Contribution of the screen traps for beetles' migration flow evaluation in rubber agrosystems in the south-eastern Côte d'Ivoire

DOUAN Bleu Gondo[1]*, DANON Aubin Silvère Djiwha[2], BEUGRE N'djiha Isabelle[3], GUINAGUI N'doua Bertrand[4], KODJO Adaba Tano Thierry[2], KRA Kouadio Dagobert[2], KWADJO Koffi Eric[2], DOUMBIA Mamadou[2]

[1]*University Peleforo GON COULIBALY, Department of Animal Biology, BP 1328 Korogho, Côte d'Ivoire.*
[2] *University Nangui Abrogoua, UFR-SN Department of Natural Sciences, 02 BP 801 Abidjan 02 Côte d'Ivoire.*
[3] *National Agronomic Research Center, Rice program, Man station, BP 440 Man, Côte d'Ivoire*
[4] *University Félix Houphouët-Boigny, Pedagogical and Research Unit: Plant Physiology and Pathology, Côte d'Ivoire*
*Corresponding author: E-mail: bleudouan80@gmail.com / douanbleu@upgc.edu.ci , Tél: +225 0708323696
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1 ABSTRACT

This study focuses on the migration flow of beetles entering and leaving rubber plantations in the south-east of Côte d'Ivoire. To do this, the screen trap was used in different habitats including rubber plantations aged 1 to 5 years, aged 6 to 10 years, aged over 15 years and a forest taken as a control. The results showed that, in general, the beetles leave the plantations more than they enter them. The proportion of beetles leaving in all habitats is 69.54% against 30.46% for those entering. There is no difference between the numbers of beetles leaving and entering rubber plantations aged 1 to 5 years and 6 to 10 years. However, for plantations older than 15 years and the forest, the numbers of insects that leave are higher than those that enter these habitats. Of all the habitats, the average numbers of insects that leave are higher in the forest with 127.08±22 individuals. Plantations aged 6 to 10 years recorded the greatest number of beetles entering the habitats with 33.25 ± 17.25 individuals on average. The family richness of beetles leaving habitats is higher in the forest with 11.35 ± 0.79 families on average and is lower in plantations aged 1 to 5 years with 7.16 ± 0.87 families. As for the incoming side of the habitats, plantations aged 1 to 5 years are richer in families with 7.33 ± 1.48 individuals and the forest is less so with 6.5 ± 0.73 families on average. Finally, the dynamics of beetles entering and leaving habitats throughout the year show that insects come out more during the rainy seasons with a peak in the number of insects leaving in April and November. However, during the dry seasons these, insects enter more habitats with a peak in numbers in February and March.

2 INTRODUCTION

Agrosystems in tropical zones are environments colonized by different living organisms including invertebrates. Among these invertebrates, insects in cultivated habitats are as diverse as they are numerous. Knowledge of them requires the use of appropriate traps according to the type and behaviour of each insect. For example, the pitfall trap is used for capturing insects moving on the soil surface (Lang *et al.,* 2011 and Skvaria *et al.,* 2017), the yellow pan trap for phytophagous insects and floricultural insects (Yattara *et al.,* 2013), and interception traps including Malaise traps and screen traps for sailing insects moving from one system to

another or within the same system (Kra, 2010 and Chapelin, 2013). Among these interception traps, the screen trap has proven to be very effective in studying the entomofauna of rubber plantations (Douan *et al.,* 2021). Its effectiveness depends on the reaction of these insects following contact with the obstacle (Lamarre *et al.,* 2012). The dynamics of insect migration within habitats, i.e. their entry and exit from plantations, is a natural phenomenon that can have both beneficial and negative consequences for plantations. Indeed, these migrations can generate significant economic and health costs if the insect is a major predator, if it carries pathogens or if it is a crop or tree pests. However, insects that migrate in habitats can also be an asset in pest management if they are natural enemies or very good pollinators. Therefore, the need to know the flow of these beetles involved in migration within rubber plantations is important, because this group of insects is the most diverse and represents both the largest and the smallest. insect specimens, therefore play different roles in the habitats they colonize (Leraut, 2003 and Carpenato *et al.,* 2005). This is how this study was initiated for the evaluation of the entrances and exits of beetles in rubber plantations in order to know their migration flow by the use of a screen trap.

3 METHODOLOGY

3.1 Study site: This study was carried out in an area of high rubber production in Côte d'Ivoire, namely the southeast. The study site was that of the African Society of Rubber Plantations and precisely in the Integrated Agricultural Unit of Bongo, located in the department of Grand-Bassam, in the region of Sud-Comoé (Figure 1). The locality of Bongo (5°29' North latitude; 3°35' West longitude), has an equatorial climate, with two rainy seasons. The larger season runs from mid-May to the end of June and the smaller runs from early October to mid-December. These two rainy seasons are separated by two dry seasons which start from mid-December to mid-March and mid-July to the end of September (Abé, 2005). This study area belongs to the Guinean domain and is part of the ombrophile sector. It is characterized by the variety of plant formations due to the edaphic conditions. The region has dense evergreen humid forest-type vegetation which has deteriorated as a result of very intense human activity (Guillaumet and Adjanohoun, 1971).

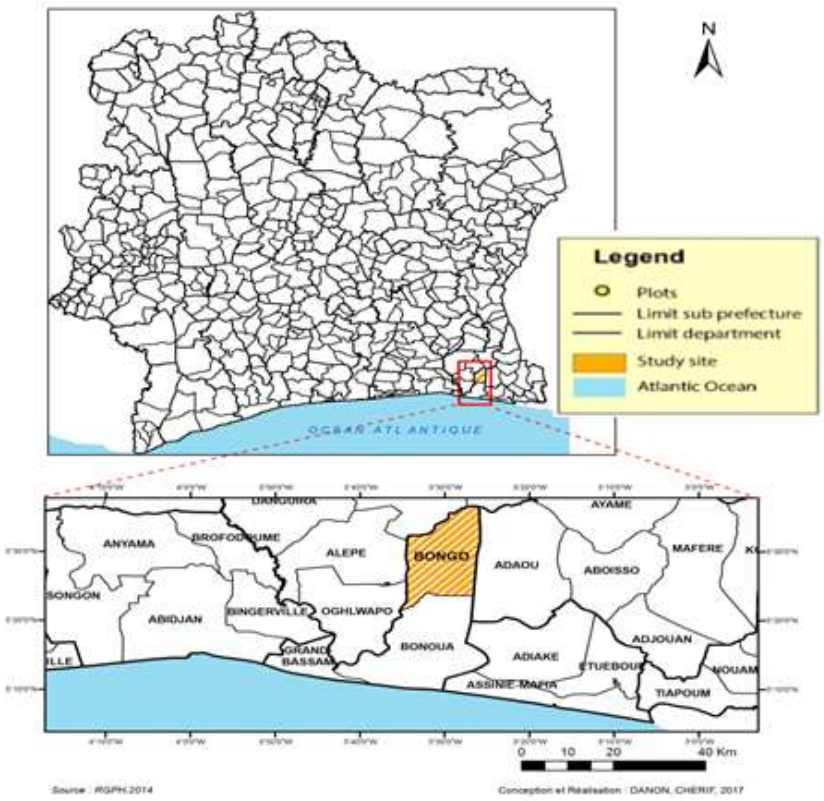


Figure 1: Study area

3.2 Choice of sampling habitats: The choice of habitats in which the samples were taken was based on the age and physiological state of the rubber plants. Thus, four types of habitats were chosen. These are rubber tree plantations between 1 and 5 years old with young plants not yet in production, plantations between 6 and 10 years old with plants that have recently entered production, and plantations over 15 years old with old plants still in production. Finally, a forest in which no cultivation activity is carried out was taken as a control.

3.3 Description of the screen trap: These are two-way interception traps, designed to capture insects on the fly, moving from one plant system to another or within a plant system. The screen traps used have been modified and made by hand. They consist of a rectangular frame (1 m × 0.8 m) of transparent plastic below which a receptacle is attached. The whole is placed 1.5 m above the ground and supported by two pillars. The insect during flight strikes the frame on the entering or exiting side of the trap and falls into one of two receptacles containing a mixture of soapy water and salt placed below each side of the frame (Figure 2).

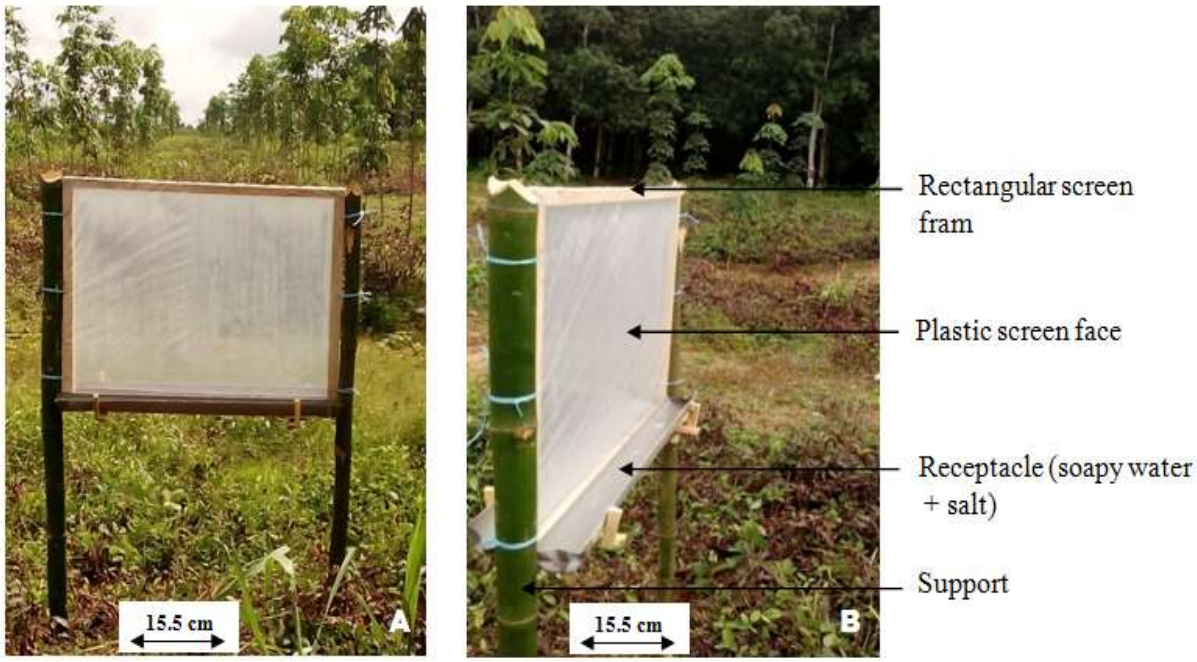


Figure 2: Screen Trap (A: front view; B: side view)

3.4 Laying trap and sampling insects: Two 200 m transects spaced 50 m apart were drawn. On each transect, two screen traps were placed. The traps were placed at the beginning and at the end of the transects, either at the entrance and exit of the different habitats chosen so that any insect entering and leaving of these habitats through the transects was captured (Figure 3). The device was the same in the different habitats. The laying of the traps was carried out twice in the month at an interval of 15 days from each laying for a year. Forty-eight hours (48h) after each trapping, insect harvesting was carried out. The insects collected were sorted and the beetles were put in pillboxes labelled according to date, habitat, and transect. Then, the samples were transported to the laboratory of the Agricultural Entomology Unit of Nangui Abrogoua University for identification.

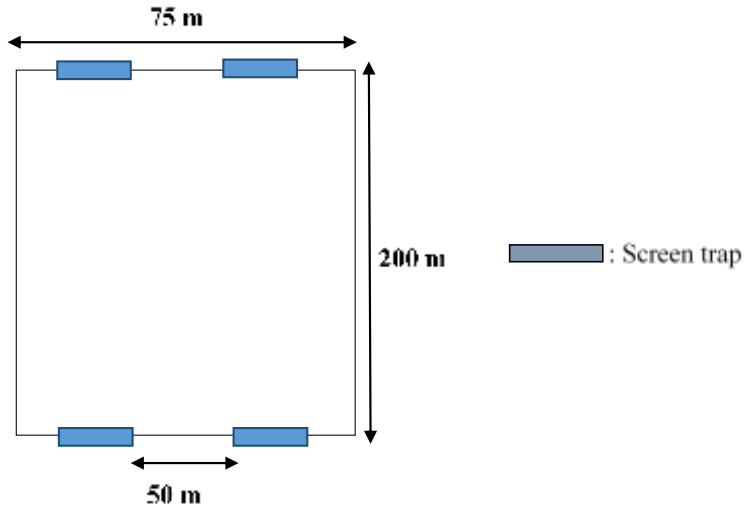
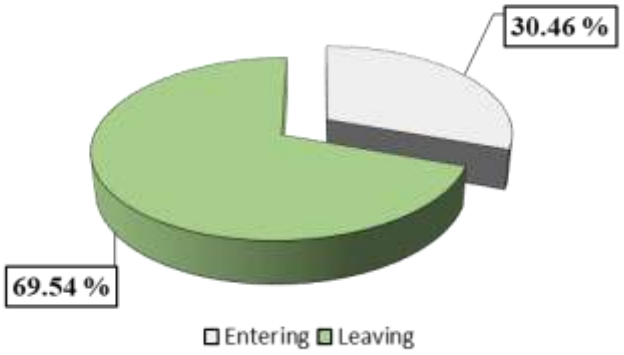


Figure 3: Sampling device

3.5 Data analysis: The data collected following the identifications were analyzed using the SATISTICA7.1 software. One-way analysis of variance (ANOVA1) and post-ANOVA were used to compare data on the relative abundance and family richness of beetles on the exiting and entering side of the screen trap for each habitat. Long before, a logarithmic transformation was performed to normalize the data and stabilize the variables that were not. Fisher's LSD test at the 5% threshold made it possible to classify the means into different homogeneous groups. The two-by-two comparison of the abundances of beetle on the outgoing and incoming sides of each habitat was made by Student's t test at the 5% threshold.

4 RESULTS

4.1 Numbers of beetles according to habitats: A total of 4383 beetles were captured. The proportions of beetles obtained according to the sides leaving and entering habitats show that beetles leave habitats more than they enter them. The percentage of beetles leaving is 69.54% and that of those entering is 30.46% (Figure 4). The proportions of beetles entering and leaving each habitat show that only plantations aged 1 to 5 years have more insects entering than leaving with respectively 54.17% and 45.83%. Concerning the other habitats, the results show that insects leave more than they enter with 77.99%, 74.83% and 58.71% of individuals leaving respectively for the forest, plantations aged 6 to 10 years and those older than 15 years. Finally, the smallest proportion of insects entering habitats is recorded at the forest level with 22.01% of individuals (Figure 5). The average numbers of beetles entering and leaving the plantations show that those leaving the plantations are more numerous than those entering them are. The average numbers of outgoing insects are higher in the forest with 127.08±22 individuals. The lowest values have been recorded in plantations between 1 and 5 years old. Regarding beetles entering habitats, the results show that the highest numbers have been obtained in plantations aged 6 to 10 years with 33.25 ± 17.25 entering individuals on average. Statistical tests comparing two by two the numbers of beetles entering and leaving each habitat show a significant difference between the average abundance of insects leaving and entering the forest ($p = 0.000$) and the plantation over 15 years old ($p = 0.001$). No significant difference is recorded in plantations aged 1 to 5 years and 6 to 10 years with respectively $p = 0.8$ and $p = 0.055$ (Figure 6).



Entering: proportion of beetles entering habitats; Leaving: proportion of beetles leaving habitats.

Figure 4: Proportion of beetles according to side entering and leaving

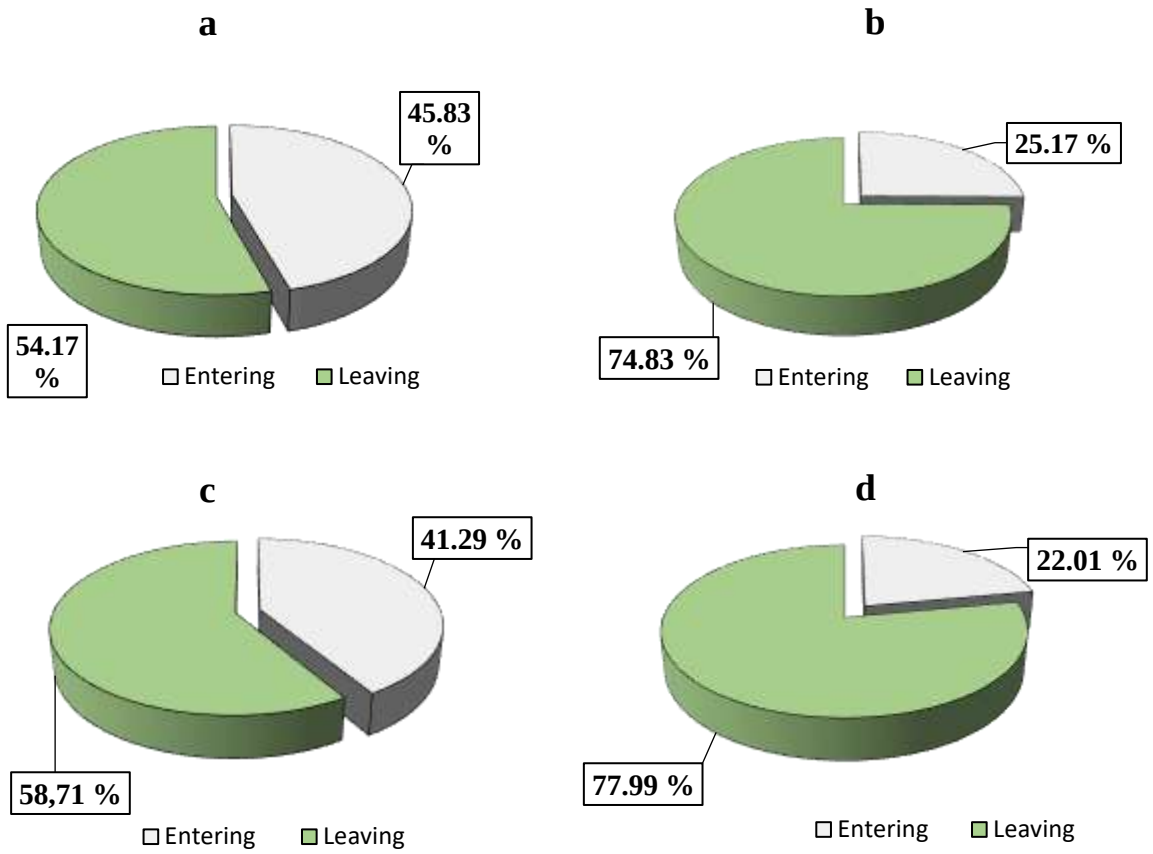
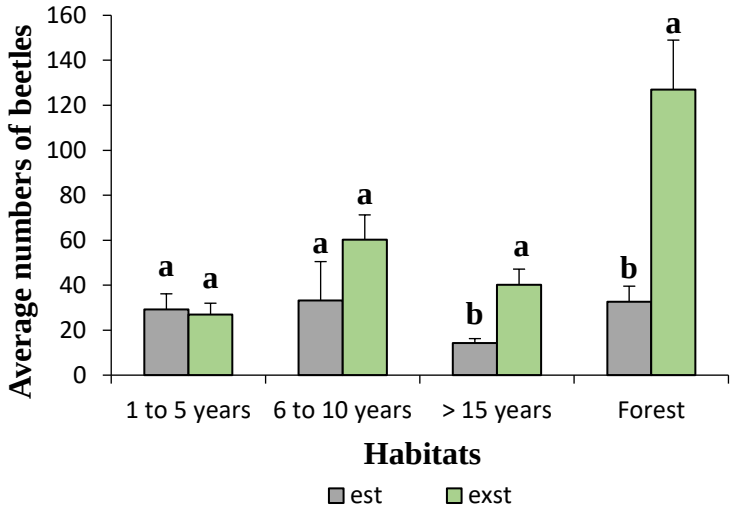


Figure 5: Proportion of beetles exiting and entering each habitat

Entering: proportion of beetles entering habitat; Leaving: proportion of beetles leaving habitat. a: rubber plantation aged 1 to 5 years; b: rubber plantation aged 6 to 10 years; c: rubber plantation over 15 years old; d: Forest.



exst: number of beetles in the side screen trap exiting the habitats; **est:** number of beetles in the screen trap on the side entering habitats. 1 to 5 years: rubber plantation aged 1 to 5 years; 6 to 10 years: rubber plantation aged 6 to 10 years; > 15 years: rubber plantation aged more than 15 years.

Figure 6: Number of beetles entering and leaving the different habitats

4.2 Number of beetle families according to habitats: The calculation of the family wealth of the Beetles shows that the average number of families is higher on the side entering the plantation aged 1 to 5 years and 6 to 10 years with respectively 7,33±1,48 and 7,33±0,81 families on average. However, no significant difference is observed with p = 0.67. Regarding the outgoing side of the plantations, the average number of families is higher in the forest with 11.35 ± 0.79 and decreases to 7.16 ± 0.87 families on average in the plantation aged 1 to 5 years, with a significant difference in family wealth on this side of the habitat (p= 0.01). The two-by-two comparison of the average number of families in each plantation according to the incoming and outgoing side shows that there is no significant difference between plantations aged 1 to 5 years and 6 to 10 years. However, significant differences have been observed in plantations older than 15 years and in the forest (Table 1).

Table 1: Beetle's family richness according to the outgoing and incoming sides of the habitats

Side of the trap	Habitats				p
	1 to 5 years	6 to 10 years	> 15 years	Forest	
est	7,33±1,48aA	7,33±0,81aA	5,91±0,49aA	6,5±0,73aA	0,670
exst	7,16±0,87aA	8,91±1,35aA	8±0,71bB	11,35±0,79bB	0,010
p	0,115	0,09	<0.001	<0.001	

Per row/column, the values followed by the same lowerscript /superscript do not differ at 5% significance (ANOVA-one way and Fisher LSD Test).
exst: number of beetles in the side screen trap exiting the habitats; **est:** number of beetles in the screen trap on the side entering habitats. 1 to 5 years: rubber plantation aged 1 to 5 years; 6 to 10 years: rubber plantation aged 6 to 10 years; >15 years: rubber plantation aged more than 15 years.

4.3 Dynamics of the beetle migration flow according to habitats: The dynamics of beetles entering and leaving habitats show that in plantations aged 1 to 5 years, beetles enter more than they leave throughout the year except during the months of October and November. Regarding plantations aged 6 to 10 years, the number of beetles leaving these habitats is much higher than those entering them throughout the year. As for plantations over 15 years old and the forest, beetles leave these habitats almost all year round except during the months of February and March when they enter them the most. Peak numbers of insects leaving habitats are recorded during the months of April, October, and November. Regarding the number of insects leaving habitats, the peaks are observed during the months of February, March, and December (Figure 7).

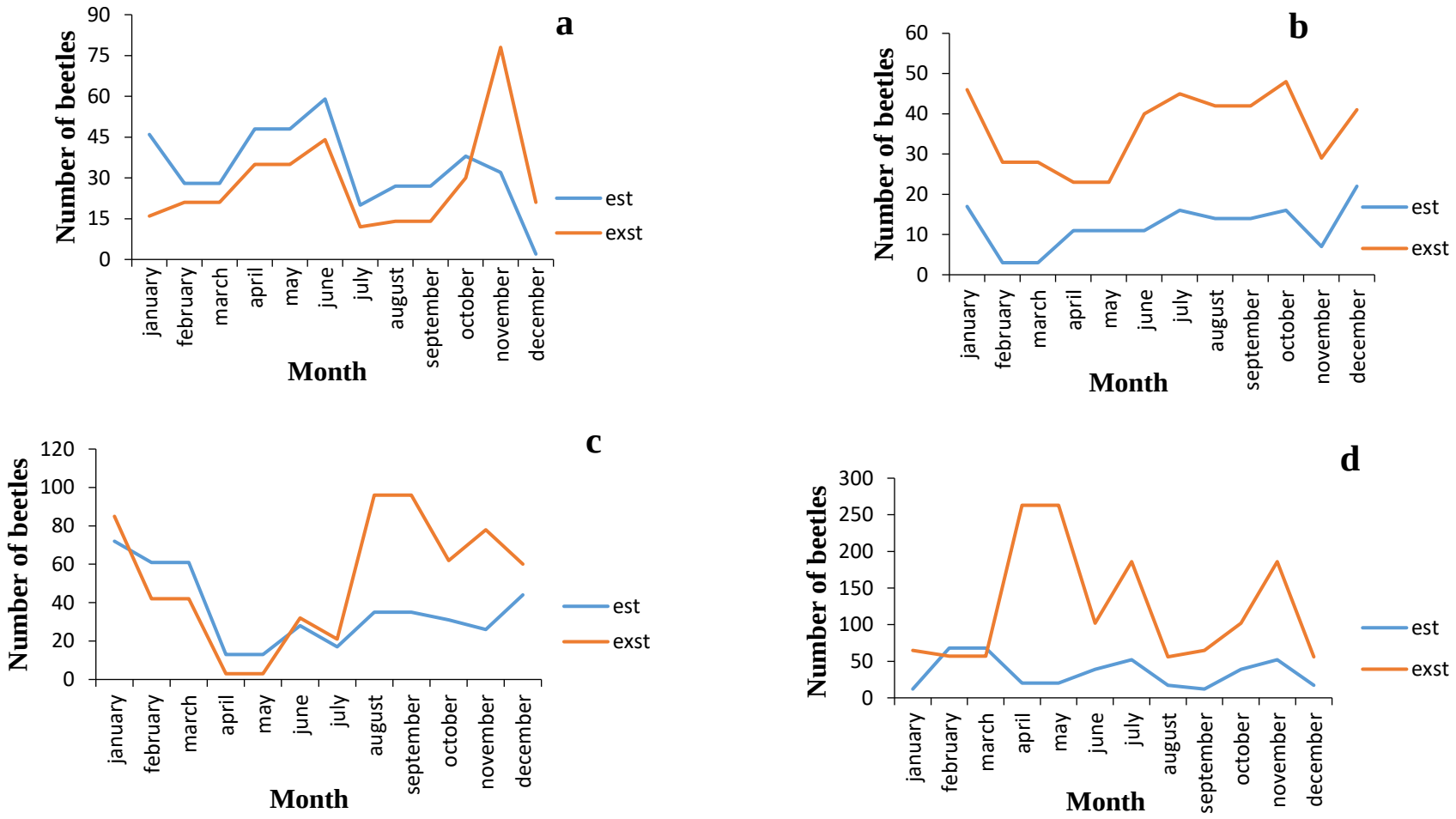


Figure 7: Dynamics of the migration flow of Beetle according to the entrances and exits of each habitat
exst: number of beetles in the side screen trap exiting the habitats; **est:** number of beetles in the screen trap on the side entering habitats.
a: plantation aged 1 to 5 years; **b:** Plantation aged 6 to 10 years; **c:** plantation over 15 years old; **d:** Forest.

5 DISCUSSION

The screen trap was the only type of trap used and the results show that from a general point of view, beetles leave habitats more than they enter them. However, taken in isolation, the flow of beetles is different in each habitat. The flow in plantations between 1 and 5 years old and 6 and 10 years old is uniform. There is no significant difference between the abundance of beetles leaving and entering these plantations. According to Bouget (2004), the fragmentation of habitats would regulate the flow of insects and would be the basis of this uniformity of beetle abundances on the outgoing and incoming sides of young plantations. Indeed, the regular maintenance activities of young plantations and those newly entering production would participate in the movements leaving and entering uniformly in these habitats. Manual weeding would disturb the sensitive insects that will tend to leave the plantations, while those which are not very likely to enter. The flow of beetles in habitats is not uniform in rubber plantations over 15 years old and in the forest with a highly significant difference recorded at the forest level. The abundance of insects leaving the forest is very high and would be due to the fact that this habitat would be a place of rest, transit or reproduction for insects on the one hand. On the other hand, because of behavioral phenomena related to the sense of orientation of insects. Indeed, Nicole (2002) stipulates that the recognition of the host plant is done by phylotaxis which is a reaction of locomotion towards a light source or by geotaxis directed downwards. These two stimuli would act simultaneously and would explain this strong migration of beetles outside the forest. Regarding the difference in the abundance of beetles that leave and enter plantations older than 15 years, it would be due to the dense canopy of rubbers plants in this habitat that would push the insect to migrate to a source luminous as mentioned by Barbalat (1995). Our results are contrary to those of Charles (1999) who emphasizes that gaps or windthrow caused by the death of certain rubber plants would increase the structural diversity of the floristic cover on the ground, hence the modification of trophic resources. Thus, these diverse places would attract a group of insects, characterized by a massive entry of insects into habitats. This difference in results would be due to the fact that in our study, gaps or windthrow in old rubber plantations are less or rare. Note also that the ability of insects to leave or enter a habitat is due to the neighborhood phenomenon. An unfavorable neighborhood compared to the other would lead to a high flow and an abundance of individuals migrating towards the most favorable. Thus, Wealth in the family evolves differently according to the plantations and according to the type of neighborhood. Some habitats close to forests and old plantations will experience a strong migration of insects within them. Infrastructure such as paved roads and nearby tracks would have an effect on the migration of insects in habitats. Duelli *et al.* (1990) report that wide grass strips had no significant effect on insect flux in their study. The ability of a habitat to allow a flow of individuals to circulate constitutes its permeability. It associates the structural connectivity of the elements of the landscape, and the behaviour of the species and opposes the viscosity and the roughness which would be linked to the complexity of the habitats (Lassau *et al.,* 2005). Also, Charrier *et al.* (1998) report that some beetles of the Carabidae family have the ability to move in open environments while others such as foresters are able to do so in complex environments

6 CONCLUSION

This work was conducted to assess the migration flow of beetles leaving and entering rubber plantations through the screen trap. Our study shows that, in general, insects leave the studied habitats more than they enter them. Taken individually, the movement patterns of beetles in plantations aged 1 to 5 years and 6 to 10 years are uniform. As a result, young plantations are

more conducive to the circulation of insects, and therefore to their entry and exit more than 15 years and in the forest. In these habitats, insects leave more than they enter. As for the dynamics of beetles according to the migration flow, the rainy seasons are more conducive to the massive exit of insects, while the dry seasons are for a massive entry into the habitats. It therefore turns out that the screen trap could be used on other farms and would make it possible to account for the entrances and exits of insects in these habitats. In addition, it should be taken into account in crop management decisions, especially in agrosystem monitoring programs.

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