

An expert system to help taxonomic classification in avian archaeology: a first attempt with bird species from Tierra del Fuego

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Received: 11 Sep., 2001

Accepted for publication: 26 Feb., 2002

ESTÉVEZ J., MAMELI L., GOODALL N. 2002. An expert system to help taxonomic classification in avian archaeology: a first attempt with bird species from Tierra del Fuego. In: Proceedings of the 4th Meeting of the ICAZ Bird Working Group Kraków, Poland, 11-15 September, 2001. *Acta zoologica cracoviensia*, 45(special issue): 383-391.

Abstract. This paper presents a computer system designed to help archaeozoologists and archaeologists in the identification of bird bones. As an example we have chosen the southernmost American bird species of Tierra del Fuego in Argentina, where our main zooarchaeological work has been achieved.

Key words: Avian osteology, identification, self help expert system.

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I. INTRODUCTION

Taxonomic classification is the first step for avian archaeology. Anatomical and specific classifications are based on the analysis of morphological and biometrical trends. Through the comparison of overall morphology and the consideration of specific characters and measurements, we can arrive at a diagnosis. The great number of bird species and the slight differences between them signifies that bird bone identification is more difficult than that of mammal bones. Overall the number of Argentinean birds includes 82 Families and over 1000 species (NAROSKY & YZURIETA 1993). Tierra del Fuego, the region we deal with in this paper, has a total of 44 Families and over 198 common species. It is even more discouraging to note that biologists have problems determining the correct taxonomy of living species. For example, a problem has arisen in the separation of the cormorants of Tierra del Fuego. See for instance the different opinions regarding the King Cormorant *Phalacrocorax albiventer* (LESSON, 1831) and the Blue Eyed Cormorant *Phalacrocorax atriceps* KING, 1828 in OLROG (1984) and CLARK (1986). The problems increase if we attempt to determine a species from its bones.

We did not even have a complete avian osteological reference collection at our disposal in Argentina. It is impossible to have a good reference collection and a good avian archaeozoologist at every site. This is why we believe it would be very useful to have an instrument for preclassification

and to help with information management. Instead of a classical atlas (e.g. COHEN & SERJEANTSON 1996; GILBERT et al. 1981) we propose a new computer identification assistance system to help the specialist and the field archaeologist to approach the data. As with the regular task of species identification the expert system will manage morphological features of an osteological collection as well as size criteria (BARCELÓ 1996). Hence it is based on a picture and on a measurement database. This idea was proposed by ESTÉVEZ (1991) some years ago. At that time, the computer video card hardware produced black and white images, and we only had access to slow and low capacity computers. We first developed a system that had a measurement database and a reduced pictorial database of European species. A series of algorithms showed the place of a specimen in the measurement universe of the database by plotting univariate bar diagrams for each measurement and bivariate scattergrams for pairs of measurements. We also included the choice of drawing histograms for known species measurements compared to the specimen in question. This system could link measurements and statistical plots to a black and white picture of the bone. The system was supported by a Classic Apple Computer with a 40 Mb hard disk, a videocamera digital-image capturing device, and was managed by a specifically written BASIC Program. A problem encountered was the relative slowness of the system. The complicated integration of different components made the system hermetic. The poor quality of the image capturing systems available in the early stages of development of our system was disappointing.

Today speed of computers, the possibility of taking them to the field, the availability of cheap and powerful digital cameras, and the widespread nature of standard programs to handle databases and to process images allowed us to improve our earlier system.

Our new system arose from our archaeological research and avian osteological identifications in Tierra del Fuego (Fire land), Argentina. Over the recent years (ESTÉVEZ & VILA 1995), more than 13,000 bones have been recovered from just a single site, Tunel VII (MAMELI 2000). In Tunel I 10 times more bird bones were recovered. The need for a computer assisted taxonomic device is evident.

We developed this system using the osteological collection from the Acatushún Museum in Harberton, Tierra del Fuego. This collection contains one of the largest samples of marine mammals and birds of the southern extreme of South America. It has been built over twenty-six years, starting in 1976, by N. GOODALL. Founded by the Goodall Foundation and other private institutions. It offers the biggest cetacean bone collection in the world. A large osteological sample from 2200 mammal and 2000 bird specimens from the southernmost South-American islands and seas are kept in the Museum.

A c k n o w l e d g e m e n t s. This paper is a result of the research project "Computer Assisted Visualization of Archeological Material", which is being developed at the Universitat Autònoma de Barcelona. The Project is funded by the Spanish Ministry of Education and Culture (project PB.98.0088). Frank DIRRIGL has made a very helpful set of comments and specially a lot of corrections of the "spanglish" manuscript to improve it and to make it readable for native English speakers.

II. BUILDING THE EXPERT SYSTEM

Our present approach was developed to avoid the inflexibility of our earlier system version. We have constructed a flexible system by using independent components. You can use the system as a whole or only part of it, improve new capabilities or increase and change the databases.

The expert system contains two basic modules: A Picture Database and a Measurement Database. Both are linked to a general skeleton with program scripts, which connect further to different modules. To the skeleton scripts we can attach several algorithms or standard statistical packages to assist the researcher with taxonomic classification based on a specimen's fit within a range of measurements. With each new identification the specimen's measurements can be added to the database to improve the systems ability to suggest an identified taxon.

Each user of the system can modify, attach or use different statistical, self-developed procedures, or commercial third part programs. Each module or commonly available software can be linked or detached from the basic skeleton.

P i c t u r e D a t a b a s e

At present the database contains the pictures of the major long bones of commonly recovered species from Tierra del Fuego. Colour pictures include cranium (lateral, dorsal, caudal, ventral views), mandibula (dorsal, lateral), sternum (lateral, ventral), scapula (lateral, costal), furcula (caudal), coracoid (lateral, cranial), humerus (cranial, caudal), radius (cranial, caudal), ulna (cranial, caudal), carpometacarpus (cranial, caudal), synsacrum-pelvis (ventral, dorsal, lateral), femur (cranial, caudal), tibiotarsus (cranial, caudal), and tarsometatarsus (dorsal, plantar). In some cases, we have added additional views.

The picture resolution allows visualization of each element to at least natural size on the screen. Some of the elements, faces and detail can be enlarged for 2x, 4x and 5x avoiding pixeling. A scale is included to avoid the distortion produced by different computer resolutions and screens sizes.

We took the pictures with a standard Sony Mavica© camera, which is user friendly and disposes very strong macro photography capability. The raw images were cleaned and fixed scaled (in 72 ppi) with a centimeter reference using Adobe Photoshop© and saved in a TIFF format. We believe there has to be (at least now) a compromise between image definition and file size because of the speed and carrying capacity considerations (e.g. the program and data-bases need to be stored on a single CD). For birds smaller than 20cm, not yet extensively included, macroscopic images with higher magnification are needed.

M e a s u r e m e n t D a t a b a s e

Currently we completed standard measurements for the major bird species of Tierra del Fuego, based on the system proposed originally by MOURER-CHAUVIRÉ (1975). We followed this approach because it was the one used (ESTÉVEZ 1979; VILETTE 1983) for the study of Pleistocene birds of Catalonia (Spain) and in our first system (ESTÉVEZ, 1991). This descriptive system is also used in other analyses of bird bones from sites in Tierra del Fuego by LEFÈVRE (1989). It has some deviations from the main widespread system of von den DRIESCH (1976), but it coincides for most measurements. Naturally, it would be optimal if we could develop a step wider and extract more discriminant measurements for some problematic distinctions of fuegian avian osteology (e.g., for distinguishing ducks or sexual dimorfism). However we planed to attach this new information as a module in future releases of the system.

New measurements were taken using a digital caliper and an import program created by us. Data are stored in a standard Microsoft Excell™ sheet linked to the system skeleton. This allows, very easily, the enlargement of the measurements database, inserting data published in references.

S t a t i s t i c a l p r o c e d u r e

The expert system utilizes a simple statistical algorithm that compares the measurements of an unknown specimen with the measurement data in the database. We adopted this solution after reviewing the use of size index scaling techniques for research on archaeozoological collections from the Middle East (MEADOW 1999). If this system can discriminate between domestic and wild mammal stock, then we believed, it could be also useful for birds. Additionally, we have completed more sophisticated multivariate analyses that helped us in the distinction between bones of different penguin or cormorant species. But in most cases a less sophisticated procedure is enough to show the distinction of the questioned specimens. Therefore our system is linked with a bar-diagram procedure for single measurements and with a bivariate scattergram for measurement combinations.

L i n k s

Figure 1 shows the different levels that lead a researcher towards a preliminary identification based on visual and measurement data provided by the expert system. The following descriptions guide the user through the different steps. First the program asks the user what element of the skeleton they want to classify. This can be answered by clicking on a very simple graph (Fig. 2). The next screen shows how the measurements must to be taken and requires the user to input any possible

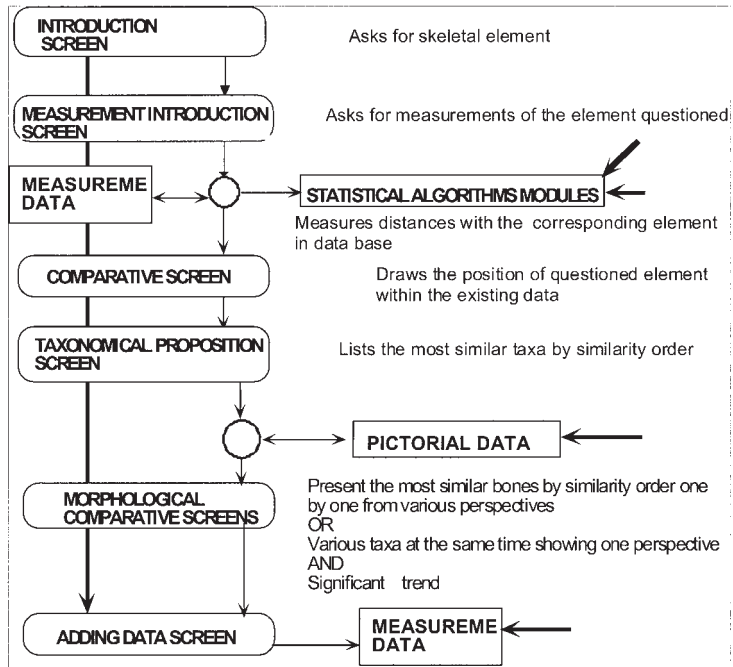


Fig. 1. Expert System's Flow Diagram.

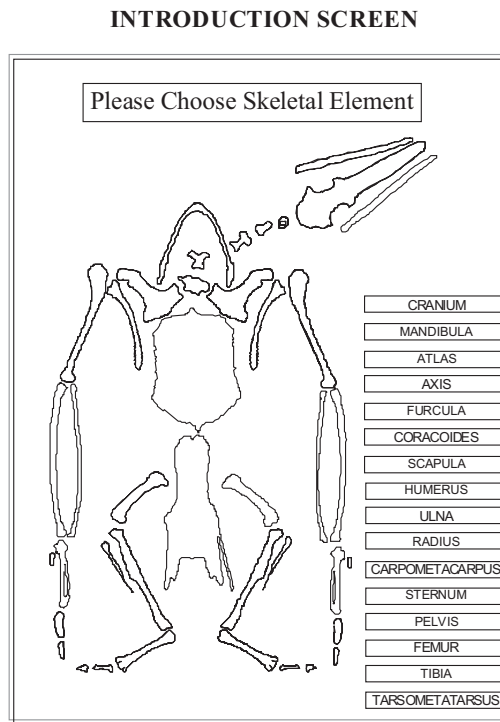


Fig. 2. First Screen: asking for the element you want to classify.

ones (Fig. 3). The comparison program runs next, which takes the measurements of the database and calculates an absolute sum of Log ratio distances to the input measurements. Although the program can run only with some of the requested measurements, the more measurements input the more reliability it acquires. Finally a list of species is ranked in the order of probability based on the distance between the measurements you have entered and those in the database (Fig. 4). Alternatively, a simple bivariate scattergram graph can be chosen were the new entered specimen is plotted against the database measurements (Fig. 5). A link to a more sophisticated multivariate graph can

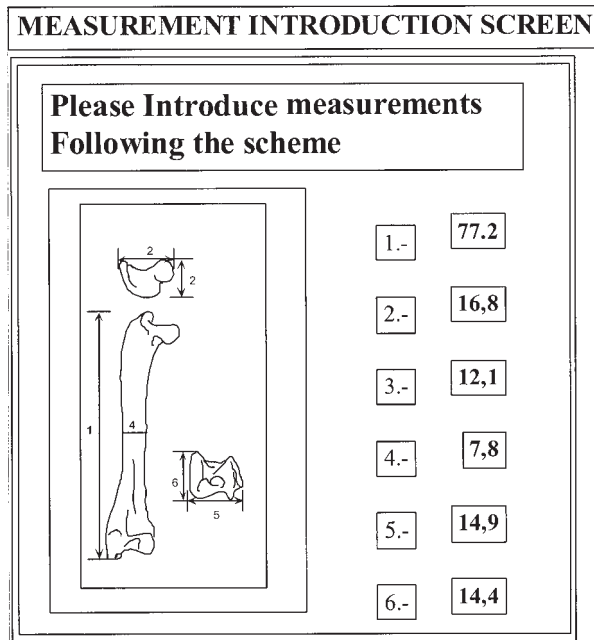


Fig. 3. Introducing measurements.

also be included. The pictures of the corresponding bones can be viewed in order of probability, which allows for morphological comparisons (Fig. 6). At any time, the user can examine different perspectives available in the image-database or, alternatively, select a comparative screen showing the same bone of different species (Fig. 7). Finally, the researcher can recall the most significant morphological traits on the pictures displayed (Fig. 8). As the pictures are saved in standard TIFF formats, the pictures can be edited to add more significant features detected or important to a researcher's current work.

On a satisfactory determination, you can add the measurements you have taken to the measurement database. Thus the system can be expanded including each newly classified or saved specimen.

III. REMARKS

After further exploring the difficulties and testing the performances of our system, we will be able to expand or improve it to include other geographical areas and/or bird species. The major goal of the system is to assist researchers with the initial comparative osteology of birds. Consequently,

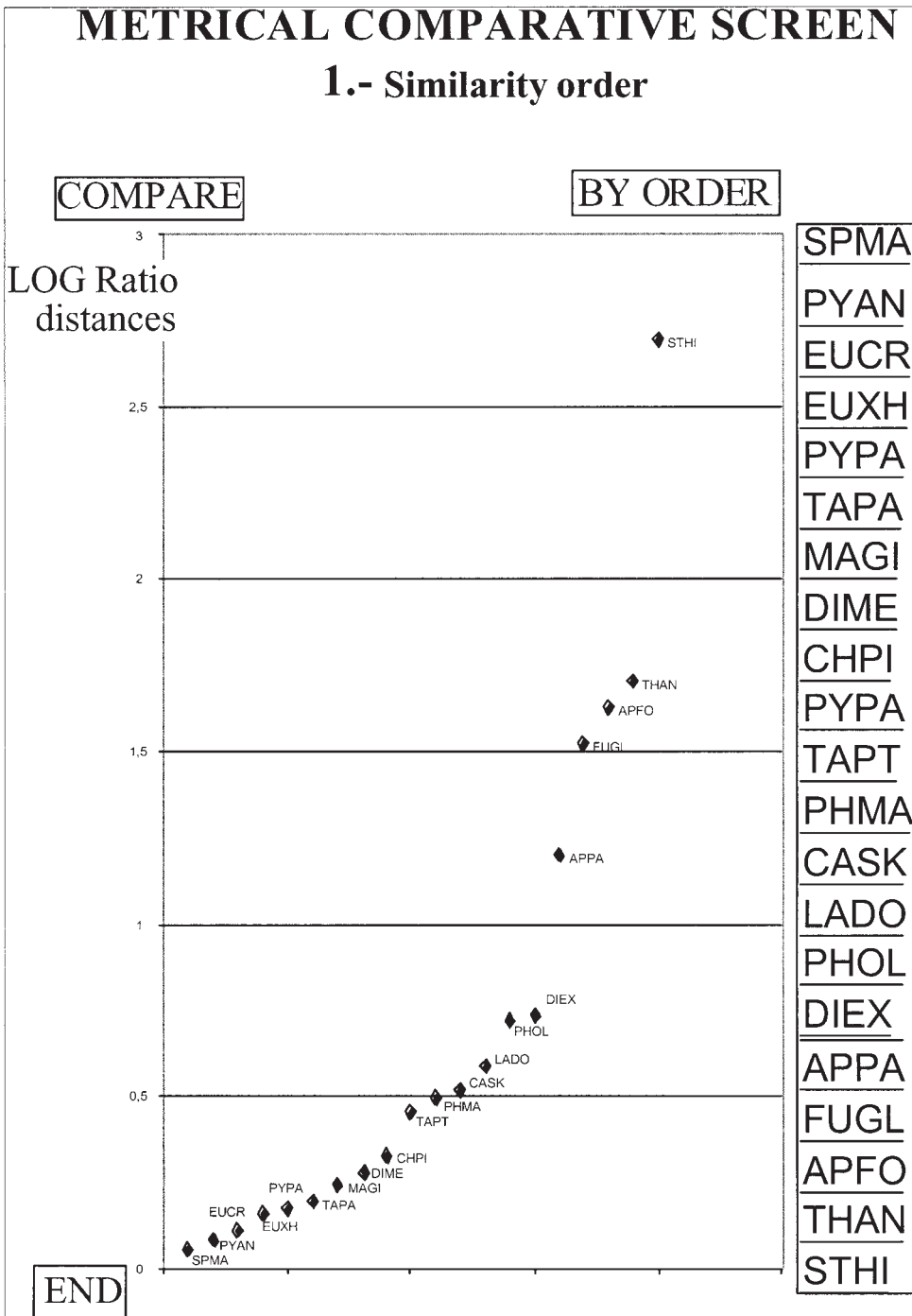


Fig. 4. Comparative Screen. Calculating and plotting the absolute sum of the Log ratio distances of the specimen to be identified to the database sample of specimens. The column at right show the acronyms composed by the two first letters of each word of the species nomina.

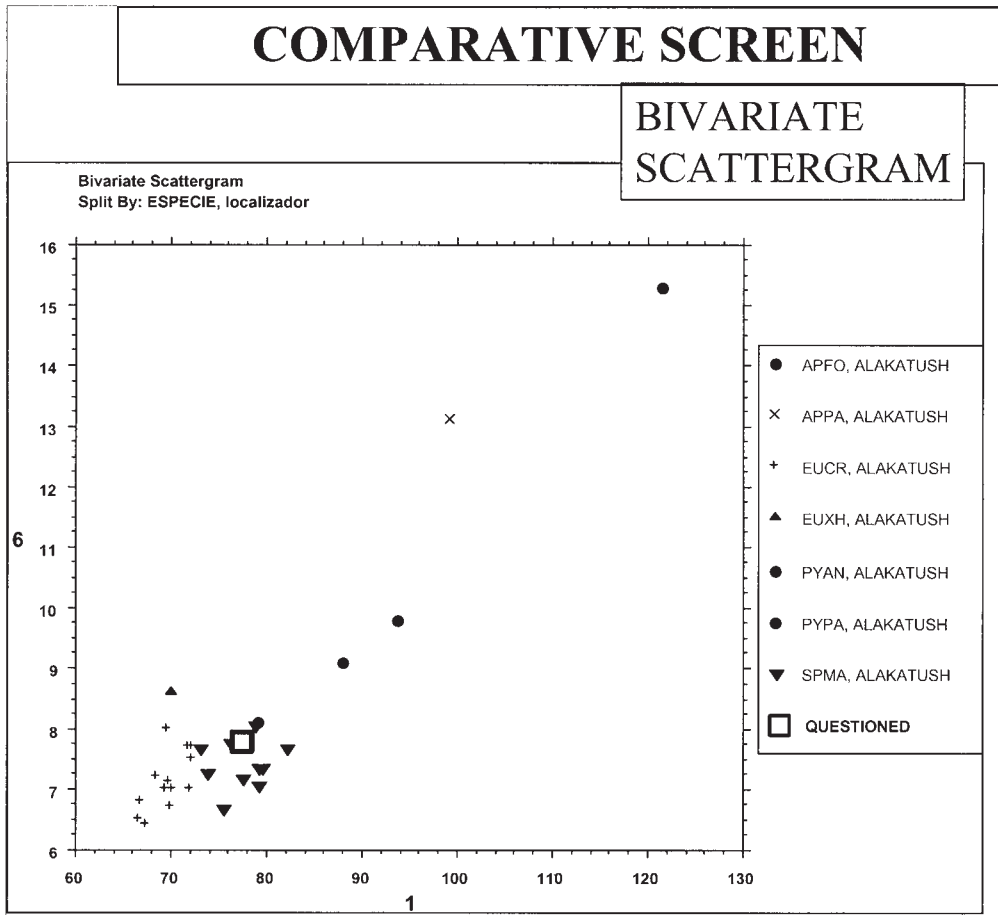




Fig. 5. Preliminary results. A special mark points to the classified bone and compares it with the previously measured material.

the use of such a system is not a surrogate for real experience in avian osteology, nor a good reference collection. But both are almost lacking in South America. For an European archaeozoologist reaching this continent it can represent an introduction to the avian osteology of this region. Our purpose in developing this computer aided identification system was also to provide a portable field system when a comparative osteological reference collection is not available or when it is not possible to transport archaeological bones to the reference collections. It can be useful to assist non specialist with preliminary sorting and identification (i.e., parataxonomy) of archaeofaunal samples before identifications can be confirmed by taxonomic specialists. Finally it can be an instrument to assist an avian osteologist, providing a quick overview of both pictorial and measurement databases and a sort of specific traits notebook to accumulate new experience. An expert system is by definition not better than the people that created it (BARCELÓ 1996). It must be open to criticism and improvement while the people working with it gain expertise too. This is the main lesson we have learned from our system development.



MORPHOLOGICAL COMPARATIVE SCREEN
 1. - By similarity order one by one from various perspectives



COMPARE  BY ORDER



 END



- SPMA
- PYAN
- EUCR
- EUXH
- PYPA
- TAPA
- MAGI
- DIME
- CHPI
- TAPT
- PHMA
- CASK
- LADO
- PHOL
- DIEX
- APPA
- FUGL
- APFO
- THAN
- STHI

MORPHOLOGICAL COMPARATIVE SCREEN
 2. - TWO SPECIES by various perspectives

COMPARE  PROX  BY ORDER

CAUD  CRAN 

EUCR  PHMA 

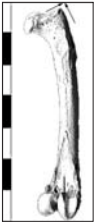
END  DIAGNOSE HELP 


- SPMA
- PYAN
- EUCR
- EUXH
- PYPA
- TAPA
- MAGI
- DIME
- CHPI
- TAPT
- PHMA
- PHAT
- LADO
- PHOL
- DIEX
- APPA
- FUGL
- APFO
- THAN
- STHI

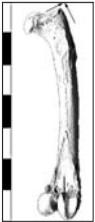

Fig. 6. Results. Taxonomic identification for the archaeological specimen ordered by probability index referred to database measurements of the osteological reference collection used in the database.

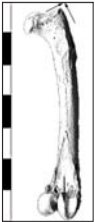

Fig. 7. Comparing the same bone of different species available on the pictorial database.

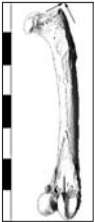

MORPHOLOGICAL COMPARATIVE SCREEN
 3. - Showing significant trends

COMPARE  BY ORDER

PROX 

CAUD  CRAN 

EUCR  PHMA 

END  DIAGNOSE HELP 

- SPMA
- PYAN
- EUCR
- EUXH
- PYPA
- TAPA
- MAGI
- DIME
- CHPI
- TAPT
- PHMA
- PHAT
- LADO
- PHOL
- DIEX
- APPA
- FUGL
- APFO
- THAN
- STHI

Fig. 8. Comparing results with the explicit indication of relevant features and identifying traits.

REFERENCES

- BARCELÓ J. A. 1996. Arqueología Automática. Inteligencia Artificial en Arqueología. Cuadernos de Arqueología Mediterránea, II. Laboratorio de Arqueología de la Universidad Pompeu Fabra. Editorial AUSA Sabadell.
- CLARK R. 1986. Aves de Tierra del Fuego y Cabo Hornos, Guía de campo. Ediciones L.O.L.A. Buenos Aires.
- COHEN A., SERJEANTSON D. 1996. A manual for the identification of bird bones from archaeological sites. Archetype publications. London.
- DRIESCH A. V. D. 1976. A Guide to the Measurements of Animal Bones from Archaeological sites. Peabody Museum I. Harvard.
- ESTÉVEZ J. 1979. La Fauna del Pleistoceno catalán. Tesis Doctoral Universidad de Barcelona. Barcelona.
- ESTÉVEZ J. 1991. Cuestiones de fauna en arqueología. [In:] A.VILA (ed.) Arqueología C.S.I.C. Madrid. Pp: 57-81.
- ESTÉVEZ J., VILA A. 1995. Encuentros en los conchales fueguinos. Treballs d'Etnoarqueologia, No. 1 Universitat Autònoma de Barcelona-C.S.I.C. Bellaterra-Madrid.
- GILBERT B. M., MARTIN L.D., SAVAGE H. G. 1981. Avian Osteology. B. Miles GILBERT editor. Laramie.
- LEFEVRE C. 1989. L'Avifaune de Patagonie australe et ses relations avec l'homme au cours des six derniers millénaires. These pour l'obtention du diplôme de doctorat. Université de Paris I. Paris.
- MAMELI L. 2000 Análisis arqueoavifaunístico del yacimiento arqueológico Túnel VII, Tierra del Fuego, Argentina. Trabajo de investigación. Doctorado Arqueología prehistórica. Universidad Autónoma de Barcelona. Barcelona.
- MEADOW R. H. 1999. The use of size index scaling techniques for research on archaeozoological collections from the Middle East. [In:] C. BECKER, H. MANHART, J. PETERS, J. SCHIBLER (eds) – *Historia Animalium ex ossibus. Beiträge zur Paläoanatomie, Archäologie, Ägyptologie, Ethnologie und Geschichte der Tiermedizin. Festschrift für Angela von den Driesch zum 65 Geburtstag.* München. Pp: 285-300.
- MOURER-CHAUVIRÉ C. 1975. Les oiseaux du Pléistocène moyen et supérieur de France. Thèse de Docteur d'Etat. Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon n°84. Lyon.
- NAROSKY T., YZURIETA D. 1993. Guía para la identificación de las aves de Argentina y Uruguay. Eudeba. Buenos Aires.
- OLROG C. C. 1984. Las aves argentinas. Administración de Parques Naturales. Buenos Aires.
- VILETTE P. 1983. Avifaunes de la fin du Pleistocene superieur et de l'Holocene dans le sud de la France et en Catalogne. Systematique-Paleoenvironnement-Palethnologie. These de doctorat de troisieme cycle. Université Claude Bernard, Lyon I. Lyon.