Effect of replanting systems on populations of *Strategus aloeus* (L.) and *Rhynchophorus palmarum* (L.) associated with the oil palm OxG interspecific hybrid (*Elaeis oleifera* × *Elaeis guineensis*) in Southwestern Colombia

Efecto de sistemas de renovación sobre las poblaciones de *Strategus aloeus* L. y *Rhynchophorus palmarum* L. asociadas al híbrido interespecífico OxG (*Elaeis oleifera* × *Elaeis guineensis*) de palma de aceite en la zona sur occidental colombiana

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ABSTRACT

The oil palm replanting process produces a large amount of organic matter that, as it begins to decompose, becomes a breeding ground for various pests, including *Strategus aloeus* and *Rhynchophorus palmarum*. Different crop replanting systems are being used today. The method used depends on the plantation and it is basically associated with the costs involved in the process. However, sometimes too little attention is paid to other issues related to the new crop, such as plant health and agronomic management. This study evaluated the effect of different crop replanting alternatives in relation to two pest populations affecting oil palm plantations. Pest populations of *S. aloeus* and *R. palmarum* were assessed and monitored for 27 months using seven replanting methods. It was found that the largest number of individuals of *R. palmarum* and *S. aloeus* was associated with the stem felling and stacking method. No individuals of the two pest species were found when the felling and burying method was used. The exposed organic matter method that had the lowest number of individuals of both pest species was the felling, chipping, spreading method.

Key words: oil crops, clearing, felling, stem, pests, biomass.

RESUMEN

El proceso de renovación en el cultivo de palma de aceite genera una gran cantidad de materia orgánica, que al iniciar su descomposición facilita el proceso de reproducción de plagas entre las que se encuentran *Strategus aloeus* y *Rhynchophorus palmarum*. En la actualidad se utilizan diferentes sistemas para renovar el cultivo, el método usado depende de la plantación y está asociado básicamente a los costos que genera la labor, sin embargo, en algunas ocasiones no se presta atención a otros aspectos del nuevo cultivo tales como el manejo sanitario o el mismo manejo agronómico. En este trabajo se evaluó el efecto de diferentes alternativas de erradicación (renovación) del cultivo relacionadas con las poblaciones de dos plagas de importancia que afectan las palmas. Se realizó un monitoreo durante 27 meses de las poblaciones de *S. aloeus* y *R. palmarun* presentes en un lote con siete métodos de renovación. Se encontró que la mayor cantidad de individuos de *R. palmarum* estuvieron asociados al método de tumbar y apilar los estípites, igualmente ocurrió con *S. aloeus,* presentando los valores más altos en el mismo método. No se encontraron individuos de las dos plagas en el método de apilado en canales, y el método con materia orgánica expuesta y con menor cantidad poblacional de ambas plagas fue el método de tumbar picar y esparcir.

Palabras clave: oleaginosas, erradicación, tumbar, estípite, plagas, biomasa.

Introduction

Oil palm plantations are replanted for technological, health and economic reasons. This is very important in order to improve the agronomic techniques implemented as well as to facilitate the use of new planting materials. In the case of the Southwestern region of Colombia, replanting was necessary because of the outbreak of bud rot disease in 2006, which affected palms of different ages, leading to the destruction of over 90% of the area planted with *E. guineensis* (Martínez and Silva, 2009).

Therefore, the potential biomass left in the field is very high as approximately 30,000 ha of oil palms are expected to be replanted in a short period of time (Quintero, 2010), with a production of about two million tons of decaying

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biomass. This is important because this waste poses a risk to new plantations, as it can become a breeding ground for pests and diseases. Therefore, it is important to devise strategies to accelerate the decomposition process to reduce the time that this waste remains in the field to a minimum, minimizing the impact of pests on new plantations.

Based on experiences from other countries such as Malaysia, Liau and Ahmad (1991) reported that poor oil palm disposal practices created ideal conditions for the proliferation of the insect pest *Oryctes rhinoceros* Illiger, causing losses of 40% in the first year of harvest.

In Colombia, replanting research studies have focused on its effect on the growth and development of new crops (Ruiz *et al*., 2009). This is the first study focused on the effect of clearing and replanting on the dynamics of insect pests, which is particularly important because of the plant health approach. Therefore, this study aimed to learn about the behavior of pests associated with oil palm cultivation under different biomass removal and disposal systems to devise strategies for a comprehensive plant health management program.

Materials and methods

This experiment was conducted in the Southwestern oil palm-growing area of Colombia, on the Palmeiras plantation, located in the municipality of Tumaco, in the department of Nariño. An area of land was selected that was planted with oil palm *E. guineensis* in 1981, with 90% bud rot incidence (BR) as of 2009. Seven clearing systems were implemented (Tab. 1, Figs. 1 through 7) in plots of approximately 1,400 m^2.

New palm material (Coari × La Me) was planted after the palms were cleared and OxG interspecific hybrid materials were disposed; 28 experimental units with 23 palms each were used, distributed in an area of 11 ha.

Statistical analysis

The experiment was performed under a completely randomized design with four replicates, each replicate had 23 plants. To examine the effect of the renovation method and sampling period, a repeated measures analysis of variance (ANOVA) was performed using the general linear model (GLM) procedure. Tukey's multiple range test was used to compare differences between the means of a number of *R. palmarum* and *S. aloeus* individuals between the renovation methods. We used Statistical Analysis with SAS/STAT® Software (SAS Institute, Cary, NC) for all the statistical analyses.

Sampling of *S. aloeus* and *R. palmarum* in oil palm residues

Observations were made to assess the impact of the insect-pests *R. palmarum* and *S. aloeus* on the new crop as well as on the waste generated from the clearing process, using a sampling method developed by the Pests and Diseases Program of Cenipalma, taking into account the insects' eating habits and life cycle.

Sampling method for S. aloeus

In the case of *S. aloeus*, the assessments started 8 months after implementing the different clearing methods, with a frequency of three months. The method implemented (Ulloa *et al.,* 2010) varied depending on how the waste was treated and disposed of, as follows:

No chopping methods: Palm stems were cut with a chainsaw into 2-m-long sections. These sections were slit open lengthwise and thoroughly checked for the presence of larvae, pupae and adults of the insect pests. For method removal, although little or no waste was left in the field, the assessment was conducted at the final disposal sites in order to observe the behavior of the insect pests in areas located far away from the crop field.

Stem chipping methods: palm stems were chipped into small pieces to assess the presence of insect pests in their

TABLE 1. Diseased palms removal systems evaluated in the study.

No.	Method	Description
1	Herbicide	Herbicide application to standing palms
2	Stacking	Felling and stacking between every two rows of hybrid palms
3	Chipping and stacking	Felling, chipping and stacking between every two rows of hybrid palms
4	Chipping and spreading	Felling, chipping and spreading throughout the area and incorporating into the ground using tillage equipment
5	Removal	Felling the palms and removing them from the experimental plot
6	Felling and burying	Felling and stacking palms in dug-out ditches between every two rows of palms and then covered with soil
7	Carbonization	Palms felled and chipped for carbonization, forming piles of biomass consisting mainly of stem chips

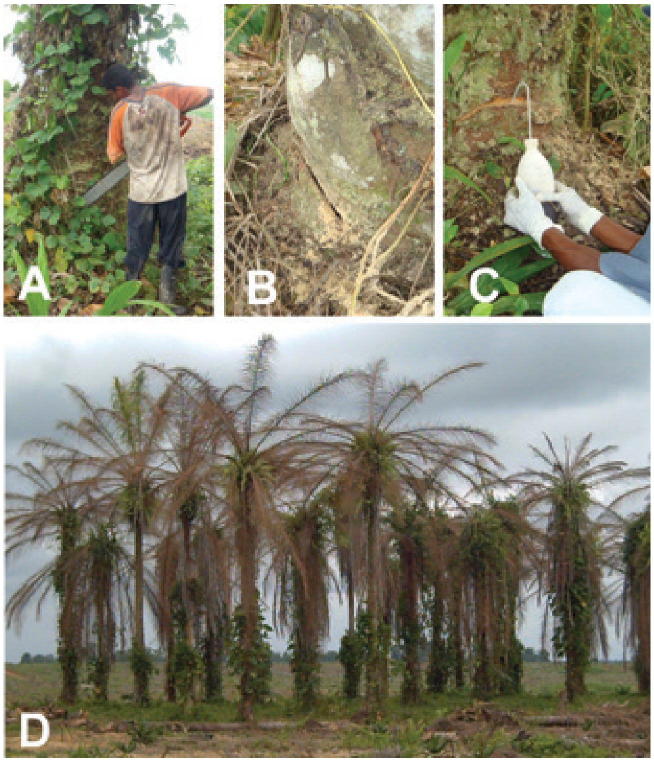

FIGURE 1. Herbicide application to standing palms. A, court chainsaw 50 cm above the ground; B, cut between 5 and 10 cm depth and inclination of 45°; C, application of 100 cm^3 of the herbicide sodium methanearsonate (MSMA); D, effect of the herbicide on the palm one month after application.

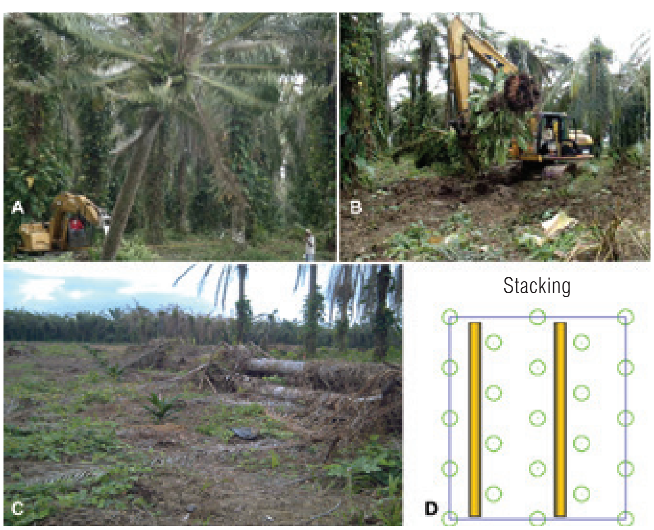

FIGURE 2. Stacking: felling and stacking whole palms between every two rows of hybrid palms. A, felling of palms with backhoe; B, transporting stipes with backhoe; C, stacking of palms in the interline crop; D, schematic layout of stipes in the treatment plots.

FIGURE 3. Chipping and stacking of palm. A and B, felled stipes cut by backhoe; C, stacking of waste every two rows of palm; D, detail of a stack of palm residues.

FIGURE 4. Chipping and spreading of palm. A, felled stipes cut by backhoe; B, slice of stipes in the field; C, spreading of the material in the field; D, final appearance of spread-out material.

FIGURE 5. Removal: felling and removing palms from the experimental plot.

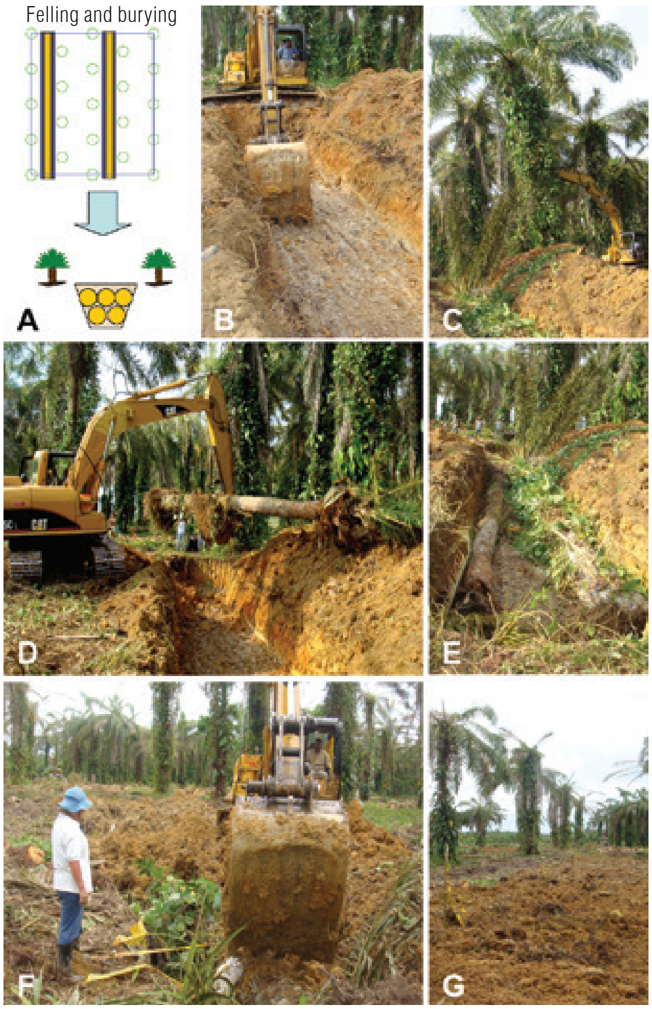

FIGURE 6. Felling and burying. A, schematic of treatment design; B, excavated channels; C, laying the palms; D and E, stacking palms in the channel; F, covering channel with the excavated soil; G, final state treatment.

FIGURE 7. Carbonization: palms were felled, chipped and subjected to a carbonization process where piles of biomass consisting mainly of stem chips were burned. These piles of biomass were covered so that the pyrolysis process reduced the airflow to produce charcoal. The fire was then extinguished and the produced charcoal collected. A, stacking of stipes for initial cut; B, formation of stacked pieces of stipes; C, coverage stacked with grass; D, coverage of the pile with soil; E, mount stacked carbonization per plot; F, final Appearance stack operation; G, removal of coal; H, coal obtained at the end of the process.

various stages of development. Assessments were conducted at the final disposal sites, recording and classifying the different stages of the insect development: larvae were classified into three sizes: small (< 2.0 cm), medium (between 2.1 and 4.0 cm) and large (> 4 cm) This method was also used for the assessment of *S. aloeus* in the waste produced when using the felling and stacking method, the removal method and felling and burying method. These assessments were performed both in the waste and in the surrounding ground.

Sampling methodology for *R. palmarum*

In the beginning, sampling was done with the help of a field worker equipped with a chainsaw and a shovel. Palms were cut down, leaves were cut off and cross-sections were sawed off at different points of the stem (Tab. 2).

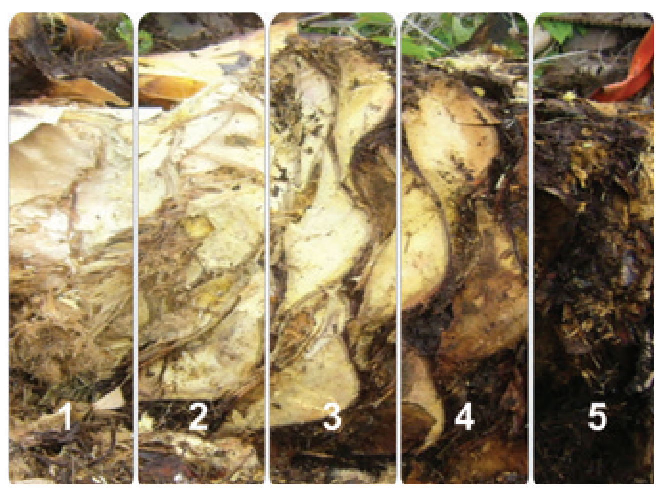

FIGURE 8. Differentiation of *R. palmarum* larvae sampling points in an oil palm.

Petiole bases were cut off at each sampling site and checked for the presence of different stages of insect development (larvae, pre-pupae, pupae or adults) for *R. palmarum*.

TABLE 2. Stem sampling points for *R. palmarum*.

Site	Sampling site
1	Meristem zone
2	Upper level leaves 17 - 25
3	Middle level leaves 25 - 33
4	Lower level leaves 33 - 52
5	From leaf position 52 to 1 m in the stem

For the following assessments, in the case of the whole palms, the number of individuals found at different levels of the stem (Fig. 8) was recorded. For stems cut into sections, the method used was the same as for *S. aloeus*.

Results and discussion

*Rhynchophorus palmarum i*n residues

In the initial sampling for *R. palmarum,* we found significant differences between treatments and over time ($P \leq 0.05$) in the methods of herbicides and felling and stacking. Chipping and stacking, and chipping and spreading treatments showed the presence of insect pests at different stages of development during the first months after the clearing (Fig. 9). From the seventh month onwards, no insect pests were found in the waste from the felling, chipping and stacking, and chipping and spreading methods, mainly due to the fact that after the sixth month, residues were partially decomposed and thus not attractive to *R. palmarum*.

A large population of adult *R. palmarum*, 30 in total, was found in the herbicide method. However, the samplings made at 12, 14, 21 and 28 months showed no presence of larvae due to a rapid drying of tissues that stopped their development. Avendaño *et al.* (2008) found similar results when injecting stems with the systemic herbicide monosodium methanearsonate (MSMA).

The largest number of individuals, 18 in total, was found in stacking in the first sampling. Although in the subsequent assessments, there was a decrease in the number of insect pests in different stages of development; the continuous presence of the insect pests was evident throughout the trial (Fig. 9). According to Ooi and Heriansyah (2005), these piles of palms can take up to 2 years to decompose completely and are attractive to insect-pests due to the decay of the diseased plant material.

The decline in the number of *R. palmarum* adults was due to the gradual decay of plant material which is its food source. In the first months of sampling, after the palms were removed, higher populations of larvae were found which completed their life cycle in the piles of palms, causing the greatest damage by boring into the stems of standing palms.

The number of *R. palmarum* larvae in the first evaluations of waste produced from chipping and stacking suggests that this insect pest completes its cycle in decaying oil palm trees. The other samples did not show the same trend because these residues were probably not attractive to this insect pest. According to Aldana *et al.* (2010), *R. palmarum* adults are attracted to the decomposition of oil palm bud rot infected tissues; it is possible that there was no decomposition of tissues at that time.

After the first year of assessments, it was found that, in most of the methods used, the presence of insect pests in the various stages of development declined probably due to the decomposition of most of the plant material. This confirms the report from Aldana *et al.* (2010), who found that the insect can reproduce for up to one year after the felling and removal of the material.

The observations made during the study show that the size of the stem chips affected the insect's capacity to colonize tissues. In the case of *R. palmarum*, chips of 7 cm or less did not allow the insect to complete its life cycle within them. In chips twice as thick (which have a slower decomposition rate), the insect will have a greater chance to complete its cycle as it will have more tissue to feed from to complete its cycle and emerge.

The removal treatment was carried out at the final disposal site, not in the field where the new crop was growing. These measurements showed high values in the number of adult insects in the first months of assessment. High values of larval density were found, with an average of 7 individuals in different larval instars from month 6 through month 17, when the state of decomposition of the material stopped being attractive to the insect pest.

This information suggests the importance of the final disposal site when the total removal method is used, whether by termination of the vegetative cycle or in the event of an outbreak of disease, to reduce the high risk of producing a breeding ground for species such as *R. palmarum* and *S. aloeus*.

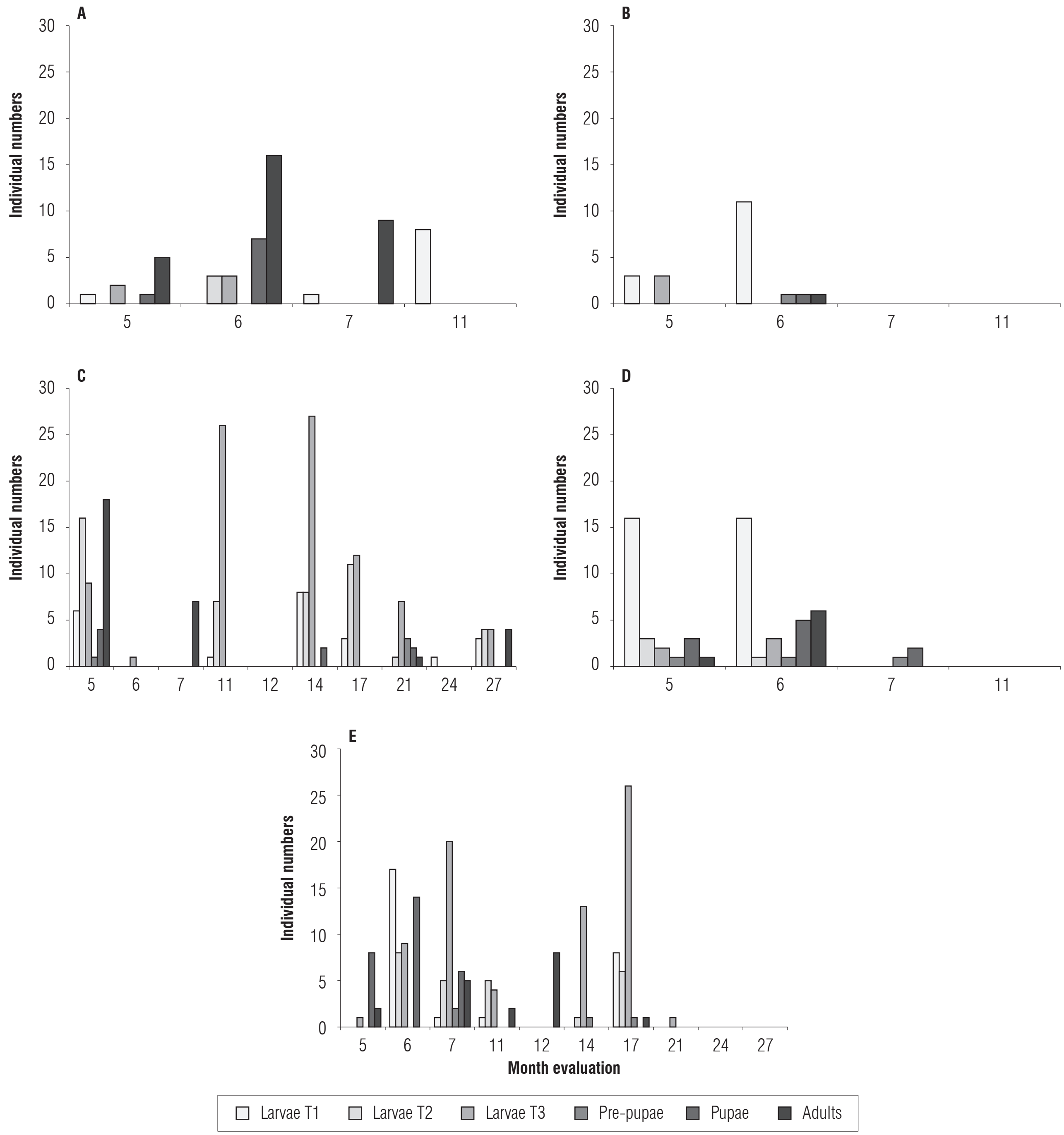

FIGURE 9. Individuals of *R. palmarum* by developmental stage in different assessments on waste disposal systems. A, herbicide; B, chipping and stacking; C, stacking; D, chipping and spreading; E, removal. Assessments from month 5 through month 27 after planting.

When analyzing the interaction of treatments in different developmental stages of the pest through a multiple range test, we found significant differences for the Removal and Stacking treatments.

In the staking and burying method, no insect pests were found in the residuals due to the continuous presence of water. The carbonization treatment showed no presence of the insect pests as the plant material was transformed into inorganic compounds due to high temperatures, rendering them no longer attractive to the insect pests.

Strategus aloeus in residues

The behavior of *S. aloeus* in the oil palm waste showed contrasting results for the different methods assessed. As for the results presented for the pest *R. palmarum*; we found significant differences between the treatments and over time ($P \leq 0.05$). In the stacking treatment, the first values

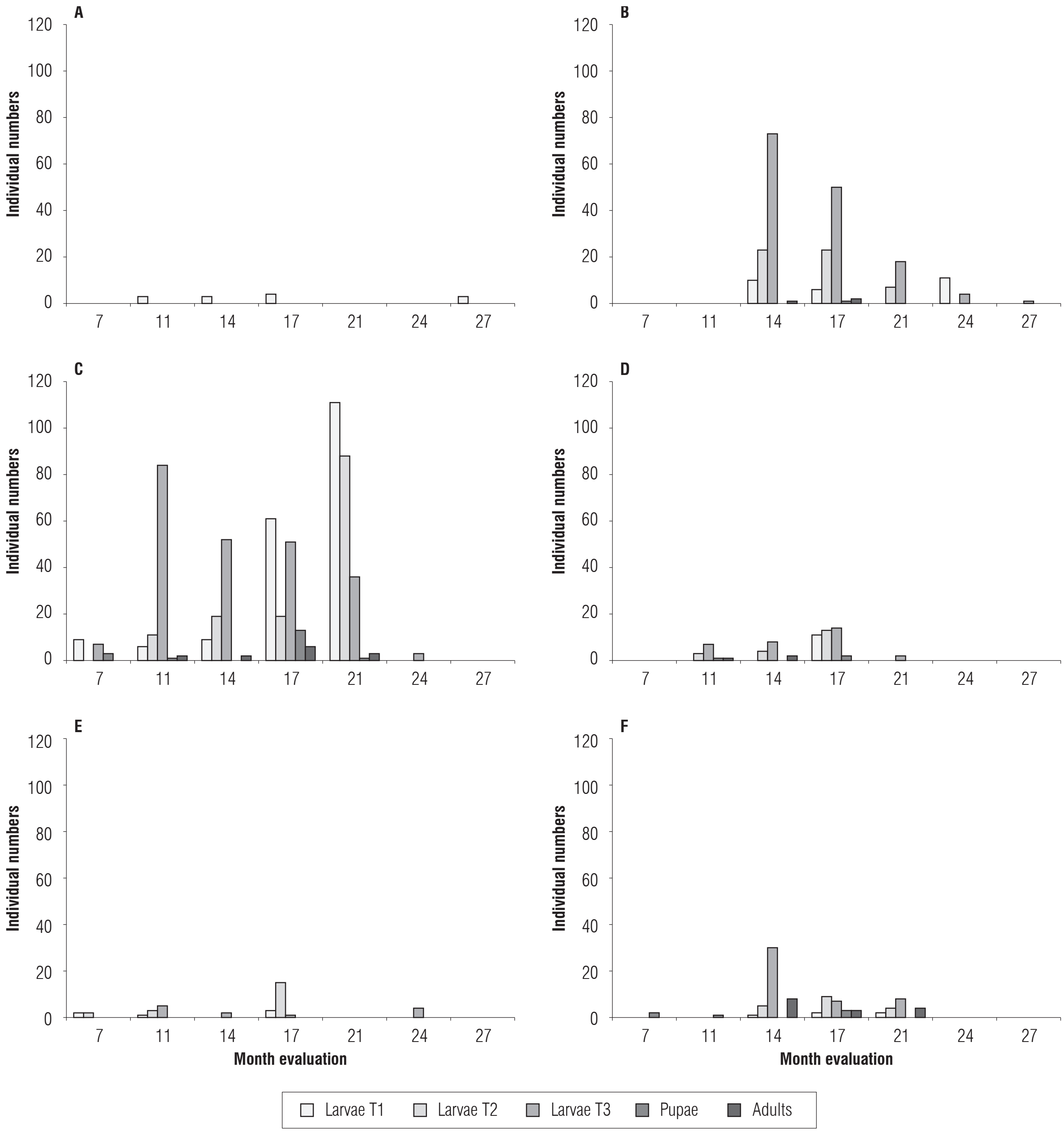

FIGURE 10. Individuals of *S. aloeus* by developmental stage in different assessments on waste disposal systems. A, herbicide; B, stacking; C, chipping and stacking; D, chipping and spreading; E, removal; F, carbonization. Assessments from month 5 through month 27 after planting (MAP).

recorded were low compared with the number of individuals in larval stages found in month 14 due to the gradual decomposition of the stems over time, which converted into breeding sites for the pest insects.

In previous studies in the Central oil palm-growing area of Colombia, it was observed that 85.6% of a population of 1,000 *S. aloeus* larvae was found inside the stems that were in contact with the ground (Ahumada *et al*., 1995). The place occupied within the stem depended on the degree of decomposition and high water content as female insects had a clear preference for depositing their eggs under these conditions (Ahumada *et al*., 1995).

For the Felling, chipping and stacking treatment, the presence of up to 6 individuals/m^2, including three in the last larval instar and one adult, was observed. This trend continued until month 21 of the sampling. Although, according to Ahumada *et al*. (1995), since the life cycle of *S. aloeus* exceeds 300 d, the increasing presence of individuals in different instars from month 7 onwards and until month 21 was due to the fact that the insect develops within the waste disposal system and this cycle had not yet been completed at the time the data were collected as most of the insects found were in the larval stage.

The assessment of these two methods confirms the report from Ahumada *et al*. (1995), who stated that the degree of decomposition of the stems is variable and not dependent on the time when the material was cleared from the field. However, the way in which the waste is grouped directly and proportionately affects the rate of decomposition. The direct contact between waste increases the rate of decomposition; therefore, more insects will be found when using the felling, chipping and stacking method, as compared to the felling and stacking method (Fig. 10).

Finally, the results showed that, of the replanting methods used in this research, the most efficient method to control *S. aloeus* and *R. palmarun* was the stacking and burying method. It is clear that burying the stems eliminates the habitat these insects need to develop. However, this method is expensive and time consuming so it would be recommended only in the event that insect pests are very hard to control. On the other hand, taking into account economic issues, it was found that the most efficient method to control these two insect pests when organic matter is exposed to the environment is the felling, chipping and spreading method as the waste decomposes rapidly due to size.

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