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Sketch of trees and shrubs host to epiphytoid parasites (Loranthaceae) in cocoa based agrosystems in the department of Daloa, in the Central-West of Côte d'Ivoire

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Abstract

The parasitism of parasitic vascular plants of the Loranthaceae family is an ecological problem due to the high number of woody host and fruit species that they parasitize. The aim of this study is to contribute to knowledge of the woody plants which host epiphytoid parasites (Loranthaceae) in agrosystems based on cocoa trees. The inventories by surface survey and itinerant methods, completed with direct observations were carried out. In total, 73 host species of Loranthaceae were inventoried in cocoa trees in the department of Daloa. This taxonomic diversity of hosts, distributed in 55 genera and 22 families is infested by 4 parasitics (*Globimetula dinklagei* subsp. *assiana*, *Phragmanthera capitata*, *Tapinanthus bangwensis* and *T. globiferus*) Among these parasites, *T. bangwensis* is the most frequent and abundant on the hosts. The infestation rate of the inventoried host trees and shrubs is of the order of 29.46% and the infestation intensity is 2.98 tufts/tree. Among the host cohort, 21.92% of fruit species economically important to farmers are heavily parasitized.

Keywords: Loranthaceae, cocoa trees, woody species, rate, intensity of infestation, Côte d'Ivoire

Introductions

Côte d'Ivoire is a predominantly agricultural country where cultivated trees and shrubs such as coffee and cocoa trees occupy a prominent place in the economy (Aguilar *et al.*, 2003) [1]. In cocoa plantations particularly, the presence of phytopathogenic plants of the Loranthaceae family living on other woody plants is observed (Amon, 2006) [2]. These parasitic plants, once developed on the trunk or branches of the host, establish functional links with the latter's tissues through a system called a sucker (Boussim, 2002) [5]. Through this system, they take from the infested subject, the water and the necessary mineral salts they need for their own development. Through this mode of infestation, the parasitic Loranthaceae cause enormous damage to the cultivated and non-cultivated host, sometimes ranging from total invasion to total loss of yield in infested crops (Salle, 2004) [19]. In West Africa, the parasitism of these plant parasites has become an ecological problem due to the high number of woody species they infest (Houenon *et al.*, 2015) [15]. Indeed, these parasitic plants constitute a real nightmare for the farmers who lead, against them, a battle of uncertain fate (Boussim, 2002) [5]. According to the literature, several studies are carried out in order to find means of effectively combating these parasitic plants (Boussim *et al.*, 1995; Traoré *et al.*, 2003; Soro, 2006; Dibong *et al.*, 2008; Houenon *et al.*, 2015) [4, 9, 15, 21, 23]. The present work, which aims to contribute to a better knowledge of the parasitic Loranthaceae encountered in Côte d'Ivoire, is part of this commitment of the research community around the world to reduce the growing expansion of these epiphytoid parasites on the trees and shrubs. However, despite the inventories carried out in Côte d'Ivoire, at the current state of knowledge, the exhaustive list of economically important or non-economically important woody host species of Loranthaceae within agrosystems is still poorly known and poorly documented. This study aims to find out which trees and shrubs are victims of the Loranthaceae infestation in cocoa-based agroecosystems in the department of Daloa, in the Central-West of Côte d'Ivoire.

Material and methods

Material

The biological material consisted of Loranthaceae and woody plants. The technical material includes a geographic positioning device (GPS), a digital camera, a tape measure, sisal wire, stakes and survey sheets.

Methods

Study area

The study was carried out in cocoa plantations in the region of Daloa, in the Central-West of Côte d'Ivoire (Figure 1), with geographical coordinates 6°27'00" North latitude and

5°56'00 West longitude. The Daloa study area is located 141 km from Yamoussoukro, the political capital of Côte d'Ivoire. It is located in the Guinean area characterized by an equatorial type climate with two rainy seasons and two dry seasons (Eldin, 1971) [12]. Annual precipitation varies between 1300 mm and 1800 mm. It belongs to the mesophilic sector with vegetation formerly made up of dense humid semi-deciduous forests, cleared forests and mesophilic savannas (Guillaumet and Adjanohoun, 1971) [13]. But today, these plant formations are experiencing gradual degradation in favor of cocoa, coffee, rubber trees plantations, etc. (Mrapka, 2018) [16].

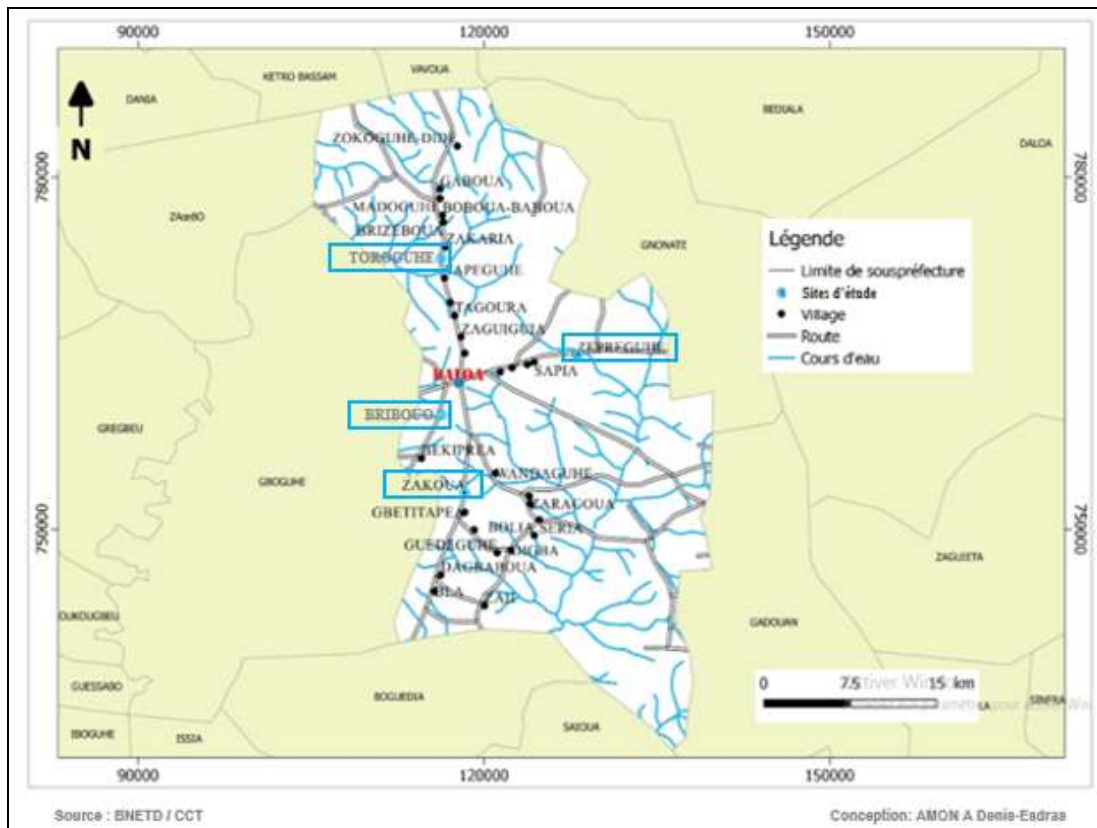


Fig 1: Location of the prospected sites in the Daloa region

Data collection

For the present study, the surface survey method which consists of counting the feet of cocoa trees found on square or rectangular areas, supplemented by direct observations in order to note the presence or absence of the parasite on trees and shrubs (Soro, 2010) [22] were adopted in eight (8) agrosystems based on cocoa trees in four villages : Zépréguhé (06°54'09.27"N and 06°21'28.84"W), Toroguhé (06°56'41.01"N and 06°27'49.77"W), Zakoua (06 ° 48'06.24 N and 06°27'07.58"W) and Bribouo (06°52'09.88"N and 0630'20.45"W) in the Daloa region. The inventory consisted of counting the non-parasitized trees and shrubs and those parasitized, the Loranthaceae species in question and their number of tufts in two plots of 50m × 50m (2500 m²) delimited and arranged alternately at different places in each selected plantation per village to make an inventory of trees and shrubs that may or may not be parasitized. For a careful inventory, the unit plot was subdivided into 5 strips 10 meters wide and 50 meters long. The data collected made it possible to determine the degree of infestation of host trees and shrubs by rate and intensity according to the formulas (Amon, 2006) [2]:

- Infestation rate (*Txi*):

$$Txi = \frac{Nip}{Nti} \times 100$$

with *Txi* - Infestation rate; *Nip* - Number of parasitized individuals; *Nti* - Total number of individuals identified;

- Intensity of infestation (*Ii*):

$$Ii = \frac{Nt}{Ntii}$$

with *Ii* - Intensity of infestation; *Nt* - Total number of Loranthaceae tufts; *Ntii* - Total number of infected individuals identified.

Statistical analyzes

Microsoft Excel 2016 software was used to classify the numerical data and to construct the various illustrative graphs. One-way analysis of variance (ANOVA) was performed using STATISTICA version 7.1 software to compare the rate and intensity of infestation of parasitic

Loranthaceae on trees and shrubs. When the differences were significant, the means were separated by Duncan's test at the 5% significance level ($\alpha < 0.05$).

Results and discussion

Results

Woody species hosts of Loranthaceae recorded

In total, 73 woody host species of Loranthaceae belonging to 55 genera and 22 families were inventoried in cocoa plantations in the department of Daloa (Table 1). The Fabaceae constitute the richest family in host species with 15 species, either 20.55% of the total number of hosts inventoried. Next come the Malvaceae with 8 species (either 9.58% each), followed by Apocynaceae and Moraceae with 7 species each (either 9.72% each), Meliaceae, Myrtaceae, Rubiaceae and Rutaceae with 4 taxa each (either 5.47% each). The remaining families, three of them have 2 species (2.73% each) and 8 grouped together under the term "others" with 1 species each (1.37%, each). Among others are Bignoniaceae and Urticaceae (Figure 2).

Of this cohort of host plants identified, 16 species are fruit-bearing, either 21.92%.

Among these 73 host species, 49 species were found in cocoa farms in Bribouo, 37 species in Zépréguhé, 28 species

in Zakoua and 24 species in Toroguhé (Table 1).

In terms of numbers of species, the richest genera are *Albizia* (5 species, or 9.09% of the total genera). Then come *Citrus* and *Ficus* with 4 species each, either 7.27% of the total genera). *Acacia*, *Azalia*, *Bombax*, *Coffea*, *Eugenia*, *Milicia*, *Rauwolfia* and *Terminalia* with two species each, either 3.63% of the total genera. The other genera each contain one species (either 2.43% of the total genera).

These are among others *Alstonia*, *Cecropia*, *Bridelia*, *Parkia* and *Persea*. These 73 host species are parasitized by 4 species of Loranthaceae, *Globimetula dinklagei* subsp. *assiana* Engl. (Figure 3A), *Phragmanthera capitata* (Spreng.) Ballé, *Tapinanthus bangwensis* (Engl. and K. Krause Danser (Figure 3B) and *T. globiferus* (A. Rich.). They are divided into 3 genera (*Globimetula*, *Phragmanthera* and *Tapinanthus*).

Among these parasitic species, *T. bangwensis* is more frequent and infesting with 59 taxa infested, either 80.82% of host spectrum within the cocoa tree based agrosystems studied. *P. capitata* infested 34 taxa (46.54% of host spectrum), *G. dinklagei* with 15 infested taxa (20.55% of host) and *T. globiferus* with only 6 infested taxa (8.21% host).

Table 1: Lists of host species and infestation status in cocoa agrosystems

No	Species & genera	Families	Localities				Parasitic species				Parameters		
			Br	To	Za	Ze	Gd	Pc	Tb	Tg	Infn rate (%)	Infn intensity	
1	* <i>Anacardium occidentale</i> L.	Anacardiaceae			+	+				+		25.33	2
2	* <i>Spondias mombin</i> L.	Anacardiaceae	+	+	+	+	+	+	+	+	+	75	13
3	* <i>Annona muricata</i> L.	Annonaceae				+	+			+		48.28	3.50
4	<i>Xylopia aethiopica</i> (Dunal) A. Rich.	Annonaceae	+							+		21.33	2.25
5	<i>Alstonia boonei</i> De Wild	Apocynaceae			+	+	+			+		36.67	3.73
6	<i>Funtumia elastica</i> (Preuss.) Stapf	Apocynaceae	+	+		+				+		13.80	1.25
7	<i>Holarrhena floribunda</i> (G. Don) Dur. & Schinz var. <i>floribunda</i>	Apocynaceae			+					+		9.84	1.20
8	<i>Picalima nitida</i> (Stapf) T. Durand & H. Durand	Apocynaceae	+							+		17.14	2
9	<i>Rauwolfia macrophylla</i> Ruiz et Pav.	Apocynaceae	+						+			3.33	1.18
10	<i>Rauwolfia vomitoria</i> Afzel.	Apocynaceae	+			+			+			6.67	2
11	<i>Voacanga africana</i> Stapf ex. Scott-Elliot	Apocynaceae	+			+			+	+		33.33	3
12	<i>Newbouldia laevis</i> (P. Beauv.) Seemann ex Bureau	Bignoniaceae			+					+		18	1.34
13	<i>Cordia platythyrsa</i> Bak.	Boraginaceae						+		+		2.58	1
14	<i>Cecropia peltata</i> L.	Cecropiaceae		+	+				+	+		31.85	2.47
15	* <i>Garcinia kola</i> Heckel	Clusiaceae	+	+					+	+		33.33	7
16	<i>Terminalia catappa</i> L.	Combretaceae			+		+			+		47.5	5.67
17	<i>Terminalia mentaly</i> H. Perrier	Combretaceae				+	+					18.27	2
18	<i>Cnestis ferruginea</i> DC.	Connaraceae	+							+		14.75	1.58
19	<i>Bridelia grandis</i> Pierre ex Hutch.	Euphorbiaceae			+		+					13.95	1.25
20	<i>Hevea brasiliensis</i> (Willd. ex A. Juss.) Müll. Arg.	Euphorbiaceae				+	+	+	+			58.38	10.53
21	<i>Acacia ataxacantha</i> DC.	Fabaceae		+		+			+	+		48.75	3.16
22	<i>Acacia auriculaeformis</i> A. Cunn. ex. Benth.	Fabaceae	+			+			+	+	+	44	2.75
23	<i>Azalia africana</i> sm. & Pers.	Fabaceae			+	+			+	+		50	3.25
27	<i>Azalia bipindensis</i> Harms	Fabaceae	+	+					+	+		42.85	3
25	<i>Albizia adianthifolia</i> (Schumach.) W. Wigh	Fabaceae	+	+	+	+			+	+		50	5.50
26	<i>Albizia guachapele</i> (Kunth.) Dugand	Fabaceae	+			+				+		49.18	3.55
27	<i>Albizia glaberrima</i> (Schum. & Thonn.) Benth.	Fabaceae				+			+	+		43	3.45
28	<i>Albizia lebbeck</i> (Linn.) Benth.	Fabaceae	+	+	+	+	+			+		55	4.80
29	<i>Albizia zygia</i> (DC.) J. F. Machor.	Fabaceae	+		+				+	+		50	4
30	<i>Amphimas pterocarpioides</i> Harms	Fabaceae	+					+		+		15.17	1.25
31	<i>Anthonotha macrophylla</i> P. Beauv.	Fabaceae				+			+			9.21	1.45
32	<i>Baphia bancoensis</i> Aubrev.	Fabaceae	+	+	+					+		7.14	1
33	* <i>Parkia biglobosa</i> (Jacq.) Benth.	Fabaceae				+				+		26.67	2.15
34	<i>Pentaclethra macrophylla</i> Benth.	Fabaceae			+					+		16.25	2
35	* <i>Tamarindus indica</i> L.	Fabaceae	+	+		+				+		12.89	1.19
36	<i>Persea americana</i> Mill.	Lauraceae	+	+	+	+	+	+	+	+	+	71.43	11.27

37	<i>Tectona grandis</i> L. f.	Lamiaceae		+					+		45.80	2.16								
38	* <i>Adansonia digitata</i> L.	Malvaceae			+		+	+	+		37.67	2								
39	<i>Bombax buenopozense</i> P. Beauv.	Malvaceae	+			+		+			35.15	2.80								
40	<i>Bombax costatum</i> Pellegr. & Vullet	Malvaceae Malvaceae	+	+					+		14.29	1.15								
41	<i>Ceiba pentandra</i> (L.) Gaertn.	Malvaceae	+	+					+	+	50	3.80								
42	* <i>Cola nitida</i> (Vent.) Schott & Endl.	Malvaceae	+		+	+	+	+	+		60	11.75								
43	<i>Tarrietia utilis</i> (Sprague) Sprague	Malvaceae	+	+					+		29.80	2								
44	* <i>Thebroma cacao</i> L.	Malvaceae	+	+	+	+	+	+	+	+	45.87	4.95								
45	<i>Sterculia tragacantha</i> Lindl.	Malvaceae	+			+			+		29.09	2								
46	<i>Azadirachta indica</i> A. Juss.	Meliaceae	+		+				+		13.33	2.25								
47	<i>Carapa procera</i> DC.	Meliaceae		+					+		9.09	2								
48	<i>Treulia africana</i> Decne	Meliaceae	+				+		+		11.35	1.60								
49	<i>Trichilia djalensis</i> A. Chev.	Meliaceae	+	+	+	+		+			25.80	2.15								
50	<i>Pentaclethra macrophylla</i> Benth.	Mimosaceae	+						+		14.47	1.73								
51	<i>Antiaris toxicaria</i> var. <i>africana</i> (Engl.) C.C. Berg	Moraceae				+		+			16.25	1.80								
52	<i>Ficus exasperata</i> Vahl	Moraceae		+	+			+	+		33.33	3								
53	<i>Ficus lutea</i> Vahl	Moraceae		+				+			6.67	2								
54	<i>Ficus sur</i> Forssk.	Moraceae	+			+			+		18.75	2.75								
55	<i>Ficus thonningii</i> Blume	Moraceae	+			+			+	+	7.4	1								
56	<i>Milicia excelsa</i> (Welw.) CC. Berg	Moraceae	+	+	+	+			+		27.67	1.50								
57	<i>Milicia regia</i> (A. Chev.) C. C. Berg	Moraceae			+			+			18.29	1.13								
58	* <i>Eugenia malaccensis</i> L.	Myrtaceae	+		+	+		+	+		37.78	2.50								
59	* <i>Eugenia miegeana</i> Aké Assi	Myrtaceae	+						+		13.33	1.6								
60	<i>Psidium guajava</i> L.	Myrtaceae	+	+	+	+		+	+		47.05	2.50								
61	<i>Pycnanthus angolensis</i> (Welw.) Warb.	Myrtaceae	+			+		+	+		57.25	3.75								
62	<i>Coffea arabusta</i> Capot et Aké Assi	Rubiaceae				+			+		7.50	1.50								
63	* <i>Coffea canephora</i> A. Froehner	Rubiaceae	+	+					+		15.33	2.25								
64	<i>Morinda lucida</i> Benth.	Rubiaceae	+	+		+		+			17.5	1.80								
65	<i>Sabicea africana</i> (P. Beauv.) Hepper	Rubiaceae	+	+					+		27.27	2.80								
66	* <i>Citrus aurantium</i> L.	Rutaceae	+					+			22.22	3								
67	* <i>Citrus grandis</i> (L.) Osb.	Rutaceae				+	+		+		35	2								
68	* <i>Citrus limon</i> (L.)	Rutaceae			+				+		37	3.75								
69	* <i>Citrus sinensis</i> (L.) Osb.	Rutaceae	+		+	+		+	+	+	50	3.35								
70	<i>Chrysophyllum cainito</i> L.	Sapotaceae	+		+				+		17.14	1.53								
71	<i>Myrianthus aboreus</i> P. Beauv.	Urticaceae	+						+		25.50	2								
72	<i>Gmelina arborea</i> Roxb.	Verbenaceae				+			+		26.67	2.50								
73	<i>Tectona grandis</i> L. f.	Verbenaceae	+	+					+	+	35.29	3.75								
Total											49	26	28	37	11	34	59	6	29.46	2.98

NB: Br - Bribouo, To - Toroguhé, Za - Zakoua, Ze - Zépreguhé, + - Presence, * - Fruit species, Gd - *Globimetula dinklagei* subsp. *assiana*, Pc - *Phragmanthera capitata* var. *capitata*, Tb - *Tapinanthus bangwensis* and Tg - *Tapinanthus globiferus*, infn - infestation

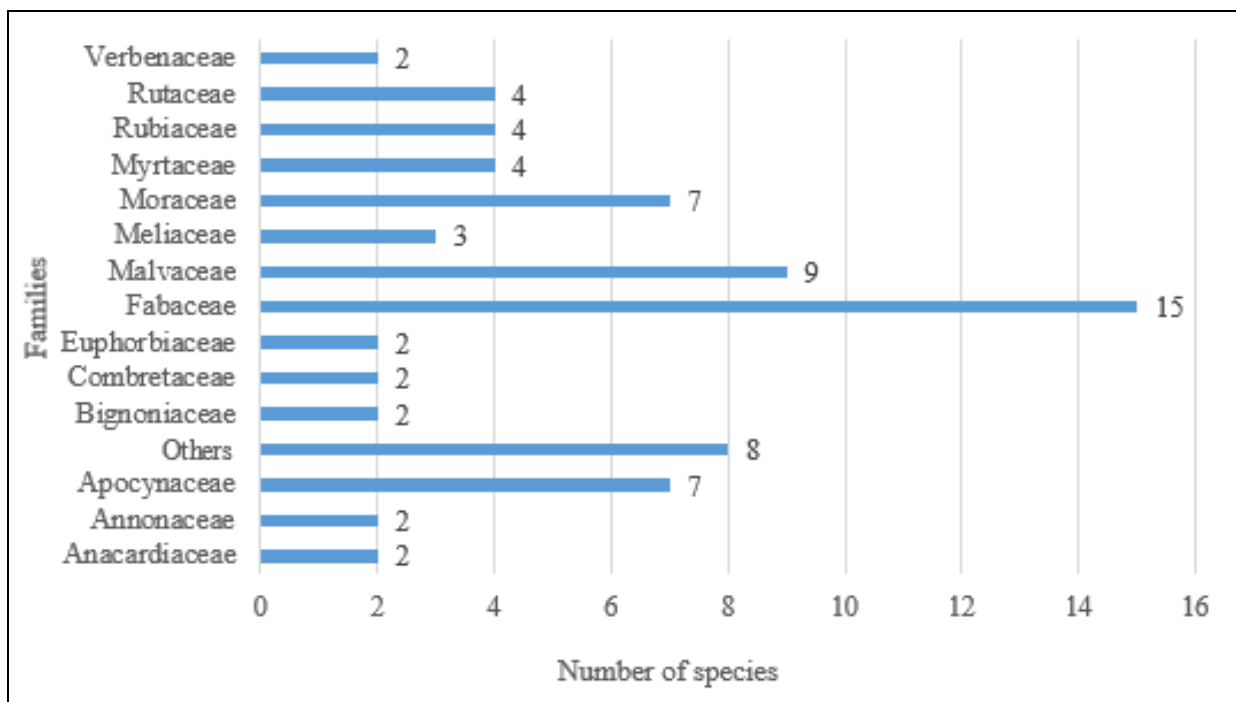


Fig 2: Host families by number of species



Fig 3: Loranthaceae species: A and B identified on hosts in cocoa farms

Infestation of trees and shrubs registered in cocoa trees

The infection rate varies between 2.58% in *Cordia platythyrsa* and 75% in *Spondias mombin* (Table 1). Rate values greater than or equal to 50 are obtained for 10 host species: *Albizia adianthifolia*, *A. lebbek* (Figure 14A), *A. zygia*, *Azalia africana*, *Ceiba pentadra* (Figure 14B), *Citrus sinensis*, *Cola nitida*, *Hevea brasiliensis*, *Persea americana* (Figure 14C) and *Spondias mombin*. Among these species, *Spondias mombin* (75%) and *Persea americana* (71.43%) register the strong attacks. Likewise, in the cohort of 53 host taxa, the weakest attacks were registered at *Cordia platythyrsa* (2.58%) and *Rauwolfia macrophylla* (3.33%). Next are *Tamarindus indica* (6.89%), *Baphia bancoensis*, *Ficus mucoso* and *Xylopi aethiopica* with a rate value of 7.14% each.

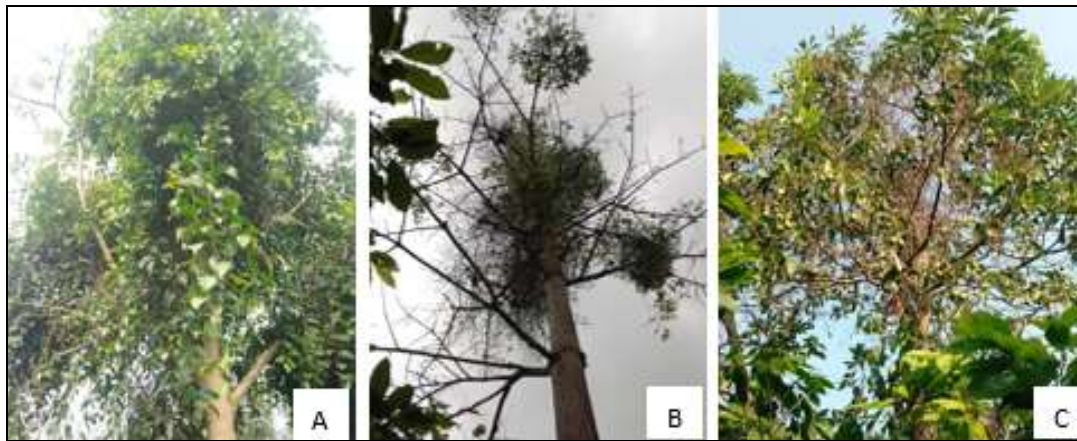


Fig 4: Some Loranthaceae host species found in cocoa plantations: A - *Albizia lebbek*, B - *Ceiba pentadra* and C - *Persea americana* densely parasitized

Regarding the intensity of the infestation, the averages obtained vary between 1 clump/tree in *Baphia bancoensis* and 13 clumps/tree in *Spondias mombin* (Table 1). *Spondias mombin* (13 tufts/tree), *Cola nitida* (11.75 tufts/tree), *P. americana* (11.27) and *Hevea brasiliensis* (10.53%) show high infestation intensities. Additionally, the lower less infestation intensities (2%) were registered in 21 host species. Mention may be made among others: *Bombax costatum*, *Rauwolfia vomitoria*, *Sterculia tragacantha* and *Tarrieta utilis*.

Overall, the Loranthaceae infestation rate on the inventoried host species of cocoa plantations in Daloa department is around 29.48% and the infestation intensity is 2.98 tufts/tree.

Discussion

The study on trees and shrubs host to epiphytoid parasites (Loranthaceae) in cocoa tree based agrosystems in Daloa department have allowed to inventory 73 host species of Loranthaceae belonging to 55 genera to 22 families. This taxonomic diversity of 55 genera and 73 species is significantly lower than that of the 77 genera and 116 species obtained in agrosystems in the South-east of Côte d'Ivoire (Amon, 2014) [3] and that of 81 genera and 99 species registered by Soro (2010) [22] in Oumé, Gagnoa and Soubré, in the Central-West and in the South-West of the country. On the other hand, it is clearly higher than the 34 genera and 41 species recorded in the agrosystems of the riparian areas of the University of Lorougnon Guédé, in the Central-West of Côte d'Ivoire (Sako, 2019) [18]. The

differences obtained would be linked to the extent of the environments explored but also to climatic zones.

Among the 22 host species families recorded, the Fabaceae family is the prolific in terms of infested species with 15 taxa, followed by Malvaceae (9 host species), Apocynaceae (7 host species), Myrtaceae, Rubiaceae and Rutaceae with 4 each distinct host taxa. This result corroborates those of Houenon *et al.* (2012) [12], in Benin, de Soro (2010) [22] and de Amon (2006) [2] in Côte d'Ivoire who underlined the significant attack of Fabaceae, Apocynaceae and Rutaceae by parasitic Loranthaceae.

The evaluation of the infestation of host trees and shrubs showed that they are strongly attacked, in particular the well-known fruit trees such as *Persea americana* (71.43%), *Cola nitida* (60%), *Citrus sinensis* (50%), *Terminalia catappa* (47.5%) and *Psidium guajava* (47.05%). Similar observations have been reported elsewhere in Africa, in particular in Ghana by Cleck (1978) [6] on *Cola nitida*, in Cameroon by Dibong *et al.* (2009) [10] on *Persea americana* and in Benin on *Citrus sinensis* by Houenon *et al.* (2012) [15].

Of these fruit trees mentioned, *Persea americana* (71.43%) is the most infested species of Loranthaceae. Sonké *et al.* (2000) [20], in Cameroon obtained a rate of 69.44% on *P. americana* and reported the polyphagous character of Loranthaceae on this fruit species in which they found a privileged target in sub-Saharan Africa. The presence of this species in cocoa trees under the influence of these phytopathogenic plants should be monitored and controlled.

The overall infestation rate of trees and shrubs, hosts of Loranthaceae in agroecosystems, is around 29.48%. This rate is lower than that of 37.94 recorded by Amon *et al.* (2015) [7] in agrosystems in the Sud-Comoé region. The difference noted would be due to the extent of the environments explored.

The cohort of 73 host species inventoried in the various cocoa plantations of the department of Daloa is infested with 4 species of Loranthaceae (*Globimetula dinklagei* subsp. *assiana*, *Phragmanthera capitata*, *Tapinanthus bangwensis* and *T. globiferus*). All these species have already been collected in the agrosystems of Central-west Côte d'Ivoire (Soro, 2010, Mrapka, 2018, Amon *et al.*, 2020) [8, 16, 22].

Of the 4 species mentioned, *T. bangwensis* is more frequent and abundant in cocoa farms in the Central-West of Côte d'Ivoire. This result confirms the work of Sako (2019) [18].

Conclusion

The trees and shrubs of cocoa-based agrosystems in the department of Daloa, in the center-west of Côte d'Ivoire are parasitized by 4 species of Loranthaceae (*Globimetula dinklagei* subsp. *assiana*, *Phragmanthera capitata*, *Tapinanthus bangwensis* and *T. globiferus*). One of these species, namely *T. bangwensis* is more frequent and abundant on hosts within cocoa trees. The taxonomic diversity of the identified host species is 73 species belonging to 55 genera and 22 families. The infestation rate of woody species is around 29.48% and the infestation intensity is 2.89 tufts/tree. Among the host cohort, the rates and intensities of infestation of fruit species that are economically important to farmers are high.

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