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MAKILING BIODIVERSITY INFORMATION SYSTEM (MakiBIS): DEVELOPMENT OF AN ONLINE SPECIES INFORMATION SYSTEM FOR MOUNT MAKILING

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ABSTRACT – Mt. Makiling is a Philippine biodiversity hotspot listed as one of the 170 conservation priority areas established by the Philippine government. With the vast amount of ecological and biological information about the flora and fauna of Mt. Makiling, the Makiling Biodiversity Information System (MakiBIS) has been developed to serve as a repository for these data. Species information included in the MakiBIS are taxonomy, conservation status, habitat, general description and photo. Currently, MakiBIS contains information for 716 species.

MakiBIS is a web based database system using open source web tools such as PHP, jQuery, and MySQL. It is capable of sharing data using the Darwin Core format which is a standard for sharing biodiversity data used by international biodiversity systems such as the Global Biodiversity Information Facility (GBIF). MakiBIS has the core functionalities of a biodiversity information system. Researchers act as administrators and are the ones who encode species information to the system. Ordinary users are only allowed to view species information either through using the search function or browsing the Taxonomic Tree feature. The system can also export an XML dataset following the Darwin Core standard which can be imported by other biodiversity information systems that use the same format.

MakiBIS may serve as a prototype in the development of a national Biodiversity Information System (BIS) that will be useful in addressing the need to set national baseline, measurable targets and indicators to facilitate assessment of biodiversity progress and as well as basis for national and local decision-making.

Keywords: Biodiversity Information System, Darwin Core, Mount Makiling

INTRODUCTION

The Mt. Makiling Forest Reserve (MFR) is well-known to be one of the megadiverse tropical rain forests in the Philippines. About four types of vegetation are recognized in Mt. Makiling based on altitude: upper montane rain forest (above 1000 m), lower montane rain forest (above 750 m), lowland evergreen rain forest (100 – 500 m), and Parang vegetation consisting of a mixture of grassland and second-growth forest (Fernando et al. 2004). An estimated 225 families, 949 genera, and 2,038 species, 19 sub-species, 167 varieties, and many cultivars of flowering plants and ferns have been recorded from the MFR (Pancho 1983; LLDA 2005). Fernando (2004) has listed 15 endemic species of angiosperms found within the area.

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In terms of faunal diversity, Mt. Makiling has a remarkable record. It is home to an estimated 120 avian species, with 59 endemics belonging to 26 families (Mallari et al. 2001; Gonzales 2000). Moreover, at least 50 species of mammals, 120 bird species, six amphibian species, 19 reptile and a number of fish species (Rabor 1977) were recorded. Although no exhaustive studies on insects, except perhaps for the butterflies (Cayabyab 2000) and mealybugs (Lit and Calilung 1994), Mt. Makiling appears to support a very high diversity of this faunal group. MFR was identified as an extremely high critical area for conservation priority in the Philippines (DENR-PAWB and UPCIDS 2002). Because of its marked biodiversity, researchers continue on studying and exploring areas of Mt. Makiling to protect and maintain its integrity.

Biodiversity data in Mt. Makiling is astounding. A biodiversity database will help facilitate various environmental management processes including decision-making, operation, monitoring and evaluating ecosystems. Though prolific in data, biodiversity information on Mt. Makiling are scattered, fragmented, heterogeneous, and inaccessible. For these reasons, there is a need to integrate these data by developing a system of cataloguing biological diversity. Information systems are tools beneficial in centralizing huge biodiversity information that use internet as a medium (Tsontos & Kiefer 2002).

Biodiversity Information System (BIS) is an environmental information system that supports data-intensive sets of databases from museums, academic researches and field observations (Torres et al. 2006). BIS in the Philippines is on its early years. The Protected Areas and Wildlife Bureau (PAWB) of the Department of Environment and Natural Resources (DENR) with cooperation of ASEAN Centre for Biodiversity established the Philippine National Clearing-House Mechanism (PCHM) in 2010 which furnishes the need of integrating information on biodiversity. Several information systems have been developed such as Forestry Information System by Forest Management Bureau (FMB) of Department of Environment and Natural Resources (DENR), Philippine Biodiversity Information Platform (PhilBIP) of Philippine-American Academy of Science & Engineering and Mt. Malindang Biodiversity Information System (DENR 2009, PAASE 2011 & PCAARRD DOST 2012).

The sharing of data between different information systems becomes difficult because of differences in structures and formats used. The Global Biodiversity Information Facility (GBIF) provides a network to share biodiversity information through the use of Darwin Core format in order to achieve its vision of a world in which biodiversity information is freely and universally available for science, society, and a sustainable future (Delgado et. al 2005). The Darwin Core is a body of standards which includes glossary of terms intended to facilitate the sharing of information about biological diversity. These terms were organized using Extensible Markup Language (XML) to store and share information regardless of structure.

The objective of this study was to build a system referred to as Makiling Biodiversity Information system or MakiBIS that would manage taxonomic information of Mt. Makiling species that follows the Darwin Core standards as well as provide functionality to share information through an XML dataset exporter. MakiBIS will also include other features including species description, habitat, conservation status and photo.

SCOPE AND LIMITATION OF THE STUDY

The study developed a system that will only hold species data from a single site which is Mt. Makiling. MakiBIS was tested and confirmed to run only on desktop based browsers and not on

mobile browsers. The system is currently being tested on a local host machine and can only be accessed from computers belonging to a local area network.

METHODOLOGY

Requirements Gathering and System Design

Software Tools

The MakiBIS was developed using WAMP 2.2a, CodeIgniter_2.03, and JQuery on a computer with a Windows 7 operating system. WAMP is a web development environment for the Windows operating system. It consists of Apache2 for the web server, PHP for the web scripting language, and MySQL for the database. JQuery is a library that simplifies JavaScript scripting. CodeIgniter on the other hand is an open source PHP development framework that facilitates the use of the Model-View-Controller (MVC) architecture.

Database Structure

A total of 25 tables were created for the system that was divided into four major groups. The groups with their corresponding tables are as follows:

- Users Group – tables belonging to the Users Group contain user information. The tables admin and encoder_information belong to this group.

- Taxonomy Group – tables belonging to the Taxonomy Group hold the taxonomical information of the species. Tables from this group include the following: domain, kingdom, phylum, class, table_order, family, genus, and species .

- Basic Information Group – tables belonging to this group contain basic traits and other useful information about a species. Table from this group are: conservation_status, description, economic_use, habitat, reproduction_mode, species_author, synonyms, and vernacular_name.

- Reference Group – tables belonging to this group house bibliographic information about the species. Tables from this group include reference, reference_book, reference_book_chapter, reference_journal, reference_proceedings, reference_project_report and reference_thesis.

User Levels

Two user levels were identified and became the basis of the roles of the users of the System. A user with the Guest user level or role can only search and view all species and does not need an account while a user with the Administrator user level can add, edit, and delete species information as well as all of the privileges of a Guest user. Administrator users need to create a MakiBIS account.

Functional Requirements

The following Functional Requirements were identified and became the basis of the core features of MakiBIS.

- Log In and Log Out – Administrator users must be logged in to the system to perform the other functionalities.

- Add Species - Administrator users can add species and subsequent species information.

- Add Reference - Administrator users can add reference and subsequent reference information.

- Edit Species - Administrator users can modify existing species information.

- Delete Species – Administrator users can delete existing species information.

- View All Species - All users can view a list of all the existing species in the system.

- View Species Profile - All users can view species information.

- Search Species - All users can search the system for a species limited to genus and/or specific epithet only.

- Search Reference - All users can search references limited to type of reference and/or author only.

- Upload Photo – Administrator users can upload a photo of a certain species.

- View Taxonomic Tree - All users can search for a species using a Taxonomic Tree.

- Export XML dataset – Administrator users can export an XML file containing all information that can be represented through Simple Darwin Core.

Coding, Testing, and Debugging

After identifying the requirements mentioned above, MakiBIS was coded using the tools listed under the Software Tools Section (WAMP, CodeIgniter, and Jquery). During the development of the MakiBIS software, it was tested at the programmers' level and the errors were subsequently debugged.

Data Population

The MakiBIS was then ready for data population after being tested and debugged. Species records which were then stored in spreadsheets were transferred to the system. However, minor glitches were still identified by the encoder and these were addressed by releasing minor revisions of the MakiBIS. Currently, information on a total of 716 species was encoded in MakiBIS.

RESULTS AND DISCUSSION

Cross-Platform Compatibility

MakiBIS was designed to run on any desktop operating system (Windows, Mac, or Linux) since it is a web application and only needs a supported web browser to run. The system was tested and guaranteed to run on Internet Explorer, Firefox, and Google Chrome web browsers.

Logging In, and Logging Out

Administrator users need to log in to the system through the URL http://localhost/NewMakiBIS (Figure 1) to be able to perform functionalities such as Add, Edit, and Delete Species. Non registered users are still allowed to use the system but are limited to viewing information on the system. The log out functionality terminates a user's current session.

Figure 1. Login Page

Adding a Reference

References are equally important as species information in MakiBIS. An administrator cannot add species information to the system if it is not derived from a journal, book, or any other valid literature. The Add Reference (Figure 2) function allows an administrator to add a reference and its corresponding bibliographic information. The system accepts six types of references namely, Book, Book Chapter, Journal, Thesis, Proceedings, and Project Report.

Adding, Editing, and Deleting Species Information

Administrator users have the ability to add, edit, and delete species information to and from MakiBIS unlike ordinary users or visitors who can only view species information. Before an administrator can add a species, the reference of the species must first be selected from the system. References that are not yet present in the system can be added using the Add Reference functionality discussed previously. Once the

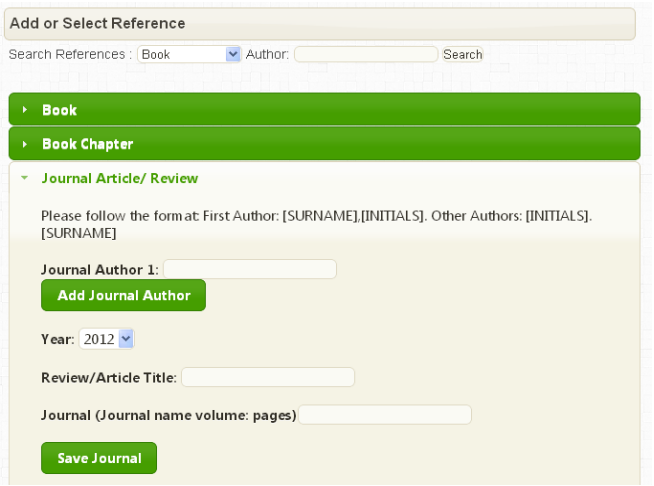

Figure 2. Add Reference Panel

reference has been selected, the input form where the genus and specific epithet will be asked is loaded (Figure 3.). The higher taxonomic groups will automatically be associated if available for the supplied genus. In case the higher taxonomic group is not yet available in the system, the administrator must input the correct taxonomic group. MakiBIS always checks if the higher taxonomic group is present in the system and if so, automatically completes the taxonomic information of a species. An administrator can also edit species information through the Edit Species functionality and can also delete erroneous entries with the Delete Species functionality (Figure 4.).

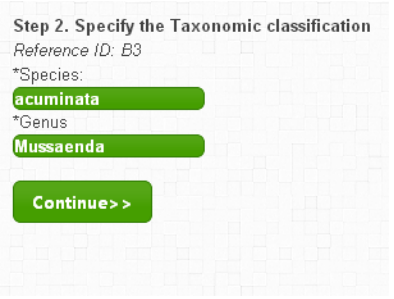

Figure 3. Add Species

View Functionalities

MakiBIS provides two ways by which a user can view species information. The first one is with the View All Species button which shows a list of all available species information (same as Figure 4.). Clicking on the scientific name link will direct the user to the Species Information Page while selecting the Edit link lets an administrator edit the corresponding species information. Selecting delete removes the chosen species information record from the system. Users can also browse species information using the Taxonomic Tree (Figure 5). The Taxonomic Tree is an expandable and collapsible tree view of the taxonomic groups. The tree includes the three domains of life down to the genus and specific epithet. Users can click on the specific epithet to view the profile page of the species.

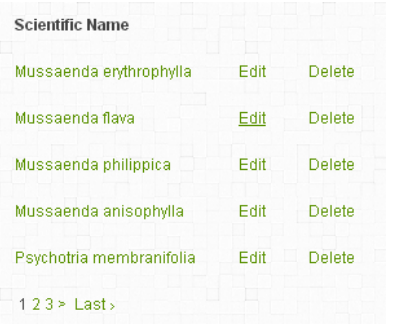

Figure 4. Edit and Delete Species

Upload Photo

The Upload Photo functionality is only provided to users with administrator privileges. An upload button was provided in the Edit Species page wherein users could browse pictures of the species for uploading. Any size of photo can be uploaded although the picture will be resized to 150x150 pixels when it is displayed.

XML Dataset Exporter

The XML Dataset Exporter feature allows an administrator to produce a report of all species information following the Darwin Core format. Terms that were included in the report were the following: specificEpithet, genus, family, order name, class, phylum, kingdom, scientificNameAuthorship, vernacularName,

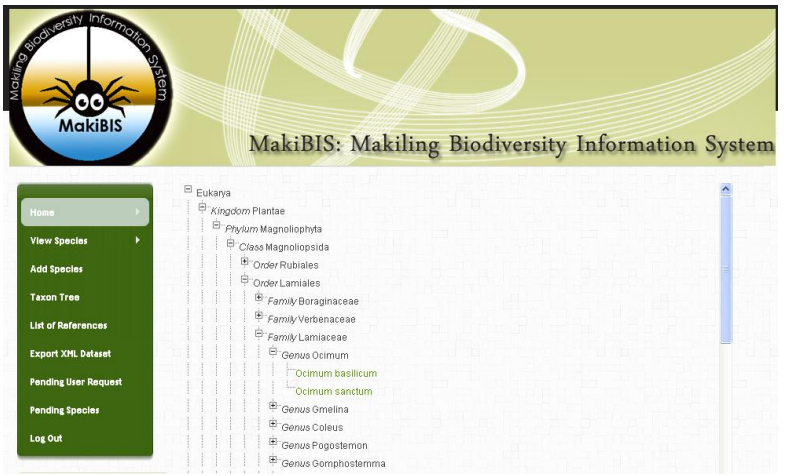

Figure 5. The Taxonomic Tree

reproductiveCondition. Figure. 6 shows a sample of the Darwin Core Format report.

MakiBIS Deployment and Use

MakiBIS is deployed on the local area network of the Ecoinformatics Laboratory of the Institute of Biological Sciences, University of the Philippines Los Baños and is being used by the MakiBIS research team. Table 1 shows the problems encountered by the encoder while using the MakiBIS and the corresponding fixes and actions made by the programmers.

Information contained in MakiBIS

MakiBIS currently contains information on taxonomy, habitat, general description and conservation status as well as photo of a total of 716 species (Figure 7). These 716 species belong to 404 genus, 135 families, 62 orders, 3 phyla, 2 kingdoms and 3 domains.

Table 1. Problems Reported and Corresponding Fixes and Actions While Using MakiBIS

Problem	Fix/Action
Editing species information and changing the uploaded picture cannot be done at the same time.	It was recommended that editing text and changing or uploading a picture be done separately for the mean time.
Filling up of all fields is required, i.e. when entering species information, text boxes cannot be left blank.	The programmers suggested that an "N/A" (not applicable) be entered instead of leaving a text box blank.
Long data entries are not allowed and are cut short.	It was found out that most data were limited to 256 characters long and they were increased to 256 characters long.

```
<?xml version="1.0" encoding="UTF-8" ?>
- <SimpleDarwinRecordSet xmlns="http://rs.tdwg.org/dwc/dwcrecord/" xmlns:dc="http://purl.org/dc/terms/" xmlns:dwc="http://rs.tdwg.org/dwc/terms/"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://rs.tdwg.org/dwc/dwcrecord/ ../../xsd/tdwg_dwc_simple.xsd">
    <!--  In practice the schema location should be the following. The above was to   -->
    <!--  allow the resolution of the namespace in a self contained package with the documentation.   -->
    <!--   xsi:schemaLocation="http://rs.tdwg.org/dwc/dwcrecord/ http://rs.tdwg.org/dwc/xsd/tdwg_dwc_simple.xsd">   -->
  - <SimpleDarwinRecord>
      <dwc:specificEpithet>erythrophylla</dwc:specificEpithet>
      <dwc:genus>Mussaenda</dwc:genus>
      <dwc:family>Rubiaceae</dwc:family>
      <dwc:order>Rubiales</dwc:order>
      <dwc:class>Magnoliopsida</dwc:class>
      <dwc:phylum>Magnoliophyta</dwc:phylum>
      <dwc:kingdom>Plantae</dwc:kingdom>
    </SimpleDarwinRecord>
  - <SimpleDarwinRecord>
      <dwc:specificEpithet>membranifolia</dwc:specificEpithet>
      <dwc:genus>Psychotria</dwc:genus>
      <dwc:family>Rubiaceae</dwc:family>
      <dwc:order>Rubiales</dwc:order>
      <dwc:class>Magnoliopsida</dwc:class>
      <dwc:phylum>Magnoliophyta</dwc:phylum>
      <dwc:kingdom>Plantae</dwc:kingdom>
    </SimpleDarwinRecord>
  - <SimpleDarwinRecord>
      <dwc:specificEpithet>gerascanthoides</dwc:specificEpithet>
      <dwc:genus>Cordia</dwc:genus>
      <dwc:family>Boraginaceae</dwc:family>
      <dwc:order>Lamiales</dwc:order>
      <dwc:class>Magnoliopsida</dwc:class>
      <dwc:phylum>Magnoliophyta</dwc:phylum>
      <dwc:kingdom>Plantae</dwc:kingdom>
    </SimpleDarwinRecord>
```

Figure 6. The Darwin Core XML Report

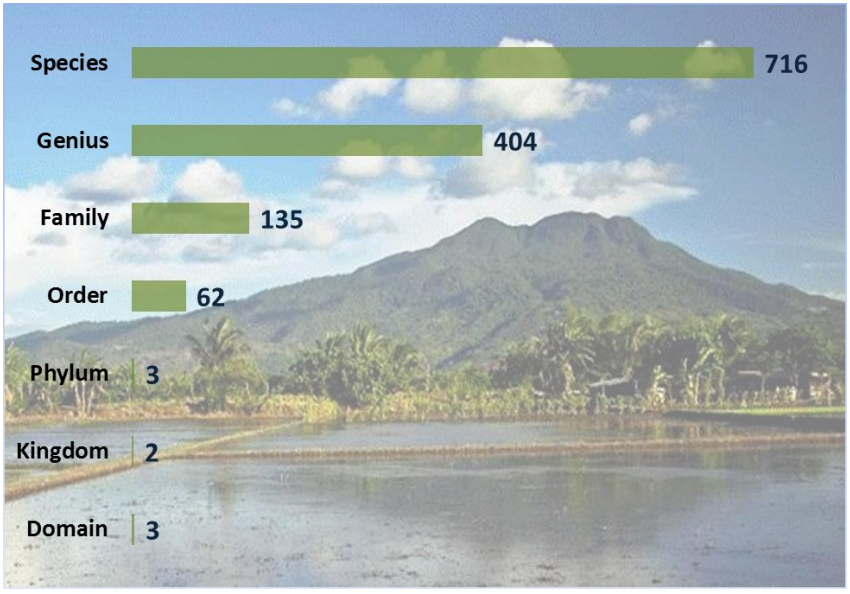

Figure 7. Summary of Species Information currently stored in MakiBIS.

CONCLUSIONS AND RECOMMENDATIONS

MakiBIS can perform the core functionalities of a biodiversity information system such as adding, editing, deleting, and viewing species information. It can also generate a report of all species information in the database following the Darwin Core Standard which allows it to be shared to other biodiversity information systems that follow the same standard.

Third party web applications can be used to further enhance the features of the system such as Google Maps integration which can display current locations of species using the map of Mt. Makiling. It is also recommended to populate the system with a robust amount of data to further test its capability and performance to handle large data sets.

Makiling Biodiversity Information system or MakiBIS will manage taxonomic information of Mt. Makiling species that follows the Darwin Core standards as well as provide functionality to share information through an XML dataset exporter. MakiBIS may serve as a prototype in the development of a national Biodiversity Information System (BIS) that may be adopted by PAWB-DENR in implementing the Philippine National Clearing-House Mechanism. The national BIS will be useful in addressing the need to set national baseline, measurable targets and indicators to facilitate assessment of biodiversity progress and as well as basis for national and local decision-making.

STATEMENT OF AUTHORSHIP

Fermin Roberto G. Lapitan is the lead author of this article and is a Co-Project Leader of the Makiling Biodiversity Information System (MakiBIS) Project. As system analyst and project manager in the development of the information system he was responsible for gathering the software requirements of the system as well as leading the software development team in creating the system. As lead author, Prof. Lapitan prepared the draft and finalized the writing of this article for publication.

Damasa B. Magcale-Macandog is also a Co-Project Leader of the MakiBIS Project. She led the team of researchers in gathering and consolidating the species information which was used as the initial data of the system. She provided critical information which lead to the identification of the software requirements of the system. Dr. Magcale-Macandog also prepared the draft and finalized the writing of this article together with Prof. Lapitan.

Mark Dean S. Raymundo and Alfred G. Dela Cruz were the software developers of MakiBIS. They were under the direct supervision of Prof. Lapitan in developing the system based on the software requirements identified. They were also responsible in the preparation of the draft of this article.

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