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Intraplant distribution of immatures lifestages of *Antichloris viridis* Druce, 1884 (Lepidoptera: Arctiidae) on plantain (*Musa* AAB, sub – group plantain, cv. Hartón) in the south of Maracaibo's lake, Venezuela

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Abstract

Two commercial plantations were selected in the Francisco Javier Pulgar and Colón parishes, Zulia state, Venezuela, with the aim of determining the distribution of *Antichloris viridis* in the plantain plant. The development phases of the plants (GD) were classified in six degrees, according to the number of leaves and the physiological status of the plant. The defoliation percentage and the presence of eggs, and small, medium and large larvae and pupae per leave was determined. Three stratum per plant were determined: upper, medium and lower. The greatest numbers of *A. viridis* inmatures were found on GD4 and GD5 plants ($P<0.05$) at La Providencia orchard, and GD4 at El Manantial orchard. Values ≥ 10% of defoliation in GD3 and GD4 were observed in both orchards. Significantly higher defoliation was found in the presence of 5 or more larvae at la Providencia orchard and ≤ 2 at El Manantial. Regarding the distribution within plants of *A. viridis* stages, the largest number of immature stages was found on the middle stratum GD4. These data suggest that monitoring for immature stages of *A. viridis* could be better accomplished by examining the middle stratum of plants on GD4.

Key words: Sampling, vertical distribution, defoliation, Arctiidae, foliage feeders, monitoring.

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Introduction

The crop of Hartón plantain in Venezuela is very important, not only by the socio-economical structure of the primary sector but also by its agriculture exportation potential to United States and Europe. Zulia state is the main producer nationally. Here, the south area of Maracaibo's lake has the highest number and the highest production units of the country, located between the Escalante and Mucuiepe river, specifically in the riverside of the Chama river, with a surface of 186.112 ha from which 78.366 ha are able for the crop of plantain and from these, 50.000 ha approximately are being sowed with plantain (*Musa* AAB, cv. Hartón), (17).

After the Sigatoka Negra, the most important phytosanitary problem in the plantain crop is represented by the attack of different species of defoliators lepidopters, among these is the Gusano Mota of banana, *Antichloris viridis* Druce, which is known as the most important defoliator associated to the plantain plantations in the south of Maracaibo's lake and in other countries (1, 2,3,5,6,8,13,14,16,20).

The population growth in these and in new genres of defoliator insects are produced more frequently, with higher intensity and in different season of the necessity of doing further studies with the aim of improving the design of programs for the integral handle of pest and the establishment of sampling methods of the main defoliator species, to then be able to determine the economical infestation area for the most important species, however, in the case of the musaceae the available literature is limited, without previous history that would allow the follow-up systems of the population, and without any knowledge of distribution, specially vertical and aerial, of defoliator larvae. It is not known either the quantification of the crop yields in relation to the lost of the foliar area, which is an important parameter in a integral program of pest handle.

In a research done of the biogeographical distribution of defoliator insects in 11 sectors of the south of the Maracaibo's lake, was found that *A. Viridis* is widely distributed in the country, being present in 100% of the visited sectors; and being the specie with higher economical importance in all the area of study, specially at el Chivo and Cuatro Esquinas, Zulia state (5).

In Venezuela, investigations done to determine the population parameters of *A. viridis*, started in the 90s. Likewise, Domínguez *et al.* (4), employing the modified Pinese and Piper scale (15), counted eggs, larvae and pupae, and the defoliation percentage trying to know the preferences of these insects in relation to the development stages of the plants. The knowledge of the vertical and aerial distribution of a determined defoliator specie offer a fast and trustable sampling method to estimate the population of larvae per leave or per stratum inside the plant as well as the affected area, which serves as a base for the decision-making in a program for the integral handle of pest.

The determination of the location of the different stages of these species in the plant (vertical distribution) and their location preferences in the sowed field (aerial distribution) might generate a valuable information on the ecology of the specie as well as to improve better and more efficient sampling procedures to achieve a well done estimate of the population and other basic aspects. Previous investigations indicate that eggs and larvae that were discriminated by their size (lower of 1 cm; between 1 and 2 cm and higher of 2 cm) of *A. viridis* in relation to the number and position of leaves, conclude that leaves with higher density of eggs and larvae were those of 1, 2 and 3; suggesting a female preference of this insect of laying eggs in the upper stratum or in the existence of a higher pressure of depredation or parasitism in the lower stratum (4).

In other crops with similar handle, as in the case of the oil palm in Costa Rica, the larvae population of *Opsiphanes cassina* has been estimated through counted averages in leaves 17 or 25, just in one or two palms per hectare (7, 18) when the population is distributed uniformly, besides researcher determined that larvae of *Oiketicus kirbyi*, are more abundant in the apical or sub-apical leaflets of that place of the plant (18, 19), confirming the necessity of needing information about the relative distribution of larvae per leaves according to their different positions in the phyllotaxy to facilitate the sampling work, due to the counting of larvae in the entire leaf might take lots of time, specially when are tiny larvae.

The purpose of this investigation is to determine the distribution of eggs, larvae and pupae of *A. viridis*, in leaves inside the plants, and the leaf to be sampled inside the "Development degrees" (GD) of the plantain plants, in two farms located in Francisco Javier Pulgar and Colón parishes, in the South of Maracaibo's Lake, Venezuela, as well as to estimate the defoliation values; with the aim of finding more efficient and simple sampling methods, to obtain an effective follow up of this important defoliator pest.

Materials and methods

Area of study

The investigations were done in two commercial crops where the application of chemical products were stooped during the realization of the essay, located at El Manantial farm of Francisco Javier Pulgar parish (on the right side of Chama river), with 30 ha of the crop, located at El Chivo, on the road toward Santa Rosa, with coordinates 8° 52´ 23" N and 71° 38´ 38" O, altitude of 9 msnm, and La Providencia farm of Colón parish (on the left side of Chama river), with 150 has, located in the area Caño Blanco, with coordinates 8° 42´ 17" N and 71° 53´ 00" O, with altitude of 30 msnm. The agroecological conditions of the area are typical of the micro region Chama; with annual mean temperature of 28.06 ºC, mean average relative humidity of 82.7%; mean annual precipitation of 1.313,8 mm and annual mean evaporation of 1.598,5mm (11, 12).

Field methodology

The selection of these plantations corresponded to the choice of plantations with presence of *A. viridis*, with a population density of 2 larvae/leaf, in the medium stratum of the plant, that is, leaves 5, 6 and 7. This was a randomized estimation, due to there is not any information that might be useful as a guide, to estimate the levels of economical damage.

With the aim of having uniform sampling methods, plants were defined under six categories according to their development and/or physiological phase, denominating this factor as "Development grade" (GD), considering the artificial clue based in the scale proposed by Pinese and Piper (15), and modified in six types by Domínguez *et al.* (4). These types are presented in table 1 and figure 1.

Plants were selected at random over lines of 60 m of longitude and taking as line a plant of each GD in 10 m, with a total of 15 lines, 6 plants per line and 90 plants in total per each plantation to be sampled; with a farm area of 7.200 m^2, and 180 plants in two plantations; being the total area of the essay of 14.400 m^2. At the same time, and with the aim of identifying the position of leaves to be sampled, a numbering of these was done following the natural phyllotaxy of the plant, beginning from the youngest plant as "the first" without counting the flag leaf (the youngest leaf with a non develop foliar limb) and following

Table 1. Definition of the "Development degrees" of the plantain plants for the sample of *A. viridis* in the South of Maracaibo's Lake, Venezuela.*

Development degrees	Distinctive characteristics
GD1	Plants with more than three leaves
GD2	Plants with from four to six leaves.
GD3	Plants with from seven to ten leaves.
GD4	Plants with more than ten leaves, but before flowering.
GD5	From the flowering to the "finger" of the bunch form a 90º angle with the shoot.
GD6	When "fingers" of the bunch form a 90º angle with the shoot to the crop

*The newest leaf is not considered to the non developed foliar limb

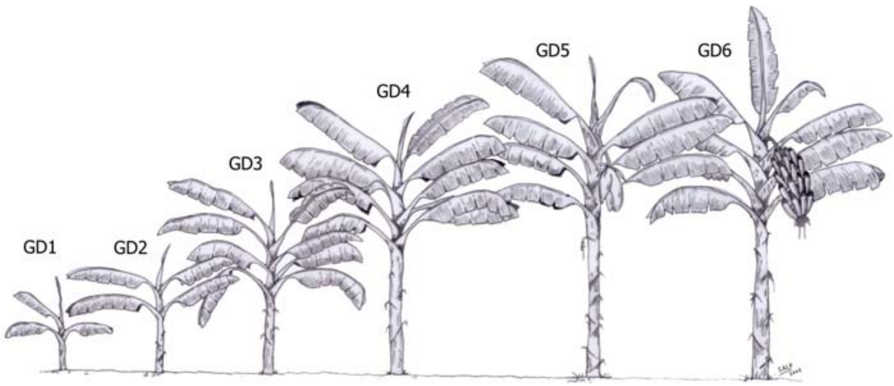

Figure 1. Schematic profile of GD of plantain plants. Scale modified by Domínguez *et al.* 1998.

the order of the petioles until numbering the oldest one. The defoliation consisted on cutting the leaf on its petiole using a cutter machine (a tool with long wood or metal handle, with a sharp knife in one of its extremes, which is used to defoliate and to crop).

Each selected plant was totally defoliated, and each sampled leaf was considered, counting eggs, larvae and pupae of *A. viridis*, as well as the defoliation percentage. Larvae were classified in L1: with a longitude ≤ of 1 cm; L2: > of 1 cm and < of 3 cm; L3: larvae ≥ of 3 cm.

The defoliation percentage was measured quantitatively, dividing each leaf imaginarily in four sector or quadrants, and assigning a relative percentage value of defoliation in only one sector of the leaf. The used types were determined in a scale with multiples values of five, that is, between 0= without damage until 100= 100% of defoliation. A follow-up was done in some localities to know the existence possibility of other defoliator species of the crop in the region, to then choose only two plantations with an almost exclusive presence of *A. viridis*. This does not discharge the existence probability of other defoliator insects in that moment, which were not considered by their low frequency, hence all the estimated defoliation was assigned as already done by larvae of *A. viridis*.

Statistical methodology

The field information was registered in papers specially designed for that purpose and the information was analyzed statistically in order to determine the distribution of variables and also to choose the most adequate procedures through the use of the statistical software SAS (21). The analysis of the information determined that variables do not accomplish the normal distribution, which is a necessary condition to do the procedures of T and F tests, that is, traditional parametric tests. Hence, it was proceeded to use the transformation of square root of X, square root of X+1, the logarithmic value, arch-sine and the cubic root, none of which resulted satisfactory, therefore it was proceeded to use «Non Parametric» tests using the statistical χ^2 that is distributed according to squared Chi or applying it in distribution tables of frequencies for variables, to which was additionally determined the contingence coefficient to establish the association between them. The Kruskal and Wallis test was applied to try the equality hypothesis between the average frequency of the studied variables by effect of GD.

In some cases, the information obtained directly in the field showed high variation coefficients for some variables, which determined the grouping necessity in types. As in the case of the defoliation percentage that was separated only in two types, <10% and ≥10% of defoliation, considering that these values of lost of the foliar area are already critical in the musaceae plants. Likewise, for the case of eggs, larvae and pupae of the insect, grouping were done to then be analyzed individually and groupally, this last mentioned as «Presence of the insect». In the position of leaves, analysis showed results that justify its consideration under three types of stratum; upper stratum: leaves N1 1, 2 and 3; medium stratum: leaves N1 4, 5 and 6; lower stratum: leaves Nº 7 and the oldest.

Results and discussion

In table 2 are presented the infestation frequency of *A. Viridis* (amount of eggs, larvae and pupae) in relation to the GD of plants at La Providencia farm. Of 679 cases only 414 were included where the insect was found. With the Kruskal-Wallis test an infestation frequency was determined, which was statistically significant (P<0.05) in plants GD4 and GD5; followed by GD3 and GD& and lastly GD1 and GD2. This scarce reference of GD1 and GD2 might be due to the presence of toxics substances in young plants, supposition that has to be determine in the future; while in the case of adult plants might be due to the more lignified texture and lower content of nutritious substances; causing a higher difficulty so larvae may nourish from them, this might be the refusal cause of this kind of plants. This results agree to the obtained by Manley (10) who found that most larvae of *Ceramidia butleri* nourish from the leaves of the flowered banana plants.

At El Manantial farm, 281 cases of infected plants with A. *v*., were found of a total of 682, and using Kruskal-Wallis test the same infestation frequency was determined, which was statistically significant (P<0.05) in GD4 plants, followed by GD3, GD5 and GD6 and lastly GD1 and GD2, as can be observed in table 3.

These results allow to recommend the counting of immature

Table 2. Infestation frequency of *A. viridis* and its relation to the GD of the plantain plants at La Providencia farm, Zulia state, Venezuela.

		Development degree						
	Frequency	1	2	3	4	5	6	Total
Infestation	1-2	0	6	15	23	12	11	67
	2-3	0	7	18	19	13	10	67
	3-4	0	2	12	16	7	7	44
	4-5	0	1	10	14	10	4	39
	≥5	10	3	21	53	58	52	197
	Total	10[c]	19[c]	76[b]	125[a]	100[a]	84[b]	414

*Presence of the insect= amount of found eggs, larvae and pupae.
Different letters in the same line indicate a statistically significant independence (P<0.05).

A. *v*. that might be done in the future to follow-up this pest, as well as to determine the economical values of infestation, which must concentrate in plants with GD4, representing less physical effort and less waste of time for sampling.

Relating the GD to the percentage frequency of defoliation that was found, the Kruskal wallis test ratifies the preference of these insects by GD4 plants. In tables 4 and 5, the observed defoliation frequencies that are lower or higher of 10% are presented compare to GD of the plant for the two studied localities.

In table 4 can be seen that at La Providencia farm, the defoliation percentage ≥ 10%, values that are considered as critical, are statistically

Table 3. Infestation frequency of *A. Viridis* and its relation to the GD of plantain plants at El Manantial farm, Zulia state, Venezuela.

		Development degree						
	Frequency	1	2	3	4	5	6	Total
Presence of the insect	0-2	5	10	19	59	26	27	146
	2-3	0	0	20	18	13	11	62
	3-4	0	2	7	10	2	11	32
	4-5	0	0	5	4	3	4	16
	≥5	0	1	7	9	3	5	25
	Total	5[c]	13[c]	58[b]	100[a]	47[b]	58[b]	281

*Presence of the insect= amount of found eggs, larvae and pupae.
Different letters in the same line indicate a statistically significant independence (P<0.05).

Table 4. Frequency of the defoliation percentage caused by *A. viridis* in relation to the GD of plantain plants at La Providencia farm, Zulia state, Venezuela.

Frequency/ percentage		Development degree						
		1	2	3	4	5	6	Total
% of defoliation	<10	38[c]	63[b]	87[a]	75[a]	112[a]	44[b]	419
		5.74	9.28	12.82	11.04	16.34	6.48	61.71
	≥10	7[c]	15[c]	44[b]	92[a]	42[b]	60[a]	260
		1.03	2.21	6.48	13.55	6.18	10.30	39.75

Different letters in the same line indicate statistically significant independence (P<0.05).

higher (P<0.05) in GD4 plants, a 13.55% of 39.75%. These values, do contrast with 61.71% of cases with minor defoliations at 10%, but can not be directly compare due to the defoliation is an accumulative effect in the time, not necessarily related to the population of the illness at the moment of the sample.

At El Manatial farm (table 5), the Kruskal-Wallis test points that results are significant (P<0.05) and in plants with GD4 the defoliation percentage was higher than 10%, almost duplicating the rest in 13.93% of cases.

These results show that inside GD4 and GD5 plants, previously identified as the most adequate in relation to the infestation frequency and interpreted as a preference for the insect by the types of plants (tables 2 and 3), can be chosen with more time and accuracy in the sample, only GD4 plants with the purpose of determining population levels that might be related in the future to some parameters that would help to make decisions about strategies of the pest handle.

When analyzing both factors,

Table 5. Frequency of the defoliation percentage caused by *A. viridis* in relation to the GD of plantain plants at El Manantial farm, Zulia state, Venezuela.

Frequency/ percentage		Development degree						
		1	2	3	4	5	6	Total
% of defoliation	<10	33[c]	53[b]	65[b]	74[b]	129[a]	72[b]	426
		4.84	7.78	9.53	10.85	18.92	10.56	62.48
	≥10	10[c]	24[c]	59[a]	95[a]	24[c]	44[b]	256
		1.47	3.52	8.65	13.93	3.52	6.45	37.54

Different letters in the same line indicate a statistically significant independence (P<0.05).

which are the infestation frequency and the % of defoliation, is found that at La Providencia farm (table 6) is a significant statistical logical association between them (P<0.05) using the Kruskal-Wallis test with a higher infestation frequency related to a higher defoliation.

At El Manantial farm (table 7), values of low infestation of the insect (>0 and >2) are the highest, independent to the defoliation percentage. These results might be disguised by previous populations which might had been absent at the moment of the sample. In this farm results suggest an earlier attack of the pest, with a high % of defoliation though of low values of the insect frequency. This information might be used as a guide by the fact of finding more than two species of *A. viridis* at any of its stratum in order to face in a short term high defoliations.

Distribution by stratum

In relation to the position of the leaf toward the phyllotaxy of the musaceae once analyzed the obtained results, was considered the necessity of joining them in three stratum: lower, medium, upper.

These results indicate that a higher frequency of infestation is found in the upper and medium stratum which are statistically significant (P<0.05). Independently to the GD of plants, these are the stratum that better estimate populations of *A. viridis* and where should be focused the attention when doing samples for this purpose, since the lower stratum is not constant in the time.

If defoliation values are considered the same or higher than 10% as well as the presence of the insect in relation to each of the considered stratum, is found that the medium stratum, also statistically related (P<0.05) is the one that has the highest defoliation values, being higher than 10% and though differences in relation to the presence of the insect are not so market, an accurate choice of the stratum to be sampled would indicate the medium stratum (table 8).

These results indicate that it is

Table 6. Relation between the frequency of the defoliation percentage and the presence of *A. viridis* on plantain plants at La Providencia farm, Zulia state, Venezuela.

Frequency/ percentage		Presence of the insect					
		>0 <2	>2 <3	>3 <4	>4 <5	>5	Total
% of defoliation	<10	38[b]	37[b]	19[c]	24[b]	102[a]	419
		5.59	5.45	3.38	3.53	15.02	61.71
	≥10	29[b]	30[b]	21[b]	15[c]	97[a]	260
		4.27	4.42	3.09	2.21	14.28	38.29

Different letters in the same line indicate a statistically significant independence (P<0.05).

Table 7. Relation between the frequency of the defoliation percentage and the presence of *A. viridis* on plantain plants at El Manantial farm, Zulia state, Venezuela.

Frequency/ percentage		Presence of the insect > 0 <2	>2 <3	>3 <4	>4 <5	>5	Total
% of defoliation	<10	72[a]	16[b]	6[c]	3[c]	0[c]	426
		10.55	2.34	0.88	0.44	0.00	62.46
	≥10	74[a]	46[b]	26[b]	13[c]	25[b]	256
		10.85	6.75	3.82	1.90	3.67	37.54

Different letters in the same line indicate a statistically significant independence (P<0.05).

possible to define the best moment and place for the sample with the aim of estimating the population of *A. viridis* and therefore, to make decisions defining parameters as for example the economical value of infestation and the best moment for the application of any handle measure for this defoliator lepidoptera, that might contribute to reduce or eliminate the application of chemical products.

According to the obtained results, the most adequate sample must be done in GD4 plants, in leaves of the medium stratum (leaves from 4 to 6); agreeing to the results obtained in previous investigations (5), where a non-replicated sample methodology was applied, taking plants at random in the time and in the space without considering the

Table 8. Frequency in percentage between the defoliation percentage and the presence of *A. viridis*, in relation to the vertical stratum of the plantain plants and at La Providencia and El Manantial farms.

	La Providencia farm			El Manantial farm		
	Upper stratum	Medium stratum	Lower stratum	Upper stratum	Medium stratum	Lower stratum
Defoliation < 10%	63.48[a] n=266	28.40[b] n=76	8.12[c] n=34	65.72[a] n=280	25.82[b] n=110	9.45[c] n=36
Defoliation ≥10%	25.77[b] n=67	44.99[a] n=117	29.22[a] n=119	24.62[b] n=63	51.55[a] n=132	23.82[b] n=61
Presence of the insect	54.05[a] n=180	69.91[a] n=165	64.54[b] n=71	25.65[a] n=343	58.67[a] n=242	52.57[b] n=97

Different letters in the same line indicate a statistically significant independence (P<0.05).

physiological status or GD of these, found that the highest number of larvae are in the intermediate area of the plant, between leaves 4 and 7. However, future investigations must be done to corroborate the previous mentioned in other localities and other defoliator species in the determination of parameters, as the total number of leaves to be sampled, critical number of insects per leave, relation between lost of the foliar area and yield, among others.

Conclusions and recommendations

The highest infestation of *A. Viridis* was found in GD4 plants, with an approximation of 112.5 examples of the insect, that are statistically different (P<0.05) compare to the others GD. The highest % of defoliation (P<0.05) was observed in GD4 plants, where an average of 93.5 plants with more than 10% of defoliation was found, which represent more than 13% of the total of plants compare to the others GD.

In relation to the distribution in the plant of *A. viridis*, the medium stratum of leaves from 4 to 6 is where the highest infestation of the insect is observed, with an average of 64.29 individual, that were statistically significant (P<0.05) compare to the rest of the stratum. The same happens to the values of the defoliation percentage that reached an average of 27% (P<0.05)

There should be further investigations with the aim of obtaining a better precision determining the population parameters of *A. viridis*., in order to study these aspects in other locations determining parameters as the total number of leaves to be sampled, critical number of insects per leaf, relation between lost of the foliar area and yield, value of the economical damage, maximum lost damage, among others; with the purpose of supporting the elaboration and practice of an integral handle program of this pest, corroborating the results of this investigation in the time and in different localities and in the different localities to improve the population information of *A. viridis* and of other defoliators in plantain in the South of Maracaibo's Lake.

It might be important to do population evaluations in the six GD by each sampled part, with the aim of obtaining a wider population information, hence to know the aerial distribution of *A. viridis* inside the plantation.

According to the obtained results and the considerations previously mentioned, leaves 4 and 6 must be chosen from GD4 plants to do samples for determining the useful population parameters as a base for the integral handle programs to attack this pest.

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