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Poligui René Noel
Crops Production Department, National Higher Institute of Agronomy and Biotechnology (INSAB), University of Sciences and Technologies of Masuku (USTM), Gabon

Apinda Legnouo Emelie Arlette
Research Institute in Tropical Ecology (IRET), National Center for Scientific and Technological Research (CENAREST), Gabon

Nzandi Henri
Crops Production Department, National Higher Institute of Agronomy and Biotechnology (INSAB), University of Sciences and Technologies of Masuku (USTM), Gabon

Odjele Brishka Cornelie
Ingeneer student at Crops Production Department, National Higher Institute of Agronomy and Biotechnology (INSAB), University of Sciences and Technologies of Masuku (USTM), Gabon

Corresponding Author:
Poligui René Noel
Crops Production Department, National Higher Institute of Agronomy and Biotechnology (INSAB), University of Sciences and Technologies of Masuku (USTM), Gabon

Presence of *Pseudacysta perseae* (Heidemann) (Hemiptera: Tingidae) and it relate predatory mirid *Stethoconus praefectus* on *Persea americana* at Franceville, Gabon

Poligui René Noel, Apinda Legnouo Emelie Arlette, Nzandi Henri and Odjele Brishka Cornelie

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Abstract
A local pest survey was carried out at Franceville town on september 2022, within Avocado trees. The study aimed to record the avocado lace bug *Pseudacysta perseae* (Heidemann) (Hemiptera: Tingidae) and it impact on the host plant *Persea americana* L. (Lauraceae), based on recognizing and characterizing the insect pest symptoms, detecting it presence and local potential enemies. Results revalead that symptoms were observed in all parts (100%) of Franceville, with attacked trees ranging from 3.33 to 90%. The pest injury ranges from little foliage brown spots to complete tree defoliation. A predatory mirid diagnosed as *Stethoconus praefectus* (Distant) (Hemiptera: Miridae) was recorded feeding on the avocado lace bug *P. perseae*. Typical symptoms and both insect pictures were provided. Further studies are needed to highlight the pest distribution in the country and the predatory effectiveness.

Keywords: *Pseudacysta perseae*, *Hemiptera, Persea americana*, *symptoms*, *Stethoconus praefectus*, Gabon

Introduction

Pseudacysta perseae (Heidemann) (Hemiptera: Tingidae), commonly known as the avocado lace bug (ALB), is one of the major harmful pests on leaves of *Persea americana* (Lauraceae) [1, 2]. It also occurrs on closer sepecies fom same genus Persea, i.e., *P. borbonia* and *P. pallustris* [1, 2]. This insect pest is originally reported from Puerto Rico, and it is currenlty present in Bermuda, the Dominican Republic, Mexico, Surinam, and the United States [1, 2], Caribbean islands and in northern South America [3, 4, 5, 6, 7]. Given to available literature, there is any record reported from African and Asian countries [8]. The insect level impact on the avocado tree is most of times correlated to it natural regulators [3, 9]. Therefore, several natural enemies have been recorded, namely common predators as Chrysoperla rufilabris (Burmeister) (Neuroptera: Chrysopidae) and Paracarniella cubana (Bruner) (Heteroptera: Miridae), Tingidoletes praelonga Gagné (Diptera: Cecidomyiidae) [10], and *Stethoconus praefectus* (Distant) (Hemiptera: Miridae) [11, 12]. Egg parasitoids were also identified as Oligosita spp. (Chalcidoidea: Trichogrammatidae) [3] and mymarid species Erythmelus klopomor Triapitsyn [13]. In African avocado producer countries, there is any informations on *Pseudacysta perseae*, neither it relate natural enemies. Our goal in this study is to awarn about the presence of this pest and local predator in Gabon. The symptoms, prevalence and mpact of the *P. persea*e are presented, and the pest predatory mirid is identified and described.

2. Materials and Methods

2.1 Study sites

The study was carried out on September 2022 via an one time and intensive large survey of the pest presence and attacks in Franceville town, within trees of home gardens. Five areas, as fitheen parts of the town, were selected in order to have a deep and complete monitoring space covering. The town was subdivided on East, Center, West, North and South areas of three districts each one, and geographical coordinates of the fiftheen sampling sites (Table 1) were recorded via a GPS Garmin etrex10.

Table 1: Sampling sites distribution

Areas	Sampling sites	Observed trees	Altitude	GPS coordinates
North	Franceville 2	30	324m	1°36′21″S;13°35′12″E
	Ondzei	30	320m	1°37′28″S;13°36′50″E
	Ongwegne	30	337m	1°35′39″S;13°34′49″E
East	Awaye	30	392m	1°38′08″S;13°37′35″E
	Epila	30	458m	1°37′21″S;13°38′13″E
	Ongali	30	305m	1°37′19″S;13°36′55″E
Center	Ombele	30	301m	1°37′04″S;13°36′33″E
	Potos	30	293m	1°37′54″S;13°34′49″E
	Yoko	30	294m	1°37′49″S;13°36′28″E
West	Maba	30	417m	1°37′47″S;13°34′24″E
	Makana	30	351m	1°38′02″S;13°33′34″E
	Mbaya	30	326m	1°38′08″S;13°32′27″E
South	Mangoungou	30	359m	1°38′59″S;13°36′25″E
	Yene	30	381m	1°39′06″S;13°33′57″E
	Wendje	30	373m	1°38′01″S;13°35′39″E

2.2 Sampling method

The occurrence of ALB and it relate predatory mirid was assessed by direct visual observations on 30 avocado trees per site. In each site, all the accessible trees were observed, the height was evaluated using a 3m height wood ruler as template, and five parts of the tree's foliage were theoritically discriminated base on the canopy circonference at the ground, following a model used by some authors on the african plum tree in Congo Brazzaville [14]. All the tree's parts were visually examined in order to record symptoms (Fig.1).

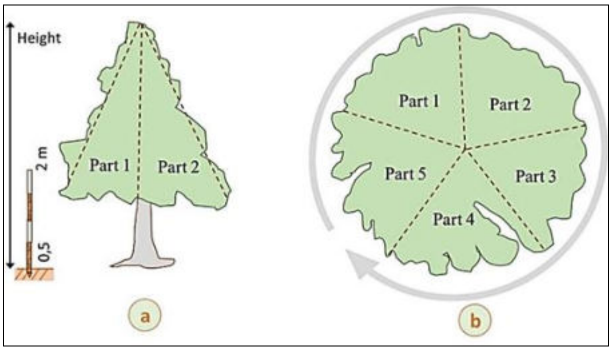

Fig 1: Height and canopy parts of a sampling tree (**a.** height, **b.** observed parts of canopy)

2.3 Symptoms and pest impact level

Once near a sampling tree, when the presence of symptoms is recorded, five twigs with injury were randomly selected and individually observed. Symptoms intensity was evaluated base on a scale built following the Davis scale model used to measure the impact of Fall Army Worm *Spodoptera frugiperda* (Lepidoptera: Noctuidae) on maize [15]. The current and adapted scale was compound with five levels (Fig.2) (level$_1$ = twig with any attack; level$_2$ =twig with one to two attacked leaves; level$_3$ =twig with three to five attacked leaves; level$_4$= twig with more than five attacked leaves; level$_5$=total defoliated tree).

Fig 2: Symptoms scale illustration (a. healthy twig, b. twig with one attacked leaf, c. twig with at least three attacked leaves, d. twig with more than five attacked leaves, e. defoliated tree).

2.4 Insect pest and natural enemie prevalence

The presence of the avocado lace bug and it relate predtory mirid was assessed in each part of the town, taking in account a sample of 30 trees randomly selected. The insect pest specific symptoms were the main critera of the recognizing it attacks on trees. For each observed avocado tree, five twigs were inspected, accordingly to the symptoms presence. The attacked leaves were individually analysed to recognize and identify both the pest and potential natural enemies, folowing their different stages (eggs, nymphs and adults). The prevalence level of attacked trees and twigs were calculated using following basic formula:

$$= \frac{\text{Number of infested stools}}{\text{Total of infested stools}} \times 100\,[\%]$$

Infested tools in this study correspond to a number of plants, twigs or leaves bearing insects. Therefore, total number of stools represent all the sampling plants, twigs or leaves.

2.5 Insect identification

With their specifics characteristics, the avocado lace bug was easily identified in field. Neverthless, some individuals insects were collected with the help of fine paintbrush and preseved in 70% ethyl alcohol in 15ml glass vials for later laboratory observations and identity confirmation. Furthermore, some predatory mirids were captured and placed into rearing boxes with their preys, and transported to the Crop Plants Protection Laboratory (CPPL) of the National Higher Institute of Agronomy and Biotechnology (INSAB) from the University of Sciences and Technologies of Masuku (USTM). The laboratory analyses were performed under a magnifying Leica z-step microscope, allowing to observed typical characters for each insect species. The predatory species *S. praefectus* was identified following morphological specific characteristics provided by available littérature [5, 12, 16]. The provided color images of *P. persea*e and *S. praefectus* were captured using incorporated Techno park4 camera.

2.6 Data analysis: Descriptive statistics, such as percentages, frequency tables, charts, simple means and was used to describe and present data generated.

3. Results and Discussion

3.1 Symptoms and pest injury level

The symptoms of ALB on avocado tree foliage consists on yellow chlorosis and brown necrotic patches on inside of leaves (Fig. 2a and 2b). The avocado lace bug feeding damage start in the interior of the leaf. Tip and leaf edges can burn like salt damage. Heavy feeding can lead to leaf drop and reduce fruit yield. In the underside of the attacked leaves, the insects (Fig. 2c) are usually present, with their black spotting corresponding to eggs covered with excrements (Fig. 2d).

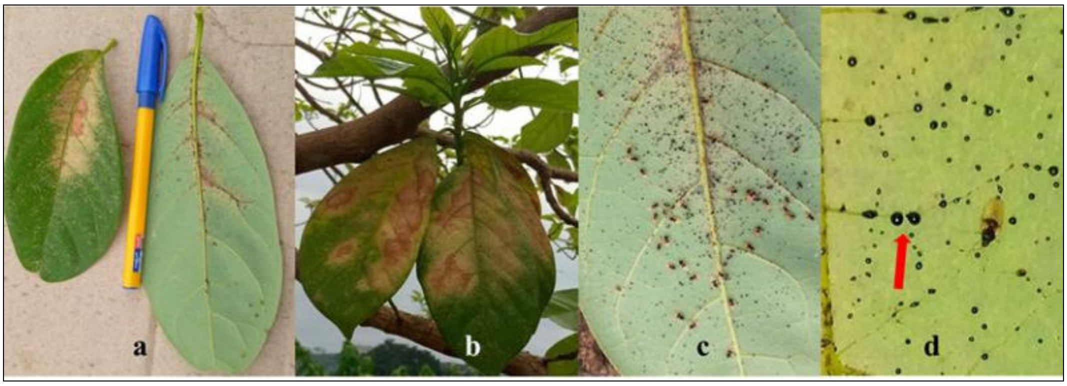

Fig 3: Symptoms of ALB (a. yellowish and necrotic blotch on uperside and underise of leaf, b. yellow chlorosis and brown necrotic patches, c. a lace bug colony, d. eggs covered with excrements)

These necrotic blotches and yellowing are the common damage observed, but some heavy attacks can lead to brown dead necrotic patches, and all the plant defoliation.

Survey of Avocado trees within home gardens took place in fifteen sampling sites with altitude ranging from 294m to 458 m. All the sites allowed to observe 450 trees with 3.9 ± 2.61 m to 11.08 ± 3.58 m height, and 32.22% plants displaying symptoms (Table 1). Highest attacks were recorded at the Center part of the town (61.11% of trees, for 90% at Potos site) followed by the East part (35.56%, for 86.6% at Ongali site), both sites with lowest altitude (294 to 305m) (Table1). The global injury level was low and ranged from 0.30 ± 0.21 to 1.53 ± 0.20, with high rates in the same former site. The analysis of the symptom's prevalence compaired to the sites altitude, the trees height, and the injury level, showed that there is any strong correlation between the percentage of trees bearing symptoms and the former three parameters (Fig. 3).

Table 2: Symptoms and injury level (30 trees per site)

Areas	Sites	Altitude	Trees' height	Symptoms Prevalence (%)		Injury level
				Per area	Per trees	
North	Franceville 2	324m	4.05 ± 2.48	10	10.00	0.43 ± 0.27
	Ondzei	320m	5.36 ± 3.95		16.67	0.61 ± 0.31
	Ongwegne	337m	11.08 ± 3.58		3.33	0.60 ± 0.55
East	Awaye	392m	4.16 ± 0.98	35.56	10.00	0.50 ± 0.35
	Epila	458m	7.34 ± 3.15		10.00	0.83 ± 0.21
	Ongali	305m	3.99 ± 2.61		86.67	0.85 ± 0.28
Center	Ombele	301m	6.79 ± 1.44	61.11	56.67	1.33 ± 0.19
	Potos	293m	5.82 ± 2.22		90.00	1.53 ± 0.20
	Yoko	294m	5.77 ± 3.06		36.67	0.80 ± 0.30
West	Maba*	417m	7.75 ± 3.51	14.44	20.00	0.97 ± 0.25
	Makana*	351m	7.17 ± 4.09		10.00	1.13 ± 0.38
	Mbaya	326m	6.85 ± 3.34		13.33	0.30 ± 0.21
South	Mangoungou	359m	7.41 ± 3.09	16.67	26.67	0.73 ± 0.32
	Yene*	381m	6.61 ± 2.22		16.67	0.72 ± 0.94
	Wendje	373m	6.86 ± 2.59		6.67	0.40 ± 0.32

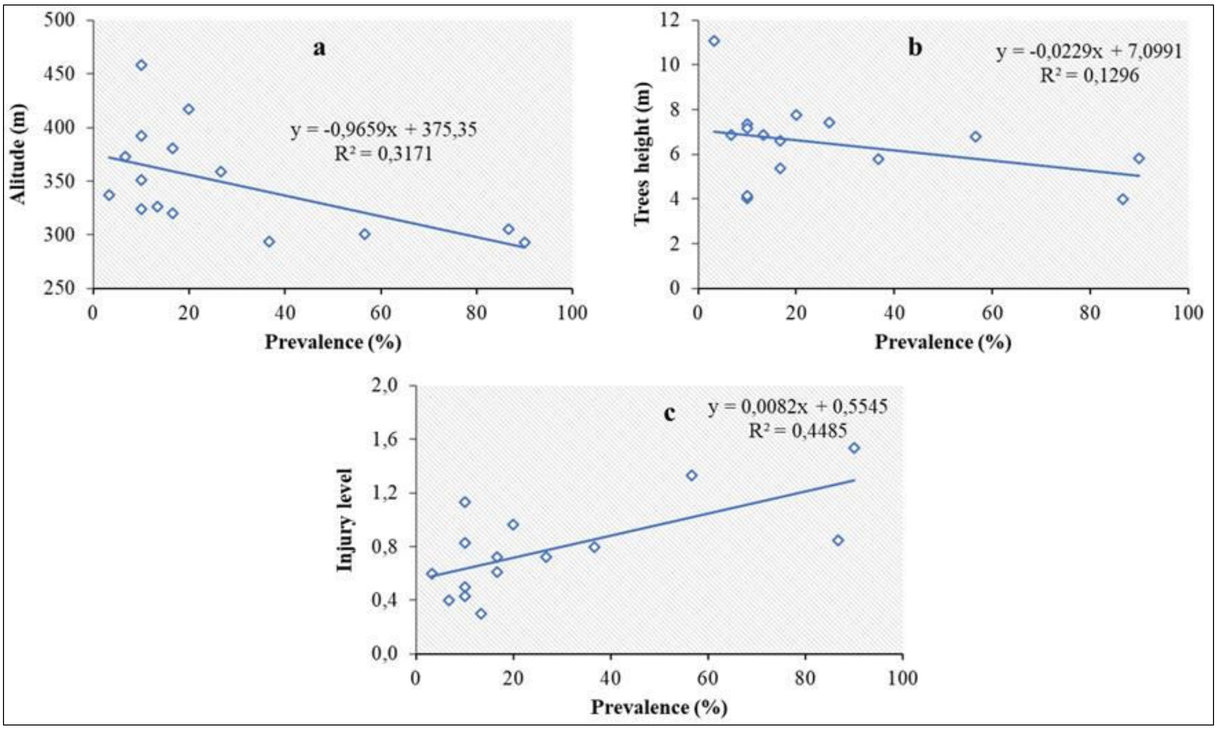

Fig 1: Relationship between symptom's prevalence and three factors (**a**. sites altitude, **b**. Trees height, **c**. injury level).

With concern of value of relationships (R^2), the symptom rates and the altitude (R^2=0.32) (Fig. 3a), and the symptom rates and the threes height (R^2=0.13) (Fig. 3b) had respective negative correlation, whereas the symptom's rates and the injury (R^2=0.45) showed a positive but weak correlation (Fig. 3c). Indeed, some highest injuries were recorded where symptom's prevalence was strong, but only whitin few sites.

3.2 Pest and predator prevalence

3.2.1 *Pseudacysta perseae*

The insect prevalence did not follow the trees height. The North of the town allowed record of weak attacks (10%, with 3. 33% at Ongwegne site) (Table 2). The presence of *P. persea* on the attacked trees (At) ranges from 12.50 to 100%, whereas 13.33 to 61.78% corresponded to twigs bearing insects among symptomatic branches. The different instars prevalence was respectively 13.33 to 80.00% for eggs, 0.00 to 80.00% for both nymphs and adults.

Table 3: Prevalence of Pseudacysta persea (%)

Areas	Sites	On At*	On 5 twigs per At	Eggs	Nymphs	Adults
North	Franceville 2	20.00	33.33	50.00	10.00	40.00
	Ondzei	88.24	21.33	32.00	14.67	17.33
	Ongwegne	100.00	20.00	20.00	0.00	40.00
East	Awaye	100.00	13.33	13.33	0.00	26.67
	Epila	33.33	20.00	60.00	0.00	0.00
	Ongali	57.69	61.78	70.67	58.67	56.00
Center	Ombele	58.82	56.67	66.00	48.00	56.00
	Potos	44.44	37.78	25.00	33.33	55.00
	Yoko	30.77	53.33	80.00	30.00	50.00
West	Maba*	-	-	-	-	-
	Makana*	-	-	-	-	-
	Mbaya	25.00	26.67	80.00	0.00	0.00
South	Mangoungou	12.50	80.00	80.00	80.00	80.00
	Yene*		-	-	-	-
	Wendje	50.00	13.33	40.00	0.00	0.00
Total	15	51.73	38.57	52.45	24.97	38.27

Legend: At*= Attacked trees

3.2.2 *Stethoconus praefectus*

Fiel observations allowed to record 48 individuals of the predatory mirid (21 larvae and 27 adults), respectively 47 (21 larvae and 26 adults) at Potos, and one adult at Ombele site.

3.3 Insect diagnosis

3.3.1 *Pseudacysta perseae* (Heidemann) (Hemiptera: Tingidae)

The Avocado lace bug is easily recognizable through their chracteristic behaviour and morphology. Both larvae and adults feed exclusively on the undersides of foliage but do not attack fruits. Eggs, immature stages and adults are visible on the underside of leaves, and the crawling stages usually feed together in colony (Fig. 4a). Eggs are covered with black excrements. Immatures ALB are dark red to black color, and smaller in size than adults. Adults are about 2 mm size in length and 1 mm in breadth,with oval shape, yellow antennae and legs, and black tips, bearing a black horizontal stripe across the blackish or brownish hemelytra (Fig. 4b).

3.3.2 *Stethoconus praefectus* (Distant) (Hemiptera: Miridae)

Stethoconus praefectus (Fig. 4c to e) is also called the predatory mirid of the Avocado lace bug, one of the harmfull pest of this host plant. Its larvae are greyish, with a very pointed adomen, dark to brown legs, and white to yellowish terminal antennal segment at the base (Fig. 4c). Within adults, considering the length from the head to the apex membrane, females size is larger (3.7 mm) than males (3.3 mm). External line of membrane cell is longer and truncate for females, whereas the males one is bold and completly close. Eyes are anteriorly prominent; the antennal segment I is dark brown; segment II is yellowish brown at base and apically dark brown; segment III is yellowish (Fig. 4d); segment IV is dark brown at base and pale at apex. The scutellum is apically hooked (Fig. 4e). For females' legs, the first femur is dark brown, pale at apex, the second and third femora are dark brown at base and on apical half. Tibiae and tarsi are pale yellow or white. For males' legs, the first femur is completly dark brown, the second and third femora are dark brown at base and on apical half. Tibiae and tarsi are also pale yellow or white.

Fig 4: ALB and it predatory mirid (a. colony of ALB on underside of attacked leaf, b. magnifying ALB, c. larvae of predatory mirid, d. female of *S. praefectus* predating in ALB adult, e lateral view showing a hook tip of the predator scutellum).

3.4 Discussion

3.4.1 Symptoms and pest injury level

Symptoms of the Avocado lace bug *Pseudacysta perseae* have been described and evaluated in Franceville. The presence of symptoms in all parts and sites of franceville is to explain that the ALB local propagation is done by wind (fligth). Injury was globally weak, but two threes were completly defolated, as descrbed by former authors in USA [1, 2]. The record of this pest is an important discovery, as for Gabon than the Central Africa region or the African continent. For this pest has never been reported from Africa, current results might help to index this insect as a new threat for African Avocado orchards. Untill this study, the occurrence of ALB was reported from Puerto Rico, Bermuda, the Dominican Republic, Mexico, Surinam, United States [1, 2], Caribbean islands and in northern South America [3, 4, 5, 6, 7]. It presence in this country is unexpected, because Gabon does not import fruits nor avocado seedlings from former cited regions. Neverthless, face to the climate change and the world global trade, this pest could have been accidentally introduced in Gabon. The neighboring countries could also be suspected as potential sources of introduction, namely both Congo Brazzaville and Cameroon where fruit's importations are frequent. Sailers from Congo Brazzaville used to transport some fruits within leaves of trees as *Maprounea africana* Müll. Arg. (Euphorbiaceae) and *Dacryodes edulis* (G.Don) H. J. Lam (Burseraceae), from Congo to Franceville [17, 18]. In this context, infested leaves of avocado could have been transported from a nearest neigboring country to Gabon.

3.4.2 Insect prevalence

Given that the hot spot of the ALB spreading seems to be Potos site, the town commercial center, it worth thinking that the pest came from nearest localities of Congo where fresh fruits are regularly provided at Franceville. The center site recorded more attacks and highest injury because the insect could had been probably escaped here. The heigh prevalence in nearest sites is obviously correlated to the insect spreading dynamic. The last and hypothetical explication is that the insect could have been always occurring in wild hosts from same botanical family, but has never be discovered. This way is worthy to be assumed, because in some areas where the ALB occurrs, species from *Persea* have been reported as alternative host plants. For in Gabonese context, there are woody spontaneous species belonging to Lauraceae, namely *Ocotea usambarensis*, *Beilschmiedia obscura*, *B. anacardioides* which wood is used in ebenistry [19]. The same author indicates that *Persea americana, Cinnamomum camphora*, *C. zeylanicum* and *C. cassis* are cultivated and introduced species. Is the ALB able to occur on local and other introduced species ? Further studies my take in acout this question. If the tree's height does not influence the ALB prevalence, the highest infestation levels were recorded in the sites with lowest altitudes. Somewhere, the attacks intensity could had been presumably, but not strongly, correlated to site altitudes. The current context showed that the original point of introduction seems to be the center town wich is (with the other neiboring sites) located in lowest altitudes. This correlation seems to be a random coincidence. Elswhere, the difference of the pest prevalence between sites seemed to be linked to the insect population dynamic. So, the duration of infestations, and the presence of a local predatory mirid *Stethoconus praefectus*, each one or both, could have been main factors justifying low, midle or high insect levels.

The discovery of *Stethoconus praefectus* in Franceville (South Gabon) provides un unexpected biological way to control the ALB. So, adults and larvae of this mirid species were observed predating in *P. persea*. Even if this beneficial agent was only found in two closer sites, there is a promizing interest to rear this predator and then release it in field. If the presence of it prey (*P. persea*) is not yet well elucidated, the occurrence of *Stethoconus praefectus* is not a surprise because it is known to be native to Africa and South

East Asia [15, 20]. The same authors reported *S. praefectus* as preying on other tingid species, namely on *Teleonemia scrupulosa* and on *Stephanitis typicus* (Heteroptera: Tingidae) in India. *Teleonemia scrupulosa* is a pest or insect feeder of *Lantana camara* (Verbenaceae) [20]. Given the presence of L. *camara* and of *T. scrupulosa* (We newly observe*)* in Franceville, it is not surprising that *S. praefectus* occurs in this town. In Franceville, favourable conditions for the development of predatory mirid seemed to be in place. Therefore, all local strategies against ALB might take in account *S. praefectus* as a predator with high potential of biological control. This mirid is kown to be effective on controlling the ALB [11].

3.4.3 Diagnosis

Base on characteristics of symptoms and morphological organs, the Avocado lace bug *Pseudacysta perseae* was clearly identified. It presence is a new event for avocado orchards, and a serious threat for fruit trees culture. This insect is newly observed in Franceville and Gabon, because former studies did not allow to observe it [17, 18]. There is also no literature awarning about it occurrence in Africa. The current discovery might help to advise other countries to be vigilent when controling imported avocado fruits, especially if there are fresh leaves in packages. Quarantine measures might also help to avoid the pest propagation. Neverthless, the identification of *Stethoconus praefectus* is a good indication allowing to a potential mass rearing and release of this biological agent. It presence at Franceville is to indicate that the predator might be well established in this town.

4. Conclusion

The avocado trees of Franceville are infested by a new coming pest *Pseudacysta persea*. All parts of the town are affected, and injuries range from leaves yellowing around necrotic blotches to trees complete defoliation. Tree's height might not be factor of *P. perseae* spreading. Altitude showed a weak correlaton with *P. persea*. The highest prevalence may correspond to the area of the insect introduction. However, the presence of the predatory mirid *Stethoconus praefectus* highlights that this beneficial insect might be a key on maintaining populations of *P. perseae* under low levels in Franceville. Further studies are underway to assess other predators and parasitoids, and ways for national, regional, or African global stategy for an effective biological control of ALB.

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