Palaeoenvironmental Records and Php Possibilities: Results and Perspectives on an Online Bioarcheological Database

Enora Maguet, Jean-Baptiste Barreau, Chantal Leroyer

CAA2015

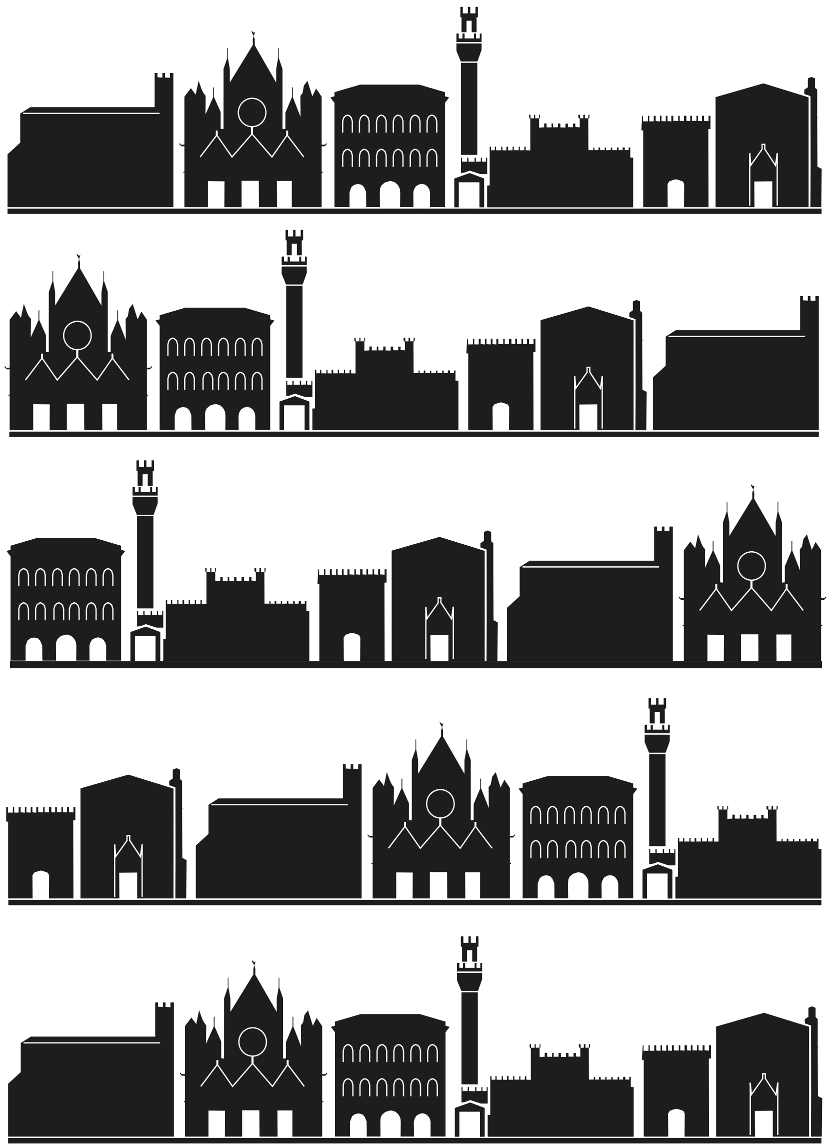
KEEP THE REVOLUTION GOING >>>

Proceedings of the 43rd Annual Conference on Computer Applications and Quantitative Methods In Archaeology

edited by

Stefano Campana, Roberto Scopigno, Gabriella Carpentiero and Marianna Cirillo

Volumes 1 and 2



UNIVERSITÀ DI SIENA 1240

Computer Applications & Quantitative Methods in Archaeology

CAA2015

KEEP THE REVOLUTION GOING >>>

Proceedings of the 43rd Annual Conference on Computer Applications and Quantitative Methods in Archaeology

edited by

Stefano Campana, Roberto Scopigno, Gabriella Carpentiero and Marianna Cirillo

Volume 1

Archaeopress Archaeology

ARCHAEOPRESS PUBLISHING LTD
Gordon House
276 Banbury Road
Oxford OX2 7ED

www.archaeopress.com

CAA2015

ISBN 978 1 78491 337 3
ISBN 978 1 78491 338 0 (e-Pdf)

CAA2015 is availabe to download from Archaeopress Open Access site

This book is available direct from Archaeopress or from our website www.archaeopress.com

Table of Contents

Palaeoenvironmental Records and Php Possibilities: Results and Perspectives on an Online Bioarcheological Database

Enora Maguet
enora.maguet@gmail.com

Jean-Baptiste Barreau
jean-baptiste.barreau@univ-rennes1.fr

Chantal Leroyer
chantal.leroyer@univ-rennes1.fr

UMR 6566 CREAaH, Université de Rennes 1, France

Abstract: ABCData project is an online bioarchaeological database, that essentially gathers palynological and anthracological data. This relational database was built using a framework (FuelPHP), and the different interfaces and applications were all developed through computer programming, using several languages and open access libraries. In particular, we developed a palynological query interface associated to a SVG graphics generation tool. We tested ABCData's functioning through the integration and the analysis of numerous palynological cores that had already been studied with a different method. This study revealed a great accordance between the two methods, and highlighted some bias and the necessity of permanently watching over of the statistic distribution of the samples.

Keywords: Database, Programming, Palaeoenvironment, Interdisciplinary, PHP

Introduction

Over the last few years, palaeoenvironmental matters have been more systematically integrated to archaeological questions. The difficulties that are inherent to these multiproxy studies lead us to attach a prior attention to the IT management of a huge data corpus, which gather several disciplines and set numerous problems of storing, safeguarding, using and standardizing this complex information.

In the national and European context, there are many projects (GDRE Bioarch, ANR Bioarchéodat) and databases (Arbodat, I2AF, European Pollen Database) whose main objective is to enable the data collection, comparison and overview through a normalized frame of reference and appropriate computer-based tools. All these bases, if meant to coexist and enrich each other, must allow collaboration and must be fully compatible or interoperable. Such aspect is perhaps the biggest difficulty and one of the main concerns databases creators and administrators have to deal with.

Nevertheless, these projects mostly concern anthracology, carpology and archaeozoology. As a consequence, palynological data is often treated separately since its applications are out of the field of archaeology. It is also challenging to handle these data because of the difficulties linked to the chronological assignment of samples, the amount of data required to interpret the results, the differences between the sequences in terms of preservation and level of taxinomical identification, as well as the conditions which affect the archaeological site (Reille 1990).

Our project ABCData (Archaeology, Biodiversity, Chronology Data) focused on creating a tool for the input, the visualisation and the use of paleobotanical data which works in consonance with the specificities of this discipline. In order to overcome the difficulty of using a local software program, we transferred the data to a server, and we built a website (http://archeosciences-abcdata.osuris.org) which handles all the functionalities of the database. The start of the programming work used an open framework (FuelPHP 5.3) to develop the interface basic tools. This database was then fully programmed with different languages (php, javascript, html, css) and different libraries in open access gives. As a result, it is a very flexible tool which fits well the needs of paleoenvironmental disciplines, helping us to explore new possibilities in terms of analysis and graphic visualisation of results. Thus, one of the major aspects of this project is the setting of a query interface (for the time being, the interface deals only with palynological input) which allows us to conduct both synthetic and parametric approaches of the integrated data. A graphic displaying tool and a library (PHPExcel) which enables importing and exporting results under a spreadsheet are also related to the query interface.

The final phase was devoted to a series of analyses of the palynological content of 43 sedimentary cores from the Paris Basin, in order to compare ABCData performances to the synthetic history of the basin vegetation set on the empirical merging of the same data, since the late Epipaleolithic times (Leroyer 1997).

1 Database creation

ABCData's functioning relies on the existence of two complementary interfaces: an administrator interface handled by PhpPgadmin, and a user interface, resulting from our programming work. The putting on line of the database has therefore taken place in several steps. First we designed the

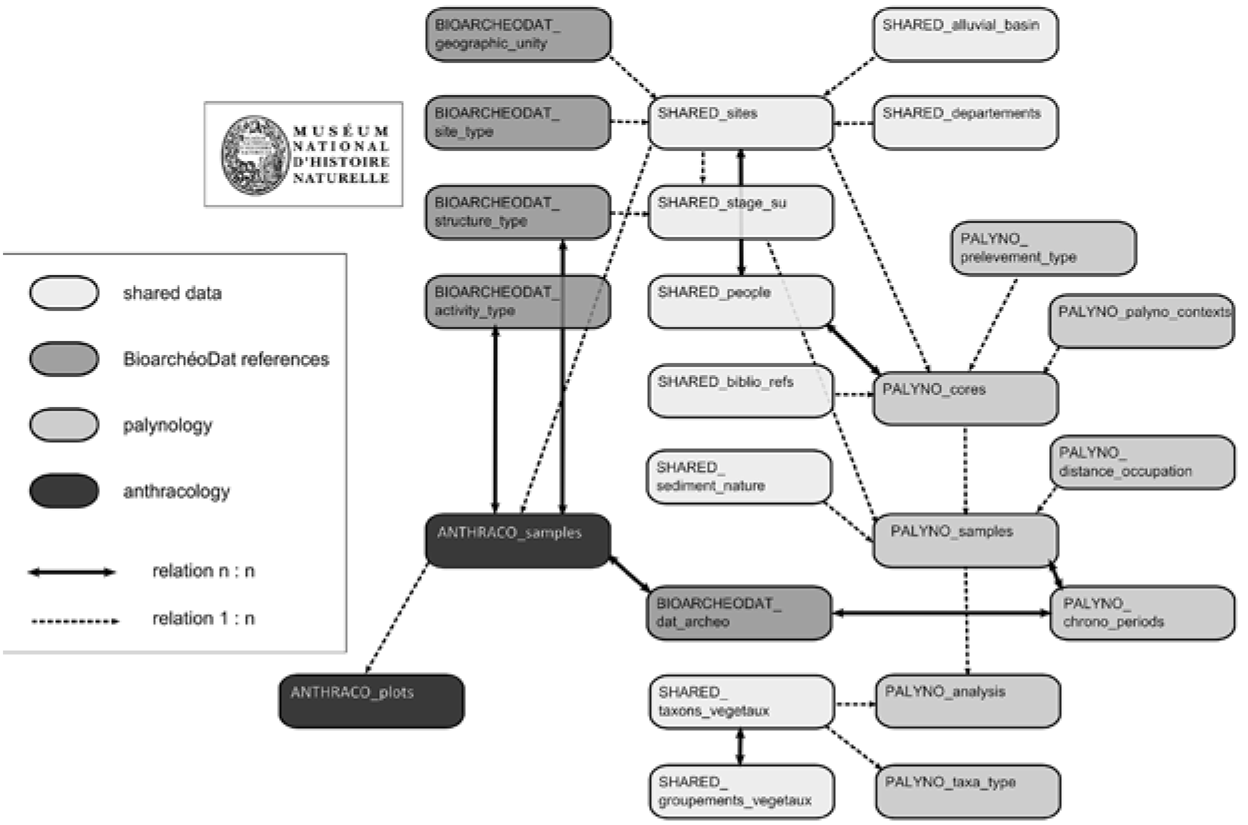


Fig. 1. ABCData's relational architecture.

structures of the tables and the nature of the links between them, then we had to create these tables in PhpPgadmin, to translate this architecture within the source files, and finally to program all the ABCData's specific functionalities.

1.1 Data architecture

Fundamentally the data dealt through ABCData aim to quantify the taxa occurrences (only botanical taxa for the moment) in the analysed samples, while preserving all information liable to enlighten this analyse such as dating, evaluation of the preservation quality, analysis methods or archaeological context.

It is particularly essential to use common and normalized vocabulary in order to carry out analyses on different sequences or different materials. This is one of the advantages of using permanent tables (Kreuz and Shafer 2002), which help to standardize input and exclude redundancies. All the data shared by several elements must appear in one same table in order to avoid as far as possible the redundant elements. ABCData is therefore composed by a large number of tables (Fig. 1) belonging to four categories identified with a prefix: the specific data about anthracology, the specific data about palynology, the data belonging to the different disciplines and the permanent data issuing from Bioarcheodat project frame references. Each table includes an identifying field on which weighs a uniqueness obligation and which is automatically filled by the sequence associated to the table. The n-n (or many to many) relation type are expressed within specific tables. It constitutes an adapted answer to situations where a record can be associated to different values of the same attribute, and these attribute values associated to several records.

The organisation of palynological data, widely inherited from the already developed SGBDR (Maguet 2013), has nevertheless gone through many modifications, for it was absolutely necessary to take into account the interoperability with other SGBD and the compatibility with anthracological data. The table corresponding to botanical taxa was conceived in order to deal with problems caused by the differences in the resolution level of taxa determination, both between palynology and anthracology, and between several sequences of pollen or charcoal. Indeed, many parameters may influence upon the degree of precision of these determinations, such as material preservation, microscope performances or the analyst's own sensibility (Maguet 2014). It therefore contains a field 'name' which corresponds to the most common degree of determination, and a field 'precision' which allows the user to indicate additional information when a more precise degree of determination is possible.

1.2 Data integration into PhpPgadmin

The administrator interface PhpPgadmin, which works with PostgreSQL, allows us to create, to define, to update and delete the different tables and their fields. The link between these tables relies on the existence of primary keys ('id') that are absolutely unique and automatically incremented using numerical sequences. The use of a relational model had already

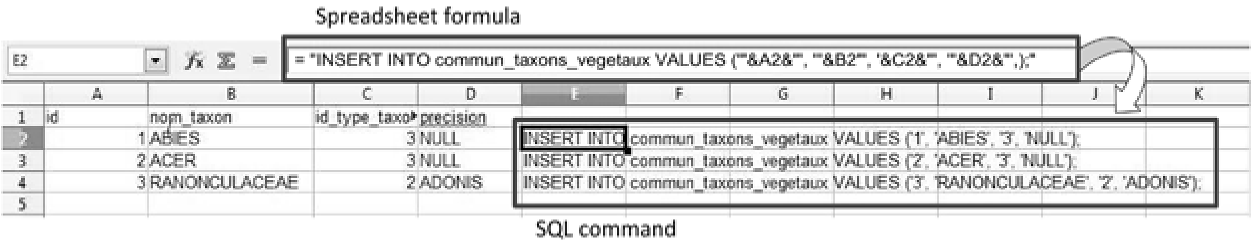


FIG. 2. SPREADSHEET FORMULA AND SQL COMMANDS.

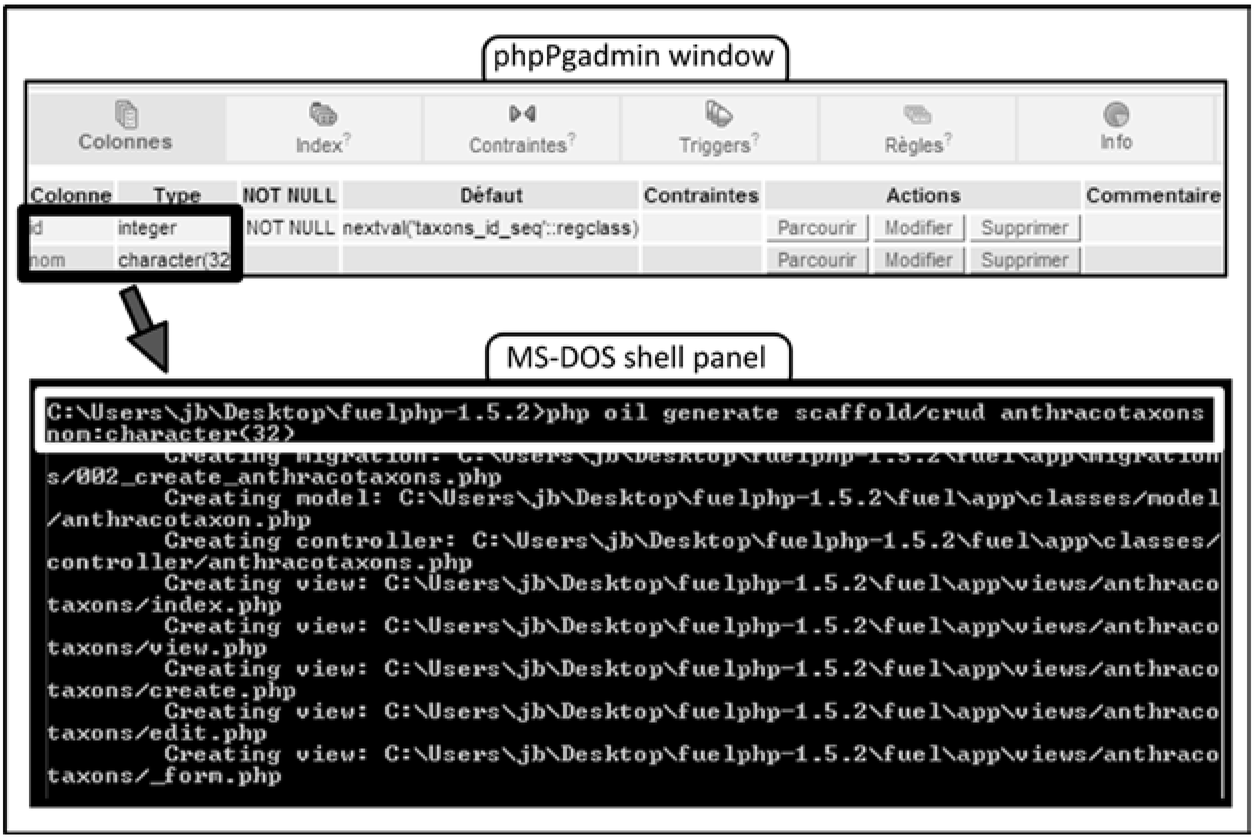


FIG. 3. MS-DOS FILES GENERATING PROCESS.

been recommended and the functioning widely described by Tomlinson (1993), when he created an archaeobotanical database on British and Irish datasets. He particularly insisted on the fact that this relational model is based on the creation of independent tables in which every line must be different and identified by a primary key that should preferably be a numeric element.

In phpPgadmin, you can input your data directly, but generally it is more convenient to use SQL commands which correspond to the updating commands (INSERT, UPDATE, and DELETE) (Fig. 2). Using these commands, the integration of data from spreadsheets goes very fast.

1.3 Creation of the source files

The creation of the CRUD (Create, Read, Update, Delete) source files was realized thanks to a web open-source framework called FuelPHP. This framework follows the HMVC (Hierarchical Model View Controler) architecture. This technology ensures the possibility to generate automatically the source files when their architecture is widely repeated, as well as writing the code which corresponds to the major functions from the CRUD. This first step is realized through the MS DOS Shell (Fig. 3), and allows us to have, for each table of phpPgadmin, different source files: a controller, a model, and a set of five different views (index, view, _form, create, edit). In the controller, there are different functions that are associated to each view, and who define and compute every variable that is called in the view files.

Mostly, these variables rely on the data from the phpPgadmin interface, and it is the model that ensures the link between these data and the controller (Fig. 4). The variables often correspond to associative tables, called 'arrays', which means that they are composed by the association of a key to a set of different values

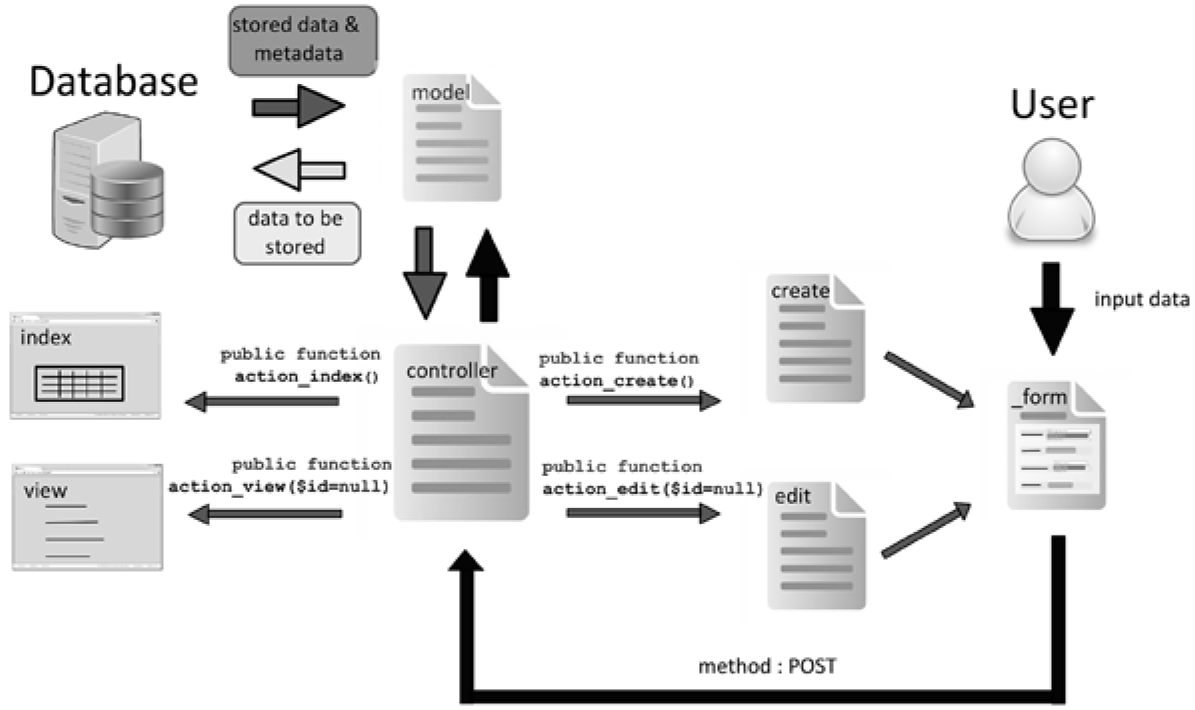


Fig. 4. Relations between the different source files, the base and the user.

or attributes. Again, this attribute can also be an array, which is nested within the first one. This interlocking of data constitutes an essential point concerning php data management. To access the different levels and values, you can use the square bracket based syntax when the loop system allows you to browse every line of a given array (Fig. 5).

All these source files must be then transferred on the server using a FTP client such as FileZilla. After that, they can be updated through a code source editor (such as Notepad ++), connected to the FTP server.

2 Development of tools

We were able to work on an interface which met our needs in terms of display, input, import/export, queries and even security, from the files generated by the FuelPHP framework and thanks to different programming languages. Generally, the structure of the files proposed by the framework imitates the structure of the base, its tables and fields. The interface we seek to construct, however, is different from this architecture so as to answer as efficiently as possible to the users' demands.

Furthermore, we analysed the functionalities of Gpalwin, a program that was adapted to the palynologists' needs (Goeury 1997), and it led us to add more fields. These fields contain information mainly about calculations on the characteristics of samples and profiles in terms of diversity of the pollen content.

2.1 Data import and export: Forms

The use of forms ensures the direct input of the data into the base. Different data types correspond to different field types: Text data will be shown in drop-down lists; numerical data must be provided in numbers whose format is defined in the structure of the table. Another possibility is creating checkboxes for Boolean data. In the forms, the fields correspond mainly to html programming, where data is retrieved from php variables, essentially for displaying drop-down lists (Fig. 6).

[Fig. 6: Relations between different source files while creating form fields]

All data provided by the user will be inserted into the controller through the $_POST variable, and then it will be treated by a function dedicated to saving these values in the corresponding tables. This function submits all provided data to the model of the table in order to verify that the proposed values correspond to the format defined for each field. It the user tries to insert data in a different format, the information will not be saved and an error message will appear.

2.2 Data import and export: PhpExcel

The tools to import and export spreadsheet files have been developed from a PHPExcel 1.8.0 library, which is integrated to the base as a package. It enables reading, writing and creating spreadsheet files under several formats.

For us, it was of vital importance to ensure the possibility to add the provided data directly into other types of support. This functionality is guaranteed for the main tables; secondary tables have a small number of entries. Thus, for the main tables, data can be imported from spreadsheet files through the creation of a visible element (upload), which is associated to an action in the controller (action_upload), and allows the user to affect the columns of the file s/he designed in different fields of the selected table. Another function (uploaded data), is executed as

```php
<?php

    //Declaring an array
        $array[] = array('id' => 0, 'value' => 10);
        $array[] = array('id' => 1, 'value' => 20);
        print_r($array);

            //Will display: Array ( [0] => Array ( [id] => 0 [value] => 10 )
                                    [1] => Array ( [id] => 1 [value] => 20 ) )

    //Accessing the values
        $value_0 = $array[0]['value'];
        echo "value of line 0 = ".$value_0;

            //Will display: value of line 0 = 10

    //Creating a loop
        foreach ($array as $line):
            echo "value of pointed line = ".$line['value']."<br>";
        endforeach;

            //Will display:
                // value of pointed line = 10
                // value of pointed line = 20

     //Declaring a variable from the database
            $data['table'] = Model_table::find(array('order_by' => array('id' => 'asc')));


?>
```

Fig. 5. Examples of array management in php.

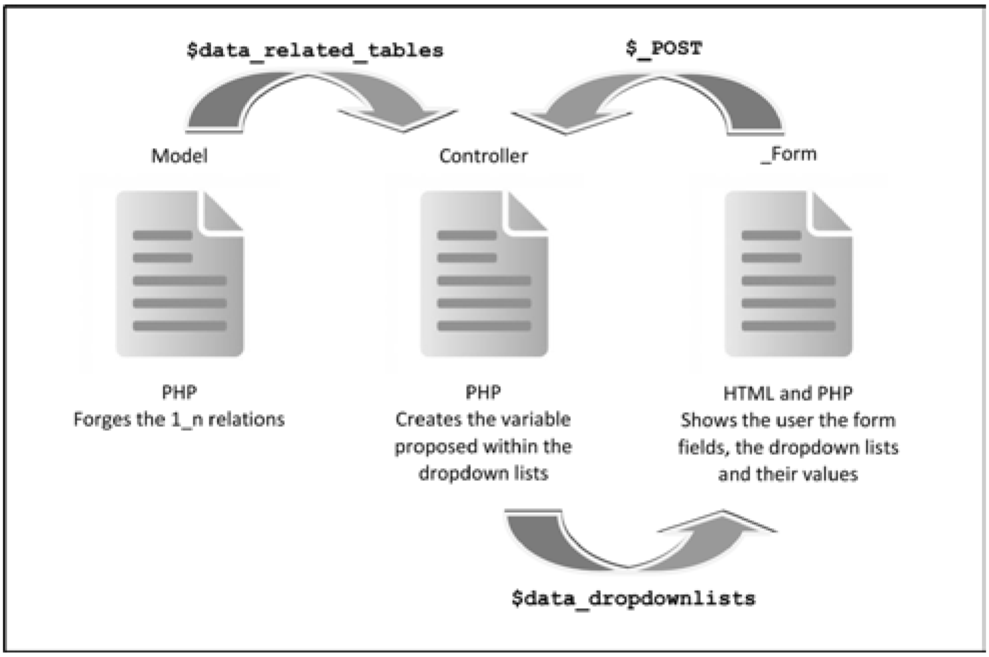


Fig. 6. Relations between different source files while creating form fields.

the visible element is loading. Thanks to the PhpExcel library, this function allows saving the posted file on a temporary location and reading it in order to retrieve the data it contains and to construct a PHP variable (Fig.7a.). Then, for each column identified in the file, the drop-down list of the different table fields will be shown. Once each column has affected a field, the data in each line of the sent file will be compared to the model and then it will be added to the table. There is, nonetheless, an aspect which must be taken into account. The imported file must not contain any empty cell. These must be necessarily replaced by the value 'NULL' in the case of text type fields and '-1' in the case of number type fields.

Likewise, exporting tables under the excel file format goes through the addition of a new visible element (download), controlled by a function (action_download). The variables to be exported are posted from the element which corresponds to their visualisation thanks to a PHP form. This form contains a hidden field which allows sending the variable containing the data in a linear form (thanks to the serialize function). It is

```
<?php
//UPLOAD                    a. upload function code elements

    if(!empty($_FILES))
    {
        //Setting the temporary name and temporary location
            $filename = 'uploaded_file.xlsx';
            $tmp_name = $_FILES["my_file"]["tmp_name"];
            move_uploaded_file($tmp_name, DOCROOT.'assets/files/'.$filename);

        //Uploading the file using the PHPExcel library
            $excel = new PHPExcel();
            $inputFileName = DOCROOT.'assets/files/uploaded_file.xlsx';
            $inputFileType = PHPExcel_IOFactory::identify($inputFileName);
            $objReader = PHPExcel_IOFactory::createReader($inputFileType);
            $objReader->setReadDataOnly(true);
            $objPHPExcel = $objReader->load($inputFileName);
            $sheet = $objPHPExcel->getSheet(0);
    }
//DOWNLOAD                  b. download function code elements

        $objPHPExcel = new PHPExcel();

        $head = array('id', 'label_1', 'label_2', 'label_3');

        //head
            $head_col = 0;
            foreach ($head as $col):
            $objPHPExcel->getSheet()->setCellValueByColumnAndRow($head_col, 1, $col);
            $head_col++;
            endforeach;

        //body
            $body_line = 2;
            foreach ($data['requetes'] as $line):
                $body_col = 0;
                foreach ($line as $cell):
                    $objPHPExcel->getSheet()->setCellValueByColumnAndRow($body_col, $body_line, $cell);
                    $body_col ++;
                endforeach;
                $body_line ++;
            endforeach;

        //Writer
        $objWriter = new PHPExcel_Writer_Excel2007($objPHPExcel);
        $objWriter->save(DOCROOT.'assets/files/downloaded_file.xlsx');
?>
```

FIG. 7. PARTS OF THE UPLOAD AND DOWNLOAD FUNCTIONS CODE INVOLVING THE PHPEXCEL LIBRARY.

possible then to write the document, to save it on a temporary location and to request its download from a visible element thanks to the functionalities of the library (Fig. 7b.).

2.3 Query interface

The creation of a query interface adapted to palynologist's issues constituted one of the most important goals of the ABCData project. One of the prior concerns about it was to guarantee on one side the possibility to have numerous parameters of queries while being able at a later stage to add some more developments (and especially to include anthracological queries), and on the other side the accuracy of the results. Results have been permanently checked using the local RDBMS query results (Maguet 2013).

To build up this query interface, we added to the original MVC a new set of source files, including new controllers, models and views. Users can select a great amount of parameters to run their queries, then the base computes the results to be displayed, and offers one to download the table or to see the results on the form of a graph.

2.4 Query fields management

The query interface shows the user a list of parameters he can select in order to study the effect of this parameters selection on the global results. The view that manages this selection is deeply associated to a javascript file which handles the interactions between the user and the base (for example with dropdown lists, checkboxes, etc.). All parameters are linked to information available about samples, cores, sites, datings or taxa, or even calculation methods (tab. 1).

2.5 Calculation of the results

The calculation of the results necessitated the creation of a great number of new functions, added to the controller. First of all, all the values corresponding to the selected criteria and all the primary keys of the sample responding to these criteria must be identified and isolated. If the samples must be classified according to their chrono-cultural attribution, a specific function orders these chrono-cultural periods so that they will appear in a consistent way on a temporal axis.

Characteristics of the samples location Alluvial basin Altitude Sediment nature Palynological context (river bed, swamps, archaeological site...) Distance to the nearest archaeological site	**Calculation methods** Vary the taxa excluded from the sum base (i.e. the total number of pollen grains) Express the results in quantity of pollen grains or in % of the sum base Express the results in % of the samples in which the selected taxa are lower or higher to a given quantity. Express the results for each selected taxa or sum the results of all the taxa
Chronological attributions Lower and upper chronological boundaries Chrono-cultural period(s)	**Selection of the taxa** By name By group (heliophytic, ruderals...) By type (woody plants, grass plants, ferns...)
Quality of the samples Preservation rating Diversity Relative diversity	**Clustering queries** By chrono-cultural period(s) By alluvial basin By distance to the nearest archaeological site Palynological context

Tab. 1. Parameters displayed in ABCData's query interface.

The values corresponding to the rate of each plant among each sample is recalculated depending to the sum base parameters, and several functions are in charge of the reliability and representation evaluations.

One of the biggest issues concerning this kind of programming work is to take into account all the values that can be possibly chosen for each parameter. In order to simplify these numerous possibilities management, a specific function was designed, its role is to analyze the chosen parameters list and to build a variable that turns all the parameters into a set of numeral codes. Depending on these codes, the different functions that must be run to compute the results will not be the same for each query.

2.6 Display of the charts

Different kind of graphic representation (Fig. 8) that had to undergo a specific programming phase, are supported by ABCdata. The type of graphic representation known as pollen diagram generally corresponds to the analysis of a sedimentary core in which different samples have been isolated at different depths. But here, the data to be represented are obtained from queries that combine the results of several cores. This does not allow using depth as an axis of the graph. Nevertheless, in many cases, queries show results according to well-defined chronological periods, which can be placed on a time axis. Therefore, values to be shown do not correspond to exact points but to intervals, hence its representation as a histogram. Furthermore, graphics obtained from these queries contain a significantly higher number of taxa than that of a single sequence. The way it is presented on a website, needs an adapted solution. The setting of this tool begins with the creation of a php files group (controller, model, view), associated with a javascript file stored in the */.../public/assets/js* directory. Same as with exporting spreadsheet files, the results of the queries are linearized and sent through a hidden form.

The functions of the controller are designed to define the variables that are later used by the javascript file. Once the php variables are declared in the controller, it is necessary to declare them in javascript, in the view. A tag which will work as a support for the construction of the graph is inserted, and then a script is opened so as to write on it. This procedure corresponds to the javascript language. We also use an online javascript library, D3.js, called in the template file. This library allows us to use the data corresponding to the query results as a material for the construction of a *Scalable Vector Graphic* (SVG) that represent these results. Finally, by doing a *mouseover*, it is possible to read the values of the different histogram windows. In order to export these graphs, a plugin such as SVG Crowbar proves to be an excellent solution. The .svg files, once they have been downloaded, can be opened and edited with Inkscape.

3 Database testing

The functioning of the base was tested through a series of queries we run after the integration of a great amount of palynological data coming essentially from the research work of Chantal Leroyer (UMR 6566 Rennes). All the palynological records we integrated to ABCData have therefore already been analyzed and commented (Leroyer 1997; Leroyer and Allenet de Ribemont 2006), allowing us to compare ABCData's results to the previous numerous publications. Furthermore, the exploitation of these data places itself among a vivid research dynamic supported by the remarkable quantity of palynological and archaeological data available in this region, due to the importance of rescue archaeology surveys in this area.

3.1 Palynological integrated data

Altogether, 31 sites which are mainly located in three different valleys (Oise, Marne and Seine) have been recorded (Fig. 9). In these locations 43 cores were removed, not in the archaeological

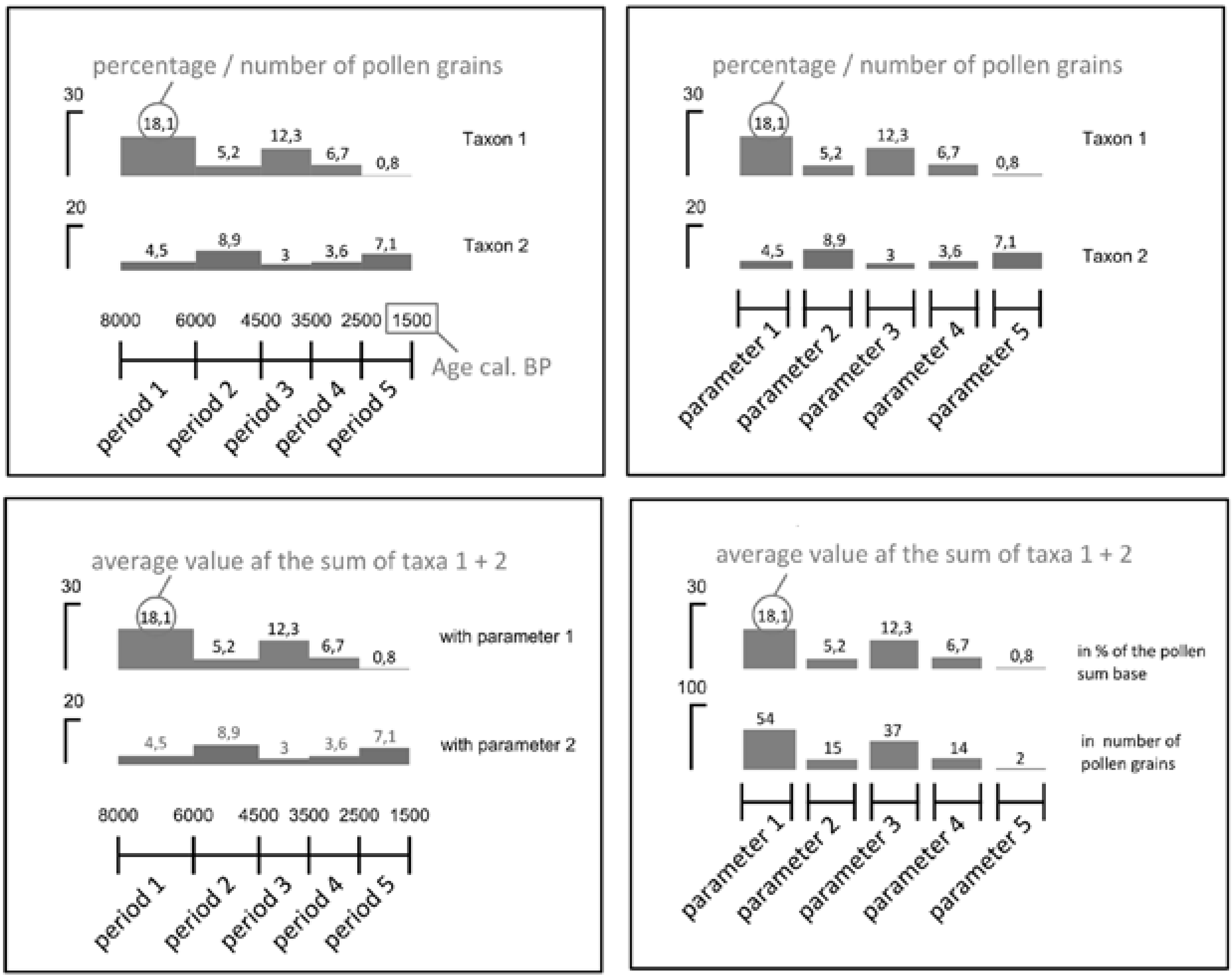


Fig. 8. The different diagrams displayed in ABCData's query interface.

sites themselves but in more suitable contexts, mainly in valley-bottom infilling contexts. They represent a total of 996 samples that have been considered as reliable and associated to a chrono-cultural period (tab. 2). This chronological attribution is firstly set on the pollen-assemblage zone (PAZ), but also on various dating methods (^{14}C, dendrochronology, archaeological remains), as well as age-depth models (David, 2014). We characterized 32 chrono-cultural periods (annexe 2), their age is defined in calibrated BP, and that may be replaced in a larger context corresponding to the local pollen-assemblage zones identified in the area (Leroyer 1997), and to the Mangerud's chronozones (Mangerud *et al*. 1974) calibrated in B.C. (Walnus and Nalepka 2010).

The sample distribution has also been studied according to the periods and the distances between the collecting area of the samples and the nearest attested archaeological site (Fig. 10).

3.2 Results produced

The exploitation of the data through the query interface, associated to the chart displaying tool, enabled us to obtain the synthetic diagrams showing the evolution of all vegetation taxa within a period from the end of the Late Glacial Period (12350 cal. BP) to the middle of the 19th century. On the diagrams presented here (Fig. 11; Fig. 12), we have chosen to represent only the major or the particularly significant taxa concerning the history of the evolution of the vegetation cover.

The results of this study were compared to the data already published on the history of the vegetation in the Paris Basin (Leroyer 1997; David *et al*. 2012; David 2014) and especially to numerous works focused on the identification of ancient marks of anthropization of the natural landscape (Leroyer 2004; Leroyer 2009; Leroyer and Allenet de Ribemont 2006; Leroyer *et al*. 2012; Leroyer *et al*. 2014). They constitute a statistical synthesis of the totality of the available data, and as such they provide precious information about the evolution of the proportion of the different taxa throughout time. Nevertheless, they should not be considered as a quantitative restitution of the vegetation cover composition during the Holocene Period, that only the modelling studies of the pollinic data may approach. However, these synthetic results are enhanced with the results of queries allowing us to isolate some samples or to carry out different statistical reasoning, more adapted to palaeoenvironmental questionings. The distribution of the available samples according to the chrono-cultural period and the distance in relation to the settlements also constitute an important source of information allowing us to qualify or to explain some observations.

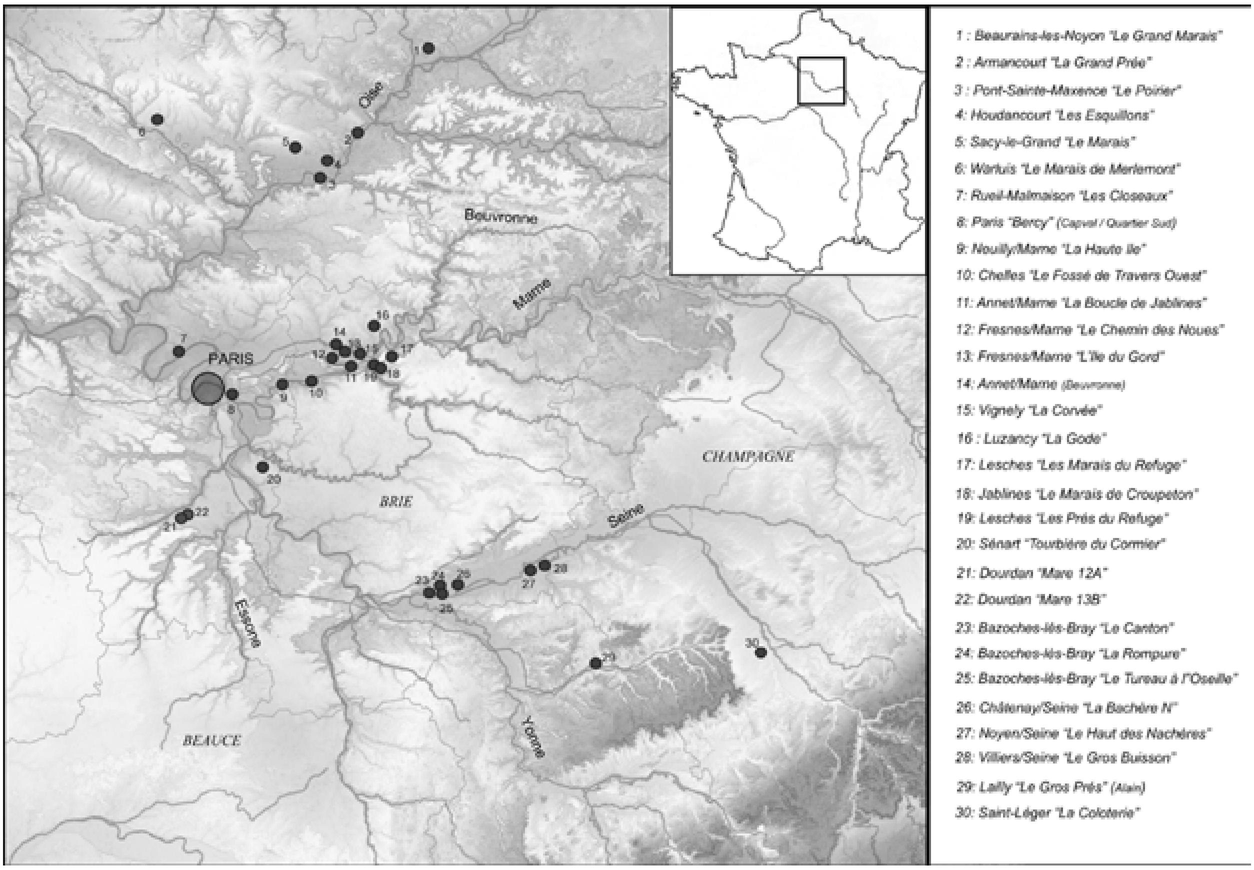


FIG. 9. LOCATIONS OF THE DIFFERENT PALYNOLOGICAL CORES INTEGRATED INTO THE BASE.

4.1 Mesolithic Period

The records corresponding to the end of the Late Glacial Period and to the Mesolithic times send back a quite expected picture of the vegetation evolution, with firstly an open field landscape associated to steppe vegetation. Then the transition to the Preboreal period is clearly marked by a forest recapture stage led by heliophytic taxa, mainly the birch (*Betula*) and the pine (*Pinus*). From the Early Atlantic, corresponding to the transition between medium and recent Mesolithic in the Paris Basin, a remarkable phenomenon can be observed: the queries studying the average of ruderal vegetation show us that in the samples collected less than 100m from an attested human settlement, the rates of ruderal species can reach more than 8%, whereas they are usually included between 2.5 and 3.5% among the other samples (Maguet 2014). These differences could then reveal the mark of a very light form of anthropization of the landscape that can only be observed at immediate proximity of human occupations. However, the traces of cereals in samples assigned to the Late Mesolithic could show a vice of designation or a problem of chronological assignation of the samples. The final stages of the Mesolithic period can in fact be sometimes contemporary of the arrival of the first Danubians (Leroyer *et al*. 2014).

4.2 Neolithic Period

During the Neolithic times, no disturbance of the woody plants, nor noticeable increase of pollinic evidences of anthropization can be detected, although the presence of cereals pollens leaves no doubt about the existence of agricultural activities. The study of the assemblages in accordance with the distance to the human occupation shows us again that the recording of ruderals and cereals is much more important near the sites. This is what notably explains the importance of the ruderals (more than 5%) in the Chasséen-Michelsberg Kultur, period for which about half the samples are located less than 100 meters far from an archaeological site (Maguet 2014). These elements therefore speak in favour of the hypothesis of an anthropogenic impact perceptible as soon as the earliest Neolithic groups settle down, but effective and observable only on local scale. The environment during this period seems therefore relatively open, although the main woody plants keep an important part, and the traces of the cereal agriculture remain low. Furthermore, it is important to note that the first farming exploitation methods and their environmental impact are still not well known. It is more likely that a part of the agro-pastoral activities of the Neolithic period have left very few traces in the palynological records. Especially the semi-nomadic agricultural techniques called slash and burn, that places the crops in the middle of a mass of forest acting as a filter and stimulates the renewal of the forest areas, have few chances of being detected only by means of palynology (Vuorela 1986). Finally, the filter put upon these data by the expansion of the alder during the Late Atlantic, which has an affect both during the material dropping in ponds surrounded by the waterside woodland, and also during the calculation of the results in percentage of the sum base (Leroyer 1997; Leroyer and Allenet de Ribemont 2006), creates a further obstacle to the identification of the first landscape disruptions.

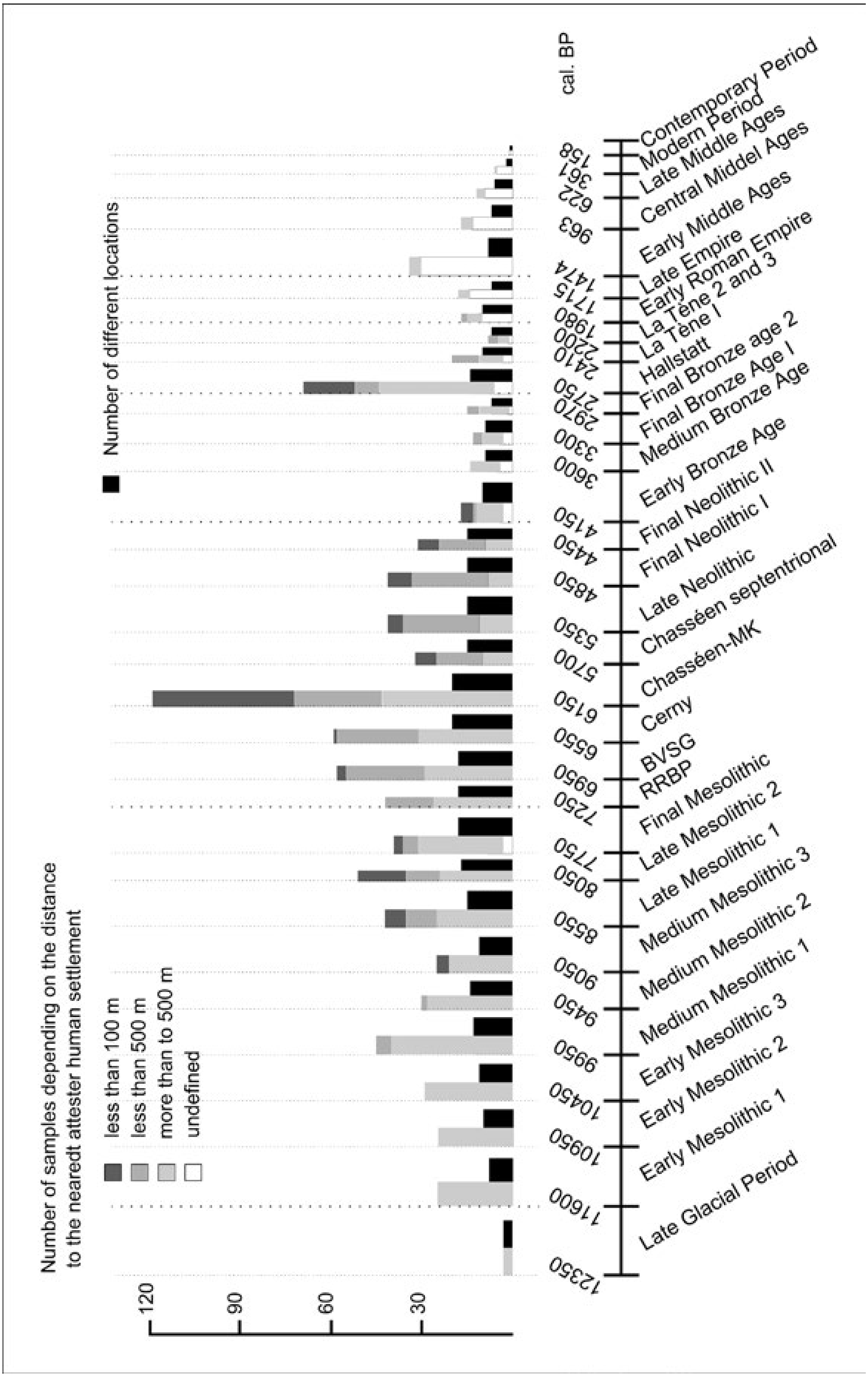


FIG. 10. DISTRIBUTION OF THE SAMPLES INTEGRATED INTO THE BASE.

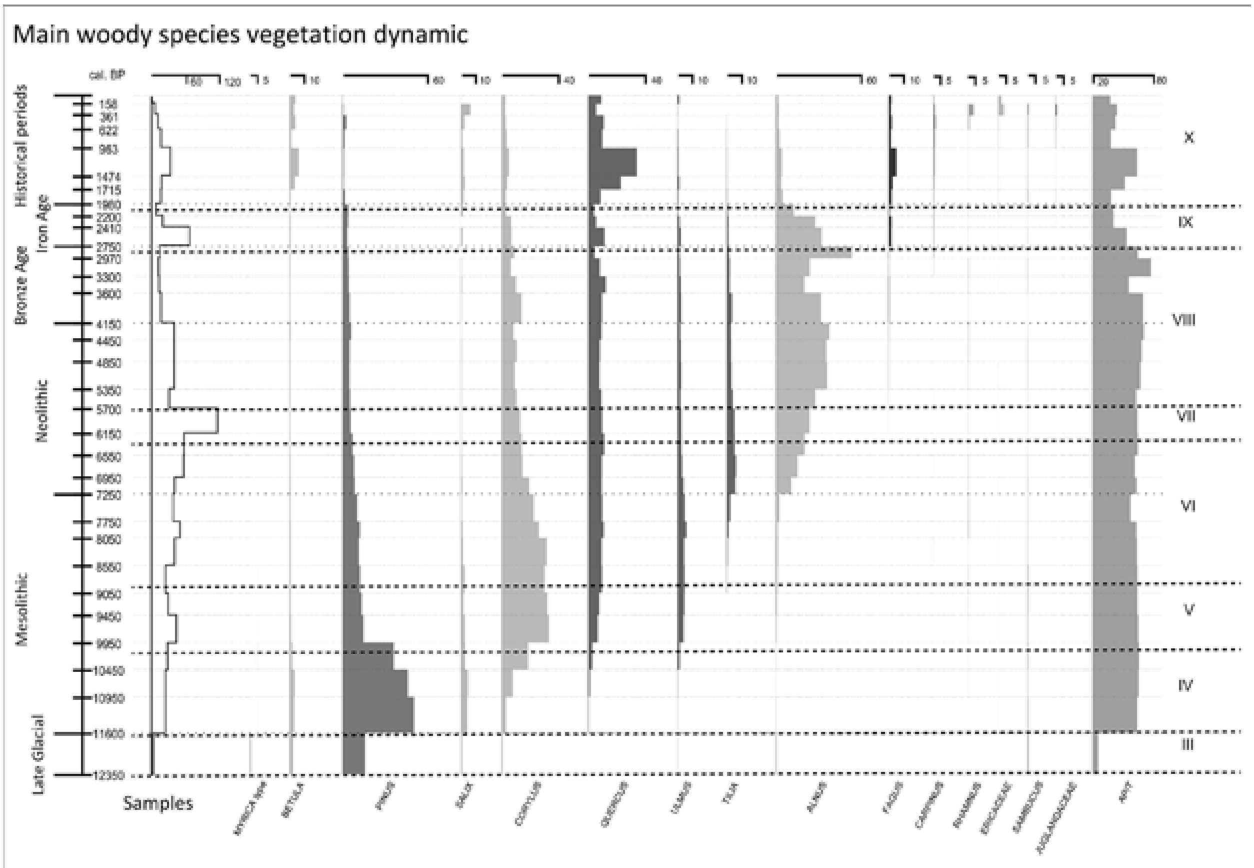


FIG. 11. PALYNOLOGICAL DIAGRAM OF THE MAIN WOODY SPECIES.

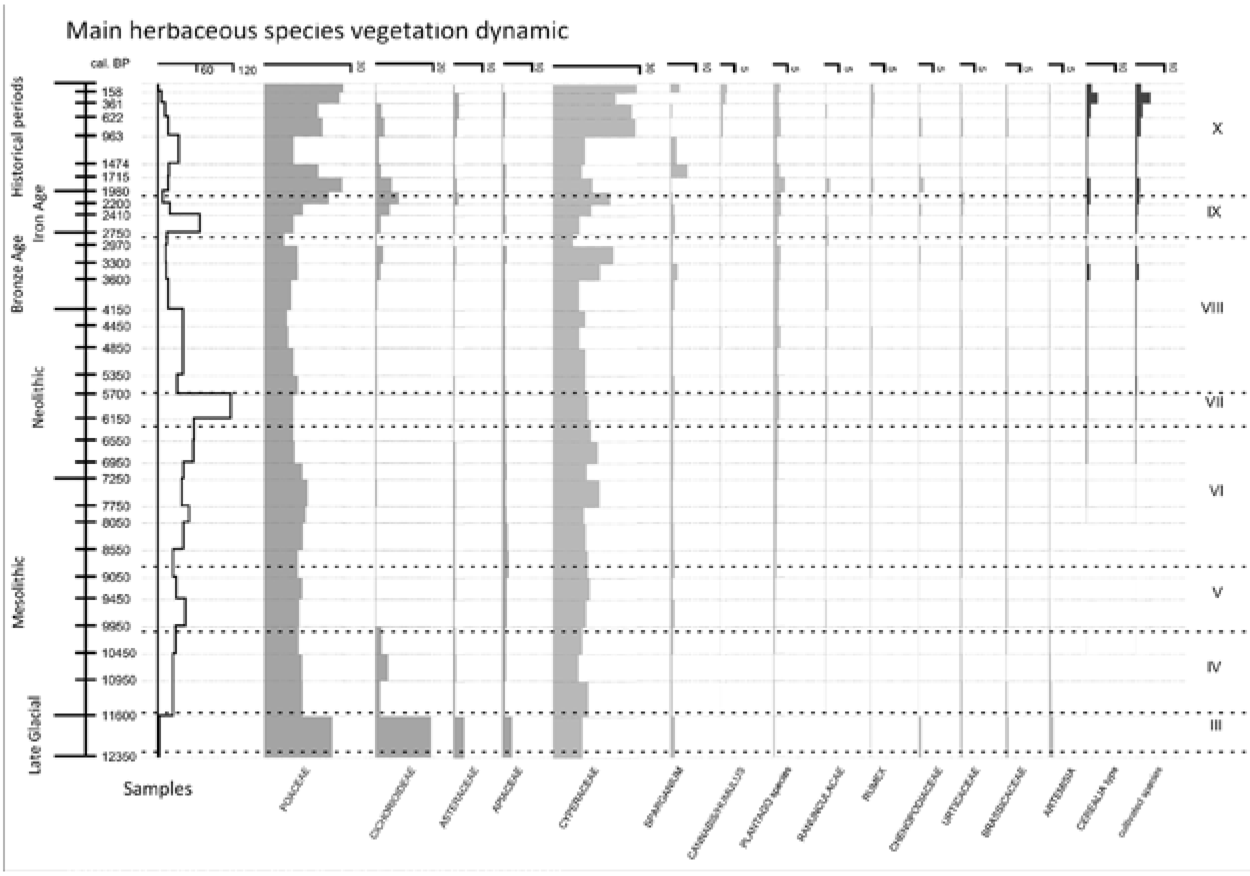


FIG. 12. PALYNOLOGICAL DIAGRAM OF THE MAIN HERBACEOUS SPECIES.

Dates cal. BP	PAZ	Chronozones (Mangerud and al. 1974)	Chrono-cultural periods of reference		Dates cal. BC/AD
	X	Subatlantic	Historical Periods	Contemporary period	1950
				Modern period	1792
				Late Middle Ages	1474
				Central Middle Ages	1328
				Early Middle Ages	987
				Late Roman Empire	476
				Early Roman Empire	235
-2050	IX		Iron Age	La Tène 2 and 3	-30
				La Tène 1	-250
				Hallstatt	-460
-2850	VIII	Subboreal	Bronze Age	Final Bronze Age 2	-800
				Final Bronze Age 1	-1020
				Medium Bronze Age	-1350
				Early Bronze Age	-1650
			Final Neolithic	Final Neolithic 2	-2200
				Final Neolithic 1	-2500
			Late Neolithic		-2900
			Central Neolithic	Chasséen septentrional	-3400
-5750	VII	Atlantic: Late Atlantic		Chasséen-MK	-3750
				Cerny	-4200
			Early Neolithic	BVSG	-4600
-6350				RRBP	-5000
			Final Mesolithic		-5300
	VI	Atlantic: Early Atlantic	Late Mesolithic	Late Mesolithic 2	-5600
				Late Mesolithic 1	-6100
			Medium Mesolithic	Medium Mesolithic 3	-6600
-8950	V	Boreal		Medium Mesolithic 2	-7100
				Medium Mesolithic 1	-7500
-10150	IV	Preboreal	Early Mesolithic	Early Mesolithic 2	-8000
				Early Mesolithic 1	-9000
-11450	III	Late Dryas	Late Glacial Period	Quaternary/Late Glacial	-9650
-12950	II	Alleröd			-10400
-13650		Early sup. Dryas			
-13600	I	Bölling		Late Glacial	
					-16050

Tab. 2. Chrono-cultural periods and chronozones of references.

4.3 Bronze Age

From the Bronze Age, a smaller number of samples are available, and we know less about the population of the Paris Basin during this period. The synthetic diagrams prove us a relative continuity between the Neolithic period and the Early Bronze Age, with only a short rise of the hazel (*Corylus*) noticeable at less than 100 meters from the sites (Maguet 2014). This may show a short phase of forest recovery, or eventually new forms of forest management (David 2014). Indeed, together with the increasing growth of the hazel, important rates of the nitrophilic group can be observed. The move to the Medium Bronze Age is branded by a slight increase of the poaceae averages, which suggests a dynamic of landscape opening or woodland clearing, the poaceae being eventually able to grow among lightly thick forest areas (Leroyer 1997). Otherwise we can notice an increase of recorded cereal (*Cerealia* type) quantities as well as a greater proportion of samples in which the cereal ratio is higher than the 1% threshold, even though it happens to be samples to which no nearby settlement is connected. During the Medium Bronze Age, the sudden decrease of cereal quantities seems startling. Actually the explanation of these values comes from a lack of sample diversity: half of them come from a unique site consequently carrying a disproportionate weight in the averages calculation (Maguet 2014). This point highlights an important bias which puts in evidence the necessity of a stronger development of the means of controlling the distribution and the representativeness of the samples, in order to regulate the synthetic results. Keeping in mind these reticences about the reliability of the study bearing on the 2nd Final Bronze, it looks as if the end of Subboreal period could correspond to a stage of wood plants destabilization revealed by the forest and heliophitic vegetation decrease. To sum up, the Bronze Age appears therefore printed by a better perception of anthropization evidences suggesting reinforcement of human grip on the environment, a rise of farming lands or even a use of forest resources for metallurgy (Leroyer 1997). Though no samples closely related to an archaeological settlement after the Early Bronze Age can be found, the recording of the varied IPAs tends to reinforce this hypothesis.

4.4 Iron Age and Historical times

If the samples associated to the Hallstatt culture constitute a quite satisfying corpus, they are less numerous and more disconnected with the archaeological sites of the 2nd Iron Age. Nevertheless the transition to the Subatlantic period around 600 cal. BC corresponds to the beginning of a dynamic which will last until the end of the Early Roman Empire. It starts with a quick withdrawal of alder linked to the expansion of the beech tree and of the opening of the landscape, colonized by *Poaceae* and *Cichorioideae*, opening realized against most of the wood plants to the exception of the hornbeam (*Carpinus*) which slightly gains ground. At the beginning of the Gallic period, the timid presence of new crops such as fax, rye, walnut, and vine can be noticed. It is mainly from the beginning of the La Tène culture that a significant increase of the cereal percentage is recorded (Maguet 2014).

Between the Early and the Late Roman Empire, a very clear break is characterized by the lessening of crops excepting rye (*Secale* type) and chestnut (*Castanea*) as well as ruderals, together with a very clear increase of the oak and the heliophytic plants. Therefore the dynamic initiated since the Bronze Age seems then to invert as a new growth of forest vegetation can be observed. The rates of the heliophytic plants (*Corylus* and *Betula*), correlated to the weakness of anthropization indicators confirms a recovery of the environment by these pioneering vegetation. The ruderal assemblage composition and the low averages of *Cerealia,* suggest a predominance of pastoralism as the main agricultural activity until the High Middle Age, in accordance with the expected results (Leroyer, 1997). From the Carolingian times an increase of all the crops and pastures (dry or damp) can be observed. This tendency persists from the Early Middle Age to the 20th century, with a drop of *Castanea* and *Secale* type to the benefit of C*erealia* type which confirms its supremacy among the cultivated taxa. Nevertheless the poverty of the available sample corpus for the more recent periods forbids any further interpretations.

5 Conclusion

With this project, we aimed to open new perspectives for the development of palaeoenvironmental field, as the archaeologists are more and more interested in reconstructing the past ecosystems, understanding the evolution of animals and plants, and comprehending the role of human societies within the natural landscape.

The creation of ABCData, from the base programming to the analysis of the integrated data, allowed us to evaluate the interest computer programming could bring to our domain, and to get a better estimation of the advantages, requirements and issues of this application. Now we must highlight the complexity of the program writing and the weight of the IT resources used notably for the query results computing with the php language. Consequently, the results must always be cautiously considered before validation. We also discovered new possibilities in terms of storage, exploitation and visualisation of the results. The integration of information about the samples, together with the paleobotanical data, allows us to run queries that study the impact of some influent parameters in order to try out some hypothesis and explain some phenomena. It particularly pointed out the misrepresentation of the global results caused by unbalanced distributions of the samples.

Interdisciplinarity is also an essential element that still has to be developed, particularly concerning the comparison between palynological and anthracological data. That confrontation has already proved to be fertile (Leroyer *et al*. 2011). Besides, the archaeozoological part is currently being developed, and on the long term ABCData should be able to host malacological data. It would also be interesting to integrate into the base a larger quantity of data, from other areas or attributed to other periods, in order to run queries involving new parameters. Finally, GIS interface will soon be added to the base and we would like to be able to explore the graphic possibilities offered by the D3.js library and to consider the creation of a 3D landscape reconstruction tool.

Bibliography

David, R., Leroyer, C., Mazier, F., Lanos, P., Dufresne, P., Allenet De Ribemont, G., Aoustin, D. 2012. Les transformations de la végétation du bassin parisien par la modélisation des données polliniques holocènes. In Bertoncello, F. and Braemer, F. (eds.), *Variabilités environnementales, mutations sociales. Nature, intensités,* *échelles et temporalités des changements. Actes des XXXIIe rencontres internationales d'archéologie et d'histoire d'Antibes*: 53-68. Antibes, Éditions APDCA.

David, R. 2014. *Modélisation de la végétation Holocène du Nord-Ouest de la France : Reconstruction de la chronologie et de l'évolution du couvert végétal du Bassin parisien et du Massif armoricain.* Unpublished PhD thesis, Université de Rennes 1.

Goeury, C. 1997. GpalWin : gestion, traitement et représentation des données de la paléoécologie. In *Actes du XVe symposium de l'A.P.L.F.* : 31. Lyon.

Kreuz, A. and Shafer, E. 2002. A new archaeobotanical database program. *Vegetation History and Archaeobotany* 11: 177–9.

Leroyer, C. 1997. *Homme, climat, végétation au Tardi- et Postglaciaire dans le Bassin parisien : apport de l'étude palynologique des fonds de vallée*. Unpublished PhD thesis, Université Paris 1 Panthéon-Sorbonne.

Leroyer, C. 2004. L'anthropisation du Bassin parisien du VIIe au IV millénaire d'après les analyses polliniques des fonds de vallées : mise en évidence d'activités agro-pastorales très précoces. In Richard, H. (ed.), *Néolithisation précoce. Premières traces d'anthropisation du couvert végétal à partir des données polliniques*, Collection Annales littéraires, série 'Environnement, Sociétés e t Archéologie' 7: 11-27. Besançon, Presses Universitaires de Franche-Comté.

Leroyer, C. and Allenet De Ribemont, G. 2006. L'anthropisation du paysage végétal d'après les données polliniques : l'exemple des fonds de vallées du Bassin parisien. In P. Allée and L. Lespez (eds.), *L'érosion, entre société, climat et paléoenvironnement* : 63-72. Clermont-Ferrand, Presses Universitaires Blaise Pascal.

Leroyer, C. *et al*. 2009. Base de données et S.I.G. palynologiques sur l'Age du Fer en France : une autre approche du paysage végétal et de son anthropisation. In I. Bertrand, A. Duval, J. Gomez De Soto, P. Maguer (eds.), *Habitats et paysages ruraux en Gaule et regards sur d'autres régions du monde celtique. Actes du XXXIe colloque international de l'Association Française pour l'Etude de l'Age du Fer, Chauvigny, 17 - 20 mai 2007*, II, Mémoire A. P. C. XXXV: 447–68.

Leroyer, C., Coubray, S., Allenet de Ribemont, G., Perrière, J., Pernaud J.-M. 2011) Vegetation dynamics, human impact and exploitation patterns in the Paris Basin through the Holocene: palynology vs. Anthracology. *SAGVNTVM* 11: 81-2.

Leroyer, C., David, R., Mazier, F., Allenet de Ribemont, G., Lanos, P., Dufresne, P. (2012) Environnement et anthropisation du milieu durant l'âge du Bronze dans le Bassin parisien : l'apport des données polliniques et de la modélisation du couvert végétal. In Melin, M., Mougne, C. (eds.), *L'Homme, ses ressources et son environnement dans le Nord-Ouest de la France à l'âge de Bronze : actualités de la recherche. Actes du Séminaire Archéologique de l'Ouest*: 7-26. Rennes.

Leroyer, C., David, R., Maguet, E., Mazier, F., Allenet de Ribemont, G., Lanos, P., Dufresne, P. 2014. *Environnement et anthropisation du milieu durant le Néolithique dans le Bassin parisien : l'apport des données polliniques et de la modélisation du couvert végétal* (in press).

Maguet, E. 2013. *Création et exploitation d'une base de données palynologiques sur le Mésolithique et le Néolithique du Bassin parisien*. Rennes, Mémoire de Master 1 « Histoire et Archéologie », Université de Rennes 2.

Maguet, E. 2014. *Mise en ligne d'une base de données paléoenvironnementales : développement et applications*. Rennes: Mémoire de Master 2 « Paléontologie, Préhistoire, Paléoenvironnements », Université de Rennes 1.

Mangerund, J, Andersen, S. T., Berglund, B.E., Donner, J. 1974. Quaternary stratigraphy of Norden, a proposal for terminology and classification. *Boreas* 3, 3: 109–26.

Reille, M. 1990. *Leçons de palynologie et d'analyse pollinique*. Paris, Éditions du CNRS.

Tomlinson, P. 1992. Design and implementation of a relational database for archaeobotanical records from Great Britain and Ireland. *Circaea, The Journal of the Association for Environmental Archaeology* 10, 1: 1–30.

Vuorela, I. 1986. Palynological and historical evidence of slach-brun cultivation in South Finland. In Behre, K. E. (ed.), *Anthropogenic indicators in pollen diagrams*: 53-64. Rotterdam, A. A. Balkema.

Walanus, A., Nalepka, D. 2010. Calibration of Mangerud's boundaries. *Radiocarbon* 52, 4: 1639–44.