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Proposal of a faunal remains database

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ABSTRACT: The paper considers some problems related to the development of a computerised tool for archiving and processing faunal remains. We present a database management system used by the Prehistoric Section and by the Medieval Archaeology Area of Siena University's Archaeology and Art History Department and by the Prehistoric Ecology section of the Environmental Sciences Department.
The application is open and flexible. It has been created according to the experience of the LIAAM (Laboratory of Information Technology Applied to Medieval Archaeology; http://archeologiamedievale.unisi.it). Evolution of the database since 1996, detailed description of its functionality and potentialities are dealt under an archaeozoological perspective. The paper faces also aspects related to information technology, such as data architecture, normalisation of language, programming of user interfaces and automation utilities.
The proposed DBMS has proven to be efficient. Digital recording reduces the occurrence of errors during data entry, allows comparison between different contexts and provides powerful tools for real time processing of one or more samples.

KEY WORDS: ARCHAEOZOOLOGY, DATABASE MANAGEMENT SYSTEM, MEDIEVAL ARCHAEOLOGY

RESUMEN: Este trabajo valora una serie de problemas relacionados con el desarrollo de una herramienta informatizada para procesar y archivar restos de fauna. Se presenta un sistema de manejo de datos utilizado por la sección de Prehistoria y el Área de Arqueología Medieval del Departamento de Arqueología e Historia del Arte de la Universidad de Siena, así como por la sección de Ecología Prehistórica del Departamento de Ciencias Ambientales.
La aplicación es flexible y abierta. Ha sido creada de acuerdo con la experiencia del LIAAM (Laboratorio de Tecnología de la Información Aplicada a la Arqueología Medieval; http://archeologiamedievale.unisi.it). La evolución de esta base de datos desde 1966, la descripción detallada de su funcionalidad, así como de sus potencialidades son analizadas desde una perspectiva arqueozoológica. El trabajo aborda también aspectos relacionados con la tecnología de la información tales como la arquitectura de los datos, la normalización del lenguaje, la programación de interfacies de usuario y las utilidades de la automatización.
El sistema DBMS propuesto ha demostrado ser efectivo. El registro digital reduce la comisión de errores durante la introducción de datos al tiempo que permite comparaciones entre diferentes contextos y proporciona poderosas herramientas para el procesado en tiempo real de una o más muestras.

PALABRAS CLAVE: ARQUEOZOOLOGÍA, SISTEMA DE MANEJO DE BASES DE DATOS, ARQUEOLOGÍA MEDIEVAL

1. THE DBMS *ANIMAL BONES* DBMS: BASIC PROBLEMS IN PLANNING A SOLUTION

The database system was conceived at the LIAAM (Laboratory of Information Technology Applied to Medieval Archaeology, http://medievalarchaeology.unisi.it), a structure of the Siennese University's Archaeology Department (regarding the LIAAM's activities see Francovich, 1999; Valenti, 1998a, 1998b, 2000; Valenti *et al.*, 2001). It was initially thought for storing and managing data of faunal remains from the excavation of Poggio Imperiale (Poggibonsi- prov. of Siena), a pilot project of our Laboratory.

The subsequent planning and development of this tool is the result of a continuous and fruitful effort, put forward by an interdisciplinary team of specialists: archaeologists, zooarchaeologists, palaeontologists and database developers (Boscato *et al.*, 2000, in press). Paolo Boscato directs the project and has always introduced new stimulating ideas. Vittorio Fronza is engaged in all the IT aspects and especially in adapting database management technology to ongoing archaeological and zooarchaeological research. Finally, Frank Salvadori acts as the connecting ring between database management and zooarchaeological research. The DBMS has been tested for more than 5 years on different bone samples.

Our approach in planning a database is focused mainly on creating a tool capable of producing knowledge. Such a goal is not always easily achieved. Constant engagement in improving available features has been the engine of a feedback process on data architecture, which has brought to a progressive step-up in managing research potentialities (Figure 1).

The *Animal bones* DBMS, implemented in a FileMaker Pro environment and part of a larger excavation database, represents therefore an open and flexible tool. In fact, it has been continuously updated in order to meet different research directions and to manage more information classes. The actual version can be considered the third release of the system (Figure 3).

The first product was planned in winter 1996-1997 and implemented as a flat database on zooarchaeological records. An upward relationship within a hierarchical tree ensured linking to excavation contexts. The relationship between the table *Animal bones* and the table *Stratigraphic Units* was maintained through a key-field (or identifier) built on a string containing reference to excavation area and number of the stratigraphical unit.

Starting with this first release, the user interface was planned to be intuitive and make data entry easy for specialists who were accustomed to paper record sheets. All data concurring to form a single bone record appeared on the screen.

In planning the DBMS, representation of osteometric data turned out to be quite complex. The solution we adopted provided a number of fields corresponding to the maximum possible amount of measures on a single anatomical element. That means having 50 fields, according to the measurements suggested by Angela Von den Driesch for the cranium of several species (Driesch, 1976). Each field had a numeric label, which changed its osteometric meanings on a species and anatomical element basis. Field n° 1, for example, corresponded to the bone's greatest length (GL) in the case of a record regarding an ox's metacarpus; the same field in a record of an isolated horse's molar represented its occlusal length.

In extending the use of the database developed for Poggio Imperiale to all the excavations of the Medieval Archaeology Area of our Department, major adjustments were applied to the data model. These affected especially the key-field for the relationship with the stratigraphic contexts table (where a string identifying the excavation project was added to the previous key made up by excavation area and context number) and the management of osteometric measures. The animal bones DBMS turned into a relational system based on a hierarchical structure. It was linked upwards with the excavation database as before, and downwards with a new table called *Measures*. Osteometric data were therefore separated from the animal bones archive, becoming in fact a module of the system. Such a solution optimized the architecture, making the DBMS faster and more reliable. Data entry of the measures occurred directly from the main table through a Filemaker Pro portal. This can be seen as a window within the main *Animal bones* table, showing data from the related *Measures* table (Figure 4).

The third and last major upgrade has been completed at the end of 2000. It involved again important improvements on data structure (see chapter 2 and Figure 2). Moreover, two other aspects have been considered. Firstly, the elaboration of specific vocabularies and *thesauri* to normalize data entry and avoid errors. Secondly, the development of statistical features.

This release can be intended as a standardized tool in recording and processing zooarchaeological data; it is now adopted by all projects of the Medieval Archaeology Area. The database has already been tested on the excavations of Poggio Imperiale (Poggibonsi, Siena), Campiglia Marittima (Livorno) and S. Maria del Carmine monastery in Siena. It is currently being used to store data from the medieval period excavations of Rocca di Selvena (Grosseto), Cathedral of Siena, Castle of Miranduolo (Chiusdino, Siena), Castle of Rocchette Pannocchieschi (Grosseto). It has also been taken up by the Prehistory Section of our Department and by the Prehistoric Ecology Section of the Environmental Sciences Department.

At present the database, taking into consideration the Medieval Archaeology Area only, contains 19.691 Filemaker records, stored in 8 different tables:

– *Animal bones* container: 5.805 records
– *Slaughter marks* module: 545 records
– *Alterations* module: 1.447 records
– *Find measures* module: 5.105 records
– *Literature references* module: 3.092 records
– *Taxonomical references* library: 28 records
– *Anatomical references* library: 1.071 records
– *Osteometric measures* library: 2.598 records

The architecture of the system has been enhanced with two new modules on taphonomical data: slaughtering marks and traces of alterations caused by natural, animal or anthropic agents (see chapter 3 and Appendix for a detailed description of fields).

A relevant subject in redefining the database system has been dealing with standardisation of the language, especially in relation to fields containing synthetic information such as species, anatomical identifier, anatomical subtype, number, side, etc. Normalisation of terms has been achieved through the elaboration of specific vocabularies and *thesauri*. It is of primary importance to keep in mind that faunistic data readability and availability depends heavily on the formal clear-

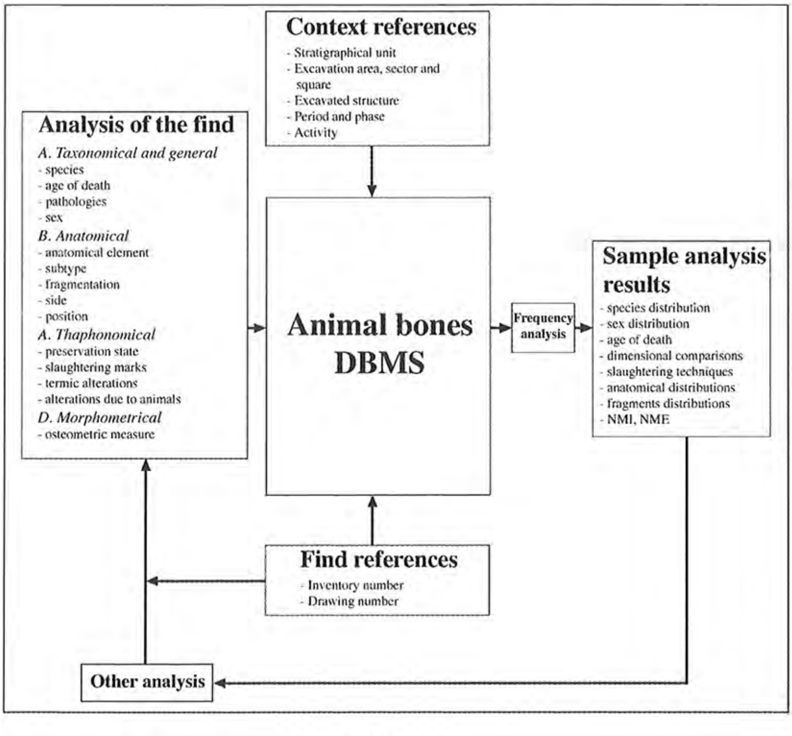

FIGURE 1
Model of archaeozoological data storing/analyzing process.

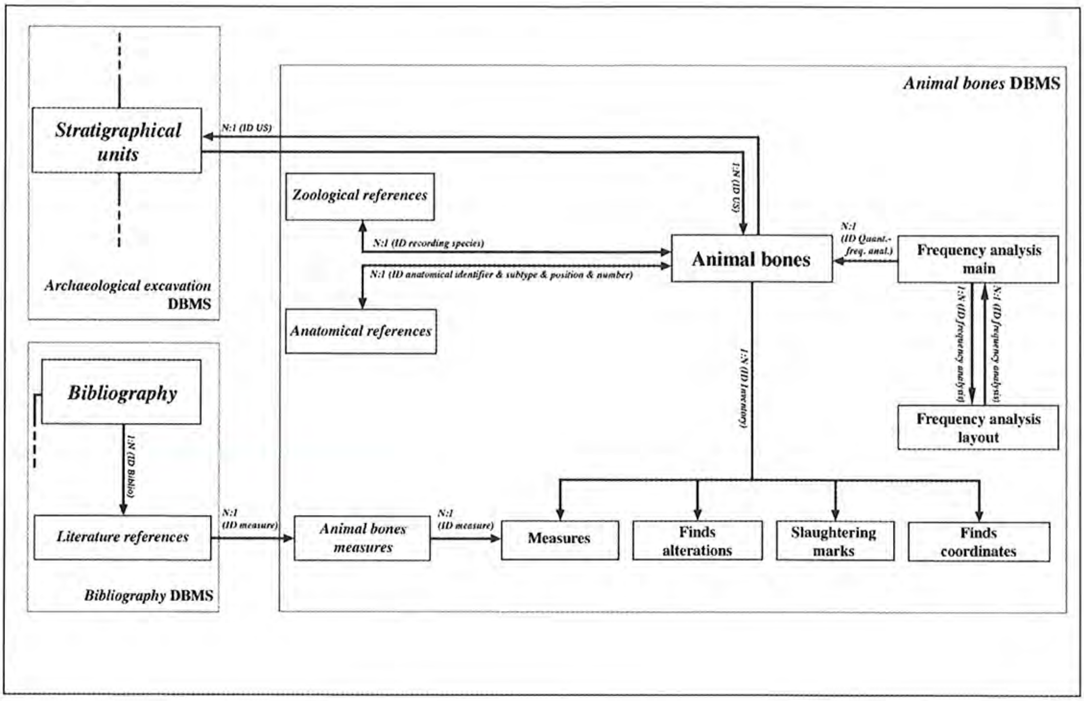

FIGURE 2
Animal bones DBMS. Relational data architecture.

ness and correctness of these term collections. But it is also true that adopting strictly predefined lists of values in data entry involves the risk of structural errors, especially if we omit consideration of zoological peculiarities such as osteological differences between species. An example can help us making this concept clear. In the case of a bovine incisor, having access to a list about its position containing the generic values "upper" and "lower" might mislead the user, since the only possible value is "lower".

During the processing phase, especially if it occurs a fairly long time after data entry, the accumulation of errors could be a source of heavy inconveniences. If we use the previous example, questions that might arise in such cases could be: was it really a bovine incisor and therefore the position value is wrong? Or was it rather an incisor of another species? In most cases researchers would be forced to discard the information or newly examine the finds, causing useless waste of energy and time. It has to be pointed out that such an operation would anyway be possible through the inventory number given to each record of the database and the presence of fields regarding the collocation in the store room.

Data entry errors, especially in the case of large samples, have to be considered as "physiological" and cannot be completely avoided. In order to limit such incongruities, our system provides three "libraries", which are used to build specific *thesauri* (value lists).

The first, called *Taxonomical references*, contains indications about the current zoological systematic (class, order, family, etc.), for each recorded species. Data is entered during laboratory analysis, when a bone fragment belongs to a species that has not been recorded before. It should be clear, by now, how problems related to taxonomical determination of a bone fragment have deeply influenced the data structure of the system. Yet another essential question had to be addressed. We applied to the records a systematic based on factors that cannot always be traced back to a single bone fragment. It was therefore necessary to adopt the use of a specific field, called *Recording species*, which performs the relationship between the library and the animal bone records. Such a solu-

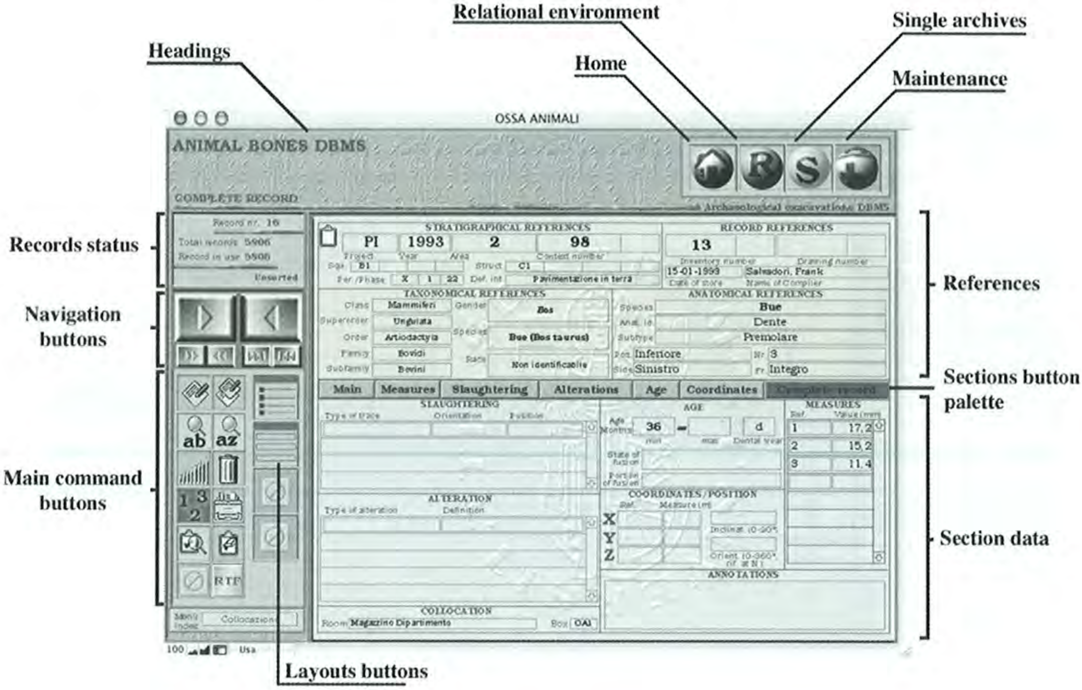

FIGURE 3
Animal bones DBMS. Main functions of the user interface.

tion allows the researcher to follow personal criteria in defining the most suitable values to identify the species of studied bone remains. The terms "ox" and "ox1", for example, might represent two different domestic bovine forms of a settlement, having morphological diversities but pertaining to the same species *Bos taurus*.

The second library has been defined as *Anatomical references* and contains all osteological elements for each family (*Bovidae*, *Canidae*, *Equidae*, etc.). We decided to discard a solution based on the detail of *Species*, in order to avoid excessive complexity. In fact, differences in the number of bones of *taxa* pertaining to the same family are minimal, if not totally absent. The usefulness of such a tool is strictly connected to the language standardisation issue. In the case of the bovine incisor cited above, the value "upper" does never appear in the list of terms associated to the field *Position* since it does not exist in the library. For the same reasons, it would be impossible to enter the fifth metacarpus of a horse or the fourteenth thoracic vertebra of a dog. Errors made by the user are therefore heavily limited.

The third (and last) library, called *Osteometric measures*, has a direct relationship with the modules *Measures* and *Literature references*. It aims at minimizing the possibility of errors while entering the measurements taken on a bone. At the same time, it allows immediate visualization of references to the methodological literature the measure is based on (author, title, pages and the short term of the measure). Once more, an example might help in understanding the feature. If we have to record the osteometric values of a sheep humerus, the list of measure numbers will not contain the range from 1 to 50, but only the existing values for that specific bone. If we choose the value 1 from the list, it means we are measuring the greatest length; references to the literature (Driesch, 1976) and the short name of the measure (GL) will be automatically displayed in the appropriate fields. Obviously, the library is not limited to Von den Driesch's method. It can store any measurement systems a researcher finds useful, of any author and regarding any zoological class.

This solution has also been provided to allow correct reading of osteometric data by archaeozo-

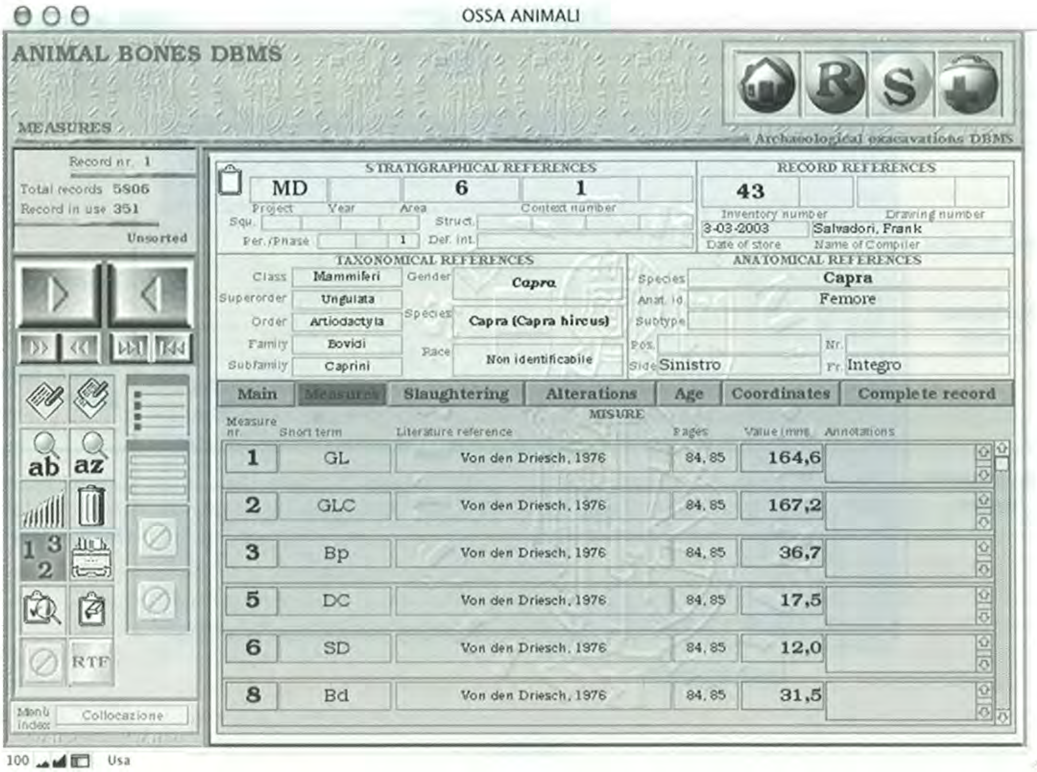

FIGURE 4

Animal bones DBMS, section MISURE-measures. Layout of the section with the related table's portal highlighted in dark grey.

ologists and paleontologists, especially in consideration of a web version of the system (see the last chapter of this paper). Such a standardized dataset would be an extremely useful tool in comparisons between samples belonging to different chronological and geographical contexts.

Another essential aspect in planning and developing our system has been the evaluation of a proper detail level in recording data. We decided to base the DBMS on a very high precision level, in order to obtain a sort of "personal ID" of every single bone. Information quality and processing potentialities are, in fact, directly associated to exhaustiveness in articulation of raw data. Clearly the decision about which parts of the database to fill in depends on the single researcher, and is usually influenced by a number of factors such as quality of finds, importance of archaeological sites, particular research interests, time-schedules, etc. Each case requires careful evaluation of detail level in data entry; if it is limited to a few fields, the potential in terms of processing will obviously be low. In the experimental cases of Poggio Imperiale (Poggibonsi, Siena) and Campiglia Marittima (Livorno) we tried to reach completeness in data entry. A little lengthening in laboratory analysis and recording times has been fully rewarded by high speed and potential during the subsequent elaboration phase.

Planning a section dedicated to statistic and quantitative elaboration has been the last step of the project. We aimed, from the beginning on, at the production of a tool allowing real time processing of acquired data, and not only storing of large amounts of records. Four operations are actually performed automatically by the database: basic statistical analysis (such as frequency and related standard deviation), data retrieval and presentation through a simple user interface, export of processed information in RTF text format ready for publication, export of data in a tabular format in order to produce charts.

The most important feature is probably the frequency analysis tool. It aims at the production of real time information on find distribution following personalised criteria. Two different options have been provided to guarantee an objective processing of the faunal sample, allowing in depth and diversified analysis paths. One is based on a hierarchical criteria list and the other leaves free choice in the order of the parameters. Hierarchical frequency analysis is based on three large parameter classes, ordered as follows:

I. Stratigraphical criteria, involving the fields *Excavation*, *Year*, *Excavation area*, *Excavation sector*, *Excavation square*, *Excavated structure*, *Period*, *Phase*, *Stratigraphical context definition*, *Interpreted context definition*, *Stratigraphical unit*;

II. Taxonomical criteria, involving the fields *Class*, *Superorder*, *Order*, *Family*, *Subfamily*, *Genre*, *Species*, *Race*;

III. Anatomical and archaeozoological criteria, involving the fields *Recording species*, *Anatomical identifier*, *Anatomical subtype*, *Position*, *Number*, *Side*, *Fragmentation*, *Pathologies*, *Minimum age*, *Maximum age*, *Age range*.

It is possible to choose one or more fields from each set. The frequency analysis is based on the combination of all fields, in selected order within the single classes but following strictly the class hierarchy listed above. This means that by choosing the field *Excavated structure* in the stratigraphical parameters and *Recording species* in the archaeozoological parameters we would get a quantitative distribution of the species in every excavated structure. The free choice option lets the user decide the field sequence that composes the frequency criterion. It is possible, for instance, to launch an analysis reversing the order of the fields used in the previous example. What we would obtain is a bone fragments distribution of excavated structures within each species. In both cases the chosen parameters are turned into an analysis identifier, where the combination order of all the fields determines the nature of the statistical output.

The results are finally shown in a separate layout table (Figure 5), where the processed data can be visualized and exported as described above. It is therefore possible to get exhaustive and synthetic representation of the studied bone sample in several formats: database layout, tabular data ready to be charted, ready-for-publication formatted text.

The frequency routines allow also basic NMI analysis, at different detail levels. Accuracy can be set by the parameters choice. It can vary from a very simple degree based on anatomical element and side, to more precise outcomes by adding fragmentation, age, osteometric data. Such an approach fits also NME analysis. With the current database release, in order to obtain minimal numbers from the frequency analysis results, we obviously have to isolate the most representative values for each parameter set. We plan to add automatic support for this kind of processing, through our user interface, in the future.

Other synthetic data, such as withers height, reconstructed total lengths in fishes, etc. are easily derived from the measurements stored in the specific module. The standardised recording system of osteometric data allows any kind of calculation. These can be implemented by the user through queries and mathematical functions, using the appropriate osteometric coefficients.

2. DATABASE MANAGEMENT ASPECTS IN THE DEVELOPMENT OF THE DBMS *REPERTI OSTEOLOGICI ANIMALI* (*ANIMAL BONES* DBMS)

This chapter deals closely with IT aspects applied to archaeology, obviously focusing on database management and especially describing the structure of the DBMS for archaeological excavation and its animal bones subsystem.

In applying database management techniques to archaeology we have to consider in first place all the requirements linked to specific data classes. Subsequently, we have to elaborate a data model which can join the strict (and often abstract) logical principles of computer science with the growing facilities of the hardware/software platforms available on the market.

We have to point out that it is sometimes hard for cognitive procedures aiming at the production of social and economical models to match the methods of information technology. Most solutions usually set up by computer analysts concern data models which scarcely need updates or improve-

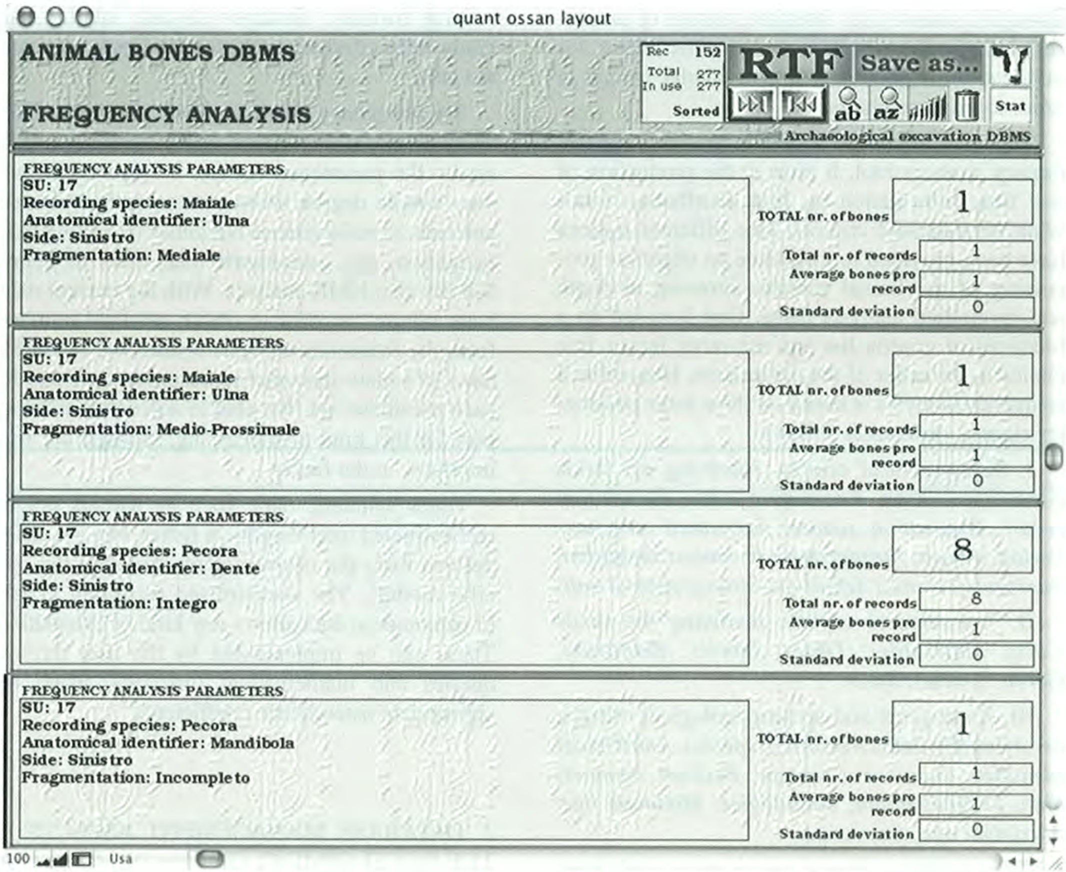

FIGURE 5
Animal bones DBMS. Output layout of the frequency analysis feature.

ments. The same cannot be said for scientific databases related to research activities, where data classes to be possibly managed within a project can hardly be foreseen (Fronza, 2000).

During the planning of a database, and more generally of a computer solution in archaeology, we have to be very careful about two points:

a. The creation of an open data structure. Archaeological research is often dynamic and evolves according to the targets of the project. At the same time investigations sometimes require deeper analysis as the project goes on. Only a flexible architecture of data ensures the creation of effective systems.

b. Clear definition of detail in recording data. The detail level is directly connected with the efficiency of the database. An ideal solution should match two different needs: in depth study of particular aspects of the project and profitable data availability.

Neglecting these two assumptions might lead to the creation of inefficient or partial solutions.

In designing the data model we followed strictly a few basic rules, derived from the approach described above:

a. Data structure has to be exhaustive. It has to provide a sufficient number of fields in order to register most different kinds of information derived from an osteological sample. Taxonomical, taphonomical and osteometric aspects have to be considered independently from the diachronical settlement context of the remains.

b. The database has to be provided with a simple and intuitive user interface, making data entry and elaboration easy also for researchers without a deep knowledge of computers.

c. Data identification, querying and retrieval features have to be simple and powerful, since they are a primary need of the researchers.

d. The database has to drastically reduce the amount of time needed for operations such as frequency analysis of bone distributions and other basic data processing.

RELATIONAL ARCHITECTURE

The archaeological excavation database management system is based on a relational model presenting a hierarchical tree structure. It is therefore a "vertical" product, with all the advantages and limits that this implies (Fronza, 2000, 2001). The tree is organized on four levels:

I. The research project with the main data regarding investigations (table *Excavations*). It coincides with the concept of archaeological site in a landscape perspective.

II. The spatial, temporal and interpretative parts of the excavation project. It involves the tables *Excavation Area*, *Excavation sectors*, *Excavated structures* (buildings, roads, etc.), *Excavation phases*, etc.

III. At the third level in the hierarchy we find stratigraphical data with the tables *Activities* and *Stratigraphical units*.

IV. At the lowest levels are all tables (or subsystems) regarding different classes of finds (pottery, metals, glasses, coins, etc).

The actual release of the animal bones DBMS is obviously positioned at this last level and represents an evolution of the hierarchical structure described above. It is based on a loose entity-relationship model, configured as a modular subsystem composed by different kinds of tables (Figure 2):

a. The container *Animal bones*;

b. The libraries *Taxonomical references*, *Anatomical references* and *Osteometric measures*;

c. The modules *Measures*, *Finds alterations*, *Slaughter marks*, *Finds coordinates*, *Literature references*.

Moreover, the subsystem *Bibliography* is used by one of the libraries (see description below).The *Animal bones* container represents the master table, at the highest level of the subsystem's architecture. It is linked upwards, in the tree of the *Archaeological excavation* DBMS, with the table *Stratigraphical units* through a "many-to-one" relationship. The same relationship cardinality (even though with a different meaning, as described later in this chapter) is established with the libraries *Taxonomical references* and *Anatomical references*. On the other hand, the container stays at a higher level ("one-to-many" relationship) in respect to the modules *Measures*, *Finds alterations*, *Slaughter marks*. The module *Finds coordinates* corresponds to an exception in the relationship cardinality, which is in this case "one-to-one" (the module is logically at the same level of the container-master table).

All modules are related to the main table through an identifier (or key-field) based on the inventory number. The tables *Measures*, *Finds alterations* and *Finds coordinates* are defined as generic modules containing auxiliary data for all the find classes subsystems within the *Archaeological excavation* DBMS. The module *Slaughter marks* belongs only to the animal bones database.

A hierarchical relationship ("many-to-one") is established, as we have seen, between the container *Animal bones* and the libraries *Taxonomical references* and *Anatomical references*. Even though this is physically true in the system's architecture, on a conceptual level the libraries can not be seen as part of the hierarchical tree. They act transversally on the database structure, supporting correct data treatment.

A third library, called *Osteometric measures*, completes the animal bones subsystem. The module *Measures* is related to it with a "many-to-one" relationship. The library is also linked to the subsystem *Bibliography*, since it needs references to methodological literature. This is accomplished through the module *Literature references*.

The last two tables of our database are used to perform frequency analysis of finds: *Frequency main* and *Frequency layout*. The first table acts as a processing tool, while the second is employed to present the results (Figure 5).

USER INTERFACE AND AUTOMATION UTILITIES

The personalized user interface, developed and implemented at the LIAAM, is one of the main advantages of the *Archaeological excavation* DBMS and of its subsystems. We tried to achieve easiness of use and completeness of available features, through a personalised graphical look of container tables. Push-buttons palettes, background images, controls, scripts and routines have been used in development.

At the highest level, the user interface is made of three different environments:

a. *Single Archives*, allowing creation, modification and querying of data in single tables.

b. *Relational environment*, where it is possible to browse and query the whole database through thematic relational indexes based on excavation phases, excavated structures, stratigraphical units, etc.

c. *Maintenance*, to operate the main preservation functions on the DBMS.

Tables are accessed through layouts composed of a central part with the data, surrounded on top and on the left side by a command area with headings and sets of push buttons. The main features provided through the user interface are:

a. Linear navigation through records;

b. Record creation, duplication, modification and deletion;

c. Record marking functions;

d. Automatic querying, filtering and sorting procedures;

e. Printing routines;

f. Statistical analysis tools.

Data complexity of the animal bones subsystem (especially the high number of fields) has determined the splitting up of visualization layouts in thematic sections (Figures 3, 4).

We have also concentrated on the development of programmed routines, aiming at the solution of specific problems in order to simplify repetitive tasks and minimize processing times. The best example, in the case of the *Animal bones* DBMS, is represented by the frequency analysis described above. Archaeozoologists usually perform this processing on simple spreadsheet tables, which carry out the calculations. Changing the frequency parameters often implies heavy data rearrangement within the sheets, causing confusion and loss of time. On the opposite, the use of automated routines introduces high flexibility in summarizing samples. Having real time responses allows the specialists to explore different research directions and optimize the feedback process (generated data can induce new questions). The usefulness of this utility in terms of working productivity is impressive.

3. DATA SECTIONS

We have already seen how, in the *Animal bones* DBMS, the user has access to an interactive environment made of different windows dedicated to single topics (Figures 3, 4). Each subject corresponds to a table in the data model. Seven sections are accessible through the buttons located centrally on the screen. Six are dedicated to data entry and manipulation (*Main, Measures, Slaughter marks, Alterations, Age* and *Coordinates*), while the last one summarizes all the information pertaining to the single recorded remains (*Complete record* section).

The *Main* screen is made up of subsections dedicated to data entry of information connected with the excavated context, the find inventory, the taxonomical and anatomical identification and other elements. Data entry in the subsection called *Context references* regards only the fields *Excavation*, *Area* and *Stratigraphical unit*, while exhaustive data about every single layer are stored in a dedicated table easily retrievable by the user.

Every find is identified by an inventory number and, if a graphical representation is provided, by a drawing number; both are also written on the bags containing the bones. Our intention is to make sure that every single recorded remain can be found in the store room at any time, even after years.

The subsection called *Taxonomical references* stores zoological indications pertaining to the bones and has been implemented in order to allow analysis on a wider scale than that of the species (especially in the case of large samples). Data entry of zoological information is accessed through the button located on the upper right part of the screen, which allows the user to interact with the external library called *Taxonomical references*. The table contains fields describing the taxonomical categories of the zoological nomenclature and a field called *Recording species*. This last one represents the identifier of the species, aprioristically determined by the researcher. Such a choice has proven to be effective in avoiding problems due to taxonomical identification of bone fragments (as discussed in the first chapter of this paper).

Fields related to osteological identification are in the lower part of the screen, under the buttons (Figures 3, 4). They are: species (the value list derives from the records of the *Taxonomical references library*) and the relative bone fragment, eventually the subtype (as it happens, for example, for carpal and tarsal bones), the number (in the case of vertebrae or teeth) and the position (teeth and phalanxes). The value lists of these fields are automatically refreshed every time the user enters the species. This is obtained through a second library, called *Anatomical references*, which contains all the single osteological elements pertaining to a family. Two more fields, also structured with predefined value lists, make the find definition complete:

SIDE AND FRAGMENTATION

Another important field is the *Number of fragments*; the value depends mainly on the detail level adopted in recording animal bones. For example, the unidentifiable fragments of the same context may be catalogued in one record.

Other fields in this section are *Sex* (entered if identifiable), *Pathologies* (regarding pathologies we are planning a specific subsection of the database), *Storing Place* and *Box* (reference to the physical location of the finds), *Annotations*.

Osteometric data is accessed through a specific section, displaying a portal made up of two fields: *Number* (the identifier to the *Measures* module) and *Value*. The *thesaurus* associated with the identifier derives from a separate table acting as a library of all possible measurements for each bone (see description in the previous chapter).

Two more sections are concerned with some taphonomical aspects regarding slaughtering and alterations. The first is structured in three fields: type of impact, orientation in respect to the sagittal axe and position on the bone. The second allows recording of all different alteration processes, and of the relative agents (natural, anthropic and animal) that concurred in modifying the original structure of the bone.

A dedicated section stores data regarding age of death. In this case the fields are minimum and maximum age, dental wear index (with a reference to author and title), the bone fusion state and the preserved portion.

Finally, a section allows to find the exact position of bone fragments within excavation areas. Fields are X, Y and Z coordinates taken from fixed points in the excavation area, bone inclination and orientation.

4. FINALITIES AND FUTURE AIMS

First experiences in the use of the animal bones database revealed a flexible and functional tool. The organisation of the graphical layout, which orders in a sequence all available data pertaining to a bone fragment, makes up a real compilation itinerary. This helps the archaeozoologist in reaching an exhaustive and reasoned examination of the sample.

The coherent recording system also facilitates analysis and information sharing. Nonetheless, in some cases data comparison can be tricky, especially because of differences in excavation methods (earth can be sieved or not, excavations can be conducted on large open areas or concentrate on small sectors, etc.). Anyway, such problems belong to a wider methodological perspective and do not regard directly the use of the database.

The system has shown its usefulness especially in comparison of osteometric and quantitative data within the same sample as well as across different sites (first results of such applications can be found in Salvadori, in press).The personalised value lists help in the visualisation of categories and subsets during data processing. By using these vocabularies it is quite simple to obtain real time observations and numeric consistence of particular groupings.

We observed that filling in the digital record sheet for each single bone fragment does not take much longer than the traditional annotation system, especially if we consider the significant reduction of possible errors while recording data.

The database has undergone intense and is still partly ongoing experimental implementation at the Medieval Archaeology Area and at the Prehistory Section of the Department of Archaeology and Art History of the University of Siena. New records are progressively entered by researchers studying different samples. In fact, we are setting up a coordinated method of archaeozoological data storing and processing through the use of a common digital system. This opens new perspectives in building tools which can yield synchronic and diachronic information from the micro-scale (a single site) to a macro-scale (regional, or even larger, inter-site correlations).

At the same time data structure is constantly improved. Evolution of our discipline and of technologies, differentiation in research subjects and the large number of stored data will often lead us to revisions on the proposed model.

Our next goal is to set up the database on a network. We are thinking at a solution with diversified access, based on at least two levels: as a geographic network and through Internet (Figure 6). The idea is to involve colleagues in order to establish a team, which tests the database on a wide range of contexts. Recent developments in network technology would make this easily possible. Such a project could be organised into independent operative units, logging in as clients on a central server-resident database. Each unit would have access to all stored data, but could modify only their own records. In this way peripheral groups would collaborate in the creation of an outstanding tool for the production of important synchronic-diachronic data synthesis. At the same time it would help widening the range of approaches to the discipline manageable through the database.

Once the entry and processing of a single project has been completed, the information could be published on Internet (if the data owners agree) and become accessible to anyone interested. Real time dataflow and information exchange through the world wide web is, by now, a common practice of our society. It clearly applies also to the zooarchaeological community: international success of the ZOOARCH discussion list is an example that can't be disregarded.

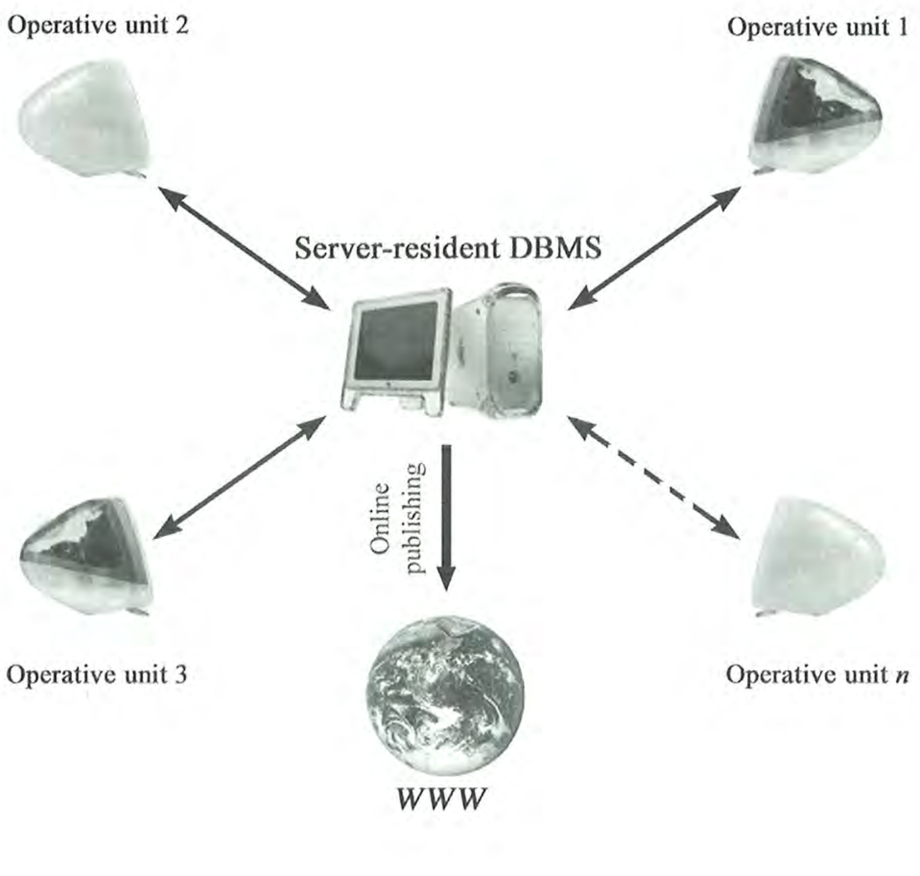

FIGURE 6
Data sharing of the *Animal bones* DBMS on a geographic network and on the world wide web (client/server architecture).

We believe that the proposed database architecture might evolve as a useful tool for archaeozoology by creating favourable conditions for further progress of our discipline. Especially because it encourages a fruitful cooperation between researchers, that develop and use a common system. We hope it will improve the knowledge of past societies by assisting the creation of diachronic relation models between men and animals (Albarella, 1995).

APPENDIX (FIGURES 3, 4)

This appendix describes, step by step, the operational sequence concerning data entry of an animal remain record within our DBMS.

Step 1 section MAIN: Use the specific button to create a new record and enter the short name of the project, the area and the context number in the subsection STRATIGRAPHICAL REFERENCES.

Step 2 section MAIN: enter the inventory number and, eventually, the drawing number in the subsection RECORD REFERENCES,.

Step 3 section MAIN: enter the particular recording species in the subsection RECORDING SPECIES.

Step 4 section MAIN: enter the bone fragment's characteristics in the subsection ANATOMICAL IDENTIFIERS. In particular the user has to fill in the name of the bone, the side and the fragmentation (such as proximal, distal, medio-proximal etc.). Other data to be eventually entered are:

– subtype as it happens in the case of teeth, vertebrae carpals, etc.;

– position in the case of teeth (upper-lower) and phalanxes (anterior-posterior);

– number, if the anatomical element requires it (teeth, vertebrae, etc.).

Step 5 section MAIN: enter, in the subsections Sex and Pathologies, the respective values eventually observable on the recorded bone.

Step 6 section MAIN: enter, the total number of fragments having the same characteristics in the sections 1-5.

Step 7 section MEASURES: enter the osteometric data; for each measure the user has to fill in the identifying number and the value in mm.

Step 8 section SLAUGHTERING: enter the values regarding visible traces of slaughtering. The section contains three fields:

– impact type, expressed by an open (modifiable) *thesaurus*;

– orientation in respect to the sagittal axe, expressed by a *thesaurus* made up of three values (longitudinal, transversal, oblique);

– position of the evidence, filled in through an open vocabulary with terms like caudal, cranial, etc.

Step 9 section ALTERATIONS: enter the values referring to evidence of alterations in the original bone structure. The type of the alterations are expressed by a non-modifiable *thesaurus* of three values (natural, anthropic, animal), while their definition has a non-modifiable thesaurus of 11 values (abrasion, bio-perturbation, fluitation, erosion, fracturing and corrosion due to natural alterations; mastication and gnawing due to animal alterations; boiling, combustion and slaughtering due to anthropic alterations).

Step 10 section AGE: the user enters data related to minimum and maximum estimated age of death, expressed in months; dental wear is entered in the specific subsection, with an eventual reference to methodological literature. The subsection FUSION contains data referring to the epiphysial fusion state through a *thesaurus* of ten values and the fusion portion through a *thesaurus* of three values (body, articulation, body/articulation).

Step 11 section COORDINATES: enter spatial references of the bone find within the excavated context. Values concern the three spatial coordinates X, Y, Z (with a reference to one of the excavation's points with absolute coordinates), the grade of immersion of the find and its orientation in respect to the north.

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