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Efficiencies of three insect collection methods in Lamto, Côte d'Ivoire

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Insects are of ecological and economic importance. This study was carried out to compare the efficiency of the three main insect sampling methods namely, sweep net, hand sampling and the light trap and also to show the biodiversity distribution from Lamto habitats for good biological conservation. A total of 379 individuals belonging to 9 orders were collected. Significantly, more individuals were collected by sweeping net compared to hand sampling and light trap. From the capture rate, highest rate was recorded for sweeping net (0.720) followed by hand (0.232) and light trap (0.047). The lowest value of Shannon's index was 0.672 with the light trap followed by hand (1.375) and the highest was 1.940 with sweeping net in Lamto's habitats. The insect orders recorded with the hand were Heteroptera, Coleoptera, Homoptera, Hymenoptera, Orthoptera, Diptera and Isoptera (F = 11.340, *P* value = 0.006). Light trap was more suitable to capture Lepidoptera (3.250%), Coleoptera (0.750%) and Homoptera (0.500%) (F= 6.659, *P* value= 0.0001). The abundance index recorded with the sweeping net commonly varied between 0.0 and 18.250%. Both sweeping net and hand insect sampling techniques were the most efficient and showed the highest insect orders complementarity. However, the use of sweep net, hand sampling and light trap were recommended to have good collection of insects.

Key words: Sweep net, light trap, hand sampling, insects' conservation, capture effectiveness.

INTRODUCTION

Territorial insects are more diverse groups of animal and are important components of ecosystem. They play important roles in the economic and ecological success of agroecosystems and are distributed in all habitats (forest and savannah) of Lamto. Large population of insects may be isolated into sub-populations from one to another due to habitat fragmentation (Hunter, 2007). These habitats (forest and savannah) indirectly through microclimate change (Li, 2017) and represent a highest importance to insect biodiversity (Wearn, 2017) and to insect abundance (Diniz et al., 2010; Elia et al., 2012; Muvengwi et al., 2017). Lamto plays an important role in supporting biodiversity conservation, for instance, provision of foods, microhabitats for the growth and distribution of insect populations. There are four seasons which are a long dry season from December to February,

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a long rainy season from March to July, a short dry season in August and a short rainy season from September to November. The methods used to collect insects include light trap, hand and sweep net (Noyes, 1989; Shimoda and Honda, 2013). Moreover, the choice of an adequate sampling methodology is crucial. Hands are the traditional method for collection of epigaeic invertebrates. It has been widely used for sampling insects in biodiversity inventories (Ramírez-Hernández et al., 2018), population and community ecology (Hunter, 2007; Ramírez-Hernández et al., 2018). The light trap is the most commonly used sampling device to study the daily activity of nocturnal insects. The reason for the wide use of hand and light trap in invertebrate sampling is their simplicity of setting and using, and their low cost. However, the interpretation of hand and light trap data is subject to many problems because they rarely reflect the true abundance of the target organisms being sampled (Shweta and Rajmohana, 2016; Ramírez-Hernández et al., 2018). However, the effectiveness of light trapping as an insect sampling method was influenced by many environmental factors that influence the efficiency of the traps (Upadhyay et al., 2000; Ramírez-Hernández et al., 2018). Despite these shortcomings, light traps and hand have continued to be used (Upadhyay et al., 2000; Ramírez-Hernández et al., 2018). The effectiveness and complementarity of three sampling methods such as sweeping net, hand sampling and light trap for collecting insects were assessed to show the biodiversity distribution from Lamto habitats for good biological conservation.

MATERIALS AND METHODS

Description of study site

The study area is Lamto station (6° 13 N, 5° 2 W) located in the center of Côte d'Ivoire (West Africa) in the transition forest-savannah. The landscape of Lamto is a mosaic which brings together scraps of dense semi-deciduous forests, gallery forests and savannahs (Menaut, 1971; Devineau, 1975).

Entomological sampling

Insects were collected from 23 October to 27 October 2007. Sampling was carried out between 05:30 to 08:00 from a forest and savannah vegetation using the sweep net and the hand and between 19:00 to 20:00 with the light trap, for a period of four days. Sweep net was used while walking around the road in the forest and adult insects were collected from the vegetation. In savannah, adult insects were collected from the vegetation in random sites. The collected insects were killed by ethyl acetate vapour, sorted out into different orders and mounted in insect boxes. All small and soft bodied insects were preserved in 70% ethanol in specimen bottles labeled to show sample station, sample method and collection date.

Identification of insects

Insects were identified up to order level with the help of entomologists and by using a binocular lens and identification keys of insects (Roth, 1974; Maurice, 1980; Delvare and Aberleng, 1989). Thus, the number of individuals collected under each order during the study period was recorded.

Data analysis

Collected insects were sorted out into orders. Total number of individuals collected under each order was used for diversity analysis. Diversity indices such as Shannon's index were calculated by using Estimate S (version 9.1.0, 2013). An analysis with ANOVA allowed comparing between mean diversity indices and mean abundance index between the three insect collection methods.Subsequently, we calculated the abundance index (AR) and the occurrence frequency (Fo) according to the formulas, respectively:

$$AR\ (\%) = \frac{a \times 100}{b} \quad (1)$$

a: Number of total individuals of order collected with the method I; b: number of total individuals collected with a method i.

$$Fo\ (\%) = \frac{Na \times 100}{N} \quad (2)$$

Na: Number of sampling of individuals of order collected with method I; N: Number of total sampling with method i.

RESULTS AND DISCUSSION

A total of 379 individuals belonging to 9 orders were collected. From the capture rate, highest rate was recorded for sweep net (0.720) followed by hand (0.232) and light trap (0.047) (Table 1). According to Shweta and Rajmohana (2016), sweep net are better than the other method to collect insects.

The lowest value of Shannon's index was 0.672 with the light trap followed by hand (1.375) and the highest was 1.940 with sweep net in Lamto's habitats (forest and savannah) (Table 2). There was a significant difference with F = 324.458, *P* value = 0.0001. Noyes (1989) and Shweta and Rajmohana (2016) studied parasitic hymenoptera capture rates and hymenoptera claiming sweep net to be most effective, respectively.

The insect orders recorded with the three insect collection methods in Lamto's habitats were Odonata, Lepidoptera, Coleoptera, Heteroptera, Homoptera, Hymenoptera, Orthoptera, Isoptera and Diptera. In fact, the majority of insect recorded were phytophagous (Lecordier, 1975).

Light trap was more suitable to capture Lepidoptera (3.250%), Coleoptera (0.750%) and Homoptera (0.500%) (F = 6.659, *P* value = 0.0001) (Table 3). In fact, nocturnal insects are collected exclusively through light trap. According to Pachkin et al. (2019) and Marchioro et al. (2020), the light traps were more attractive for the representatives of Coleoptera, Homoptera and

Table 1. Capture rate for the light trap, the hand and the sweep net.

Method	Number of individuals collected	Capture rate
Light trap	18	0.047
Hand	88	0.232
Sweep net	273	0.720

Table 2. Diversity of light trap, hand and sweep net in sampling insects.

Method	Shannon's index	CV (%)
Light trap	0.672[c]	13.3
Hand	1.375[b]	3.7
Sweep net	1.940[a]	1.0
P-value	0.0001	
F	324.458	

The means assigned to the same letter within the same column are not significantly different for the 5% Fisher test (LSD).

Table 3. Abundance index of light trap in sampling insects.

Order	Light trap	
	Abundance index (%)	CV (%)
Diptera	0.000[b]	-
Orthoptera	0.000[b]	-
Isoptera	0.000[b]	-
Odonata	0.000[b]	-
Hymenoptera	0.000[b]	-
Heteroptera	0.000[b]	-
Homoptera	0.500[b]	16
Coleoptera	0.750[b]	11
Lepidoptera	3.250[a]	12
P-value	0.0001	
F	6.659	

The means assigned to the same letter within the same column are not significantly different for the 5% Fisher test (LSD).

Lepidoptera. Light trapping as an insect sampling method was influenced by many environmental factors. The observations are in agreement with those of Nair et al. (2004) and Sheikh et al. (2016). In fact, the efficacy of light trap was influenced by the vegetation around the sampling site and by lunar light (Holyoak et al., 1997; Brehm and Axmacher, 2006; Shimoda and Honda, 2013; Keszthelyi et al., 2019). According to Upadhyay et al. (2000) and Sheikh et al. (2016), not all the light source proved efficient to attract and collect all the nocturnal insect species in a particular habitat.

The insect orders recorded with the hand method were Heteroptera, Coleoptera, Homoptera, Hymenoptera, Orthoptera, Diptera and Isoptera. The abundance index commonly varied between 0.5 and 11.75%. The highest abundance was recorded with the Isoptera (11.75%) and the lowest was recorded with the Heteroptera (0.5%). The abundance index of Heteroptera, Homoptera, Diptera, Orthoptera, Hymenoptera, Coleoptera and Isoptera were statistically different (F= 11.340, P value = 0.006) and were 0.5, 1.25, 1.75, 1.75, 2.5, 3 and 11.75%, respectively (Table 4).

The abundance index recorded with the sweep net commonly varied between 0.0 and 18.250%. The highest abundance was recorded with the Lepidoptera (18.250%) and the lowest was recorded with the Isoptera (0.0%). The abundance index of Isoptera, Homoptera, Diptera, Orthoptera, Heteroptera, Coleoptera, Odonata,

Table 4. Abundance index of hand in sampling insects.

Order	Hand	
	Abundance index (%)	CV (%)
Lepidoptera	0.000[b]	-
Odonata	0.000[b]	-
Heteroptera	0.500[b]	10
Homoptera	1.250[b]	16
Diptera	1.750[b]	16
Orthoptera	1.750[b]	16
Hymenoptera	2.500[b]	16
Coleoptera	3.000[b]	14
Isoptera	11.750[a]	14
P-value	0.006	
F	11.340	

The means assigned to the same letter within the same column are not significantly different for the 5% Fisher test (LSD).

Table 5. Abundance index of sweep net in sampling insects.

Order	Sweep net	
	Abundance index (%)	CV (%)
Isoptera	0.000[e]	-
Homoptera	3.250[de]	16
Diptera	5.000[d]	14
Orthoptera	6.500[cd]	12
Heteroptera	7.000[cd]	18
Coleoptera	7.000[cd]	17
Odonata	10.000[bc]	15
Hymenoptera	11.250[b]	11
Lepidoptera	18.250[a]	13
P-value	0.0001	
F	14.192	

The means assigned to the same letter within the same column are not significantly different for the 5% Fisher test (LSD).

Hymenoptera and Lepidoptera were statistically different (F = 14.192, P = 0.0001) and were 0.000, 3.250, 5.000, 6.500, 7.000, 7.000, 10.000, 11.250 and 18.250%, respectively (Table 5).

The lowest abundance index was due to the fact that the sampling period was theses insect period reproduction. In this sampling period, the high relative humidity reduced the activity of these insects (Butler et al., 1999; Ramamurthy et al., 2010).

Amongst the three insect's collection methods, sweep net showed the maximum ability followed by hand and light trap (Table 6). The occurrence frequency of insects of various orders in light trap, hand and sweeping net were all varied from 0.000 to 100 percent (Table 6). The total catch of light trap, hand and sweeping net were 25, 75 and 75% in Homoptera; 50, 100 and 100% in Coleoptera; 100, 0 and 100% in Lepidoptera; 0, 75 and 100% in Hymenoptera, Orthoptera and Diptera; 0, 0 and 100% in Odonata and Heteroptera and 0, 100 and 0% in Isoptera, respectively (Table 6). The observations are in agreement with those of Butler et al. (1999) and of László et al. (2012) which have mentioned that humidity of the habitat produce a rich sample of insects in general. Both sweep net and hand sampling were the most efficient and showed the highest species complementarity. Indeed, highest occurrence frequency of Coleoptera individuals with the sweep net, hand sampling and light trap showed that Lamto's habitats was sound and allow good conservation of biodiversity.

Conclusion

The methods used to collect insects include light trap,

Table 6. Occurrence frequency of light trap, hand and sweep net in insect sampling.

Order	Light trap	Hand	Sweeping net
Homoptera	25	75	75
Diptera	0	75	100
Orthoptera	0	75	100
Isoptera	0	100	0
Odonata	0	0	100
Hymenoptera	0	75	100
Coleoptera	50	100	100
Heteroptera	0	0	100
Lepidoptera	100	0	100

hand and sweep net sampling. A total of 379 individuals belonging to 9 orders were collected. Sweep net was the best method to collect different groups of insects. From the capture rate, highest rate was recorded for sweep net followed by hand sampling and light trap. Sweep net recorded the highest number of individuals. Furthermore, the results revealed that light trap do not give efficiently to provide reliable inventories from Lamto. Both sweep net and hand sampling were the most efficient and showed the highest insect orders complementarity. However, we recommend the use of the three methods-sweeps net, hand sampling and light trap to made good collection of insects from Lamto.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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