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# ‘Vertebrates’ an application dedicated to vertebrate osteology

par [Marie Meister, Rose-Marie Arbogast & Samba Soussoko](#) · Publié 08/04/2024 · Mis à jour 09/04/2024

## Background

Zooarchaeology is the branch of archaeology that studies faunal remains from excavated sites, and infers on the past relationships between humans and animals. The field dates back to the second half of the 19th century (Rüttimeyer, 1861) and has developed momentum over the last decades. It has now become a complex and potent discipline, which lies at the interface between several fields of research: history, zoology, anatomy, ethnology and molecular biology with the emergence of genetics and biogeochemistry.

Usually the animal remains found at excavation sites are bones, teeth, shells and sometimes other perishable organic matter such as feathers. These remains should be first identified anatomically and then taxonomically: which animal did they belong to, what was its sex, age, size, health condition... To address these issues when studying bones, zooarchaeologists use ‘bone libraries’, where comparative osteological collections from all known wild and domestic Vertebrate species are gathered and can be consulted (Barone, 1976; Pales & Lambert, 1971; Pales & Garcia, 1981; Schmid, 1972). In Strasbourg, such a library, the *ostéothèque*, was developed, starting in 2009, from the collections of the Musée Zoologique de Strasbourg, where it is housed today. The collections of the museum are of broad taxonomic and geographic origins (Meister *et al.*, 2019) and comprise a large number of mammalian skeletal pieces (from > 6000 specimens). A number of them are complete skeletons, mostly unmounted. Several of these ensembles were used to start and to develop the ‘[Vertebrates](#)’ project which is described below.

The project started most casually with a challenge thrown during a 2017 conversation about zoological tools. One of us (Samba) was developing an application that investigates the phylogenetic relationships among living organisms. While discussing the topic, Rose-Marie asked whether it was possible to scan/model a bear tibia in order to use it as a comparison tool! This was the beginning of the story. The application was born with two major objectives. On the one hand it was conceived as a guide for comparative anatomy based on pairwise comparisons of structures with shared evolutionary origins. On the other hand it was designed as a field tool for archaeologists. These ambitions converged with the production of the *Vertebrates* application, online since 2019. The project initially focused on Vertebrates, mostly Mammals, with the digitisation, bone by bone, of several skeletons, to constitute a 3D osteology atlas. The number of specimens added to the virtual library increases constantly, and the project should diversify in the future to explore other branches of the Metazoan tree, which includes all animal species in a tree reflecting their genealogical relationships.

## Description of the process

*Data capture*: surface topology data are generated from individual bones either by photogrammetry or by lasergrammetry. Both methods produce a 3D model that reproduces the outer shell of the bone. The size limit for these methods is 0.5 cm per bone, therefore they

are used for medium to large size animals. Smaller specimens cannot be digitised in this manner, they are instead captured by tomodesitometry scanning (by CT-scan) which generates 3D data of whole skeletons by density layers. The data are then converted into a 3D model object.

*Data optimisation:* the data obtained by any of the three techniques are subsequently optimised, first by adapting the number of polygons that define the 3D model, then by introducing colour information where necessary. In the case of CT-scan models, we create textures based on the high definition model topology.

*Data enhancement:* for each specimen, individual bones are mounted virtually into a complete 3D skeleton, taking into account all anatomical connections and joints. For some of them the skull is virtually dissociated into all distinct bones that compose it (fig. 1). A set of metadata is added that gives information about the taxonomic group the specimen belongs to, as well as about the evolutionary homologies (i.e. structure similarities in different species of organisms based upon their descent from a common ancestor) of its components. They can also tell the history of the digitized specimen itself.



Fig. 1: Visualisation of the mounted skeleton of a giraffe (*Giraffa camelopardalis* MZS Mam11097, Musée Zoologique de Strasbourg), with a skull where all individual bones are highlighted.

The virtual specimen is integrated in a 3D viewer that provides many interactive tools. It is thus possible to manipulate bones in 3D, to measure lengths, angles, to highlight pairwise homologies with structures from other specimens (fig. 2, fig. 3, fig. 4, fig. 5), to distinguish individual skull bones etc. The progressive addition of new specimens to the application contributes to continuous improvement of data.

The online version of the 'Vertebrates' application is freely available on a dedicated website ([vertebres3d.fr](http://vertebres3d.fr)) and will work with any web browser. But users can also get access, by simple registration, to offline Windows, OSX or Android installations.



Fig. 2: Comparison between the humeri from a duck and a horse.

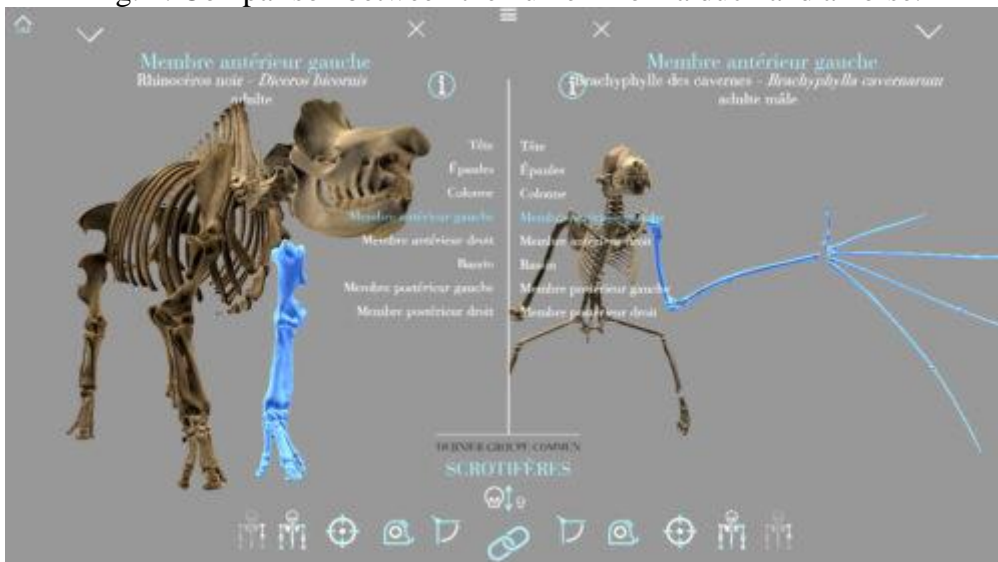


Fig. 3: Homologies between anterior members in two Vertebrate species: a rhinoceros (*Diceros bicornis* MZS Mam11260, Musée Zoologique de Strasbourg), and a bat (*Brachyphylla cavernarum*, University of Bordeaux).



Fig. 4: Visualisation of the distinct skull bones from a leopard seal (*Hydrurga leptonyx* MZS Mam04544) and a South American sea lion (*Otaria flavescens* MZS Mam11224).

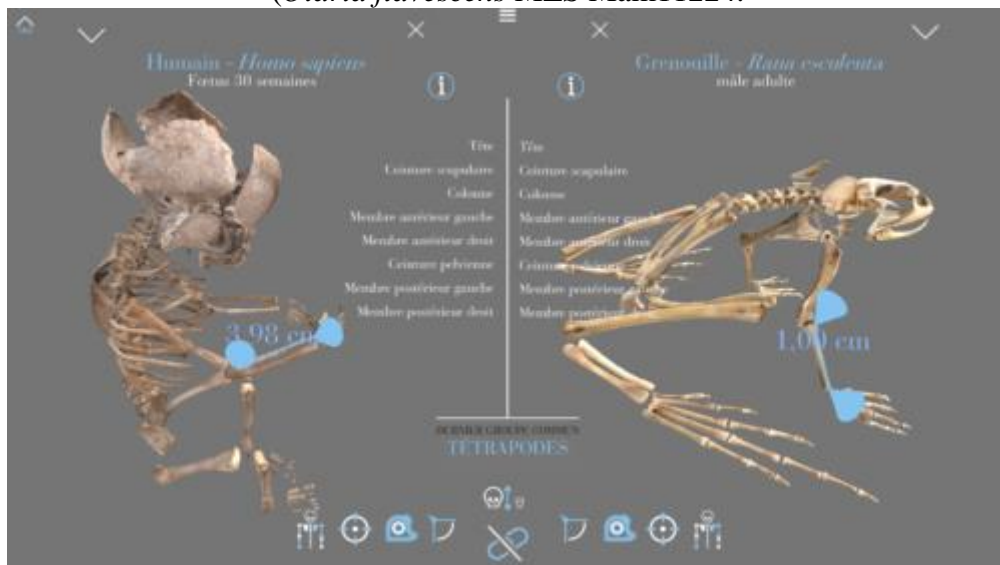


Fig. 5: Measurements of the forearm length in two specimens: a human foetus and a frog.

Thirty two mounted specimens are currently available (fig. 6). They include several Primates (humans, western gorilla, chimpanzee, Guinea baboon, orangutan), Carnivores (dog, European bear, Eurasian lynx, European otter, seal, sea lion), Ruminants (cattle, goat, saiga antelope, chamois, moose, giraffe), Perissodactyls (horse, black rhinoceros), a hippopotamus, an Arnoux’s beaked whale, a bat (Antillean fruit-eating bat), a platypus, a Bird (mallard duck), an Amphibian (edible frog) and a bony fish (ray-finned fishes: meagre).



Fig. 6: Screenshot of the entry page of the application.

The application also displays nine additional Primate skulls, and several fossils (fig. 7), including the remains of Lucy the australopithecine.



Fig. 7: Skeleton of a fossile iguanodon (*Iguanodon bernissartensis*, Institut des Sciences naturelles de Belgique).

The material was provided by the Musée Zoologique de Strasbourg, Archéologie Alsace, the Putelat collection, the University of Bordeaux, the Museum of Comparative Zoology of Harvard, the Musée national d'Histoire Naturelle du Luxembourg and the Muséum National d'Histoire Naturelle in Paris.

### **What are the advantages of *Vertebrates*?**

They are multiple. A first advantage is that the zooarchaeologist can access a reference library in a remote place where no bone library has ever set foot! She/he can access an ever-growing number of species which would not necessarily be present in local 'real' libraries (how many contain all reference rhinoceros bones for example?). The application is also meant as a ready-to-go library to be used as a field tool, directly on the excavation site. From the curator's point of view, it is important to note that the application is non-invasive for the bone collection of the library. The reference bones used here are virtual, therefore the real bones (sometimes valuable, often fragile) are safer. They do not have to be handled repeatedly which eventually contributes to their degradation. The tools offer a number of peripheral possibilities for archaeologists, such as measurements, pairwise comparisons of homologous bones from different species, and for skulls the possibility to split them into all their components for better visualisation of individual bones.

If we consider a broader use than for zooarchaeologists only, the application should be useful for teaching to illustrate the evolutionary history of vertebrates with concrete examples. It allows a visual comparison of structures that share the same evolutionary origin. One example could be the variations of the anterior member between an antelope, a bat, a whale and a human. Another recently developed tool is the comparative locomotion module including walk cycles for five Primates highlighting the way they rely on their limbs and spine (fig. 8). Such possibilities could be a support at various academic levels, from middle and high schools to veterinary, anatomy, biology or zoology courses.



Fig. 8: 3D animation of comparative locomotion for five Primates: baboon, chimpanzee, orang-utan, human and gorilla.

From a more practical point of view, the application allows the virtual mounting of the specimens which have been individually scanned from a set of bones that are not supposed to be mounted immediately. Mounting of skeletons is a delicate and expensive process which is only achieved for specimens to be displayed, such as in a museum. Most skeletal remains in collections are stored in bulk with minimal encumbrance since space is always limited in museum storage places. From a more practical point of view, the application allows the virtual mounting of the specimens which have been individually scanned from a set of bones that are not supposed to be mounted immediately. Mounting of skeletons is a delicate and expensive process which is only achieved for specimens to be displayed, such as in a museum. Most skeletal remains in collections are stored in bulk with minimal encumbrance since space is always limited in museum storage places. Last but not least, as the application is available online to anybody interested, it offers the lay public an opportunity to visit a small but thorough museum from their sofa!

## Conclusion and future directions

Today 32 complete specimens have been digitised, i.e. over 6000 bones, and are fully integrated in the application. Several additional skeleton scans were recently included: hippopotamus, seal, sea lion, platypus... all from the Musée Zoologique de Strasbourg, and several fossils. The project will now focus on Bird diversity and development. A future ambition will be to develop the same comparative approach with Arthropod species, obviously no 'Vertebrates' items! Since these animals exhibit an exoskeleton with conserved features across all taxa (spiders, insects, centipedes, crabs etc) and make up the vast majority of animal species on earth, it will be challenging to investigate their organisation with relevant examples. Most specimens will clearly be small and difficult to handle, but the use of CT-scan should provide the possibility to explore the field, starting with larger models (crabs, stag beetles or horseshoe crabs for instance). It would also add new references to the virtual library, useful namely for archaeoentomologists. The development of the 'Vertebrates' tool sheds light on the benefits that can be drawn from the curation of ancient natural history collections: it would not have been possible without them. Digitisations of samples from such collections are currently developed in many museums worldwide for various purposes and illustrate their value as a memory of past biodiversity.

**Partners** are: Laetoli Production, UMR 7044 Archimède du CNRS, Archéologie Alsace, Muséum National d'Histoire Naturelle de Paris, Royal Belgian Institute of Natural Sciences in Brussels, Musée d'Histoire Naturelle du Luxembourg.

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## Bibliographie

Barone, R., 1976. *Anatomie Comparée des mammifères domestiques*. Tome 1 : Ostéologie (2 fascicules). Paris : Vigot Frères.

Meister, M., Ludes-Fraulob, E., Koenig, P., Carita, D., Wandhammer, M.-D., 2019. The Bird collection of the Museum of Zoology in Strasbourg. *Alauda*, 87, 111-126.

Pales, L., Garcia, M. A., 1981. Atlas ostéologique pouvant servir à l'identification des mammifères du Quaternaire II. Tête, rachis, ceintures scapulaire et pelvienne. In : *Carnivores et Homme, Herbivores* (1 vol., 177 pl.). Paris : Éditions du CNRS.

Pales, L., Lambert, C., 1971. Atlas ostéologique pouvant servir à l'identification des mammifères du Quaternaire Ia. Les membres : Herbivores ; Ib. Les membres. In : *Carnivores* (2 fascicules, 84 et 48 pl.). Paris : Éditions du CNRS.

Rüttimeyer, L., 1861. *Die Fauna der Pfahlbauten in der Schweiz – Untersuchungen über die Geschichte der wilden und der Haus-Säugethiere von Mittel-Europa*. Bahnmaier, Bâle.

Schmid, E., 1972. *Atlas of animal bones for prehistorians, archaeologists and quaternary geologists*. Amsterdam, London, New-York : Elsevier publishing Company.

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Citer ce billet

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<https://bioarcho.hypotheses.org/2260>