

EcoCount: A New Digital Approach to Environmental Data Recording

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Abstract

Techniques that analyze biological remains from sediment sequences for environmental reconstructions are well established and widely used. Yet, identifying, counting, and recording biological evidence such as pollen grains remain a highly skilled, demanding, and time-consuming task. Standard procedure requires the classification and recording of between 300 and 500 pollen grains from each representative sample. Recording the data from a pollen count requires significant effort and focused resources from the palynologist. However, when an adaptation to the recording procedure is utilized, efficiency and time economy improve. We describe EcoCount, which represents a development in environmental data recording procedure. EcoCount is a voice activated fully customizable digital count sheet that allows the investigator to continuously interact with a field of view during the data recording. Continuous viewing allows the palynologist the opportunity to remain engaged with the essential task, identification, for longer, making pollen counting more efficient and economical. EcoCount is a versatile software package that can be used to record a variety of environmental evidence and can be installed onto different computer platforms, making the adoption by users and laboratories simple and inexpensive. The user-friendly format of EcoCount allows any novice to be competent and functional in a very short time.

Keywords

efficient, automated, voice recognition, user-friendly, versatile

Introduction

Analysis of biological evidence in the form of plant and animal remains is fundamental to environmental reconstruction. Biological evidence includes, but is not exclusive to pollen, spores, diatoms, plant macrofossils, mollusca, fossil insect remains, foraminifera and chironomidae. Pollen analysis is a versatile, established, and widely used technique (Lowe & Walker, 1997; Twiddle, 2012), with multiple applications ranging from environmental reconstructions to forensic evidence. Due to this diversity, we have chosen pollen analysis to exhibit the advantages of using EcoCount. Identifying, counting, and recording pollen grains and spores remain a highly skilled, time-consuming, and demanding task (Stillman & Flenley, 1996). Standard techniques necessitate the classification and recording of between 300 and 500 pollen grains from each representative sample. The quality and quantity of the preserved pollen vary, and attaining the minimum number of pollen grains can involve counting numerous slides. Green (1997) suggested the “sheer time and effort involved in counting pollen” as a significant obstacle to the progression and development of high-resolution pollen studies (France, Duller, & Lamb, 2000). Furthermore, Green (1997) correctly encouraged resolving methodological impediments in pollen analysis (palynology) as a high priority and was an advocate of automation. Although automated pollen counting systems have been proposed and are

continuing to be developed (e.g., Allen et al., 2006; Costa & Yang, 2009; France et al., 2000; Holt et al., 2011; Langford, Taylor, & Flenley, 1990; Li & Flenley, 1997), the potential of these systems appears not to have been fully realized or embraced by the palynology and wider environmental community. The reasons for this have ranged from expense of the systems, reliability and accuracy issues, and simple reluctance of the palynology community to embrace a radical change to their technique/field. However, efforts have been made to develop user-friendly low cost systems to facilitate wider availability (e.g., Costa & Yang, 2009). Until a fully reliable and financially accessible system is available, simple changes within the pollen analysis methodology can improve the efficiency of the palynologist.

There are many steps in the process of pollen analysis that do make the technique a labor-intensive and a time-consuming activity. Procedural steps such as chemical treatments during the sample preparation process are essential and cannot be removed or rushed, for example, spinning to remove water prior to acetylation. However, with

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procedural experience, the preparation of samples can be relatively efficient. Yet once the laboratory preparation phase has been successfully completed, there is ample opportunity for improvement of the current procedure. One specific area for enhancement is the actual data recording of the identified pollen and spores. Once the palynologist has identified the pollen grain or spore, the data along with ancillary information such as preservation condition, presence of charcoal, or the preparation spike (e.g., *lycopodium*) are entered onto a count sheet. The use of a paper count sheet remains a common occurrence for the palynologist and is often augmented by a number of hand tally counters (analogue and digital) that have been designated a specific pollen type. Computerized count sheets utilizing software such as Microsoft Excel have been used and remove the data entry step into subsequent programs such as Tilia/TGView (Grimm, 1992, 2004), but the current process of recording the primary pollen data represents an inefficient step in the palynologist's routine.

Currently, recording pollen types requires the palynologists to look away from the microscope, find the correct taxa on the sheet/tally counter/cell, and physically enter data, which over the duration of a full count represents a significant inefficient use of time.

We acknowledge that the process of physically recording the pollen allows the palynologist to further engage and become familiar with the evolving data set, which develops a deeper connectivity to the results. Yet, constantly breaking contact with the field of view remains a cumulative inefficient use of time. Therefore, if a record of the identified pollen could be constructed while the palynologist continues to engage with the field of view and connects to the developing data set, it would make one aspect of the pollen counting procedure more efficient and economical. The process of manually transferring data from the count sheet into a spreadsheet or directly into programs such as Tilia/TGView (Grimm, 1992, 2004) is time-consuming. If this step of physical data recording and transfer could be eliminated from the procedure, it would save further time and remove an inefficient step in the working-up of pollen data.

EcoCount—The Advantage of the New Digital Approach to Environmental Data Recording

An alternative technique that improves efficiency for data recording and transfer is presented here. The EcoCount program is a voice activated automated computer program. EcoCount uses the Microsoft Speech Application Programmers Interface (API) to perform both listening and speech synthesis. The API enables the software to record the user's voice and parse the recorded sound to identify keywords and phrases. EcoCount uses these words and phrases and interprets the user's requirement, for instance, by



Figure 1. Equipment configuration, illustrating headset with microphone linked to a laptop computer running EcoCount.

incrementing the count of a particular type of pollen. The configuration (Figure 1) can be via a headset or freestanding microphone where the palynologist tells the computer what to record. In addition, EcoCount uses the Microsoft API to enable a talkback function so that the software can engage with the palynologist either through the speakers or headphones. On recognition of a phrase such as “Count Tilia, Count Good,” the talkback function says what the computer has understood in the form of “Count Tilia, Count Good.” This informs the palynologist of the action and enables him or her to undo that count if necessary by saying the command “Edit undo.”

EcoCount operates on a simple spreadsheet format, with each taxon listed in individual cells. These cells can be included or excluded from the total count via a tick box being activated. The palynologist first creates a dictionary of taxa by adding in all the pollen and spore types they expect to observe. Once the dictionary has been created, this can be kept as a template file for expedient deployment in successive counts. Subsequent taxa types can be quickly added in during the counting and identification phase. The taxa names are entered into the sheet, via the sub menu (Figure 2). Following the addition of new pollen type(s), the program is then restarted and the computer will instantly recognize and use the recently added pollen type.

The data can be entered into the spreadsheet via two ways.

First, manually—The palynologist adds information by looking up each taxon in the spreadsheet and uses a mouse to input the value.

Each taxa cell can be increased and decreased by an increment of one, when the curser is placed on the corresponding taxa row and double clicked. If a value has been entered into the wrong cell, right click and choose decrement. This process of physically finding the correct taxa remains relatively

The screenshot shows the EcoCount v1.50 application window. The title bar reads "EcoCount v1.50 - C:\Documents and Settings\PhilMy Documents\Pollen Work\MoLAS CHC\Second Analsis\BSH BH2\BSH BH2 P6.txt". The menu bar includes "File", "Edit", "Help", and "Options". The main area is a spreadsheet with columns: "Name", "Count", "Last counted", and "Notes". A list of taxa is shown, many with checkboxes in the "Name" column. A context menu is open over the "Cichorium intybus" row, showing options: "Add name", "Delete name", "Modify note", "Increment", "Decrement", "Reset", and "Read word". At the bottom, there are buttons for "Start Listening", "Total" (displaying 301), "Last heard: <nothing>", and a row of buttons for "Good (225)", "Crumpled (34)", "Corroded (19)", "Ruptured (23)", and "Not recognised (4)".

Name	Count	Last counted	Notes
<input checked="" type="checkbox"/> Acer	0	13:27:41	
<input checked="" type="checkbox"/> Alisma	0		
<input checked="" type="checkbox"/> Alnus	7	21:32:50	A four pore grain noted
<input checked="" type="checkbox"/> Ambrosia-Type	0		
<input checked="" type="checkbox"/> Artemis	1	16:53:38	
<input checked="" type="checkbox"/> Anthriscus-type	0		
<input checked="" type="checkbox"/> Apiaceae	1	19:16:00	
<input checked="" type="checkbox"/> Aster type	22	21:55:23	
<input checked="" type="checkbox"/> Athyrium	0		
<input checked="" type="checkbox"/> Avena/Triticum	0		
<input checked="" type="checkbox"/> Belchnum	0		
<input checked="" type="checkbox"/> Betula	4	22:16:29	
<input checked="" type="checkbox"/> Botrycium	0		
<input checked="" type="checkbox"/> Brassicaceae	0		
<input checked="" type="checkbox"/> Calluna vulgaris	3	21:43:15	
<input checked="" type="checkbox"/> Caltha palustris	0		
<input checked="" type="checkbox"/> Cannabis	0		
<input checked="" type="checkbox"/> Caryophyllaceae	0		
<input checked="" type="checkbox"/> Centaurea nigra	0		
<input checked="" type="checkbox"/> centaureae cyenus	0		
<input checked="" type="checkbox"/> Chaerophyllum temulentum	0		
<input checked="" type="checkbox"/> Chenopodiaceae	34	22:16:52	
<input checked="" type="checkbox"/> Cichorium intybus	0		
<input checked="" type="checkbox"/> Cirsium	0	20:38:48	
<input checked="" type="checkbox"/> Corylus	9	20:58:57	
<input checked="" type="checkbox"/> Cruciferae	0	17:45:15	
<input checked="" type="checkbox"/> Cyperaceae	7	22:18:21	
<input checked="" type="checkbox"/> Epilobium	0		
<input checked="" type="checkbox"/> Ericaceae	4	21:42:21	
<input type="checkbox"/> Exotic	235	22:20:22	
<input checked="" type="checkbox"/> Fagopyrum	0		
<input checked="" type="checkbox"/> Fagus	2	20:26:44	
<input type="checkbox"/> Filicales	2	21:55:44	
<input checked="" type="checkbox"/> Filipendula	2	20:40:35	

Figure 2. An example of the EcoCount spreadsheet.

inefficient but does generate a digital file, which makes data transfer into Tilia/TGView (Grimm, 1992, 2004) convenient. The spreadsheet can list the taxa in alphabetical order, which is optional, and also has a time stamp displayed to tell the palynologist when the last values were added into a cell. Yet this method represents time and resource management issues, and is not the preferential use of EcoCount.

Second, automatically—Information is added via the voice recognition option within EcoCount.

The palynologist turns on the listening function and tells the computer what pollen or spores and their preservation condition the operator has identified, for example, "count *Betula*" and "count Good." The palynologist prefixes the word that he or she wants the computer to record with the command "count"; this makes the computer listen at a specific time. Even if the EcoCount program is left unattended in "listen" mode, the computer will not record data until the "count" command is heard; this function reduces the chance of background noise being mistakenly recorded by the computer and attributed to a pollen taxon. Each time a pollen type is spoken, it is automatically added into the corresponding taxa cell in the spreadsheet, by an increment of one. There is a playback function that repeats the last taxa and preservation condition recorded by the computer

to the palynologist; this function insures the correct taxa is recognized and recorded by the computer. Therefore, if it was a mistake, the command "edit undo," removes the last taxa added in. New taxa can be added into the spreadsheet at any time during the count following a simple save and restart procedure. Therefore, identification of taxa not included in the original dictionary template is not an issue. All pollen types recorded are automatically entered into a total count tally; thus, the palynologist knows when the minimal count goal has been met. Cells for the pollen preservation and unidentified pollen grains are located within the spreadsheet window (Figure 2); however, these values are not included in the total count. The preservation nomenclature of Good, Crumpled, Corroded, and Ruptured used in EcoCount has followed the categories proposed by Jones et al (2007). Due to the unfamiliar marriage of botanical names and a synthetic voice, there is a "read word" function that allows the operator to hear how the computer listens to words.

Discussion

The software described here for recording pollen is user-friendly, accurate, consistent, and very efficient. Following initial development, this program was tested and used within

a university and private consultancy laboratory setting, and we find EcoCount to be a very robust and dependable piece of software. One logistical distinction of this package is the ease with which it can be loaded onto a Mac and PC platform. The simple application of this software to pre-existing laboratory computers renders purchases of specific computers redundant. In addition, when a computer is upgraded or changed, the transfer of this software is a relatively simple process. Once installed, the ease at which the investigator can become expert makes EcoCount more efficient and effective than the traditional data recording techniques. The oral connection with the software means the investigator continues to interact with the growing data set, and by default, this action allows the time for the data to be mentally worked up by the investigator prior to the completed spreadsheet stage. This continued level of data interaction assures that familiarity with the range of pollen grains is vigorous and unexpected occurrences can be readily identified and explored. The digital count sheet is saved as a .txt file, which can be quickly opened in Excel, which in turn can be opened or imported directly into Tilia/TGView (Grimm, 1992, 2004). We find that the playback feature, where the computer immediately repeats the last recorded name, was exceptionally useful as it allows real-time error correction. Many researchers have been tired when operating a microscope and recorded something different to what was identified. Real-time oral playback for correct data recording is a more effective method for reduction of error compared with manual recording, where a mark is made against the wrong box or the wrong counter is selected, producing a false record that can result in potentially serious consequences. In addition, errors created by the operator have been known to occur during the process of manually transferring the data from a paper count sheet record into a spreadsheet or directly into Tilia/TGView (Grimm, 1992, 2004). Therefore, the playback feature is a simple safeguard that allows users the chance to realize their mistakes before it becomes a permanent error. The playback function also established a reinforced connectivity with the data that allowed the user to develop a detailed and comprehensive mental picture of the developing data set. When an entry into the spreadsheet is made, the time is also recorded. Therefore, we have begun to generate a pollen map of the microscope slide. Analysis of the time stamp map may reveal hitherto unobserved patterns of preferential pollen dispersal in different materials, for example, silicon and glycerin. We imagine that the best form of potential development for this software, applications, and functions must come from the community of users. The advantage of using the EcoCount program is that digital copies are instantly produced while counting and therefore, make the operation of data inputting from paper count sheets redundant. The production of digital files also allows collation of data for storage and archiving very simple and files can be placed within secure storage as a routine end of day activity. EcoCount was designed with pollen analysis in mind; however, due to the

ease of entering taxonomic names into the cells, the program can be adapted for any type of counting analysis, for example, diatoms, foraminifera, and plant macrofossils.

Demonstrating a quantified increase in efficiency during a pollen count due to using EcoCount has been exceptionally difficult. To date, replicating a pollen count to compare using EcoCount against traditional recording methods has been unsuccessful. Pollen samples can be immersed in silica oil to be viewed on a microscope slide. The silica fluid is a material that allows the palynologist to physically rotate grains through 360° planes to observe subtle characteristics that aid identification. When pollen are rotated, one consequence is that the grains often move to different locations on the microscope slide, especially if the cover slip is not sealed into place. Therefore, attempting to identify and count the exact same grains has been remarkably challenging. Replicating a pollen count is possible; however, the emphasis of these tests has been to compare the sums of each identified taxon to examine the pollen ratios per slide. Therefore, quantitate comparative analysis of the time allocation for the different recording techniques are problematic. Consequently, we have used a qualitative account based on feedback from use of EcoCount in an academic and private consultancy laboratory environment. The view was that using EcoCount saved time during the recording phase of the pollen count and by not turning away from the microscope, the feeling of fatigue at the end of a count session was reduced.

Conclusion

Until a full automated, reliable, and economically viable pollen counting package is readily available, pollen analysis will remain a labor-intensive and time-consuming activity. If an adaptation to a procedural technique is utilized, the efficiency of the process can be improved. Identification of the palynomorph can be a time sink; however, methods for recording the information can and have been improved. A current widely used technique for data capture is time-consuming and prone to error. Although we acknowledge the value of basic technology, pen and paper, EcoCount represents a procedural adaptation that can make one facet of pollen analysis more effective and economical. The adoption of a voice activated fully customizable digital count sheet allows the investigator the opportunity to remain engaged with the critical task, identification, for longer, utilizing his or her efforts more efficiently. EcoCount is economical as the trial version is free, and a full license is less than US\$20. The versatility of the EcoCount software package allows the investigator to remain interactive with the developing data set and has functions that can reduce the potential for errors being recorded in the data set. The continued engagement with the data set allows the investigator the time and opportunity to work up a mental picture of the data present on the slide or within the sample. The digital file format further enhances simple and expedient data transfer and storage.

Software that can be loaded onto different computer platforms makes the adoption by users and laboratories simple and inexpensive. The user-friendly format of EcoCount allows any novice to be competent and functional in a very short and efficient time. With use by the counting community, product development can be achieved to make this software a better and more powerful laboratory tool and even more user-friendly.

Authors' Note

A download and instruction guide of EcoCount can be found at www.dynamicsolutions.co.uk and follow the software link.

Declaration of Conflicting Interests

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