Annual Report 2019

Labef
Laboratoire de Biomathématiques & d'Estimations Forestières

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Our gratitude

The preparation of this annual report was led by Forest Ecology and Management Research Unit of the Laboratoire de Biomathématiques et d'Estimations Forestières (LABEF) with consistent support from all other research units. It was prepared under the supervision of its Director, Professor Romain Glèlè Kakaï. Special thanks go also to all LABEF's members for filling in the individual annual report form, for structuring, reviewing and proof-reading previous drafts.

The team of LABEF takes this opportunity to thank its partners for their technical and financial support without which the highlighted achievements would have not been possible.

Abbreviations & acronyms

AGNES	:	African German Network of Excellence in Science
FSA	:	Faculty of Agronomic Sciences
IF	:	Impact factor
IFS	:	International Foundation for Science
INRAB	:	Institut National de la Recherche Agricole du Bénin (National Institute of Agricultural Research of Benin)
LABEF	:	Laboratoire de Biomathématiques et d'Estimations Forestières
MRV	:	Measuring-Reporting-Verification
MSc	:	Master of Sciences
PhD	:	Doctor of Philosophy
RUFORUM	:	Regional Universities Forum for Capacity Building in Agriculture
UAC	:	University of Abomey-Calavi
UNA	:	Université Nationale d'Agriculture
UNSTIM	:	Université Nationale des Sciences, Technologie, Ingénierie et Mathématiques (National University of Science, Technology, Engineering and Mathematics)
WAEMU	:	
WIF	:	Without Impact Factor

Contents

Statement of the Lab Director

Dear colleagues and friends,

Once again, it is with a great pleasure I am presenting the 2019 annual report of the Laboratoire de Biomathématiques et d'Estimations Forestières (LABEF).

It's been 5 years since we got into the habit of sharing with you the annual report of LABEF achievements. This year too, the LABEF, through the involvement of all its members, made a positive contribution by significantly contributing to the advancement of forestry research with a particular emphasis on the application of biomathematics. Sustained efforts have been made to maintain leadership in the application of biomathematics in forest sciences through the implementation of both individual and collaborative projects. These research initiatives have generated several publications and have enabled members to participate in numerous international meetings. Also, through the research and training activities implemented by LABEF in 2019, capacities have been strengthened in terms of the application of biomathematics in science both for national and regional scientists who participated either to seminars and various training courses organized during the year or internships that we hosted. Our research is also contributing to offer scientific bases for decision making by policy-makers in the field of sustainable management of forest resources, and domestication of multipurpose, yet declining tree species while accounting for local people needs and beliefs. In this line, we have developed a number of technical guidelines that are now serving for rural development of agroforestry based on native tree species.

Altogether, 2019 was marked by a sustained effort by the LABEF team to keep the flame of excellence in terms of publication in international journals, participation in international meetings, competitions at both national and international levels, and research for sustainable development.

With the belief that you will enjoy reading this report, I am looking forward to share forthcoming progress of LABEF with you.

Prof. Romain Glèlè Kakaï

Director of LABEF

Part 1 – LABEF: Overview and Team

1.1. Mission, vision and objective of LABEF

Created on 27th May 2014 by Romain Glèlè Kakaï, professor in biometry and forestry, the Laboratoire de Biomathématiques et d'Estimations Forestières, is part of the school of Environment Planning and Management, Faculty of Agronomic Sciences, University of Abomey-Calavi. The Laboratory works on the development and popularization of innovative statistical methods in life sciences, and particularly in forestry, for the optimal delivery of their multiple contribution to people's quality of life.

The mission of LABEF is to enhance understanding of biological systems through effective use of biomathematical tools for sustainable forestry.

Its vision is to be a leading institution in developing mathematical tools for biologists and supporting decision makers in forestry for better life.

Its objective is to analyze the applicability of mathematics tools in life sciences and advance research and policy in forestry.

1.2. Organization of LABEF

LABEF is organized in 4 departments including fundraising department, social life department, administrative department, and research department. The research department includes four interrelated units namely: Unit of Biomathematics and Applied statistics; Unit of Forest Methods; Unit of Forest Ecology and Management and the Unit of Forest and People.

- The research unit on biomathematics and applied statistics falls into biology and mathematics and are interested in applications of mathematics in the field of biology. This unit is interested not only in the use of mathematical theories in biology but especially publishing scientific notes describing the application of different mathematical tools in life sciences.
- The Forest Methods research unit falls into the overall perspective of assessing the wood resources, biomass and carbon stock available in forest ecosystems. Hence, it provides the development of accurate and essential information for policy planning and forest resources management of the development of accurate and robust methods for estimating forest resources.

- The Forest Ecology and Management research unit is intended to understand ecological processes and patterns (forest ecosystems and forest ecosystem services, patterns and processes that govern the ecology of species and the system of which these species are parts, seed ecology) and to develop accordingly clear and applicable management policies for forest managers and decision makers.
- The Forest & People research unit undertakes investigations on forest governance approaches, their effectiveness and replicability, their socio-economic and ecological outcomes, decision-making process, benefit sharing etc.

1.3. The core management team of LABEF in 2019

Prof Romain Glèlè Kakaï is the head of LABEF. He is a Full Professor in Biometry and Forestry, researcher and lecturer at the Faculty of Agronomic Sciences. Prof Glèlè Kakaï is chairman of the scientific council of agronomic sciences, chairman of the Scientific council of the National Institute of Agricultural Research of Benin (INRAB), Chairman of the African German Network of Excellence in Science (AGNES). He is also coordinating the Doctoral program in Biometry at the University of Abomey-Calavi. His research areas include: Linear and nonlinear mixed models - Generalized linear models - Multiblock data analysis - Forest estimations - Forest management.

Dr Valère Kolawole Salako is the scientific coordinator of LABEF. His research deals with plant population and community ecology, agroforestry systems' analysis, conservation, and multivariate methods in community ecology. His academic performance has been recognized internationally with several prizes and distinctions. He is member of multiple scholar's societies and welcomes collaborative researches and grants that involves multiple complementary disciplines. Dr Salako attended several local, national and international trainings, workshops and conferences.

Dr Charlemagne Gbemavo is the head of the research unit on biomathematics and applied statistics of LABEF. His research deals with Population Ecology, Forest Estimation and Spatial Modeling. He teaches Biostatistics and Forest Estimations at the National Universities of Benin and takes the role of Biostatistician in several national or regional research projects.

Dr Rodrigue Castro Gbedomon is leading the research unit of Forest and People livelihood of LABEF. Castro's research concerns the social dimensions of biodiversity conservation, or, focus on how people perceive, use and interact with forest resources in a context of global changes. He is interested in advancing knowledge and practices on nature conservation, with a focus on topics such as ecosystem services, urban forestry, forest economics and governance etc.

Dr Rodrigue Idohou is coordinating the Forest Methods research unit of LABEF. Rodrigue research focuses on aspects of the distribution and geography of wild species, impact of human-induced factors on wild species conservation, spatial prioritization, planning, and wild species propagation. He teaches Biostatistics and Biodiversity Informatics at the National Universities of Benin. His work is collaborative in nature, and usually involves geographers, computer scientists, and biologists.

Dr Jean Didier Akpona is leading the Forest Ecology and Management research unit of LABEF. Jean Didier's research interests focuses on Environmental Governance & Ecology including forest ecology & management, seeds ecology and biodiversity conservation, pollination network and ecosystem services, leadership and wildlife conservation.

Dr Marcel Donou is in charge of the social life department of LABEF. Biostatistics and forest modeling. His PhD research focused on conservation biology with a special focus on wild palms conservation. His research interests include forest inventory, ethnobotany and beekeeping.

Afia Ombada, Bsc obtained her Bachelor degree at Sheffield Hallam University in England in 2012. She has a good communication skill and speaks fluently English which is simple to communicate with English speaking collaborators. She is in charge of the administration and all related tasks. She mostly helps the coordinator of the master program in statistics major Biostatistics for students' day to day management. She makes sure that students have their timetable, receive their lecture, submit with their homework and sit their exams on time. She also does everything students need for the good continuation of their stay throughout the program.

Part 2 – RESEARCH: Milestones & Highlights

2.1. Scientific publications in 2019

2.1.1. Publications Milestones

In 2019, LABEF members produced 69 scientific documents including 40 published papers in peer-review journals, 8 nearly published (in press) papers, 13 papers under review and two (02) technical reports. About 9% of the scientific documents were abstracts in proceedings (figure 1).

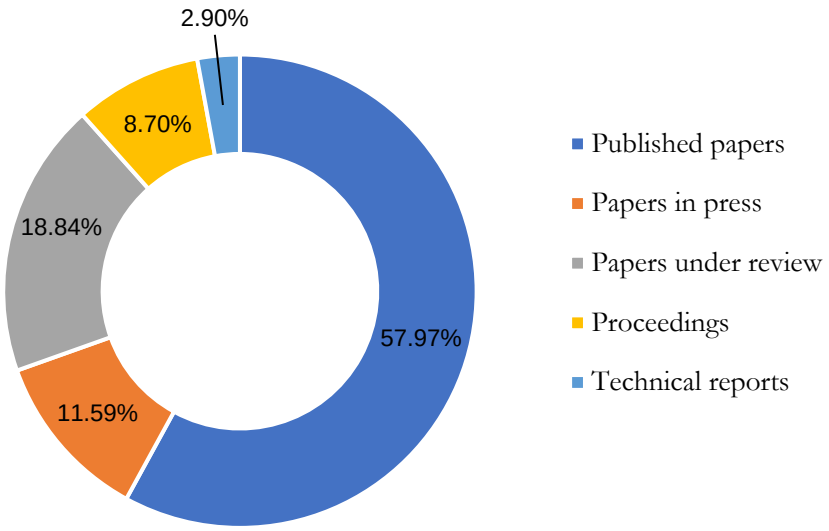

Figure 1: Publications in LABEF in 2019

2.1.2. Diversity of journals

The scientific papers produced by LABEF in 2019 were published or were near to be published in diverse journals, exactly 43 journals (Table 1). Regarding already published papers, the top (journals where higher number of papers were published) five journals for publication in 2019 were South African Journal of Botany (IF_{2018} = 1.504), Genetic Resources and Crop Evolution (IF_{2018} = 1.296), Bois et Forêts des Tropiques (IF_{2018} = 0.340), Tropical Conservation Science (IF_{2018} = 1.327), and Agroforestry Systems (IF_{2018} = 1.792).

Table 1: Diversity of journals for published, in press and under review papers

Journals	Published	In press	Under review
African Journal of Ecology	1	-	2
Afrika Statistika	1	-	-
Afrique SCIENCE	1	-	-
Agricultural Research & Technology	1	-	-
Agriculture	1	-	-
Agronomy for sustainable developement	1	-	-
Application in Plant Sciences	1	-	-
Archivos de Zootecnia	1	-	-
Biodiversitas	1	-	-
Bulletin de la Recherche Agronomique du Bénin	1	-	-
Chemometrics and Intelligent Laboratory Systems	1	-	-
Economic Botany	1	-	-
Environment, Development and Sustainability	1	-	-
Food Sciences and Nutrition	1	-	-
Insects	1	-	-
International Journal of biological and chemical Science	1	-	-
International Journal of Engineering and Future Technology	1	-	-
International Journal of Plant & Soil Science	1	1	-
IUCN/SCC Otter Specialist Group Bulletin	1	-	-
Journal of Agriculture and Environment for International Development	1	-	-
Journal of Applied Biosciences	1	-	-
Journal of Crop Improvement	1	-	-
Journal of Plant Breeding and Crop Science	1	-	-
Oryx	1	-	-
South African Journal of Plant and Soil	1	-	-
Annales de l'Université de Parakou : *Série « Sciences Naturelles et Agronomie »*	**2**	-	-
Agroforestry Systems	**2**	-	-
Tropical Conservation Science	**2**	-	-
Bois et Forêts des Tropiques	**3**	-	-
Genetic Resources and Crop Evolution	**3**	1	1
South African Journal of Botany	**3**	-	1
African Crop Science Journal	-	1	-
African Journal of Rural Development	-	-	3
Agricultural sciences	-	1	-
Agriculture and Food Security	-	-	1
Annales des Sciences Agronomiques	-	1	-
Fuel	-	-	1
Modeling Earth Systems and Environment	-	2	-
Neobiota	-	1	-
Neural Processing Letter	-	-	1

Journals	Published	In press	Under review
Plant Ecology and Evolution	-	-	1
Scientifica	-	-	1
Tropical Ecology	-	-	1

2.1.3. Diversity of research domains

As for previous years, LABEF contributed in knowledge in several research domains. Scientific papers published by LABEF covered several research disciplines as illustrated on figure 2. The most investigated research disciplines in 2019 were quantitative ethnobotany (6 published papers), plant breeding and biotechnology (5 papers), biostatistics (4 papers), soil science and plant nutrition, biosystematics and ecology, and agroforestry (with 3 papers each).

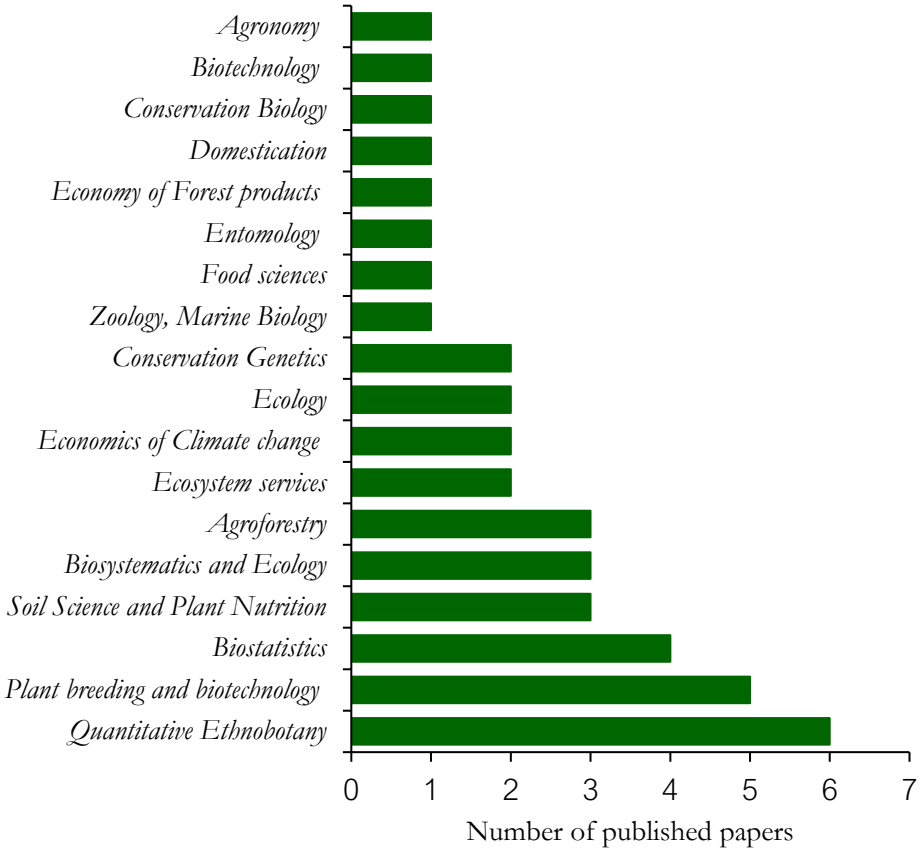

Figure 2: Diversity of research domains for published papers by LABEF in 2019

2.1.4. Performance and highlights

In terms of performance in scientific publication, LABEF produced overall more documents in 2019 than last year even though there were more published papers in 2018 (figure 3a). The quality of already published or nearly published (in press) papers has significantly increased with more than 90% of papers in international standard journals. Moreover, 67.50% of published papers appeared in journals with impact factor (figures 3b & 4a). As far as nearly published papers were concerned, 37.50% of papers were in journals with impact factor (figures 3b & 4b), while, for papers under review, 61.54% of papers were with impact factor journals (figure 3b & 4c). The standard of quality in publishing remain similar to 2018 with approximatively the same number (about 30 papers) of papers published in journal with impact factor.

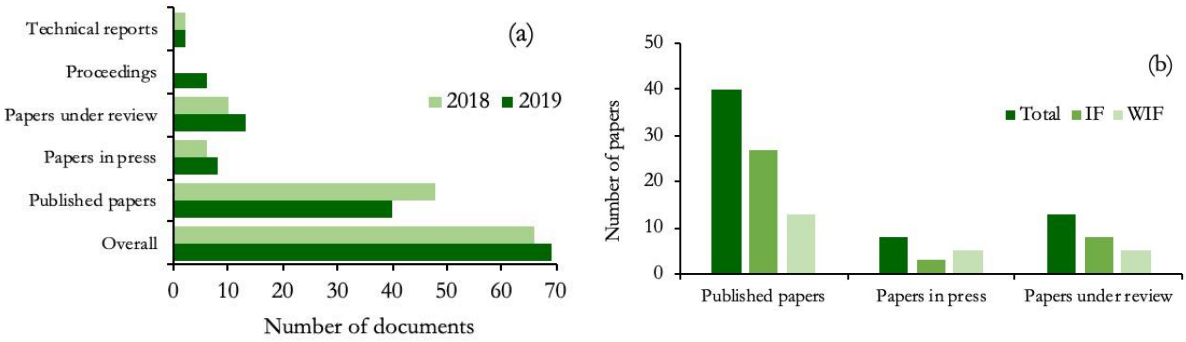

Figure 3 : Trends (a) and quality (b) in publications

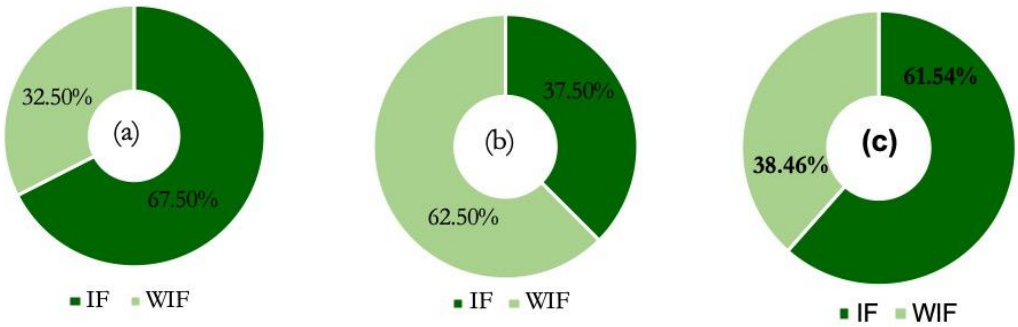

Figure 4: Categories of published (a), in press (b) and under review (c) papers in 2019

The cumulative impact factor was 38.127 in 2019 and is lower than in 2018 (49.553), possibly because of the relatively lower number of published papers in 2019. Regarding papers in press and papers under review there was an increase in quality of journal for publication compared to 2018, with cumulative impact factor of 4.074 and 12.636 respectively (figure 5).

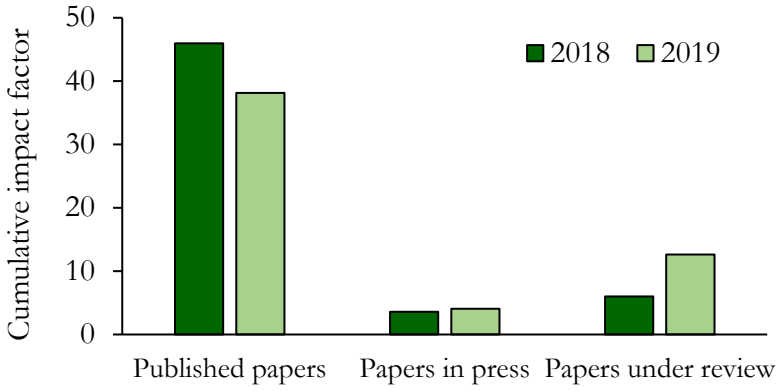

Figure 5: Cumulative impact factor in 2018 and 2019

In 2019, about 47% of published papers was in journal with at least one point for impact factor (IF ≥ 1), with more than 12% of papers in journal with more than two point for impact factor (figure 6a). For papers in press, 25% has at least one point for impact factor (figure 6b). For papers in consideration for publication (under review) more than 30% will surely have at least one point for impact factor (figure 6c).

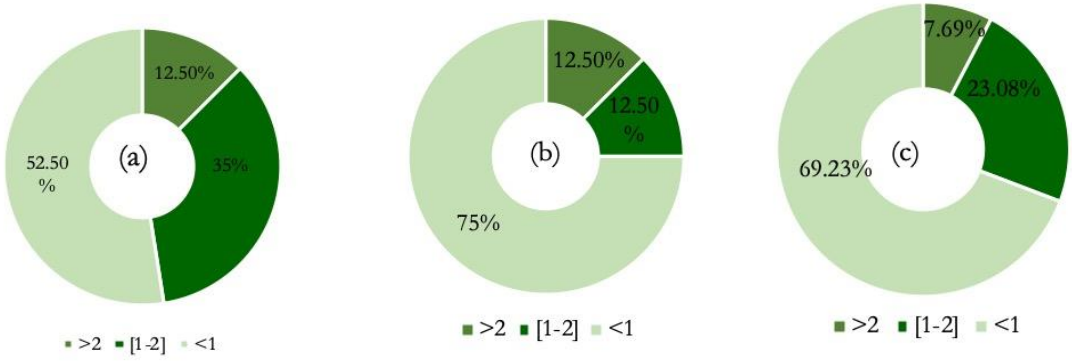

Figure 6: Range of impact factor of published (a), in press (b) and under review (c) papers

2.1.5. Authorship and leadership position in publications in 2019

Achievements regarding scientific publications in 2019 have been effective because of the strong involvement of the team. For instance, members of LABEF first authored 40% of published papers, and were among three first authors for the same percent of published works (40%).

2.2. Prizes, awards and recognition in 2019

In 2019, as for previous years, members of LABEF have been celebrated for the excellence in scientific research. Among the prizes, awards and recognition in 2019, we have:

- Appointment of Dr Charlemagne Gbèmavo as Assistant Professor at National University of Sciences, Technology, Engineering and Mathematics (UNSTIM).

- Nomination of Dr. (Associate Professor) Belarmain Fandohan and Dr Valère K. Salako as mentors for the mentoring of African Future Leaders in the OnePlanet Fellowship Program (https://oneplanetfellowship.org/).

- Lion's Dean Awarded to Dr Jean Didier Akpona for his outstanding performance in the Entrepreneurship and Innovation Pitch Competition at the African Leadership University School of Wildlife Conservation (https://sowc.alueducation.com/).

- Appointment of Dr Rodrigue Idohou as Assistant at the Ecole de Gestion et de Production Végétale et Semencière of the National University of Agriculture

- Nomination of Prof Romain Glèlè Kakaï as the Chair of African-German Network of Excellence in Science (https://agnes-h.org/?lang=fr).

- Excellence scholarship awarded to Dr Gbedomon by the Swiss Confederation for a postdoctoral research at the University of Geneva.

2.3. Research projects in 2019

In 2019, LABEF conducted several projects including small, medium and large research projects. Small grants projects were conducted by individual members and the amount is often less than USD 25000. A total of fourteen (14) small grants projects were implemented in 2019 at LABEF. Among them, six (06) were funded by the International Foundation for Science (IFS). The small grants implemented by the members in the lab in 2019 are summarized in table 2.

Table 2: Small research grants in LABEF in 2019

N°	Grants	Recipient	Topic / subject
1	International Foundation for Science (IFS)	Parfait Agonha	Habitat use, food preferences and conservation status of preferred food resources of elephants in the Pendjari National Park, Benin: implications for conservation and management
2	International Foundation for Science (IFS)	Mahoutin Gildas Serge Zanvo	Assessing the ethnobiology, structure, productivity, and ecosystem services of mangroves to inform their sustainable management in Benin
3	International Foundation for Science (IFS)	Melain Anago	Floristic diversity, stand structure, socio-economic importance, and ecological role of liana in two biodiversity hotspots forest reserves of Benin: implications for sustainable management
4	International Foundation for Science (IFS)	Ahuéfa M. Kegbe	Deciphering effects of provenances and production techniques on fruit ecophenotypic variation, germination, hypocotyl growth and biochemical content in *Borassus aethiopum*, a wild palm tree in Benin
5	International Foundation for Science (IFS)	Frederic Tovissode	Integration of biotic interactions and spacial genetic structure for effective conservation of the threatened tree species *Afzelia africana* Sm. ex pers. (Fabaceae–Caesalpinioideae) in Benin
6	International Foundation for Science (IFS)	Amandine Akakpo	Assessing the domestication potential of *Cochlospermum tinctorium* A.Rich, a neglected and underutilized medicinal and food subshrub species in Benin
7	EMS-Simons for Africa, Collaborative research continuation A2 visit	Bruno Lokonon	Research visit grant from EMS-Simons for Africa
8	EMS-Simons for Africa, Collaborative research continuation A2 visit	Sewanou Hermann Honfo	Research visit grant from EMS-Simons for Africa
9	Technical Centre for Agricultural and Rural Co-operation	Bruno Lokonon	Travel grant from CTA (Technical Centre for Agricultural and Rural Co-operation).

N°	Grants	Recipient	Topic / subject
10	Rufford Small Grant	Bruno Lokonon	Participatory Actions for Conservation of the Critically Threatened Multipurpose *Caesalpinia bonduc* (L.) Roxb in Southern Benin
11	Rufford Small Grant	Corine Sinsin	Ecophysiological Test and Vulnerability Assessment of Mangroves to Inform their Restoration in Benin
12	WAEMU Fellowship	Mahoutin Gildas Serge Zanvo	
13	AGNES Mobility Grant	FredericTovissode	
14	AGNES Mobility Grant	Sewanou Hermann Honfo	

As far as medium (USD 25000-200000) and large (over USD 200000) research projects are concerned, in 2019, LABEF hosted 06 medium and large projects from which 2 were new. The medium and large projects under going in 2019 are presented in table 3:

Table 3: Research projects of LABEF in 2019

N°	Project title	Project type	Partner countries	Funding institution	Period
1	Vers une gestion durable des mangroves au Bénin : dynamique spatio-temporelle, biodiversité, usages et gestion locale, capacité de séquestration de carbone et impacts des changements climatiques	Medium	Benin	Fonds national de la recherche scientifique et de l'innovation technologique (FNRSIT)	2017-2020
2	Scaling up African baobab food products valuation through enhancement of their safety and value chains for food and nutritional security in Benin (West-Africa)	Large	Benin	Mastercard Foundation & The Regional Universities Forum for Capacity Building in Agriculture (RUFORUM)	2018-2022
3	Enhancing nutritious food availability through	Large	Benin; Mali;	Fondation Agropolis,	2017-2020

N°	Project title	Project type	Partner countries	Funding institution	Period
	promotion of native edible tree/shrub species in Sub-Saharan Africa (TREEFOOD)		Burkina Faso; Niger; Denmark; Belgium	Fondazione Cariplo & Fondation Daniel et Nina Carasso	
4	Restauration, conservation et gestion durable des zones humides côtières du Costa Rica face au changement climatique	Medium	Costa Rica, Benin	French Facility for Global Environment (FFEM)	2018-2022
5	Setting up a system of evaluation of the land use dynamics and follow up indicators of the transboundary biosphere reserve of the Mono	Medium	Benin, Togo	Observation spatiale des forêts d'Afrique Centrale et de l'Ouest/ IRD	2017-2019
6	Mentoring young men and women agricultural graduates in the search for decent jobs in the labour market	Medium	Benin	International Development Research Centre (IDRC)	2019-2021

For more details on medium and large projects, please visit our web site: http://labef-uac.org/en/ongoing-projects/

In the frame of these projects, LABEF has partnered with several regional and international institutions from Burkina Faso, Mali, Niger, Denmark, Costa-Rica, Belgium.

2.4. Bachelor, Master & PhD theses in 2019

In 2019, two students (one male man and one female) have completed their BSc training and defended their theses in natural resources management. A total of twenty MSc students have completed their MSc degree in LABEF including 8 females and 12 males (figure 7a). Among these theses, 13 were completed in biostatistics and 7 in natural resources management (figure 7b).

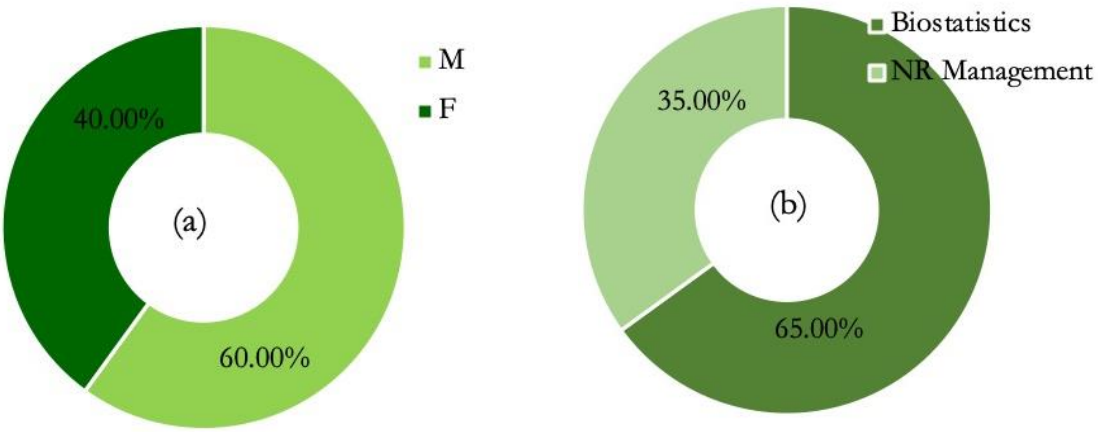

Figure 7: Gender balance (a) and fields of research (b) for Master theses -- NR = Natural Resources

A PhD thesis was defended in natural resources management in LABEF in 2019. Seventeen (17) PhD research initiatives are ongoing in various research fields (figure 8a) and at different stages (figure 8b). The principal fields of research for ongoing PhD projects was biometry (47.06%). More than 50% of PhD students were in their third year. 17.65% of PhD students were female.

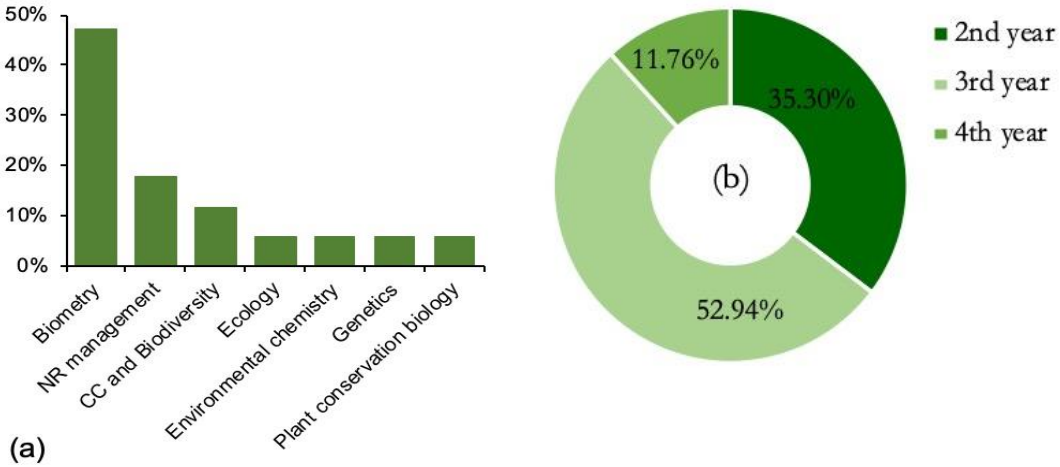

Figure 8: Fields of research (a) and stages of ongoing PhD theses in 2019

Part 3 – RESEARCH: Connection, share and networking

3.1. Collaboration in publication and other scientific activities in 2019

As usual, since its creation, in 2019, LABEF collaborated with researchers from various countries for research and scientific publications. These collaborations have been national, regional and international. Thus, the collaborations took place with 13 countries (figure 9a). More than 80% of collaborations for publication was done in the African continent.

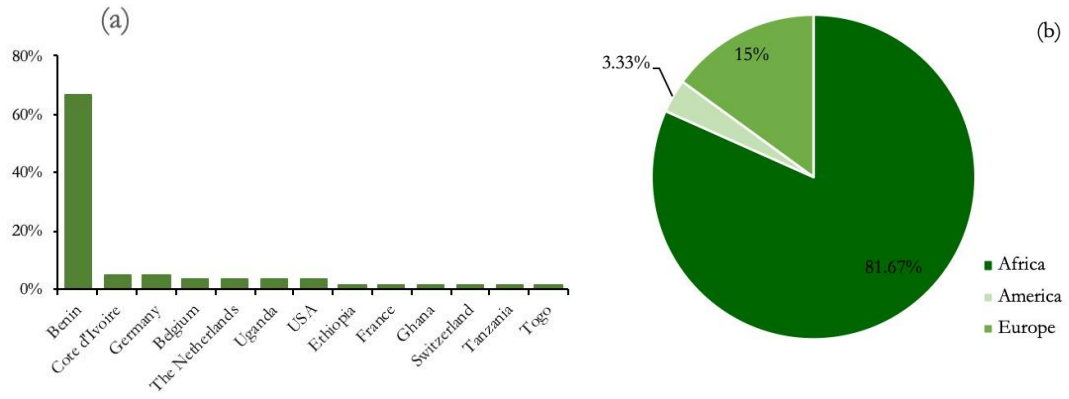

Figure 9: Countries (a) and world regions (b) of co-authors of publications of LABEF in 2019

3.2. Visitors to LABEF in 2019

Apart from collaboration for scientific publication, LABEF received three senior researchers for knowledge sharing with its members and the research community of the university of Abomey-Calavi. These researchers came from various institutions and countries (table 4).

Table 4: Received visitors in 2019

Visitor	Institution
Dr. David CROS, Oil palm geneticist	CIRAD, Direction Régionale Afrique Centrale, Yaoundé, Cameroun
Dr. Arnaud Monty, Professor of plant genetics and ecophysiology	Liège University, Gembloux Agro-Bio Tech;
Prof Ngonghala Calistus, Professor of Biomathematics	Département de Mathématiques, Université de Floride, USA.

Photo1 : Prof Ngonghala Calistus training M.Sc. students in epidemiological modeling (credit: Dr Valère Salako)

Photo 2 : Dr. Arnaud Monty with students working on mangroves and local authorities of the village where an experiment was set-up (left) and visit of mangroves with the team (right) (credit: Corine Sinsin)

3.3. Participation to scientific meetings in 2019

LABEF members attended 40 international conferences/workshops worldwide in 2019. These conferences were held in 15 countries (figure 10a). 67.50% of participants to those conferences/workshops presented oral communication (figure 10b). Significant effort has been done in participation to international

conferences/workshops in 2019 compared with 2018. There was an increase of 148.75% of the number of attended international scientific meetings.

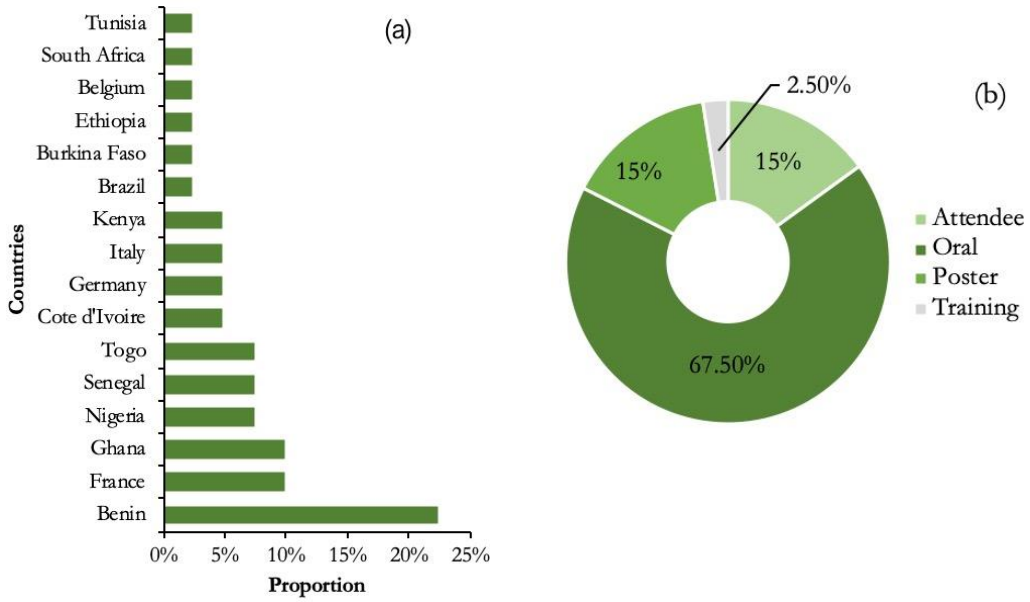

Figure 10: Host countries of conferences attended by LABEF members in 2019 (a) and roles of participants (b)

Part 4 – CONTRIBUTION: Capacity buildin

4.1. Graduate program in Biostatistics and Post graduate program in Biometry

4.1.1. Graduate program in Biostatistics (MBIOST)

Presentation of the MBIOST

Since its creation in May 2014, LABEF implements an international graduate program in Biostatistics. This master program offers an extensive and unique training in recent statistical methods and tools toward their applications in Life sciences. At the end of the training, graduated students can easily go into professional life as Biostatistician or engage in research in Biostatistics by integrating a doctoral school. This training is open to Bachelor Degree holders in Life Sciences domains (agronomy, health, biology, environment, etc.), or in Mathematics/Statistics or Master Degree holders wishing to acquire knowledge and know-how in the field of data collection and analysis. The Master in Biostatistics has fully trained and released four batches of professional biostatisticians and data analysts. The 7th batch of students started in September 2019 and enrolled 21 students from 02 countries (Benin and Liberia). As for date, 122 students were trained or are mastering in the program. The program is supported by an Intra-ACP Academic Mobility Program (AGREEMENT NUMBER 2013-4177/001-001), RUFORUM and the African Excellence Center for Mathematics Sciences and Application (ACE-MSA) under the auspices of the World Bank Group.

Aims of the MBIOST

The MBIOST program aims to provide Food Enterprises, Projects, Health Sector (Units of Clinical research), Department of Medical Information, etc.), Public and Private Research Institutions, Non-Governmental Organizations (NGO), International Organization (FAO, UNDP, World Bank, etc.), Education and International Research Institutions, with talented Biostatisticians and data analysts. The abilities this training gives in data collection, management, statistical analysis and valorization allow graduates to practice job of Biostatisticians in charge of Statistical Studies in various sectors.

How to apply?

Visit the website www.labef-uac.org and fill in the online application form (http://labef-uac.org/application). Candidates from Benin could submit their applications to the secretary of the programme, located at the Laboratory of

Biomathematics and Forests Estimations. Please visit the webpage of the Master for detailed information (http://labef-uac.org/en/master/).

4.1.2. Post graduate program in Biometry

In addition, since the academic year 2017-2018, the doctoral school of agronomic sciences and water resources is offering a PhD programme in Biometry under the coordination of Prof Glèlè Kakaï Romain (the Head of LABEF). Six members of LABEF who graduated from the Master program in Biostatistics are currently enrolled in the PhD program (Tovissodé Frederic, Honfo Sewanou Hermann, Amagnidé Aubin, Lokonon Bruno, Essomanda Tchandao Mangamana and Ahlonsou Ceptime), and some of them are almost ready to defend their theses.

4.2. The internship program in 2019

Apart from the Master's program in biostatistics, the laboratory offers internship opportunities to students at the Bachelor's or Master's level and even doctoral students or early career researchers from any nationality. These internships are organized in two levels: (i) academic internship, (ii) regional professional internship.

4.2.1. Academic internship

As for previous years, in 2019, LABEF received BSc and MSc students for a period of 3 to 6 months for internships. During their stay in the lab, they are introduced to basic statistics, R statistical software, and thematic trainings. They also participated to training sessions and contribute to research activities in the Lab. In 2019, LABEF received three (03) BSc students from the University of Abomey-Calavi and one (01) MSc student from the National University of Agriculture of Porto Novo.

4.2.2. Regional professional internship

In 2019, LABEF welcomed four PhD students (2 males and 2 females) from Laboratoire de Biologie et Ecologie Végétales, Université Joseph Ki-Zerbo (Burkina Faso), and one early career researcher from Centre International de Recherche-Développement sur l'Élevage en zone Subhumide (CIRDES) Bobo-Dioulasso, Burkina Faso. During their stay, specific training modules were organized depending on their expectations. Appendix A1.12 summarizes the purpose of regional interns received in 2019.

We hope to welcome more interns in the future. For details, requirement and condition for participating in the internship programs of LABEF, please contact the Lab (contact.labef@gmail.com).

4.3. Conferences & seminars held in LABEF in 2019

As usual, in 2019, LABEF organized some scientific seminars to share scientific knowledge on hot topics with researchers and scholars of the University of Abomey-Calavi and research centers nearby the University. A total of 3 free-of-charge seminars were organized and they covered various scientific concerns as mentioned in table 5.

Table 5: Scientific seminars at LABEF in 2019

Topic	Guest speaker	Date
Application of mixed model analysis for crop improvement: prediction of genetic values with BLUP and Bayesian methods	David CROS (PhD) – (Oil palm geneticist CIRAD, Direction Régionale Afrique Centrale, Yaoundé, Cameroun)	16th January 2019
Experiments in controlled and semi-controlled conditions: interests and applications in plant ecology	Dr. Arnaud Monty (Liège University, Gembloux Agro-Bio Tech Biodiversity and Landscape, Gembloux, Belgium)	18th January 2019
Introduction to statistical modelling of infectious diseases	Prof Ngonghala Calistus, Professor de Biomathematics, Department of Mathematics, University of Florida, USA.	17th – 21st June 2019

For details about these scientific seminars, see Appendix 4 and visit our website (www.labef-uac.org).

Apart from these free-of-charge seminars, two paid training sessions were organized by LABEF in 2019. These training sessions covered tools for data analysis in R. Table 6 provides information on these training sessions.

Table 6: Topics and periods of paid training sessions at LABEF in 2019

Topic	Period
Introduction to data analysis with R	21 - 25 January 2019
Advanced multivariate methods for complexes dataset analysis and visualisation : Principles and applications in R	22 - 26 April 2019

Moreover, two workshops were organised by LABEF in collaboration with CEBIoS (Belgium Museum). Details of these workshops were as follow:

1. Training workshop on Measuring-Reporting-Verification (MRV) projects formulation for the CEBioS programme in Ouidah from 14th to 18th October 2019.
2. Workshop of CEBIoS' Alumni organised in Ouidah from 11th to 15th November 2019;

Participants to these two workshops were from several countries including Benin, Burundi, Democratic Congo, Congo Brazzaville, Belgium and Rwanda.

Photo 3: Training workshop on Measuring-Reporting-Verification (MRV) projects formulation for the CEBioS programme in Ouidah from 14th to 18th October 2019: (left) Family photo of participants (right) Participants receiving the training on projects developing tools (crédit: Dr Jean Didier Akpona)

Appendices

Appendix 1. Scientific activities in LABEF in 2019

- A1.1. Defended theses in 2010
- A1.2. On-going theses in 2019
- A1.3. Completed Master in 2019
- A1.4. Scientific papers published in peer-review journals with IF in 2019
- A1.5. Scientific papers published in peer-review journals without IF in 2019
- A1.6. Scientific papers in press in peer-review journals with IF in 2019
- A1.7. Scientific papers press in peer-review journals without IF in 2019
- A1.8. Scientific papers under review in peer-review journals with IF in 2019
- A1.9. Scientific papers under review in peer-review journals without IF in 2019
- A1.10. Technical reports and books in 2019 in 2019
- A1.11. Participation to conferences/seminars/workshops in 2019
- A1.12. List of interns/trainees received in 2019

Appendix 2. Abstracts of published scientific papers in peer-review journals in 2019

Appendix 3. Abstracts of on-going theses in 2019

Appendix 4. Abstracts of scientific seminars organized by LABEF in 2019

Appendix 1. Scientific activities in LABEF in 2019

- A1.1. Defended theses in 2010

Name	Research topic	Research field
Atanasso A. Justin	Effects of abiotic and biotic factors on the early recruitment of the threatened *Afzelia africana* Sm. ex Pers. (Fabaceae-Ceasalpinioideae) in the Pendjari Biosphere Reserve (Benin, West Africa)	Natural resources management

- A1.2. On-going theses in 2019

N°	Student full name	Gender	Level	Field of Research	Topic
1	Eclou Innocent	M	4th year	Environmental chemistry	Assessment and analysis of agro-ecological aspects of cotton farming systems for a sustainable cotton production in Benin.
2	Gnonlonfoun Isidore	M	3rd year	Ecology	Dynamics of savanna plants: effects of trophic interactions between elephants and woody plants in Pendjari Biosphere Reserve in Benin, West Africa
3	Houndonougbo Juliano	M	3rd year	Plant conservation biology	Ecology, conservation and domestication of *Parkia biglobosa* (Jack.) R. Br. (Mimosoideae) in Benin, West Africa
4	Amagnide Aubin	M	3rd year	Biometry	Empirical studies of plotless sampling techniques in vegetation studies
5	Hounmenou Castro	M	3rd year	Biometry	Global optimization in multilayer perceptron neuronal networks
6	Lokonon Bruno	M	3rd year	Biometry	Empirical comparison of parameter estimation methods used in generalized linear mixed model (GLMM) with applications on ecological data

N°	Student full name	Gender	Level	Field of Research	Topic
7	Honfo Hermann	M	3rd year	Biometry	Linear mixed effects models for fitting multivariate longitudinal data: application to natural regeneration of *Adansonia digitata* L.
8	Tovissode Frederick	M	3rd year	Biometry	Performance of Generalized Linear and Nonlinear Mixed Models under flexible semi-non parametric and parametric distributions: applications to plant-plant interactions and gene dispersal in *Afzelia africana*
9	Savi Merveille	M	3rd year	Biometry	Advanced system dynamic analysis approach to enhance the control of malaria in West Africa
10	Kafoutchoni Medard	M	2nd year	Plant genetics	Genetics of yield and yield components of Kersting's groundnut [*Macrotyloma geocarpum*] (Harms) Maréchal & Baudet]
11	Zanvo Serge	M	2nd year	Natural Resources Management	Population structure, dynamics, and ecosystem services of mangroves in southern Benin, West Africa: implications for sustainable management
12	Sinsin Corine	F	2nd year	Climate change and biodiversity	Resilience and vulnerability of mangroves to climate change in Benin, West Africa
13	Donhouede Janine	F	2nd year	Natural Resources Management	Morphological variation, genetic diversity and proximate composition in *Annona senegalensis* in Western and Southern Africa
14	Ahlonsou Ceptime	M	2nd year	Biometry	Study of error rate in discriminant analysis on functional data
15	Amoussou Eldys	M	3rd year	Climate change and biodiversity	Evaluation et prédiction des effets des changements climatiques sur les PFNLs d'Afrique tropicale : Conséquences sur la distribution des espèces et implications économiques
16	Tchandao Mangamana Essomada	M	2nd year	Biometry	Multiblock data analysis: new developments
17	Assogba Orgely Doris Imeilda	F	4th year	Natural Resources Management	Ecology and dynamics of baobab regeneration (*Adansonia digitata* L.) in Benin (west Africa)

- A1.3. Completed Master in 2019

Student name	Field	Sex	Topic	Supervisor	Co-supervisor
AGOUNDE Gafarou	Natural resources management	M	Dispersal constraints influence the suitability of the habitat of elephant food resources in the W-Arli-Pendjari-Oti-Mandouri-Keran (WAPOK) transboundary ecosystem, West-Africa	Pr. Dr. Ir. Romain GLELE KAKAÏ	Dr. Ir. Valère SALAKO Dr Ir Rodrigue IDOHOU
GANDAHO Mahugnon Mihinnoudéa Cléo-Claudia	Natural resources management	F	Ecophenotypic diversity of *Parkia biglobosa* (Mimosaceae) in the sub-humid AND semi-arid zones OF Benin	Pr. Dr. Ir. Achille E. ASSOGBADJO	Dr Valère SALAKO Dr Rodrigue IDOHOU
SABO Prospère	Natural resources management	M	Sociocultural importance, stand structure and vulnerability of *Boswellia dalzielii* Hutch in the *Boucle du Mouhoun* region (Burkina Faso)	Pr. Dr. Ir. Romain GLELE KAKAÏ Prof. Dr. OUEDRAOGO Amadé	Dr Valère SALAKO Dr Charlemagne GBEMAVO
Gbèdomèdji Hurgues Aristide HOUENON	Natural resources management	M	Stand structure and farmers' management of health problems of the bush mango tree, *Irvingia gabonensis* (Aubry-Lecomte ex O'Rorke) Baill. in agrarian systems of Southern Benin (West Africa)	Pr. Dr. Ir. Achille E. ASSOGBADJO Pr. Hounnankpon YEDOMONHAN	Dr. Ir. Valère SALAKO Dr. Ir. Rodrigue IDOHOU
Mariette AGBOHESSOU	Natural resources management	F	Natural stand structure and vegetative propagation of the African baobab *Adansonia digitata* in Benin	Pr. Dr. Ir. Achille E. ASSOGBADJO	Dr. Ir. Valère SALAKO Dr. Ir. Rodrigue IDOHOU
Charlotte Fabri (Belgium)	Natural resources management	F	Park dependency and its effect on park management attitudes: a case study of Pendjari Biosphere Reserve, Benin	Prof. dr. ir. Steven van Passel	Dr. Ir. Jean Didier AKPONA
LAURA HASAERS (Belgium)	Natural resources management	F	Factors influencing the compensation for reduced access to Pendjari Biosphere Reserve, Benin: a contingent valuation study	Prof. dr. ir. Steven van Passel	Dr. Ir. Jean Didier AKPONA
Ndeye Khady Guisse SECK	Biostatistics	F	Inference in under dispersed count data: a literature synthesis and	Pr. Dr. Ir. Romain GLELE KAKAÏ	Dr. Ir. Valère SALAKO

			comparison of five flagship approaches		
Spéro Cédrick HOUNDEKPONDJI	Biostatistics	M	Effect of pre-processing methods and data splitting on optimized training of Multilayer Perceptron Neural Networks	Pr. Dr. Ir. Romain GLELE KAKAÏ	Dr. Ir. Valère SALAKO
Hemaho Beaugard TABOE	Biostatistics	M	Understanding the persistence of Lassa fever virus transmission in West Africa: a modeling approach	Prof. Calistus N. NGONGHALA	Pr. Dr. Ir. Romain GLELE KAKAI
SEGBEMON Malvina	Biostatistics	F	Non parametric and parametric proportional hazards models: Application to survival of HIV / AIDS patients on antiretroviral treatment	Prof Kossi GNEYOU	Pr. Dr. Ir. Romain GLELE KAKAI
DETE Clarisse	Biostatistics	F	Regression and frailty models in survival analysis: simulation and application with HIV/AIDS data in Benin	Prof. Kossi GNEYOU	Pr. Dr. Ir. Romain GLELE KAKAI
KOTANMI Brezeski	Biostatistics	M	Clustering analysis to improve propensity score matching in estimating the average treatment effect on threated	Prof. Dr. Ir. Romain GLELE KAKAI	
HOUNGBO Ezeckiel	Biostatistics	M	Phenotipic selection-based training set for improving genomic selection accuracy	Prof. Marcel SENOU	
SALIOU Manzid	Biostatistics	M	Variance Components in a Random Regression Model by Legendre Polynomials applied to milk yield data	Prof. Marcel SENOU	
CHACHA Ebenezer	Biostatistics	M	Seed traits, dispersal mechanisms and implications for population dynamics.	Pr. Dr. Ir. Romain GLELE KAKAÏ	Dr. GAOUE Orou
GNANVI Janyce	Biostatistics	F	Performance of Cochran's Q test versus Permutation (Randomization) test with application to Check-All-That-Apply (CATA) data	Pr. Dr. Ir. Romain GLELE KAKAÏ	
AGBANGLANNON Pagal	Biostatistics	M	Technical efficiency of organic Cotton farming systems in Benin: A non-	Dr. (MC) Epiphane SODJINOU	Pr. Dr. Ir. Romain GLELE KAKAI

			parametric distance function approach.		
FONTON Perince	Biostatistics	M	Effect of response-variable features on the performance of beta regression with mixed effects: application on hand hygiene analysis of Healthcare workers	Pr. Dr. Ir. Romain GLELE KAKAÏ	
AGBOVOEDO Robert	Biostatistics	M	Performance of modeling algorithm given range and rarity of species l: RF, SVM, GLMs, MaxEnt, BRT.	Dr (MC) Belarmain FANDOHAN	

A1.4. Scientific papers published in peer-review journals with IF in 2019

Disciplines	N°	Authors' Names	Title of the article	Journals	IF
Plant Breeding and Biotechnology	1	Sodedji K.A.F., Agbahoungba S., Nguetta S.P.A., Agoyi E.E., Ayenan M.A.T., Sossou S.H., Kouassi B.A., Mamadou C., Assogbadjo A.E. & Kone D.	Cowpea resistance to legume pod borer (*Maruca vitrata fabricius*): genetic advances, challenges and future prospects.	Journal of Crop Improvement	0.870
Plant Breeding and Biotechnology	2	Kumi F., Badji A., Mwila N., Odong T., Ochwo-Ssemakula M., Tusiime G., Gibson P., Biruma M., Prom L.K., Cuevas H.E., Agbahoungba S. & Rubaihayo P.	New sources of sorghum resistant genotypes to downy mildew disease in Uganda	Biodiversitas	0.880
Ecology	3	Banla T., Houehanou D.T., Savi M.K., Idohou R., Glèlè Kakaï R. & Kokou K.	Population structure of *Pterocarpus erinaceus* Poir. across a protection gradient in sudanian savannahs of Togo, west Africa	African Journal of Ecology	0.893
Biosystematics and Ecology	4	Salako V.K., Vihotogbé R., Houéhanou T., Sodé I.A. & Glèlè Kakaï R.	Predicting the potential impact of climate change on the declining agroforestry species *Borassus Aethiopum* Mart. in Benin: a mixture of geostatistical and SDM approach.	Agroforestry Systems	1.792
Ethnobotany	5	Adjahossou S. G. C., Houehanou D. T., Toyi M., Salako V. K., Ahoyo C.C., Lesse P., Tente B. & Houinato M. R. B.	Connaissances locales des usages de *Isoberlinia spp.* Selon les facteurs sociaux au moyen-bénin (Afrique de l'ouest).	Bois et Forêts des Tropiques	0.340
Conservation Genetics	6	Houehanou T. D., Prinz K. & Hellwig F.	Characterization of 15 nuclear microsatellite markers for *Afzelia africana* (fabaceae) and related species	Application in Plant Sciences	1.232
Conservation Genetics	7	Houehanou D. T., Prinz K., Hellwig F., Assogbadjo A.E, Gebauer J., Glèlè Kakaï R.L. & Sinsin B.	Morphological traits variation of *Afzelia africana* Sm. along climatic gradient and anthropogenic disturbance in Benin (west Africa).	Genetic Resources and Crop Evolution	1.296
Ethnobotany	8	Lawin IF, Houètchégnon T., Fandohan A.B., Salako V.K., Assogbadjo A.E. & Ouinsavi C.A.	Connaissances et usages de *Cola millenii* K. Schum. (malvaceae) en zones guinéenne et soudano-guinéenne au Bénin.	Bois et Forêts des Tropiques	0.340
Soil Science and Plant Nutrition	9	Sossa E.L., Agbangba C.E., Dagbenonbakin G.D., Tohoun R., Tovihoudji P.G. & Amadji G.L.	Organo-mineral fertilization enhances the acceptability of smooth cayenne pineapple fruit (*Ananas comosus* (L.) Merrill) for european export and domestic consumption in Benin.	Agriculture	2.040

Disciplines	N°	Authors' Names	Title of the article	Journals	IF
Soil Science and Plant Nutrition	10	Sossa E.L., Agbangba C.E., Amadji G.L., Agbossou K.E & Hounhouigan D.J.	Integrated influence of soil tillage, nitrogen–potassium fertiliser and mulching on pineapple (*Ananas comosus* (L.) Merr.) growth and yield	South African Journal of Plant and Soil	0.240
Agroforestry	11	Gandji K., Tovissodé F.C., Azihou A.F., Akpona J. D. T., … & Glèlè Kakaï R.L.	Morphological diversity of the agroforestry species *Moringa oleifera* Lam. as related to ecological conditions and farmers' management practices in Benin (west Africa)	South African Journal of Botany	1.504
Ecosystem Services	12	De Bisthoven L.J., Rochette A.J., Verheyen E., Akpona J.D.T., … & Hugé J.	Conserving african biosphere reserves: a workshop on the valuation of ecosystem services in man and the biosphere reserves	Oryx	2.801
Conservation Biology	13	Atanasso J. A., Mensah S., Azihou A.F., Djossa B. A., Glèlè Kakaï R. & Assogbadjo A.E.	Heterospecific tree density and environmental factors affect *Afzelia africana* Sm. population structure in the Pendjari biosphere reserve, west Africa: implications for management and restoration	Tropical Conservation Science	1.327
Economy of Forest Products	14	Ettian M.K.; Sodjinou E.; Akouedegni G.C.; Djenontin A.J.; Pomalegni S.C.B. & Mensah G.A.	Evaluation économique des aulacodes d'élevage engraissés avec trois niveaux de compléments alimentaires dans la production du kilogramme de viande Grand-Lahou, Côte d'Ivoire (Afrique de l'Ouest).	Archivos de Zootecnia	0.440
Ethnobotany	15	Avakoudjo H.G.G., Hounkpèvi A., Idohou R., Koné M.W. & Assogbadjo E.A.	Local knowledge, uses, and factors determining the use of *Strychnos spinosa* organs in Benin (west Africa)	Economic Botany	1.481
Domestication	16	Salako, V. K., A. M. Kégbé, F. J. Chadaré, K. M. Kafoutchoni, A. Amagnidé, R. C. Gbedomon, A. E. Assogbadjo, C. Agbangla & R. Glèlè Kakaï	Potential for domestication of *Borassus aethiopum* Mart., a wild multipurpose palm species in sub-saharan Africa.	Genetic Resources and Crop Evolution	1.296
Food Sciences	17	Chadare F.J., Idohou R., Nago E., Affonfere M., Agossadou J., Fassinou T.K., Kénou C., Honfo S. Azokpota P., Linnemann A.R. & Hounhouigan D.J.	Conventional and food-to-food fortification: an appraisal of past practices and lessons learned	Food Sciences and Nutrition	1.202
Ethnobotany	18	Ouachinou J.M.-A.S., Dassou G.H., Idohou R., Adomou A.C. & Yédomonhan H.	National inventory and usage of plant-based medicine to treat gastrointestinal disorders with cattle in Benin (west Africa)	South African Journal of Botany	1.504

Disciplines	N°	Authors' Names	Title of the article	Journals	IF
Biosystematics and Ecology	19	Vihotogbé R., Idohou R., Gebauer J., Sinsin B. & Peterson T.	Estimation of cultivable areas for *Irvingia gabonensis* and *I. Wombolu* (Irvingiaceae) in Dahomey-gap (west Africa)	Agroforestry Systems	1.792
Biosystematics and Ecology	20	Vihotogbé R., Raes N., Van Den Berg R.G., Sinsin B & Sosef M.S.M.	Ecological niche information supports taxonomic delimitation of *Irvingia gabonensis* and *I. Wombolu* (Irvingiaceae).	South African Journal of Botany	1.504
Ethnobotany	21	Agbo R.I., Vihotogbé R., Missihoun A.A., Aladé Dagba R., Assogbadjo A.E & Agbangla C.	Indigenous knowledge of *Detarium microcarpum* Guill. & Perr. (caesalpiniaceae) and implication for conservation in Benin (west Africa).	Environment, Development and Sustainability	1.676
Entomology	22	Boafo H.A., Affedzie-Obresi S., Gbemavo D.S.J.C., Clottey V.A., Nkegbe E., Adu-Aboagye G. & Kenis M.	Use of termites by farmers as poultry feed in Ghana	Insects	2.130
Biotechnology	23	Laly J., Gbemavo D.S.J.C., Gbaguidi A.A., Dossou-Aminon I. & Dansi A.	*Dioscorea dumetorum* (Kunth) Pax, a neglected and underutilized yam species in Benin: folk classification and post-harvest conservation.	Genetic Resources and Crop Evolution	1.296
Ethnobotany	24	Adjahossou S.G.C., Houéhanou D. T., Toyi M., Salako V.K., Ahoyo C.C., Lesse P., Tente B. & Houinato M.R.B.	Dépendance socioculturelle des connaissances locales des usages de *Isoberlinia spp.* au moyen-bénin, Afrique de l'ouest	Bois et Forêts des Tropiques	0.340
Agroforestry	25	Gnonlonfoun I., Assogbadjo A.E., Gnaglè C.P. & Glèlè Kakaï R.	New indicators of vulnerability and resilience of agroforestry systems to climate change in west Africa.	Agronomy for Sustainable Development	4.263
Ecosystem Services	26	Gnonlonfoun I., Kassa B., Azihou F., Mensah S., Glèlè Kakaï R.L. & Assogbadjo A.E.	Perceived effects of elephants' presence and damages on ecosystem services supply in the Pendjari biosphere reserve, west Africa	Tropical Conservation Science	1.327
Biostatistics	27	Tchandao E.M., Cariou V., Vigneau E., Glèlè Kakaï R.L. & Qannari El M.	Unsupervised multiblock data analysis: a unified approach and extensions	Chemometrics and Intelligent Laboratory Systems	2.321

A1.5. Scientific papers published in peer-review journals without IF in 2019

Disciplines	N°	Authors' Names	Title of the article	Journals
Plant breeding and biotechnology	1	Kpoviessi A.D., Agbahoungba S., Agoyi E.E., Chougourou D.C. & Assogbadjo A.E.	Resistance of cowpea to bruchid (*Callosobruchus maculatus* Fab.): Status of knowledge on the genetic advances.	Journal of Plant Breeding and Crop Science
Plant breeding and biotechnology	2	Agoyi E.E., Sognigbe N., Kafoutchoni M., Ayena M., Sodedji F.A.K., Agbahoungba S., Sossou H.S., Vodouhe R. & Assogbadjo A.E.	Kersting's groundnut [*Macrotyloma geocarpum* (Harms) Maréchal & Baudet] crop attracts more field pests and diseases than reported before	Agricultural Research & Technology
Soil Science and Plant Nutrition	3	Amonmide I., Dagbenonbakin G., Agbangba C.E. & Akponikpe P.	Contribution à l'évaluation du niveau de fertilité des sols dans les systèmes de culture à base du coton au Bénin	International Journal of biological and chemical Science
Agronomy	4	Chabi F.O., Dagbenonbakin G.D., Agbangba C.E., Oussou B., Amadji G.L., Ahoton E.L. & Saïdou A.	Soil fertility level and cropping practices determining soybean yield in Northern East and Center of Benin	International Journal of Plant & Soil Science
Ecology	5	Azonningbo S.H.W., Adjakpa J.B.D.M., Chidikofan G.F. & Agbangba C.E.	Espèces indicatrices d'oiseaux de la zone humide d'importance internationale du Sud-Ouest du Bénin (Site Ramsar 1017)	Afrique SCIENCE
Biostatistics	6	Lokonon B.E., Beh Mba R., Gbeha M & Glèlè Kakaï R.	Parameters Estimation Methods in Generalized Linear Mixed Models Applied in Ecology: A Critical Review.	International Journal of Engineering and Future Technology
Zoology, Marine Biology	7	Dognimon S., Djagoun C.A.M.S., Djego S., Akpona H.A., Djego J., Akpona T.J.D. & Sinsin B.	Spotted-necked Otter (*Hydrictis maculicollis*) distribution and determining factors of habitat occurrence in the lower Ouémé Valley, Southern Benin	IUCN/SCC Otter Specialist Group Bulletin
Economics of Climate change	8	Sodjinou E., Hounkponou S.K. & Chabi Adjobo M.A.A.	Facteurs déterminant l'adoption des stratégies d'adaptation aux changements climatiques au Bénin : cas des producteurs de maïs	Bulletin de la Recherche Agronomique du Bénin (BRAB). Numéro spécial Économie et Sociologie Rurales (ESR) – Novembre 2019
Economics of Climate change	9	Sodjinou E. & Hounkponou S.K.	Impact des changements climatiques sur les revenus des ménages agricoles au Bénin : Evidence basée sur l'application du modèle Ricardien	Annales de l'université de Parakou : série « sciences naturelles et agronomie »

Plant breeding and biotechnology	10	Kotchofa R., Baimey H., Fanou A., Zadji L. & Sodjinou E.	Diversity and distribution of sweet potato weevils (*Cylas spp.*) in southern Benin	Annales de l'université de Parakou : série « sciences naturelles et agronomie »
Agroforestry	11	N'djolossè K., Adoukonou-sagbadja H., Gbèmavo C. D., Kodjo S., Badou A., Maliki R. & Adjovi N.R.A.	Agro-morphological characterization of preselected cashew (*Anacardium occidentale* L.) mother trees in Benin farmer's plantations	Journal of Agriculture and Environment for International Development
Biostatistics	12	Honfo S.H.& Glèlè Kakaï R.	Empirical study of computational techniques used for parameters estimation in multivariate linear mixed effects models	Afrika Statistika
Biostatistics	13	Honfo S.H., Houetohossou A., Assogbadjo A. & Glèlè Kakaï R.	Effective use of statistical tools in agricultural sciences: a critical review of multivariate modelling methods	Journal of Applied Biosciences

- A1.6. Scientific papers in press in peer-review journals with IF in 2019

Disciplines	N°	Authors' Names	Title of the article	Journals	IF
Plant breeding and biotechnology	1	Kpoviessi A.D., Datinon B., Agbahoungba S., Agoyi E.E., Chougourou D.C., Sodedji F.K.A., Assogbadjo A.E.	Source of resistance among cowpea accessions to bruchid (*Callosobruchus maculatus* F. Coleoptera: Chrysomelidae) in Benin	African Crop Science Journal	0.29
Biodiversity conservation	2	Juliano Houndonougbo, Barthelemy Kassa, Sylvanus Mensah, Valère Kolawole Salako, Romain Glèlè Kakaï, Achille Ephrem Assogbadjo	A global systematic review on conservation and domestication of *Parkia biglobosa*, an indigenous fruit tree species in Sub-Sahara African traditional parklands: current knowledge and future directions	Genetic Resources and Crop Evolution	1.296
Conservation biology	3	Gbedomon RC, Salako VK, Schlaepfer MA	Diverse views among scientists on non-native species.	Neobiota	2.488

- A1.7. Scientific papers press in peer-review journals without IF in 2019

Disciplines	N°	Authors' Names	Title of the article	Journals
Soil Science and Plant nutrition	1	Katé S., Sossa E. L., Agbangba C. E., Idohou R., Sacla Aïde E., Tovihoudji P.G.	Mineral fertilization influences the acceptability of fresh pulp and juice made from sugarloaf pineapple	Agricultural sciences
Ethnobotany	2	Assogbadjo B. E. J., Hounkpèvi A., Barima Y. S. S., Akabassi G. C., Assogbadjo A. E. & Glèlè Kakai R.	Connaissances endogènes des plantes alimentaires locales dans les systèmes agroforestiers traditionnels de la zone Périphérique du noyau central de la forêt classée de la Lama au Bénin	Annales des Sciences Agronomiques
Soil Science and Plant nutrition	3	Sabaï K., Sossa E. L., Anago N. F., Tovihoudji P.G., Chabi T.O.Y, Kiki F. G.H., de-SOUZA J.F., Agbangba C. E.	Influence of microdose of mineral fertilizer and organic manure on the production of groundnuts in southern Benin	International Journal of Soil and Plant
Biosystematics and Ecology	4	Relique Ignace Agbo, Rodrigue Idohou, Romaric Vihotogbé, Antoine Abel Missihoun, Rollande Aladé Dagba, Achille Ephrem Assogbadjo, Clément Agbangla.	Spatio-temporal dynamics of suitable habitats for Detarium microcarpum Guill. & Perr. (Caesalpiniaceae), a priority food tree species in Benin (West Africa).	Modeling Earth Systems and Environment
Biosystematics and Ecology	5	Agbangba C.E., Vianou A., Idohou R.	Spatio-temporal prediction of potential areas for pineapple [*Ananas comosus* (L.) Merrill] cultivation in Benin (west Africa) under climate change using ecological niche modeling	Modeling Earth Systems and Environment

- A1.8. Scientific papers under review in peer-review journals with IF in 2019

N°	Disciplines	Authors' Names	Title of the article	Journals	IF
1	Plant breeding and biotechnology	Djanta M.K.A., Agoyi E.E., Agbahoungba S., Quenum F.J.B., Chadare F.J. and Assogbadjo A.E.	Vegetable soybean, edamame: Research, production, utilization and analysis of its potential in Sub-Saharan Africa.	Agriculture and Food Security	0.96
2	Ecology and Natural resources management	Jean Adanguidi, Elie Antoine Padonou, Afio Zannou, Sidol B.E. Houngbo, Idelphonse O. Saliou, Symphorien Agbahoungba	Consumption, level of satisfaction and fuelwood supply strategy in mangrove areas of RAMSAR sites 1017 and 1018 in Benin, West Africa	Fuel	5.128
3	Ecology of Estuarine ecosystems	Gnansounou Constant, Agadjihouèdé Hyppolite, Salako Valère, Tohoun, Roméo, Houssou, Arsène Glèlè Kakaï Romain and Lalèyè Philippe	Water physico-chemical characteristics and patterns in phytoplankton diversity and assemblages in a West African mangrove ecosystem	African Journal of Ecology	0.893
4	Conservation Biology	Justin Akpovi Atanasso, Sylvanus Mensah, Valère Kolawolé Salako, Roméo Tohoun, Romain Lucas Glèlè Kakaï, Achille Ephrem Assogbadjo	Factors affecting survival of seedling of *Afzelia africana*, a threatened tropical tree in West Africa	Tropical Ecology	0.95
5	Ethnobotany	Juliano Houndonougbo, Barthelemy Kassa, Valère Kolawole Salako, Rodrigue Idohou, Achille Ephrem Assogbadjo, Romain Glèlè Kakaï	Perceived variation of fruit traits, and preferences in African locust bean (*Parkia biglobosa*) in Benin: implications for domestication	Genetic Resources and Crop Evolution	1.296
6	Plant morphology	Achille Hounkpèvi, Valère Kolawolé Salako, Janine Conforte Fifonssi Donhouédé, Emilienne Houévo Daï, Frédéric Tovissodé, Romain Glèlè Kakaï, Achille Ephrem Assogbadjo	Intraspecific trait variation patterns of the wild soursop *Annona senegalensis* (Annonaceae) along a climatic gradient in Benin, West Africa	Plant Ecology and Evolution	1.012
7	Biosystematics and Ecology	Assogba D., Idohou R., Chirwa P., Assogbadjo A.E.	Habitat suitability modelling for African baobab in Benin (West Africa): a spatial model integrating dispersal events	South African Journal of botany	1.504

N°	Disciplines	Authors' Names	Title of the article	Journals	IF
8	Ecology, Plant Domestication	Vihotogbé R, Vianou, Idohou R, Assogbadjo AE, Glèlè Kakaï	Population structure and climate induced shifts in the geographic range of *Mondia whitei* (Hook.F.) Skeels (Apocynaceae)	African Journal of Ecology	0.893

- A1.9. Scientific papers under review in peer-review journals without IF in 2019

N°	Disciplines	Authors' Names	Title of the article	Journals
1	Plant breeding and biotechnology	Agbahoungba S., Adoukonou Sagbadja H., Agoyi E.E., Houinde P. J., Adandonon A., Assogbadjo E.A. and Sinsin B.	Caractérisation génétique moléculaire de 50 accessions de niébé (Vigna unguiculata L. Walp) en utilisant des marqueurs microsatellites (SSRS).	African Journal of Rural Development
2	Plant breeding and biotechnology	Agbahoungba S., Datinon B., Agoyi E.E, Tossou H.T., Assogbadjo A.E. and Sinsin B.	Sources of resistance to flower bud thrips (*Megalurothrips sjostedti* Trybom) among Benin cowpea germplasm.	African Journal of Rural Development
3	Plant breeding and biotechnology	Agbahoungba S., Assogbadjo A.E and Sinsin B.	Development of insect resistant high yielding cowpea varieties in Benin: A review of the implementation of the Post doc fellowship and lessons learnt	African Journal of Rural Development
4	Machine learning / Neural network Modelling	Castro G. Hounmenou, Romeo Tohou, Kossi Essona Gneyou, Romain Glele Kakaï	Empirical determination of optimal configuration for characteristics of a multilayer perceptron neural network in nonlinear regression	Neural Processing Letter
5	Ethnobotany	Souleymane Compaore, Lazare Belemnaba, Achille Hounkpevi, Rodrigue Idohou, Issouf Zerbo, Sylvin Ouedraogo and Adjima Thiombiano	Diversity of plants used in the management of hypertension by three associations of traditional healers along climate gradient in Burkina Faso	Scientifica

- A1.10. Technical reports and books in 2019

Field of research	N°	Authors' Name	Title	References
Soil Science and Plant nutrition	1	Dagbenonbakin G. D., Agbangba C. E., Fayalo G., Amonmide I., Mensah G. A.	Influence du parcage et son effet résiduel sur la croissance et le rendement du cotonnier au Bénin	Dépôt légal N° 11839 du 28/11/2019, Bibliothèque Nationale (BN) du Bénin 4ème trimestre
Agroforestry	2	Hounsou-Dindin G., Salako V.K., Idohou R., Sero N., Gbedomon R.C., Chadare F.J., Glèlè Kakaï R., Sinsin B., Assogbadjo A.E.	Fiche technique pour la culture de feuilles fraîches du baobab (*Adansonia digitata* L.)	Hounsou-Dindin G., Salako V.K., Idohou R., Sero N., Gbedomon R.C., Chadare F.J., Glèlè Kakaï R., Sinsin B., Assogbadjo A.E., 2018. Fiche technique pour la culture de feuilles fraîches du baobab (*Adansonia digitata* L.). Laboratoire de Biomathématiques et d'Estimations Forestières. Université d'Abomey-Calavi (UAC), Série Agroforestière N°: AGF/001/2018, Abomey-Calavi, Bénin

A1.11. Participation to conferences/seminars/workshops in 2019

N	Title	Period	Type of presentation	Country	Participant
1	9th Bonn Humboldt Award Winners' Forum "Frontiers in Biogeography, Ecology, Anthropology, and Evolution. Humboldt and the 'Cosmos' revisited in the 21st Century	16th - 20th October 2019	Attendee	Germany	Belarmain A. Fandohan
2	OnePlanet fellowship : atelier d'orientation et de formation sur le mentor	16th - 21st September 2019	Attendee	Kenya	Belarmain A. Fandohan
3	Connecting Minds Africa 2019	25th - 27th September 2019	Poster	Kenya	Belarmain A. Fandohan
4	2nd International Conference on Statistics and Applied Economics, Abidjan, Côte d'Ivoire	17th - 20th June 2019	Oral	Cote d'Ivoire	Bruno Lokonon
5	Training on Agroforestry and the Nationally Determined Contributions to the Paris Climate Accord (NDCs), Montpellier, France	19th May 2019	Attendee	France	Bruno Lokonon
6	1st summer school in Statistics and Data Science for African French-speaking young researchers in M'bour, Sénégal	1st - 5th July 2019	Attendee	Senegal	Bruno Lokonon
7	4th World Congress on Agroforestry in Montpellier, France	20th - 22nd May 2019	Poster	France	Bruno Lokonon
8	2nd edition of Doctorials of Doctoral School of Agronomic and Water Sciences of University of Parakou	4th - 6th November 2019	Oral	Benin	Bruno Lokonon
9	Short research stay at UFR SEFS of the Université Gaston Berger-Saint Louis (Sénégal)	July-August 2019	Training	Senegal	Bruno Lokonon
10	Empirical determination of optimal configuration for characteristics of a multilayer perceptron neural network in nonlinear regression	10th - 14th June 2019	Oral	Nigeria	Castro Hounmenou
11	Configuration optimale des réseaux neurones de type perceptron multicouche en régression non linéaire	17th - 20th June 2019	Oral	Cote d'Ivoire	Castro Hounmenou
12	Robust estimation in multivariate multiple nonlinear regression with multilayer perceptron neural networks	1st - 5th July 2019	Oral	Senegal	Castro Hounmenou
13	Evaluation of the robustness of imputation methods combined to	8th - 11th September 2019	Oral	South Africa	Castro Hounmenou

N	Title	Period	Type of presentation	Country	Participant
	backpropagation algorithm in frame of non-linear multiple regression				
14	15th Annual General Meeting of RUFORUM	30th November to 7th December 2019	Attendee	Ghana	Constant Setondé Gnansounou
15	4th World Congress on Agroforestry. Agroforestry: strengthening links between science, society and policy.	20th - 22nd May 2019	Poster	France	Doris Assogba
16	Decision Tree Analysis: principles and applications in biological sciences	10th - 14th June 2019	Oral	Nigeria	Emile Agbangba
17	Artificial intelligence techniques in environmental sciences: applications and prospects	10th -14th June 2019	Oral	Nigeria	Emile Agbangba
18	Problématique actuelle de la Gestion Intégrée de la Fertilité des Sols	7th December 2019	Oral	Benin	Emile Agbangba
19	3rd International Symposium of the University of Kara	23rd - 27th September 2019	Oral	Togo	Essomanda Tchandao Mangamana
20	International Conference on Chemometrics in Analytical Chemistry	9th - 10th April 2019	Oral	Italy	Essomanda Tchandao Mangamana
21	International Conference on Chemometrics in Analytical Chemistry	9th - 10th April 2019	Oral	Italy	Essomanda Tchandao Mangamana
22	1st summer school in Statistics and Data Science for African French-speaking young researchers in M'bour, Senegal	1st - 5th July 2019	Oral	Senegal	Hermann S. Honfo
23	EVAMAB closing workshop	13th - 17th May 2019	Oral	Ethiopia	Jean Didier Akpona
24	Ecosystem Services Partenership (ESP) conference at Kpalimé, Togo	17th - 20th June 2019	Oral	Togo	Jean Didier Akpona
25	Programme du 1er Atelier du projet CESP 2019-10 "Utiliser l'infrastructure et le réseau du CHM pour renforcer l'acquisition et le partage de données biodiversité"	14th - 18th October 2019	Oral	Belgium	Jean Didier Akpona
26	Ecosystem services conference in Benin	11th - 15th November 2019	Oral	Benin	Jean Didier Akpona
27	Socioeconomic factors supporting possession of African locust bean trees by local communities in two contrasted climatic zones of Benin in West Africa	14th - 18 October 2019	Oral	Burkina Faso	Juliano Houndonougbo

N	Title	Period	Type of presentation	Country	Participant
28	Systematic review on conservation biology of a threatened food tree *Parkia biglobosa* (Mimosoideae) in Africa	16th - 20th September 2019	Oral	Benin	Juliano Houndonougbo
29	Patterns of tree possession, perception of variation and preferences in African locust bean in Benin	29th September - 05th October	Poster	Brazil	Juliano Houndonougbo
30	2nd edition of Doctorials of Doctoral School of Agronomic and Water Sciences of University of Parakou	4th - 6th November 2019	Oral	Benin	Juliano Houndonougbo
31	Conférence OSFACO : Des images satellites pour la gestion durable des territoires en Afrique	13th - 15th March 2019	Oral	Benin	Rodrigue Idohou
32	Deuxième édition de la semaine de la biodiversité et de le recherche forestière Thème 2019 - Notre biodiversité, notre nourriture, notre santé	21st - 24th May 2019	Attendee	Benin	Rodrigue Idohou
33	5th ISESCO-COMSATS-INIT International Conference on Agriculture, Biotechnology and Food Security: Role of ICTs & 3rd TYAN International Thematic Workshop on Sustainable Agriculture, Food Security and Biotechnology: Best Strategies and Good Practices	4th - 6th November 2019	Oral	Tunisia	Rodrigue Idohou
34	9th Bonn Humboldt Award Winners' Forum "Frontiers in Biogeography, Ecology, Anthropology, and Evolution. Humboldt and the 'Cosmos' revisited in the 21st Century	16th - 20th October 2019	Poster	Germany	Romaric Vihotogbé
35	Third international seminar of KARA University	23rd - 27th September 2019	Oral	Togo	Serge Zanvo
36	2nd edition of Doctorials of Doctoral School of Agronomic and Water Sciences of University of Parakou	4th - 6th November 2019	Oral	Benin	Serge Zanvo
37	West African Cowpea Consortium (WACC) Annual Meeting	15th - 18th October 2019	Oral	Benin	Symphorien Agbahoungba
38	15th Annual General Meeting of RUFORUM	30th November - 7th December 2019	Oral	Ghana	Symphorien Agbahoungba
39	15th Annual General Meeting of RUFORUM	30th November - 7th December 2019	Oral	Ghana	Symphorien Agbahoungba
40	15th Annual General Meeting of RUFORUM	30th November - 7th December 2019	Poster	Ghana	Symphorien Agbahoungba

- A1.12. List of interns/trainees received in 2019

Names	Institution	Purpose of the stay	Period
Compaoré Souleymane PhD student	Laboratoire de Biologie et Ecologie Végétales Université Joseph KY-ZERBO, Burkina Faso	i) analyser les données d'inventaire floristique ; ii) Proposer au moins un manuscrit à soumettre à l'appréciation de l'équipe du LABEF à partir des résultats de l'analyse des données.	06 Juin au 04 Juillet 2019
Dr Abel S. BIGUEZOTON	Centre International de Recherche-Développement sur l'Élevage en zone Subhumide (CIRDES) 01 B.P. 454 Bobo-Dioulasso 01 – Burkina Faso	Analyses multivariées et les modèles linéaires à effets mixtes sur données longitudinales	02 au 13 Décembre 2019
Korotimi OUEDRAOGO, PhD Student	Laboratoire de Biologie et Ecologie Végétales, Université Joseph Ki-Zerbo Burkina Faso	Modélisation de la niche écologique dans le logiciel Maxent et les Méthodes d'analyse multivariées des données de végétation avec le logiciel R	02 au 13 Décembre 2019
Ounyambila LOMPO, PhD Student	Laboratoire de Biologie et Ecologie Végétales, Université Joseph Ki-Zerbo Burkina Faso	Modélisation de la niche écologique dans le logiciel Maxent et les Méthodes d'Analyse Multivariées des données de végétation avec le logiciel R	02 au 13 Décembre 2019.
Apolline SANOU, PhD Student	Université Joseph Ki-Zerbo de Ouagadougou (Burkina Faso)	« Introduction à l'analyse de données dans le logiciel R » et les « Modèles linéaires généralisés : principes et applications dans le logiciel R »	02 au 13 Décembre 2019.

Cowpea resistance to legume pod borer (*Maruca vitrata fabricius*): genetic advances, challenges and future prospects

Sodedji K.A.F., Agbahoungba S., Nguetta S.P.A., Agoyi E.E., Ayenan M.A.T., Sossou S.H., Kouassi B.A., Mamadou C., Assogbadjo A.E. & Kone D.

Journal of Crop Improvement
doi:10.1080/15427528.2019.1680471

Abstract

Cowpea (*Vigna unguiculata* (L.) Walp) is a highly nutritious grain legume crop in the world. However, cowpea production is constrained by legume pod borer (*Maruca vitrata Fabricius*) (LPB), which feeds on various parts of cowpea plant, causing a complete crop failure. An analysis of the existing literature revealed LPB as a serious threat to cowpea production worldwide, with a more noticeable damage in Africa. Attempts to develop and use LPB-resistant cowpea varieties have not shown significant results because of challenges, such as interspecific crossing barriers, genetic variability among LPB strains, effects of genotype-by-environment interaction, limited knowledge of the genetic architecture of the trait, and the socio-political barriers to the adoption of transgenic cowpea varieties in some countries. Combining multi-environment trials with precise phenotyping would help optimize selection of best-performing cowpea genotypes to reduce LPB infestation. Many molecular tools (e.g., markers systems, genetics maps, high-throughput genotyping, and quantitative trait loci (QTL) analysis) are available to support breeding for LPB resistance in cowpea. In addition, mutation breeding, tissue culture, reverse genetics, clustered regularly interspaced short palindromic repeats (CRISPR) technologies can be used to increase genetic variability in cowpea for LPB resistance. The effective use of these technologies relies on an enabling legal and socio-economic-political environment for fast development and adoption of LPB-resistant cowpea varieties.

Keywords: Genetic architecture, genomic resources, insect pest, pod borer, *Vigna unguiculata*

New sources of sorghum resistant genotypes to downy mildew disease in Uganda

Kumi F., Badji A., Mwila N., Odong T., Ochwo-Ssemakula M., Tusiime G., Gibson P., Biruma M., Prom L.K., Cuevas H.E., Agbahoungba S. & Rubaihayo P.

Biodiversitas

doi:10.13057/biodiv/d201136

Abstract

Sorghum downy mildew (SDM) disease is still prevalent in Uganda at varying levels of incidence and severity. In this study, a total of 100 sorghum genotypes, five (5) from (U.SA, India, and Sudan) and 95 genotypes from Uganda were evaluated for resistance to downy mildew and other agronomic traits during the second growing season of 2016 (August-December). The experiment was conducted in two locations at Makerere University Agricultural Research Institute at Kabanyolo (MUARIK) and Abi-Zonal Agricultural Research and Development Institute (Abi-ZARDI) research station at Arua. The experimental design used was 10 x 10 alpha lattice design with three replicates. Data were collected on plant disease incidence (PDI), plant disease severity (PDS), area under disease progress curve (AUDPC), days to 50% flowering, plant height, 1000 seed weight, and grain yield. Results for analysis of variance showed highly significant differences ($P < 0.001$) in genotypes, location, and AUDPC, yield and yield components. Disease incidence varied significantly ($P < 0.001$) between locations, and Arua recorded highest disease incidence and severity of 80.6 and 2.8, respectively. Results from correlation analysis showed a highly significant ($P < 0.001$) positive association of downy mildew disease incidence with AUDPC (0.835) which suggests that the severity of SDM disease increased with disease incidence, whiles significant ($P < 0.001$) negative correlation was recorded for days to 50 % flowering (-0.302), 1000 seed weight (-0.471), and grain yield (-0.585), suggesting that grain yield and yield component decreased significantly with increase in SDM incidence and severity. Two resistant (PI 656061 and PI 533831) and four moderately resistant (E 40, MAKSO 8, PI 655990 and Epuripur) genotypes were identified from this study. These genotypes were recommended for sorghum breeding program against downy mildew disease.

Population structure of *Pterocarpus erinaceus* Poir. across a protection gradient in sudanian savannahs of Togo, west Africa

Banla T., Houehanou D.T., Savi M.K., Idohou R., Glèlè Kakaï R. & Kokou K.
African Journal of Ecology
doi:10.1111/aje.12556

Abstract

Human-modified systems come as innovative ones necessary to be more understood to attain biodiversity conservation goals. This study aimed to assess the effect of human disturbance on the population structure of *Pterocarpus erinaceus* in different land use types (Highly protected area, Moderately protected area and Non-protected area) in Sudanian savannahs of Togo. Data were collected in forty randomly set plots (50 m × 30 m) within each land use type. Population structure parameters and leaf and leaflet morphological traits were evaluated and compared among the land use types by performing different statistical analyses. Results showed an adverse effect of human disturbance on adult and juveniles densities as well as the total height (significant difference between highly protected and non-protected areas; $p < 0.001$). Diameter class structures revealed in the three land use types an inverted J-shape indicating the predominance of young individuals. Significantly greater ($p < 0.001$) values of leaflet length were observed in the non-protected area compared to highly protected one. The human-mediated area impacted the diameter-height relation and the one among assessed leaf and leaflet traits. These findings are tools to be incorporated in new policy development for the future management of this tree species population.

Keywords: human-mediated area, population structure, *Pterocarpus erinaceus*, Togo, West Africa

Predicting the potential impact of climate change on the declining agroforestry species *Borassus Aethiopum* Mart. in Benin: a mixture of geostatistical and SDM approach

Salako V.K., Vihotogbé R., Houéhanou T., Sodé I.A. & Glèlè Kakaï R.
Agroforestry Systems
doi:10.1007/s10457-018-0262-2

Abstract

Predicted effects of climate change (CC) on plant species distribution have raised concerns on their conservation and domestication. Appropriate stand density may enhance species ability to adapt to CC. Therefore, combining species distribution modeling (SDM) and spatial pattern of density should provide insightful information for setting conservation actions. We combined

geostatistical and SDM techniques to assess (1) current tree density spatial pattern and its relationship with bioclimatic zone (humid, sub-humid, and semi-arid), land-use type (protected areas vs. agrosystems), and soil type (eight types), and (2) present-day and future distributions of suitable habitats under low-RCP4.5 and high-RCP8.5 emissions scenarios for *Borassus aethiopum*, a declining agroforestry palm in Benin. Data were obtained from 2880 one-ha plots. Semivariogram and kriging were used to model spatial patterns of density while Maximum Entropy was used for SDM. Tree density followed an isotropic spatial model with a range of 2.15 km, indicating extremely fragmented density pattern. Tree density was 8-times higher in protected areas (PAs, 68.6 ± 5.09 trees ha−1) than in agrosystems (8.4 ± 0.31 trees ha−1) and greater on ferruginous soils. Though 80% of the country was currently highly suitable with similar trend for PAs and agrosystems, future predictions showed major habitat loss (20–61%), particularly under RCP8.5. While changes were similar between PAs and agrosystems, the decrease in habitat suitability was pronounced in the semi-arid zone where the species is currently widely distributed with higher abundance. Very weak link was found between present-day abundance and present-day and future distribution. It is concluded that *B. aethiopum* has a fragmented density pattern and will be sensitive to CC. In-situ and circa-situ conservations or orchards establishment were suggested depending on the projected changes and the bioclimatic zone. The approach used here is exemplary for other agroforestry tree species.

Keywords: SDM, Geostatistics, MaxEnt, Underutilized species, Palm, Agroforestry

Characterization of 15 nuclear microsatellite markers for *Afzelia africana* (fabaceae) and related species

Houehanou T.D., Prinz K. & Hellwig F.
Application in Plant Sciences
doi:10.1002/aps3.1249

Abstract

PREMISE: *Afzelia africana* (Fabaceae) is a valuable, internationally vulnerable tree species in tropical Africa. The development of specific simple sequence repeat (SSR) loci is necessary for population genetic studies in this tree species and its closest relatives.

METHODS AND RESULTS: Fifteen new polymorphic microsatellite markers were developed for *A. africana* using Illumina next- generation sequencing. We tested the polymorphism of the 15 loci in three populations in Benin, West Africa. The number of expressed alleles per locus varied from one to 12. The

levels of observed and expected heterozygosity ranged from 0.100 to 1.000 and from 0.095 to 0.882, respectively. Most markers successfully amplified in the closely related species *A. quanzensis* and *A. bipindensis*, but less so in *A. bipindensis*.

CONCLUSIONS: Because of their cross- amplification ability, these newly developed loci will serve as useful tools for future molecular analyses on A. africana and related species.

Keywords: *Afzelia africana*; conservation genetics; Fabaceae; simple sequence repeat (SSR); sustainable management; West Africa.

Morphological traits variation of *Afzelia africana* Sm. along climatic gradient and anthropogenic disturbance in Benin (west Africa)

Houehanou D.T., Prinz K., Hellwig F., Assogbadjo A.E, Gebauer J., Glèlè Kakaï R.L. & Sinsin B.

Genetic Resources and Crop Evolution
doi:10.1007/s10722-019-00773-x

Abstract

Afzelia africana Sm. is a tree species found in different climatic conditions affected by chronic human disturbance. It is known that trees can respond to their environments by changing their morphological traits. Also, as plants store their reserves in fruits, seeds and leaves, long-lasting disturbance may impact morphological traits of fruits, seeds and leaves. Thus, in this study, we evaluated (1) the variation of morphological traits of *A. africana* according to climatic conditions and human disturbance, and (2) the relationships among morphological traits. Twelve morphological parameters based on fruits, seeds and leaflets were assessed across three climatic zones and compared for individuals in protected and disturbed landscapes. Univariate and multivariate analyses were used to evaluate the effects of climatic factors and disturbance. Highest values for fruit, seed and leaflet traits were observed in humid areas indicating for best performance under optimal conditions. Significant adverse effects of human disturbance were observed for traits in the humid and drier areas. The interaction between climatic conditions and disturbance was significant for most traits suggesting a climate-dependent effect of the disturbance on evaluated traits. Bioclimatic variables were thus identified as potential drivers of traits. Some significant and positive associations were observed among fruit and seed traits. These morphological trait variations are valuable insights to guide sustainable management and conservation of *A. africana* populations in different climatic zones and habitats types in Benin.

Keywords: Morphological traits, Climatic gradient, Human disturbance, Sustainable management, Conservation

Connaissances et usages de *Cola millenii* K. Schum. (malvaceae) en zones guinéenne et soudano-guinéenne au Bénin

Lawin I.F., Houètchégnon T., Fandohan A.B., Salako V.K., Assogbadjo A.E. & Ouinsavi C.A.

Bois et Forêts des Tropiques
doi:10.19182/bft2019.339.a31716

Abstract

Although a number of wild fruit trees in Benin have been studied, others, such as *Cola millenii* K. Schum., are still relatively undocumented. The aim of this study was to collect ethnobotanical knowledge on *C. millenii* among socio-cultural groups in Benin. Individual structured interviews were conducted with 1009 people. Relative frequency of citation and the efficiency index were used to assess the relative importance of each use and the degree of effectiveness of the plant in treating given ailments. *C. millenii* falls into eight different use categories. Most frequently cited is use of the fruit pulp for food, and malaria is the most frequently cited ailment. Overall, the species is considered to be very effective against malaria, jaundice, stomach pains, high blood pressure, stiff joints, fatigue, fever and vertigo; fairly effective against asthma, pregnancy-related disorders and swollen feet; and not effective to treat a low sperm count. The leaves are most frequently used to treat ailments, mainly as decoctions. The Anii and Chabè use the species preferentially for food, while the Adja and Kotafon mainly use it for magical purposes, to make brushes and as construction wood. It is used most frequently for medicinal purposes by the Aïzo, while the Mahi consider it to be most useful for construction. Trade is mainly in the leaves and fruit. Despite its importance, the species is under pressure in various ways and inadequately protected. Future Studies need to focus on sylvicultural techniques with a view to domesticating the species.

Keywords: *Cola millenii*, ethnobotany, wild fruit trees, socio-cultural groups, West Africa.

Organo-mineral fertilization enhances the acceptability of smooth cayenne pineapple fruit (*Ananas comosus* (L.) Merrill) for european export and domestic consumption in Benin

Sossa E.L., Agbangba C.E., Dagbenonbakin G.D., Tohoun R., Tovihoudji P.G. & Amadji G.L.

Agriculture
doi: 10.3390/agriculture9030065

Abstract

Heterogeneity in pineapple fruit quality explains the low export volume of fruits from Benin to the international market. This work aims to investigate influences of organo-mineral fertilizer on a) pineapple fruit yield, b) fruit quality and the proportion of fruits meeting European export standards, and c) fresh fruit acceptability for domestic consumption. The experimental design is a split-plot with three replications where the main factor is organic manure (poultry litter) (P0 = 0 t ha^{-1}, P2 = 10 t ha^{-1}) and the sub-plot factor, N-P-K fertilization in kg ha^{-1} (T0:100-30-150, T1: 200-60-300, T2: 400-120-600, and T3: 600-180-900). To evaluate the percentage of fruit meeting European standards, a generalized linear model with binomial error structures was used. A sensorial test was carried out on fresh pulp to assess the preference of fruit meeting domestic criterion. A preference mapping was assessed through an acceptability test with a nine-point hedonic scale. Organo-mineral fertilizer significantly improved fruit weight ($p = 0.012$), fresh juice weight ($p = 0.042$), total soluble solids ($p = 0.032$), and the percentage of fruits meeting European standards ($p < 0.001$). Better fruits meeting export standards were found with treatments P1T1, P2T0, and P2T3 (83.33 ± 28.87%). Fruits from treatments P0T2, P2T1, P1T3, and P2T2 were highly accepted for domestic consumption (70%). The results suggested that organo-fertilizer producing fruit achieving exportation standards may differ from those satisfying domestic preferences. Moreover, the findings suggested that the ratio crown length: fruit length, which is a key ratio for exportation standards, is not related to physico-chemical quality. Finally, the findings have implications for the sustainability of pineapple production for domestic and exportation purposes.

Keywords: integrated fertilization; quality; consumers; standards

Integrated influence of soil tillage, nitrogen–potassium fertiliser and mulching on pineapple (*Ananas comosus* (L.) Merr.) growth and yield

Sossa E.L., Agbangba C.E., Amadji G.L., Agbossou K.E. & Hounhouigan D. J.
South African Journal of Plant and Soil
doi:10.1080/02571862.2019.1570568

Abstract

Pineapple is one of the most important fruit in the world and its production requires appropriate cultural practices. This work aimed to investigate the influences of soil tillage, nitrogen–potassium (N-K) fertiliser and mulching on pineapple growth and yield. The experimental design was a split-split plot with four replications. The main factor was soil tillage (at two levels: flat tillage and ridging), the subplot factor was N-K fertilisation (at five levels: 1.6 N and1.6 K, 5.8 N and 6.6 K, 10 N and 11.6 K, 1.6 N and 11.6 K, and 10 N and 1.6 K, in g plant^{-1}) and the sub-subplot factor was use of fresh pineapple residues (at three levels: surface mulching (at 10 t ha^{-1}), 10 t ha^{-1} buried residues at10 cm depth, and no mulching). Growth and yield parameters were recorded. A mixed ANOVA model was performed on 'D' leaf characteristics, biomass production and yield. The results suggested that soil ridging and burying of 1 kg m^2 of crop residues improved pineapple growth and yield. Nitrogen–potassium combinations 10 N and 11.6 K,1.6 N and 11.6 K, and 5.8 N and 6.6 K (in g plant^{-1}) resulted in better plant development and higher yield.

Keywords: buried residues, fertilisation, pineapple, ridging

Morphological diversity of the agroforestry species Moringa oleifera Lam. as related to ecological conditions and farmers' management practices in Benin (west Africa)

Gandji K., Tovissodé F.C., Azihou A.F., Akpona J.D.T., … & Glèlè Kakaï R.L.
South African Journal of Botany
doi:10.1016/j.sajb.2019.10.004

Abstract

Moringa oleifera Lam. is an agroforestry species grown for its various uses. Despite its great socio-economic importance, the species is still not well exploited and considered as a neglected and underutilised species. This study aimed at identifying the morphotypes of *M. oleifera* and assessing how they were related to climatic conditions and farmers' management practices. The study was conducted in 30 districts spanning the three biogeographical zones and 11 major sociocultural groups of Benin. Twenty-four morphological traits describing the trunk, crown, leaf, leaflet, pod, and seed were collected on 810 adult individuals

randomly selected within districts. Linear mixed-effects models were used to investigate variation in morphological traits of M. oleifera according to biogeographical zones and management practices. Then, hierarchical clustering and canonical discriminant analyses were performed on morphological traits to identify and characterise the morphotypes of *M. oleifera*. Results revealed great variability in morphological traits of *M. oleifera* according to climate gradient and farmers' management practices. Four morphotypes were identified with five morphological traits (number of tertiary branches, leaf maximum width, leaf length, pod length and dry pod weight) as the most discriminant. According to the most harvested organs (leaves and seeds), the best morphotype was from the sudano-guinean zone. These findings are crucial for selection and breeding programs and for the improvement of domestication strategies of the species. This will support efficiently the implementation of more environmental and socioeconomic-friendly promotion of the species through its cultivation and use in Benin, as well as in West Africa.

Keywords: *Moringa oleifera*, Morphological traits, Diversity, Morphotypes, Biogeographical zones

Heterospecific tree density and environmental factors affect *Afzelia africana* Sm. population structure in the Pendjari biosphere reserve, west Africa: implications for management and restoration

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Tropical Conservation Science
doi: 10.1177/1940082918822604

Abstract

Information on how abiotic and biotic factors affect species population structures and regeneration are critical for understanding plant growth in natural habitats. Here, we used the data from three spatially distinct populations of *Afzelia Africana* Sm. in the Pendjari Biosphere Reserve in Benin, to determine how the species population structures respond to abiotic and biotic factors. *Afzelia africana* population structures were studied using several parameters including basal area, tree height, density of successive diameter classes, and size class slope. We tested for individual effects of abiotic (mound density, soil type, and terrain slope) and biotic (heterospecific tree density) factors on the species population structure. We also tested for similarity of species composition among studied *A. africana* population stands. Results revealed a tree density structure with mature individuals, and size class distribution indicating a recruitment

bottleneck at the juvenile stage (10–20 cm diameter), possibly due to mammal browsing, natural and artificial fires. Heterospecific tree density was positively associated with *A. africana* adult density but negatively related to the species growth parameters (mean diameter, basal area, and tree height). These results indicate some degrees of niche overlap between *A. africana* and coexisting species but also partly reflect *A. africana* tolerance and adaptation to limited resources environment. Soil type significantly influenced both basal area and regeneration density, greater values being observed on silt-sand-rocky soils. Basal area was higher on steeper slope, probably a result of species conservative strategies. These findings were discussed in line with management and restoration action needs in the Pendjari Biosphere Reserve.

Keywords: abiotic factors, Importance Value Index, size class distribution, soil type, slope, tree height

Evaluation économique des aulacodes d'élevage engraissés avec trois niveaux de compléments alimentaires dans la production du kilogramme de viande Grand-Lahou, Côte d'Ivoire (Afrique de l'Ouest)

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Archivos de Zootecnia
doi:10.21071/az.v68i261.3934

Résumé

L'objectif de cette étude est de faire l'évaluation économique des aulacodes d'élevage engraissés avec trois niveaux de compléments alimentaires dans la production du kilogramme de viande Grand-Lahou, Côte d'Ivoire. Le dispositif expérimental était composé d'un bloc aléatoire simple à trois traitements, de rations alimentaires à trois répétitions composées de trois lots de cinq à dix aulacodes chacun. Les lots des aulacodes testés sont répartis en 2 groupes de 3 lots chacun suivant leurs stades physiologiques (en croissance, en engraissement et en entretien). Les trois niveaux de substitution du fourrage vert par une ration complémentaire énergétique dans l'alimentation des aulacodes d'élevage sont composés de : les rations 75 % de fourrages et 25 % de compléments alimentaires (ration T25), 50 % de fourrages et 50 % de compléments alimentaires (ration T50), et 85 % de fourrages et 15 % de compléments alimentaires (ration T15). L'analyse technico-économique est réalisée avec 60 aulacodes en croissance (AC) âgés de 28 jours, 60 aulacodes en engraissement (AEng) âgé de 140 jours et 45 aulacodes reproducteurs en entretien (AEnt) âgés de plus 224 jours dont 36

aulacodines (femelles) et neuf aulacodins (mâles). Les résultats de cette étude ont montré que les meilleures performances de reproduction statistiquement significatives (P<0,05) sont enregistrées chez les aulacodines sous la ration T15 et étaient les suivantes : un intervalle de parturition de 151,58 j ; un taux de fertilité de 16,67 % ; une prolificité de 5,71 aulacodeaux ; un taux de survie de 88,77 %. L'optimum économique, stable et performant de rations alimentaires à base de 15% de concentrés alimentaires a révélé un meilleur coût économique de 437,32 F CFA. Le bénéfice réalisé pour la production de 1 kg de viande d'aulacode d'élevage est 9 853,70 F CFA. En somme, la substitution du fourrage vert par une ration complémentaire énergétique T15 dans l'alimentation des aulacodes d'élevage ayant 85 % de fourrages confirme le taux d'au moins 70 % de régime alimentaire de base conseillé par la recherche et déjà vulgarisé en aulacodiculture.

Keywords : Aulacode, Évaluation, Niveaux de compléments, Aliments, Kilogramme de viande, Côte d'Ivoire.

Local knowledge, uses, and factors determining the use of *Strychnos spinosa* organs in Benin (west Africa)

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Economic Botany
https://doi.org/10.1007/s12231-019-09481-0

Abstract

Green monkey orange (*Strychnos spinosa*) is an important multipurpose tree in rural communities in sub Saharan Africa, including Benin. The objectives of this study were to (i) examine the various indigenous uses of *Strychnos spinosa*, (ii) assess local perception of the major threats to *Strychnos spinosa*, and (iii) identify the conservation strategies adopted by local communities to ensure its sustainable use in Benin. A participatory rural appraisal study was undertaken across three climatic zones in Benin. Data were collected through structured questionnaires involving 733 informants from 22 ethnic and 7 sociolinguistic groups. Correspondence analysis (CA) showed that S. spinosa is most widely used in the Sudanian zone (20 uses). About 73% of the informants used *Strychnos spinosa* as food, and 68% used it for medicine. The most valued organs were fruits, leaves, bark, and seeds. The major threats to *Strychnos spinosa* were human activities rather than climatic factors. Religion and cultural values were the main strategies adopted by local communities to conserve the species. The value of *Strychnos spinosa* is well appreciated in Benin, and local knowledge depends on the particular climatic zone, ethnic group, study level, and gender.

Keywords: *Strychnos spinosa*, Ethnobotany, Local knowledge, Traditional uses, Wild edible fruits, Benin.

Potential for domestication of *Borassus aethiopum* Mart., a wild multipurpose palm species in sub-saharan Africa.

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Genetic Resources and Crop Evolution
doi:10.1007/s10722-019-00777-7

Abstract

Borassus aethiopum Mart. is a multipurpose palm native to mainland Africa. Fruits and hypocotyls are the most exploited parts which collection/harvest threats the species. As a pre-requisite for its domestication, this study assessed the (1) environmental-induced diversity in morphological traits of fruits and (2) differences in growth and weight of hypocotyls from one-seeded, two-seeded, and three-seeded fruits from three provenances in the three climatic regions of Benin. 5400 fruits collected from 180 trees in six populations were measured for fruits and tree morphological traits. A randomized complete block design with three replicates was used for the experimentation in each region. Variation in fruit morphological traits was not influenced by climatic regions. The greatest variation (65–94%) in fruit morphological traits was located at tree level, highlighting that selection of many fruits and individual trees within a few populations would capture large variation of fruit traits. Tree diameter at breast height (18.5–52 cm), total (6.4–19.6 m) and bole (4.8–17.6 m) height, and fruit length (7.00–20.50 cm), dry weight (98–2552 g), shape index (0.59–2.80), and number of seed (1–3) were the most discriminative traits of studied populations. Clustering of the trees resulted into five morphotypes based on discriminating traits. Morphotypes 1 and 2 showed high performances for fruits and seeds production. These morphotypes are good candidates for selection and breeding programs. Irrespective of the provenances, best performances of hypocotyls were observed in the humid region. This study provides important baseline information for the domestication of *B. aethiopum*.

Keywords: Domestication, Morphological traits, Provenance, Hypocotyl, Climatic regions, Benin

Conventional and food-to-food fortification: an appraisal of past practices and lessons learned

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Food Sciences and Nutrition
doi: 10.1002/fsn3.1133

Abstract

Food fortification is an important nutrition intervention to fight micronutrient deficiencies and to reduce their incidence in many low- and middle-income countries. Food fortification approaches experienced a significant rise in the recent years and have generated a lot of criticism. The present review aimed to shed light on the actual effect of food fortification approaches on the reduction of malnutrition. A set of 100 articles and reports, which have dealt with the impact of food fortification on malnutrition, were included in this review. This review identified a broad selection of local raw materials suitable for a food-to-food fortification approach.

Keywords: food fortification, malnutrition, micronutrient deficiencies, outcomes

National inventory and usage of plant-based medicine to treat gastrointestinal disorders with cattle in Benin (west Africa)

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South African Journal of Botany
doi:10.1016/j.sajb.2019.03.037

Abstract

Gastrointestinal disorders remained recurrent with livestock in Benin despite huge import of veterinary drugs at high costs. Nevertheless, the country abounds rich and varied anti-gastrointestinal flora which are hardly known, neglected and underutilized. The present study investigated the diversity of plants used to treat gastrointestinal disorders and documented the traditional knowledge associated with them. A total of 690 breeders and farmers were interviewed using open-ended and semi-structured interviews. Data were collected on the identity of the informants, plants and plant parts used, gastrointestinal disorders treated and usage types. Data were analyzed through calculation of relative frequency of citation (RFC), and use of descriptive statistics, multivariate analysis, bar charts and balloon plot. A total of 158 medicinal plant species belonging to 60 families

and 130 genera were identified. The most represented were Leguminosae (18%) and Combretaceae (6.4%). Thirty-one plant families were mentioned to be highly utilized, among which the most important were Zygophyllaceae, Phytolaccaceae, Rubiaceae, Lamiaceae, Loranthaceae, Thymelaeaceae and Flacourtiaceae. The species were reported to treat seven gastrointestinal disorders. The most frequently cited were intern parasitosis (35%), diarrhea (29%) and constipation (17%). Leaves (40%) and stem barks (28%) are the plant parts mostly used to treat those disorders. The species with the highest value for RFC were: *Khaya senegalensis*, *Anacardium occidentale*, *Cassia sieberiana*, *Pterocarpus erinaceus* and *Vitellaria paradoxa*. Socioeconomic factors influencing ethnobotanical knowledge about these species were: age, profession and geographic location of the informants. Further analysis of chemical and pharmacological content of those species are necessary to ascertain the efficiency of their claimed properties and relieve farmers of these disorders.

Keywords: Benin, Ethnoveterinary plants, Gastrointestinal disorders, Cattle

Estimation of cultivable areas for *Irvingia gabonensis* and *I. Wombolu* (Irvingiaceae) in Dahomey-gap (west Africa)

Vihotogbé R., Idohou R., Gebauer J., Sinsin B. & Peterson T.

Agroforestry Systems
doi:10.1007/s10457-018-0193-y

Abstract

Cultivation of priority plant species ensures their sustainable management. African bush mango trees (*Irvingia gabonensis* and *I. wombolu*) are the most exploited Irvingiaceae species. Experts disagree on the status of these very similar taxa, as taste remains the only character by which they can be distinguished in the field. We combined occurrences and environment data in ecological niche models to assess suitable areas for the two species. *Irvingia gabonensis* presented a wider occurrence area due to cultivation across contrasting ecological areas. *Irvingia wombolu* does not appear to be cultivated and only occurred in southwestern Togo. These differences in range is likely determined by phenological limitations of *I. wombolu*, reinforced by differences in local management systems, thus confirming the failure of market development to impact useful plant species' conservation significantly. Highly suitable areas for *I. wombolu* were in the Volta Forest, where *I. gabonensis* saw low suitability, while out of this inverse situation was observed, as regard environmental suitability. These differences are significant, implying different ecological adaptation. However, anthropogenic influences, related to domestication history, are also important. Therefore,

updated genetic investigations and field trials in contrasting ecological areas are required for understanding the origin of differences between these two forms.

Keywords: Bush mango, Cultivation, Ecological niche modelling, Non-timber forest products

Ecological niche information supports taxonomic delimitation of *Irvingia gabonensis* and *I. Wombolu* (Irvingiaceae)

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South African Journal of Botany
doi:10.1016/j.sajb.2019.08.025

Abstract

African bush mango trees (Irvingiaceae) are priority food trees in West and Central Africa. There are bitter- and sweet-fruited species, which are difficult to distinguish based on morphological characters. This has led to a debate about their correct taxonomic status. Furthermore, it is unclear whether they are native to the Dahomey Gap, the dry and hot area, separating the two West African forest blocks. This study evaluates the ecological differences between bitter- and sweet-fruited species in tropical Africa, and the nature (wild vs. cultivated) of the occurrences in the Dahomey Gap, in order to discuss the current taxonomical opinions. *Irvingia gabonensis* and *I. wombolu* occurrence data were combined with climate and soil data in MaxEnt to produce environmental niche models. Environmental niche identity tests were carried out in ENM-Tools. Wild sweet-fruited trees were predicted in the Guinean–Congolian phytogeographical region, while the predicted occurrence of bitter-fruited trees extended to the Guineo–Congolia/Sudania and Lake Victoria transition zones. The related niche difference is significant, supporting the taxonomical opinion that bitter- and sweet-fruited species are two different taxa. We also conclude that bitter-fruited trees occur naturally in the Volta forests (Dahomey Gap). Moreover, our results support that *I. gabonensis* is not native to the Dahomey Gap. In historical times, they were probably introduced from Nigeria.

Indigenous knowledge of *Detarium microcarpum* Guill. & Perr. (caesalpiniaceae) and implication for conservation in Benin (west Africa)

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Environment, Development and Sustainability
doi: 10.1007/s10668-019-00477-3

Abstract

Detarium microcarpum Guill. & Perr. is a priority food tree species in West Africa, but its use pattern and conservation is little known across different sociocultural areas of Benin. In this study, we analyse the determinants of *D. microcarpum* traditional uses pattern and how these determinants influence the species' conservation in Benin. Thus, 730 respondents were participated in semi-structure interview across the North and Central regions of Benin. The information related to local names, traditional uses of different plant parts, management systems and conservation of *D. microcarpum* was recorded from the respondents. Use value (UV), ethnobotanical use value (EUV) and organ use value (OUV) were calculated. These statistics were used to assess the structure and variability of traditional use categories of plant parts among the sociocultural groups, gender and age groups. Results indicated that local names were spatially structured and linked to local communities' cultural origins, according to the recent human migration roads in West Africa. In total, 42 traditional uses of seven categories were gathered. UV in relation to sociocultural groups ranges from 7.62 (Idatcha and Fon) to 16.08 (Peulh and Lokpa); within the gender, UV ranges from 9.96 (women) to 11.15 (men); and within the age groups, UV ranges from 9.37 [18–30 years old] to 14.14 [65–100]. The species' UV significantly depended on respondents' sociocultural group, age and gender. Moreover, the age, gender and sociocultural groups significantly influenced the species' use pattern. Ethnobotanical use value ranges from 0.35 (fodder) to 6.22 (traditional human medicine). OUV ranges from 2.62% (flower) to 42.38% (leaf). The various uses of the species' roots, leaves and bark in traditional pharmacology and their high-quality firewood and tasty fruits determined the various local management systems. Thus, considering the current threats (intensive use of the roots, trunk, leaves and branches, and habitat degradation) conservation measures are needed to ensure the survival, conservation of distribution pattern and sustainable use of the species.

Keywords: Benin, Indigenous knowledge, Conservation, *Detarium microcarpum*, Ethnobotany

Use of termites by farmers as poultry feed in Ghana

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Insects
doi: 10.3390/insects10030069

Abstract:
The aim of the study was to gather information on the use of termites by farmers as feed for indigenous poultry in Ghana and factors affecting its use. We conducted surveys in four regions in Ghana to collect information, by the administration of questionnaires, on the use of termites as poultry feed, termite species collected, species not used and collection methods. Samples of termite species mentioned were collected and identified to the genus level. Twenty-three percent and 19% of farmers mentioned that termites are always or often used to feed poultry whereas 11% never use termites. A binomial regression analysis showed that their utilization was affected by region, sex, education, farm size and income. Termites collected belonged to eight genera, the main ones being Macrotermes, Trinervitermes and Odontotermes. Five collection methods are used to obtain termites and involve either breaking mounds or using containers as traps. Collection methods vary with species and region and the abundance of termite genera varies with season. Farmers identified some species as poisonous to poultry. Termites are important in indigenous poultry production because they are a readily available protein source for local farmers. However, better collection methods need to be developed to aid their optimal use.

Keywords: termites; Macrotermes; Trinervitermes; Odontotermes; Ghana; poultry feed

Dioscorea dumetorum (Kunth) Pax, a neglected and underutilized yam species in Benin: folk classification and post-harvest conservation

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Genetic Resources and Crop Evolution
doi: 10.1007/s10722-019-00762-0

Abstract
Dioscorea dumetorum (Kunth) Pax is a yam species of great potential but so far scientifically neglected in Benin Republic. Using participatory rural appraisal (PRA) tools and techniques, thirteen (13) villages selected according to the importance of species production in the northern and central Benin were

surveyed to assess the endogenous knowledge related to its diversity, production, conservation and use. According to synonymy, 18 landraces of *D. dumetorum* were identified and gathered into three groups. The main criteria used by farmers to describe the three groups of *D. dumetorum* are shape, flesh color, color and appearance of the skin of the tubers. According to this study, the landraces group that produces round or elongated, yellow-fleshed, gray skinned and smooth tubers with a few rootlets at their head is most cultivated in the study area. In addition, polyculture (59.53% of responses) is the predominant mode of culture. For the farmers surveyed, the production of *D. dumetorum* is declining due to several constraints where the most important are attacks of tubers by termites, lack of markets for the flow, long production cycle and maladjustment of any landraces identified with crushed yam, chop and stew. Storing tubers in heaps under the tree is the most common and widespread method of post-harvest conservation (65.60%). For all ethnic groups involved in *D. dumetorum* production in the study area (Yoruba, Fon, Otamari, Lokpa, Bariba and Peulh), the crop has a high food value. For some of them, the species also has a significant potential to play an important role in spirituality, human wellbeing and improving health.

Keywords: Cultural practices, *Disocorea dumetorum*, Endogenous knowledge, Post-harvest conservation

Dépendance socioculturelle des connaissances locales des usages de *Isoberlinia spp.* au moyen-Bénin, Afrique de l'ouest

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Bois et Forêts des Tropiques
doi : 10.19182/bft2019.339.a31702

Abstract

Isoberlinia doka Craib & Stapf and *Isoberlinia tomentosa* (Harms) Craib & Stapf are both native African tree species. Although considered of little value in the past, they are now proving useful to local populations. In Central Benin, traditional knowledge on the genus *Isoberlinia* is widely applied in local development strategies, but little documented. This study aimed to assess (i) endogenous knowledge on uses of the two species and (ii) the effects of five sociocultural factors, and their interactions, on the use value of the two species in Central Benin. Ethnobotanical surveys were conducted with 480 respondents divided into eight sociocultural groups. Relative frequency of citation (RFC) and use value (UV) were calculated and analysed into their principal components (PCA),

and generalised linear models (GLM) were produced based on Poisson distributions. The Mahi and Nago people make more use of *I. doka* as roof timbers; the Dendi and Holli make more use of *I. tomentosa* for building. Simple single-factor models show that among the factors tested, the sociocultural group determines variations in the use of the two species, while professional activities also influence the use of *I. tomentosa*. Our assessment of the simultaneous effects of the five social factors and their interactions in a single multiple model shows that the differences in use value of *I. tomentosa* among the sociocultural groups can be amplified by professional activities. Furthermore, for *I. doka*, the model including sociocultural groups only shows the fewest uses. In developing policies to manage the two species sustainably, sociocultural factors must therefore be a primary consideration, followed by professional categories and, for *I. tomentosa* and to a lesser extent, household size.

Keywords: Traditional knowledge, sociocultural factors, use pattern, use intensity, interactions, Benin.

New indicators of vulnerability and resilience of agroforestry systems to climate change in west Africa

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Agronomy for Sustainable Development
doi :10.1007/s13593-019-0566-2

Abstract

Climate change threatens ecosystems, including traditional agroforestry parklands. Assessing the level of vulnerability and resilience of any ecosystem to climate change is important for designing sustainable adaptation strategies and measures. We assessed farmers' perceptions of the vulnerability of agroforestry systems to climate change in Benin. The objectives of the study were to (i) assess the effect of changes in climatic conditions on agroforestry systems, (ii) assess the endogenous indicators of vulnerability of agroforestry systems to climate change, and (iii) analyze agroforestry and cropping systems' resilience to climate change. We hypothesized that some agroforestry systems are more resilient to climate change than others. A total of 233 household heads were surveyed, and seven agroforestry systems were assessed. Data collected included components, indicators of vulnerability, and the level of resilience of agroforestry systems. We characterized the agroforestry systems using a proportion of each woody trees species and density of tree. We differentiated the agroforestry systems with regard to vulnerability indicators using canonical factorial discriminant analysis with heplots for pairs of discriminant variables. The resilience of agroforestry and cropping systems was evaluated on a scale of 0 to 3 (0—not resilient to 3—most

resilient). The number of components damaged in the system was the main indicator of the vulnerability of *Anacardium occidentale* and *Citrus sinensis* parks to climate change effects. Local people perceived age and density of *Vitellaria paradoxa* parks and mixed parks (*Vitellaria paradoxa–Parkia biglobosa*) as factors determining the vulnerability of these agroforestry systems to the effects of climate change. All agroforestry systems were perceived to be resilient to climate change but in different degrees. *Manihot esculenta* was reported as the most resilient crop to climate damage. For the first time, we found out specific endogenous indicators of the vulnerability of agroforestry systems to climate change, which are important to identify better adaptation strategies.

Keywords Agroforestry systems, Climate change, Traditional ecological knowledge, Ecosystem services, Food security

Perceived effects of elephants' presence and damages on ecosystem services supply in the Pendjari biosphere reserve, west Africa

Gnonlonfoun I., Kassa B., Azihou F., Mensah S., Glèlè Kakaï R.L. & Assogbadjo A.E.

Tropical Conservation Science
doi: 10.1177/1940082919865979

Abstract
Information on how biotic factors influence delivery of ecosystem services (ES) in natural systems is important for holistic landscape management. In this study, we assessed the perceived effects of elephants' presence on ES supply in the Pendjari Biosphere Reserve in West Africa. A total of 112 respondents, including riparian communities and reserve officials, were interviewed. First, we used ranking techniques based on stakeholders' perceptions to evaluate differences in perceived importance of ES. Second, we assessed the perceived impact of elephants on ES supply from both direction and intensity perspective. Third, we assessed the economic importance of threatened ESs and elephants' damages related economic losses incurred by households. Twenty-seven ES were enumerated, 13 provisioning ES, 12 cultural ES, and two from the regulating and maintenance ES category. Provisioning ES were perceived as the most important although not significantly different from other categories. PES were also found to be most affected negatively by elephants' impacts. However, elephants' presence increased supply of cultural ES. The average cost of the losses due to elephants' negative impacts ranged from \$174.80 to \$586.05 per year and per victim household. These results were discussed in relation to management actions necessary to facilitate coexistence between elephant and local populations.

Keywords: biotic disturbances, ecosystem services, perceptions, economic valuation, protected areas

Unsupervised multiblock data analysis: a unified approach and extensions

Tchandao E.M., Cariou V., Vigneau E., Glèlè Kakaï R.L. & Qannari El M.

Chemometrics and Intelligent Laboratory Systems
doi: 10.1016/j.chemolab.2019.103856

Abstract

For the analysis of multiblock data, a unified approach of several strategies such as Generalized Canonical Correlation Analysis (GCCA), Multiblock Principal Components Analysis (MB-PCA), Hierarchical Principal Components Analysis (H-PCA) and ComDim is outlined. These methods are based on the determination of global and block components. The unified approach postulates, on the one hand, two link functions that relate the block components to their associated global components and, on the other hand, two summing up expressions to compute the global components from their associated block components. Not only several well-known methods are retrieved but we also introduce a variant of GCCA. More generally, we hint to other possibilities of extensions thus emphasizing the fact that the unified approach, besides being simple, is versatile. We also show how this approach of analysis although basically unsupervised could be adapted to yield a supervised method to be used for a prediction purpose. Illustrations on the basis of simulated and real case studies are discussed.

Keywords: Multiblock data; Generalized canonical correlation analysis; Multiblock principal components analysis; Hierarchical principal components analysis; ComDim

Resistance of cowpea to bruchid (*Callosobruchus maculatus* Fab.): Status of knowledge on the genetic advances

Kpoviessi A.D., Agbahoungba S., Agoyi E.E., Chougourou D.C. & Assogbadjo A.E.

Journal of Plant Breeding and Crop Science
doi :10.5897/JPBCS2019.0818

Abstract

Cowpea [*Vigna unguiculata* (L.) Walp.] is an important food legume. This crop considered as source of dietary protein is also used as a leafy vegetable in many African countries. Its usage as food and animal fodder is focused on food security and diminishing malnutrition particularly in marginal areas. Bruchid (*Callosobruchus maculatus*) is the most damaging, cosmopolitan pest of stored

cowpea grains especially in the tropical region. Damage caused by this pest in cowpea is irreversible, resulting in significant loss of the grains. Several management approaches including physical barriers and biological or chemical methods are used for controlling bruchid in cowpea. Considering the qualitative and quantitative damages caused by bruchid to cowpea in storage, it is important to tackle the bruchid infestation. Development of cowpea lines resistant to bruchid is the most effective, eco-friendly and durable approach to limit the losses associated with this pest. This paper presents a review of the importance of cowpea grain, the extent of bruchid damage in cowpea and the possible control measures. The advances of conventional and molecular breeding in building resistance against this cowpea pest in cowpea are also discussed highlighting the knowledge gaps and their implications. The knowledge of the status of genetic advances will inform breeders and researchers in the development of bruchid-resistant cowpea lines.

Keywords: Bruchid resistance, cowpea, genetic improvement, storage insect pest.

Kersting's groundnut [*Macrotyloma geocarpum* (Harms) Maréchal & Baudet] crop attracts more field pests and diseases than reported before

Agoyi E.E., Sognigbe N., Kafoutchoni M., Ayena M., Sodedji F.A.K., Agbahoungba S., Sossou H.S., Vodouhe R. & Assogbadjo A.E.

Agricultural Research & Technology
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Abstract

It has long been reported that kersting's groundnut [*Macrotyloma geocarpum* (Harms) Maréchal & Baudet] is less susceptible to field pests and diseases. Previous reports focused on bruchids and weevils as the major pests exerting biotic stress on the crop. In the process of setting up a breeding program for the crop in Benin, field experiments were established in four research stations and mission trips organized to visit farmers' fields across the major kersting's groundnut growing areas of Benin. It was observed that the crop is attacked by many field pests and diseases. In total the crop is attacked by: i) Fungi: wilt disease, white mold disease, rust disease, ii) viruses, iii) invertebrates: aphids, grashoppers, caterpillars, millipedes on pods, and iv) Vertebrates: birds, rodents and rabbits This short communication aims to correct the perceptions of practically no field disease and pest attack so far reported on *Macrotyloma geocarpum*.

Keywords: *Macrotyloma geocarpum*; Wilt; White mold; Virus; Millipede; Aphids

Contribution à l'évaluation du niveau de fertilité des sols dans les systèmes de culture à base du coton au Bénin

Amonmide I., Dagbenonbakin G., Agbangba C.E. & Akponikpe P.
International Journal of biological and chemical Science
https://www.ajol.info/index.php/ijbcs/article/view/189717

Résumé

Le coton est la principale culture de rente au Bénin. L'accroissement continu des superficies cultivées a entraîné la sédentarisation des cultures avec pour corollaire la dégradation des sols et la baisse des rendements. L'objectif de l'étude est d'évaluer le niveau de fertilité des sols des bassins cotonniers du Bénin. Ainsi, 30 échantillons de sol ont été prélevés auprès de 30 producteurs de coton. Les résultats ont montré des sols sablo-limoneux avec un taux d'argile de 7,38 à 12,65%. La teneur en azote varie de 0,055 à 0,076% avec un pH de 5,7 à 6,5. Le taux de matière organique est compris entre 1,20 à 1,52%. La somme des cations échangeables varie de 3,98 à 6,98 cmol+ /kg et la capacité d'échange cationique (CEC) entre 5,35 à 7,91 cmol+ /kg. Le phosphore assimilable est compris entre 5 et 13 cmol+ /kg. En définitive, les sols présentent de bonnes propriétés physiques, de piètres caractéristiques chimiques et par conséquent un faible niveau de fertilité, ce qui compromet la durabilité du système de production. L'application des amendements organiques et minéraux est donc indispensable pour le relèvement du pH et de la teneur en matière organique de ces sols.

Mots clés : Sédentarisation agricole, fertilité des sols, matière organique.

Soil fertility level and cropping practices determining soybean yield in Northern East and Center of Benin

Chabi F.O., Dagbenonbakin G.D., Agbangba C.E., Oussou B., Amadji G.L., Ahoton E.L. & Saïdou A.
International Journal of Plant & Soil Science
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Abstract

Soybean is a food security crop in Benin due to its high nutritional value but its yield in the farmers' cropping system is very low. The present study aims to provide appropriate response to the yield variability among fields in two agro-ecological zones of Benin namely: Southern Borgou zone (AEZ 3 in the north) and cotton zone of central Benin (AEZ 5). Soil samples were collected from 0-20 cm depth in 120 fields (50 in the AEZ 3 and 70 in the AEZ 5). pH (water), soil organic carbon (Walkley and Black method), total nitrogen (Kjeldahl

method), CEC (0.01 N ammonium acetate at pH 7 method) and available phosphorus (Bray 1) were determined in the laboratory of Soil Science Water and Environment (LSSEE) of the National Agricultural Research Institute of Benin (INRAB). Cropping system (crop rotations, soil fertility management practices) were also collected using an open-ended questionnaire. Classification and regression trees (CARTs) models were used for data analyses. Soybean yield variability among the agro-ecological zones were registered and the highest yield recorded was less than 1 $t.ha^{-1}$. Considering soil characteristics, soil organic matter level was the most important variable determining yield variability. Furthermore, quantities of P applied and farmyard manure were cropping practices inducing yield variability (86.4% and 15% of the variability respectively). Our results also show that, yield differences noticed among the agro-ecological zones were induced by CEC and pH (water). The study suggested promotion of integrated soil fertility management practices to sustain soybean yield in the study area.

Keywords: Soil fertility, yield variability, farmyard manure, integrated soil fertility management, CART models.

Espèces indicatrices d'oiseaux de la zone humide d'importance internationale du Sud-Ouest du Bénin (Site Ramsar 1017)

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Afrique SCIENCE
http://afriquescience.net/PDF/15/5/20.pdf

Résumé

Les oiseaux sont des bio-indicateurs de santé écologique des zones humides. L'étude vise à sélectionner les espèces indicatrices d'oiseaux de la zone humide d'importance internationale du Sud-Ouest du Bénin. La méthode d'analyse IndVal (Indicator Values) a été utilisée pour déterminer la valeur indicatrice des espèces d'oiseaux du lac Ahémé, de la lagune côtière et du Bas Delta du Mono et des saisons climatiques. La significativité de ces valeurs a été appréciée par les tests de permutation. Au total, 4 espèces indicatrices de la grande saison pluvieuse, 2 de la petite saison pluvieuse et 8 de la grande saison sèche sont identifiées. Vingt-quatre (24) espèces indicatrices d'oiseaux de la lagune côtière, 18 du Bas Delta du Mono et 10 du lac Ahémé sont sélectionnées. Les informations obtenues sont utiles pour l'élaboration des politiques de développement durable du Site Ramsar 1017.

Mots-clés : oiseaux, espèces indicatrices, IndVal, site Ramsar 1017, Bénin.

Parameters Estimation Methods in Generalized Linear Mixed Models Applied in Ecology: A Critical Review

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International Journal of Engineering and Future Technology

Abstract

The use of GLMMs is widespread in ecology since last decades. However, GLMMs likelihood function is analytically intractable. As a result, various approximation methods have been introduced with different degrees of accuracy. This study assesses the frequency of usage of different GLMMs estimation methods in ecology and makes a comprehensive discussion of these methods to deepen the understanding of users. Original articles in ecology from 2007 to 2016 were identified via keywords searching using web search engines. A total of 802 articles were selected. The usage of GLMMs increases exponentially from 2007 to 2016. Thereafter, 297 papers were sampled through careful reading of their abstracts. Ten estimation methods were reported and the most used were penalized quasi-likelihood (35.02 %) and Laplace Approximation (28.28 %). Useful expected information from GLMMs was not notified in several articles. Random components were not described in 220 articles (74.07%). Overdispersion was evaluated in only 23.23 % of the articles. It is important that users of GLMMs check elementary statistical conditions and report appropriate information from their findings.

Keywords: Generalized models, fixed and random effects, approximation methods, ecology, performance.

Spotted-necked Otter (*Hydrictis maculicollis*) distribution and determining factors of habitat occurrence in the lower Ouémé Valley, Southern Benin

Dognimon S., Djagoun C.A.M.S., Djego S., Akpona H.A., Djego J., Akpona T.J.D. & Sinsin B.

IUCN/SCC Otter Specialist Group Bulletin
http://www.iucnosgbull.org/Volume36/Dognimon_et_al_2019.html

Abstract

Spotted-necked otters (*Hydrictis maculicollis*) are present in several major river systems in southern Benin, and their environmental requirements link them to food and water security issues as the region is so densely populated by humans. The lack of baseline data on their distribution and ecology is another major

constraint that the species is facing in Benin. The present study aims to determine otter's distribution and factors affecting the habitat selection in a highly human impacted environment. We conducted a survey on Spotted-necked otter presence/absence in the localities in the lower Ouémé valley in Southern Benin using the non-probabilistic "snowball" sampling method. We then assess the habitat and environmental requirements of Spotted-necked otter from field observations. The spotted-necked otter has shown a wide distribution in southern Benin with the presence signs confirmed in 89% of recorded sites from local perception. According to variables explaining the presence only habitat characteristics such as vegetation cover was significant. The Spotted-necked otter did show a surprising flexibility in their environmental requirements. Our results demonstrate a high adaptability of a threatened carnivore to altered landscapes and show how this flexible behavior opens opportunities for recovery.

Keywords: Spotted-necked otter, Distribution, Habitat choice, Ouémé valley

Facteurs déterminant l'adoption des stratégies d'adaptation aux changements climatiques au Bénin : cas des producteurs de maïs

Sodjinou E., Hounkponou S.K. & Chabi Adjobo M.A.

Bulletin de la Recherche Agronomique du Bénin (BRAB). Numéro spécial Économie et Sociologie Rurales (ESR)

Résumé

Les changements climatiques affectent de plus en plus l'environnement rural, l'équilibre agraire et l'écosystème forestier causant ainsi la baisse de la productivité et de l'efficacité, la rareté de la main d'œuvre et une faible rentabilité du secteur agricole. Les stratégies d'adaptation deviennent indispensables pour les producteurs face à l'ampleur des effets néfastes des changements climatiques. L'objectif de l'étude était d'analyser les stratégies d'adaptation aux changements climatiques utilisées par les agriculteurs et les facteurs déterminant l'adoption de ces stratégies. Les données utilisées dans l'étude provenaient des enquêtes qualitatives mais aussi des entretiens structurés avec 360 ménages sélectionnés de manière aléatoire dans 12 communes situées dans six des 12 départements du Bénin. Les résultats obtenus ont révélé que face aux changements climatiques, les producteurs ont utilisé diverses stratégies touchant directement ou non l'agriculture. La mise en œuvre du plan de conservation du sol, l'utilisation de plantes améliorantes, l'utilisation des variétés à cycle court, la rotation des cultures, le changement de date de semis ou la pratique de semis échelonnés et la plantation d'arbres ont été les stratégies d'adaptation observées sur le terrain. La décision d'adopter ces stratégies/options d'adaptation a été significativement influencée par les paramètres climatiques notamment les précipitations et la température. Des quantités de pluies faibles ou trop élevées ont augmenté la

probabilité d'adoption des stratégies d'adaptation aux changements climatiques. La probabilité que les producteurs utilisent des stratégies d'adaptation au changement climatique augmente aussi avec l'accroissement de la température. De même, la participation aux Champs Ecoles Paysans (CEP) a eu une influence positive sur l'adoption des stratégies d'adaptation aux changements climatiques. Les producteurs ayant collaboré avec la vulgarisation ont adopté les mesures de conservation du sol et les plantes améliorantes de la fertilité des sols. La probabilité que les hommes s'adaptent aux changements climatiques est supérieure de 13 points à celle des femmes. La vulgarisation et la mise en place de CEP ont permis d'améliorer la connaissance des agriculteurs sur le changement climatique et de renforcer leur capacité d'adaptation à travers l'adoption de certaines mesures.

Mots clés: Variabilités climatiques, Stratégies d'adaptation, Champs Ecoles Paysans, Producteur de maïs, Bénin

Impact des changements climatiques sur les revenus des ménages agricoles au Bénin : Evidence basée sur l'application du modèle Ricardien

Sodjinou E., Hounkponou S.K.

Annales de l'université de Parakou : série « sciences naturelles et agronomie »
http://www.hubrural.org/Impact-des-changements-climatiques.html?lang=fr

Résumé

L'objectif de cette étude était d'analyser les perceptions paysannes de l'effet des changements climatiques sur l'agriculture et d'évaluer l'impact de ces changements climatiques sur les revenus agricoles des producteurs. Pour ce faire, des données qualitatives et quantitatives ont été collectées dans six des douze départements du Bénin sur un échantillon aléatoire de 360 ménages. Des statistiques descriptives et le modèle ricardien ont été utilisés pour apprécier l'impact des variables climatiques sur les revenus. Les résultats indiquent les effets des changements climatiques sur les systèmes culturaux s'expriment en termes de baisse de la production agricole due à la variabilité des précipitations ; l'émergence de maladies, de ravageurs et de vecteurs pathogènes ; de nouvelles distributions spatiales des ravageurs et insectes nuisibles ; et une pluviométrie erratique et imprévisible. La réduction de la précipitation apparaît plus néfaste sur le revenu agricole des producteurs que l'accroissement de la température. Une réduction des précipitations d'un millimètre entrainerait, *ceteris paribus*, une baisse du revenu agricole net de 614 FCFA/ha. La réduction du revenu agricole net est plus forte chez les producteurs n'utilisant pas de stratégies d'adaptation aux changements climatiques que chez ceux utilisant des stratégies d'adaptation. Enfin, toute action

visant l'amélioration de la fertilité des sols, dans le but de limiter l'effet néfastes des changements climatiques, entraînera une amélioration du revenu agricole des producteurs. De même, l'investissement public devrait être concentré dans la recherche sur les variétés à haut rendement, tolérantes à la chaleur et /ou sujettes aux inondations.

Mots clés : Changement climatique, adaptation, agriculture, impact, perception, Bénin.

Agro-morphological characterization of preselected cashew (*Anacardium occidentale* L.) mother trees in Benin farmer's plantations

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Journal of Agriculture and Environment for International Development
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Abstract

One of the main causes of low cashew nut yields in African countries is the lack of improved planting materials used for plantation establishment. It is therefore necessary to efficiently select planting material to increase cashew nut yields. The objective of this study was to assess the agro-morphological diversity of preselected cashew mother trees for facilitating their further selection in cashew plantations in Benin. Thirty-one variables were measured. These variables, including 12 quantitative and 19 qualitative, were selected in cashew descriptors developed by Bioversity International. Statistical tools were performed for the assessment of the 394 cashew mother trees preselected in 23 administrative districts originating from the four major cashew nut production regions in Benin: Atacora-Donga, Borgou, Zou-Collines and Plateau. A Factorial Analysis on Mixed Data and a Hierarchical Cluster Analysis (HCA) were carried out to group the individuals. Finally, a morpho-metric characterization of the different groups based on quantitative discriminant descriptors from a multivariate analysis of variance (MANOVA) was carried out. The HCA result on mixed data showed three significant morpho-metric groups of cashew mother trees. Discriminant stepwise analysis carried out on all 31 morpho-metric descriptors showed that 15 were found to be the most discriminating (5 quantitative and 10 qualitative descriptors) of the morpho-metric groups ($P < 0.001$). The leave vein crossing, hermaphrodite flower rate, apples unit weight, abnormal flower number and nut basis shape showed significant positive or negative correlations. These results suggest the existence of an important phenotypic variability among Beninese

cashew accessions that could be used in cashew tree breeding program being implemented in Benin.

Keywords: cashew planting material, phenotypic variability, varietal breeding, Benin Republic

Empirical study of computational techniques used for parameters estimation in multivariate linear mixed effects models

Honfo S.H.& Glèlè Kakaï R.

Afrika Statistika
doi:10.16929/as/2019.2061.149

Abstract

An empirical study was conducted to assess the performance of some computational techniques used in multivariate linear mixed effects models (MLMM). Performances of four computational techniques were compared based on their accuracy, relative bias, relative efficiency and computing time according to sample size, between-variables and within-subjects correlations. The accuracy, relative bias, relative efficiency and computing time in estimating MLMM parameters varied significantly according to the computational techniques, sample size and correlations. Further theoretical developments are required to improve the accuracy of the four techniques in estimating variances' components.

Keywords: multivariate linear mixed models; simulation; estimation accuracy; estimation relative bias; efficiency.

Effective use of statistical tools in agricultural sciences: a critical review of multivariate modelling methods

Honfo S.H., Houetohossou A., Assogbadjo A. & Glèlè Kakaï R.

Journal of Applied Biosciences
doi:10.4314/jab.v142i1.10

Abstract

Objectives: A critical review was conducted to assess effective use of multivariate modelling methods for data analysis in agricultural sciences and related fields.

Methodology and Results: Four main agricultural fields were considered: biology; agronomy; ecology; and food nutrition. Two journals were randomly

selected per agricultural field and up to 250 articles were downloaded considering a ten-year period (2008-2017) per journal. From papers, informationsuch as: statistical methods used; and whether multivariate modelling methods were required and used for data analysis or not, was recorded. Basic statistical methods: descriptive statistics, univariate parametric tests and related tests (post-hoc tests, normality test, and homoscedasticity tests) were the most frequently used. Advanced statistical methods such as multivariate descriptive and modelling methods, Bayesian methods, recorded the least use values. Multivariate modelling methods were rarely used though they were sometimes required according to agricultural fields. The highest and lowest effective uses of statistical methods were recorded for the agronomy and biology field, respectively.

Conclusion and application of findings: There is a gap between the development of advanced statistical methods, their usefulness and accessibility to analyse data in applied sciences especially agricultural sciences. Further investigations in statistical methods' development may integrate and justify their usefulness in applied sciences. Collaborations between applied scientists and statisticians are necessary for better analysis of research data.

Keywords: multivariate modelling techniques, effective use, agronomy, critical analysis, statistical methods

Assessment and analysis of agronomic and ecological aspects of cotton farming systems for a sustainable cotton production in Benin (West Africa)

ECLOU S. Innocent

Cotton is the main cash-crop in Sub-Saharan Africa whose estimated population of 856 million in 2010, is projected to exceed two billion shortly after 2050. It plays a very important role in the economy of several African countries, including Benin Republic. However, most current cotton production systems are not sustainable and this could become a significant obstacle to the future development of these countries. Particularly in Benin Republic (West Africa), the massive use of pesticides and other agrochemicals in conventional cotton production methods results in severe environmental and health problems. But No study was conducted in Benin Republic on persistence and degradation of pesticide residues in soils under cotton cultivation. Yet we know that Organic cotton which by definition is cotton produced without chemicals, appears as a solution. However, low productivities observed in biological or organic cotton production systems are an obstacle to the adoption by farmers of these cropping systems. Nevertheless, the existence of biological or organic cotton shows that it is possible to produce cotton without using chemicals. It is in this context this study intends to evaluate and analyse the agro-ecological impacts not only of conventional and organic cotton production systems currently used in Benin but also some innovative cotton production methods which could give good yields and protect more environment and human health. This doctoral thesis study seeks to: (i) review the existing literature on cotton production in Africa, (ii) analyse effects of different cotton production practices on its agronomical performances, (iii) analyse effects of different cotton practices on soil fertility characteristics, (iv) assess pesticide residues impacts following different cotton farming systems, (v) Quantify pyrethroid and organophosphate pesticide residues in soils from cotton production area and (vi) analyse pyrethroid and organophosphate pesticides persistence and degradation in incubation study. This study is being conducted in two different cotton agroecological zones of Benin Republic. This research project is funded by the Kingdom of Denmark.

Keywords: Organic cotton, agronomical performances, pyrothroid and organophosphate pesticides, Benin.

Dynamics of savanna plants: effects of trophic interactions between elephants and woody plants in Pendjari Biosphere Reserve in Benin, West Africa

GNONLONFOUN Isidore

Elephant's populations of Pendjari Biosphere Reserve have doubled in two decades with significant impacts on woody plants' communities in West Africa. Wildlife ecosystems are hotspots of amount ecological processes operating between mammalian herbivores and woody plants. Herbivory dynamic and outcomes are the most ecological processes documented in herbivores-trees interactions. However, herbivory influence across trees' ontogenetic stages and growth dynamic; effects on ecosystem functioning and services supply is less documented and darkness still remains on the most tree defensive traits and relative importance of different types of traits involved in tree defense. This thesis assessed the effect of elephants feeding behavior on (i) tree demography and carbon sequestration, (ii) ecosystems functioning and services supply and (iii) trees'structural defensive and tolerance traits in a semi-arid wildlife reserve in West Africa. Ecological modelling based on Generalized linear mixed effects models families, allometric equations, beta, piecewise and multiple multivariate linear regressions and ordered logistic regression were the main statistics run on two years forest inventory data collected in 60 1-ha plots along 20 transects long of 5 km each distributed across the biosphere reserve following elephants density gradient. Results indicated high ontognetic differences of mean density inside and across ecosystems with large and small reproductive trees less abundant. High beta diversity was detected following elephants populations density gradient. One to two growth survival thresholds were detected with *Senegalia gourmaensis* the most vulnerable tree. Sites with high elephants density showed low trees' biomass and carbon sequestration values for *Balanitex aegyptiaca, Diospyros mespiliformis* and *Tamarindus indica*. Ecosystems services potential assessment revealed twenty-seven important ecosystem services (ES), 13 provisioning ES (PES), 12 cultural ES, and two from the regulating and maintenance ES category. PES were perceived as the most important although not significantly different from other categories. PES were also found to be most affected negatively by elephants' impacts. However, elephants' presence increased supply of cultural ES. The average cost of the losses due to elephants' negative impacts ranged from $174.80 to $586.05 per year and per victim household. We found that climate change increased 6.61 times elephants' feeding on wild fruit trees and imped trophic interactions. Fruit production decreased and impacted negatively frugivorous

feeding. Seventy-eight food webs were identified, and 70.71 % exhibited decline in their functionality. Trees' architectures acted as evolutionary or plastic functional defensive traits and spines' effect is species and ontogenetic stage dependent. Intra-specific variability of spines characteristics of *Vachellia hochui*, *Mayetenus senegalensis*, *Vachellia seyal* and *Senegalia gourmaensis* was source of effective tree defensive strategies. Community heterogeneity effect on elephants browsing severity and defensive trait induction was species and environment dependent. Thus, high conspecifics density slowed down spines length but increased spines density induction among *Senegalia goumaensis* individuals. high mortality probability and low resprouting success were noted. Epicormic resprouting was the dominant tolerance trait among shrub savannas trees. 61.11 % of shrub savannas trees' resprouting showed significant mean leaf area (LA) reduction compared to consepecifics seed-regenerated individuals and only *Senegalia doudgeoni* individuals showed opposite trends indicating either a phenotypic plasticity or evolution of functional trait. Intraspecific and interspecific variation of LA accounted for 12.9 % and 75.97 % of the whole LA variation. Managements strategies must encompass fencing of vulnerable trees' populations. Future researches must disentangle the effects of neighbor identity and functional traits variation on fitness and defense of focal nearby plants.

Keywords: herbivory, defense strategies, elephants, ecology, evolutionary biology**,** population. demography, functional trait induction, intraspecific variation, ecosystem services, west African wildlife reserves.

Empirical studies of plotless sampling techniques in vegetation studies

AMAGNIDE Aubin

Sampling consists in techniques for selecting a sample from a large population with techniques for efficient and accurate estimating of some parameters of that entire population from measurements made on the sample. Before 1980, in quantitative ecology, sampling techniques were one of the least well understood tools. A survey of literature revealed that quadrat or plot sampling was the technique often used in ecological survey. However, quadrat pattern (size and shape) constitutes an important issue for ecologists to survey plant community. For these authors, quality of parameters estimates depends on plot size and shape. For instance, increasing plot size is known to improve estimation while rectangular and square plots are more suitable in tropical forests. Indeed, circular plots are known to be more accurate than other plot shape by more controlling

edge effect but there are notoriously difficult to establish in tropical forests. Nevertheless, some issues remained a question of burning importance with quadrat pattern. The general objective of this research is to improve estimators from plotless sampling techniques in vegetation studies. Specifically, the study (i) critically review literature of plotless sampling techniques in vegetation studies, (ii) optimise using simulation techniques variable area transect method, point quarter method, ordered distance method and nearest neighbour method, (iii) empirically compare the performance of variable area transect method, point quarter method, ordered distance method and nearest neighbour method, (iv) establish a density estimator model in case of imperfect detection and distance measurement errors. This study revealed in the first objective that plotless sampling methods are mainly used to estimate population density. Furthermore, this study showed that among the plotless sampling methods that were described, some remains slightly documented in ecology to date (variable area transect, T-square sampling, ordered method, triangle method). Results obtained also showed that the spatial distribution of organisms impacted the performance of these methods, hence affecting density estimates despite efforts done by some researchers to improve their robustness. All plotless sampling methods recorded their best performance when the population is randomly distributed. When the population is uniformly or contagiously (clump) distributed, most of them produced the largest bias of density estimate. However, over all spatial patterns, distance measurements at least to the third nearest neighbour (variable area transect, angle-order method, ordered distance and point-centered quarter techniques) were the best preferred methods. Results from second objective showed that tree-density was well estimated by ODM irrespective of true density values when a population is randomly distributed. In case of aggregative pattern, trees density was underestimated with increasing trend according to the density value. On average, the best performance was reached with 25 random sampling points and 9th individual from each point for this method. Regarding VATM, only small density values were well estimated (lower than 300 individuals per hectare) even for a random pattern of trees. Density estimates became far from true ones with aggregative pattern of trees. On average, the best performance of VATM was reached with 10th individual along each transect and the smallest transect width (5 meters). Results obtained suggest that VATM outperformed ODM for small density values, in addition to its easiness in field implementation. Therefore, to survey vegetation, one may prefer variable area transect technique to ordered distance technique.

Keyworks: Plotless sampling, quadrat methods, density estimation, plant community, Monte Carlo experiment.

Linear mixed effects models for fitting multivariate longitudinal data: application to natural regeneration of *Adansonia digitata* L.

HONFO Sèwanou Hermann

Research experiments in applied sciences such as agriculture, management of natural resources sciences and medicine are often complex and characterized by multiple observations on several variables measured repeatedly over the time (plant growth, study on regeneration, climate change, and epidemiology studies). For analyzing such data, the most appropriate method when there is significant correlation between variables of interest is the multivariate linear mixed effects model (MLMM). Various MLMM approaches have been developed and are available. Though, these MLMMs methods present some computational problems due to either the dimension of the joint covariance matrix of the random effects or the number of variables and/or the number of used random effects per variable. How do these methods really perform according to the above computational factors? Which method can be considered as the best one, or which methods are better for which situations? Does the time spacing considered for collecting data influence the performance of MLMMs? These are various fundamental research questions that need to be addressed. Therefore, the present PhD thesis aims at bringing an added value to multivariate linear mixed effects models methods for fitting longitudinal data through (i) the assessment of the performance of MLMM methods according to computational factors; (ii) the assessment of the effect of the variation of time spacing on the precision parameters'estimation using MLMMs (ii) he assessment of the effects of biotic and abiotic factors on the regeneration potential of *Adansonia digitata* L. in Benin using longitudinal data in MLMM framework.

Keywords: multivariate linear mixed effect model, longitudinal data, *Adansonia digitata*, regeneration

Comparison of parameter estimation methods used in generalized linear mixed model (GLMM) with applications on ecological data

LOKONON Bruno

The use of Generalized Linear Mixed Models (GLMMs) is widespread in ecology last decades since it is a more flexible approach for analyzing non-normal data when random effects are present. This popularity has led to a lot of methodological research. Despite the availability of accurate methods for estimating GLMM parameters in simple cases, complex GLMMs are challenging to fit. As a result, various approximation methods have been introduced in the literature with different degrees of accuracy. The main problem in parameters estimation with GLMMs is that, in contrast to linear mixed models, likelihood

function of GLMMs is analytically intractable. To tackle the intractability, different estimation methods and packages have been proposed. Specific research questions we address in this situation are: Do differences exist in term of robustness among the estimation methods in terms of parameter bias of fixed effects and variances of the random effects? What are the performances of the R packages involved in each estimation method? Through my PhD thesis, I plan to assess, analytically and empirically, the robustness of the existing estimation methods and packages in order to contribute to an accurate use of these methods.

Keywords: GLMM, estimation methods, simulations, packages, performance, ecology.

Performance of Generalized Linear and Nonlinear Mixed Models under flexible semi-non parametric and parametric distributions: applications to plant-plant interactions and gene dispersal in *Afzelia africana*

TOVISSODE Frederick

Generalized Linear Mixed Models (GLMMs) and Nonlinear Mixed Models (NLMMs) have now become part of tools commonly used by researchers in all applied sciences. Traditionally built on the normality/Poisson assumptions, these modelling devices have been shown to suffer distributional restrictions, what may substantially bias estimations and mislead decision making. Numerous proposals have thus emerged to tackle some aspects of this problem, introducing flexibility in distributions. The new models generally bear more computational challenges than their normal counterparts. This has led to the development of many estimation procedures which have problem-dependent performances. The present work aimed at refining flexible distribution based GLMMs and NLMMs in order to provide a benchmark for practitioners facing the miscellaneous approaches relaxed. We considered very flexible classes of parametric distributions (skew scale mixture of normal; discrete gamma) and an equally flexible semi-nonparametric class of distributions. The advantage of these distributions resides in not only their ability to represent a large range of skewness and kurtosis but also the possibility to recover the normal/Poisson distribution when the data does not support departure from these distributions. Specifically, our goals were to (1) assess the performance of a Generalized Linear Mixed Model for binary outcome under skew scale mixture of normal random effects and link function; (2) assess the performance of a discrete gamma Generalized Linear Mixed Model for count data under skew scale mixture of normal random effects; (3) compare the performances of Semi-Nonparametric and Parametric Nonlinear Mixed Models; and (4) apply the developed models to assess the effects of climatic gradient; human disturbance and nursing on survival and growth of seedlings in *Afzelia africana* Sm. populations in Benin. Preliminary

results support flexible binary/count models as more adequate than their traditional counterparts under non normal/Poissonian distributions.

Keywords: skew scale mixture, semi-nonparametric, flexible link, non equidispersion control, EM algorithm, Gauss Hermite quadrature, Bayes factor, *Afzelia africana*

Global optimization in multilayer perceptron neuronal networks

HOUNMENOU Castro

Multilayer Perceptron Neural Networks (MLP) constitute a very rich family of non-linear functions, whose main characteristic is to model non-linear systems. When the data from these systems contain a high proportion of observations contaminated with errors whose magnitude and structure may be arbitrary, robust estimators in the breakpoint sense are generally defined as the overall minimum of some non-convex measure of the errors. Thus, the problem of overall optimization of the learning algorithms used in MLPs arises. In addition, although neural networks have demonstrated their ability to provide good predictive and predictive performance, the problem of choosing hyper-parameters is very critical for these networks because the size of the search space increases exponentially with the number of intermediate layers. This thesis focuses on these classes of problems whose objectives are to: (i) establish a mathematical formalism of MLPs with multivariate response and several hidden layers, (ii) propose an extension of the generalized least squares error function for learning imprecise data in the context of nonlinear regression, (iii) give an estimation and a test for multidimensional regression models for imprecise data, (iv) determine the optimal configuration of MLPs and finally (V) analyze their behavior with respect to missing data.

Keywords: Multidimensional regression models, Optimization, Artificial neural networks, Machine learning

Multiblock data analysis: new developments

TCHANDAO MANGAMANA Essomanda

The collection of several blocks of variables measured on the same individuals has become a common practice nowadays to study complex systems in several domains of investigation. For the analysis of such data blocks, unsupervised methods are often used when the aim of the study is to explore the structure of these data blocks and assess their relationships. On the other hand, supervised methods are used when there is one or several response block(s) of variables to

be predicted from one or several explanatory block(s) of variables. Since multiblock data analysis has been the focus of many research works these last three decades or so, a plethora of methods have been proposed for both unsupervised and supervised context. Therefore, it is difficult for practitioners to see the add value of one method compared to others. The aim of our thesis is: (i) to provide a unified approach that brings several unsupervised methods under the same umbrella; (ii) clearly pinpoint the similarities and differences between these strategies of analysis; (iii) propose new variants of unsupervised methods; (iv) set up a unified approach for supervised methods; (v) propose new supervised methods.

Keywords: Generalized Canonical Correlation Analysis, Multiblock Principal Components Analysis, ComDim, Latent Root Multiblock Principal Components Analysis, Multiblock Partial Least Squares Regression.

Morphological variation, genetic diversity and proximate composition in *Annona senegalensis* in Western and Southern Africa

DONHOUEDE Janine

Annona senegalensis Pers (Annonaceae) is a multipurpose shrub with high food and medicinal properties. In Benin republic (Western Africa) as well as Mozambique (Southern Africa), the species is widely used by rural households for various purposes. Unfortunately, its distribution area in both countries is threated with increasing uncontrolled fire frequency which might lead to the erosion of genetic materials of the species. The present study aims at (i) determining morphometric variability and fruits production of *A. senegalensis* across fire gradient in Benin and Mozambique, (ii) assessing the genetic diversity in different populations along fire gradient in Benin and Mozambique, (iii) determining the impact of fire on the nutrients content of *A. senegalensis* pulps, leaves and seeds across fire gradient in Benin and Mozambique. To achieve these objectives, a total of 4 populations represented by 30 individuals per population will be sampled along fire gradient in each country for morphometric measurements, fruits, leaves and seeds collection for laboratory analysis. Genetic diversity will be assessed using Simple Sequence Repeats (SSRs) markers. Then, Proximate composition and mineral analysis will be investigated using the standard methods for food recommended by the Association of Official analytical Chemist (AOC). R software will be used for statistical data analysis. Findings of the current project are expected to provide useful information related to the impact of fire on *A. senegalensis*, contribute to the species valorization in Benin and Mozambique and provide helpful information in designing sustainable management and domestication strategies of *A. senegalensis* for the well-being of poor people who depend it.

Keywords: *Annona senegalensis*, Fire frequency, Diversity, Nutrients composition.

Distance functions for farm technical efficiency analysis with application on organic cotton farming systems in Benin

AHLONSOU Ceptime Galilée

Performance analysis constitutes an important issue for sustainable development in many developing countries. For this purpose, the conventional production function has been for a long time used in the most of performance analysis studies either to assess the productivity or the efficiency. However, this approach become impracticable in some situations where firm can produce simultaneously multiple outputs This kind of production technology is known in the literature as multiple output production technology. Then, the single-output production function appears inappropriate to accommodate the multi-input and multi-output technology. Therefore, distance functions approaches were developed to overcome some limitations of the conventional production function by allowing to model multi-output and multi-input production technology. One important justification of the wide use of the distance functions is that it is especially suitable in the presence of multi-output production and when the cost minimization scenario may be questionable. The principal advantage of the distance function representation is that it allows the possibility of specifying a multiple-input, multiple-output technology when price information is not available or alternatively when price information is available but cost, profit or revenue function representations are precluded because of violations of the required behavioural assumptions. Since the development of distance functions, it was not until recent years that applications involving distance functions have begun to appear in numbers namely in agriculture field, industry, transport, environment, energy and many others application areas. While distance functions have been the interest of many works and useful in many fields of application, this study aims to evaluate the performance of distance functions in order to provide a benchmark for practitioners when using distance functions approach with application in agricultural sector which constitutes an important place in economic growth of many developing countries. This raise up the following relevant questions Do the distance functions work effectively in all situations ? knowing that the performance of distance functions vary from one situation to another (technical efficiency, eco-efficiency, etc.), one may ask (1) if the distance functions show a best performance in a given situation (e.g, technical efficiency analysis) ? ; (2) What are the factors that affect the performance of distance functions ? (3) How do the distance functions work in practice?

Keywords: Distance functions, production function, performance analysis, efficiency.

Ecology, conservation and domestication of *Parkia biglobosa* (Jack.) R. Br. (Mimosoideae) in Benin, West Africa

HOUNDONOUGBO Juliano

Indigenous fruit trees (IFTs) play a pivotal role in the livelihoods of many rural and urban communities across West Africa. For instance, many multipurpose tree species with medicinal value are harvested for local health needs as well as for sale in national and international industries. However, the growing demand for IFTs used for both domestic and commercial uses has, in many cases, led to unsustainable management of traditional agroforestry systems. The most direct ecological consequence of the extraction of fruit trees is the alteration of survival, growth and reproduction rates of the harvested individuals. These changes can in turn affect the structure and viability of harvested natural stands. Among the useful tree species exploited by local people in West Africa, *Parkia biglobosa* or African locust bean (Mimosoideae) appears to be one of useful agroforestry species with important socio-economic and cultural values for local people. However, previous studies have shown a decrease in the distribution of the species in Benin due to its high socio-economic and cultural importance for local communities which tend to overexploit plant organs without taking into account its low regeneration potential. Despite the rapid decline of *P. biglobosa* in its natural habitats due to increasing anthropogenic pressures, little is known about the literature currently available on this species, the folk classification systems and morphological diversity of its fruits, the potential of fruit production, the structural characterization and predictions of its future distribution under climate change and dispersal constraints in West Africa. Such investigations are worth addressing to inform the development of policies by conservationists in order to sustainably manage this overexploited multipurpose tree species. To fill these gaps, we propose to study the ecology, conservation and domestication of African locust bean in Benin. Thus, our study is part of a global framework for developing sustainable conservation and domestication strategies linked to *P. biglobosa* as a contribution to its rational exploitation and management in Benin.

Keywords: African locust bean, indigenous fruit tree, agroforestry systems, sustainable conservation, domestication, West Africa.

Population structure, dynamics, and ecosystem services of mangroves in southern Benin, West-Africa: implications for sustainable management

ZANVO Mahoutin Gildas Serge

Mangrove forests cover a small fraction of the earth's surface, but contribute disproportionately to ecosystem services, including carbon (C) storage. These forests are being rapidly degraded as demand for economic development grows. In recognition of the multiple benefits of mangrove forests, rehabilitation of degraded forests is being carried out in many regions, Benin included. Thus, it is important to understand all drivers of mangroves' sustainable management. The goal of this study is to understand how human disturbances affect population structure, wood productivity, dynamic and ecosystems services of mangroves to inform their sustainable management in Benin. Specifically, the study aims to: (a) assess impacts of human disturbances on mangroves stand diversity and structure; (b) evaluate carbon stock potential of Benin's mangrove forests accounting for human disturbance levels; (c) estimate annual wood productivity of principal mangrove species (*A. racemosa* and *A. germinans*) using locals allometric equations; (d) examine and understand effects of human disturbances on tree population dynamics of principal mangrove species (*A. racemosa* and *A. germinans*) and (e) determine mangrove wood demand for local communities and their willingness to use potential substitute species. This study will be carried out in south Benin during three years. The overall sampling scheme will consist of selecting 20 mangroves sites with respect to their disturbance level: high exploited sites and low sites. Ten (10) sites will be selected by disturbance level, selection of such sites will be done after an exploration. Using the quadrat sampling technique, 600 plots of 10 m × 15 m will be established to assess impact of human disturbances on taxonomic diversity, structural diversity and population structure of mangroves. The same plots will be used for establishing specific and generic allometric equations for estimating tree biomass and carbon sequestration potential. Some trees of principal species will be selected and tagged in order to evaluate annual biomass productivity. Permanent sample plots of 10m × 25m will be established for evaluating mangrove trees population dynamics. Semi-structured interviews, focus groups using questionnaires and direct observations will be used to collect data allowing mangrove wood consumption estimation. As key results expected, the study will allow to have a great data on Benin mangrove forests structure, carbon stock and biomass productivity, mangrove trees population dynamics current mangrove wood demand and future mangrove wood demand estimation.

Key worlds: mangrove, carbon, management and Benin.

Appendix 4. Abstracts of scientific seminars organized by LABEF in 2019

Topic: Application of mixed model analysis for crop improvement: prediction of genetic values with BLUP and Bayesian methods

Guest Speaker: David CROS (PhD) – *(*Oil palm geneticist *CIRAD, Direction Régionale Afrique Centrale, Yaoundé, Cameroun)*

Date of the seminar: 16th January 2019

Abstract: The selection of elite individuals among a population of candidates requires partitioning the observed phenotypic values (data records) into genetic and environmental effects. This can be done based on a linear mixed model where the genetic values are considered random. One of the major interests of the mixed model is its ability to exploit the genetic correlations arising from the relatedness between individuals. The mixed model can be analyzed with best linear unbiased predictor (BLUP) methodology and with Bayesian approaches. Until recently, the relatedness between individuals was estimated based on pedigree. However, this yield expected relationships, which can differ widely from the value of interest, i.e. the realized relationships. The traditional pedigree-based relationships are now being replaced by molecular relationships computed from a large number of markers covering the whole genome. This opened the way to genomic predictions of genetic values, which gives the possibility of predicting the genetic value of individuals without data records, providing they were genotyped with the same markers as the individuals used to calibrate the genomic model. This new approach is expected to revolutionize plant breeding.

This seminar first gave basic information regarding the genome and SNP markers and presented the model of quantitative genetics, gene effects and the computation of pedigree-based and genomic relationships. In a second part, it showed how to predict genetic values by mixed model analysis and presented the genomic selection approach. The participants learned how to implement that with the R software.

Keywords: linear mixed model, BLUP, quantitative genetics, genomic predictions, breeding value.

Topic : Les expérimentations en conditions contrôlées ou semi-contrôlées : intérêts et applications en écologie végétale

Guest Speaker: Dr. Arnaud Monty *(Liège University, Gembloux Agro-Bio Tech Biodiversity and Landscape, Gembloux, Belgium)*

Date of the seminar: 18th January 2019

Abstract : De nombreuses expérimentations sont utilisées pour comprendre le fonctionnement des espèces végétales, en particulier dans un contexte de changement global. Il est pour cela souvent nécessaire de contrôler les conditions environnementales, totalement ou en partie, ce qui s'avère un défi pour le chercheur. De la chambre de culture contrôlée à l'expérimentation en plein air, diverses techniques et approches permettent de gérer la variabilité des conditions environnementales pour répondre au mieux à diverses questions relative à l'écologie des espèces végétales. Ainsi, le choix du dispositif expérimental et des méthodes statistiques est primordial, et doit être réfléchi en fonction des contraintes (possibilités techniques, coûts, durée de l'expérimentation) et des questions de recherches. Après quelques rappels théoriques, les avantages et inconvénients de différents niveaux de contrôle de l'hétérogénéité, comme les blocs aléatoires complets, la randomisation, l'utilisation d'enceintes contrôlées, etc. seront abordés et discutés à travers une série d'exemples. Ces exemples concerneront des espèces végétales et des questions de recherches diversifiées : niche édaphique de *Aeollanthus saxatilis* (herbacée cupricole africaine) ; adaptation de *Senecio inaequidens* (herbacée sud-africaine introduite en Europe) aux variations de climat ; performances d'*Ambrosia artemisiifolia* (adventice des cultures d'origine américaine) en limite d'aire ; et germination de *Robinia pseudoacacia* (arbre exotique utilisé en plantations).

Mots clés : Adaptation, Eco-physiologie, Ecologie expérimentale, Changement climatiques, Clines, Plantes

Topic : Introduction à la modélisation des maladies infectieuses

Guest Speaker : Prof Ngonghala Calistus, Professeur de Biomathématiques, Département de Mathématiques, Université de Floride, USA

Date of the seminar: 17th to 21st June 2019

Les maladies infectieuses font partie des plus grands ennemis naturels de l'homme. Bien que beaucoup d'efforts aient été investis dans la lutte contre ces maladies, dont certaines ont été éliminées dans certaines parties du monde, de nombreuses maladies infectieuses se développent encore et sont à l'origine d'une grande morbidité et mortalité dans le monde, notamment en Afrique subsaharienne. Il s'avère donc nécessaire de déployer des efforts collectifs et interdisciplinaires pour identifier de nouveaux moyens plus efficaces de contenir ces maladies. La modélisation mathématique est l'un des outils indispensables pour l'atteinte d'un tel objectif. Cette modélisation requiert toutefois des aptitudes en mathématique et statistique ainsi que des outils spécifiques qui ne sont pas forcément accessibles à tous alors que le besoin devient de plus en plus grandissant. C'est dans ce contexte que le *Laboratoire de Biomathématiques et d'Estimations Forestières* (www.labef-uac.org) de la Faculté des Sciences Agronomiques de l'Université d'Abomey-Calavi, en partenariat avec l'Institut de Mathématiques et de Sciences Physiques (IMSP) et avec le soutien de la Commission pour les pays en développement et l'Union International de Mathématiques a organisé un cours d'une semaine consacré à la modélisation de données relatives aux maladies infectieuses. Durant ce cours, les participants ont été initiés aux concepts de base des modèles de dynamiques des maladies infectieuses, aux diverses techniques de modélisation des maladies infectieuses, comment associer les modèles de maladies infectieuses aux données de manière cohérente, et comment évaluer et comparer des modèles. Les participants ont également reçu des cours sur la formulation de bonnes questions de recherche, la méthodologie de recherche pour répondre aux questions, ainsi que comment conclure, interpréter et communiquer leurs résultats à un large public. Ces cours ont été complétés par des sessions de pratiques dans le logiciel MATLAB et des travaux individuels ou de groupe. D'autres discussions parallèles ont inclus la recherche et la demande de subventions et d'emplois dans les universités.