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Biodiversity and parasitism of Loranthaceae on citrus cultivated in the Mongo department

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Abstract

Citrus farming is currently a main sector in Africa in general, particularly in the sub-Saharan region. Citrus farming in Cameroon has been expanding since the cocoa crisis and thanks to its financial and economic benefits. The research aim was to evaluate the parasitism of Loranthaceae on citrus trees in the Mongo department. Direct observations were made in the canopy of 796 citrus trees in seven arrondissements, and included species identification, and the Loranthaceae species growing on their foliage. Alive and dead tufts were numbered to estimate parasitism density and mortality rate. Five species of Loranthaceae identified on six citrus species. Tapinanthus predominated with three species, *T. bangwensis T. preussii* and *Tapinanthus* sp. *Phragmanthera capitata* was the most frequent (75.37%), and *T. preussii* was scattered (2.33%). The highest mean parasitic density was obtained in *T. bangwensis* has the higher parasitic density (5.76±5.17 tufts/tree), followed by *Helixanthera mannii* (5.42±4.13 tufts/tree). The highest rate of parasitism was obtained on *C. maxima* (89.77%), and the highest natural mortality rate of Loranthaceae was on *C. medica* (12.5%). Loranthaceae have already greatly expanded in Citrus, it recommended to set up a monitoring system to protect the yields.

Keywords: Cameroon; Hemiparasite; Rutaceae; Parasitism density; Production area

1. Introduction

Citrus are of the most important fruit trees worldwide cultivated. They generated incomes for farmers and provide high-quality nutritional intakes, particularly for their high mineral, vitamin and fiber content [1]. World citrus production is currently estimated at 85 million tons of fruits, including about 8.3 million in North Africa [2]. In tropical Africa, the great producing countries citrus fruits are Nigeria, South Africa, Guinea and Senegal. Products and by-products obtained from citrus fruits have a great socio-economic interest. For example, the juice of a ripe orange or mandarin contains about 12% sugar and soluble solids, 1% citric acid and 50 mg vitamin C (ascorbic acid) per 100 g. One glass of orange juice is therefore sufficient to provide the daily requirement of vitamin [3]. Citrus trees are cultivated throughout the country, and the cultivation occurs in ecological niches that are well defined by boundaries, sometimes physical or administrative [4]. The main citrus fruits produced are oranges (*C. sinensis*), mandarins (*C. reticulata*), lemons (*C. limon*), limes (*C. medica*), pomelos (*C. paradisi*) and grapefruits (*C. maxima*). They are mostly cultivated by small farmers and provides many incomes diversification following the downfall of cocoa and coffee in the international market. Farmers have then increased the cultivation of the citrus to ensure that their incomes are spread throughout the year [5]. The production was estimated to be 22,792 tons after a market research survey [6]. For example, orange local demand can

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be estimated at least 150,000 tons per year, estimation based on the average consumption of fresh oranges per habitant per year of European Union [4].

However, citrus face the ever-changing pests attacks such as parasitic plant of the family of Loranthaceae that are one of the main harvests threatens in tropical Africa [4]. Loranthaceae commonly referred as "African mistletoes", are epiphytic phanerogams, hemiparasites who establish more or less spherical tufts on the host canopy. They have a specific organ called haustorium, which establishes xylemic connections with the host tissues [7]. The family of Loranthaceae are represented in Cameroon by 26 species belonging to 7 genera. commercially crops species such as rubber tree, avocado, cocoa, coffee, and shea tree appear heavily infested by Loranthaceae and yield losses are often significant [8, 9]. On the other hand, several farmers have reported Loranthaceae tufts on their citrus tree. It is thus important to study this relationship. The research aim is to investigate the loranthaceae species growing on citrus trees. The specific objectives were to (i) inventory the Loranthaceae species grown on Citrus trees, and (ii) study the level of parasitism of citrus species,

2. Material and methods

2.1. Study area

The research was carried out in the Mongo Department of the Littoral region. It is located in the western part of the former Eastern Cameroon and extends from south to north for nearly 140 km, but its width does not exceed 40 km and covers an area of 372,300 ha. It lies between latitudes 4°3'20" North and longitudes 9°57'30" East (Figure 1). The Mongo Department is characterized by a tropical climate, rainfall is high during nine months in the year, and the short dry season has little effect. The average temperature is 25.3 °C, and the rainfall have 2,862 mm a year.

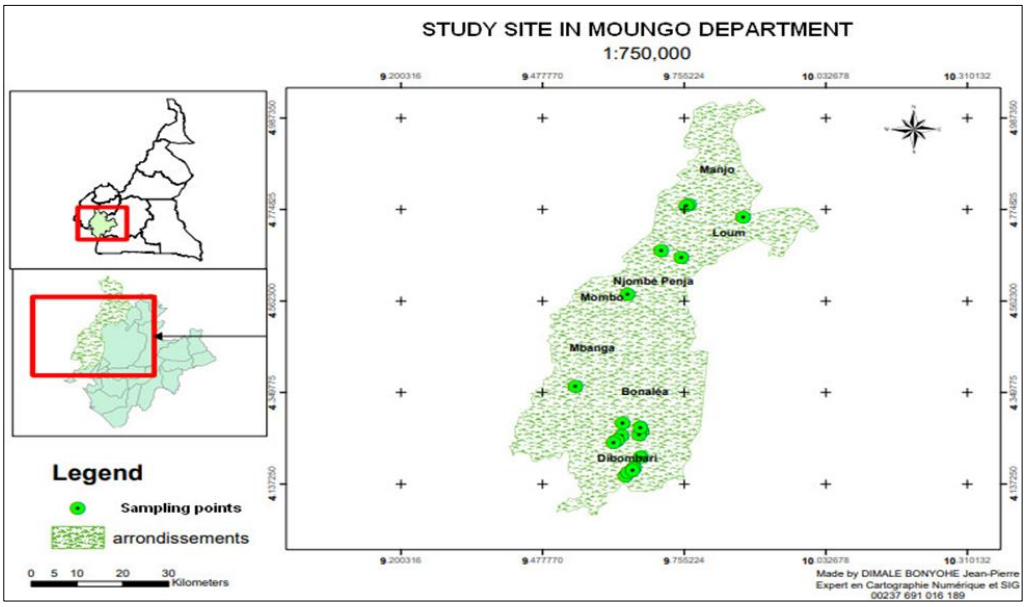

Figure 1 Map of the study area

2.2. Methods

2.2.1. Sampling method

The investigations were made in the period from October 2020 to January 2021 in 19 villages located in seven arrondissements. The type of sampling method chosen was systemic sampling. The data were collected in three types of cultivation systems: House Park, orchard, and agroforestry system. Thus, in each village, four transects with a length of 500 m were laid out from a central intersection, and following a direction from the center to periphery. Along these transects, on each citrus tree encountered, Loranthaceae was checked by direct observations in the canopy which the shape of their clumps. The species were identified by their characteristically colored flowers. In the absence of flowers, the identification of was completed using reference manuals such as Flore du Cameroun, or else at the National

Herbarium of Cameroon (NHC), as well as at the Plant Biology Laboratory of the University of Douala. To determine the natural mortality of Loranthaceae, dead Loranthaceae tufts were counted on host trees without the nature of species.

2.2.2. Data processing and analysis

From the data collected, it was thus possible to determine:

- Parasitic sensitivity (Pse), which is the number of species of Loranthaceae that can overspread on a host specie in a study area [10];
- Parasitic frequency (Pf) is the ratio of the number of individuals parasitized by a specie (Ni) to the total number of individuals parasitized (Np). Pf (%) = (Ni / Np) x 100.
- Parasitism rate (Pr) is the ratio of the number of trees parasitized (Np) to the total number of trees at a site (N). Pr = Np / N x 100 [11].
- Parasitism density (Pd) is the total number of tufts of Loranthaceae encountered on an individual. The average parasitic density (APd) was calculated by dividing Pd by the total number of parasitized trees (Np). APd = Pd / Np [12];
- Mortality rate (Mr) corresponds to the ratio of the number of died tufts (Ndt) to the total number of tufts of an individual (Pd). Mr (%) = Ntd / Pd x 100 [9].

3. Results

3.1. Citrus diversity

A total of 796 individuals of citrus trees were inventoried in the study area, belonging to six species. *C. sinensis* and *C. reticulata* were the most common species with 292 and 263 individuals recorded respectively. They were followed by *C. limon* (124 individuals), *C. maxima* (83 individuals), and *C. medica* (28 individuals). *C. paradisi*, showed the less number of individuals (Table 1).

3.2. Parasitism on the trees

3.2.1. Loranthaceae species identified

Five species of Loranthaceae were identified on 601 citrus trees in the study area. They belong to three genera, Helixanthera, Phragmanthera and Tapinanthus. The latter is the most diverse with two species: *T. bangwensis, T. preussii*, and *Tapinanthus* sp. The others genera are monospecific and contain species such as *H. mannii* and *P. capitata* (Figure 2).

Table 1 Distribution of Citrus species in the different arrondissements

Species	Dibombari	Ebone	Loum	Manjo	Mbanga	Njombe	Souza	Total
Citrus limon	16	1	0	35	4	43	25	124
Citrus sinensis	28	27	57	6	2	58	114	292
Citrus maxima	10	5	1	1	0	59	7	83
Citrus medica	0	3	1	0	0	24	0	28
Citrus paradisi	0	0	0	0	0	6	0	6
Citrus reticulata	106	0	84	7	1	39	26	263
Total	160	36	143	49	7	229	172	796

Figure 2 Loranthaceae species identified in the study area. A: *Helixanthera mannii*; B: *Phragmenthera capitata*; C: *Tapinanthus sp*; D: *Tapinanthus preussii*; E: *Tapinanthus bangwensis*

3.2.2. Parasitic density

The number of species of Loranthaceae ranged from 1 to 4 species on a parasitized tree with an average of 1.61±0.76 specie per tree. This means "sensitive specie" according to the parasitic sensitivity gradient. However, *C. limon* and *C. reticulata* revealed a higher parasitic sensitivity (4 species) than *C. maxima*, *C. medica*, *C. paradisi*, and *C. sinensis* which encountered 3 species (Table 2).

Figure 3 indicate the contribution of each Loranthaceae specie to the parasitic density of citrus species. It reveals that *P. capitata* and *H. mannii* were present on all the citrus species. This attest that both species are the prevalent Loranthaceae on citrus species. The higher contribution of *P. capitata* recorded on *C. limon* (60.97%), and the lower was on *C. reticulata* (37.83%). The contribution of *H. mannii* ranged from 41.07% on *C. medica* to 49.67% on *C. maxima*. The contribution of *T. preussii* was very high on *C. paradisi* (36.36%), compared to its different contributions observed on other citrus species (< 1.97 %). This denote a preference of this specie for *C. paradisi*, and can then be allotted as a specialist. *T. bangwensis* has been recorded all citrus species, except *C. medica*.

Table 2 Number of species of Loranthaceae recorded on the Citrus species

	C. medica	***C. limon***	***C. reticulata***	***C. sinensis***	***C. maxima***	***C. paradisi***
Minimum	1	1	1	1	1	1
Maximum	3	4	4	3	3	3
Mean ± SD	1.87±0.99	1.98±0.87	1.43±0.70	1.51±0.72	1.96±0.65	2.71±0.49

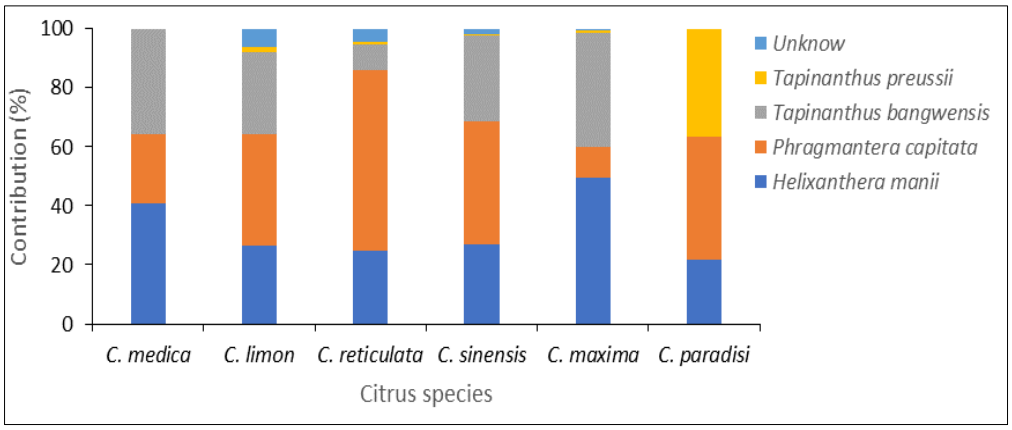

Figure 3 Contribution of Loranthaceae species in the parasite abundance of the citrus trees

3.2.3. Parasitic frequency

P. capitata was found on 453 individuals, thus a parasitic frequency of 75.37%, *H. mannii* followed with 43.93 % and *T. bangwensis* reached 30.95 %. *T. preussii*, showed the lower parasitic frequency (2.32%). A total of 4825 tufts of Loranthaceae have been enumerated on the citrus species. *P. capitata* recorded 2127 tufts, followed by *H. mannii* (1430 tufts) and *T. bangwensis* (1071 tufts). *T. preussii* and *Tapinanthus* sp. obtained 39 and 158 tufts, respectively (Table 3). These results attest that *P. capitata* can therefore be considered as the common specie of parasitized citrus trees, and occur with *H. mannii* and *T. bangwensis*. Regarding *T. preussii*, it was considered as a scarce specie.

3.3. Level of parasitism of Citrus trees

3.3.1. Level of parasitism of Citrus trees - Rate of parasitism

A total of 601 parasitized trees of 796 Citrus trees was found in the study area, with a parasitism rate of 75.50%. The higher parasitism rates were for *C. maxima* (89.77%) and *C. paradisi* (87.5%), and the lower obtained on *C. sinensis* (68.70%) and *C. medica* (47.06%). The higher parasitic density was 55 tufts in *C. limon*, followed by *C. sinensis* with 45 tufts and *C. reticulata* (42 tufts). *C. medica* with 21 tufts purchased the lowest parasitic density. Regarding the average parasitic density, it was higher on *C. paradisi* (23.57±7.06 tufts/tree) followed by *C. limon* (11.18±10.26 tufts/tree). The lowers averages of parasitic density were founded on *C. sinensis* (6.91 ± 7.70 tufts/tree) and *C. medica* with 8 ± 7.85 tufts/tree (Table 4).

3.3.2. Natural mortality of Loranthaceae

A total of 332 died tufts of Loranthaceae have been encountered hosts trees, for a mortality rate of 6.88%. The higher values obtained on *C. medica* (12.5%), *C. paradisi* (10.91%), and *C. limon* (10.20%). The lowers mortality rates were perceived on *C. reticulata* (5.93%) and *C. maxima* (0.79%) (Figure 4). For these results, *C. maxima* can thus be considered as sensitive to the Loranthaceae induction.

Table 3 Frequency of Loranthaaceae species on the host trees

Loranthaceae species	***Number of host plants***	***Parasitism frequency (%)***	***Number of tufts***
Helixanthera mannii	264	43.93	1430
Phragmanthera capitata	453	75.37	2127
Tapinanthus bangwensis	186	30.95	1071
Tapinathus preussii	14	2.33	39
Tapinanthus sp.	50	8.32	158

Table 4 Parasitism traits of citrus species

Hosts species	Number of infected trees	Total number of trees	Parasitism rate (%)	Parasitism density (Tufts per tree)		
				Minimum	Maximum	Mean SD
C. medica	8	17	47.06	1	21	8±7.85
C. limon	71	94	75.53	1	55	11.18±10.26
C. reticulata	257	327	78.59	1	42	8.49±7.02
C. sinensis	179	262	68.32	1	45	6.91±7.70
C. maxima	79	88	89.77	1	29	9.66±6.80
C. paradisi	7	8	87.5	11	33	23.57±7.06

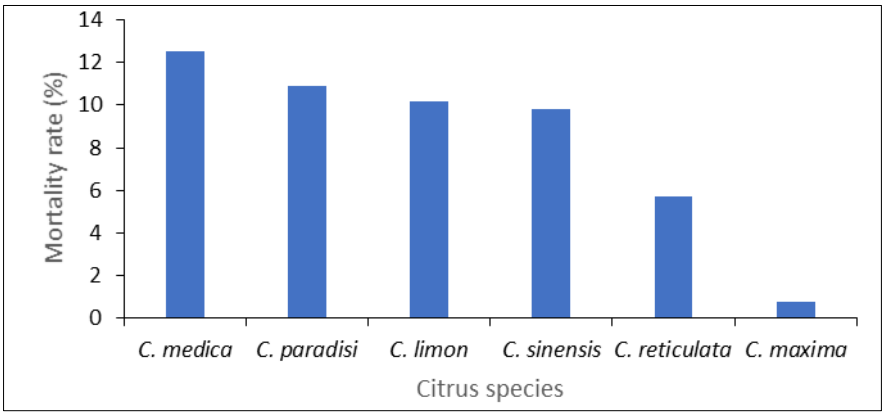

Figure 4 Natural mortality rate of Loranthaceae on citrus species

4. Discussion

Five species of Loranthaceae have been identified after the investigations: *Helixanthera mannii*, *Phragmanthera capitata*, *Tapinanthus bangwensis*, *Tapinanthus preussii*, and unknown specie. Three of these species, *H. mannii*, *P. capitata* and *T. preussii*, had been already mentioned in this region [13, 14]. *T. bangwensis* had previously been reported in the West Cameroon Highlands [15, 16]. The presence of *T. preussii* both in the low-lying coastal zone and in the western highlands means his adaptation at the low-lands climatic conditions.

P. capitata has already been observed on other cultivated plants such as *Persea americana*, *Theobroma cacao*, *Psidium guajava*, or *Hevea brasiliensis* [8, 10, 17]. It has also been reported on forest species such as *Cola nitida*, *Diospyros crassiflora*, *Irvingia gabunensis* [13, 18]. This confirms its ability to colonize several habitats, and species, hence the name of ubiquist which has been attributed to it by some authors. However, P. capitata was poorly reported in the Sudanese and Sudano-Sahelian regions [9, 19], but was still observed in southern Côte d'Ivoire, Benin and Ghana [3, 9, 20]. This makes it possible to qualify *P. capitata* as a specialist in the Guinean-Congolese zone.

Parasitism rates on citrus fruit ranged from 47.06% in *C. medica* to 89.77% in *C. maxima*, an average of 75.50%. These values are higher than those obtained in the same region on rubber trees (57.85%), and cocoa trees (35.33%) [10, 14]. In a larger scale, this rate is greater than the 10.44% found on cocoa trees in southern Cameroon [21], but also the 55.07% found on plum tree in western region [16], and 14.10% recorded on rubber trees in southern Côte d'Ivoire [22]. However, it is less than the 96% obtained on shea in northern Benin. It must therefore be noted that the parasitism rate obtained in the study area is the highest in the Guinea-Congo area, and becomes comparable to parasitism in the Sudano-Sahelian area.

C. medica showed the lowest parasitism rate and parasitic density. This is due to the shape of its dense foliage, but also to the presence of many thorns along its twigs and twigs. [23] Showed, by way of comparison, that bark quality influenced tree infestation by *Struthanthus polyanthus*, thus inferring that Loranthaceae parasitism depends on host

biological parameters. This is confirmed by higher parasitic rates and density in *C. maxima* and *C. paradisi*, two species with much fewer spines and thinner foliage.

5. Conclusion

At the end of this study, it appears that citrus trees of Mongo department are sensitive to the parasitism of Loranthaceae. Two Loranthaceae species occur on the trees, and one particularly aggressive on *C. paradisi*. Parasitism rate and parasitism density were elevated on all the citrus species. The natural mortality rate observed on the trees could be exploited for further researches on the sensitivity and resistance of citrus to parasitism by Loranthaceae.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

This work has no any conflict of interest with the authors.

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