leaving the interpretation to the final step of the analysis. In order to achieve this objective, we should use the same methodology, one that facilitates the way we compile the data and the way we can share the information and compare it within different sites.

KEYWORDS: METHODOLOGY, DATABASE, ALPHANUMERIC CODES, BONE REMAINS, ARCHAEOZOOLOGY

RESUMEN: La base de datos es una herramienta importante para recopilar toda la información necesaria por parte de cualquier aespecialista en Arqueozoología. Sin embargo, estos no utilizan una metodología común para describir los restos óseos, y eso complica la posibilidad de comparar los resultados de diferentes yacimientos. Por estas razones, en primer lugar, es necesario proporcionar una base de datos completa y versátil y, en segundo lugar, emplear una metodología rápida y objetiva. En este caso, proponemos un método simplificado basado en códigos alfanuméricos.

Hemos diseñado cuatro bases de datos en FileMaker©, todas ellas interrelacionadas y centradas en una parte del análisis arqueozoológico: 1) datos del yacimiento, taxonomía; 2) modificaciones

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tafonómicas; 3) osteometría; 4) análisis de dientes. Además, para las modificaciones tafonómicas hemos creado una compilación de códigos alfanuméricos que simplifican y resumen la descripción de la morfología ósea, el origen y los morfotipos de las fracturas y la localización de las modificaciones tafonómicas. Esta nueva metodología se ha aplicado a diferentes muestras. Algunas de ellas tienen un origen antrópico, otras son acumulaciones naturales, e incluso mixtas. En todos los casos hemos pretendido contrastar los resultados de forma objetiva, dejando la interpretación para el análisis final. Para lograr este objetivo, debemos utilizar una metodología común, que facilite la forma de recopilar los datos y la manera de compartir y comparar la información entre los diferentes yacimientos.

PALABRAS CLAVE: METODOLOGÍA, BASE DE DATOS, CÓDIGOS ALFANUMÉRICOS, RESTOS ÓSEOS, ARQUEOZOOLOGÍA

INTRODUCTION

Archaeozoologists generally study bone assemblages that contain a large number of remains, to which we apply taxonomy, osteometry, taphonomy and other type of analyses. There also tend to be great differences in these assemblages depending on the type of site and/or chronologies in question. For this reason, the most convenient and effective way of storing all the information is to use a standardized database.

Nowadays it would be impossible to conduct any archaeological research project without creating a database. However, they are generally developed by the research team and are rarely shared with other teams. Thus, the main problem comes when we need to compare assemblages from different sites or different types, where the amount of information based on primary data (taxonomic and anatomical determination, age, sex, presence/absence of elements, modifications, etc.) is recorded in very different ways, despite sharing the same methodological basis. At this point, our greatest concern is how to make all these data homogeneous and how to record the information without it being influenced by subjective opinions. Our intention here is to propose a change aimed at creating a common platform for recording such data that enables the subsequent comparison of the results.

Attempts to create a shared database package and recording methods to facilitate the storage and comparison of information, have already been proposed by other authors. In the 1970s a whole series of alphanumeric codes for studying several skeletal elements were published, providing the first homogeneous classification system for all archaeozoologists (Gifford & Crader, 1977). A few years later, the book by Klein & Cruz-Uribe (1984) covered a whole series of methodologies linked to the treatment and description of archaeozoological assemblages, which were subsequently expanded on by Münzel (1988) for the case of anatomical elements and Lyman (1994) for a more general study of vertebrate taphonomy, which was revisited by Reitz & Wing (2008) and Gifford-Gonzalez (2018) in their most recent compendia. The publication of methodologies currently constitutes a vast corpus with which archaeozoologists have to work, systematizing it in our respective databases. However, there has recently been some concern about how data should be treated and how best to store them. Some researchers have suggested creating a database incorporating new technologies such as barcodes, touch-screen, speech-recognition and GIS, which would speed up the data collection process (Dibble, 2015). Others have proposed the use of relational databases, which should be taught to students in the early stages of the syllabus (Jones & Hurley, 2011). However, these approaches do not consider the need to generate a series of common codes and homogeneous means of recording data for the scientific community that go beyond implementing the technological side of the old methods of recording information. Nevertheless, recently other authors are also concerned about this methodological problem and have made another proposal (Discamps, 2020).

In this paper, we propose a new database for studying faunal material in an archaeological and neo-taphonomic contexts, with a user-friendly interface in which the methods commonly used by archaeozoologists are adapted to a new series of alphanumeric codes, offering a more effective way of recording and processing data.

METHODS

When designing the database, the main objective was to create a platform that could contain all kinds of bone assemblages, regardless of their origin and formation, with a simple, intuitive interface that was easy to fill in. This was done by standardizing the descriptions that had been made to date, but in a more objective, descriptive manner without resorting to individual interpretations. A series of alphanumeric codes was also developed, meaning that data could be entered more quickly and facilitating the subsequent extraction and comparison of data. After a long process of trial and error, where we considered which fields and codes actually needed to be recorded and which should be expanded, deleted or changed (Real, 2012, 2021), the new database started to take shape. Once it had been created and after a long test period during which some teething problems were solved, it was possible to improve the codes in order to cover most specimens. Since then, the database has been applied to anthropogenic assemblages of different chronologies, assemblages generated by carnivores and birds of prey, and even neo-taphonomic samples (e.g. Gordón-Baeza, 2016; Morales, 2015; Machado & Pérez, 2016; Pérez, 2019; Real, 2012, 2021; Sanchis *et al*., 2014, 2016, 2019).

THE DATABASE

A database (DB) was designed using *FileMaker*© software. Our DB consists of a primary database and three secondary ones, all of which are independent but automatically interrelated with one another. This relationship is based on a number of basic fields such as record number, site information, genus and anatomical element. All of them have a simple interface that is quick to use. Separate databases are used according to the type of information compiled in each: general, dental, osteometry and modifications.

In terms of how it works, each specimen is recorded with a unique number (Record number) in the “Main DB”. Then if we wish to add specific information related to the other databases, a new record is generated in the secondary database using the same record number as in the Main DB. Thanks to this dependent field, the other corresponding basic fields are filled in automatically. Moreover, when the specimen is recorded in the secondary databases, a specific correlative Record number is created in each of them.

Main database

The main database is divided into four separate columns depending on the type of data being recorded (Suppl. Figure 1A). The first column, in white, includes the (record and inventory) reference numbers and the buttons that allow records to be created. Information related to the site and the stratigraphic location of the items is also shown. The second column can be used for recording taxonomic and anatomical data and information about age and sex.

The next section (column 3) contains the fields related to the taphonomic study in terms of fractures, thermal and anthropogenic alterations and those caused by other predators. The list of modifications only includes fields that indicate their presence and if we wish to describe each of these in more detail, it is necessary to go to the “Modifications DB”. Lastly, column 4 includes miscellaneous information such as diagenetic modifications, measurements, notes and comments.

Teeth database

This database was created in order to record the specific features of teeth that are identified (Suppl. Figure 1B). The remains are recorded in the main database and their description is then added to the Teeth DB, so it is normally used for complete teeth or those which are sufficiently well preserved to be used to study age and/or seasonality. The specific information that is recorded is divided into four blocks. The first two columns include information linked to the Main DB and the description of the tooth: name, location and state of preservation. The third column is used to record the measurements and state of wear of teeth belonging to different taxa of ungulates, such as caprines, cervids and carnivores. The last block refers to measurements and wear of equid teeth. Lastly, it should be noted that a presentation called “Measurement” has been included, which specifies with the aid of drawings how each of the measurements should be taken (Suppl. Figure 1C).

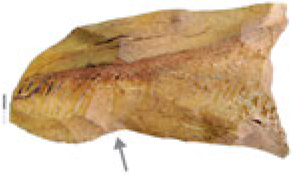
OLD DESCRIPTIONS	NEW DESCRIPTIONS	REMAINS
Complete distal epiphysis of humerus with part of the diaphysis and complete circumference. Ossified.	H, 150, 5, X2	 Cova de les Cendres (Upper Palaeolithic). *Oryctolagus cuniculus*
With fresh fracture on the diaphysis	II.2.4	
Fragmented distal epiphysis of second phalange with a few part of the diaphysis and incomplete circumference.	Fa2, 055, 3, X2	 Cova de les Cendres (Upper Palaeolithic). *Cervus elaphus*
Longitudinal fresh fracture on the diaphysis and distal epiphysis	II.1.3	
Cut-marks on the dorsal part of the distal zone of the diaphysis	cut-marks on 2dtd	
Almost complete mandible with the incisive part and the body	Hem, 555, 5	 El Salt (MiddlePalaeolithic). *Oryctolagus cuniculus*
With dry fracture on the body/ramus	III.3.4	
Fragment of diaphysis of humerus, with uncomplete circumference	H, 050, 2, 2	 El Salt (MiddlePalaeolithic). *Equus ferus*
Fresh fracture on the diaphysis	II.4.2	
Percussion mark on the lateral/dorsal distal part of the diaphysis	percussion on 2dtdl	

FIGURE 1
Comparative table between old descriptions and new descriptions based on the same bone fragment.

Modifications database

This database can be used to describe the modifications identified on the bone surfaces, including anthropogenic modifications (cut marks, tooth marks and fractures) and those caused by other predators (resulting from dental action and digestion) (Suppl. Figure 2A). It is designed for recording each of the modifications, even if they are on the same surface or overlapping, as they are given their own Mark Record number, which is always linked to the Record number in the Main DB. It is arranged in columns, like the other databases, where the first two columns contain the fields linked to the Main DB. The third offers fields related to the origin and morphology of the alteration: type of mark, origin, agent, location, morphology, distribution, direction, intensity and quantity. The last column includes fields for recording the length and width of unilateral or bilateral modifications, and a "Notes" and "Comments" section.

Osteometry database

This database was created to allow a specific osteometric study. The first and second columns include information dependent on the Main DB (Suppl.Figure 2B). The next column shows a list of specific measurements referred to as "Osteo" plus a correlative number, corresponding to the measurements defined by Driesch (1976). To make the measuring procedure easier, the last column includes a drawing of a skeleton with buttons to access pictures of each anatomical element and a description of how each measurement should be taken (Suppl.Figure 2C).

Other features

In terms of how the Database works, buttons have been added to facilitate repetitive tasks such as recording identical fragments, for which the information can be copied as many times as needed. Some basic calculations have also been added, such as the size range, based on length, or the calculation of dental indices in the case of equids. Lastly, there are also buttons to facilitate tasks such as those related to taxonomy, e.g. by specifying the genus, the remaining information is automatically filled in. A DB has also been added to offer an explanation and illustrations of all the new codes that are used. Abbreviations have been used to record the bone type and the anatomical group to which it belongs. This is also the case for the colour of thermal alterations. All of them are intuitive, representing the first letter or the first two letters in the case of repetitions.

ALPHANUMERIC CODES

Bone fragment morphology

Codes in this section specify what percentage has been preserved in each specimen and whether each of its anatomical parts are fragmented or complete, using a combination of three digits (Suppl. Figure 3). The first digit refers to the proximal part, the second to the diaphysis or middle part, and the third to the distal part. The preservation of each of these three digits is expressed in numbers and letters, where 1 means it is complete, 5 corresponds to fragmented, 0 is used when it is missing and "X" when it is not ossified.

In the case of fragments of diaphysis, this is also combined with the amount of circumference, their length and the bone area they belong to (Suppl. Figure 4). The code for the area or the location of modifications (of the same type) also consists of two parts: the first indicates only the area –proximal (1), diaphysis or middle part (2) and distal (3)– whereas the second indicates the specific surface by means of a letter or combination of letters (dorsal, medial, lateral and plantar).

Fracture morphology

The second broad group of codes refers to fracture morphotypes (Suppl.Figure 5-10). Each of the codes consists of two major blocks. The first relates to the origin of the fragment, which is identified with Roman numerals: dry (I), fresh (II), mixed (III) and indeterminate (IV). The second is shown with numbers 1 to 6 and contains up to three digits, each combination specifying a particular morphology that has been observed repeatedly. Its use depends on the anatomical element.

Joint ossification

In the database, the determination of the state of joint ossification has been coded in order to facilitate its further study. The code that has been created consists of two parts: the first refers to the proximal epiphysis and the second to the distal (Suppl. Table 1). There are four options for both of these: fused (2), partially fused (1), unfused (0). For fragments where the joint is not present and it is therefore impossible to know whether or not they are fused, X is used.

RESULTS AND DISCUSSION

In this section we want to show, on the one hand, the improvement that the use of these new codes would represent with respect to the previous data recording methods. For the other hand, how much more effective the use of this common methodology is for different assemblages and their subsequent comparison.

Old and new descriptions

Before this methodological compendium was created, archaeozoological and taphonomic studies were generally based on a detailed description of the features of each fragment. In this regard, as shown in Figure 1, the old descriptions are long-winded, they vary according to the researcher and it is difficult to make comparisons. In contrast, by applying the new codes it is possible to simplify the information that is recorded without losing any data or quality in the record.

Moreover, apart from simplifying the data recording process, the codes can be easily combined in tables to provide more information. In our case, we use dynamic tables in *Excel*© to compare and contrast different data (Table 1). In this regard, by using alphanumeric codes rather than longer, variable descriptions, it is possible to create tables combining quite a large number of fields. Thus, a greater quantity of information can be obtained by combining different data. In the example in Table 1, relating to European rabbit (*Oryctolagus cuniculus*) remains (humerus) from level XII (Upper Palaeolithic) of Cova de les Cendres (Moraira-Teulada, Alicante), the data regarding fragmentation (codes on the left) and ossification and laterality (codes at the top) are combined in order to obtain the MNI. It can be seen that there are 16 individuals aged over 3 months (showing ossification of the distal joint), at least three individuals younger than 10 months (without ossification of the proximal joint) and one individu-

	Right						Left				Indeterminate			Total
	00	**0X**	**1X**	**2X**	**X2**	**In**	**00**	**2X**	**X2**	**In**	**0X**	**2X**	**In**	
Complete														1
Proximal complete														
100				1										1
150								1						1
1XX	1						1							2
Proximal fragmented														
500						1		1		1		1	2	7
550		1	2								1			4
5XX		1					1							1
Diaphysis														
050						6				4			11	21
Distal complete														
001					3				1					4
011									1					1
051					12				11					22
Distal fragmented														
005					1				2	1			1	5
055									1					1
	1	**2**	**2**	**1**	**16**	**7**	**2**	**2**	**16**	**6**	**1**	**1**	**14**	**71**

TABLE 1

Example of a dynamic table combining different items: Bone fragment (Complete, Proximal complete, Proximal fragmented, Distal complete, Distal fragmented, Diaphysis), laterality and the ossification code. Rabbit (*Oryctolagus cuniculus*) humerus remains from Cova de les Cendres level XII (Upper Palaeolithic) (Real, 2021).

al aged approximately 9-10 months (showing partial ossification of the proximal joint).

Bone assemblages' comparison

Our research group comprises several specialists who work on faunal bone assemblages from different chronologies and origins: remains accumulated by humans and other predators (carnivores and birds of prey) from the Middle Palaeolithic to the Mesolithic. Hence, we are interested in being able to compare the data for each sample quickly and easily. We shall therefore show the specific application of the fracture codes (morphotypes).

First, it was applied to two rabbit bone assemblages: level XI of Cova de les Cendres (Real, 2021) and level Xa of El Salt (Alcoi, Valencia) (Pérez, 2019). The first pertains to an Upper Magdalenian anthropogenic accumulation in a cave. The second is a mixed accumulation (by anthropic and natural agents) from the Mousterian in a shelter. The results of the studies were organised by anatomic elements and are shown in Table 2. It is easy to compare the two assemblages using the repeated codes.

In the case of the rabbit remains, considerable differences between the assemblages can be observed. At Cendres we recurrently see remains with fractures on fresh, which are characteristic of a deposit that was regularly accumulated by humans, especially if we look at the long bones and metapodials (Real, 2021). At El Salt, on the other hand, the diversity of fresh fracture morphotypes for the different anatomical elements shows the mixed origin of the assemblage, its nature as a shelter and the diverse associated taphonomic damage (Pérez, 2019).

Secondly, the fracture morphotypes were applied with the same criteria to assemblages of medium-sized animals such as red deer (*Cervus elaphus*) and Iberian ibex (*Capra pyrenaica*) from the aforementioned sites. In this regard, it can be seen that the variety of morphotypes at Cendres is some-

	Cova de les Cendres (XI)	**El Salt (Xa)**
RED DEER AND IBERIAN IBEX		
Mandible	II.5.1	II.4, II.4.1, II.5, II.5.1, II.6.1
Vertebra	II.1.2	II.2.1, II.2.2, II.4, II.4.2
Rib	II.4.2, II.2.4	II.1, II.3, II.4, II.4.2
Scapula	-	II.5
Pelvis	II.5.3, II.4.2	II.5.1, II.5.2
Long bone with proximal epiphysis	II.1.1, II.1.2	II.1, II.1.2, II.1.3, II.2.2, II.2.3, II.2.4, II.3.4, II.4.1, II.4.2, II.4.3, II.4.4, II.5.1, II.5.2.2, II.6.1
Long bone with distal epiphysis	II.1.2	II.1, II.1.2, II.1.3, II.2.1, II.2.2, II.2.3, II.2.4, II.3.4, II.4.2, II.4.3, II.4.4, II.5.2.2, II.5.3, II.6.1
Long bone without epiphysis	II.4.2	II.1, II.1.1, II.2, II.2.1, II.3, II.4, II.4.1, II.4.2, II.4.3, II.5, II.5.1, II.5.2
Metapodial	II.4.2, II.2.2, II.1.2	II.1.2, II.1.3, II.2.2, II.4, II.4.1, II.4.2, II.4.3, II.4.4
Phalanx	II.2.2, II.4.2, II.2.4	II.2.1, II.2.2, II.2.4, II.3.4, II.4.2, II.4.4, II.5.2.2
	Cova de les Cendres (XI)	**El Salt (Xa)**
RABBIT		
Mandible	II.6.1, II.1, II.4.1, II.5.1	II.1.2, II.3, II.3.3, II.6.1
Vertebra	II.1.2, II.4.1, II.4.2	II.1.2
Rib	II.1, II.2.4, II.3.4	-
Scapula	II.4.2, II.2, II.1.1	II.2, II.2.1, II.4.1
Pelvis	II.5.2, II.5.1, II.1.1	II.1, II.1.1, II.3.2, II.3.1, II.5.3, II.6.1
Long bone with proximal epiphysis	II.1.1.1, II.1.1, II.1.1.3, II.1.4	II.1, II.1.1, II.1.3, II.2.3, II.3.1, II.3.4, II.4.3, II.4.4, II.5.4.3, II.6.1
Long bone with distal epiphysis	II.2.4, II.1.4, II.1.2	II.1, II.1.2, II.1.3, II.2.3, II.2.4, II.3, II.3.4, II.4.3, II.4.4, II.5.3, II.5.4.3, II.6.1
Long bone without epiphysis	II.4.2, II.1, II,2	II.1, II.1.1, II.1.2, II.1.4, II.2, II.2.1, II.2.4, II.3, II.3.3, II.4, II.4.1, II.4.2, II.6.1
Metapodial	II.1.4, II.1.3, II.3.4	II.2.3, II.2.4, II.3.4, II.4.3, II.4.4, II.5.4.3
Phalanx	II.3.4, II.2.4	-

TABLE 2

Classification of the fresh fracture morphotypes by anatomical element and taxa used on Cova de les Cendres level XI (Real, 2021) and El Salt level Xa (Pérez, 2019).

what lower than in the rabbit remains, although it does remain constant, which is typical of specific, repeated butchering human activities. However, the variety of morphotypes at El Salt continues to be high, possibly linked to the aforementioned conditions and to the somewhat more varied processing of the different taxa accumulated by human groups, depending on the anatomical element and size of the prey.

CONCLUSIONS

The application of this new methodology, including the numerical codes, has been effective in the subsequent analysis of the data collected. If we compare the use of the traditional definitions (such as "proximal part plus fragment of diaphysis"; "complete circumference" and "length of diaphysis greater than half") with the new formulae (550, 5 and 4), we observe a reduction in text and greater homogeneity between the descriptions of the remains, allowing them to be grouped according to common characteristics and compared. Furthermore, fracture morphotypes also provide greater objectivity when characterising types of fracture and extracting repeated consumption patterns, especially in the case of lagomorphs, which are so abundant at sites in the Mediterranean area of the Iberian Peninsula.

Archaeozoological assemblages always present specific characteristics based on different factors (location, chronology, preservation), so it is therefore difficult to compare and contrast data. The aim of the proposed DB is to extract as much information as possible in the most objective manner, leaving its interpretation for the data analysis phase. By using this methodology for various sites that have been studied, from different contexts and faunal assemblages with diverse features and states of preservation, it is possible to overcome the problems of recording and comparing data that often arise in archaeozoological and taphonomic analyses.

Our intention is to continue with this project and provide a version of the database and codes in both Spanish and English. It would be very helpful to apply it to other faunal bone assemblages and for other researchers to use it in order to continue checking its usefulness and further improve the records. Lastly, our ultimate goal would be to create a website from which to obtain and download the database interface in a free version, together with an explanation of how it works and the new codes and abbreviations. As a result, a Big Data repository could also be created in which to store the raw data for each archaeological assemblage, with open access for the scientific community. For the moment, we offer the possibility to download the FileMaker version from here: https://doi.org/10.5281/zenodo.6670359

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SUPPLEMENTARY MATERIAL

See supplementary material at https://revistas.uam.es/img/Archeofauna/Supplementary_Material_Real_et_al.pdf

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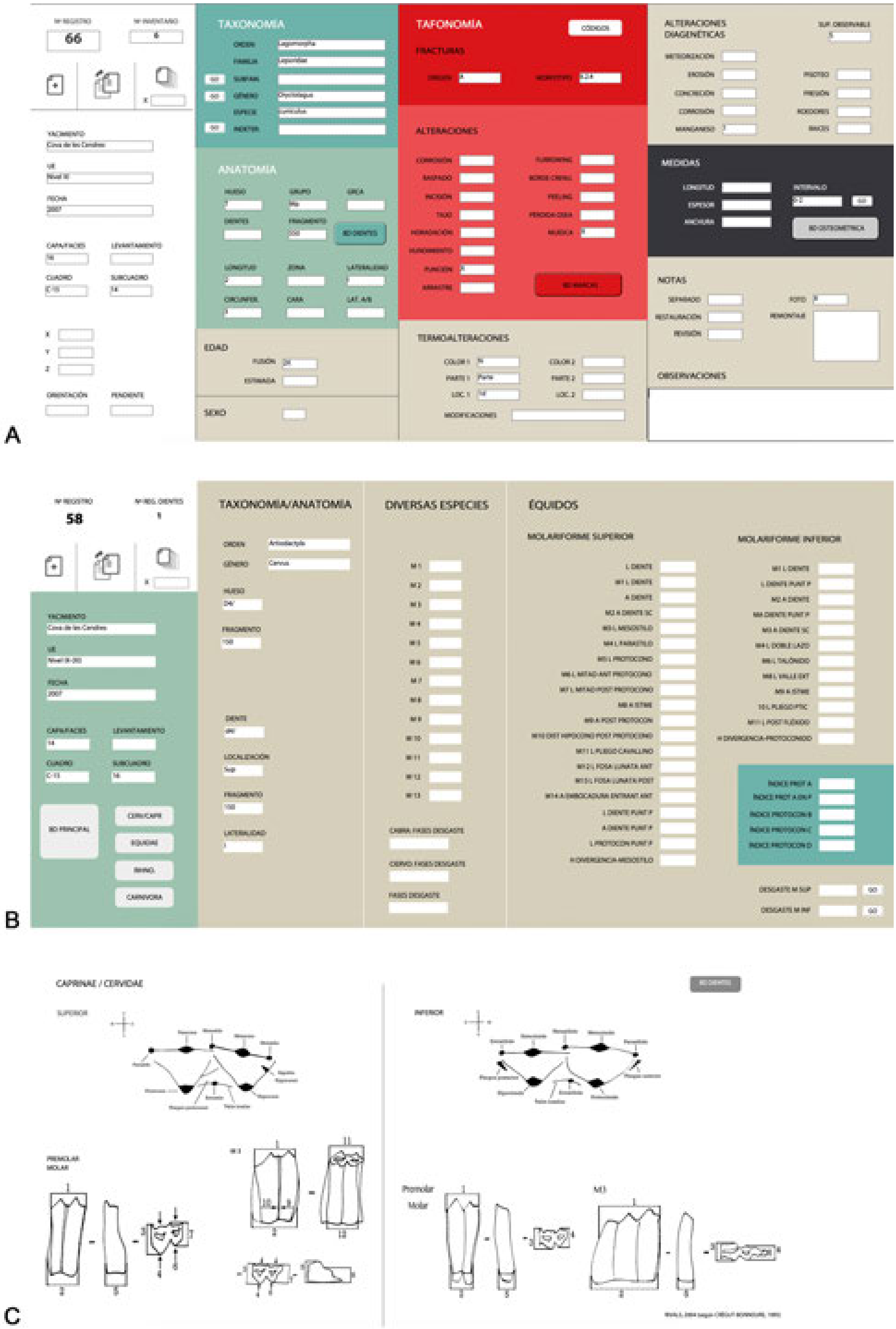
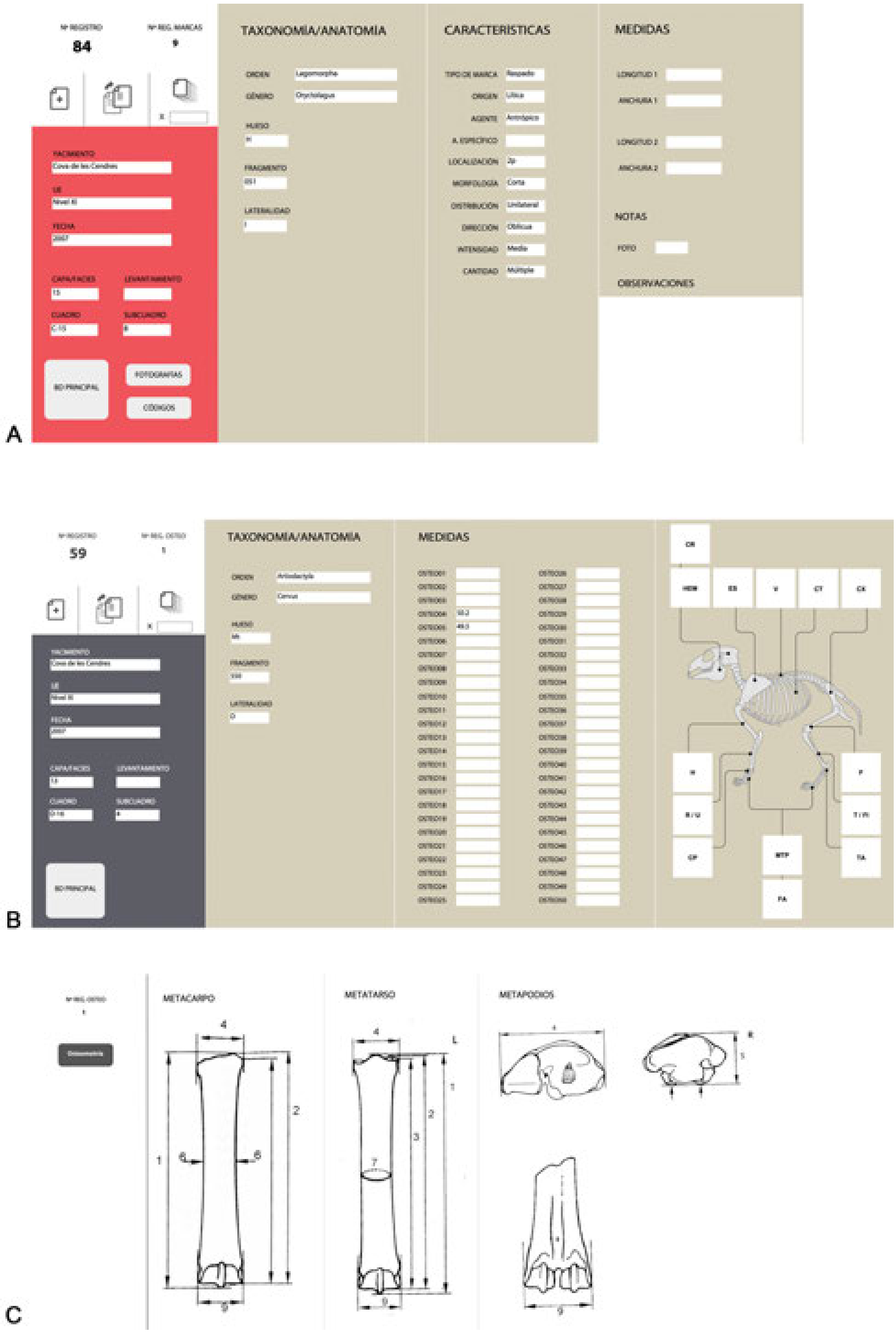
INTRODUCTION



SUPPL. FIGURE 1

A) Main DB. B) Teeth DB. C) Explanation of how to measure the teeth.



Nº REGISTRO 84
Nº REG. MARCAS 9
YACIMIENTO Cova de les Cendres
UE Nivel XI
FECHA 2007
CAPA/FACIES 15
LEVANTAMIENTO
CUADRO C-15
SUBCUADRO 8

TAXONOMIA/ANATOMIA
ORDEN Lagomorpha
GÉNERO Oryctolagus
HUESO H
FRAGMENTO 051
LATERALIDAD I

CARACTERISTICAS
TIPO DE MARCA Raspado
ORIGEN Lítica
AGENTE Antrópico
A. ESPECÍFICO
LOCALIZACIÓN Zp
MORFOLOGÍA Corta
DISTRIBUCIÓN Unilateral
DIRECCIÓN Oblicua
INTENSIDAD Media
CANTIDAD Múltiple

MEDIDAS
LONGITUD 1
ANCHURA 1
LONGITUD 2
ANCHURA 2
NOTAS
FOTO
OBSERVACIONES

Nº REGISTRO 59
Nº REG. OSTEO 1
YACIMIENTO Cova de les Cendres
UE Nivel XI
FECHA 2007
CAPA/FACIES
LEVANTAMIENTO
CUADRO
SUBCUADRO

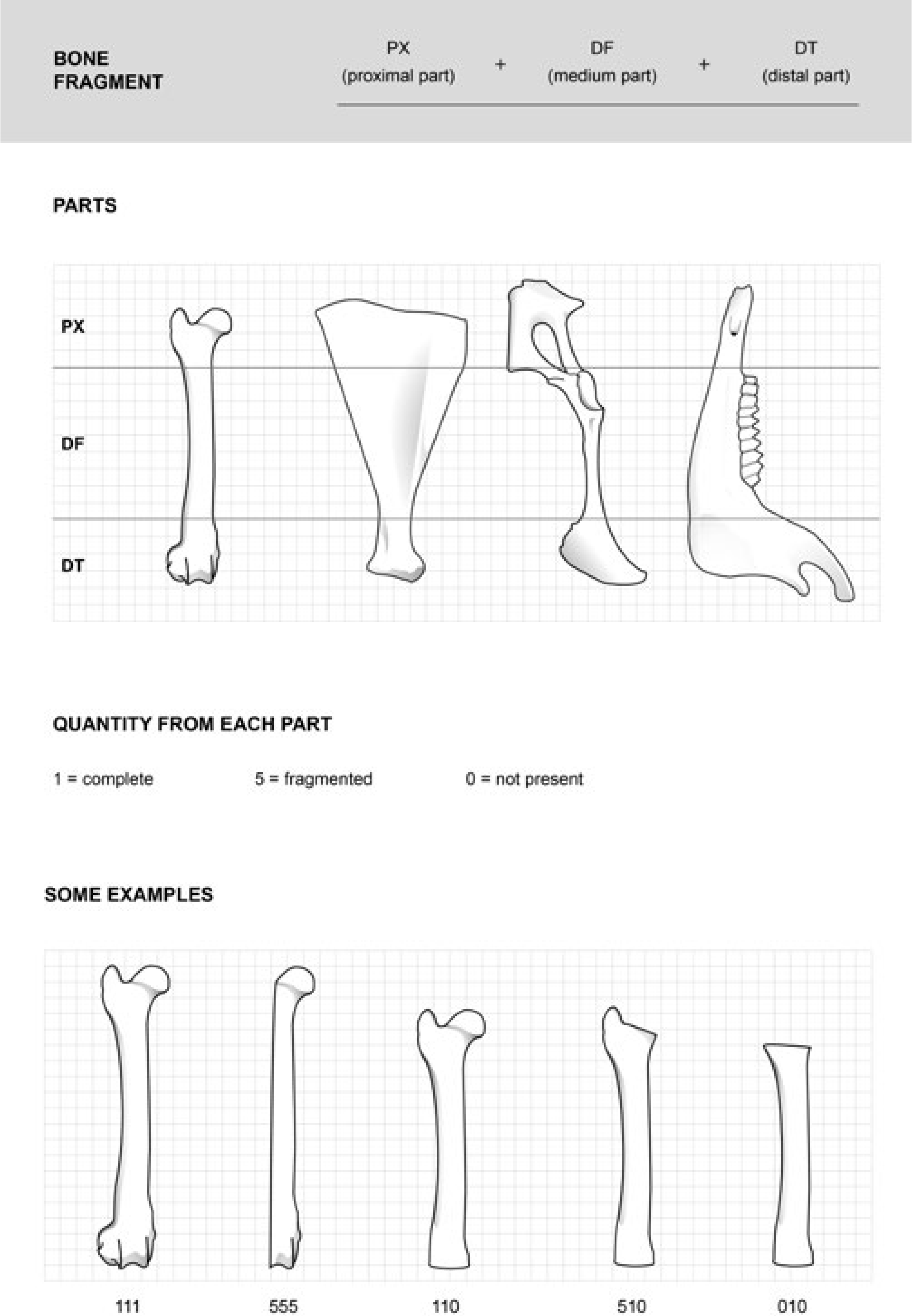
TAXONOMIA/ANATOMIA
ORDEN Artiodactyla
GÉNERO Cervus
HUESO Mt
FRAGMENTO
LATERALIDAD D

MEDIDAS

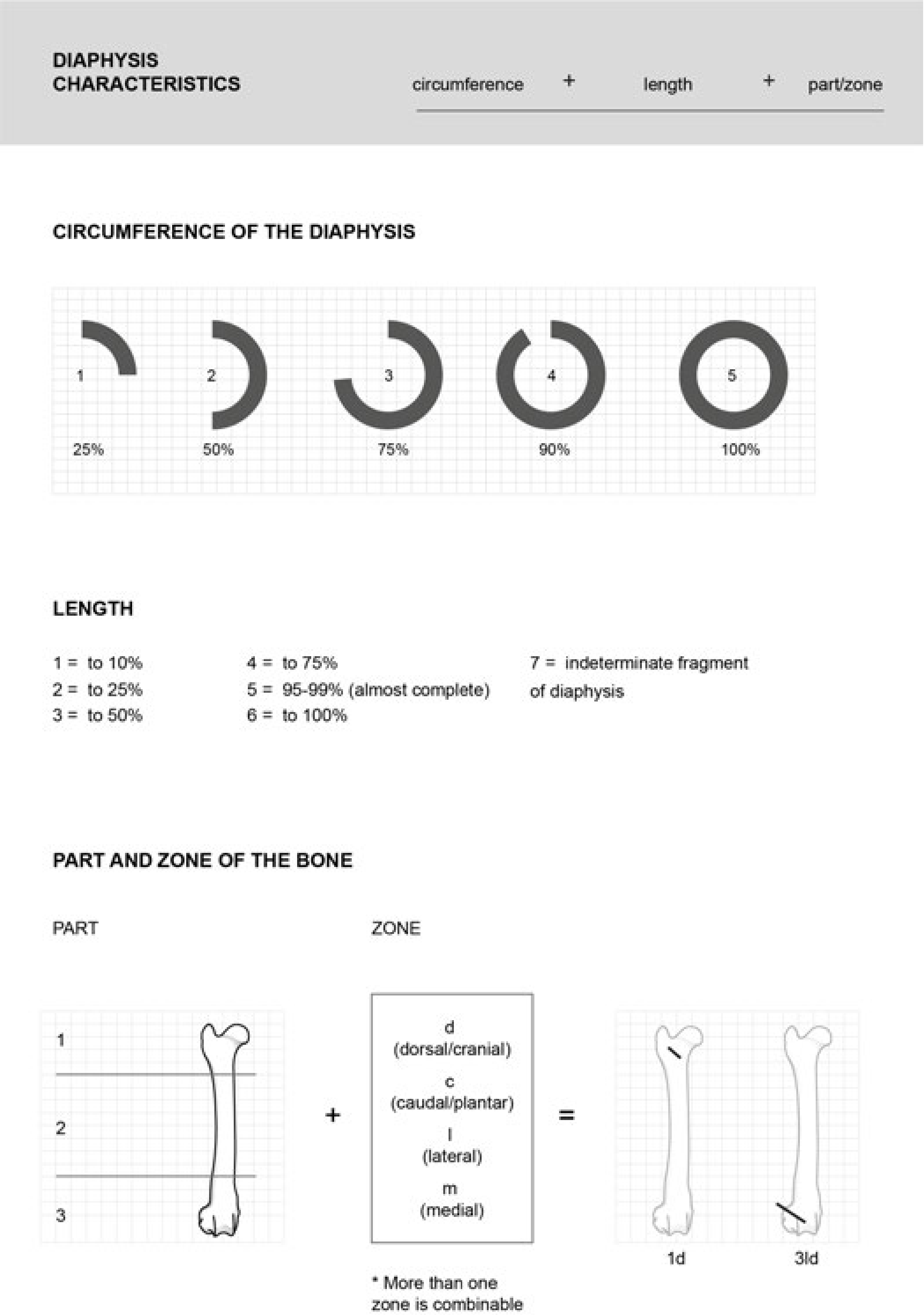
Nº REG. OSTEO 1

SUPPL. FIGURE 2

A) Modifications DB. B) Osteometry DB. C) Explanation of how to measure the bone. Drawing taken from Drierch (1976).



SUPPL. FIGURE 3
Codes of *Bone fragment*.



DIAPHYSIS CHARACTERISTICS

circumference + length + part/zone

CIRCUMFERENCE OF THE DIAPHYSIS

LENGTH

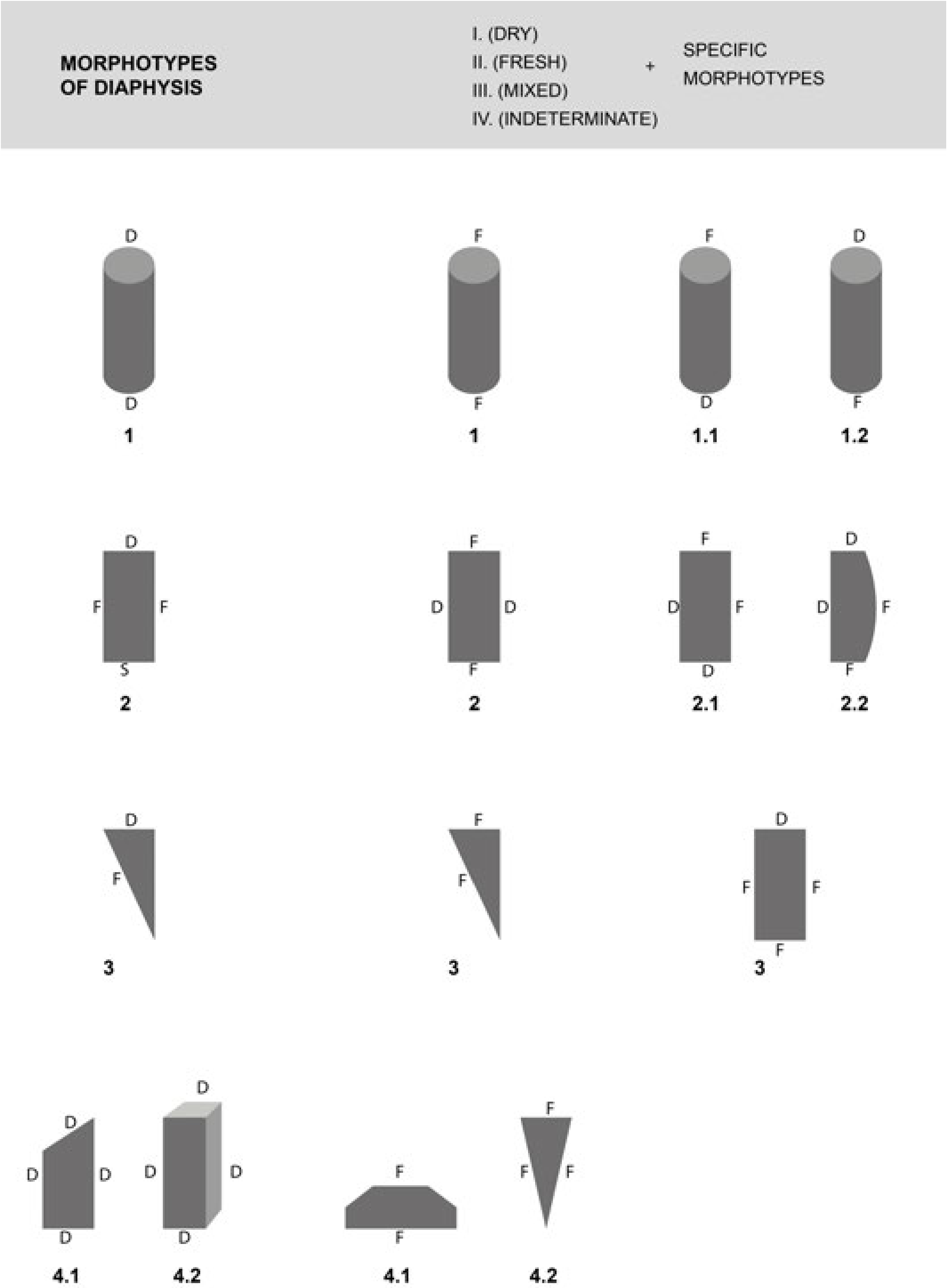
1 = to 10%
2 = to 25%
3 = to 50%
4 = to 75%
5 = 95-99% (almost complete)
6 = to 100%
7 = indeterminate fragment of diaphysis

PART AND ZONE OF THE BONE

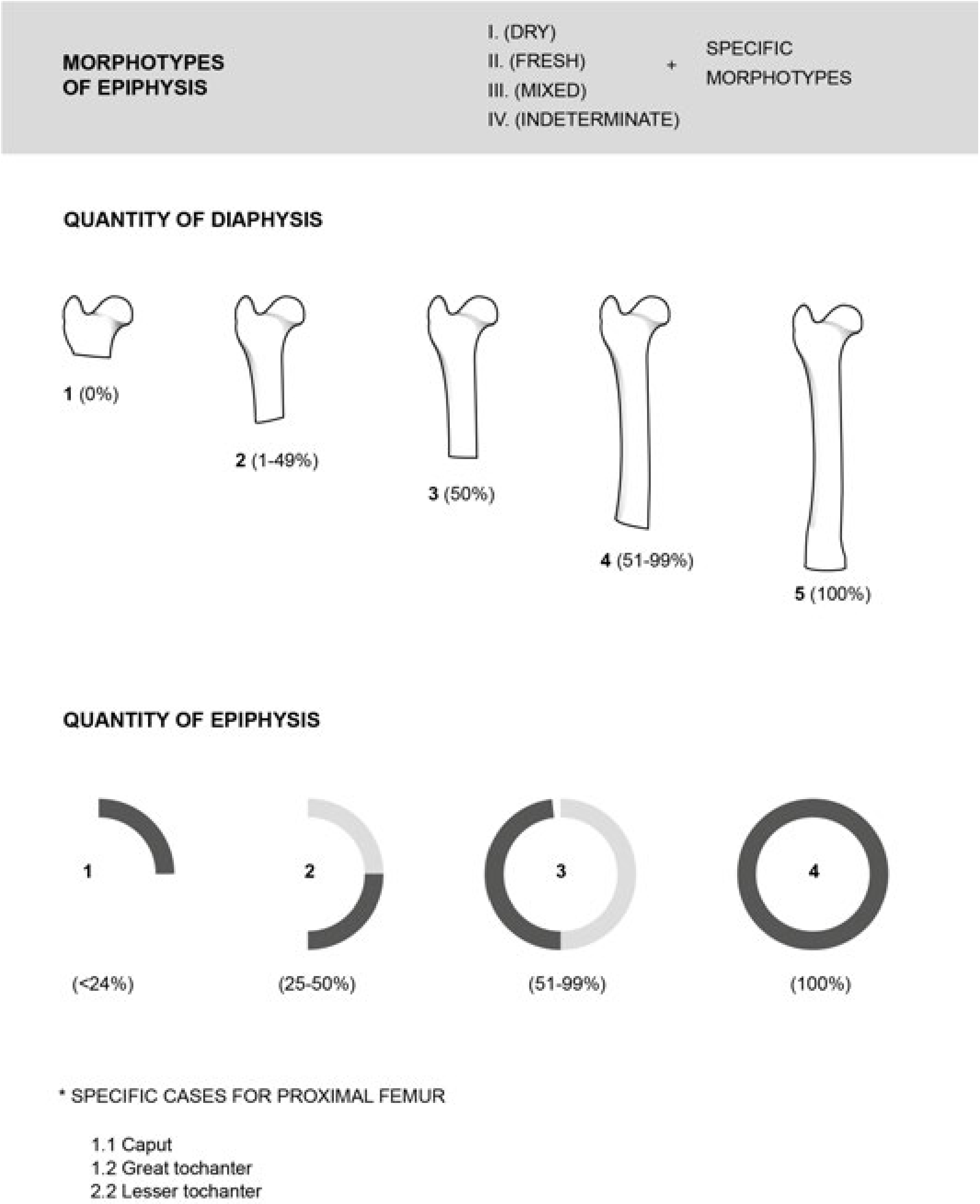
* More than one zone is combinable

SUPPL. FIGURE 4

Codes of *Diaphysis characteristics*: circumference, length, part and zone of the bone (location).



SUPPL. FIGURE 5
Morphotypes of diaphysis.



SUPPL. FIGURE 6

Morphotypes of epiphysis.

Archaeozoologists generally study bone assemblages that contain a large number of remains, to which we apply taxonomy, osteometry, taphonomy and other type of analyses. There also tend to be great differences in these assemblages depending on the type of site and/or chronologies in question. For this reason, the most convenient and effective way of storing all the information is to use a standardized database.

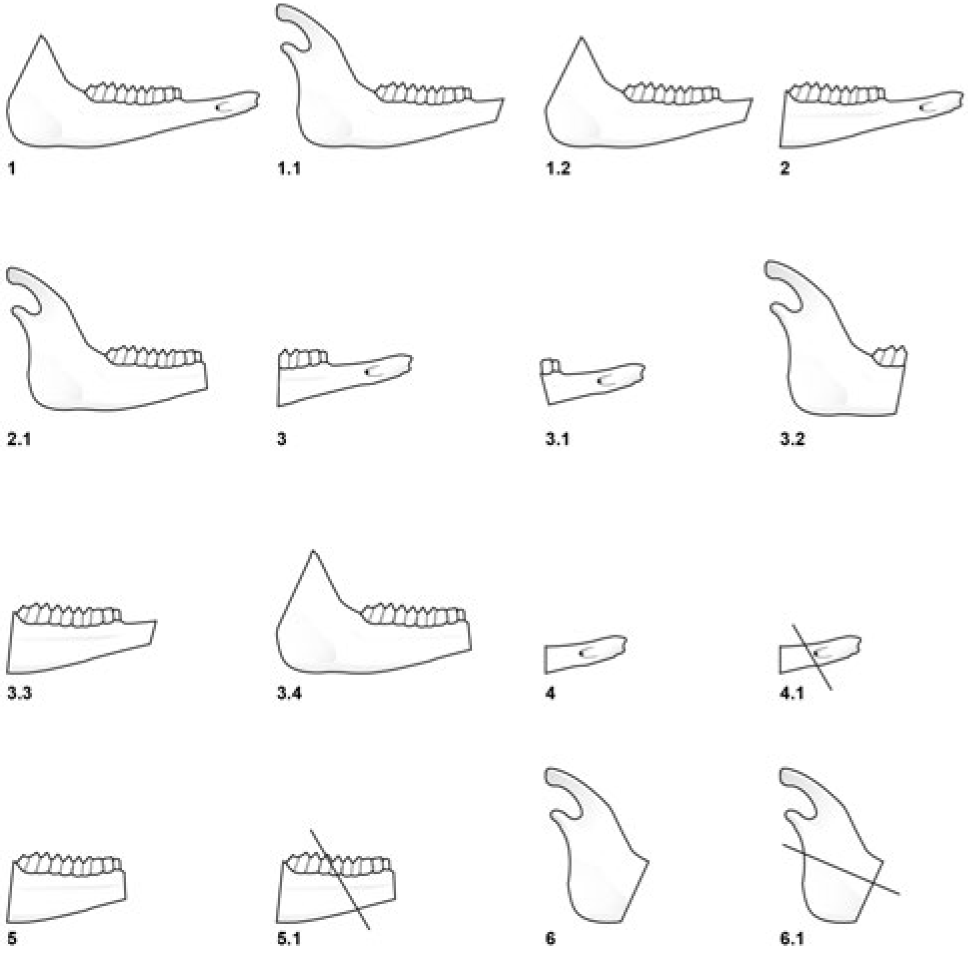
Nowadays it would be impossible to conduct any archaeological research project without cre

MORPHOTYPES OF MANDIBLE

I. (DRY)
II. (FRESH)
III. (MIXED)
IV. (INDETERMINATE)

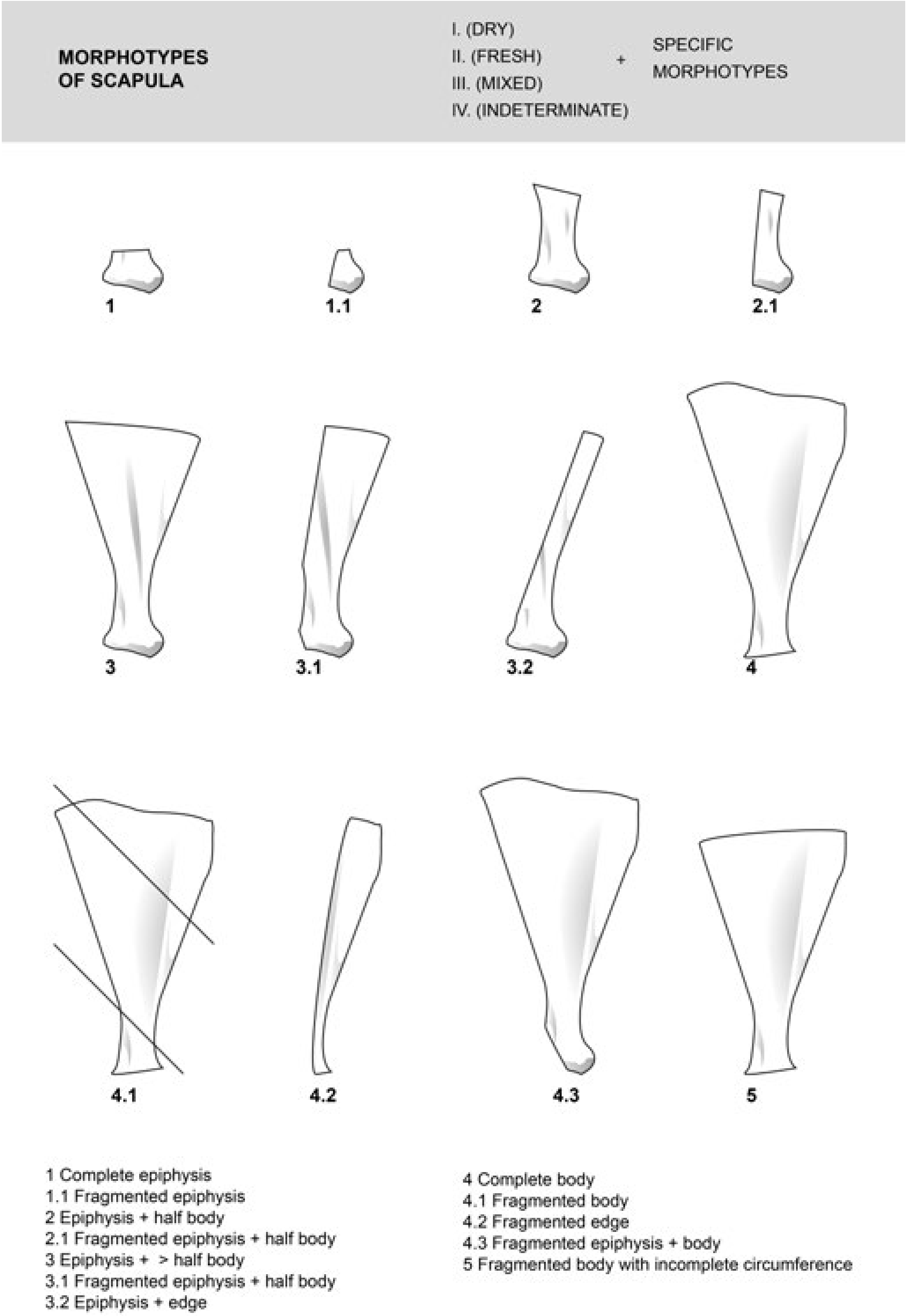
\+

SPECIFIC MORPHOTYPES



1 Incisive part + body + fragmented ramus
1.1 Fragmented incisive part + body+ ramus
1.2 Fragmented incisive part + body+ fragmented ramus
2 Incisive part + body
2.1 Body+ ramus
3 Incisive part + half body
3.1 Incisive part + first part of the body
3.2 Half body + ramus
3.3 Fragmented incisive part + body
3.4 Body+ fragmented ramus
4 Incisive part
4.1 Fragmented incisive part
5 Body
5.1 Fragmented body
6 Ramus
6.1 Fragmented ramus

SUPPL. FIGURE 7
Morphotypes of mandible.



SUPPL. FIGURE 8

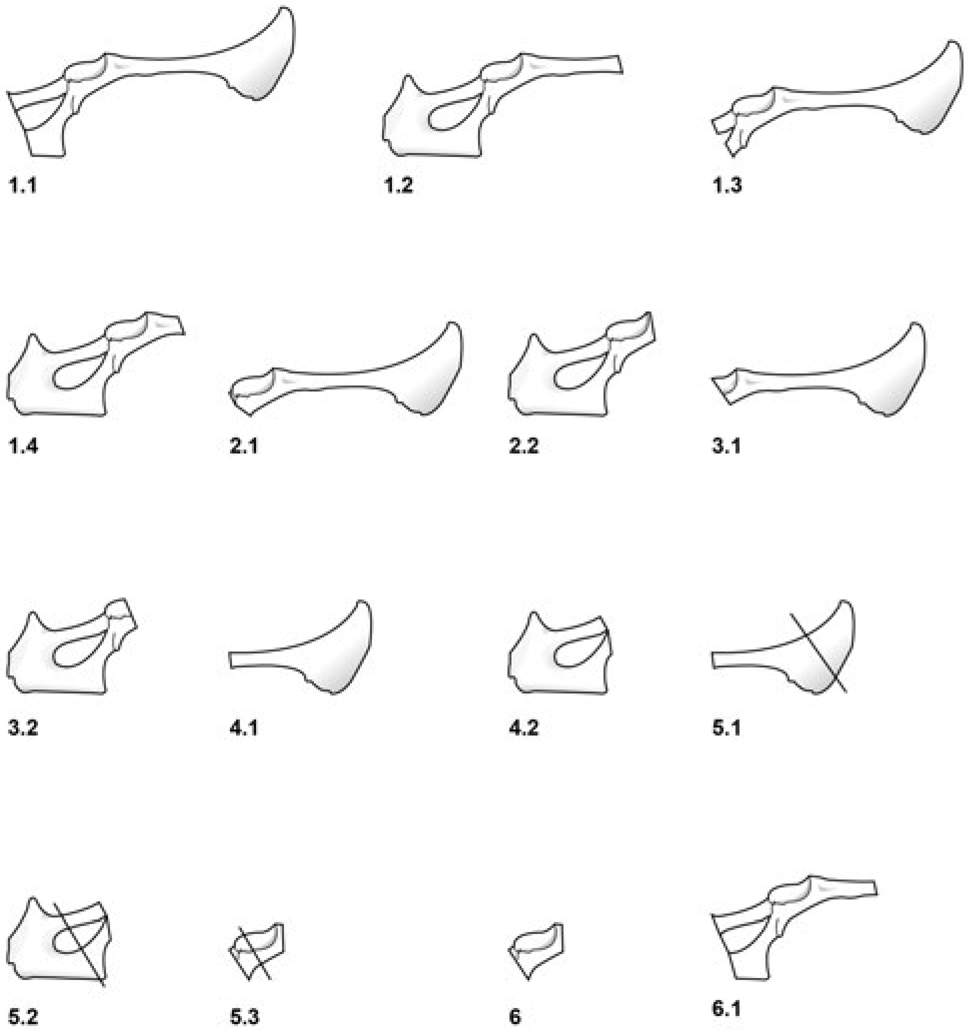
Morphotypes of scapula.

MORPHOTYPES OF PELVIS

I. (DRY)
II. (FRESH)
III. (MIXED)
IV. (INDETERMINATE)

\+

SPECIFIC MORPHOTYPES



1.1 Ilium + half isquium
1.2 Isquium + 1/2 ilium
1.3 Ilium + acetabulum + <half isquium
1.4 Isquium + acetabulum + <half ilium
2.1 Ilium + acetabulum
2.2 Isquium + acetabulum
3.1 Ilium + half acetabulum
3.2 Isquium + half acetabulum

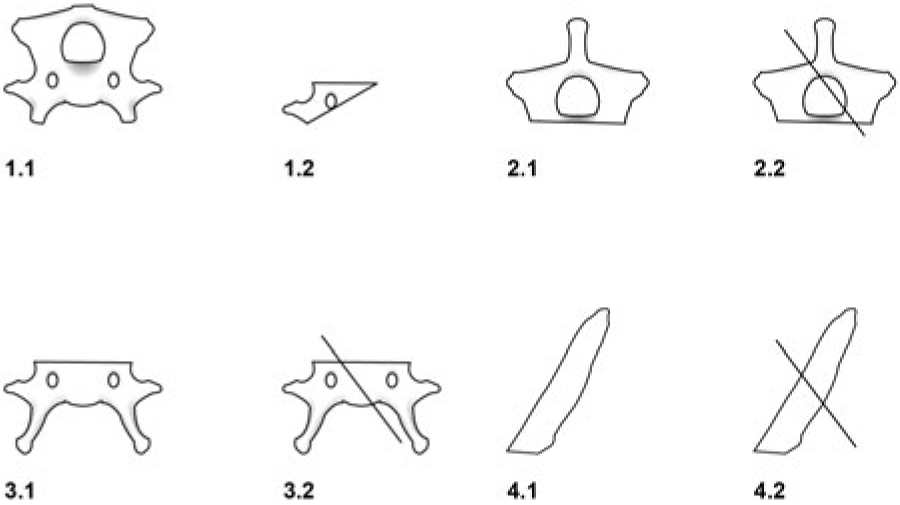
4.1 Complete ilium
4.2 Complete isquium
5.1 Fragmented ilium
5.2 Fragmented isquium
5.3 Fragmented acetabulum
6 Complete acetabulum
6.1 Acetabulum + fragmented ilium and isquium

SUPPL. FIGURE 9
Morphotypes of pelvis.

MORPHOTYPES OF VERTEBRAE

I. (DRY)
II. (FRESH)
III. (MIXED)
IV. (INDETERMINATE)

\+ SPECIFIC MORPHOTYPES



1.1 Complete vertebra without spinous processes
1.2 Indeterminate fragment
2.1 Complete arch
2.2 Fragmented arch
3.1 Complete body
3.2 Fragmented body

4.1 Complete spinous process
4.2 Fragmented spinous process
5.1 Complete articular process
5.2 Fragmented articular process

* add ".1" if the remain conserve some of the spinous processes
* add ".2" if the remain conserve all the spinous processes

SUPPL. FIGURE 10

Morphotypes of vertebrae.

CODE	DEFINITION
22	complete with ossified epiphysis
11	complete with nearly ossified epiphysis
12	nearly ossified proximal epiphysis and ossified distal epiphysis
21	ossified proximal epiphysis and nearly ossified distal epiphysis
00	complete without ossified epiphysis
02	unossified proximal epiphysis and ossified distal epiphysis
20	ossified proximal epiphysis and unossified distal epiphysis
10	nearly ossified proximal epiphysis and unossified distal epiphysis
01	unossified proximal epiphysis and nearly ossified distal epiphysis
X2	without proximal epiphysis and ossified distal epiphysis
2X	ossified proximal epiphysis and without distal epiphysis
X0	without proximal epiphysis and unossified distal epiphysis
0X	unossified proximal epiphysis and without distal epiphysis
X1	without proximal epiphysis and nearlyossified distal epiphysis
1X	nearly ossified proximal epiphysis and without distal epiphysis

SUPPL. TABLE 1
Codes for the epiphysis ossification.

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Mariscadores en las costas del Caribe colombiano en época prehispánica y moderna: una reflexión para evaluar el impacto humano en los ecosistemas marinos desde la arqueomalacología y la etnoarqueología

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RESUMEN: En este trabajo se compara los tamaños de las conchas de la explotación humana por parte de los antiguos y actuales habitantes en ecosistemas marinos en el Caribe colombiano. El propósito es iniciar la investigación en torno al impacto de las poblaciones humanas en los ecosistemas marinos mediante las medidas de la altura del caracol *Melongena melongena* (Linnaeus, 1758) en contextos prehispánicos, comparando dichas medidas con la investigación etnoarqueológica en la comunidad de Leticia (Bahía de Barbacoas, Cartagena). Las excavaciones realizadas en el año 2018 en el barrio de El Pozón de la ciudad de Cartagena (Colombia) permitieron la documentación de niveles arqueológicos del período Formativo (5250 a. P). El sitio identificado, La Islita de El Pozón, es un conchero depositado sobre una llanura costera y terraza marina, cuyas especies malacológicas dominantes son el caracol *Melongena melongena* y el bivalvo *Anomalocardia brasiliana*. Aunque no se dispone de una profundidad temporal e información de varios sitios sobre el patrón de consumo de los moluscos y el impacto de los seres humanos sobre los ecosistemas marinos que permita hacer una validación estadísticamente significativa, la reducción de la media de talla del gasterópodo *Melongena melongena* puede ser atribuido a la presión de depredación sobre este recurso.

PALABRAS CLAVE: ARQUEOLOGÍA, ECOLOGÍA HISTÓRICA, PESCA MARINA, GASTERÓPODOS, CARIBE, COLOMBIA

ABSTRACT: This work compares the sizes of molluscs from the human exploitation of ancient and current inhabitants in marine ecosystems in the Colombian Caribbean. The purpose is to initiate research on the impact of human populations on marine ecosystems by measures of the length of the *Melongena melongena* (Linnaeus, 1758) snail in pre-Hispanic contexts comparing these measures with ethnoarcheological research in the community of Leticia (Bahía de Barbacoas, Cartagena). Excavations carried out in 2018 in the Pozón neighborhood of the city of Cartagena (Colombia) allowed the documentation of archaeological levels of the Formative period (5250 a. P).). The identified site, La Islita de El Pozón, is a shellmound deposited on a coastal plain and sea terrace, whose dominant malacological species are the *Melongena melongena* snail and the bivalve *Anomalocardia brasiliana*. Although there is no temporal depth and information from various sites on the pattern of molluscs' consumption and the impact of humans on marine ecosystems that allows statistically significant validation, the reduction of the average size of the *Melongena melongena* gastropod can be attributed to the predation pressure on this resource.

KEYWORDS: ARCHAEOLOGY, HISTORICAL ECOLOGY, MARINE FISHERIES, GASTROPODS, CARIBBEAN, COLOMBIA

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INTRODUCCIÓN: LOS IMPACTOS EN LOS ECOSISTEMAS COSTEROS DESDE LA ARQUEOLOGÍA

Uno de los grandes retos de la arqueología es evaluar la interacción de los seres humanos y el ambiente a largo plazo y cómo sus modos de vida han cambiado las distribuciones de plantas y animales antes del Holoceno (Kintigh *et al*., 2014). Estudios arqueológicos y antropológicos han demostrado que los ambientes modernos son producto de actividades humanas a largo plazo y proporcionan un contexto para evaluar el cambio del planeta, cuestionando las concepciones de lo natural y abordando las interacciones humano-ambiente desde un enfoque interdisciplinario (Descola, 1996; Ulloa, 2001; Crutzen, 2002; Zeder *et al*., 2006; Zalasiewics *et al*., 2008; Doughtry *et al*., 2010; McClenachan *et al*., 2010; Fuller *et al*., 2011; Rick & Erlandson, 2020).

Algunos autores han considerado a los moluscos como recursos secundarios (Osborn, 1977). En contraposición, otros argumentan que es un recurso predecible e importante para las dietas de las poblaciones prehistóricas (Erlandson, 2001). Se han desarrollado investigaciones arqueológicas sobre los efectos de las poblaciones prehistóricas en los ambientes marinos, en particular, los efectos de la depredación humana en los moluscos y la consecuente disminución de su talla. Dado que estos organismos están sujetos al estrato, son predecibles, requieren poca tecnología especializada para explotarlos y, por lo tanto, son susceptibles a las acciones antrópicas (Raab, 1992; Douros, 1993; Deboer *et al*., 2000; Anderson, 2001; Mannino & Thomas, 2002; Klein *et al*., 2004; Braje, 2007; Milner *et al*., 2007; Morrison & Hunt, 2007; Erlandson *et al*., 2008; Rick & Erlandson, 2020).

Se ha evaluado la relación entre los cambios climáticos y la disminución de las tallas de los moluscos y su relación con la actividad humana (Morrison & Addison, 2008). Mannino & Thomas (2002) especificaron los siguientes criterios para determinar impactos sobre invertebrados, estas variaciones pueden ser resultado de cambio climático:

1. Abundancia absoluta de especies preferidas disminuirá a lo largo del tiempo de un depósito.
2. El tamaño medio del esqueleto del molusco disminuirá progresivamente de muestras tomadas desde la parte inferior de un depósito a la parte superior.
3. El tamaño medio de las muestras arqueológicas de una especie será significativamente menor que en una población no explotada.
4. Las especies menos fácilmente adquiridas aumentarán en número en un depósito.
5. Las especies más difíciles de procesar aumentarán en número.

Según los criterios anteriores, se compara los tamaños de los moluscos de la explotación humana de los antiguos y actuales habitantes en ecosistemas marinos en el Caribe colombiano para sentar una base para el estudio de los impactos antrópicos sobre los moluscos. Este impacto se evaluó preliminarmente mediante las medidas de la altura del caracol *Melongena melongena* de contextos prehispánicos y de la investigación etnoarqueológica en curso en la comunidad de Leticia (Bahía de Barbacoas, Cartagena).

A continuación, se contextualizará el sitio arqueológico, posteriormente se resumirá la información etnográfica. La siguiente sección describirá la metodología empleada. Finalmente se presentarán y discutirán los resultados. La reducción de la media de talla del gasterópodo *Melongena melongena* puede ser atribuido a la presión de depredación sobre este recurso.

EL CONTEXTO ARQUEOLÓGICO: LA ISLITA DE EL POZÓN

El conchero la Islita de El Pozón está localizado en el barrio El Pozón en Cartagena, Bolívar. El sitio (Figura 1A y 1B) se encuentra a una latitud de 10°24’20.58”N y una longitud de 75°27’33.81”O. El conchero tiene unos 418 m de perímetro, una forma ovoide y un área de 10,8 m^2 . Este se encuentra cruzado en dirección sur norte por el arroyo la Hormiga o Limón (Chupundlum), el cual se bifurca en el extremo suroriental del depósito. Está situado a 2,58 m al sur de la Ciénaga de la Virgen y a 8,7 Km de la costa actual (Carvajal-Contreras, 2019) (Figura 1C).

La prospección definió el perímetro del conchero y su levantamiento mediante el registro de una sucesión de puntos o track con GPS, se realizó la excavación de una prueba en el patio de la casa de una familia del barrio el Pozón, cuyas dimensiones

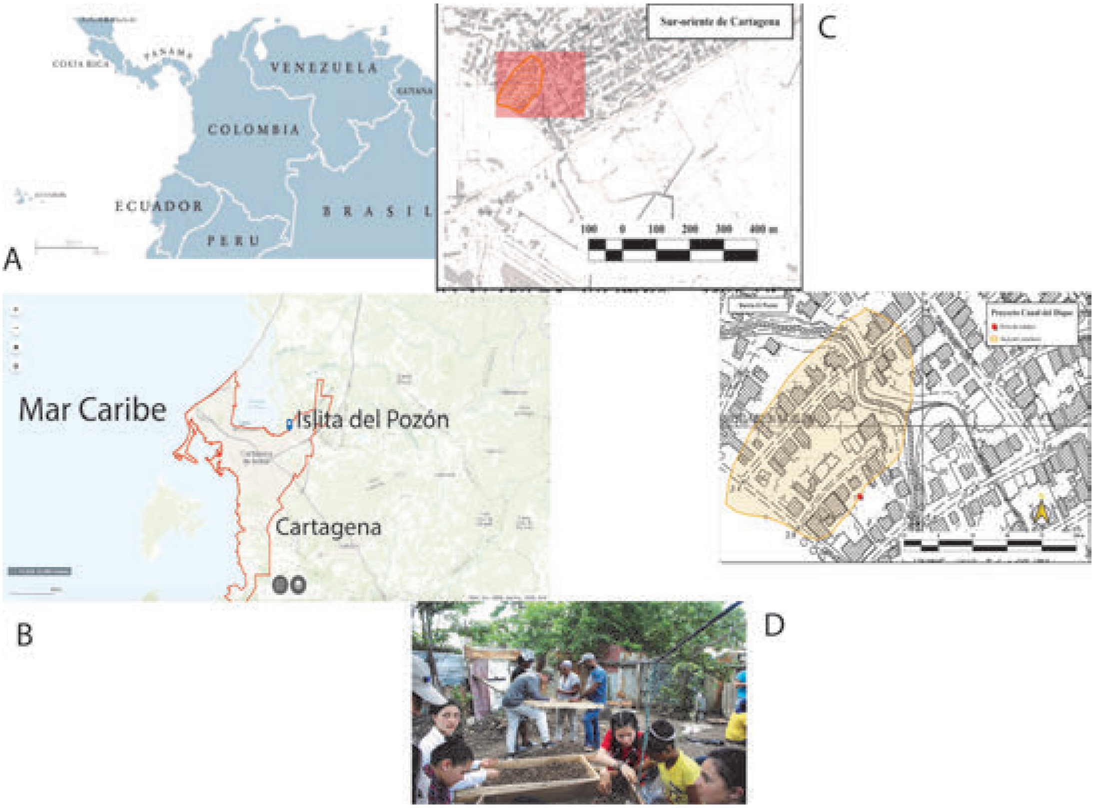


FIGURA 1
Ubicación del conchero arqueológico la Islita de El Pozón (modificado de Cortes *et al.*, 2018).

son 1 m X 1 m y un muestreo de columna (0,25 m^2) en la esquina noroccidental de la misma (Figura 1D).

El análisis del material cerámico sugiere que el conchero fue ocupado durante el Formativo temprano entre 5300 a.P. a 2980 a.P. (Martín & Sandoval, 2020; Carvajal-Contreras, 2022) por poblaciones que utilizaban cerámica similar a Canapote y Barlovento para usos diferentes a la preparación de alimentos, dado que los fragmentos encontrados no presentan alteración térmica relacionada con la cocción y no se identificaron fogones. No se encontraron vasijas completas (Carvajal-Contreras, 2019). Esta información, junto a los análisis geoarqueológicos realizados por Cortés *et al*. (2018) en los que se sugiere que el suelo se formó gracias a aportes fluviales, muestra que el conchero la Islita de El Pozón es un contexto de basurero. Fueron pocos los restos de artefactos líticos y estos no están relacionados con el procesamiento de alimentos vegetales o explotación de los recursos animales. No se reportaron enterramientos o estructuras de vivienda ni muestras de carbón en la prueba excavada.

El análisis de los materiales permitió observar que las personas consumieron principalmente recursos marinos como peces, bivalvos, gasterópodos, mamíferos, aves y reptiles. Las personas que depositaron los restos de moluscos y vertebrados en el conchero obtuvieron los recursos acuáticos como la *Melongena melongena*, la *Anomalocardia brasiliana* y los peces de la familia Ariidae y Carangidae que habitan en aguas poco profundas y de arena lodosa propias de lagunas de manglar. Restos de peces de la familia Diodontidae y Sparidae sugieren un ambiente de arrecife. Los vertebrados terrestres recuperados en la muestra aluden a bosques de manglar en las proximidades del sitio (Carvajal-Contreras, 2019).

No se observaron fracturas o cortes de origen antrópicos en todos los restos de animales y estos no se ven afectados por la termoalteración. Tampoco se observaron artefactos hechos en concha o huellas en los moluscos producto de su extracción. Tanto los invertebrados como los restos de vertebrados, en su mayoría peces, corresponden a recursos alimenticios que fueron obtenidos muy cerca de la costa. No se observaron restos de peces cartilaginosos (Carvajal-Contreras, 2019).

Los elementos anatómicos de los peces sugieren que se traían los animales completos y se desechaban en este depósito, en tanto que para los otros vertebrados sólo están presentes en los depósitos las partes menos carnosas como falanges y metapodios. Preliminarmente se puede pensar que los habitantes del conchero de El Pozón operaban exclusivamente en aguas litorales y ambientes terrestres cercanos a su asentamiento. Al no hallarse anzuelos, pesas u otro artefacto para pescar, y por la etología de las especies identificadas, es posible pensar que estos grupos humanos utilizaban redes o trampas intermareales de materiales perecederos para la obtención de recursos marinos (Cooke, 2001).

Es probable que la recolección de moluscos en el conchero la Islita de El Pozón fuese selectiva. Se registraron sólo dos especies; el caracol *Melongena melongena* y el bivalvo *Anomalocardia brasiliana* (Carvajal-Contreras, 2019). Esta identificación es diferente a la reportada en el conchero de Barlovento, muy cerca al sitio de estudio y contemporáneo en términos de material cerámico, donde las especies dominantes son la *Melongena melongena* y *Chione histrionica*. Investigaciones en sitios contemporáneos a la Islita de El Pozón como Monsú Canapote, Barlovento y Puerto Chacho sugieren que estas poblaciones de cazadores-recolectores disponían de otros moluscos como *Anomalocardia brasilienesis, Crassostrea rhizophorae, Polymesoda solida, Nerita versicolor, Lobatus gigas* entre otros (Reichel-Dolmatoff, 1955; Archila, 1993; Álvarez & Maldonado, 2009).

Los datos de paleoclima, fósiles, fechas de radiocarbono y tafonomía relacionados con los cambios del nivel del mar y la geomorfología costera son escasos en la costa Caribe colombiana. La información climática del Caribe Colombiano a partir de polen y moluscos sugieren períodos secos entre el 5.000 a.P. al 4000 a.P (Bueno, 1970; Van Der Hammen, 1986; Vernette, 1989; Rull, 1992; Van der Hammen *et al*., 1992; Behling & Hooghiemstra, 1998). El Caribe Colombiano se caracterizó en el Holoceno medio entre 5300 a.P. al 3.200 a.P. por lagunas costeras poco profundas, el incremento del nivel del mar y la intercalación de periodos de mayor o menor precipitación. Antes de estas fechas no existían dichas condiciones (Vélez *et al*., 2014). Un estudio interdisciplinario sobre terrazas marinas y la morfología costera sugiere que la heterogeneidad observada hoy, estaba presente durante el Holoceno tardío hace 3.500 a.P. como producto de la convergencia intertropical que generó vientos más fuertes, una deriva de sedimentos y mayores condiciones de humedad aislando la Ciénaga de Tesca, a partir de 2.000 a.P. los ambientes marinos prevalecieron, así como las condiciones de humedad se intensificaron producto de posiblemente el fenómeno de la Niña (ENSO). Este fenómeno sumado al tectonismo reciente (La falla del Dique y volcanismo de lodo) es el responsable del levantamiento casi 3 milímetros de estas terrazas, indudablemente tuvieron injerencia en la ocupación humana y la posición de los concheros cercanos a la Bahía de Cartagena y del Canal del Dique (De Porta *et al*., 2008; Martínez *et al*., 2010).

Nieto-Bernal *et al*. (2013) afirman que los invertebrados como otros recursos marinos en el Caribe colombiano están en estado de sobreexplotación actual como fuente de proteínas y como materia prima para artesanía o elaboración de cosméticos, siendo las especies más explotadas el *Lobatus gigas* y *Cittarium pica* en la Guajira. De acuerdo con estos autores, la *Melongena melongena* es explotada de manera artesanal en casi todo el litoral Caribe colombiano. Córdoba *et al*. (2017) muestran desde la biología, los datos de abundancia, densidad y talla para especies como el *Lobatus gigas* pero no hay datos para *Melongena melongena*. En otras localidades como la Bahía de Cispatá se han hecho evaluaciones biométricas de este caracol y se ha reportado recuperación de la población (Córdoba *et al*., 2017).

LA INFORMACIÓN ETNOARQUEOLÓGICA: EXPLOTACIÓN DE MOLUSCOS EN LA COMUNIDAD DE LETICIA

Durante la investigación arqueológica financiada por el Instituto Colombiano de Antropología e Historia- ICANH- en el 2012 (Carvajal-Contreras, 2012, 2013), se observó que la población actual del corregimiento de Leticia aún explota moluscos *Melongena melongena* y sus restos se encuentran dispersos por toda la zona, agrupándose tanto en concheros prehispánicos como acumulaciones modernas.

La continuidad de la investigación cuenta con el apoyo de la Fundación de Investigaciones Arqueológicas Nacionales -FIAN- del Banco de la República, y se desarrolla actualmente el proyecto “Etnoarqueología en el Canal del Dique”. El objetivo de esta investigación es documentar la materialidad de las poblaciones de pescadores actuales en las comunidades de Leticia y Pasacaballos (Cartagena, Bolívar) y su relación con movilidad, estacionalidad, pesca y recolección de moluscos. Esta investigación busca establecer un modelo para la interpretación de la subsistencia de comunidades prehispánicas en relación con la utilización de espacios, tecnologías y uso de recursos acuáticos en el Caribe colombiano (Carvajal-Contreras, 2017).

La vereda de Leticia es una comunidad pequeña dentro del corregimiento de Pasacaballos a unos 25 Km al sur occidente de Cartagena sobre el Canal del Dique y colindante con la Bahía de Barbacoas (Figura 2A). La Bahía de Barbacoas es un estuario de 120 Km de área, limitada al norte por la península de Barú que la separa de la bahía de Cartagena de Indias. En su costa oriental se encuentra el Canal del Dique (Figura 2B). La población de Leticia y la vecina población del Recreo se encuentran aisladas de tierra firme por la construcción en 1958 de los caños Matunilla y Lequerica. Dicha construcción se realizó para disminuir la aportación de sedimentos a la Bahía de Cartagena (Gómez *et al*., 2018).

La comunidad de Leticia está conformada por casi 350 personas, en su mayoría afrodescendientes, distribuidas en al menos 65 viviendas, siendo la agricultura y la pesca las actividades económicas principales (Bello & Vidal, 2014; Gómez *et al*., 2018). La práctica de pesca artesanal y recolección de moluscos está dirigida a la subsistencia. La obtención de recursos malacológicos, principalmente la *Melongena melongena*, se desarrolla a lo largo de todo el año, a nivel de grupo familiar tanto por hombres y mujeres como adultos y niños, utilizando diversas técnicas tradicionales (mano, el pie, un pequeño palo) que requieren mínima inversión y no están industrializada. Los gasterópodos se extraen de áreas intermareales lodosas poco profundas en la Bahía de Barbacoas en las vecindades de Leticia y en la comunidad de Santa Ana durante la marea baja. Una gran parte de los moluscos se destina a su venta en Cartagena para ceviches, os-

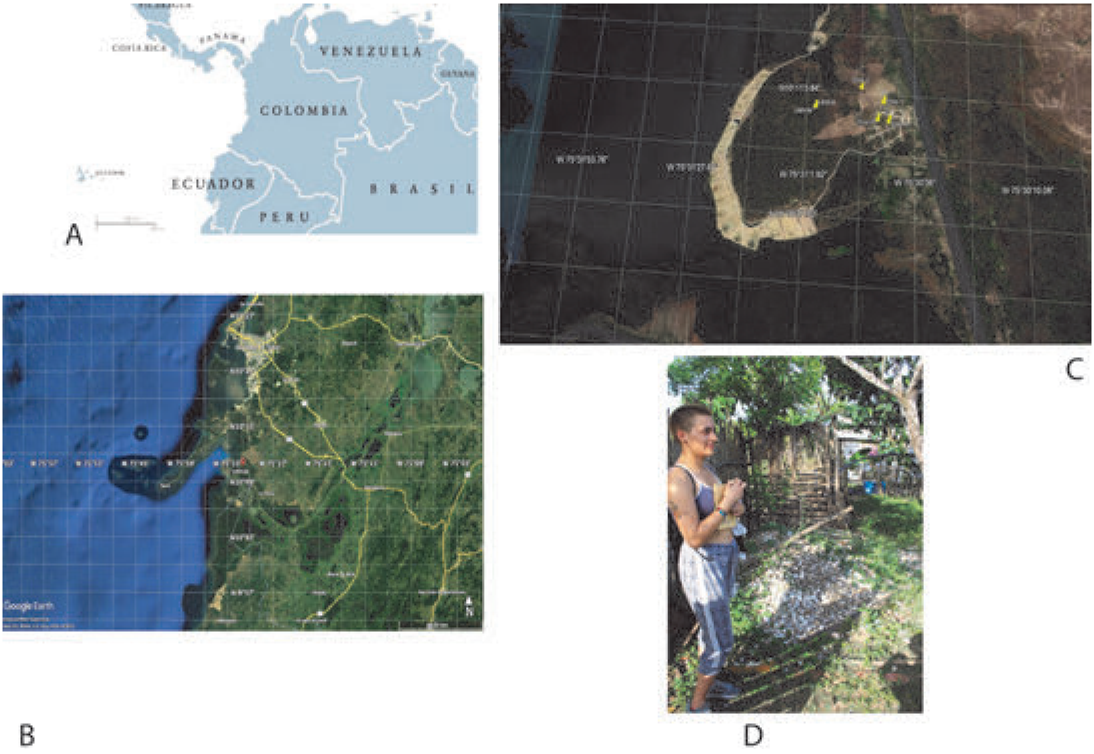


FIGURA 2
Ubicación de los concheros actuales en Leticia, Bolívar (modificado de Google Earth).

cilando el precio por kilo entre $10.000 y $15.000 pesos colombianos.

En las viviendas, las personas limpian los caracoles y los hierven en ollas en las cocinas externas a la casa. Estas ollas se colocan en una especie de fogón. Por último, se descartan los cuerpos y opérculos en las esquinas cerca de las viviendas, lo que lleva a la formación de los montículos de no más de 10 cm de profundidad. La carne se coloca nuevamente en ollas para cocinar y posteriormente se pica en trozos para su posterior consumo y venta, sobre todo al mercado de Bazurto y las cevicherías de Cartagena. Los montículos se dejan expuestos por semanas. Seguido, se recolectan en sacos y son permanentemente descartados a las afueras del caserío (Figura 2B).

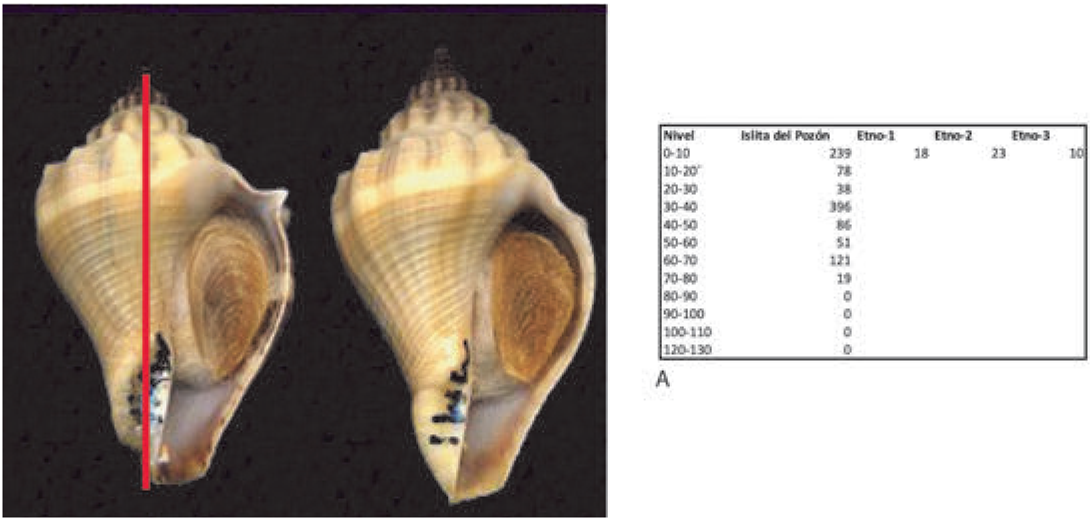
Se excavaron cuatro acumulaciones antrópicas actuales producto de la pesca artesanal del gasterópodo *Melongena melongena.* Estos tenían una profundidad de menos de 20 cm (Figura 2D).

ANÁLISIS ARQUEOMALACOLÓGICO: MATERIALES & MÉTODOS

Metodológicamente para la identificación taxonómica se ha recurrido al libro Moluscos Marinos del Caribe Colombiano: un Catálogo Ilustrado (Díaz & Puyana, 1994), así como la base de datos WoRMS –World Register of Marine Species- para la denominación de los taxones (http://www.marinespecies.org/index.php). Los ecofactos recuperados en la malla de 5 mm fueron clasificados anatómicamente, taxonómicamente y se cuantificaron para evaluar la diversidad, abundancia de los taxones y su relación con el ambiente. En este informe el término "identificado" significa que los restos de animales pudieron ser atribuidos al nivel taxonómico más bajo posible i.e. familia, género, orden o especie, teniendo en cuenta regiones diagnósticas como la espira, columela entre otros.

La cuantificación de datos en el presente estudio incluirá el NISP (número de especímenes identificados: por sus siglas en inglés) para cada grupo taxonómico encontrado en cada unidad estratigráfica (Claassen, 1998; Reitz & Wing, 2008; Giovas, 2009). El NISP registra el número de bivalvos y univalvos enteros o fragmentados (Figura 3A).

Se registraron los procesos tafonómicos tales como la integridad, incrustación, perforación, abrasión y disolución ácida, al igual que los procesos culturales como el calentamiento (Claassen, 1998; Rick *et al*., 2006; Morrison & Cochrane, 2008). Se identificaron los agentes tafonómicos naturales y antrópicos que actuaron sobre la malacofauna identificada y contribuyeron a la formación de los concheros (Claassen, 1998; Beovide *et al*., 2014) en cada muestra colectada en los cuatro depósitos con conchas actuales de Leticia. Entre los aspectos registrados se tuvo en cuenta el estado de conservación de los materiales (grado de meteorización,



Nivel	Islita del Pozón	Etno-1	Etno-2	Etno-3
0-10	239	18	23	10
10-20'	78			
20-30	38			
30-40	396			
40-50	86			
50-60	51			
60-70	121			
70-80	19			
80-90	0			
90-100	0			
100-110	0			
120-130	0			

FIGURA 3

Medida de altura o longitud de *Melongena melongena* (B) y Número de Especímenes Identificados (NISP) en la Islita de El Pozón y las muestras etnográficas de Leticia (A). Fotografía modificada de Bill Frank http://www.jaxshells.org/.

fragmentación y abrasión), ubicación y orientación de los restos malacológicos. Igualmente, se realizó la medida de individuos completos denominada altura o longitud total en mm con calibrador digital Mituoyo con especificaciones de mediciones entre o a 150 mm en incrementos de 0.01mm. La altura o longitud total es la distancia máxima de extremos entre la apertura y el ápice (Figura 3B).

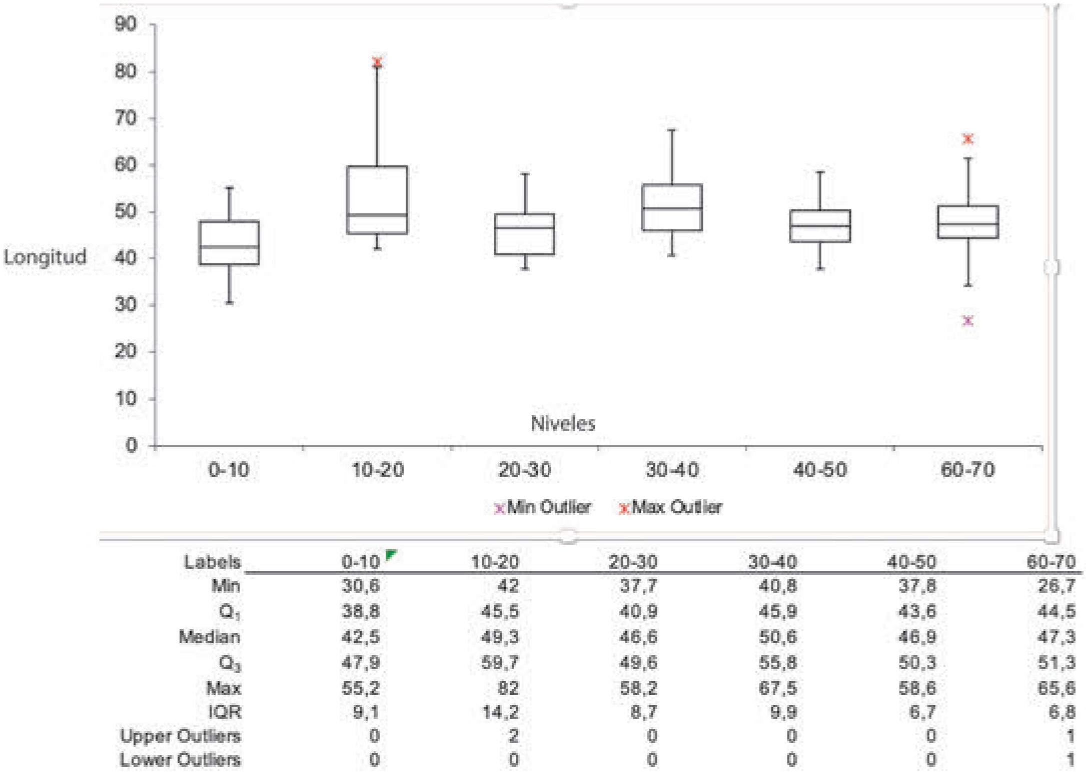
Las muestras del sitio de la Islita de El Pozón provienen de la excavación de una unidad de prueba 1 m x 1 m por niveles arbitrarios de 10 cm. Cada nivel se tamizó utilizando una malla de 5mm; recuperándose fauna de vertebrados y artefactos. Para una recuperación total de ecofactos, se realizó una muestra de columna en la esquina noroccidental de la unidad de excavación de prueba. Esta columna tenía una dimensión de 25 cm^2, tomándose todo el sedimento por niveles arbitrarios de 10 cm de grosor en una bolsa. En el laboratorio, este sedimento se zarandeó en mallas de 5 mm y 2 mm.

Cada bolsa fue procesada recuperando todos los restos de animales en la malla de 5 mm para luego ser clasificados y cuantificados. Los restos bajo la malla de 2 mm no fueron identificados para el presente artículo, pero fueron cuantificados. En cuatro basureros modernos en Leticia se recogió un litro de conchas para registrar y analizar por basurero de grupo doméstico. Esta colección de restos animales siguió los mismos criterios utilizados para las muestras arqueológicas.

RESULTADOS

La caracterización métrica del gasterópodo *Melongena melongena* corresponde a los especímenes completos o enteros de 6 muestras del contexto arqueológico asociados a los seis niveles arbitrarios del conchero (Figura 3A). En los niveles restantes, el material malacológico es muy escaso y fragmentado, no había conchas completas o enteras que permitieran tomar el alto del caracol.

Por otra parte, se han efectuado la toma del alto del caracol de tres muestras de *Melongena melongena* recolectadas en la población de Leti-



Labels	0-10	10-20	20-30	30-40	40-50	60-70
Min	30,6	42	37,7	40,8	37,8	26,7
Q_1	38,8	45,5	40,9	45,9	43,6	44,5
Median	42,5	49,3	46,6	50,6	46,9	47,3
Q_3	47,9	59,7	49,6	55,8	50,3	51,3
Max	55,2	82	58,2	67,5	58,6	65,6
IQR	9,1	14,2	8,7	9,9	6,7	6,8
Upper Outliers	0	2	0	0	0	1
Lower Outliers	0	0	0	0	0	1

FIGURA 4

Medidas de longitud de *Melongena melongena* en contexto arqueológico.

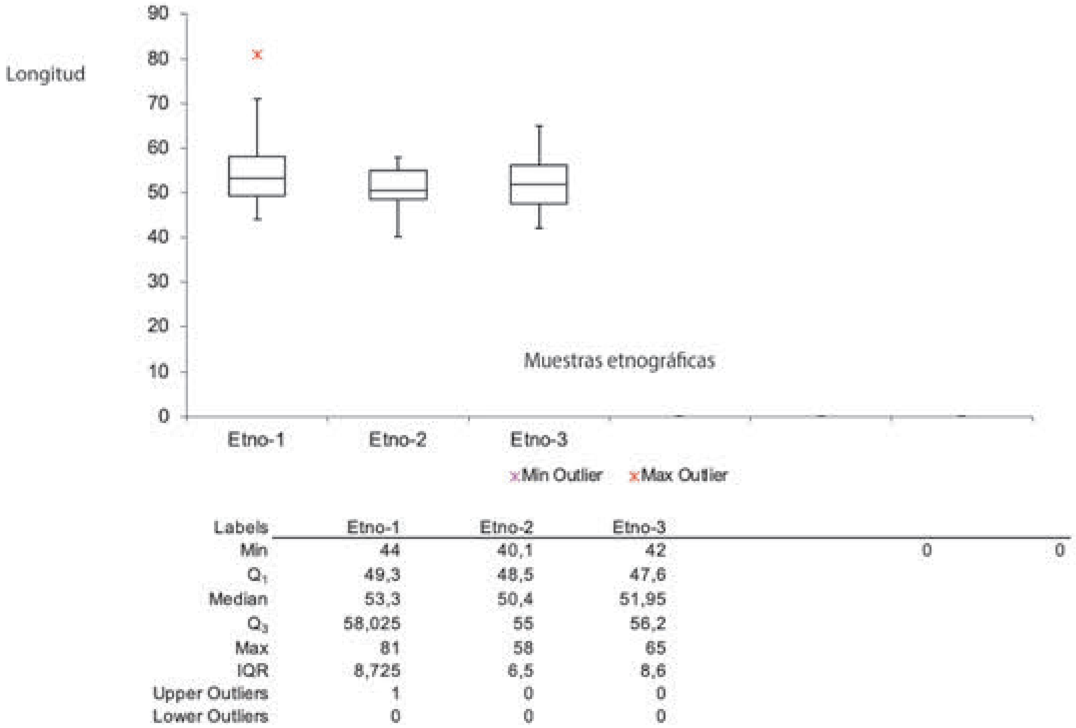
cia vereda de Pasacaballos, un corregimiento de la ciudad de Cartagena. El material malacológico es muy escaso en el depósito de origen moderno y la conchas enteras permitieron efectuar la medición (Figura 3A). Como se mencionó, los pobladores explotan esta especie de áreas intermareales lodosas poco profundas en la Bahía de Barbacoas durante la marea baja todo el año. Estos especímenes del caracol *Melongena melongena* correspondían a conchas extraídas por varias semanas en basureros modernos que tenían una profundidad de menos de 20 cm.

La Figura 4 muestra los resultados de la longitud o alto de los ejemplares arqueológicos. En total, se han medido 365 ejemplares de seis niveles del conchero, con un promedio de longitud de 47,7 mm. La longitud de los caracoles oscila entre 39,2 y 81,2 mm. La mayoría de los especímenes son pequeños en relación al promedio reportado por Díaz & Puyana (1994). La media en los diferentes niveles sugiere que se recolectaron especímenes con una talla mayor en el nivel 30-40 con relación al nivel de 0-10.

La Figura 5 muestra los resultados de la longitud de los ejemplares etnográficos. En total, se han medido 51 ejemplares de tres concheros modernos, con un promedio de 52,7 mm. La longitud de los caracoles oscila entre 42 y 81 mm. Al igual que las muestras anteriores, los especímenes son pequeños.

Estas observaciones preliminares del material arqueológico y etnográfico sugieren que el caracol *Melongena melongena* presentaba tallas menores a los 60 mm. Según Díaz & Puyana (1994) es una concha grande que crece en promedio entre 80 a 100 mm.

En las Figuras 4 y 5, se grafica los valores tanto para las muestras arqueológicas como para las muestras etnográficas y se calcula la media. Puede observarse que la distribución de los especímenes de *Melongena melongena* es asimétrica tendiendo hacia valores menores de 60 mm. Los resultados obtenidos no indican un tamaño significativamente menor de las muestras arqueológicas y las muestras etnográficas, siendo en ocasiones incluso mayores los especímenes arqueológicos que los especímenes etnográficos.



Labels	Etno-1	Etno-2	Etno-3			
Min	44	40,1	42		0	0
Q_1	49,3	48,5	47,6			
Median	53,3	50,4	51,95			
Q_3	58,025	55	56,2			
Max	81	58	65			
IQR	8,725	6,5	8,6			
Upper Outliers	1	0	0			
Lower Outliers	0	0	0			

FIGURA 5

Medidas de longitud de *Melongena melongena* en contexto etnográfico.

DISCUSIÓN Y CONCLUSIONES

Como se mencionó en la introducción, varios estudios han demostrado los impactos en invertebrados intermareales a causa incluso del forrajeo humano a pequeña escala. Este estudio muestra reducción del tamaño del caracol copey *Melongena melongena* en el conchero la Islita de El Pozón con respecto al promedio y su comparación con los concheros actuales de la localidad de Leticia indican que sus dimensiones son mayores.

Si bien esta investigación solo muestra la información del tamaño y consumo de un taxón malacológico en un sitio arqueológico y su comparación con evidencia etnográfica, puede a futuro permitir datos iniciales para valorar el impacto de los seres humanos sobre los ecosistemas marinos, el tamaño medio de las muestras arqueológicas y etnográficas del caracol copey es menor que el tamaño de la población promedio.

Según los criterios desarrollados por Mannino & Thomas (2002), el criterio de disminución a lo largo del tiempo del caracol *Melongena melongena* en la Islita de El Pozón no se cumple como lo indica la Figura 3A, como tampoco el criterio de disminución del esqueleto del molusco, los tamaños son menores al promedio pero se mantiene el largo del caracol *Melongena melongena* en todos los niveles. No se tiene información para evaluar los criterios tres y cuatro, es decir las especies en términos de facilidad para su adquisición o dificultad para su procesamiento. El único criterio que se cumpliría es el criterio tres, la disminución del esqueleto de *Melongena melongena* en muestras arqueológicas y muestras etnográficas por comparación con poblaciones no explotadas como lo indica Díaz & Puyana (1994).

Aunque no hay fechas radiocarbónicas, la datación relativa por medio de la estratigrafía y la cerámica sugieren que la Islita de El Pozón es un conchero que fue ocupado por un corto tiempo contemporáneo con los sitios de Puerto Chacho, Canapote, Barlovento y la fase Barlovento de Monsú. Algunos autores sugieren que para el Caribe colombiano durante este periodo, han ocurrido constantes cambios entre el 5000 a.P. hasta 2950 a.P. relacionados con el aumento de las líneas costeras que han afectado la distribución y talla de taxones y, por lo tanto, afectarían el acceso a recursos alimenticios (Van der Hammen, 1986; Archila, 1993; Oyuela & Rodríguez, 1995). Para otros investigadores, en este momento prevalecieron las condiciones actuales de nivel del mar, ambientes marinos, humedad y tectonismo que variaron de acuerdo al fenómeno de la Niña (ENSO) (De Porta *et al*., 2008; Martínez *et al*., 2010; Vélez *et al*., 2014).

Esta información no es concluyente en términos de cambio climático, pero sugiere el caracol copey *Melongena melongena* es explotado con alta intensidad en contextos arqueológicos y etnográficos de Cartagena y Leticia (Bolívar). Muestras más grandes e investigación adicional en concheros que cubran un periodo más largo de tiempo mejorarían la interpretación de los datos aquí expuestos.

Adicionalmente, otras investigaciones arqueológicas han discutido diferentes razones para la disminución de tamaños a través del tiempo relacionadas con los seres humanos (Erladson *et al*., 2008, 2011) como cambios en patrones de depredación (Codding *et al*., 2014); cambios estacionales del uso de los recursos (Jerardino, 1997; Lotfus *et al*., 2019); cambios en los patrones de asentamiento (Attennbrow, 2007) y diferencias de las mareas (Campbell, 2008). Por lo tanto, para el caso de la Islita de El Pozón y en general para el caribe colombiano, se tendría que evaluar los patrones de depredación, estacionalidad, patrones de asentamiento y variaciones de mareas, así como fechas de radiocarbono para dar una mayor comprensión de la explotación de recursos marinos en el pasado.

Para finalizar, este documento plantea el desafío de ampliar los estudios en el Caribe colombiano sobre la relación de la explotación de los ecosistemas marinos, la actividad humana y el cambio climático, a partir de los restos de animales encontrados en sitios arqueológicos.

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Étude ostéométrique des principaux os des membres et de la ceinture du membre thoracique chez le Faisan de Colchide (*Phasianus colchicus* L., 1758)

Osteometric study of the main limb bones and of the thoracic limb girdle of the Common Pheasant (*Phasianus colchicus* L., 1758)

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RESUME : Les référentiels ostéométriques conséquents pour les oiseaux font globalement défaut, notamment en archéozoologie. Un référentiel ostéométrique pour les principaux os des membres et de la ceinture du membre thoracique du Faisan de Colchide (*Phasianus colchicus* L., 1758) a été réalisé. Ce travail repose sur un échantillon de 54 individus, 26 mâles et 28 femelles, âgés de 12 à 24 mois. Au-delà des données statistiques de base uni- et bivariées, des analyses multivariées (ACP) ont permis de traiter les 72 mesures linéaires retenues, parmi les 81 de départ, et de faire ressortir le dimorphisme sexuel. Les 22 mesures les plus discriminantes ou les 18 mesures les plus pertinentes pour l'archéozoologie apportent une information aussi fiable que les 72 mesures initiales, mais rendent la méthodologie de travail pour l'archéozoologue plus simple. Cette étude met en évidence un dimorphisme sexuel très net et propose des valeurs seuil, statistiquement significatives entre les mâles et les femelles, pour chaque variable.

MOTS-CLEFS : OSTEOMETRIE, OS DES MEMBRES, CEINTURE DU MEMBRE THORACIQUE, FAISAN DE COLCHIDE, *PHASIANUS COLCHICUS*

ABSTRACT: Avian osteometric repositories have been traditionally elusive research tools, particularly in zooarchaeology. Here we offer an osteometrical baseline for the main bones of the limbs and thoracic girdle of the Common Pheasant (*Phasianus colchicus* L. 1758). The database consists of a sample of 54 individuals, that includes 26 males and 28 females, aged from 12 to 24 months. In addition to the basic uni- and bivariate statistical data, multivariate analyses (PCA) were used to treat the 72 linear measurements chosen from among the 81 starting measurements also to highlight sexual dimorphism. The 22 most discriminating measurements, or the 18 most relevant measurements for zooarchaeology, yield information as reliable as the 72 initial measurements, providing a far simpler methodology for zooarchaeological purposes. This

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study evidences the very clear sexual dimorphism existing in the analyzed elements of the Common Pheasant, providing statistically-significant threshold values between males and females for each of the variables.

KEYWORDS: OSTEOMETRY, LIMB BONES, COMMON PHEASANT, *PHASIANUS COLCHICUS*

RESUMEN: Los referenciales osteométricos son escasos en el caso de las aves, especialmente en arqueozoología. En este trabajo presentamos una base de datos osteométrica para los principales huesos apendiculares y de la cintura torácica del faisán vulgar (Phasianus colchicus L., 1758). La muestra se compone de 54 individuos, de los cuales 26 machos y 28 hembras, comprendidos entre 12 y 24 meses de edad. Más allá de la estadística uni- y bivariada, los análisis multivariados (ACP) han permitido explorar el comportamiento de 72 medidas lineales seleccionadas de entre las 81 con las que contábamos al inicio del estudio, a fin de resaltar diferencias asociadas con el dimorfismo sexual. Las 22 medidas más discriminatorias, así como las 18 más operativas en arqueozoología, proporcionan una información tan fiable como la generada por las 72 medidas originales, simplificando sobremanera el trabajo del arqueozoólogo. El análisis evidencia un patente dimorfismo sexual en todos los elementos estudiados y propone umbrales osteométricos, estadísticamente significativos, que permiten diferenciar machos de hembras, en todas las variables estudiadas.

PALABRAS CLAVE : OSTEOMETRIA, HUESOS APENDICULARES, CINTURA TORACICA, FAISAN VULGAR, *PHASIANUS COLCHICUS*

INTRODUCTION

Ce travail s'inscrit dans ce qu'il est convenu d'appeler la recherche de modèles ou de référentiels pour les études archéozoologiques. En effet dans l'optique de caractériser l'histoire des populations animales (Zeuner, 1963; Bökönyi, 1974; Clutton-Brock, 1999; Porter, 2002), les observations réalisées sur les os provenant d'un chantier de fouille archéologique seront d'autant meilleures que ces os seront comparés à des modèles morphologiques voisins. Le choix de la population de comparaison est donc du plus haut intérêt et la recherche de modèles les plus approchants possibles des populations anciennes a été, et ce depuis longtemps (Zalkin, 1960 ; Fock, 1966; Matolcsi, 1970) un souci de l'archéozoologue.

Des données biométriques existent pour un certain nombre de familles d'oiseaux actuels (Bocheński, 1985; Stewart, 1999, 2007; Bocheński & Campbell, 2005; Denis Ávila & Estévez Rodríguez, 2010; Badenhorst *et al*., 2012; Emery *et al*., 2016). Des travaux importants ont été menés sur différentes espèces européennes, notamment par la Faculté de Médecine Vétérinaire de l'Université de Munich, mais aussi par l'unité d'anatomie comparée de l'Ecole Nationale vétérinaire de Nantes/Oniris (Bacher, 1967; Woelfle, 1967; Kraft, 1972; Fick, 1974; Langer, 1980; Otto, 1981; Schmidt-Burger, 1982; Tomek & Bocheński, 2000, 2009; Froget, 2003; Guillet, 2003; Visse, 2003; Joly, 2012; Lebédel, 2016). Pour la famille des Phasianidés, quelques études éparses en ostéo-morphométrie existent (pour la poule de Challans, Marguerie, 2002; la Gournay, Lelièvre, 2005; concernant la proximité ostéo-morphologique poule / faisan, Lowe, 1933; Erbsdobler, 1968; Cohen & Serjeantson, 1996; Bocheński & Tomek, 2000; Tomek & Bocheński, 2009).

L'idée d'approfondir les résultats pour une espèce de Phasianidés va dans le sens de la caractérisation d'une population, la plus proche possible des populations anciennes en termes de morphologie osseuse. L'objectif de cette étude est de fournir les données ostéométriques à partir d'une population connue et statistiquement représentative d'animaux adultes mâles et femelles. Les études relatives aux Phasianidés sauvages sont peu nombreuses (Erbersdobler, 1968; Bocheński & Kurochchkin, 1987; Tomek & Bocheński, 2009; Demiraslan *et al*., 2014) et aucune n'aborde la biométrie mâle/femelle chez le faisan à partir d'un effectif important.

Même si le faisan est une espèce rarement rencontrée dans les sites archéologiques, il constitue un bon modèle de Phasianidés, car il est peu modifié par l'homme, même lorsqu'il s'agit d'animaux d'élevage. Les caractéristiques ostéométriques pourront de ce fait éventuellement être extrapolées à d'autres espèces, notamment la poule « archéologique », moins modifiée par l'homme que les races sélectionnées actuelles.

MATERIEL ET METHODES

Matériel

Cette étude porte sur 54 faisans de Colchide, correspondant à 26 mâles et 28 femelles. Ils proviennent en majorité (n=47) du centre cynégétique de Zéralda de la Wilaya d'Alger, et de la collection ostéologique de l'Unité d'Anatomie Comparée de l'École Nationale Vétérinaire de l'Agroalimentaire et de l'Alimentation, Nantes Atlantique – ONIRIS. Il s'agit de sujets âgés de 12 à 24 mois. Pour chaque individu, les principaux os des membres et de la ceinture scapulaire ont été prélevés et préparés en vue de leur étude ostéologique.

Methode

Les os ont été prélevés et numérotés afin d'être identifiés et mis en relation avec l'animal initial. Préparés par dissection des tissus mous environnant les os, ces derniers ont été mis à tremper dans l'eau, pendant plusieurs semaines voire plusieurs mois, laissant les bactéries faire leur œuvre. À l'issue de ce processus de macération, ils ont été nettoyés à l'eau courante puis séchés plusieurs jours à l'air libre. Les os préparés de cette manière et étudiés ici sont : le coracoïde et la scapula pour la ceinture du membre thoracique ; l'humérus, le radius, l'ulna, le carpométacarpe pour le membre correspondant ; le fémur, le tibiotarse et le tarsométatarse pour le membre pelvien. La nomenclature anatomique utilisée est celle de Baumel & Witmer (1993). Pour chacun d'entre eux, plusieurs mesures ont été effectuées :

- une mesure pondérale : chaque os après séchage a été pesé à l'aide d'une balance de précision (Balance de précision KERN EG 420/1mg) ; cette donnée est noté P ;
- 81 mesures linéaires : elles ont été réalisées au pied à coulisse MITUTOYO (*Electronic Digital Caliper*, précision de l'instrument au 1/100^{e} mm ; précision des mesures conservée au 1/10^{e} mm), suivant les recommandations de la nomenclature ostéométrique aviaire (Tableau 1).

Les 81 mesures réalisées sont présentées sur la Figure 1 (1a, 1b et 1c) et leur signification individuelle est précisée dans le Tableau 2. La nomenclature internationale en anglais a été conservée dans les figures afin de permettre une meilleure correspondance par rapport aux publications de référence. Quelques mesures supplémentaires à celles réalisées par les auteurs du tableau I ont été rajoutées, comme par exemple D (depth of *facies articularis humeralis*) et G (depth of the *collum scapulae*) pour la scapula (colonne « Mesures complémentaires » du Tableau 1).

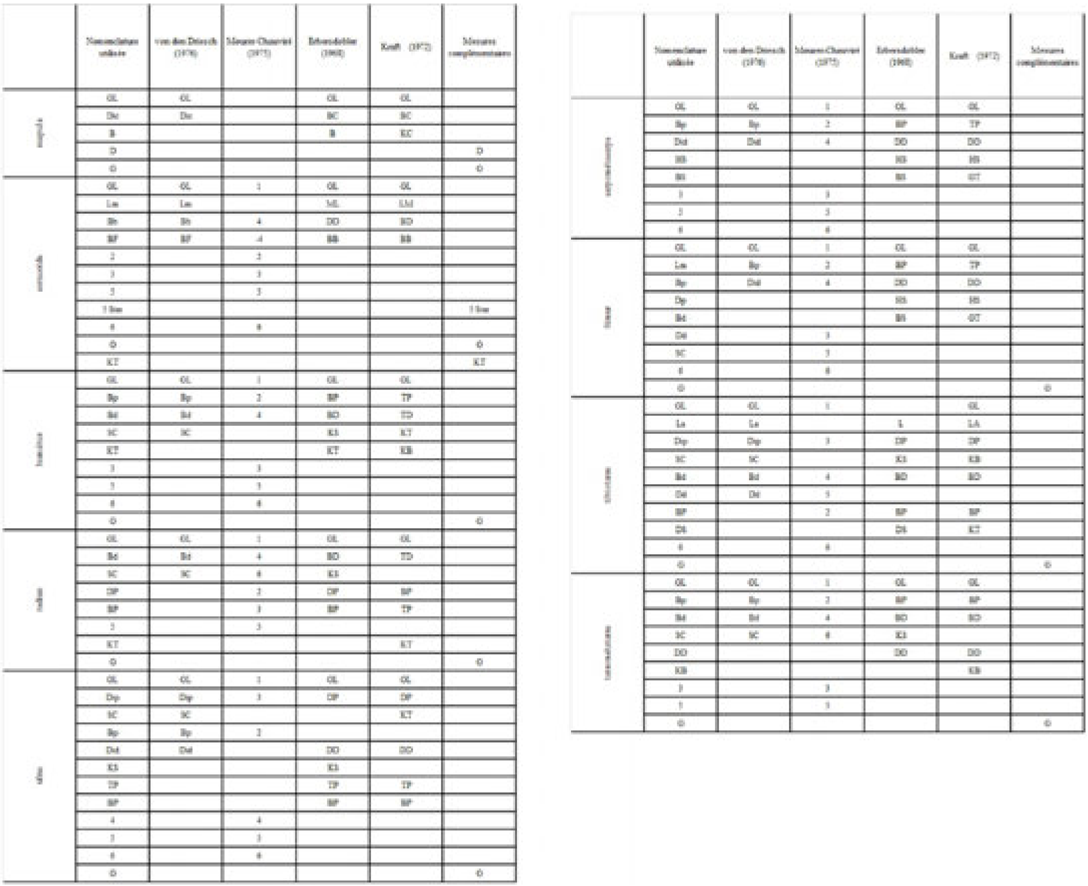
ANALYSES STATISTIQUES

Analyse univariée:

Le traitement statistique des données a été réalisé à l'aide du logiciel informatique Excel. Pour chaque variable mesurée les paramètres statistiques de position (moyenne, minimum, maximum) ont été calculés dans l'échantillon des mâles d'une part et dans l'échantillon des femelles d'autre part, ainsi qu'au sein de la population globale. La variabilité a été estimée par l'écart-type σ et le coefficient de variation CV. Exprimé en % (CV % = (σ/m) x 100 : rapport entre l'écart type σ et la moyenne m), il permet de s'affranchir de l'unité de la mesure. Afin d'essayer de mettre en évidence le dimorphisme sexuel, pour chaque variable, la comparaison des moyennes des mâles et des femelles a été effectuée par un test de Student. Celui-ci a été réalisé après vérification de l'égalité des variances dans les deux populations (test de Fisher) et de la normalité de la variable dans chaque population (test de Shapiro).

Analyse bivariée:

Les graphiques reprenant les deux paramètres les plus dimorphiques de chaque os sont présentés afin de visualiser la distribution des individus mâles et femelles. Le caractère dimorphique (DS) d'une variable est déterminé en fonction de la valeur moyenne des mâles et de celle des femelles en calculant le rapport suivant : DS (%) = (([moyenne des mâles - moyenne des femelles] / moyenne de femelles) X 100). Plus l'écart entre les valeurs moyennes des mâles et des femelles est important, plus le caractère est considéré comme dimorphique, et donc plus DS est grand. La grande longueur de l'os étant un paramètre toujours mesu-



	Nomenclature utilisée	von den Driesch (1976)	Mesures Chauviré (1975)	Erbersdobler (1968)	Kraft (1972)	Mesures complémentaires
[illegible]	GL	GL		GL	GL	
	Dc	Dc		BC	BC	
	B			B	KC	
	D					D
	⌀					⌀
[illegible]	GL	GL	1	GL	GL	
	Lm	Lm		ML	LM	
	Bb	Bb	4	DD	BD	
	BF	BF	4	BB	BB	
	2		2			
	3		3			
	5		5			
	5 bis					5 bis
	6		6			
	⌀					⌀
	KT					KT
[illegible]	GL	GL	1	GL	GL	
	Bp	Bp	2	BP	TP	
	Bd	Bd	4	BD	TD	
	SC	SC		KS	KT	
	KT			KT	KB	
	3		3			
	5		5			
	6		6			
	⌀					⌀
[illegible]	GL	GL	1	GL	GL	
	Bd	Bd	4	BD	TD	
	SC	SC	6	KS		
	DP		2	DP	BP	
	BP		3	BP	TP	
	5		5			
	KT				KT	
	⌀					⌀
[illegible]	GL	GL	1	GL	GL	
	Dip	Dip	3	DP	DP	
	SC	SC			KT	
	Bp	Bp	2			
	Did	Did		DD	DD	
	KS			KS		
	TP			TP	TP	
	BP			BP	BP	
	4		4			
	5		5			
	6		6			
	⌀					⌀
[illegible]	GL	GL	1	GL	GL	
	Bp	Bp	2	BP	TP	
	Did	Did	4	DD	DD	
	HS			HS	HS	
	BS			BS	GT	
	3		3			
	5		5			
	6		6			
[illegible]	GL	GL	1	GL	GL	
	Lm	Bp	2	BP	TP	
	Bp	Did	4	DD	DD	
	Dp			HS	HS	
	Bd			BS	GT	
	Dd		3			
	SC		5			
	6		6			
	⌀					⌀
[illegible]	GL	GL	1		GL	
	La	La		L	LA	
	Dip	Dip	3	DP	DP	
	SC	SC		KS	KB	
	Bd	Bd	4	BD	BD	
	Dd	Dd	5			
	BP		2	BP	BP	
	DS			DS	KT	
	6		6			
	⌀					⌀
[illegible]	GL	GL	1	GL	GL	
	Bp	Bp	2	BP	BP	
	Bd	Bd	4	BD	BD	
	SC	SC	6	KS		
	DD			DD	DD	
	KB				KB	
	3		3			
	5		5			
	⌀					⌀

TABLEAU 1

Correspondances entre les mesures des os selon différents auteurs.

ré par les archéozoologues (pour un corpus conséquent, voir par exemple Borvon, 2012), même si cette grandeur n'est pas la plus dimorphique ici, elle servira d'ordonnée pour faire les graphiques bivariés (GL=f (paramètre le plus dimorphique)).

Une analyse bivariée des corrélations de Pearson entre variables a été menée, afin de connaître les couples de paramètres les mieux corrélés entre eux et qui apportent donc le même type d'information. Seuls les coefficients de corrélations significatifs et supérieurs à 0,85 sont présentés dans ce travail.

Analyse multivariée:

Une Analyse en Composantes Principales (ACP) a été réalisée à l'aide du logiciel R 3.2.2 ® [*R Development Core Team*] sur les différentes variables mesurées sur les os de chaque individu : les mesures linéaires ont été incluses comme variables actives, le sexe comme variable supplémentaire. L'analyse a permis de construire trois graphiques complémentaires : i) le cercle des corrélations qui illustre la constitution du premier plan factoriel ; ii) un nuage de points qui visualise la dispersion des individus des deux sexes dans le premier plan factoriel ; iii) un graphe représentant la position des centres de gravité pour chaque sexe dans le premier plan factoriel avec leur ellipse de confiance à 95%.

Pour une question de présentation des données, tous les os ne seront pas détaillés. L'exemple exposé sera celui d'un os très souvent retrouvé en contexte archéologique (Borvon, 2012) et permettant par ailleurs un sexage sur des critères morphologiques : le tarsométatarse. S'en suivra une

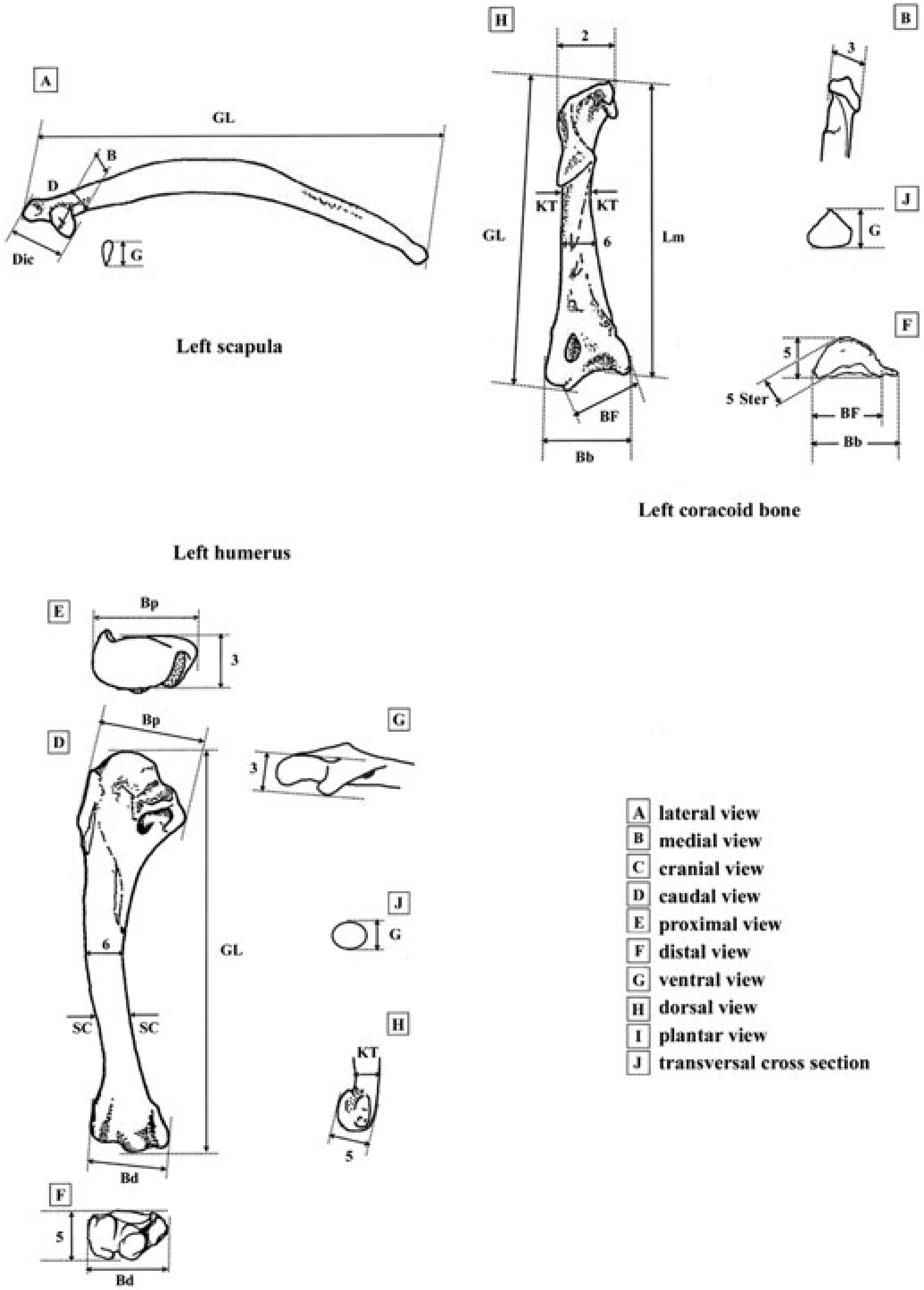


FIGURE 1A

Illustration des 81 mesures réalisées pour les 9 os retenus pour l’étude. a : scapula, coracoïde et humérus.

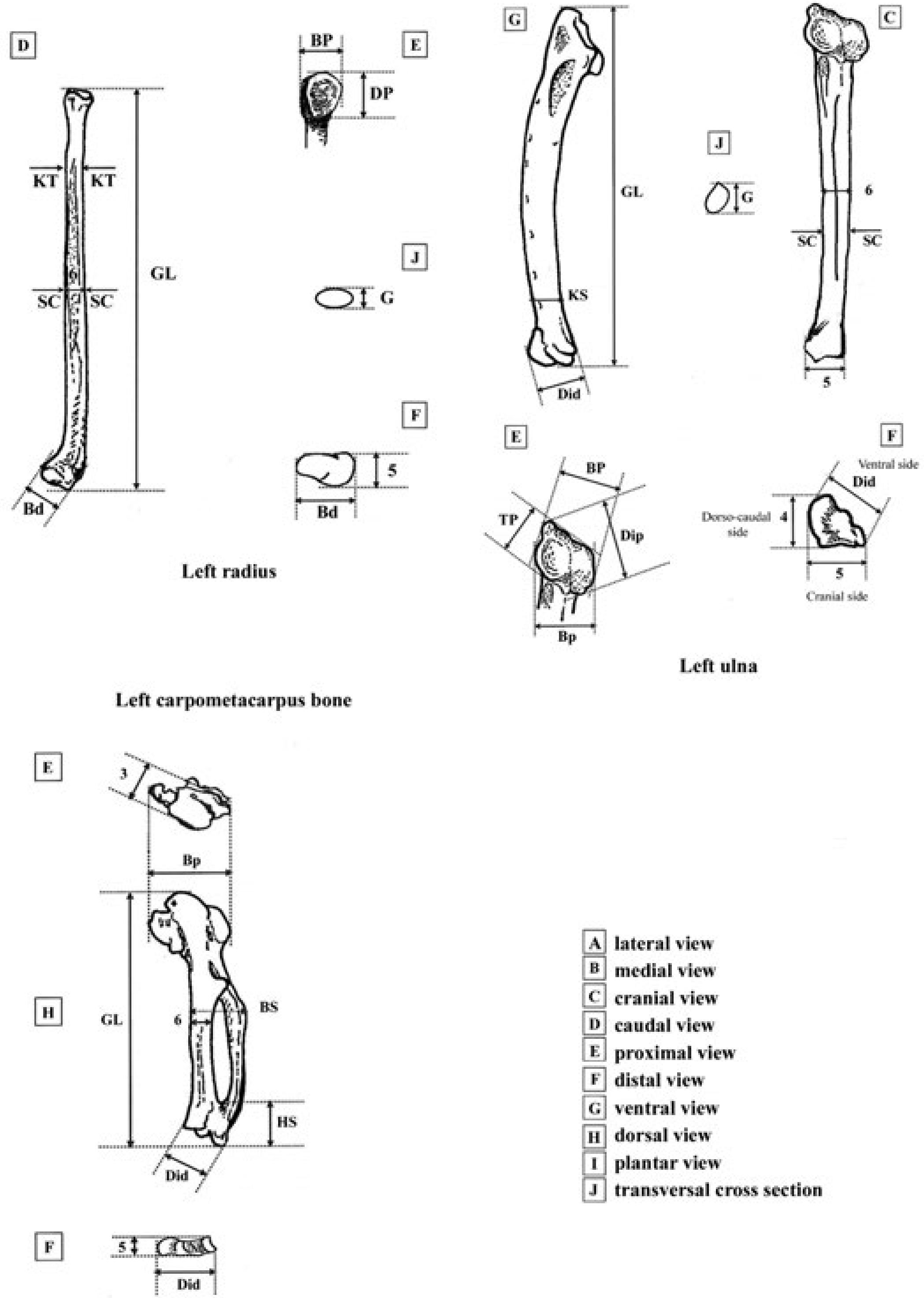


FIGURE 1B

Illustration des 81 mesures réalisées pour les 9 os retenus pour l'étude. b : radius, ulna et carpométacarpe.

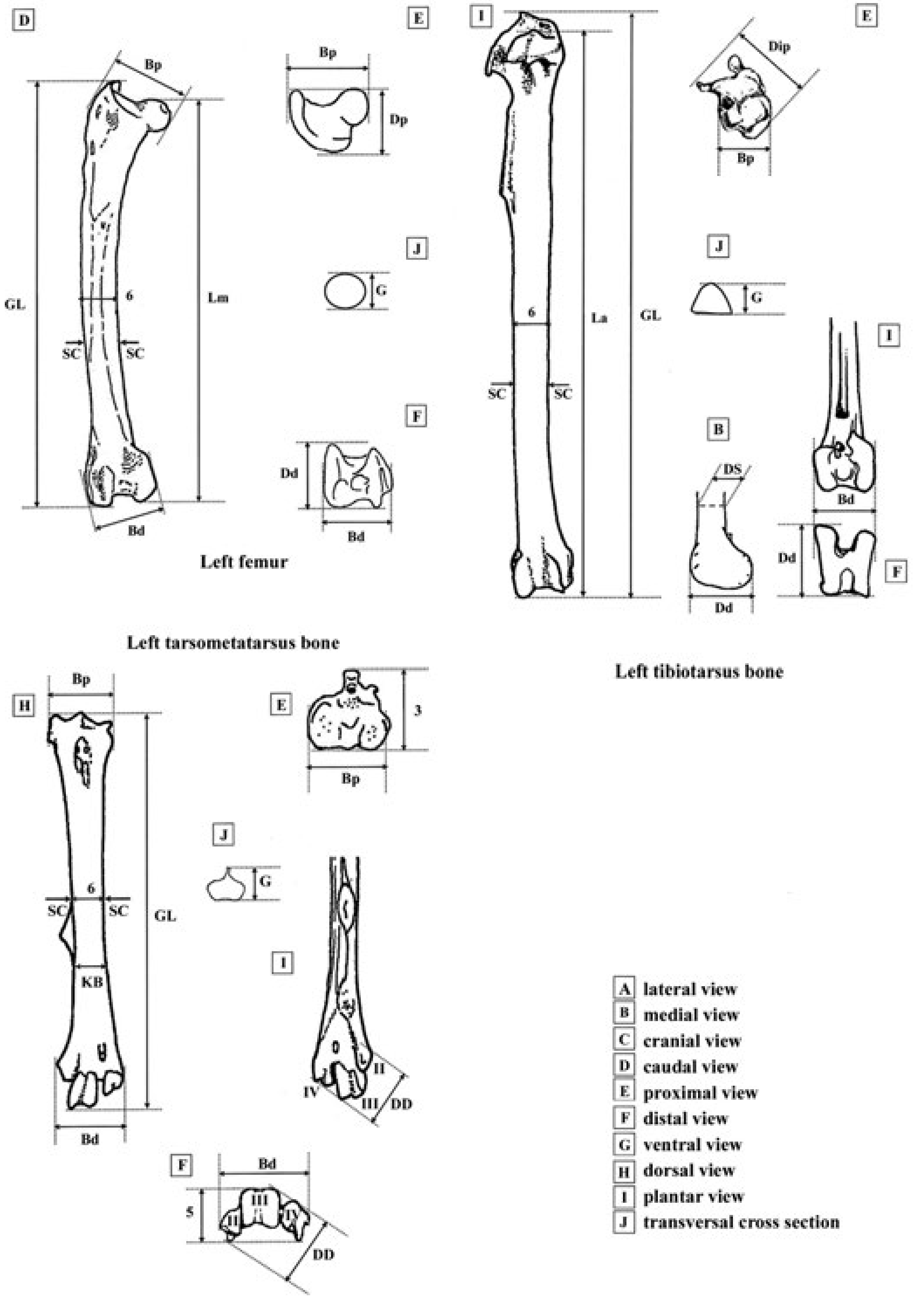


FIGURE 1C

Illustration des 81 mesures réalisées pour les 9 os retenus pour l’étude. c : fémur, tibiotarse et tarsométatarse.

étude multivariée complète, c'est-à-dire prenant en compte l'ensemble des os et des variables.

Pour tous les tests statistiques utilisés dans cette étude une probabilité de 0,05 a été retenue comme seuil de significativité.

Pour chaque os, une ACP a été réalisée avec toutes les mesures de l'os, suivie d'une modélisation par régression logistique où la probabilité de chaque sexe est estimée en fonction des variables de chaque os. Pour chacune des variables, la valeur permettant de séparer les mâles et les femelles, ainsi que le taux de mauvais classement, ont été calculés. Ainsi les variables les plus discriminantes ont-elles été ressorties de l'ensemble des variables de départ, os par os. Au-delà de ce travail purement

OS	Signification des mesures	OS	Signification des mesures
Scapula	**GL**: greatest length **Dic**: greatest cranial breadth or cranial diagonal breadth **B**: smallest breadth of the *collum scapula* **D**: depth of facies *articularis humeralis* **G**: depth of the *collum scapulae*	**Carpométacarpe**	**GL** : greatest length **Bp**: greatest proximal breadth **3**: depth of *carpal trochlea* **BS**: midwidth (or midbreadth) of *carpometacarpus* or breadth across *process intermetacarpalis* **6**: breadth of *os metacarpale majus* of midshaft (or breadth of *os metacarp. maj*. of midshaft) **HS**: height of the *symphysis* **Did**: greatest distal diagonal **5**: distal depth
Coracoïde	**GL**: greatest length **Lm** : medial length **2**: greatest proximal breadth **3**: depth of facies *articularis clavicularis* **KT**: smallest breadth of shaft **6**: breadth of midshaft **G**: depth of midshaft **Bb**: greatest basal breadth **BF**: breadth of the facies *articularis sternalis* **5**: distal depth **5** Ster: depth of facies *articularis sternalis*	**Fémur**	**GL**: greatest length **Lm**: medial length **Bp**: greatest proximal breadth **Dp**: greatest proximal depth **6**: breadth of midshaft **G**: depth of midshaft **SC**: smallest breadth of shaft **Bd**: greatest distal breadth **Dd**: greatest distal depth
Humérus	**GL**: greatest length **Bp**: greatest proximal breadth **3**: depth of *caput humeri* or proximal depth **6**: breadth of midshaft **G**: depth of midshaft **SC**: smallest breadth of shaft **KT**: smallest shaft depth (measured at the neck of the distal part) **Bd**: greatest distal breadth **5**: distal depth	**Tibiotarse**	**GL**: greatest length **La**: axial length **BP**: greatest proximal breadth **Dip**: greatest proximal diagonal **6**: breadth of midshaft **G**: depth of midshaft **SC**: smallest breadth of shaft **DS**: smallest depth of the shaft **Bd**: greatest distal breadth **Dd**: greatest distal depth
Radius	**BP**: greatest proximal breadth **DP**: greatest proximal depth **KT**: smallest breadth of shaft (near proximal end) **(SC)** = 6: breadth of midshaft **G**: depth of midshaft **Bd**: greatest distal breadth **5**: distal depth	**Tarsométatarse**	**GL**: greatest length **Bp**: greatest proximal breadth **3**: proximal depth **(SC)** = 6 : breadth of midshaft **G**: depth of midshaft **KB**: smallest shaft breadth **Bd**: greatest distal breadth **DD**: greatest distal diagonal **5**: distal depth
Ulna	**GL**: greatest length **Bp**: greatest transverse proximal breadth **BP**: greatest diagonal proximal breadth **Dip**: greatest proximal diagonal **TP**: greatest proximal depth **6**: breadth of midshaft **G**: depth of midshaft **SC**: smallest breadth of shaft **KS**: smallest shaft depth **Did**: greatest distal diagonal **4**: greatest distal depth **5**: greatest distal breadth		

TABLEAU 2

Liste et signification des mesures linéaires réalisées. La nomenclature anatomique utilisée est celle de Baumel & Witmer (1993).

Sexe		**M (g)**	**GL (mm)**	**Dic (mm)**	**B (mm)**	**D (mm)**	**G (mm)**
Mâle	n	26	26	26	26	26	26
	m	**0,85**	**78,86**	**13,24**	**5,40**	**7,29**	**3,10**
	(min;max)	(0,73;1,01)	(72,31;84,92)	(12,07;14,17)	(4,91;5,97)	(6,74;8,08)	(2,65;3,59)
	σ	0,08	2,55	0,49	0,27	0,32	0,23
	p	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**10^{-9}**
Femelle	n	28	28	28	28	28	28
	m	**0,59**	**70,04**	**11,47**	**4,67**	**6,27**	**2,64**
	(min;max)	(0,46;0,85)	(62,81;79,97)	(10,28;13,05)	(4,09;5,35)	(5,62;7,27)	(2,27;3,24)
	σ	0,09	3,72	0,55	0,27	0,34	0,24
Population totale	n	54	54	54	54	54	54
	m	**0,72**	**74,29**	**12,32**	**5,03**	**6,76**	**2,86**
	(min;max)	(0,46;1,01)	(62,81;84,92)	(10,28;14,17)	(4,09;5,97)	(5,62;8,08)	(2,27;3,59)
	σ	0,15	5,47	1,03	0,45	0,61	0,33

n : effectif ; **m : moyenne**; min : minimum; max : maximum; σ : écart-type ; *p : p-value*

TABLEAU 3A

Valeurs ostéométriques pour chaque variable. A : Scapula.

Sexe		**M (g)**	**GL (mm)**	**Lm (mm)**	**Bb (mm)**	**BF (mm)**	**2 (mm)**
Mâle	n	23	23	23	25	25	26
	m	**1,18**	**54,50**	**51,44**	**15,82**	**12,09**	**10,62**
	(min;max)	(1,00;1,50)	(50,13;57,72)	(47,83;54,03)	(14,85;16,92)	(10,84;13,65)	(9,65;11,88)
	σ	0,12	1,59	1,49	0,49	0,68	0,60
	p	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**
Femelle	n	28	28	28	28	28	28
	m	**0,77**	**48,48**	**46,02**	**13,88**	**10,62**	**9,35**
	(min;max)	(0,57;0,96)	(45,78;52,65)	(42,98;49,96)	(12,31;15,67)	(8,98;11,72)	(8,37;10,37)
	σ	0,09	1,99	1,98	0,79	0,69	0,46
Population totale	n	51	51	51	53	53	54
	m	**0,95**	**51,19**	**48,46**	**14,80**	**11,31**	**9,96**
	(min;max)	(0,57;1,50)	(45,78;57,72)	(42,98;54,03)	(12,31;16,92)	(8,98;13,65)	(8,37;11,88)
	σ	0,23	3,52	3,24	1,18	1,00	0,83

Sexe		**3 (mm)**	**5 (mm)**	**5 stern (mm)**	**6 (mm)**	**KT (mm)**	**G (mm)**
Mâle	n	26	25	25	23	26	23
	m	**7,51**	**5,37**	**5,11**	**5,66**	**5,10**	**4,12**
	(min;max)	(6,82;8,21)	(4,46;6,22)	(4,38;5,94)	(4,82;6,57)	(4,11;6,08)	(3,49;5,36)
	σ	0,39	0,44	5,11	0,49	0,50	0,39
	p	**$<10^{-9}$**	**10^{-8}**	**10^{-7}**	**$<10^{-9}$**	**10^{-8}**	**10^{-8}**
Femelle	n	28	28	28	28	28	28
	m	**6,38**	**4,65**	**4,43**	**4,77**	**4,35**	**3,50**
	(min;max)	(5,35;7,32)	(3,97;5,32)	(3,62;5,18)	(4,09;5,76)	(3,77;5,28)	(3,01;4,05)
	σ	0,39	0,36	0,41	0,36	0,31	0,28
Population totale	n	54	53	53	51	54	51
	m	**6,93**	**4,99**	**4,75**	**5,17**	**4,71**	**3,78**
	(min;max)	(5,35;8,21)	(3,97;6,22)	(3,62;5,94)	(4,09;6,57)	(3,77;6,08)	(3,01;5,36)
	σ	0,69	0,54	0,54	0,61	0,55	0,45

n : effectif ; **m : moyenne**; min : minimum; max : maximum; σ : écart-type ; *p : p-value*

TABLEAU 3B

Valeurs ostéométriques pour chaque variable. B : Os coracoïde.

Sexe		**M (g)**	**GL (mm)**	**Bp (mm)**	**SC (mm)**	**Bd (mm)**	**KT (mm)**
Mâle	n	26	26	26	26	26	26
	m	**2,89**	**75,70**	**19,87**	**6,95**	**15,12**	**5,33**
	(min;max)	(2,41;3,49)	(69,58;79,78)	(18,85;20,71)	(6,03;7,73)	(14,31;15,85)	(4,81;5,79)
	σ	0,25	2,41	0,58	0,36	0,42	0,27
	p	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**
Femelle	n	28	28	28	28	28	28
	m	**1,95**	**68,21**	**17,52**	**6,24**	**13,37**	**4,66**
	(min;max)	(1,58;2,43)	(61,54;76,16)	(16,59;19,41)	(5,73;7,18)	(12,19;14,96)	(4,09;5,57)
	σ	0,22	3,24	0,66	0,34	0,54	0,30
Population totale	n	54	54	54	54	54	54
	m	**2,40**	**71,81**	**18,65**	**6,58**	**14,21**	**4,98**
	(min;max)	(1,58;3,49)	(61,54;79,78)	(16,59;20,71)	(5,73;7,73)	(12,19;15,85)	(4,09;5,79)
	σ	0,53	4,73	1,34	0,50	1,00	0,44

Sexe		**3 (mm)**	**5 (mm)**	**6 (mm)**	**G (mm)**
Mâle	n	26	26	26	26
	m	**9,83**	**8,67**	**7,44**	**5,94**
	(min;max)	(9,21;10,49)	(8,15;9,12)	(6,57;8,17)	(5,41;6,52)
	σ	0,36	0.26	0,38	0,34
	p	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**10^{-9}**
Femelle	n	28	28	28	28
	m	**8,64**	**7,57**	**6,57**	**5,29**
	(min;max)	(8,09;9,47)	(6,88;8,31)	(5,95;7,92)	(4,76;6,35)
	σ	0,33	0,32	0,41	0,39
Population totale	n	54	54	54	54
	m	**9,21**	**8,10**	**6,99**	**5,60**
	(min;max)	(8,09;10,49)	(6,88;9,12)	(5,95;8,17)	(4,76;6,52)
	σ	0,69	0,62	0,59	0,49

n : effectif ; **m : moyenne**; min : minimum; max : maximum; σ : écart-type ; *p : p-value*

TABLEAU 3C

Valeurs ostéométriques pour chaque variable. C : Humérus.

Sexe		**M (g)**	**GL (mm)**	**Bd (mm)**	**KT (mm)**	**DP (mm)**	**BP (mm)**
Mâle	n	26	26	26	26	26	26
	m	**0,70**	**61,18**	**6,89**	**3,55**	**5,92**	**5,06**
	(min;max)	(0,60;0,80)	(56,05;63,98)	(6,34;7,39)	(3,08;3,92)	(5,51;6,31)	(4,74;5,34)
	σ	0,06	1,89	0,28	0,20	0,20	0,17
	p	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**
Femelle	n	28	28	28	28	28	28
	m	**0,48**	**55,56**	**6,10**	**3,14**	**5,13**	**4,48**
	(min;max)	(0,36;0,63)	(48,78;62,66)	(5,48;7,04)	(2,77;3,46)	(4,77;6,08)	(4,16;5,29)
	σ	0,06	2,94	0,33	0,17	0,25	0,25
Population totale	n	54	54	54	54	54	54
	m	**0,59**	**58,27**	**6,48**	**3,34**	**5,51**	**4,76**
	(min;max)	(0,36;0,80)	(48,78;63,98)	(5,48;7,39)	(2,77;3,92)	(4,77;6,31)	(4,16;5,34)
	σ	0,13	3,76	0,50	0,28	0,46	0,36

n : effectif ; **m : moyenne**; min : minimum; max : maximum; σ : écart-type ; *p : p-value*

TABLEAU 3D

Valeurs ostéométriques pour chaque variable. D : Radius.

Sexe		**5 (mm)**	**6 (mm)**	**G (mm)**
Mâle	n	26	26	26
	m	**3,55**	**3,76**	**2,63**
	(min;max)	(3,29;3,79)	(3,11;4,22)	(2,39;2,82)
	σ	0,13	0,25	0,11
	p	**$<10^{-9}$**	**10^{-8}**	**$<10^{-9}$**
Femelle	n	28	28	28
	m	**3,09**	**3,38**	**2,30**
	(min;max)	(2,85;3,83)	(2,82;3,73)	(1,95;2,79)
	σ	0,19	0,20	0,17
Population totale	n	54	54	54
	m	**3,31**	**3,56**	**2,46**
	(min;max)	(2,85;3,83)	(2,82;4,22)	(1,95;2,82)
	σ	0,28	0,29	0,22

n : effectif ; **m : moyenne**; min : minimum; max : maximum; σ : écart-type ; *p : p-value*

TABLEAU 3D (continuation)

Valeurs ostéométriques pour chaque variable. D : Radius.

Sexe		**M (g)**	**GL (mm)**	**Dip (mm)**	**Bp (mm)**	**Did (mm)**	**SC (mm)**
Mâle	n	26	26	26	26	26	26
	m	**1,84**	**67,95**	**12,98**	**9,86**	**9,86**	**4,30**
	(min;max)	(1,39;2,20)	(63,29;71,19)	(12,31;13,75)	(8,98;10,35)	(9,25;10,37)	(3,82;4,68)
	σ	0,22	1,91	0,40	0,29	0,32	0,19
	p	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**
Femelle	n	28	28	28	28	28	28
	m	**1,26**	**61,65**	**11,45**	**8,57**	**8,75**	**3,82**
	(min;max)	(0,92;1,69)	(54,28;69,34)	(10,52;12,52)	(7,77;10,08)	(8,11;9,61)	(3,50;4,58)
	σ	0,20	3,13	0,46	0,45	0,32	0,25
Population totale	n	54	54	54	54	54	54
	m	**1,54**	**64,68**	**12,19**	**9,19**	**9,28**	**4,05**
	(min;max)	(0,92;2,20)	(54,28;71,19)	(10,52;13,75)	(7,77;10,35)	(8,11;10,37)	(3,50;4,68)
	σ	0,36	4,10	0,88	0,75	0,64	0,33

Sexe	**BP (mm)**	**TP (mm)**	**KS (mm)**	**4 (mm)**	**5 (mm)**	**6 (mm)**	**G (mm)**
Mâle	26	26	26	26	26	26	26
	10,80	**8,38**	**5,88**	**8,06**	**8,34**	**4,32**	**6,29**
	(10,28;11,62)	(7,92;8,79)	(5,36;6,31)	(7,52;8,55)	(7,89;8,83)	(3,77;4,81)	(5,68;6,89)
	0,29	0,22	0,24	0,29	0,27	0,21	0,31
	$<10^{-9}$	**$<10^{-9}$**	**10^{-8}**	**10^{-9}**	**$<10^{-9}$**	**10^{-9}**	**$<10^{-9}$**
Femelle	28	28	28	28	28	28	28
	9,39	**7,38**	**5,20**	**7,05**	**7,42**	**3,88**	**5,59**
	(8,33;10,57)	(6,84;8,41)	(4,65;5,95)	(6,43;8,01)	(6,76;8,45)	(3,45;4 ,62)	(5,13;6,55)
	0,47	0,32	0,32	0,35	0,37	0,26	0,37
Population totale	54	54	54	54	54	54	54
	10,07	**7,86**	**5,53**	**7,54**	**7,86**	**4,09**	**5,93**
	(8,33;11,62)	(6,84;8,79)	(4,65;6,31)	(6,43;8,55)	(6,76;8,83)	(3,45;4,81)	(5,13;6,89)
	0,81	0,57	0,44	0,61	0,57	0,32	0,49

n : effectif ; **m : moyenne**; min : minimum; max : maximum; σ : écart-type ; *p : p-value*

TABLEAU 3E

Valeurs ostéométriques pour chaque variable. E : Ulna.

Sexe		**M (g)**	**GL (mm)**	**Bp (mm)**	**Did (mm)**	**HS (mm)**	**BS (mm)**
Mâle	n	26	26	26	26	26	26
	m	**0,98**	**39,56**	**12,23**	**7,66**	**5,94**	**9,62**
	(min;max)	(0,80;1,19)	(36,41;41,79)	(11,66;12,95)	(7,13;8,09)	(5,13;6,42)	(8,98;10,52)
	σ	0,11	1,15	0,37	0,27	0,32	0,37
	p	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**10^{-6}**	**$<10^{-9}$**
Femelle	n	28	28	28	28	28	28
	m	**0,68**	**35,45**	**10,81**	**6,92**	**5,41**	**8,60**
	(min;max)	(0,49;0,88)	(31,50;40,52)	(10,04;11,56)	(6,48;7,58)	(4,72;6,41)	(7,93;10,08)
	σ	0,09	1,99	0,41	0,26	0,40	0,49
Population totale	n	54	54	54	54	54	54
	m	**0,83**	**37,43**	**11,49**	**7,28**	**5,66**	**9,09**
	(min;max)	(0,49;1,19)	(31,50;41,79)	(10,04;12,95)	(6,48;8,09)	(4,72;6,42)	(7,93;10,52)
	σ	0,18	2,61	0,81	0,46	0,45	0,68

Sexe		**3 (mm)**	**5 (mm)**	**6 (mm)**
Mâle	n	26	26	26
	m	**5,61**	**4,13**	**3,76**
	(min;max)	(5,23;6,04)	(3,85;4,92)	(3,39;4,16)
	σ	0,19	0,25	0,19
	p	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**
Femelle	n	28	28	28
	m	**4,95**	**3,62**	**3,32**
	(min;max)	(4,54;5,56)	(3,34;4,08)	(2,91;3,89)
	σ	0,25	0,17	0,23
Population totale	n	54	54	54
	m	**5,26**	**3,87**	**3,53**
	(min;max)	(4,54;6,04)	(3,34;4,92)	(2 ,91;4,16)
	σ	0,40	0,33	0,30

n : effectif ; **m : moyenne**; min : minimum; max : maximum; σ : écart-type ; *p : p-value*

TABLEAU 3F

Valeurs ostéométriques pour chaque variable. F : Carpométacarpe.

Sexe		**M (g)**	**GL (mm)**	**Lm (mm)**	**Bp (mm)**	**Dp (mm)**	**Bd (mm)**
Mâle	n	26	26	26	26	26	26
	m	**2,63**	**85,15**	**79,56**	**16,71**	**10,65**	**15,24**
	(min;max)	(2,11;3,10)	(77,61;88,52)	(72,06;82,87)	(15,38;17,95)	(9,71;11,38)	(14,17;16,11)
	σ	0,23	2,54	2,58	0,65	0,37	0,51
	p	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**
Femelle	n	28	28	28	28	28	28
	m	**1,71**	**76,41**	**71,67**	**14,68**	**9,41**	**13,27**
	(min;max)	(1,33;2,29)	(69,08;85,51)	(64,47;80,31)	(13,53;16,19)	(8,83;10,61)	(12,09;15,22)
	σ	0,24	3,68	3,54	0,67	0,43	0,68
Population totale	n	54	54	54	54	54	54
	m	**2,15**	**80,62**	**75,47**	**15,65**	**10,00**	**14,22**
	(min;max)	(1,33;3,10)	(69,08;88,52)	(64,47;82,87)	(13,53;17,95)	(8,83;11,38)	(12,09;16,11)
	σ	0,52	5,42	5,04	1,22	0,74	1,16

n : effectif ; **m : moyenne**; min : minimum; max : maximum; σ : écart-type ; *p : p-value*

TABLEAU 3G

Valeurs ostéométriques pour chaque variable. G : Fémur.

Sexe		**Dd** **(mm)**	**SC** **(mm)**	**6** **(mm)**	**G** **(mm)**
Mâle	n	26	26	26	26
	m	**13,08**	**6,83**	**6,98**	**6,75**
	(min;max)	(12,06;13,87)	(6,23;7,56)	(6,26;7,86)	(5,67;7,84)
	σ	0,46	0.36	0,42	0,47
	p	**$<10^{-9}$**	**10^{-8}**	**10^{-7}**	**10^{-7}**
Femelle	n	28	28	28	28
	m	**11,39**	**6,16**	**6,26**	**6,06**
	(min;max)	(10,28;12,79)	(5,61;7,05)	(5,55;7,56)	(5,22;7,13)
	σ	0,55	0,38	0,47	0,42
Population totale	n	54	54	54	54
	m	**12,20**	**6,48**	**6,60**	**6,39**
	(min;max)	(10,28;13,87)	(5,61;7,56)	(5,55;7,86)	(5,22;7,84)
	σ	0,99	0,50	0,57	0,56

n : effectif ; **m : moyenne**; min : minimum; max : maximum; σ : écart-type ; *p : p-value*

TABLEAU 3G (continuation)

Valeurs ostéométriques pour chaque variable. G : Fémur.

Sexe		**M** **(g)**	**GL** **(mm)**	**La** **(mm)**	**Dip** **(mm)**	**SC** **(mm)**	**Bd** **(mm)**
Mâle	n	26	26	26	26	26	26
	m	**4,17**	**113,86**	**110,80**	**19,85**	**6,00**	**10,50**
	(min;max)	(0,42;5,24)	(103,26;118,83)	(101,07;115,52)	(18,31;21,25)	(5,08;6,67)	(9,36;11,47)
	σ	0,91	3,54	3,34	0,78	0,33	0,50
	p	**10^{-7}**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**
Femelle	n	28	28	28	28	28	28
	m	**3,07**	**100,96**	**98,22**	**17,34**	**5,33**	**9,12**
	(min;max)	(2,26;4,22)	(91,37;112,93)	(88,66;110,31)	(15,80;19,63)	(4,84;6,18)	(8,34;10,71)
	σ	0,48	4,85	4,89	0,95	0,34	0,52
Population totale	n	54	54	54	54	54	54
	m	**3,60**	**107,17**	**104,28**	**18,55**	**5,65**	**9,79**
	(min;max)	(0,42;5,24)	(91,37;118,83)	(88,66;115,52)	(15,80;21,25)	(4,84;6,67)	(8,34;11,47)
	σ	0,90	7,76	7,60	1,53	0,48	0,86

Sexe	**Dd** **(mm)**	**BP** **(mm)**	**DS** **(mm)**	**6** **(mm)**	**G** **(mm)**		
Mâle	26	26	26	26	26	26	
	10,80	**11,14**	**12,17**	**5,03**	**6,42**	**5,27**	
	(10,28;11,62)	(10,20;12,38)	(10,96;13,03)	(4,35;5,58)	(5,59;7,02)	(4,81;6,18)	
	0,29	0,49	0,59	0,29	0,31	0,31	
	$<10^{-9}$	**$<10^{-9}$**	**$<10^{-9}$**	**10^{-8}**	**$<10^{-9}$**	**10^{-5}**	
Femelle	28	28	28	28	28	28	
	9,39	**9,85**	**10,66**	**4,53**	**5,69**	**4,91**	
	(8,33;10,57)	(8,87;11,92)	(9,45;11,91)	(4,12;5,16)	(5,13;6,83)	4,48;5,57)	
	0,47	0,61	0,53	0,28	0,39	0,27	
Population totale	54	54	54	54	54	54	
	10,07	**10,47**	**11,39**	**4,77**	**6,04**	**5,08**	
	(8,33;11,62)	(8,87;12,38)	(9,45;13,03)	(4,12;5,58)	(5,13;7,02)	(4,48;6,18)	
	0,81	0,85	0,94	0,38	0,50	0,34	

n : effectif ; **m : moyenne**; min : minimum; max : maximum; σ : écart-type ; *p : p-value*

TABLEAU 3H

Valeurs ostéométriques pour chaque variable. H : Tibiotarse.

Sexe		M (g)	GL (mm)	Bp (mm)	KB (mm)	Bd (mm)	DD (mm)
Mâle	n	26	26	26	26	26	26
	m	**2,44**	**73,87**	**11,45**	**5,47**	**11,86**	**11,55**
	(min;max)	(1,92;2,96)	(66,78;79,49)	(10,37;12,61)	(4,89;5,98)	(10,67;12,83)	(10,41;12,29)
	σ	0,27	2,66	0,56	0,25	0,56	0,47
	p	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**
Femelle	n	26	26	26	26	26	26
	m	**1,46**	**63,88**	**9,92**	**4,75**	**10,15**	**9,92**
	(min;max)	(1,17;1,85)	(57,36;68,82)	(9,29;10,71)	(4,34;5,20)	(9,22;10,72)	(8,95;10,67)
	σ	0,18	3,00	0,35	0,22	0,39	0,38
Population totale	n	52	52	52	52	52	52
	m	**1,95**	**68,87**	**10,68**	**5,11**	**11,00**	**10,73**
	(min;max)	(1,17;2,96)	(57,36;79,49)	(9,29;12,61)	(4,34;5,98)	(9,22;12,83)	(8,95;12,29)
	σ	0,54	5,77	0,90	0,43	0,99	0,93

Sexe		3 (mm)	5 (mm)	6 (mm)	G (mm)
Mâle	n	26	26	26	26
	m	**11,58**	**7,99**	**5,61**	**6,59**
	(min;max)	(10,63;12,38)	(7,39;8,58)	(5,18;6,09)	(5,98;7,46)
	σ	0,51	0,35	0,24	0,38
	p	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**	**$<10^{-9}$**
Femelle	n	26	26	26	26
	m	**9,97**	**7,06**	**4,90**	**5,36**
	(min;max)	(9,06;10,64)	(6,36;7,78)	(4,52;5,46)	(4,63;5,86)
	σ	0,42	0,33	0,27	0,28
Population totale	n	52	52	52	52
	m	**10,77**	**7,52**	**5,26**	**5,97**
	(min;max)	(9,06;12,38)	(6,36;8,58)	(4,52;6,09)	(4,63;7,46)
	σ	0,94	0,57	0,44	0,71

n : effectif ; **m : moyenne**; min : minimum; max : maximum; σ : écart-type ; *p : p-value*

TABLEAU 3I

Valeurs ostéométriques pour chaque variable. I : Tarsométatarse.

statistique, et dans le but de proposer un référentiel applicable pour l'archéozoologie, les variables les plus pertinentes - soit celles largement utilisées par la communauté scientifique (Driesch, 1976) -, mais aussi les plus discriminantes, ont été ressorties de l'ensemble des 81 mesures de départ, en veillant à proposer au minimum deux variables par os, de façon à ce qu'un corpus plus restreint puisse être proposé, pour n'importe quel os de notre ensemble.

RESULTATS

Analyse univariée:

L'ensemble des résultats de l'analyse univariée sont présentés dans le Tableau 3 (Tableaux 3A à 3I).

Pour la grande majorité des spécimens étudiés, l'ensemble des neuf os étudiés est généralement présent, de sorte que l'effectif est pratiquement toujours de 54 individus.

Le calcul des coefficients de variation (CV) met en évidence deux types de variables. Certaines variables présentent des CV assez élevés. Il s'agit des masses, dont le CV varie de 21,4% pour le radius à 27,8% pour le tarsométatarse. À l'inverse, d'autres variables ont des CV assez faibles, ce qui indique un bon centrage autour de la valeur moyenne. Il s'agit de toutes les mesures linéaires, qui varient de 6,3% pour la Did du carpométacarpe (*greatest distal diagonal of carpometacarpus*) à 12% pour la mesure G du coracoïde (*depth of midshaft coracoid*).

Pour l'ensemble des variables étudiées, les différences observées entre les moyennes des mâles

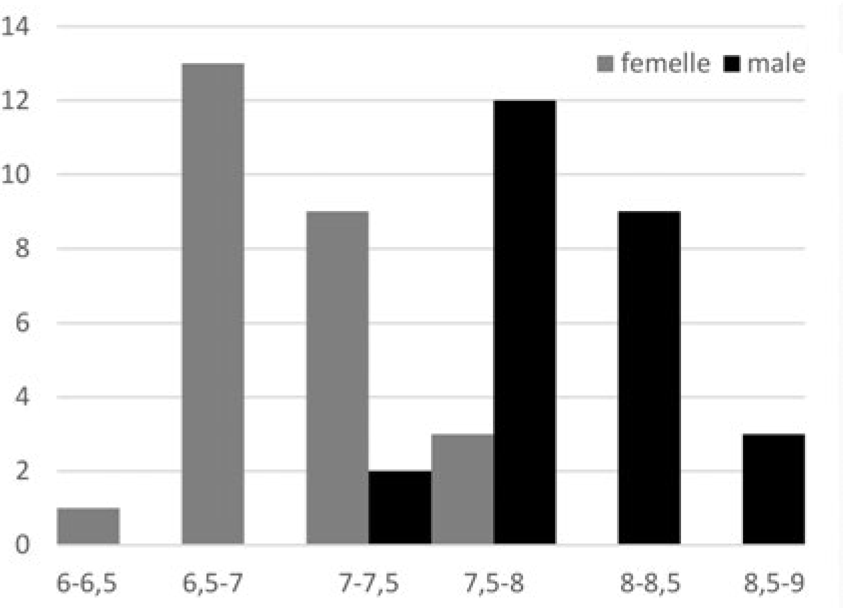


FIGURE 2

Distribution de fréquence de la mesure 5 (*distal depth*) du tarsométatarse, avec en gris les femelles (n=28) et en noir les mâles (n=26).

et celles des femelles sont hautement significatives ($p<10^{-5}$ et le plus souvent, $p<10^{-9}$; Tableau 3). Pour certains paramètres, la superposition des valeurs des mâles et des valeurs des femelles est assez faible, de sorte que l'approche du dimorphisme sexuel est tout à fait envisageable (Figure 2).

Les caractères qui présentent le dimorphisme sexuel (DS) moyen le plus important sont les masses : le DS varie de 35,9% pour le tibiotarse à 66,6% pour le tarsométatarse. Pour les variables linéaires, il varie de 7,4% pour la mesure G du tibiotarse (*depth of midshaft*) à 23,2% pour la mesure G du tarsométatarse (*depth of midshaft*). Pour chaque os, les paramètres en moyenne les plus dimorphiques sont présentés dans le Tableau 4. Au-delà de ces variables, l'archéozoologue est confronté à la réalisation pratique des mesures (reliefs osseux parfois cassés ou mesures difficiles à faire) et aux normes habituelles qui sont le plus souvent celle de l'ouvrage de Driesch (1976). Aussi, nous proposons, dans le but de rendre plus opérant notre analyse de ressortir les deux variables les plus fréquemment utilisées dans les études archéozoologiques et les plus dimorphiques pour chacun des os de l'étude (Tableau 4).

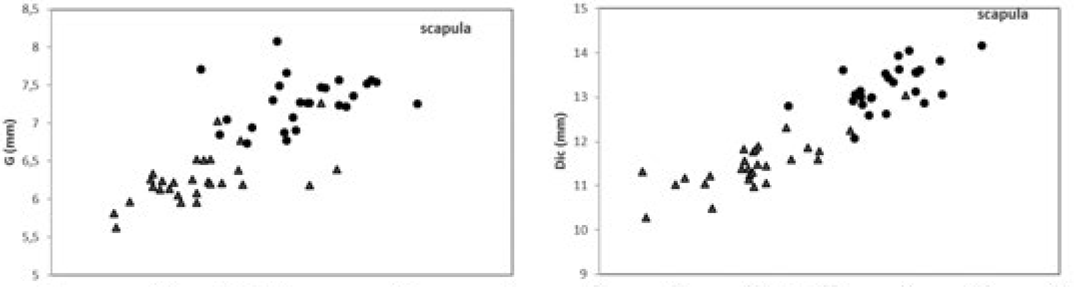


FIGURE 3A : scapula.

Diagrammes bivariés correspondant, à gauche, aux deux paramètres linéaires les plus dimorphiques en moyenne pour un os donné (DS (%) maximum), et à droite entre la grande longueur de l'os et le paramètre linéaire à la fois le plus pertinent pour l'archéozoologie et le plus dimorphique.

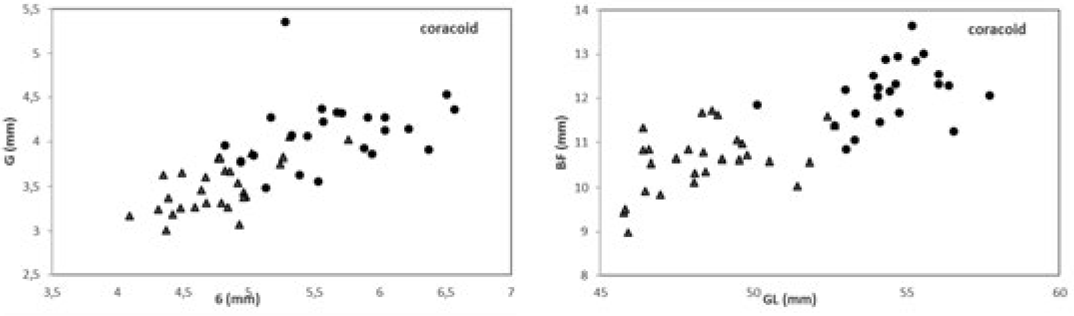


FIGURE 3B : coracoïde.

Diagrammes bivariés correspondant, à gauche, aux deux paramètres linéaires les plus dimorphiques en moyenne pour un os donné (DS (%) maximum), et à droite entre la grande longueur de l'os et le paramètre linéaire à la fois le plus pertinent pour l'archéozoologie et le plus dimorphique.

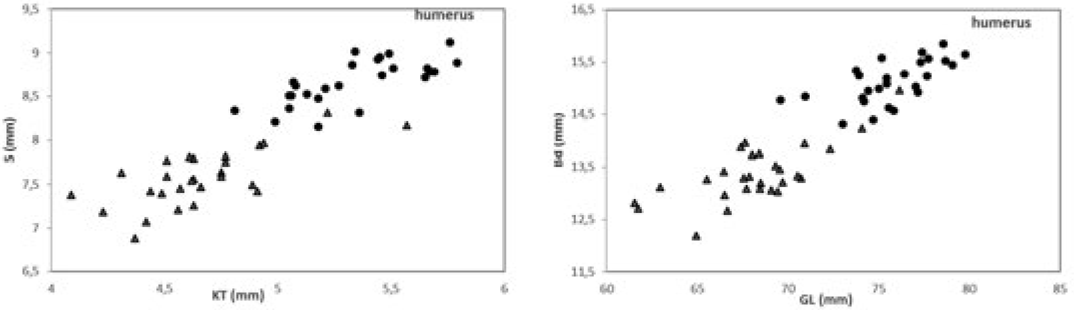


FIGURE 3C : humérus.

Diagrammes bivariés correspondant, à gauche, aux deux paramètres linéaires les plus dimorphiques en moyenne pour un os donné (DS (%) maximum), et à droite entre la grande longueur de l'os et le paramètre linéaire à la fois le plus pertinent pour l'archéozoologie et le plus dimorphique.

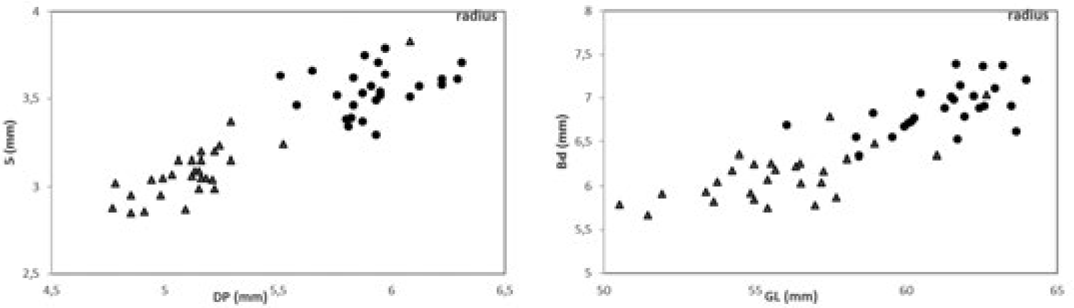


FIGURE 3D : radius.

Diagrammes bivariés correspondant, à gauche, aux deux paramètres linéaires les plus dimorphiques en moyenne pour un os donné (DS (%) maximum), et à droite entre la grande longueur de l'os et le paramètre linéaire à la fois le plus pertinent pour l'archéozoologie et le plus dimorphique.

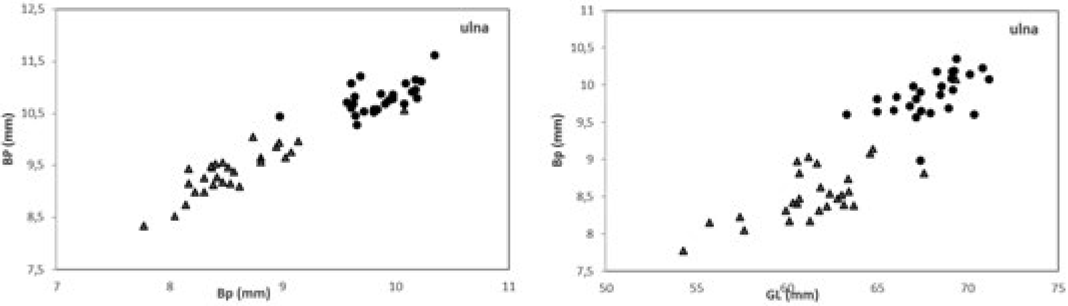


FIGURE 3E : ulna.

Diagrammes bivariés correspondant, à gauche, aux deux paramètres linéaires les plus dimorphiques en moyenne pour un os donné (DS (%) maximum), et à droite entre la grande longueur de l’os et le paramètre linéaire à la fois le plus pertinent pour l’archéozoologie et le plus dimorphique.

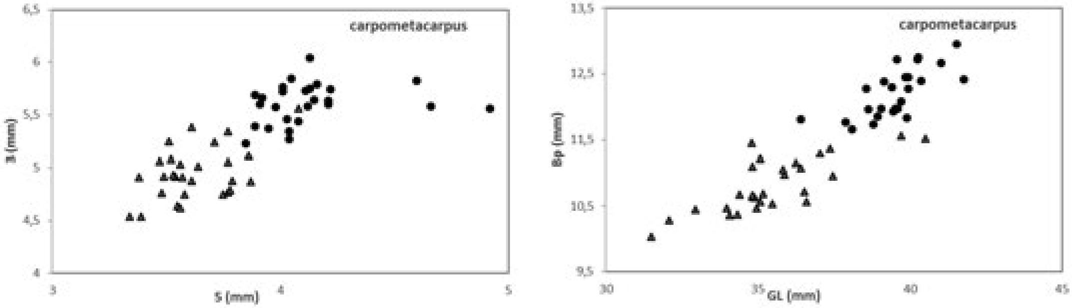


FIGURE 3F : carpométacarpe.

Diagrammes bivariés correspondant, à gauche, aux deux paramètres linéaires les plus dimorphiques en moyenne pour un os donné (DS (%) maximum), et à droite entre la grande longueur de l’os et le paramètre linéaire à la fois le plus pertinent pour l’archéozoologie et le plus dimorphique.

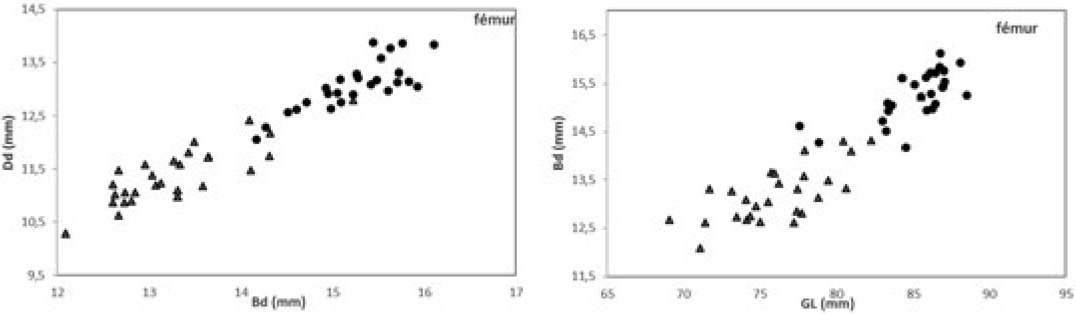


FIGURE 3G : fémur.

Diagrammes bivariés correspondant, à gauche, aux deux paramètres linéaires les plus dimorphiques en moyenne pour un os donné (DS (%) maximum), et à droite entre la grande longueur de l’os et le paramètre linéaire à la fois le plus pertinent pour l’archéozoologie et le plus dimorphique.

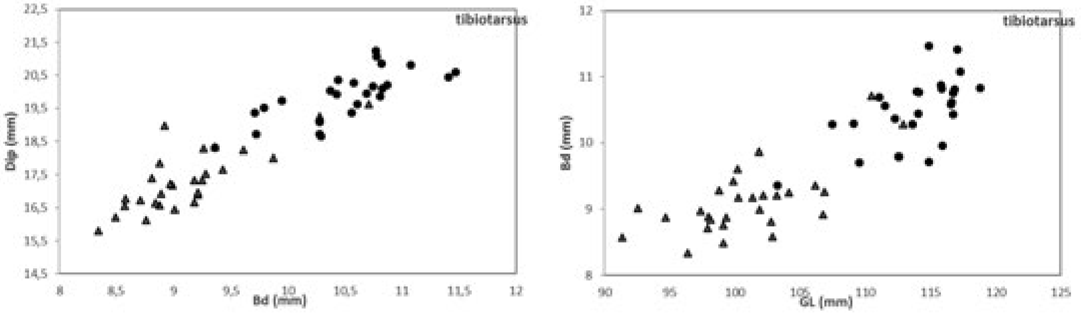


FIGURE 3H : tibiotarse.

Diagrammes bivariés correspondant, à gauche, aux deux paramètres linéaires les plus dimorphiques en moyenne pour un os donné (DS (%) maximum), et à droite entre la grande longueur de l'os et le paramètre linéaire à la fois le plus pertinent pour l'archéozoologie et le plus dimorphique.

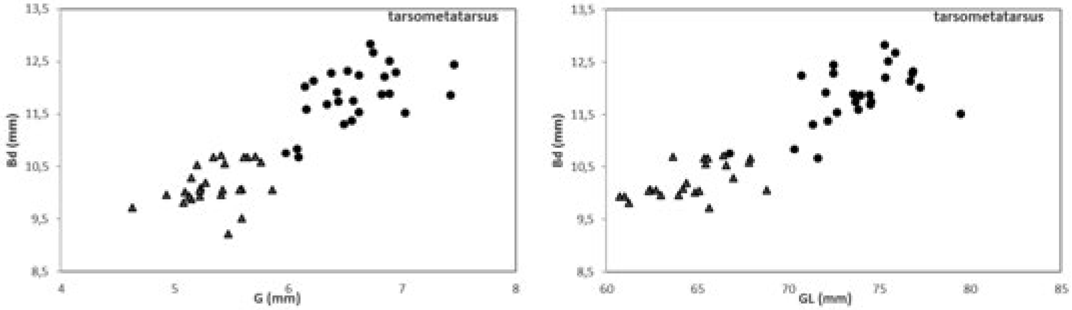


FIGURE 3I : tasométatarse.

Diagrammes bivariés correspondant, à gauche, aux deux paramètres linéaires les plus dimorphiques en moyenne pour un os donné (DS (%) maximum), et à droite entre la grande longueur de l'os et le paramètre linéaire à la fois le plus pertinent pour l'archéozoologie et le plus dimorphique.

Analyse bivariée:

À partir des résultats présentés dans le tableau IV, pour chaque os, les deux paramètres les plus dimorphiques ont fait l'objet d'un graphique bivarié de répartition des individus mâles et femelles, et d'un second graphique présentant la grande longueur de l'os en fonction du paramètre de Driesch (1976) le plus pertinent (Figure 3).

La matrice des corrélations permet de mettre en évidence des variables particulièrement bien corrélées entre elles, qu'il s'agisse des paramètres linéaires ou pondéraux, pour un os donné ou entre les os étudiés. Les coefficients de corrélation de plus de 0,9 ne sont pas rares (en gras dans le Tableau 5). Les mesures de longueur, de largeur et d'épaisseur sont très bien corrélées entre elles. La grande longueur de l'os (GL) est systématiquement corrélée avec au moins une autre dimension osseuse, voire parfois avec presque toutes les variables, comme par exemple dans le cas de l'humérus, de l'ulna, du fémur, du tibiotarse ou du tarsométatarse. Il existe donc une unité de construction morphobiométrique au sein des os des membres particulièrement importante.

Analyse multivariée:

L'ACP réalisée sur l'ensemble des variables d'un os donné montre systématiquement le même type de graphique, à savoir que le facteur I représente de loin la plus grande variabilité et a une inertie qui varie de 73,7% pour le coracoïde à 90,2% pour l'humérus. En général, le facteur I représente plus de 85% de l'inertie du plan factoriel principal, de sorte que l'axe II est très peu variable : il représente entre 3,7% pour l'humérus et 8,3% pour le coracoïde de la variabilité de la population.

Dans le cas du tarsométatarse, pris pour exemple ci-dessous, le facteur I représente 88,7% de variabilité et le facteur II 4,2% (Figure 4).

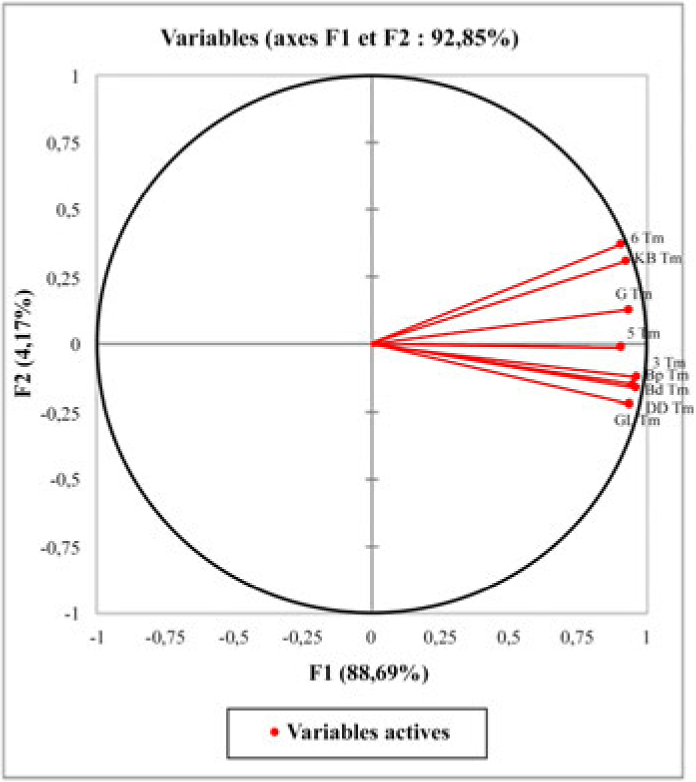


FIGURE 4a

ACP sur les 9 variables du tarsométatarse (52 individus), plan factoriel I-II.

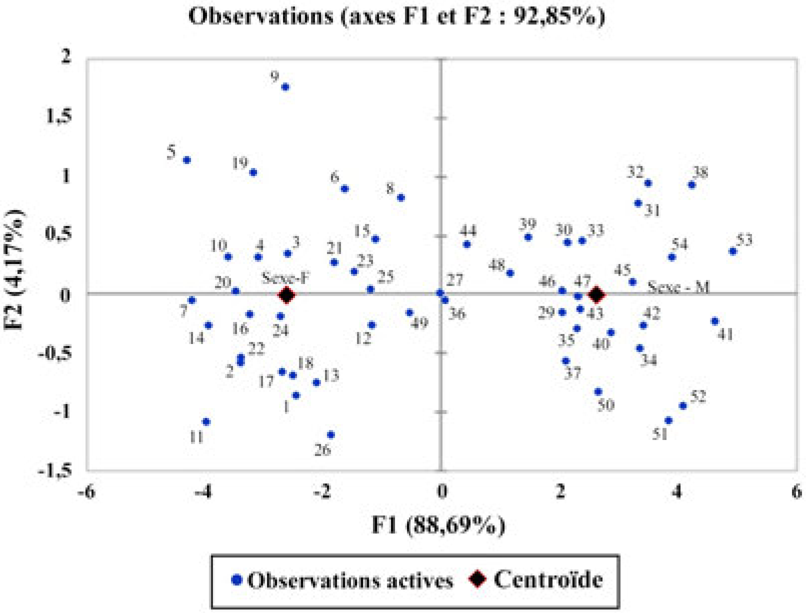


FIGURE 4b

ACP sur les 9 variables du tarsométatarse (52 individus), plan factoriel I-II (Observations).

La répartition des mâles et des femelles se fait principalement selon l'axe I qui représente un axe de taille, alors que l'axe II qui est un axe de forme ne permet aucune distinction des individus des deux sexes. Le cercle des corrélations permet de visualiser que l'ensemble des 9 variables linéaires du tarsométatarse est très fortement corrélé à cet axe et que donc toutes concourent à discriminer les mâles des femelles. Les plus corrélées à l'axe I sont 5 (distal depth), 3 (proximal depth), DD (greatest distal diagonal) et G (depth of midshaft), et les plus corrélées à l'axe II sont 6 (breadth of midshaft) et KB (smallest shaft breath) positivement et GL (greatest length) et Bp (greatest proximal breadth) négativement.

Ces résultats se retrouvent pour chaque os et également de la même manière lorsque l'on analyse de front les 72 variables linéaires des 9 os de l'étude (Figure 5).

L'analyse discriminante menée sur chacun des os à partir d'une régression logistique permet de lister les variables significativement les plus discriminantes entre les mâles et les femelles. Une série de 22 variables linéaires a donc été ressortie de façon statistique (Tableau 6). Le taux d'individus mal classés à partir de chacune de ces variables discriminantes est très faible et varie de 0% (Bp du carpométacarpe et G du tarsométatarse) à 18,5% (6 du radius). En moyenne, pour ces mesures discriminantes, le taux de reclassement est particulièrement bon, puisqu'il est d'environ 90% ce qui fait que seuls entre 2 et 3 individus mâles et femelles sont mal reclassés sur la cinquantaine que compte l'échantillon. A chaque fois, les graphiques replaçant les individus mal classés nous indiquent qu'ils sont proches de la valeur discriminante, ce qui sous-entend qu'il peut s'agir d'animaux sub-adultes (jeunes mâles par exemples) qui se mélangent avec les femelles ou de grosses femelles qui tombent dans la zone de variabilité des mâles.

DISCUSSION

Dans la littérature aviaire, certaines mesures peuvent être très voisines d'un auteur à l'autre, mais ne pas forcément être homologues. Afin de ne pas rajouter au biais lié à l'opérateur, celui de l'interprétation de la réalisation des mesures, il est apparu important d'expliciter l'ensemble des mesures réalisées dans la partie matériel et méthodes, même si cela alourdi le travail, de même qu'indiquer la correspondance avec les travaux de référence en ostéologie aviaire que sont ceux de Erbersdobler (1968), Kraft (1972), Mourer-Chauviré (1975) et Driesch (1976) (Tableau 1). Toujours dans l'esprit que ce travail puisse avoir un intérêt pratique pour l'archéozoologue, les graphiques bivariés les plus classiquement utilisés sont présentés, afin de permettre de positionner rapidement tout individu

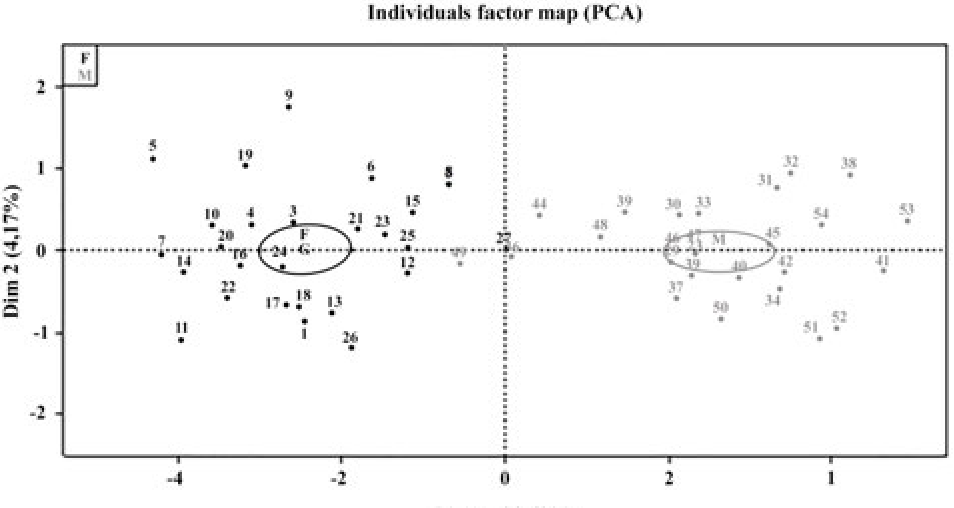


FIGURE 5

ACP sur les 72 variables linéaires des 9 os (52 individus) : plan factoriel I-II. En noir : les femelles (à gauche de l'axe I) et en gris clair les mâles (à droite de l'axe I). L'ellipse de confiance à 95% de chaque sexe est représentée.

supplémentaire. Les valeurs seuil entre mâles et femelles permettent ainsi de sexer de façon visuelle à partir de ces graphiques (Figure 3a-h).

Cette étude sur les principaux os des membres et de la ceinture du membre thoracique du Faisan de Colchide constitue un référentiel ostéométrique pour les Galliformes. Il devra être étendu à d'autres espèces, mais il met en évidence que l'ensemble des 72 variables linéaires retenues sont toutes excessivement bien corrélées entre elles. Il devient donc possible de réduire la matrice de départ à quelques mesures pertinentes, de façon à arriver à deux, trois ou quatre mesures maximum par os pour chacun des neuf os étudiés. En essayant de garder les variables les plus dimorphiques statistiquement, afin de séparer au mieux les deux sexes, l'analyse discriminante nous permet de passer de 72 mesures initiales par animal à 22 variables (Tableau 6).

En archéozoologie, l'opérateur doit en effet intégrer des contraintes qui ne recoupent pas forcément les analyses statistiques. Ainsi, certaines mensurations, bien que pertinentes mathématiquement, ne sont pas forcément faciles à mesurer (petitesse de certaines mesures), peuvent parfois poser des problèmes d'identification sur du matériel fragmenté (par exemple, la plus petite largeur de la diaphyse) ou sont rarement réalisées dans la littérature, en dehors des variables normées par Driesch (1976) utilisées par le plus grand nombre. Aussi, les variables retenues, si l'on se limite à deux mesures par os, seront différentes (Tableau 2) et limitées à 18. Il est intéressant de noter que si l'on compare les résultats obtenus par les deux méthodologies de travail (ACP à partir des 22 variables les plus discriminantes d'un côté et ACP à partir des 18 variables choisies par l'archéozoologue de l'autre), les résultats sont quasiment identiques (Figure 6).

Un paramètre osseux a été éliminé pour la réalisation d'un référentiel pour l'archéozoologie, il s'agit de la masse. Ce critère a en effet été mesuré sur notre échantillon et pourra être comparé pour des populations actuelles. Dans le cas d'os archéologiques provenant de plusieurs contextes ou de plusieurs sites en revanche, la distorsion induite par la conservation différentielle et principalement la minéralisation qui peuvent être très différentes d'un lieu à l'autre, font que cette mesure n'est pas opérante.

Si l'on compare le dimorphisme sexuel rencontré dans ce travail à ce que l'on a l'habitude de

Os	Variable	Valeur Discriminate	Nombre d'individus mal classés		Taux d'erreur
			Femelles	Mâles	
Scapula	GL	75,07	2	1	0,056
	G	2,87	3	5	0,148
Coracoïde	Lm	49,35	4	1	0,098
	3	6,95	2	3	0,093
Humérus	GL	72,29	3	2	0,093
	SC	6,61	4	5	0,167
	5	8,18	1	1	0,037
	6	7,01	3	5	0,148
Radius	GL	58,72	3	3	0,111
	KT	3,34	4	4	0,148
	DP	5,54	1	1	0,037
	6	3,57	4	6	0,185
Ulna	GL	65,18	2	3	0,093
Carpométacarpe	Bp	11,61	0	0	0,000
	Did	7,29	2	2	0,074
Fémur	Bd	14,36	1	2	0,056
	SC	6,51	6	5	0,204
Tibiotarse	GL	108,15	2	2	0,074
	La	105,36	2	2	0,074
	G	5,08	6	6	0,222
Tarsométatarse	5	7,52	3	2	0,096
	G	5,92	0	0	0,000

TABLEAU 6

Variables statistiquement les plus discriminantes pour chaque os (modélisation par régression logistique).

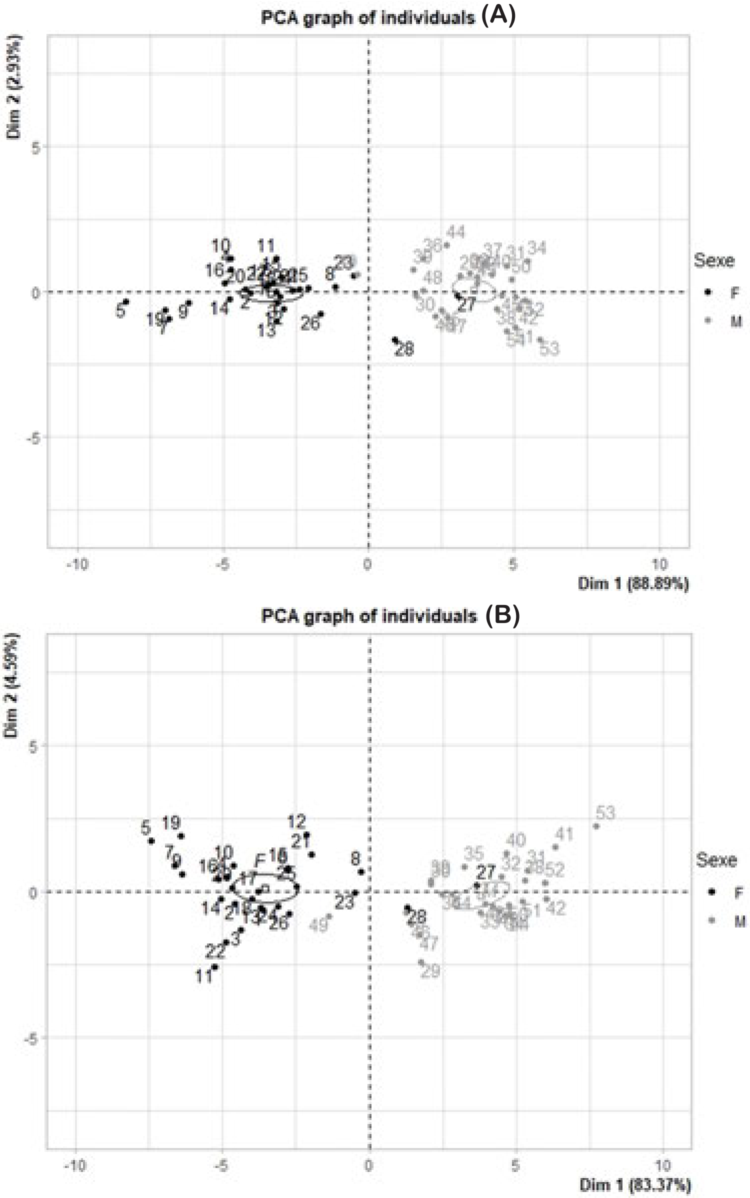


FIGURE 6

ACP (9 os, 52 individus), plan factoriel I-II, A : sur les 22 variables linéaires les plus discriminantes ; B : sur les 18 variables linéaires choisies par l'archéozoologie.

trouver dans la littérature, notamment pour les oiseaux (Lewis, 1999; Froget, 2003; Guillet, 2003; Visse, 2003; Joly *et al.*, 2014; Manin *et al.*, 2016), le Faisan de Colchide semble une espèce dont le dimorphisme sexuel au niveau osseux est important et permet de sexer assez facilement les animaux à partir des principaux os du squelette. Sans aller jusqu'à une séparation quasi parfaite comme celle rencontrée pour la tête osseuse chez le Cormoran huppé ou le Plongeon catmarin (Joly *et al.*, 2014), la superposition entre certains individus mâles et femelles est de l'ordre de ce que l'on peut observer chez le Goéland argenté. Chez certaines espèces, comme la Mouette tridactyle, le dimorphisme sexuel est beaucoup plus difficile à mettre en évidence, voire quasi impossible dans d'autres encore

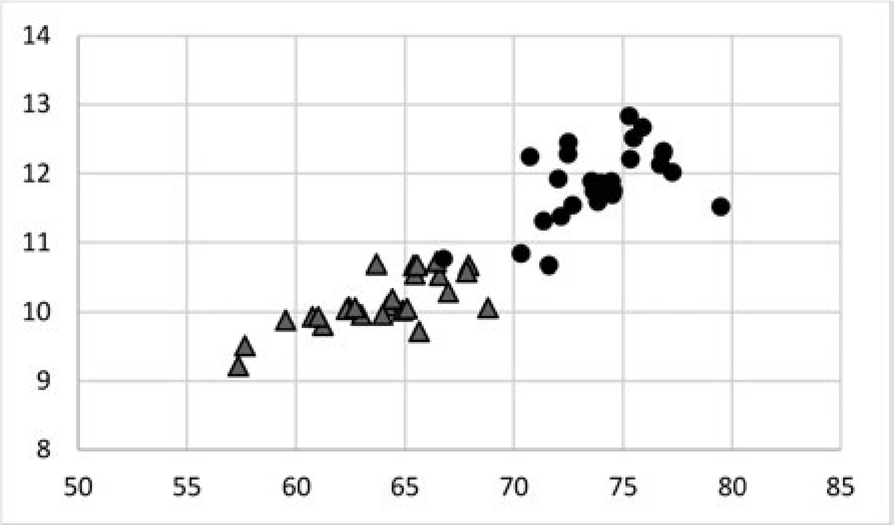


FIGURE 7

Graphique bivarié sur les variables les plus discriminantes pour l'archéozoologie (GL=f(Bd)) du tarsométatarse (n=52) ; en rond noir, les mâles, en triangle gris les femelles.

tant les mâles et les femelles ont des os indifférenciables, comme pour le Guillemot de Troïl ou encore le Pingouin Torda.

Dans le cas de l'analyse discriminante qui a été menée, pour chaque variable (Tableau 6), le graphique (Figure 7) montre que les individus mal classés sont proches de la valeur discriminante, ce qui sous-entend qu'il peut s'agir d'animaux subadultes (jeunes mâles par exemples) qui se mélangent avec les femelles ou de grosses femelles qui tombent dans la zone de variabilité des mâles. Ainsi, sur la figure 7, le mâle 39 ressort très nettement parmi le groupe des femelles. Il s'agit d'un individu de petit format, très probablement un subadulte, étant donné sa masse.

CONCLUSION

Ce travail met à disposition des chercheurs des données ostéométriques relatives à de nombreux individus pour le Faisan de Colchide. La réalisation de ce corpus autorise l'étude de la variabilité des mesures au sein d'une espèce et permet de qualifier le dimorphisme sexuel. Elle démontre que l'analyse est aussi discriminante entre les deux sexes à partir des 18 ou 22 mesures sélectionnées qu'avec les 72 mesures linaires de départ. Cette approche a été réalisée également dans l'intérêt de servir de référentiel pour une espèce proche au sein de la famille des Phasianidés qu'il est souvent difficile d'appréhender tant sa variabilité est à l'heure actuelle importante, mais qui est fréquente sur les sites archéologiques, la poule. Il conviendrait de tester cette méthode sur des races actuelles ou sur des corpus archéologiques fournis. Les corpus de référence, pour la poule domestique font en effet cruellement défaut en archéozoologie pour les périodes historiques et quelques rares études ont été menées sur des races actuelles (MacDonald, 1992; Marguerie, 2002; Lelièvre, 2005; Borvon, 2012; Peters *et al.*, 2016).

Les résultats sont ici tout à fait probants quant à la différenciation des mâles et des femelles sur la base de mensurations relativement simples à mettre en œuvre. Appliqué à la poule, l'intérêt de ce protocole résiderait dans une meilleure approche des modalités d'élevage sur les sites archéologiques, ainsi que des modalités de capture pour les espèces sauvages comme les perdrix.

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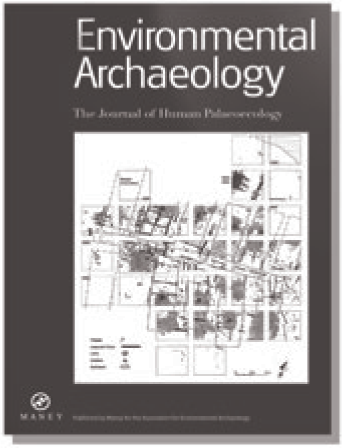
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