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Floristic diversity of Loranthaceae Family and their potential host species in Sudano-sahelian zone of Cameroon: case of Diamare plain in Far-North Region

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ABSTRACT

There is an increasing interest in parasitic plants and infectious disease community ecology in intertropical regions. The study examined the floristic diversity of Loranthaceae family and their potential host species in the ecoregion of Diamare plain in Cameroon. Reasoned sampling method was performed and experimental device consisted of 02 main treatments (Diamare and Mayo-Kani divisions), 08 secondary treatments (councils) and 32 replications (villages), with four (04) villages per council. We used itinerary botanical survey method of 1000 m x 20 m in each village, totalizing 64 ha and all parasitic plants and their potential hosts were inventoried. A total of 11 645 ligneous individuals was inventoried in the Diamare division, distributed within 65 species, 44 genera, and 22 Families. In Mayo-Kani division, a total of 16 645 ligneous individuals were inventoried, distributed in 58 species, 41 genera and 19 families. There was a significant difference between the two divisions in terms of individuals ($p < 0.001$). In total, nine parasitic plants of the Loranthaceae family were inventoried, with five species identified at the level of species (55.55%) and four species at the level of genera (44.44%): *Agelanthus dodoneifolius* (DC.) Polh. and Wiens, *Tapinanthus globiferus* (A. Rich.) Van Tiegh., *Tapinanthus oleifolus* (JC. Wendl.) Danser; *Tapinanthus voltensis* Van Tiegh. ex Balle; *Tapinanthus ophiodes* (Sprague) Danser, *Tapinanthus* sp1., *Tapinanthus* sp2., *Tapinanthus* sp3. and *Phragmanthera* sp. *Agelanthus dodoneifolius*, *Tapinanthus globiferus* and *T. ophiodes* recorded a weak parasitic specificity (PSp = 81.39%; 72.09% and 30.23% respectively). Combretaceae and Mimosaceae families showed the greatest number of sensitive host species to Loranthaceae infestation (20.89% and 16.27% respectively). There was no significant difference between parasitic specificity of Loranthaceae and parasitic sensitivity of host species ($p > 0.05$), and both were positively correlated ($r = 0.96$). Efforts are required to control the development of Loranthaceae in sudano-sahelian zone especially in ecosystem plantations.

Keywords: Floristic diversity, Loranthaceae, host species, Diamare plain, Cameroon

INTRODUCTION

Loranthaceae are locally and commonly called using the appellation "African mistletoe". They are phanerogams, hemiparasites, chlorophyllian and epiphytes which fix on aerian parts of their host (Koffi et al., 2014). These vascular parasites are responsible for varied economic, ecological, morphological and physiological damages on different cultures and ligneous vegetations

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(Sallé et al., 1998). They fix to their host using a specialized organ called haustorium, which establishes contact with the host at the level of the xylem conductive tissues (Boussim et al., 1993). These vascular parasites are present in all intertropical regions and in certain temperate zones and are sprawling to other regions. In the world, a total of 950 species and 77 genera belonging to this Family are known (Boussim et al., op. cit.).

In Africa, Polhill and Wiens (1998) identified more than 500 species of the Loranthaceae Family, and the investigations dealed mostly with crop protection. In Burkina-Faso, Boussim (2002) reported that large agroforestry surface areas parasitized by Loranthaceae led to massive tree deaths, most often in the absence of human control and intervention through diverse techniques of fight. In Ivory Coast, Soro et al. (2006) have raised an alert on the negligence of Loranthaceae Family that has now become a veritable nightmare in both natural vegetation and plantations alike. These vascular plants in the form of small shrubs develop on the trunk of their hosts. The growth of the host is thus slowed down and often ends up with death. In Cameroon, Ballé (1982) inventoried twenty six (26) species regrouped into seven (07) genera. Plantations and natural occurring woody species are main parasitic grounds of Loranthaceae. Many countries by experience have testified that Loranthaceae are responsible for decrease of productivity especially in agroforestry plantations. These parasitic species which have not been sufficiently studied and vulgarized by research foundations constitute a real threat to trees in home gardens (Dibong et al., 2008). In East Cameroon, *Theobroma cacao, Coffea robusta, Dacryodes edulis* plantations and coastal gardens along roads created by forest exploitation are major Loranthaceae targets (Dibong et al., 2012; Azo'o et al., 2013).

The Diamare plain in the sudano-sahelian ecoregion of Cameroon is facing the challenges such as overexploitation and degradation of plant resources, desertification and global warming. Being aware that Loranthaceae are parasites and capable of accelerating plant resources degradation which are already threatened in this zone, there was a great necessity of carrying out a reconnaissance survey of these hemiparasites in order to take appropriate conservation measures to preserve its diversity and regulate its growth in the study area. The survey aimed at contributing to the knowledge of Loranthaceae diversity and their potential hosts in the Sudano-sahelian zone of Cameroon in a view to fighting against degradation of resource plants.

MATERIALS AND METHODS

Study site

The study was carried out in the Far-North Region of Cameroon, in the Diamare plain including Mayo-Kani and Diamare divisions. These divisions cover a total area of 6450 km² and a population of 768 603 inhabitants (MINATD, 2010). It is located between 10°0' N to 10°48' N and 14°0' E to 14°48' E (Figure 1).The climate is of the Sudano-sahelian zone and is characterized by two seasons, a long dry season (8 to 9 months) spanning from October to May and a short rainy season (3 to 4 months) from June to September (Fotsing, 2009). Very high temperatures reaching 45 °C under shade and a very dry atmosphere are experienced from March to June. Rainfall varies between 600 and 900 mm/year, with maximum rainfall mostly between July and August (Djibrilla, 2016). Hydrography is made up of temporal flowing rivers (Mayos) which dry up at the end of the rainy season. The main soil types encountered are vertisols, hardés, sandy soils, rocky soils in mountain areas, and silty soils favorable to market gardening (FAO, 2011).

The vegetation is characterized by a shrub steppe of the Sudano-sahelian type. The most important plant species are: *Adansonia digitata, Guiera senegalensis, Tamarindus indica*, *Acacia albida*, *Acacia* spp., *Ziziphus mauritiana* and *Ficus* spp. Most of these plants are used for livestock feed (Wafo, 2008). Other African mistletoe and *Acacia albida* are appreciated for their leaves serving as fodders and their fertilizing roots. The wildlife is poor and is endangered due to the lack of a conducive environment for their development. Some species are mostly located in the mountains, and include rodents (mice, rats, damans, squirrels, hares), reptiles (lambs, lizards, snakes), locusts and caterpillars, sparrows; hyenas; panthers and wild cats; monkeys (IPCC, 2007). Most of the people rely on agriculture, livestock and forest resources to meet their basic needs.

Data collection

Inventory of potential host species and parasitic plants

The two divisions, Diamare and Mayo-Kani, constituted the basis of the study (main treatments). In each division, four (04) councils were sampled constituting the secondary treatments and four (04) villages (replications) in each council. We used reasoned sampling method developed by Grangé and Lebart (1992) for the selection of the councils, considering the presence of ligneous plant formations with individuals harboring Loranthaceae species. We also used the itinerant botanical survey method (Amon, 2006; Soro, 2010) for the floristic inventories. As such, four (04) itineraries of 1000 m x 20 m constituting the replications were made in each council, making a total of 64 ha throughout 32 itineraries (Figure 2) in different plant formations, namely gardens, reforested sites, natural sites, spontaneous trees and shrubs which are likely to be parasitized by Lorantahaceae. To avoid or reduce the homogeneity of host species that could bias the results of this research, each itinerary was realized at least 2 km away from the other.

Along the itinerary, all the woody potential host species and the parasitic plants were inventoried. For each host species, parameters such as the presence or absence of Loranthaceae species were recorded and the names of the host species and the Loranthaceae species were given on the basis of an identification key (Boussim, 2002). Also, the position of parasite on the host and the number of parasitic tufts were recorded. For each new parasite and woody host that identification on the field is not certain, a sample is collected by means of an inventory knife, or direct hand harvest. In cases of tall hosts, an inventory assistant climbs up the host and harvest the Loranthaceae for the constitution of herbarium. He equally observes properly, takes photos to permit the group to identify the species. Notwithstanding, some hosts are inaccessible and Loranthaceae species found on them were observed by means of a telescope that draws the parasite closer for proper observation.

Assessment of parasitic specificity of Loranthaceae species and parasitic sensitivity of host species

It is often stated that a good parasite does not kill its host. That said, variation in the degree of pathogenicity exhibited by various parasitic plants is great, from those which exert little impact on their hosts to those which dramatically affect the host physiology and fecundity. Pathogenicity depends upon many factors, such as the biomass ratio of parasite to host, the number of parasites attached to an individual host plant, the length of time required for the parasite to complete its life cycle, and possibly the degree of coevolutionary "tuning" that has occurred over time between the two species. All individuals of woody species which are parasitized and non parasitized were recorded and parasitic plants and number of tufts on all trees were counted. We measured the parasitic sensitivity which refers to the number of parasitic plants per host, and the parasitic specificity which refers to the number of hosts affected by the parasitic plants with respect to the total number of hosts (Houenon et al., 2012).

Data processing and analysis

We assessed diversity of potential host species with Shannon-Weaver diversity index (H') (Magurran, 2004) and Shannon's Evenness index (EQ). Diversity index takes into account not only the number of species but also whether species are more or less equally abundant, or whether in contrast one or a few species dominate.

$H' = -\Sigma Ni/N \log_2 Ni/N$, where H' = index of species diversity (bits), Ni = number of individuals of a given species i, N = total number of individuals, $\log_2$ = logarithm in basis 2.

$EQ = H'/\log_2 N$, this index varies from 0 to 1.

To describe the ecological importance of host families within each itinerary as well as for the total flora, the family importance value index (FIV) (Mori et al., 1983), was also calculated:

FIV = family relative diversity + relative density + relative dominance
Family relative diversity = (number of species in a family/total number of species) × 100
Relative density = (number of trees of the species or family/total number of trees) × 100
Relative dominance = (basal area of a species/basal area of all the species) x 100
The parasitic species were identified on the field and confirmed by other authors' surveys (Dibong et al., 2008; Soro et al., 2010; Dibong et al., 2012; Azo'o et al., 2013; Koffi et al., 2014).

The rate of parasitic specificity (PSp) of the Loranthaceae species was determined using the following formula (Hoffmann, 1994):

$$\text{PSp} = \frac{\text{NHSIPP}}{\text{TNHS}} \text{X } 100$$

PSp : parasitic specificity ;
NHSIPP : Number of host species infested by a parasitic plant;
TNHS : Total number oof host species.

Parasitic sensitivity (PSe) was appreciated for each host plant according to the number of parasitic plants/host: little sensitive host (1 to 2 parasitic plants); sensitive host (3 to 4 parasitic plants); high sensitive host (5 to 6 parasitic plants); very high sensitive host (≥ 7 parasitic plants) (Houenon et al., 2012).

Statistical analysis

Analysis of variance (ANOVA) was used to compare the host vegetation abundance between the two divisions of the Diamare plain. Student test (t. test) was conducted in order to know if differences between parasitic specificity of Loranthaceae species and parasitic sensitivity of host species were statistically significant. The relationships between parasitic specificity and parasitic sensitivity were investigated using correlation analysis (Pearson).

All the statistical analyses were performed at the level of 0.05 with Origin 6.0 and Xlstat Softwares

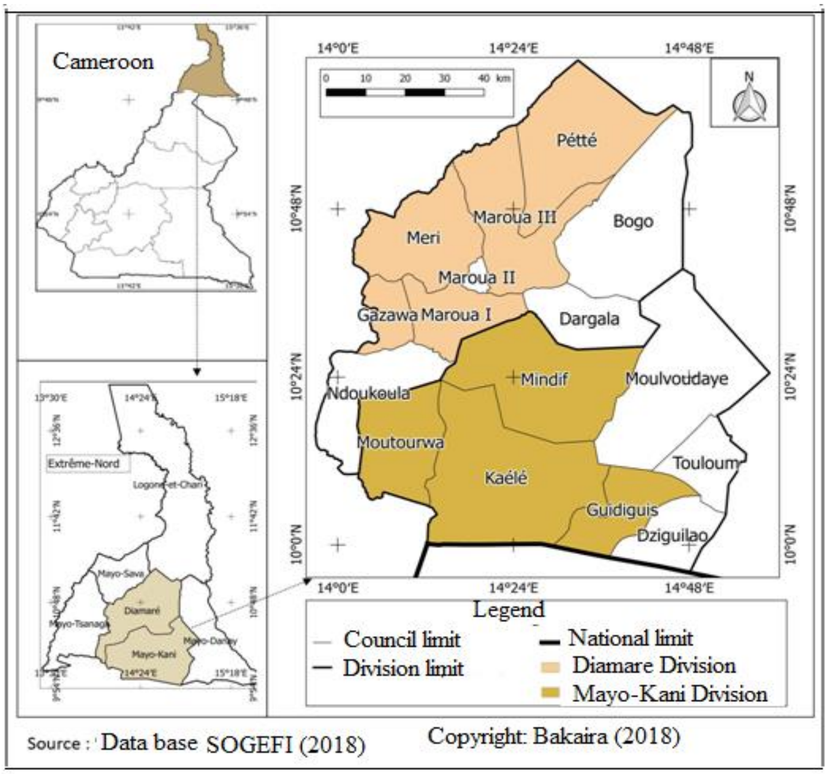

Figure 1: Map of location of the study site.

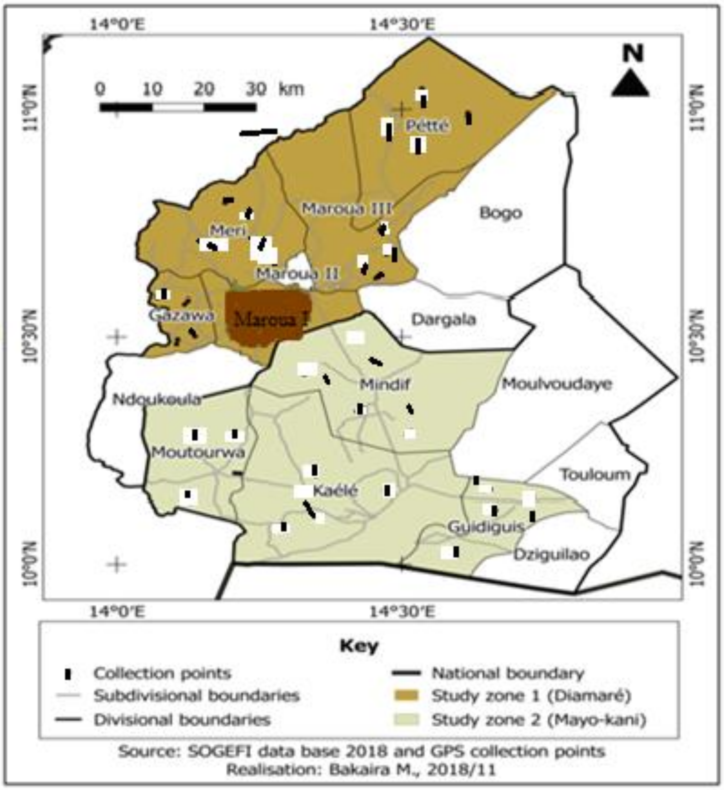

Figure 2: Map of study site showing the different points of data collection.

RESULTS

Floristic diversity and composition of potential host species in Diamare plain

A total of 11 645 ligneous individuals was inventoried in the Diamare division which are distributed in 65 species, 44 genera, and 22 Families. In Mayo-Kani division, a total of 16 645 individuals were inventoried and distributed in 58 species, 41 genera and 19 Families. Diamare division was then more diversified than Mayo-Kani division with 65 species and 58 species respectively. However, there was a very significant difference between the two sites in terms of individuals (ANOVA, $p < 0.001$). The Shannon diversity value in Diamare division was moderate (H' = 3.44 bits) and weak in the Mayo-Kani division (H' = 2.91 bits). The Shannon's Evenness index values were 0.49 and 0.34 respectively (Table 1). In Mayo-kani division, most of the individuals were concentrated on a species, *Azadirachta indica* which is largely extended in that zone.

The five (05) most importance families (those of the highest values of FIV index) accounted for 66.17% of the total FIV. They contributed 46.75% of the total number of potential host species of all the botanical surveys. The five families with the highest number of individuals and basal area were Mimosacaea (FIV = 58.79); Meliaceae (FIV = 49.41); Combretaceae (FIV = 31.53); Anacardiaceae (FIV = 28.18); Balanitaceae (FIV = 27.90). The most species-rich families were Mimosaceae (14 species); Combretaceae (11 species) and Anacardiaceae (08 species). A large group of families were represented by only one species. They were Balanitaceae, Sterculiaceae, Ebenaceae, Bombacaceae, Asclepiadaceae, Capparaceae, Celastraceae, Moringaceae, Loganiaceae, Verbenaceae, Sapotaceae, Bignoniaceae, Olacaceae and Rhamnaceae (Table 2).

Taxonomic diversity of Loranthaceae species in Diamare plain

A total of nine (09) Loranthaceae species was inventoried in Diamare plain. Five (05) of them were identified at the level of species, representing 55.55% of the total, including *Agelanthus dodoneifolius* (DC.) Polh. & Wiens, *Tapinanthus globiferus* Blume, *T. oleifolius* (J.C.Wendl.), *T. ophiodes* (Sprague) Danser and *T. voltensis* Van Tiegh. ex Balle. The four (04) other species were determined at the level of genus, namely *Phragmanthera* sp., *Tapinanthus* sp1., *Tapinanthus* sp2. and *Tapinanthus* sp3. (Figure 3).

On the whole Diamare plain, three (03) genera were determined, notably *Agelanthus* Van Tiegh., *Phragmanthera* Van Tiegh. and *Tapinanthus* Blume. The genera of *Agelanthus* and *Phragmanthera* have one (01) species each and *Tapinanthus* recorded the highest number of species, that's seven (07) species. The absolute abundance varied from one species to another, *A. dodoneifolius* recorded the highest number of individuals (18 577) followed by *T. globiferus* (4 200 individuals) and *T. ophiodes* (214 individuals). The three species represented 99.86% of the total inventoried individuals in terms of relative abundance. The least abundance ($n \leq 5$) was recorded by *T. voltensis* (03), *Tapinanthus* sp1. (05), *Tapinanthus* sp2. (02) and *Tapinanthus* sp3. (02) (Table 3). *Tapinanthus voltensis*, *Phragmanthera* sp., *Tapinanthus* sp1., *Tapinanthus* sp2. and *Tapinanthus* sp3. were only distributed in Mayo-Kani division.

Parasitic specificity of Loranthaceae species and parasitic sensitivity of host species

Amongst the 77 potential host species censused, 43 species were infested by Loranthaceae species, representing 55.84%, with 38 native species and 5 exotic species (*Azadirachta indica, Khaya senegalensis, Senna siamea, Moringa oleifera and Citrus limon*). *Agelanthus dodoneifolius* and *Tapinanthus globiferus* were very often in association on the same hosts. Regarding the parasitic specificity, three groups of parasitic plants were distinguished: weak parasitic specificity, average parasitic specificity and high parasitic specificity. The species with weak parasitic specificity were: *A. dodoneifolius* (PSp = 81.39%), *T. globiferus* (PSp = 72.09%) and *T. ophiodes* (PSp = 30.23%). *Tapinanthus oleifolius*, *Tapinanthus* sp2 and *Tapinanthus* sp3 performed average parasitic specificity (PSp = 4.65%). Three species, namely *Phragmanthera* sp., *Tapinanthus voltensis* and *Tapinanthus* sp1 realized high parasitic specificity (PSp = 2.32%).

Amongst the 43 host species, three (03) classes were distinguished according to their parasitic sensitivity: class I (little sensitive) with 29 species, representing 67.44%; class II (sensitive) with 12 species, that's 27.90%; class III (high sensitive) with 02 species (*Acacia senegal* and *Anogeissus leiocarpus*), representing 4.65% of the whole infested species. The family of Combretaceae recorded the highest percentage of host species (20.93%) followed by Mimosaceae (16.27%), and contributed about 97.81% to the biplots (axes F1 and F2) showed by principal component analysis (PCA) (Figure 4). These two families represent the most important ones in terms of family important value (FIV) in the study zone.

The independent test (t. test) showed no significant difference between parasitic specificity of Loranthaceae and parasitic sensitivity of host species (t. test, ddl = 38; $p = 0.702$; $\alpha = 0.05$). Both, parasitic specificity and parasitic sensitivity, were high positively correlated (Pearson, $r = 0.96$; $\alpha = 0.05$). The more sensitive a species, the more it's infested by several parasitic plants (Figure 5).

A total of thirty four (34) species representing 44.15% were not infested by Loranthaceae, namely *Acacia polyacantha, A. sieberiana, Albizia zygia, Entada africana, Mimosa pigra, Dichrostachys cinerea, Prosopis africana, Anacardium occidentale, Lannea acida, L. humilis, L. schimperi, Mangifera indica, Annona senegalensis, Combretum aculeatum, Guiera senegalensis, Commiphora africana, C. kerstingii, Citrus grandis, Crateva adansonii, Feretia apondanthera, Mitragyna inermis, Gardenia aqualla, Euphorbia sudanica, Ficus asperifolia, F. sycomorus, Maytenus senegalensis, Delonix regia, Eucalyptus camaldulensis, Pterocarpus erinaceus, P. lucens, Sterculia setigera, Stereospermum kunthianum, Strychnos spinosa* and *Ximenia americana* (Table 4).

Table 1: Number of taxa and diversity indices of woody species in the two divisions of Diamare plain.

Taxa and diversity indices	Diamare division	Mayo-Kani division	Total
Number of individuals	11 645	16 645	28 290
Number of Species	65	58	77
Number of Genera	44	41	53
Number of Families	22	19	27
Shannon index (bits)	3.44	2.91	3.05
Shannon's Evenness index	0.49	0.34	0.40

Table 2: Family importance value (FIV) of the five (05) most important potential host families of Loranthaceae in Diamare plain.

Species	Family	Global FIV
Acacia albida Del. *Acacia gerrardii* Benth. *Acacia hockii* De Wild. *Acacia nilotica* (L.) Willd. ex Del *Acacia polyacantha* Willd. *Acacia Senegal* (L.) Willd. *Acacia seyal* Del. *Acacia sieberiana* DC. *Albizia zygia* (DC.) J.F. Macbr. *Dichrostachys cinerea* (L.) Wight et Arn. *Entada africana* Guill. & Perr. *Mimosa pigra* L. *Prosopis africana* (Guill. & Perr.) Taub. *Pithecellobium dulce* (Roxb.) Benth.	**Mimosaceae**	**58.79**
Anacardium occidentale L. *Haematostaphis barteri* Hook f. *Lannea acida* A. Rich.s.l. *Lannea fruticosa* (Hochst. ex A. Rich.) Engl. *Lannea humilis* (Oliv.) Engl. *Lannea schimperi* (Hochst. ex A. Rich.) Engl. *Mangifera indica* L.	**Anacardiaceae**	**28.18**

Sclerocarya birrea (A. Rich.) Hochst.		
Annona senegalensis Pers. *Hexalobus monopetalus* (A. Rich.) Engl. & Diels	Annonaceae	2.15
Anogeissus leiocarpus (DC.) Guill. & Perr. *Combretum aculeatum* Vent. *Combretum collinum* Fresen *Combretum fragrans* F. Hoffm. *Combretum glutinosum* Perr. Ex DC. *Combretum molle* R. Br. ex G. Don *Terminalia glaucescens* Hochst. *Terminalia laxiflora* Engl. *Terminalia macroptera* Guill. & Perr. *Terminalia mantaly* H. Perr. *Guiera senegalensis* J.F. Gmel.	**Combretaceae**	**31.53**
Azadirachta indica A. Juss. *Khaya senegalensis* (Desr.) A. Juss.	**Meliaceae**	**49.41**
Balanites aegyptiaca (L.) Del.	**Balanitaceae**	**27.90**
Bombax costatum L.	Bombacaceae	2.0
Boswellia dalzielii Hutch. *Commiphora africana* (A. Rich.) Engl. *Commiphora kerstingii* Engl.	Burseraceae	3.15
Bridelia scleroneura Müll. Arg. *Euphorbia sudanica* A. Chev. *Grewia bicolor* Juss.	Euphorbiaceae	3.0
Calotropis procera (Ait.) Ait. f.	Asclepiadaceae	5.19
Citrus limon (L.) Burm. F. *Citrus grandis* (L.) Osbeck	Rutaceae	7.36
Crateva adansonii DC.	Capparaceae	4.0
Diospyros mespiliformis Hochst. ex A. Rich.	Ebenaceae	8.34
Feretia apodanthera Del. *Mitragyna inermis* (Willd.) Kuntze *Gardenia aqualla* Stapf. & Hutch.	Rubiaceae	12.23
Ficus asperifolia Miq. *Ficus glumosa* Del. *Ficus sycomorus* (Miq.) C.C. Berg *Ficus thonningii* Blume	Moraceae	8.36
Maytenus senegalensis (Lam.) Exell.	Celastraceae	3.0
Moringa oleifera L.	Moringaceae	7.2
Piliostigma reticulatum (DC.) Hochst.		

Piliostigma thonningii (Schum.) Milne-Redh. *Senna siamea* Lam. *Senna singueana* (Del.) Lock *Tamarindus indica* L. *Delonix regia* (Boj.) Raf.	Caesalpiniaceae	16.47
Psidium guajava L. *Eucalyptus camadulensis* F. Muel.	Myrtaceae	5.56
Pterocarpus erinaceus Poir. *Pterocarpus lucens* Guill. & Perr. *Dalbergia melanoxylon* Guill. & Perr.	Fabaceae	3.70
Sterculia setigera Del.	Sterculiaceae	1.01
Stereospermum kunthianum Cham.	Bignoniaceae	1.03
Strychnos spinosa Lam.	Loganiaceae	1.07
Vitellaria paradoxa Gaertn. f.	Sapotaceae	1.25
Vitex doniana Sweet.	Verbenaceae	1.04
Ximenia americana L.	Olacaceae	1.01
Ziziphus mauritiana Lam.	Rhamnaceae	2.99

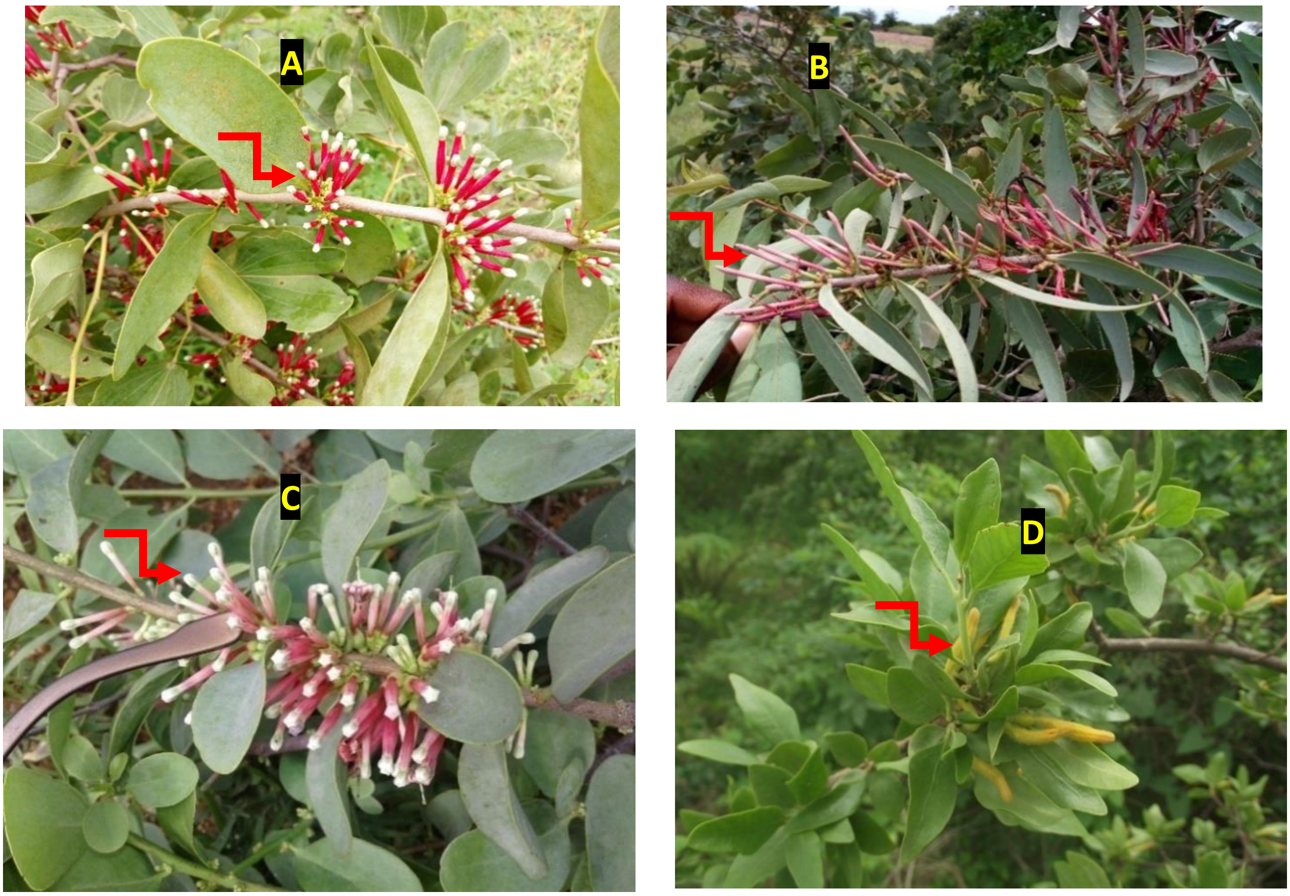

Figure 3: Loranthaceae species inventoried in Diamare plain.

A: Flowering branch of *Tapinanthus globiferus* B: Flowering branch of *Agelanthus dodoneifolius* C : Flowering branch of *T. ophiodes* D : *T. voltensis* on *Acacia senegal* E : Flowering branch of *T. oleifolius* F : Flowering branch of *Phragmanthera* sp. G: *Tapinanthus* sp1. on *Boswellia dalzielii* H: Fruiting branch of *Tapinanthus* sp2. I: *Tapinanthus* sp3. on *Lannea fruticosa*.

Table 3: Taxonomic diversity of Loranthaceae species and their abundance on host species.

Family	Genera	Species	Absolute abundance	Relative abundance (%)
Loranthaceae	*Agelanthus*	*Agelanthus dodoneifolius*	18577	80.68
	Phragmanthera	*Phragmanthera* sp.	10	0.043
	Tapinanthus	*Tapinanthus globiferus*	4200	18.24
		Tapinanthus ophiodes	214	0.92
		Tapinanthus oleifolius	10	0.043
		Tapinanthus voltensis	3	0.0001
		Tapinanthus sp1.	5	0.0002
		Tapinanthus sp2.	2	0.00008
		Tapinanthus sp3.	2	0.00008
Total		09	23023	99.93

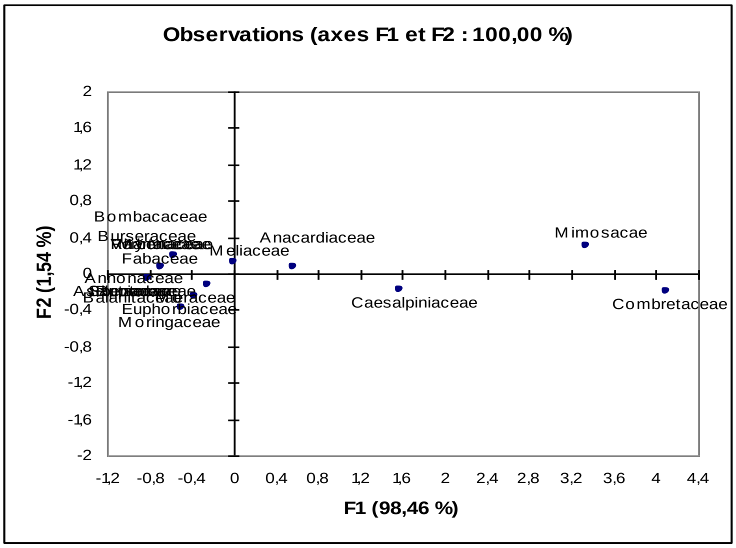

Figure 4. Similarity of host families according to their parasitic sensitivity showed by principal component analysis (PCA).

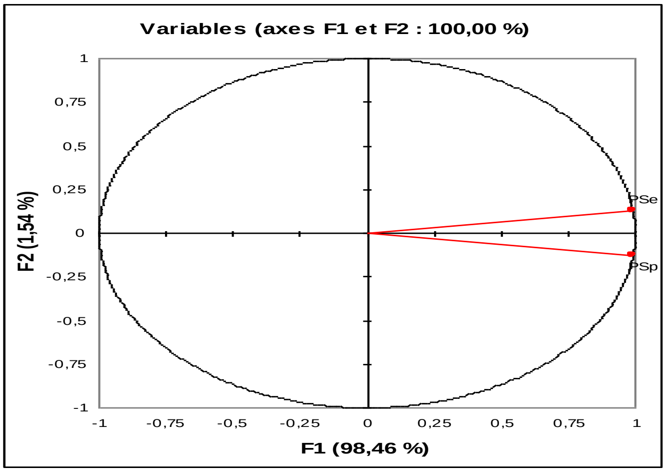

Figure 5: Correlation between PSe and PSp showed by PCA.

PSe : Parasitic sensitivity PSp : Parasitic specificity PCA : Principal component analysis

Table 4 : Specificity of Loranthaceae species and sensitivity of host species.

Host species	**Parasitic plants**										
Mimosaceae	Ad	Tg	To	Tol	Tv	Ph	Tsp1	Tsp2	Tsp3	NP	PSe
Acacia albida	+	+	-	-	-	-	-	-	-	2	ls
Acacia gerrardii	+	-	-	-	-	-	-	-	-	1	ls
Acacia hockii	+	+	+	-	-	-	-	-	-	3	s
Acacia nilotica	+	+	+	-	-	-	-	-	-	3	s
Acacia polyacantha	-	-	-	-	-	-	-	-	-		
Acacia senegal	+	+	+	+	+	-	-	-	+	6	hs
Acacia seyal	+	+	-	-	-	-	-	-	-	2	ls
Acacia sieberiana	-	-	-	-	-	-	-	-	-		
Albizia zygia	-	-	-	-	-	-	-	-	-		
Dichrostachys cinerea	-	-	-	-	-	-	-	-	-		
Entada africana	-	-	-	-	-	-	-	-	-		
Mimosa pigra	-	-	-	-	-	-	-	-	-		
Prosopis africana	-	-	-	-	-	-	-	-	-		
Pithecellobium dulce	+	+	-	-	-	-	-	-	-	2	ls
Anacardiaceae											
Anacardium occidentale	-	-	-	-	-	-	-	-	-		
Haematostaphis barteri	+	+	-	+	-	-	-	-	-	3	s
Lannea acida	-	-	-	-	-	-	-	-	-		

Lannea fruticosa	-	+ 2 8.18	-	-	+	-	-	-	-	2	ls
Lannea humilis	-	-	-	-	-	-	-	-	-		
Lannea schimperi	-	-	-	-	-	-	-	-	-		
Mangifera indica	-	-	-	-	-	-	-	-	-		
Sclerocarya birrea	+	+	-	-	-	-	-	-	-	2	ls
Annonaceae											
Annona senegalensis	-	-	-	-	-	-	-	-	-		
Hexalobus monopetalus	-	+	-	-	-	-	-	-	-	1	ls
Combretaceae											
Combretum aculeatum	-	-	-	-	-	-	-	-	-		
Combretum collinum	+	-	-	-	-	-	-	-	-	1	ls
Combretum fragrans	+	+	+	-	-	-	-	-	-	3	s
Combretum glutinosum	+	+	+	-	-	-	-	-	-	3	s
Combretum molle	+	+	-	-	-	-	-	-	-	2	ls
Terminalia glaucescens	-	-	+	-	-	-	-	-	-	1	ls
Terminalia laxiflora	+	-	-	-	-	-	-	-	-	1	ls
Terminalia macroptera	+	+	-	-	-	-	-	-	-	2	ls
Terminalia mantaly	+	+	-	-	-	-	-	-	-	2	ls
Anogeissus leiocarpus	+	+	+	-	-	+	+	-	-	5	hs
Guiera senegalensis	-	-	-	-	-	-	-	-	-		

Meliaceae											
Azadirachta indica	+	+	+	-	-	-	-	-	-	3	s
Khaya senegalensis	+	+	-	-	-	-	-	-	-	2	ls
Balanitaceae											
Balanites aegyptiaca	+	-	-	-	-	-	-	-	-	1	ls
Bombacaceae											
Bombax costatum	+	+	-	-	-	-	-	-	-	2	ls
Burseraceae											
Boswellia dalzielii	-	+	-	-	-	-	-	+	-	2	ls
Commiphora africana	-	-	-	-	-	-	-	-	-		
Commiphora kerstingii	-	-	-	-	-	-	-	-	-		
Euphorbiaceae											
Bridelia scleroneura	-	+	-	-	-	-	-	-	-	1	ls
Euphorbia sudanica	-	-	-	-	-	-	-	-	-		
Grewia bicolor	-	-	-	-	-	-	-	+	-	1	ls
Asclepiadaceae											
Calotropis procera	+	-	-	-	-	-	-	-	-	1	ls
Rutaceae											
Citrus limon	+	-	-	-	-	-	-	-	-	1	ls
Citrus grandis	-	-	-	-	-	-	-	-	-		
Capparaceae											
Crateva adansonii	-	-	-	-	-	-	-	-	-		
Ebenaceae											

Diospyros mespiliformis	+	-	-	-	-	-	-	-	-	1	ls
Rubiaceae											
Feretia apodanthera	-	-	-	-	-	-	-	-	-		
Mitragyna inermis	-	-	-	-	-	-	-	-	-		
Gardenia aqualla	-	-	-	-	-	-	-	-	-		
Moraceae											
Ficus asperifolia	-	-	-	-	-	-	-	-	-		
Ficus glumosa	-	+	-	-	-	-	-	-	-	1	ls
Ficus sycomorus	-	-	-	-	-	-	-	-	-		
Ficus thonningii	+	+	-	-	-	-	-	-	-	2	ls
Celastraceae											
Maytenus senegalensis	-	-	-	-	-	-	-	-	-		
Moringaceae											
Moringa oleifera	-	+	-	-	-	-	-	-	-	1	ls
Caesalpiniaceae											
Piliostigma reticulatum	+	+	-	-	-	-	-	-	+	3	s
Piliostigma thonningii	+	-	-	-	-	-	-	-	-	1	ls
Senna siamea	+	+	+	-	-	-	-	-	-	3	s
Senna singueana	+	+	-	-	-	-	-	-	-	2	ls
Tamarindus indica	+	-	-	-	-	-	-	-	-	1	ls
Delonix regia	-	-	-	-	-	-	-	-	-		
Myrtaceae											
Psidium guajava	+	+	+	-	-	-	-	-	-	3	s

Eucalyptus camadulensis	-	-	-	-	-	-	-	-	-		
Fabaceae											
Pterocarpus erinaceus	-	-	-	-	-	-	-	-	-		
Pterocarpus lucens	-	-	-	-	-	-	-	-	-		
Dalbergia melanoxylon	+	+	+	-	-	-	-	-	-	3	s
Sterculiaceae											
Sterculia setigera	-	-	-	-	-	-	-	-	-		
Bignoniaceae											
Stereospermum kunthianum	-	-	-	-	-	-	-	-	-		
Loganiaceae											
Strychnos spinosa	-	-	-	-	-	-	-	-	-		
Sapotaceae											
Vitellaria paradoxa	+	-	-	-	-	-	-	-	-	1	ls
Verbenaceae											
Vitex doniana	+	+	+	-	-	-	-	-	-	3	s
Olacaceae											
Ximenia americana	-	-	-	-	-	-	-	-	-		
Rhamnaceae											
Ziziphus mauritiana	+	+	+	-	-	-	-	-	-	3	s
PSp (%)	81.39*	72.09*	30.23*	4.65**	2.32***	2.32***	2.32***	4.65**	4.65**		

Ad: *Agelanthus dodoneifolius* Tg: *Tapinanthus globiferus* To: *Tapinanthus ophiodes* Tv: *Tapinanthus voltensis* Tol: *Tapinanthus oleifolius* Ph: *Phragmanthera* sp.
Tsp1: *Tapinanthus* sp1. Tsp2: *Tapinanthus* sp2. Tps3: Tapinanthus sp3 PSe: Parasitic sensitivity (ls: little sensitive host; s: sensitive host; hs: high sensitive host;
PSp: Parasitic specificity (*: weak specificity; **: average specificity; ***: high specificity ; NP: number of parasites + : presence - : absence

DISCUSSION

Tree diversity and floristic composition of potential host families

The two divisions of the Diamare plain's ecoregion showed different values of Shannon's index. The Diamare division had moderate value of Shannon's diversity index (H' = 3.44 bits) and weak in the Mayo-Kani division (H' = 2.91 bits) (Table 1). In Mayo-kani division, most of the individuals were concentrated on a species, *Azadirachta indica* which is largely extended in that zone. Kent and Cooker (1992) stated that woody communities considered rich are characterized by a Shannon diversity value of about 3.5 bits or higher. The moderate diversity in Diamare division seems to be derived from moderate anthropogenic activities at that level. Such value in savannah indicates a relative stability for the experimental year. The two divisions have shown low evenness index values (EQ ≤ 0.6). Dajoz (1982) cit. Souare (2015) reported that ecosystems that are in a transitional state or that are subject to permanent disturbances have low evenness index value.

In terms of family index value (FIV) of potential host species, Mimosaceae was the most important family throughout the Diamare plain (Table 2). It was followed by Meliaceae, Combretaceae, Anacardiaceae and Balanitaceae. The importance of these potential host families in the study site is due to the fact that drought in the Sahel has allowed natural selection of the most robust species like in these families. They are resistant to the lack and insufficient rains but also to high temperatures. These families are the most common and highly represented in tropical countries, particularly in African savannahs and more typical in sudano-sahelian zones. Similar results were found by Bognounou et al. (2009) and Froumsia et al. (2012), respectively in the sahelian zones of Burkina-Faso and Kalfou forest reserve in the sahelian zone of Cameroon.

Taxonomic diversity of Loranthaceae in Diamare plain

The Diamare plain recorded nine (09) species of Loranthaceae, distributed within three (03) genera, namely *Agelanthus* Van Tiegh., *Tapinanthus* Blume and *Phragmanthera* Van Tiegh. (Table 3). This taxonomic diversity of three genera and nine species is higher than the three genera and five species obtained in Mali (Boudet and Lebrun, 1986) and to three genera and six species obtained in Burkina-Faso (Boussim, 2002). However, this diversity is significantly lower than the six (06) genera and nineteen (19) species censused in Ivory Coast (Aké-Assi, 1984), the seven (07) genera and twenty six (26) species inventoried in the equatorial zone of Cameroon (Balle, 1982) and the four (04) genera and ten (10) species found in guinean and sudano-guinean zones in Benin (Houenon et al., 2012). The differences obtained would be due to the extent of the study area. Dibong et al. (2008) obtained four (04) genera and eight (08) species in the only Coastal Littoral Region of Cameroon. In fact, taxonomic diversity of Loranthaceae, in terms of genus and species, decreases with the aridity of the zones.

Specificity of the parasitic plants and sensitivity of the hosts

The 43 host plants censused belong to 20 various botanical families. These results corroborate those of Wiens (1998) and Houenon et al. (2012) who stated that Lorantahaceae species are polyphagous, and therefore parasitize different botanical families without any phylogenetic link. Before that, Boussim (1991) made the same observations on the polyphagous character of the *Tapinanthus* genus in Burkina-Faso. The same author pointed out the phenomenon of epiparatism or interparasitism of Loranathacea, and it was the case of *Tapinanthus globiferus* which parasitized *Agelanthus dodoneifolius*. This case of parasitism was not found in study area, but the two species were very often in association on the same hosts and recorded high significant value of parasitic specificity (PSp > 9%).

The parasitic sensitivity of the host species vary from a species to another. The most sensitive species (with 5 to 6 parasitic plants) were found among the native species, namely *Acacia senegal* and *Anogeissus leiocarpus*. A similar study carried out by Houenon et al. (2012) in guinean and sudano-guinean area in Benin pointed out four (04) high parasitic sensitive species, namely *Senna siamea*, *Acacia auriculiformis*, *Citrus sinensis* and *Tectona grandis*. These differences should be due to extent of the study zone. A total of 34 potential host species censused were found non sensitive, among which are *Mangifera indica* and *Delonix regia*. Dibong et al. (2008) in the Littoral region of Cameroon stated that these species are resistant to parasitic plants. However, a survey carried out by Amon et al. (2015) in southern region of Comoé in Ivory-Coast found out that these two species were parasitized. These results make us think that to date, there are certainly no resistant species to hemiparasites, but rather species not yet discovered not parasitized by Loranthaceae species.

Conclusion

The study aimed at contributing to the knowledge of Loranthaceae diversity and their potential hosts in the Sudano-sahelian zone of Cameroon in a view to fighting against degradation of resource plants. Diamare plain situated in this zone harbors nine species of Loranthaceae, distributed within three (03) genera: *Agelanthus* Van Tiegh., *Phragmanthera* Van Tiegh. and *Tapinanthus* Blume. They parasitize fourty three (43) host species of 20 botanical families amongst which Combretaceae and Mimosaceae were the most infested families, with 20.93% and 16.27% respectively. *Anogeissus leiocarpus* and *Acacia senegal* were grouped in class III (they hosted 5 to 6 parasites), meaning they were high parasitic sensitive in the study zone. *Agelanthus dodoneifolius* (PSp = 81.39%), *T. globiferus* (PSp = 72.09%) and *T. ophiodes* (PSp = 30.23%) performed a weak parasitic specificity. The high parasitic specificity was recorded by *Tapinanthus voltensis*, *Phragmanthera* sp. and *Tapinanthus* sp1. (PSp = 2.32%). There was no significant difference between parasitic sensitivity of host species and parasitic specificity of the Loranthaceae (t test, p = 0.702). One evident outcome from our analysis is that Loranthaceae are polyphagous and parasitize all species in various ecoregions including fragile ecological zones and plantations. An effort should be required for a better control of the development of the species in the study area.

COMPETING INTERESTS

The authors declare that they have no competing interest.

AUTHORS' CONTRIBUTIONS

Souare Konsala and Munting Tii Divine carried out the study and developed the manuscript. The other authors read and made comments that improved the manuscript.

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