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(RESEARCH ARTICLE)

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Bryophyta (Mosses) of Senegal: the case of Mosses in Herbaria and databases

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Abstract

In Senegal, Mosses constitute a large and diverse systematic group. This work is a contribution to the knowledge of Bryophyta in the herbaria of *Senegal. It specifically proposes to determine the structure of the Bryophyta on the prospected sites* in order to provide basic knowledge for a better sustainable management.

This study is carried out in the first place in the herbaria of the University Cheikh Anta Diop of Dakar/Senegal: the herbarium of the Institut Fondamental d'Afrique Noire Cheikh Anta Diop (IFAN) and the herbarium DAKAR of the Department of Plant Biology of the Faculty of Sciences and Techniques. Secondly, a consultation of different checklists and databases was conducted to collect more information**.**

This research work on the flora of the mosses allowed us to identify a total of 70 species divided into 44 genera, 24 families and 12 orders. The orders Hypnales, Dicranales and Hookeriales are the most represented. Bryaceae are dominant followed by Pottiaceae, Calymperaceae, Dicranaceae and Hypnaceae. The genera Fissidens, Calymperes, Bryum, Gemmabruym and Leucoloma are more diversified.

These results are important for the conservation of the environment and the enhancement of plant biodiversity in Senegal.

Keywords: *Bryophyta*; IFAN; DAKAR herbarium; Biodiversity; Senegal

1. Introduction

Bryophytes in the strict sense (*Bryophyta*) represent about 10,000 [21] to more than 13,000 species [19] in 845-866 genera [20, 12] and six classes worldwide. There is growing evidence that mosses are at the highest level of diversity in their evolutionary history [35]. This fairly recent diversification of mosses is probably related to the advent of Angiosperm forests offering a wide range of habitats (the bulk of moss diversity in tropical rainforests). Although mosses are rather small organisms, their morphology is relatively complex. Throughout their evolutionary history, mosses have undergone repeated morphological reduction and simplification [34], often as a result of colonization of specialized, particularly xeric or ephemeral habitats [53]. In Senegal, studies on the floristic diversity of mosses are still at the embryonic stage, despite the presence of samples in the Dakar and IFAN herbaria, two reference herbaria in the field of species conservation. Little information on bryophyte assemblages is available in these herbaria. It also seemed

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important to us to set up valuable tools for knowledge, conservation and decision support for a sustainable management of the species.

The aim of this work is to contribute *of Bryophyta* in the herbaria of *Senegal. It specifically proposes to determine the structure of the Bryophyta on the prospected sites* in order to provide basic knowledge for a better sustainable management.

2. Material and methods

2.1. Study site

The study was carried out in the herbaria of Senegal mainly in the IFAN herbarium and the DAKAR herbarium. Created respectively in 1941 by Professor Paul JAEGER and in 1960 by Professor J. MIEGE, they are reference places in the ex situ conservation of sample collections in Senegal. With as main objective the creation of a bank of all the plant species of French-speaking Africa, then of all continental and insular Africa, the Herbarium of the Institut Fondamental d'Afrique Noire Cheikh Anta Diop (IFAN) is the oldest herbarium in French-speaking Africa, centralizing the main part of the botanical activities in the former French metropolis. While the DAKAR Herbarium, attached to the Department of Plant Biology of the Faculty of Science and Technology of the Cheikh Anta DIOP University of Dakar, its main objective aimed at is to constitute a good quality and representative collection of the flora of Senegal and a remarkable knowledge base in the fields of research, training, knowledge, conservation of plant resources and African and international collaboration [23].

2.2. Methods

Visits to the herbarium collections were made to the two large herbaria and databases to establish the floristic list of bryophytes. Scientific names were checked via *Tropicos*, *Plant List* or *efloras*. The classification of [35] was used. The identification of species was possible thanks to different means. Identification keys in Africa: For mosses: the key of [48] can be used, which is also on the Internet, on the site of the Tropical Bryological Group (http://www.nhm.ac.uk/hosted_sites/bbstbg/) and the available African floras: the Flora of the Bryophytes of South Africa [51], the fascicles of the Flora of South Africa [38, 39, 42, 49] and the Flora of Gabon [50]. Other floras have been used to facilitate identification, such as the Bryophyte Flora of Augier [3] and many other papers.

3. Results

This floristic list is made up of species reported in the SONNERAT database and checklists from Africa [47, 56] and species from IFAN and DAKAR herbaria. This flora of the Mosses is made up of a total of 70 species divided into 44 genera and 24 families and 12 orders (Tab. 1). The orders *Hypnales* (8 families, 13 genera), *Dicranales* (4 families, 9 genera) and *Hookeriales* (3 families and 4 genera) are the most represented in this flora in terms of families and genera. The rest are represented by only one family (Tab. 2). In terms of species, *Dicranales* (24 species), *Hypnales* (17 species) and *Bryales* (11 species) are the most represented. In terms of diversity within families, *Bryaceae* are dominant with six genera and eleven species followed by *Pottiaceae* (4 genera, 4 species), *Calymperaceae* (3 genera, 8 species), *Dicranaceae* (3 genera, 6 species) and *Hypnaceae* (3 genera, 4 species). For generic diversity, the genera *Fissidens* (8 species), *Calymperes* (4 species), *Bryum* (3 species) *Gemmabruym* (3 species) and *Leucoloma* (3 species) are more diverse.

Table 1 List of *Bryophyta* species recorded

Orders	Families	Species
Bartramiales M. Menzel	*Bartramiaceae* Schwägr.	[1]*Philonotis brevicuspis var. peroblusata* P. de la Varde
		≡*Philonotis brevicuspis var. peroblusata* (C.M.) Broth.
		[1]*Philonotis hastata* (Duby) Wijk et Margad.
		≡*P. laxissima* (C. Müll.) Bryol. Javan
Bryales Limpr.	*Bryaceae* Schwägr.	[2]*Brachymenium leptophyllum* (Bruch et Schimp. ex Müll. Hal.) Bruch et Schimp. ex A. Jaeger
		[1]*Brachymenium wrightii* (Sull.) Broth.
		[3]*Bryum capillare* Hedw.

		[1]*Bryum erythrocaulon* (Schwägr.) Brid.
		[1]*Bryum thomeanum* P. De la Varde
		[1]*Gemmabryum coronatum* (Schwägr.) J.R. Spence et H.P. Ramsay
		≡*Bryum coronatum* Schwägr.
		[1]*Gemmabryum dichotomum* (Hedw.) J.R. Spence et H.P. Ramsay
		≡*Bryum sterile* probablement *B. bicolor Dicks*
		[2]*Gemmabryum exile* (Dozy et Molk.) J.R. Spence et H.P. Ramsay ≡*Brachymenium exile* (Dozy et Molk.) Bosch et Sande Lac.
		[1]*Leptobryum pyriforme* (L.) Wilson
		[1]*Pohlia camptotrachela var. decipiens* (Loeske) Nyholm
		≡*Webera grandiflora* Lindb. fil. var. *decipiens* Loeske
		[1]*Rhodobryum umbraculum* (Bruch ex Hook.) Schimp. ex Paris.
Hedwigiales Ochyra	*Rhacocarpaceae* Kindb.	[1]*Rhacocarpus purpurascens* (Brid.) Paris.
		≡*R. humboldtii* (Hook.) Lindb.
Orthotricales Dixon.	*Orthotrichaceae* Arn. (*Macromitriceae* S.P. Churchill ou *Zygodontaceae* Schimp.)	[1]*Groutiella tomentosa* (Hornsch.) Wijk et Margad.
		≡*G. laxotorquata* (Müll. Hal. ex Besch.) Wijk et Margad.
		[1]*Macromitrium sulcatum* (Hook.) Brid.
		≡*M. levatum* Mitt.
		[1]*Macromitrium perichaetiale* (Hook. et Grev.) Müll. Hal.
Rhizogoniales Goffinet et W.R. Buck	*Rhizogoniaceae* Broth.	[1]*Pyrrhobryum spiniforme* (Hedw.) Mitt.
		≡*Rhizogonium spiniforme* (Hedw.) Bruch. ; ≡*Rhizogonium spiniforme* (L.) Bruch.
Isobyrales M. Fleish	*Trachypodaceae* M. Fleisch.	[1]*Trachypodopsis quintasiana* Broth.
Dicranales M. Fleisch.	*Calymperaceae* Kindb.	[4]*Calymperes pallidum* Mitt.
		≡*C. decolorans* Müll. Hal ≡*C. subdecolorans* Cardot ≡*C. corbieri* Thér.
		≡*C. rabenhorstii* Hampe et Müll. Hall.
		[4,2]*Calymperes erosum* Müll. Hal. ≡*Calymperes casamancae Cardot*)
		[2]*Calymperes palisotii* Schwägr.
		[1]*Calymperes tenerum* Müll. Hal.
		≡*C. principis* Broth.
		[1,2] *Octoblepharum albidum* Hedw.
		[2]*Octoblepharum leptoneuron* Cardot
		[1]*Syrrhopodon androgynus* (Mont.) Besch.
		[1]*Syrrhopodon lycopodioides* (Sw. Ex Brid.) Müll. Hal.
	Dicranaceae Schimp.	[1]*Campylopus brevipilus* Bruch et Schimp. mixtus: *C. pilifer* Brid.
		≡*C. introflexus* (Hedw.) Brid.
		[1]*Leucobryum fouta-djalloni* Paris et Cardot.

		[1]*Leucobryum madagassum* Bresch.
		[1]*Leucoloma albulum* (Sull.) A. Jaeger
		[1]*Leucoloma fuscifolium* Besch.
		[1]*Leucoloma serrulatum* Brid.
	Erpodiaceae Broth.	[2]*Erpodium coronatum* (Hook.f. et Wilson) Mitt. var. *coronatum*
		[2]*Venturiella perrottetii* (Mont.) Pursell.
		≡*Erpodium theriotii* Broth. in Corb.)
	Fissidentaceae Schimp	[4,2]*Fissidens intramarginatus* (Hampe) A. Jaeger
		≡*F. casamancae* Cardot,
		≡*F. mathieui* Cardot
		[4,2]*Fissidens weirii* Mitt.
		≡*F. circinicaulis* Cardot
		[2]*Fissidens gardneri* Mitt.
		[2,4]*Fissidens marthae* Cardot
		[2]*Fissidens parkii* Mitt.
		[3]*Fissidens sp*
		[3,2]*Fissidens submarginatus* Bruch ex C. Krauss
Funariales M. Fleish	*Funariaceae* Schwägr.	[1]*Funaria hygrometrica* Hedw.
		≡*F. hygrometrica* (L.) Sibth.
Hookeriales M. Fleish	*Daltoniaceae* Schimp.	[1]*Lepidopilum lastii* Mitt.
		≡*L. callochlorum* C.M. (C. Juv. Spg.)
	Hookeriaceae Schimp.	[1]*Harpophyllum aureum* (Lam. ex Brid.) Spruce
		≡*H. aureum* (P.B.) Spr.
		[1]*Hookeriopsis acicularis* (Mitt.) A. Jaeger.
	Pilotrichaceae Kindb.	[1]*Callicostella fissidentella* (Besch.) Broth.
Hypnales W. R. Buck et Vitt.	*Amblystegiaceae* Kindb.	[1]*Campylium chrysophyllum* (Brid.) Loeske
	Hypnaceae Schimp.	[1]*Ectropothecium brevifalcatum* (Müll. Hall) Kindb.
		[1]*Ectropothecium perrotii* Renault et Cardot
		[1]*Gollania monodii* P. de la Varde.
		[1]*Vesicularia scaturigina* (Brid.) Broth.
	Meteoriaceae Kindb.	[1]*Floribundaria patentissima* (Müll. Hal.) M. Fleisch.
		[1]*Orthostichella versicolor* (Müll. Hal.) B. H. Allen et W. R. Buck
		≡*P. communis* C.M.
	Neckeraceae Schimp.	[1]*Porotrichum mutabile* Hampe
		≡*P. insularum* Mitt.
		[2]*Porotrichum substriatum* (Hampe) Mitt.
		≡*P. caudatum* Broth.
		[1]*Pinnatella piniformis* (Brid.) M. Fleisch.
	Pterigynandraceae Schimp.	[2]*Trachyphyllum dusenii* (Müll. Hal. ex Broth.) Broth.
		≡*Trachyphyllum dusenii* (Broth.) Broth.
		[2]*Trachyphyllum gastrodes* (Duby) A. Gepp in Hiern
	Pterobryaceae Kindb.	[1]*Orthostichidium perpinnatum* (Broth.) Dusén
	Sematophyllaceae Broth.	[1]*Taxithelium subrotundatulum* Broth. et Paris

	Thuidiaceae Schimp.	[1]*Pelekium cf. varians* (Welv. et Duby) A. Touw.
		[2,3]*Pelekium gratum* (P. Beauv.) Touw
		[3]*Thuidium sp*
Polytrichales Cavers	*Polytrichaceae* Schwägr.	[1]*Pogonatum gracilifolium* Besch.
		≡*P. rubentiviride* (Müll. Mal) Paris
Pottiales M. Fleish	*Pottiaceae* Hampe	[1]*Barbula afrofontana* (Müll. Hal) Broth.
		[1]*Eucladium verticillatum* (With.) Bruch et Schimp.
		≡*E. verticillatum* (L.) B.E.)
		[1]*Hyophila involuta* (Hook.) A. Jaeger
		≡*H. atrovirens* (Rehmann ex Müll. Hal.) Broth.
		≡*H. atrovirens* (Besch.) Broth.
		[1]*Morinia ehrenbergiana* (Müll. Hal.) Thér.
		≡*Barbula ehrenbergii* (Lorentz) M. Fleisch.

[1]= IFAN Herbarium; [2]= Check-List of O'Shea; [3]= DAKAR Herbarium; [4]=Sonnerat

Table 2 Distribution of species, genera and families in the different orders of *Bryophyta*

	Families		**Genera**		**Species**	
Orders	**Number**	**%**	**Number**	**%**	**Number**	**%**
Hypnales	8	33,3	13	29,5	17	24,3
Dicranales	4	16,7	9	20,5	24	34,3
Hookeriales	3	12,5	4	9,1	4	5,7
Bryales	1	4,2	6	13,6	11	15,7
Pottiales	1	4,2	4	9,1	4	5,7
Orthotricales	1	4,2	2	4,5	3	4,3
Bartramiales	1	4,2	1	2,3	2	2,9
Hedwigiales	1	4,2	1	2,3	1	1,4
Rhizogoniales	1	4,2	1	2,3	1	1,4
Isobryales	1	4,2	1	2,3	1	1,4
Funariales	1	4,2	1	2,3	1	1,4
Polytrichales	1	4,2	1	2,3	1	1,4
Total	24	100,0	44	100,0	70	100,0

Table 3 Distribution of species in the different taxonomic groups

Families	**Genera**		**Species**	
	Number	**%**	**Number**	**%**
Bryaceae	6	13,6	11	15,7
Pottiaceae	4	9,09	4	5,7
Calymperaceae	3	6,82	8	11,4
Dicranaceae	3	6,82	6	8,6
Hypnaceae	3	6,82	4	5,7
Orthotrichaceae	2	4,55	3	4,3

Neckeraceae	2	4,55	3	4,3
Thuidiaceae	2	4,55	3	4,3
Erpodiaceae	2	4,55	2	2,9
Hookeriaceae	2	4,55	2	2,9
Meteoriaceae	2	4,55	2	2,9
Fissidentaceae	1	2,27	8	11,4
Bartramiaceae	1	2,27	2	2,9
Pterigynandraceae	1	2,27	2	2,9
Rhacocarpaceae	1	2,27	1	1,4
Rhizogoniaceae	1	2,27	1	1,4
Trachypodaceae	1	2,27	1	1,4
Funariaceae	1	2,27	1	1,4
Daltoniaceae	1	2,27	1	1,4
Pilotrichaceae	1	2,27	1	1,4
Amblystegiaceae	1	2,27	1	1,4
Pterobryaceae	1	2,27	1	1,4
Sematophyllaceae	1	2,27	1	1,4
Polytrichaceae	1	2,27	1	1,4
Total	44	100	70	100,0

4. Discussion

Bryophytes are ancient, rather inconspicuous and poorly understood plants [2]. Bryophytes are the first plants to have diverged within the Embryophytes. They are only partially emancipated from the aquatic environment [43].

The floristic inventory has shown that the collections of bryophytes in the herbaria of Senegal are very diversified. The comparative analysis with the floras of the countries of the sub-region, the latter is less rich in terms of species. Indeed, this study is the first one carried out in this sense to better know the bryology of Senegal. The dominance of mosses is also visible in many other floras such as the *checklist of* Madagascar [44], Reunion Islands [4, 5, 7, 1], Mauritius [27]; South Africa [24, 51, 41, 38, 39, 40, 42, 34, 49], the moss and liverwort flora of Kenya [17, 18], the flora of Zimbabwe [6, 25], that of Cape Verde [8, 32, 45]. The dominance of the orders *Hypnales*, *Dicranales* and *Hookeriales* is a feature of several floras around the world: Madagascar [44], the moss and liverwort flora of Kenya [17, 18], the flora of Zimbabwe [6, 25]. *Bryaceae*, *Pottiaceae*, *Calymperaceae*, *Dicranaceae* and *Hypnaceae* are the most widely represented. This is a characteristic of tropical bryological floras. The richness of the IFAN herbarium collection is due to the fact that it is a regional level herbarium receiving a lot of samples from African countries (French Guinea, Chad, Gabon, Uganda, Sao Tome and Principe) and even outside the African continent (Guadeloupe). Contrary to the collection of the DAKAR herbarium, the weakest one, which hosts only the samples collected in Senegal. Bryophytes in Senegal have not been the object of specific studies or collection missions. Compared to other African floras, this one is similar with a strong representation of mosses on liverworts: Guinea Bissau [54], Guinea Conakry [47, 56] and African floras: from Cote d'ivoire [9], Nigeria [28, 36], Sierra Leona[31], Central Africa [10], Uganda [13], Rwanda and Zaire [15, 11, 13, 32], Seychelles[43, 22], Egypt [29, 30] and Madagascar [26].

5. Conclusion

This work has made it possible to list all the bryophyte species potentially present or collected in Senegal. It shows in particular that knowledge on the bryophytes of Senegal is dispersed with three lists of flora. This flora is dominated by the *Bryophyta* in terms of families, genera and species. Three orders dominate in the *Bryophyta*: *Hypnales*, *Dicranales* and *Hookeriales*. Within the *Bryophyta,* the *Bryaceae, Pottiaceae*, *Calymperaceae*, *Dicranaceae* and *Hypnaceae* are dominant. *Fissidens*, *Calymperes*, *Gemmabruym* and *Bryum* are more diverse in the mosses. For the *Bryophyta,* 48 species were recorded, distributed in 39 genera, 21 families and 12 orders coming from 8 countries contrary to that of the weak DAKAR herbarium whose species are all of the country. The knowledge acquired in this work on the floristic composition of the herbaria should make it possible to better know the bryoflora of Senegal and to contribute to the knowledge of the plant diversity.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

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