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Research article

THE LORANTHACEAE (MISTLETOE) HEMIPARASITES VASCULAR TREES AND SHRUBS AGROECOSYSTEMS OF THE SUD-COMOÉ REGION, DENSE EVERGREEN FOREST AREA OF COTE D'IVOIRE

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ABSTRACT: The Loranthaceae are vascular plants hemiparasites, commonly called mistletoes are now a threat to many orchards. The present study carried in the agroecosystems of Sud-Comoé district, in a forest area of Côte d'Ivoire, aims to inventory the parasites species and determine the rate and Loranthaceae infestation intensity on tree orchards. The results obtained in this work show that the attacks of parasites in orchards plants are very important. These attacks are caused by 7 parasites species recorded on the feet of cocoa, coffee, rubber and spontaneous species of agroecosystems. Hundred sixteen host species, gathered into 77 genus and 35 families were parasitized. *Tapinanthus bangwensis* and *Phragmanthera capitata* are two ubiquitous species in the study area with an abundance *Tapinanthus bangwensis* on cocoa and coffee trees. The results show that the cocoa and rubber trees are the most infected. The average rates of infestation observed cocoa is 65.79 ± 21.17 and 60.70 ± 20.89 p.c. for rubber trees. The intensity of infection was 2.22 ± 0.54 tufts per plant for rubber against 1.65 ± 0.40 tufts per plant for cocoa. The degree of infestation orchards appeared to be related to age orchards in maintenance of orchards, a location of plants in the plots and the presence of parasites vulnerable spontaneous species. In the study area, mechanical control method is used by 84.40 p.c. of the interviewed farmers. But this method of struggle against parasites is perilous in rubber production, because of the tufts located high on the tree and branches fragility.
Key words: Agroecosystems - Loranthaceae - infestation rate - intensity of infestation - Sud-Comoé

INTRODUCTION

Côte d'Ivoire is essentially an agricultural country. The Ivorian agriculture today accounts for over a quarter of GDP and about 66 per cent of export earnings [14]. The main cash crops are cocoa, coffee trees and rubber trees. Annual production of these crops for export, rise for cocoa 1200 000 tons, for coffee 200 000 tons and 256 000 tons for rubber. The Côte d'Ivoire is the largest producer and exporter of cocoa in the world and third for coffee [9, 12]. It ranks seventh among the world's natural rubber producers [14]. However, the current agricultural situation in the Ivory Coast encounter many problems such as the aging of orchards and degradation feet of cultures due to parasitic pressure which the most important are related to the family of vascular plants Loranthaceae parasites, commonly called mistletoes often causing considerable yield losses in orchards [15]. In Ivory Coast, many work related to Loranthaceae were made including Amon, [1] Ball and Halle [5], Soro [18] and Traoré *et al*. [20]. Although these works have contributed to sound the alarm about the growing expansion of Loranthaceae on perennial crops, we are witnessing the presence of increasingly marked these hemiparasites on cultivated and spontaneous woody [1, 3]. The presence of hemiparasites on perennial crops and other fruit species has now become an agronomic problem [15]. In Côte d'Ivoire, farmers call the «AIDS trees» [20]. Very few adult subjects not infested Loranthaceae. Their pressure on the branches of a subject, causes a decrease in the growth of the individual parasitized, the host sometimes becomes economically unusable [17]. However, cocoa, coffee trees and rubber trees have many socio-economic interests for the country. The Loranthaceae therefore a threat against which an energetic struggle is necessary, given the magnitude of the observed damage. It is then necessary to know the parasitic plants growing on these cash crops, to look for methods of effective fight against this scourge. Specifically, it is an inventory of species and their hosts Loranthaceae, assess the state (by the rate and intensity) of infestation of crops, identify factors that influence the infestation, specify the damage to hosts and the control method used by farmers.

MATERIALS AND METHODS

Study sites

The work was carried out in the South-Comoé (Fig. 1), administrative region, located to the southeast of Côte d'Ivoire between Ghana to the east, the district of Abidjan, the departments of Alepé, Abengourou to the west and the Gulf of Guinea to the south. It comprises three departments (Grand-Bassam, Aboisso and Adiaké). The department of Aboisso, between 5 ° 66 'and 5 ° 28' north latitude and 3 ° 12 'and 3 ° 20' west longitude, is located 116 km from Abidjan [13]. The Adiaké Department extends between 5 ° 28 'and 5 ° 21' north latitude and 3 ° 16 'and 3 ° 08' west longitude, 94 km from Abidjan [4]. As for the department of Grand-Bassam (5 ° 26 'and 5 ° 13' north latitude and 3 ° 44 'and 3 ° 58' west longitude) is located 116 km from Abidjan [1]. The climate of the region is marked by subequatorial 4 seasons: a long dry season, from December to February, a short dry season in August, a large rainy season, from March to July and a small rainy season from September to November [7]. The original vegetation type is dense evergreen forest. But most of all this plant formation almost disappeared because of excessive exploitation of wood. It is noted however, the presence of forest relics of classified forests, reserves [16] and farms.

Fig. 1: Presentation of the Sud-Comoé, region southeast of the Côte d'Ivoire

MATERIAL

The biological material consists of Loranthaceae parasites that constitute a quantitative variable (count tufts and number of species) and qualitative (species identification). It also includes trees and shrubs of agro-ecosystems which are another quantitative variable (count parasitized plants and uninfected plants) and qualitative (species identification). Agroecosystems consist of cocoa plantations, coffee plantations and rubber trees grown on a large scale in the region. The technical equipment includes a global positioning system (GPS), digital camera, binoculars and a survey sheet.

METHODS

The work took place between 2007 and 2009 in 96 cocoa plantations, coffee plantations 96 and 96 rubber plantations. The farms were selected by a random draw, at random, based on the list of all the cocoa plantations, coffee plantations and rubber trees listed by the Departmental Directorate of Agriculture. For the collection of field data, surface surveys method was used [10]. It is to delineate a parcel to identify all taxa met there. To carry out this study, a single one hectare plot area (100m x 100m) was delineated and placed in different places in the plantations. The floristic inventory was then facilitated by subdividing the plot of bands of 10 meters wide and 100 meters in length (Fig. 2). Furthermore, to assess the effect of parasites on plants from the edge of plots and those of the center of the plantations, similar plots were put on the edge, center and intermediate in orchards (Fig. 3). In each band, healthy and infected individuals, the number of clumps of parasites on infected individuals were counted to determine the state of infestation (infestation rate and intensity):

- Infestation rate (Tx) = (number of individuals infected feet / total number of individuals identified) x100;
- The intensity of infestation (Ii) = total number of clumps of Loranthaceae / total number of identified individuals.

The collected data were coded and entered and cleared Excel 5.0. The Statistica 7.1 1 has revealed the results of statistical analyzes (ANOVA). The comparison of average rates and intensities of infestation was made by Newman-Keuls tests, the probability threshold 5 pc in case of significant differences [8].

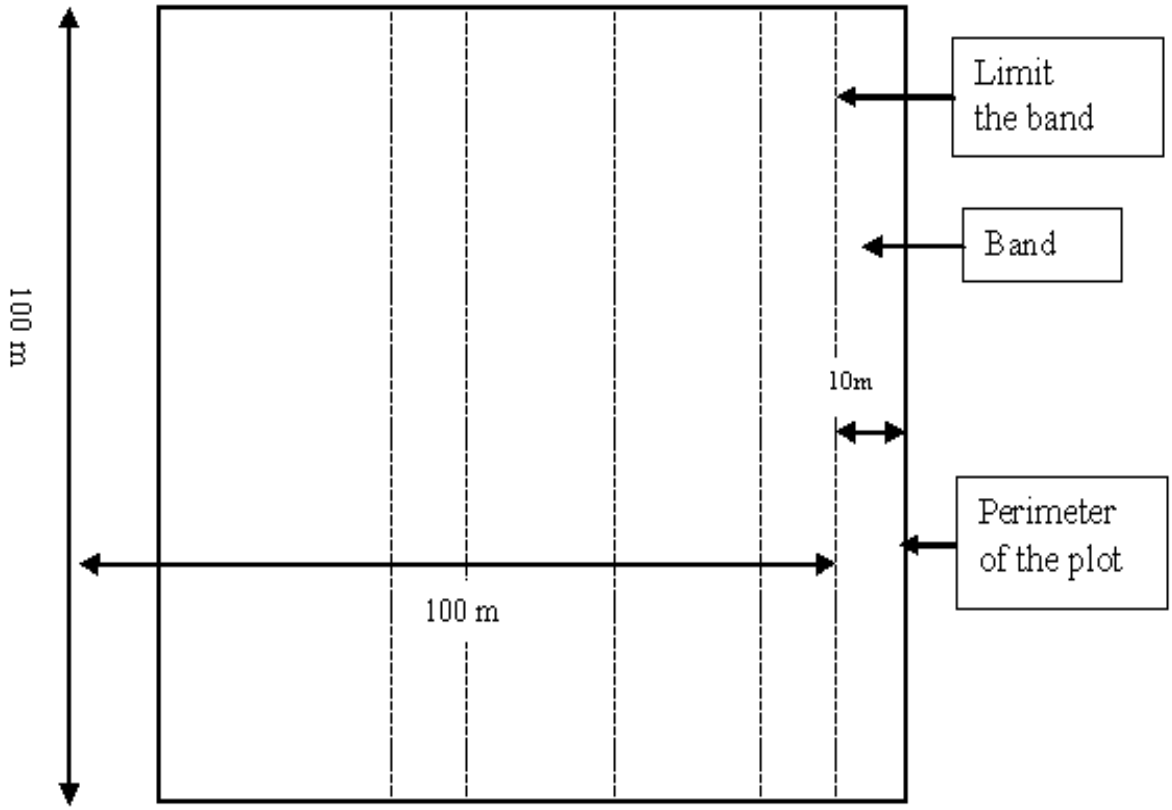

Fig. 2: Diagram of a survey of land in the rubber Aboisso

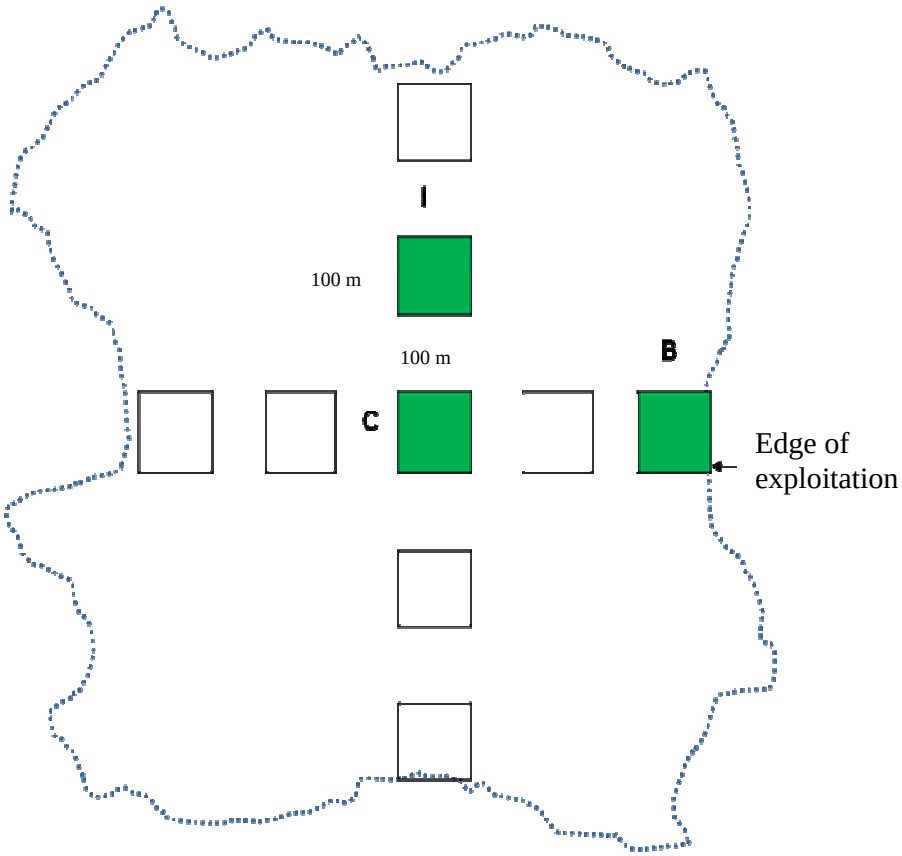

Fig. 3: Location of the plots in a plantation; B- Plot of edge; I- Intermediate plot; C- Plot in the middle

RESULTS

Floristic inventory

The methodology allowed to make the floristic inventory in agroecosystems of the Sud-Comoé region. Figure 4 shows the proportion of different types of trees and shrubs found in the farms. Regarding the main perennial crops, we surveyed 46,474 seedlings of rubber trees in the farms visited, a proportion of 20.94 pc of total seedlings encountered. As for cocoa and coffee, there is 165 793 individuals surveyed, or 74.58 pc of total seedlings.

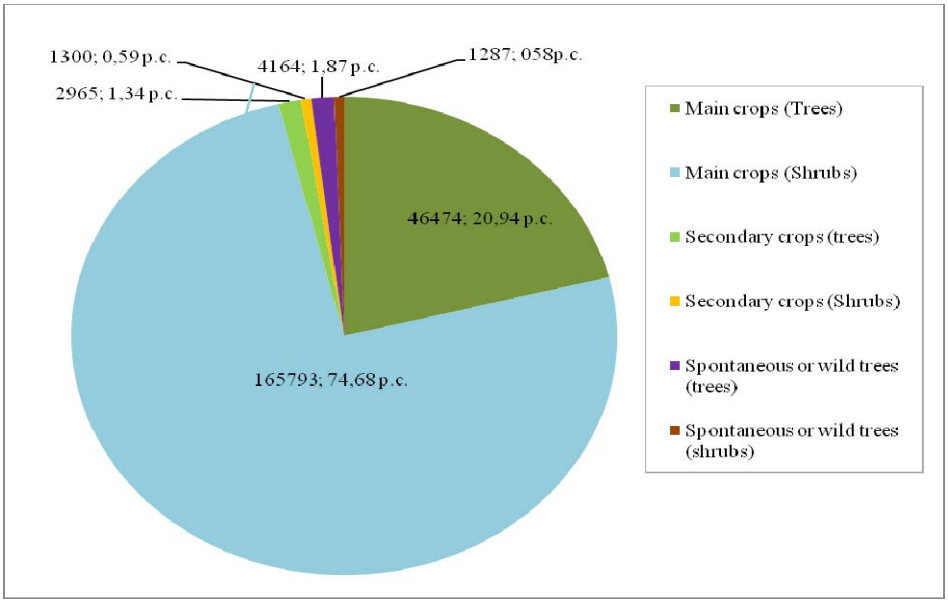

Fig. 4: Proportion of different types of trees and shrubs found in agroecosystems of Sud-Comoé

Loranthaceae species inventoried

7 species were identified and Loranthaceae identified in agroecosystems of the Sud-Comoé region. This is *Tapinanthus bangwensis* (Engl. And K. Krause) Danser (Fig 5), *Tapinanthus belvisii* (DC) Danser, *Tapinanthus sessilifolius* var. *glaber* (P. Beauv.) Van Tiegh. (Fig 6), *Phragmanthera capitata* (Spreng.) Ballé (Fig 7), *Phragmanthera capitata* var. *alba* (Spreng.) Ballé (Fig 8), *Globimetula braunii* (Engl.) Van Tiegh. (Fig 9) and *Globimetula dinklagei* subsp. *assiana* (Engl.) (Fig 10).

Fig. 5: Flowering branches of *Tapinanthus bangwensis* (Engl. et K. Krause) Danser

Fig. 6: Flowering and fruiting branches of *Tapinanthus sessilifolius* var. *glaber* (P. Beauv.) Van Tiegh.

Fig. 7: Flowering branches of *Phragmanthera capitata* (Spreng.) Ballé

Fig. 8: Leafy and flowering branches of *Phragmanthera capitata* var. *alba* Ballé

Fig. 9: Leafy and flowering branches of *Globimetula braunii* Van Tiegh.

Fig. 10: Leafy twig of *Globimetula dinklagei* Engl.

Estate infestations rubber trees, cacao trees and coffee trees

The estate of Loranthaceae of parasitism in farms of the region shows that the degree of infestation:

- rubber by department ranges from 21 to 68.22 ± 51.62 ± 22.36 p.c. for a high average value obtained Aboisso (Table 1). As for the intensity of infestation, the average ranged from 2.19 ± 0.58 and 2.26 ± 0,51touffes/plant for a significant mean value recorded in Grand-Bassam;
- cocoa per department varies between 61.45 ± 21.88 and 71.06 ± 19.21 p.c. for a high average value obtained Aboisso (Table 2). Regarding the intensity of infestation, the values range from 1.50 ± 0.27 to 1.80 ± 0.44 tufts / plant for a significant mean value recorded in Aboisso;
- coffee per department varies between 37.99 ± 20.82 and 53.24 ± 29.61 p.c. for a high average value obtained Aboisso (Table 3). The values of infestation intensity, meanwhile, ranged from 1.34 ± 0.21 and 1.66 ± 0.51 clusters / plant for a high average value recorded in Aboisso. The results show that cocoa trees and rubber trees are the most attacked in the region with average rates of infestation respectively 43.57 ± 24.21 and 65.79 ± 21.17 p.c. (Table 4). However, coffee trees are the least infected with an average of 43.57 ± 24.21 p.c. As for the intensity of infestation, rubber trees have the highest average infestation that was 2.22 ± 0, 54 tufts/plant. Variance analysis performed indicates a statistical difference between the infestation intensity of rubber and the other two cultures.

Table 1: Estate of infestation of rubber by department

Infestation	Rubber		
	Aboisso	Grand-Bassam	Adiaké
Infestation rates (p.c.)	68,22±22,36[a]	62,28±16,69[a]	51,62±21[a]
Intensity of infestation	2,19±0,58[a]	2,26±0,51[a]	2,22±0,58a

In the lines, means with the letter are not statistically different (Newman-Keuls test, P> 0.05).

Table 2: Estate of infestation of cocoa by department

Infestation	Cocoa		
	Aboisso	Grand-Bassam	Adiaké
Infestation rates (p.c.)	71,06±19,2	64,86±23,30[a]	61,45±21,88[a]
Intensity of infestation	1,80±0,44[a]	1,50±0,27[a]	1,64±0,45[a]

In the lines, means with the letter are not statistically different (Newman-Keuls test, P> 0.05).

Table 3: Estate of infestation of coffee by department

Infestation	Coffee		
	Aboisso	Grand-Bassam	Adiaké
Infestation rates (p.c.)	53,24±29,61[a]	39,47±20,52 [a]	37,99±20,82[a]
Intensity of infestation	1,66±0,51[a]	1,34±0,21[a]	1,28±0,13[a]

In the lines, Means with the letter are not statistically different (Newman-Keuls test, P> 0.05).

Table 4: Estate of infestation of cocoa trees, coffee trees and rubber trees in the area

Infestation	Cacaoyers	Rubber	Coffee
Infestation rates (p.c.)	65,79±21,17a	60,70±20,89[a]	43,57±24,21[b]
Intensity of infestation	1,65±0,40[b]	2,22±0,54[b]	1,43±0,36[a]

In the lines, affected middle letters a and b are statistically different (Newman-Keuls test, P <0.05).

Distribution of Loranthaceae on rubber, cocoa and coffee

Figure 11 shows that the orchards of the region are attacked by 7 parasitic species. These seven species are parasites on cocoa, coffee and 4 on 4 on rubber trees. *Tapinanthus bangwensis* and *Phragmanthera capitata* are more common and abundant in cocoa with a predominance of *Tapinanthus bangwensis*. On the coffee trees, there is abundance of *Tapinanthus bangwensis, Phragmanthera capitata* and also with predominance of *Tapinanthus bangwensis*. As for rubber, we have a strong presence *Tapinanthus bangwensis* and *Phragmanthera capitata* with a predominance of *Phragmanthera capitata*.

Damage on cocoa, coffee trees and rubber trees by Loranthaceae

Figure 12 shows the feet of heavily infected cocoa trees, having defoliated branches and dried under the action of parasitism Loranthaceae. At this level, it is not impossible to find on the same plant, several pest species, causing a decrease in the growth of infected individuals. In beads of training insertion points of parasites on host branches were observed, causing often languish in the distally (Fig. 13).

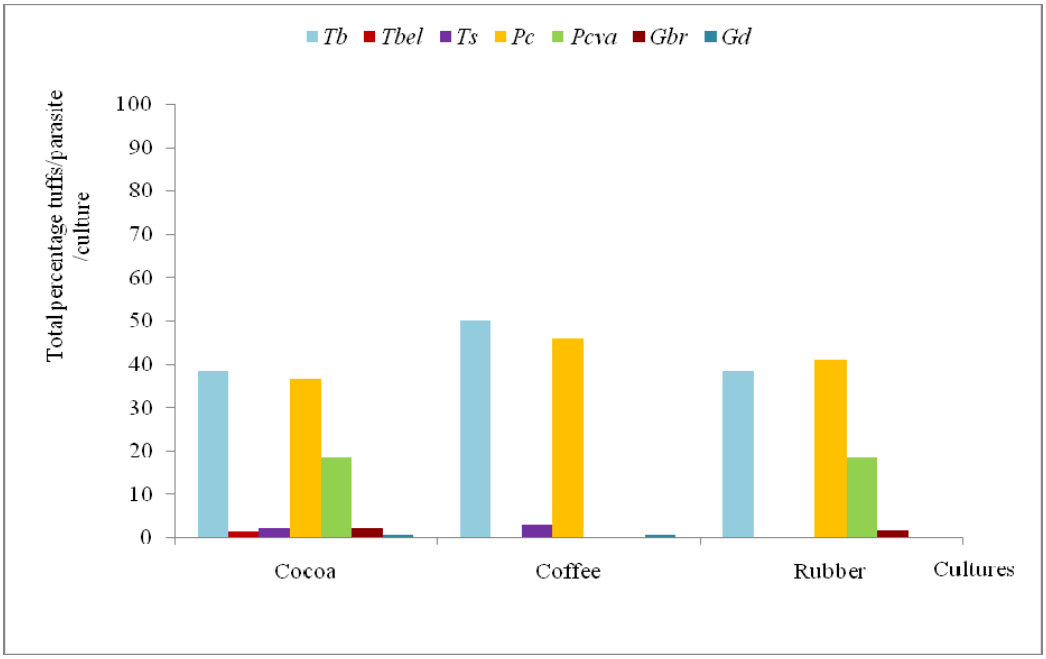

Fig. 11: Distribution of species Loranthaceae Crops

Fig. 12: Cocoa trees heavily parasitized by Loranthaceae with defoliated branches and dried

Fig. 13: Bead formation at the parasitic attachment zone (P) and hypertrophy of the distal portion of parasitized branch (H) *Coffea canephora* var. *robusta*

Factors involved in the infestation of rubber, coffee and cocoa trees

The results show that changes in the degree of infestation of crops increases with age. Adult subjects are attacked.

Figure 14 shows the crop infestation rates by locating plants in orchards. The variance analysis indicates statistically three different groups. Bordering orchards of the plants are the most attacked with an average infestation rate of 53.82 p.c. Those in middle position following an average rate of infestation of 43.65 pc In contrast, the plants are the center of orchards less attacked with an average infestation rate of 34.02 p.c.

The results also show that non-maintained orchards (Fig. 15) are attacked with average rates of high infestation than those obtained in the orchards maintained.

The presence of other very susceptible plants such as *Spondias mombin* Loranthaceae (Figure 16), *Cecropia peltata*, *Acacia mangium*, *Persea americana* and *Pycnanthus angolensis* amplifies the degree of infestation of orchards.

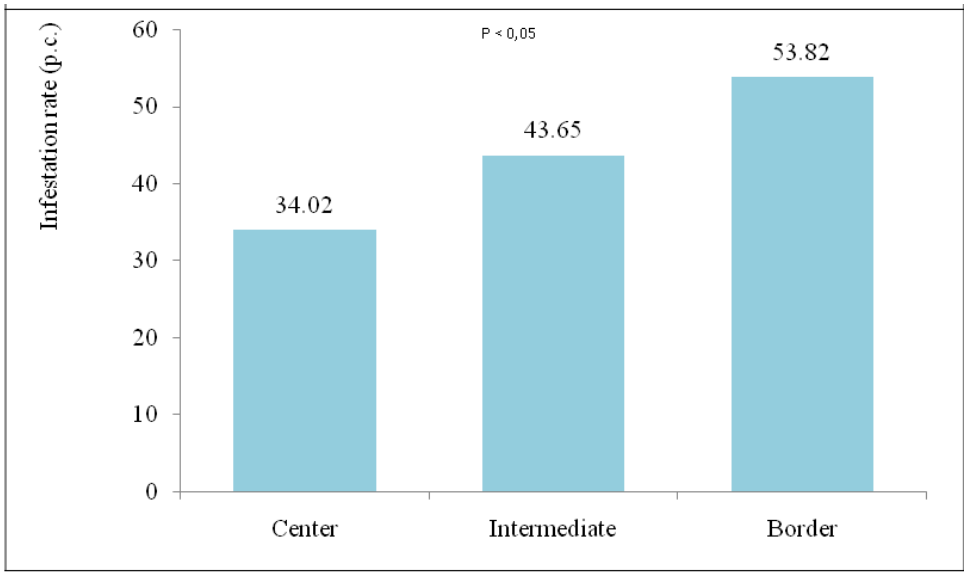

Fig.14: Infestation rate of crops depending on the location of the plants in orchards.

The letters a, b and c are statistically different (Newman-Keuls test, P <0.05).

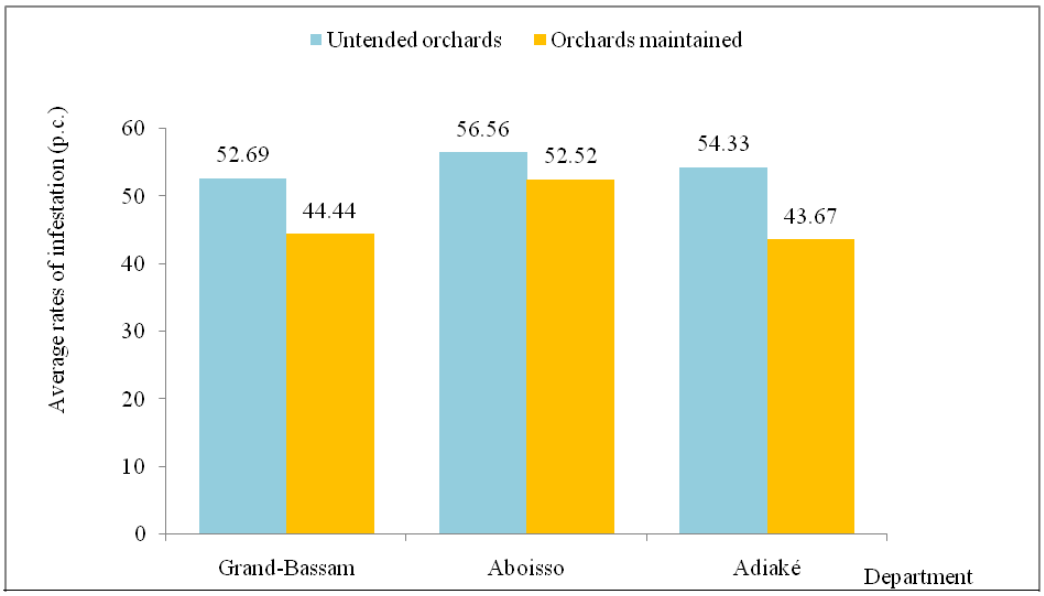

Figure 15: Orchard infestation rate based on the level of maintenance

Fig. 16: *Spondias mombin* heavily parasitized by parasitic plants

Host range of agro-ecosystems Loranthaceae

In agroecosystems of the South-Comoé region 115 host species parasitized by parasites on cocoa, coffee and rubber growing farms were identified. Guests Loranthaceae species inventoried are divided in 77 genera belonging to 35 families (Table 5). The most attacked families Apocynaceae, Caesalpiniaceae, Euphorbiaceae, Mimosaceae, Myrtaceae and Moraceae.

Tapinanthus bangwensis and *Phragmanthera capitata* are ubiquitous species but with a predominance of *Tapinanthus bangwensis* in the study area.

Table 5: Summary of the number of host species inventoried divided by gender and family, according to the orchards of South Comoé

Orchards	Total host species	Total genres	Total families
Cocoa	88	66	30
Coffee	64	52	29
Rubber	17	17	15
All orchards	115	77	35

Fight against Loranthaceae

The investigations have led to note that the mechanical control method by removing infested branches in orchards (Fig. 17) is used by nearly 157 farmers on 186 respondents, or 84.40 p.c. parasitized branches of the cocoa and coffee trees are removed using machetes or cocoa pod harvesting sickle instead of Lopper more suitable. However, this process is done without any rules (at least 30 cm upstream of the point of insertion of the parasite) and also without any control periods conducive to the fight (during the period of non-flowering and fruiting of non parasite). In terms of rubber, by pulling the control tufts on infested branches is practiced on young people (aged 1 year) whose size is between 1 and 1.5 m high. As for adult subjects (2 m and above), given the difficulties inherent in the height of the tufts located in the tops and especially the fragility of branches, the control method is nonexistent.

Figure 20: Branch of a cocoa tree infested with the parasite cut in a cocoa farm

DISCUSSION

The inventory of Loranthaceae identified seven parasitic species of trees and shrubs agroecosystems of the Sud-Comoé region. These results differ from those of Ballé and Hallé [5] that have inventoried 11 species in Ivorian forests. This difference in number of species is due to the extent of the study area, but also considered ecological environment. By against, this number exceeds the 5 species reported by Soro [16] in the Western orchards of Côte d'Ivoire.

The results show that *Tapinanthus bangwensis* is a ubiquitous Loranthaceae. It is abundant on cocoa and coffee plantations, as *Phragmanthera capitata* on rubber trees. By against, *Tapinanthus belvisii* only found in the littoral part of the region studied. This confirms the observations made by Amon [1] and Soro [18] that this parasite is a coastal species, restricted area that inhabits the coastal areas in Africa.

The average rate of infestation of all cocoa farms is 65.79 ± 21.17 p.c. and that of rubber amounts to 60.70 ± 20.89 p.c. Soro *et al*. [19] recorded similar results in test Pulses/coffee (63.20 p.c.). By against, these rates are higher than that obtained by 59.87 p.c. Houenon *et al*. [11] in citrus plantations in Benin and Soro *et al*. [19] in the test Pulses/cocoa (29.05 pc) in the forest zone of Côte d'Ivoire. According to Amon, [2] the heavy infestation of cocoa obtained is justified by the density of foliage that ensures greater security for bird seed propagators Loranthaceae.

Damage caused by pests on crops (outgrowth of training, dryness of parasitized branches, branch dieback hosts ...). According Boussim *et al*. [6], the deformations observed in individuals at guests' parasitic insertion points would be the consequence of the reaction of the host branches to contamination, while the branch dieback is due to host trophic deficit suffered by the end distal from the noisy branch. The cumulative effects of this deficit long term cause a general weakening of the host, so a drop of flowering and fruiting at some heavily infected subjects of cocoa and coffee. [11].

The results showed a variation in the degree of infection depending on the location of the plants in the plots. Indeed, the plants borders orchards are more infested than those in the center and can be explained by the fact of their combination of natural vegetation, which naturally includes host parasites. According Traoré *et al*. [20], Soro [18] and Amon [2], the birds that go on these hosts eat the pulp of the berries. The seeds previously stuck on the spout by viscin are transported directly on the border plants. Hence the low infestation level individuals from the center of plots where the birds are afraid to ask because of the human presence.

CONCLUSION

Seven species of Loranthaceae were identified in agro-ecosystems of Sud-Comoé. These seven species are parasites on cocoa which 4 were identified among them on the coffee trees and rubber trees. *Tapinanthus bangwensis* is abundant on cocoa and coffee plantations, as *Phragmanthera capitata* on rubber trees. The results show that cocoa trees and rubber trees are the most attacked orchards in the study area. Damage caused by parasitic plants in orchards were highlighted. The average rate of infestation farms appeared to be related to age orchards, at maintenance level, the location of plants in the plots and the presence of spontaneous species vulnerable to parasites.

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