

Wiki-keys for the ferns of the Flora of Equatorial Guinea

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Abstract — Flora of Equatorial Guinea is a research project coordinated by the Real Jardín Botánico of Madrid with the aim to produce a modern Flora for this almost unknown territory. One of our goals is to develop the website www.floradeguinea.com. A system of relational databases with an implemented Thesaurus - to minimize typographical mistakes - allows the on-line managing and updating of nomenclatural information, herbarium specimens, literature records, vernacular names and bibliography. Images and maps are also linked to accepted names. We are now implementing interactive keys for identification. In our wiki-based system, Scans of herbarium specimens from all species growing in the country are also being uploaded. Species from neighboring countries are included as well, since some of them could appear in Equatorial Guinea.

Index Terms — Africa, Equatorial Guinea, e-Flora, ferns, online-databases, Wiki key.



1 INTRODUCTION

Flora of Equatorial Guinea is a research project undertaken by the *Real Jardín Botánico de Madrid-CSIC*, with the collaboration of the Spanish Universities of Salamanca and Córdoba, the Kew Royal Botanic Gardens, the *Nationaal Herbarium Nederland* and the *Université Libre de Bruxelles*. The project is currently funded by the Spanish administration (reference project CGL2009-07405). The final aim of our project is to produce a modern flora of this almost unknown territory, a historic goal of the Spanish botany, rooted in former times, when these tropical regions were part of the overseas provinces of Spain, more than sixty years ago.

The interest on this region also derives from its important biodiversity. Tab. 1 shows the surface of humid rain-forests in some countries of Central Africa: only Gabon has a higher percentage of the territory covered by humid, undisturbed

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rain-forests in the Guineo-Congolian region, the most biodiverse area in the mainland of tropical Africa.

	Original tropical rainforest surface (km²)	Tropical rainforest surface nowadays (km²)	% of tropical rainforest preserved
Cameroon	376.900	155.330	41,2
Equatorial Guinea	26.000	17.004	65,4
Central African Republic	324.500	52.236	16,1
Rwanda	9.400	1.554	16,5
Nigeria	421.000	38.620	9,2
Gabon	258.000	227.500	88,2

Tab. 1 – Surface of humid rain-forest in some countries of Central Africa.

Our interest was also increased by the dissimilar floristic knowledge of the different regions of the country, reflecting once more the complicated history of the territories of Equatorial Guinea and Spain since Emilio Guinea's first trip, including questions beyond science, for example, such as the independence of Equatorial Guinea from Spain in 1968.

One of the goals of the planned modern Flora of Equatorial Guinea is the development of our website, www.floradeguinea.com, where new identifications are updated immediately. Any specialist working on the flora of Africa can freely check our results.

Presently, we are determined to go one step forward, implementing in our site a on-line interactive system with identification keys. In our wiki-based system, scans of herbarium specimens from all species growing in the country are also uploaded. Species from Gabon, Cameroon and S. Tomé & Príncipe are included as well: some of them could appear in Equatorial Guinea, although they have not been collected yet.

2 MATERIALS AND METHODS

We have planned our task in 4 different steps: 1) compilation of all literature records, 2) identification of all the available specimens, 3) compilation of checklists of taxa and specimens growing in the country, 4) compilation of a Flora, with keys for identification, descriptions, images and maps.

In order to reach the first two goals, we have designed a system of relational databases with several Thesauri, implemented to minimize typographical mistakes. Nomenclatural information, specimens data, literature records, vernacular names and bibliography can be managed and updated on-line. Digital images and maps with the distribution in Equatorial Guinea are also

linked to accepted names.

The second two goals (checklist and Flora) demanded a re-designing of the whole database structure. We used a wiki-template designed by Gregor Hagedorn and used by *KeyToNature* and other projects in the Real Jardín Botánico-CSIC, in order to translate our printed keys into an interactive system where updates done by users or editors can be automatically implemented. This also permits to include more information in the e-keys, such as e.g. scans of herbarium specimens.

The final output of the keys will be linked to the www.floradeguinea.com site, where, following the taxon name, the user can find revised nomenclatural information, a description, a list of identified herbarium specimens, a list of literature reports, digital images of herbarium specimens, links to pictures of living plants, and a sketch map where the distribution of the taxon in Equatorial Guinea is presented.

3 RESULTS AND DISCUSSION

3.1 RESULTS OF THE FLORA OF EQUATORIAL GUINEA

The gathering of literature produced a great stepping stone with the publication of the documentary databases for the Flora of Equatorial Guinea [1]. In this book, all the reports of mosses, fungi, ferns, mono- and dicotyledons from Equatorial Guinea were compiled and databased, reflecting the information as it was originally published. Widely distributed taxa from neighboring countries were also included, since they will appear in the keys for identification. Currently, this database is still growing and is managed completely on-line, since it needs to be updated with any new publication on floristics for any of the territories of Equatorial Guinea. We also go on compiling and including the names published in São Tomé and Príncipe Island, Cameroon, and Gabon. Today, 52,301 records of vascular plants are included.

The second task (collection effort), has produced as a main result a set of more than 15,000 collection numbers from Equatorial Guinea in the Madrid herbarium, with an average of 4 duplicates: this is now the main collection for the country. In our database we also include the vouchers data, especially from historical collections kept at K, BM, or in the Netherlands in the WAG herbarium, as well as those kept in Equatorial Guinea. For comparative purposes, some collections from neighboring countries were also studied. In this aspect, Missouri and Portuguese herbaria were essential, and are now databased as well. Until now, 16,615 herbarium specimens from Equatorial Guinea have been databased. Among them, about 2000 were studied carefully and assigned to a correct name.

The lack of floristic knowledge in Africa and, of course, in Equatorial Guinea, brought us to publish critical checklists before the Flora, splitting the original idea of Emilio Guinea. The main reason is clear: if we'll have waited until the information is complete to publish the Flora, and the identification keys and descriptions are made, most of the species included in the work could be extinct.

These checklists, on the contrary, provide a useful tool to start with conservation programs and strategies. The latter are especially necessary nowadays, considering that 13 million ha of primary forests are destroyed every year. This step was the one with more results in the last years.

	FWTA	Fl. GUI	Increase (%)	Nrec Country
Pteridophytes	163	226	38	8
Cyperaceae	28	96	231	22
Marantaceae	4	26	271	8
Piperaceae	9	13	44	–
Mimosoideae	9	40	344	14
Caesalpinioideae	23	124	525	45
Papilionoideae	121	157	30	48
Ebenaceae	1	28	2700	12
Melastomataceae	18	57	216	26
Commelinaceae	24	45	114	11

Tab. 2 – Numerical summary of families with checklist published since 2001. FWTA= Number of species mentioned in Equatorial Guinea in the *Flora of West Tropical Africa*. Fl.GUI=Number of species found in our study. Increase = percentage increase of our catalogue compared with the data of FWTA. Nrec Country = Number of species found in our catalogues not previously reported from Equatorial Guinea. Families in boldface include new names or species described from material collected in Equatorial Guinea.

Tab. 2 shows the numerical summary of families where checklists were published since 2001. We have published the accounts of 24 families of vascular plants and all Pteridophytes. Our main result was that floristic knowledge of the country increased by about 120 %. Applying this value to the estimation of Davis [2] of 3,250 species growing in Equatorial Guinea, using data relative to the Flora of West tropical Africa, the number of species estimated to live in the country jumps to c. 7,100, a figure similar to those of Cameroon and Gabon.

The final task is that of writing and editing the Flora. Until now, we have published two volumes of the flora, Pteridophytes and Fabaceae, with 227 and 320 species, respectively. These figures include also citations of species without herbarium support, whose distribution range and habitat render their presence in Equatorial Guinea quite possible. Moreover, several monographic treatments are being undertaken on some genera, which will probably result in the reinterpretation of several taxa. Once the first reference is published, it is easier to compare any new collection, so that we would be not surprised if these numbers will be changing soon.

3.2 RESULTS IN THE WEBSITE

The development of a new system of databases, based on MySQL allows the on-line handling of information related to herbarium specimens, literature reports, and also of those data related to accepted names, bibliography, type information or descriptions. We have included in the website all the information that we have produced in the last years, so that now all papers produced by us or by other authors but related to the country are freely downloadable [3-18].

The next step is to produce and update all the stages of the editorial process on-line. We have implemented the printed version of the keys, and now we are presenting interactive keys as well [http://www.keytonature.eu/wiki/Clave_de_familias_de_Pteridophyta_de_la_Flora_de_Guinea_Ecuatorial_%28RJB%29]. These keys are based on the wiki-structure design developed by Gregor Hagedorn within the European project *KeyToNature*, which have been used also by other projects in the *Real Jardín Botánico*, as the Gymnosperms key [*Clave de Gimnospermas* (RJB)].

The printed keys of the published volumes of the Flora are being translated to this wiki system in a relatively easy way. Until now, we have migrated all the keys for identification of ferns. In this first step the keys are in Spanish, the mother language in Equatorial Guinea, but English versions will be also prepared. We have material for starting with the translation of the key for families of vascular plants and of all the keys produced for the volume of legumes. At the end all the keys included in the Flora of Equatorial Guinea will be produced, updated and corrected on-line, and in the future from the on-line version a printed version will be published. This system allows to advance the complicated editorial process of a work like a Flora without the constraints of printed texts.

In our keys, all species growing in Equatorial Guinea are included, and a digital picture of an herbarium specimen is included close to each name. Each result in the key (family, genus or species name) is linked to a taxon page at the www.floradeguinea.com site, which has information related to nomenclature, specimens, literature records and bibliography or vernacular names. Furthermore, each accepted name is linked to several sites where more information can be consulted, such as the African Plants Database, by the *Conservatoire et Jardin Botanique of Geneva* (<http://www.ville-ge.ch/musinfo/bd/cjb/africa/recherche.php>), where accepted names for the most important african floras are included and critically presented, or the West African Plants Database developed by the Senckenberg Forschungsinstitut und Naturmuseum and by the Frankfurt University (<http://www.westafricanplants.senckenberg.de/root/index.php>), where, among other information, pictures of living plants can be examined.

4 CONCLUSIONS

High speed degradation of natural resources and the need of urgent conservation decisions have increased the value of Floras as the base to study, understand and preserve plant biodiversity.

Despite their high relevance, many Floras remain incomplete and progress

slowly, due to the large number of species involved, the highly distributed and dissimilar data, and the lack of tools promoting effective collaboration. Thus, it is common to find both personal and duplicated efforts between remote researchers.

Nowadays, in order to make the information contained in old floristic works accessible, Floras only available as hard copies are increasingly being digitized. Most of the initiatives have produced scans or fixed images of the original printed version. With the use of new technologies, printed versions are not the unique result of a flora, they appear to be just one of the possibilities.

This can be overcome by making full use of current information technology to draw the highly distributed data together and to allow the taxonomic research community to communicate efficiently. The development of an e-way of handling Floras will change traditional work-flow processes by fostering a collaborative setting, strengthening existing research networks, and making plant biodiversity information rapidly and widely accessible in a re-usable format.

Floras provide keys for the identification of plant species and additional information on each species such as synonymy, economic uses, geographical distribution and ecology. With the possibility of e-handling, floristic research will be optimized by the producers of Floras, and the consumers of information will increase. Potential users will range from traditional readership to ecologists interested in morphological traits, climate modellers or policy makers interested in distribution data.

The benefits of the wiki-keys will be:

1. More efficient production of floras, especially the keys for identification. Keys will be more interactive and easily updated, making a more dynamic and updated floristic resource in a collaborative system.

2. The output information of the work is higher and easier to access. The impact of floristic data will be greatly increased. This is providing novel uses of floristic data. The availability of digital floristic data opens opportunities for uses as i.e. datasets for modelling and web services connecting to other websites and databases.

3. The wiki-key system also promotes new collaboration mechanisms for taxonomists in order to significantly improve local and remote co-working and to eliminate redundancy of work within this scattered community. Collaborative research will foster the transferring of knowledge to the benefit of early-stage researchers, particularly in tropical and developing countries.

ACKNOWLEDGEMENT

The authors wish to thank to the Ministry of Science and Innovation of Spain for the support in the next years. We are also indebted to the Spanish Superior Research Council, especially the Department of Publications. The authorities of Equatorial Guinea, the people responsible of BATA herbarium and the National University of Equatorial Guinea (UNGE) deserve special mention. The vouchers scanned and used are mainly from our collection in MA. Nevertheless, as can be inferred from some headings, some species were obtained from abroad institutions as: Botanischer Garten und Botanisches Museum of Berlin (B), Botanische Staatssammlung München (M), Université Libre de Bruxelles (BRLU), Royal Botanic Gardens, Kew (K), Natural History Museum of London

(BM), National Botanic Garden of Belgium (BR), Muséum National d'Histoire Naturelle, Paris (P), Wageningen University (WAG) y Cameroon National Herbarium, Yaounde (YA). All of them are thanked for the permissions to use their herbarium scans.

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