

Impact of habitat on the development of Coprophagous and Xylophagous Coleopteran insects in the park of Bamingui-Bangoran (Central African Republic)

ABSTRACT

Coprophagous and Xylophagous Coleopterans are equally impacted by the fragmentation of ecosystems and are recognized for their character as indicators of certain ecosystem functions, such as the recycling of organic matter and pollination. Thus, as part of the program to restore degraded ecosystems in protected areas and others sectors of the Bamingui-Bangoran Prefecture in the Central African Republic (CAR), an inventory of insect species according to their ecological profile is needed. Insects were collected over 8 hectares corresponding to 6 different habitats in the Bamingui-Bangoran park. Sixty different traps were installed in each habitat with 100 meters of distance between the traps. The measured parameters are the number of individuals collected per week. As results, 8 coleopteran families (4 Coprophagous families and 4 Xylophagous families) were identified. The Coprophagous and Xylophagous Coleopterans were much abounded in grassy savannahs with much mixing trees with *Imperata cylindrica* and in grassy and shrubby savannahs with many flowering plants (Melliferous) and less abounded in grassy and shrubby savannahs dominated by *Imperata cylindrica*. However, repartitions of individuals fit uniform distribution in all coleopteran families belonging to Xylophagous group whereas in coprophagous, uniform distribution fit was established only for one family.

Keywords: Habitat, ecology profile, insect development.

1. INTRODUCTION

Coleopteran insects are present throughout the terrestrial environment and they reveal a significant capacity for colonization and exploitation of their environment. They also occupy a large diversity of ecological niches (Ferrand et al, 2014) and are able to exploit a wide variety of food resources.

Coprophagous Coleopteran are insects that feed on the excrement of other animals. They play an essential role in the recycling of organic matter, because they are often the cause of the decomposition of excrement. Faeces are used as food for imagoes and larvae. Each Coprophagous Coleopteran generally has a relative trophic preference for a given type of excrement (Ailli et Mahdi, 2013). Indeed, the processes of aeration, mixing and burial of faecal matter by these insects directly stimulate fungi, bacteria, and microarthropods in the soil, whose combined actions are essential for the accomplishment of recycling of faecal matter (Lussenhop et al., 1980; Lumaret, 2000).

The Xylophagous Coleopteran are insects that consume woody material during their development cycle. They form a more or less deep gallery inside the wood from the start of the colonization process or after a subcortical phase. These are phytophagous insects that live mostly at the expense of plants (Haddar, 2007; Meziane, 2017). The Xylophagous Coleopteran contribute to diversifying forest ecological niches and they play an important role in forest biological diversity, either directly or via numerous predators. In tropical zones, the Xylophagous Coleopteran species are threatened by clear cutting, forest fires and deforestation.

The Coprophagous and Xylophagous Coleopteran are equally impacted by the fragmentation of ecosystems and are recognized for their character as indicators of certain ecosystem functions, such as the recycling of organic matter and pollination.

Thus, as part of the program to restore degraded ecosystems in protected areas and sectors of the Bamingui-Bangoran Prefecture in Central African Republic (CAR), it is important to make an inventory of insects according to their ecological profile.

2. Materials and Methods

2.1. Surveyed Site

Covering an area of approximately 86,000 km² (figure 1) a large part of the Bamingui-Bangoran park is covered by protected areas, classified as World Heritage (including approximately 90% in Bamingui-Bangoran and 60% in Vakaga) while the area occupied by family farming remains negligible. These are National Parks Bamingui-Bangoran and Manovo-Gounda St. Floris, an Integral Nature Reserve (Vassako Bollo), a Wildlife Reserve

(AoukAouakalé), Sport Hunting Sectors and Areas Village Hunting. The climate of Bamingui-Bangoran is characterized by two distinct seasons and a rainfall of between 800 and 1600 mm (the number of rainy days varying from 95 to 130). The climate is linked to the Sudano-Guinean domain of AUBREVILLE (1949). The Saharan influence of the dry season (North-East harmattan) is opposed to the Guinean influence of the rainy season (South-West monsoon). The study took place between April and June 2017, in the parks of Bamingui-Bangoran.

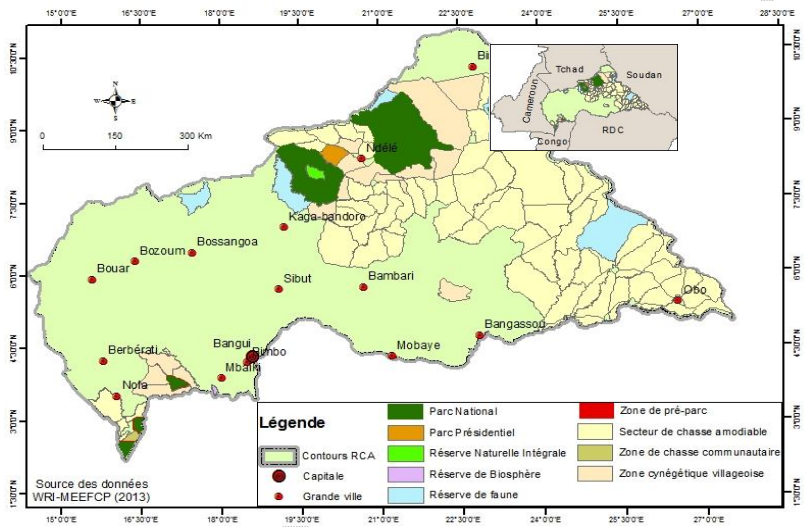


Figure1: Location of national northern park of Bamingui-Bangoran (ECOFAUNE, 2017)

A total of 8 hectares are delimited and are located respectively at a distance of 10 km in the Bamingui-Bangoran Park. In each hectare, sixty different traps are installed in the park with 100 meters of distance between the traps. Insects were collected from different habitats described in table 1.

Table 1. Description of different ecological habitat

Codification	Description of ecological habitat
H1	Dense to thorny thickets, very difficult to penetrate
H2	herbaceous <u>Herbaceous</u> stratum dominated by <i>Imperata cylindrica</i>
H3	Grassy and shrubby savannas with a few Shea trees
H4	Grassy savannas with much mixing trees with <i>Imperata cylindrica</i>
H5	Grassy and shrubby savannas with many flowering plants (melliferous)

H6	Grassy and shrubby savannahs dominated by <i>Imperata cylindrica</i>
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2.2. Insect trapping by the Barber Trap

The Barber trap (figure 2) is the most widely used and standardized method for trapping above ground soils (Piffner and Luka, 2003; Duelli and Obrist, 2003). It makes it possible to sample a variety of epigeal auxiliaries (Coleopteran, rove Coleopteran, spiders) and crop pests (slugs, wireworms, flea beetles Coleopteran, sitones). It is an easy to use and very effective method for obtaining specimens that would otherwise be difficult to obtain. To install the trap, simply dig a hole with a small hand shovel like those used for gardening and place the container in the hole.

2.2.3 The yellow bin

Many insects are attracted to the color yellow. Simply push into the soil, flush with the surface, a flat container the yellowing color with adding a little water dish soap.

2.2.4 The sweet liquid

According to the literature, a sweet liquid or honeydew is an effective method for capturing insects that are not attracted to light. This method consists of brushing a sweet liquid on a support (tree trunk...).

2.2.5 Collection and determination of the families of Coprophagous and Xylophagous Coleopteran

The assessment of the diversity and abundance of insects was carried out by collecting the insects captured in the traps weekly and for six months. Certain characteristics of the insects were determined on the sites using a magnifying glass. The samples were stored in alcohol 70%. In the laboratory, the samples were processed immediately. The samples were washed and cleared of various debris (leaves, twigs, buds, etc.). The insects were sorted in a water tank and distributed by family then repackaged by family. For the most part, identification was based on morphological criteria, the observation of which requires the use of a magnifying glass or a microscope and an identification key.

The Coleoptera are well characterized by their hardened forewings, which have become elytra. This criterion is found in other orders, but what characterizes the Coleoptera (Jeannel in Traite de Zoologie de P. GRASSE) is that the sutural edges of the elytra are juxtaposed without overlapping. The prothorax is often free from the meso and metathorax which join the abdomen quite tightly. If the coxa does not extend to the elytra, and the antennae are placed between the eyes and the mandibles, the insect is of the Carabid family (Carabidae). When the antennae end in lamellae, it is case of Coleoptera of the superfamily Scarabaeoidea. The

Comment [AM1]: Where is 2.2.1 and 2.2.2? Please check the continuity of the subtopics.

Comment [AM2]: Sould at least cite one paper as reference for the method.

Comment [AM3]: Sould at least cite one paper as reference for the method.

Comment [AM4]: The sentence seems incomplete. Please elaborate more and cite at least a paper to support the statement.

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Bruchids are small insects, usually measuring around 4mm, with some larger species measuring just over 2cm. They are protected by an exoskeleton, and slightly shorter elytra that cover the abdomen, revealing the last abdominal segment (pygidium). They are generally brownish in color, some with more colorful patterns (JeanneletPaulian, 1944; Balfour-Browne, 1956; Delvare and Aberlenc, 1989; Dajoz, 2002; Ingerson-Mahar, 2002; Bartolozzie and Werner, 2004).



Figure 2. (a) the Barber's trap; (b) a yellow bin; (c) a jar containing sweet liquid et (d) conservation of insects in alcohol 70%.

Comment [AM6]: The term "preservation" should be more accurate.

2.3.Data Analysis

The measured parameters are the number of insects collected per week. The comparison of the number of insects according to the habitats was performed using One-Way Analysis of Variances (ANOVA) followed by Tukey's HSD tests in the event of significant differences. Results are expressed as means \pm standard deviation. To establish probable trends to equal repartitions over the 6 habitats within a family, uniform distribution fit was performed using Chi-square tests for given probabilities. R software was used for all analyses. The differences are considered significant for $P < 0.05$.

3. Results

3.1 Family diversity and abundance of individuals

We identified 8 coleopteran families, 4 of which belong to the coprophagous group and the other 4 belong to the Xylophage group. A total of 20562 individuals were collected during the

survey period. The most abundant coprophagous coleopterans belonged to the *Cicindelidae* family (3848 individuals) followed by the *Geotrupidae* family (3497 individuals); *Aphodiidae* and *Scarabaeidae* families totalized 3191 and 2782 individuals, respectively (Figure 3). In Xylophagous group, the *Tenebrionidae* family was the most abundant (2287 individuals) followed by the *Bruprestidae* family (1729 individuals); *Scolytidae* and *Cerambycidae* families were represented by 1635 and 1593 individuals, respectively (Figure 3).

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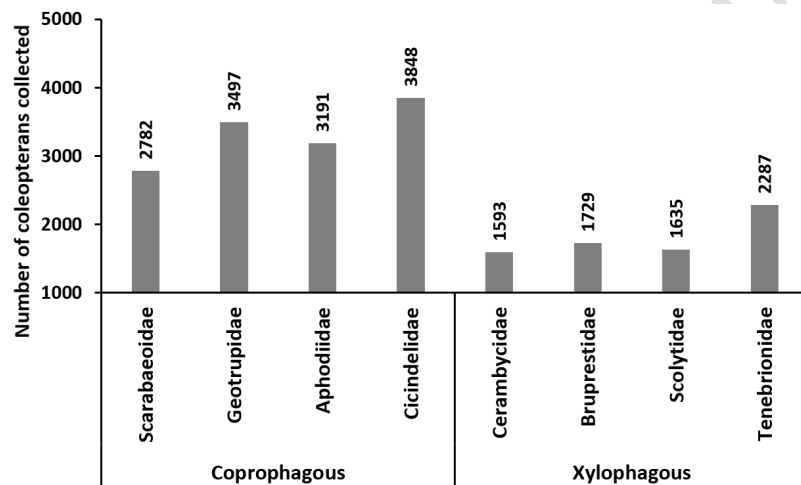


Figure 3. Abundance of Coprophagous and Xylophagous coleopterans collected over the 6 months of survey.

3.2. Repartition of Coprophagous Coleopterans in the habitats

Globally in all Coprophagous coleopteran families, H6 was the habitat where significantly lower numbers of individuals were recorded (Table 1). The average repartition of insects in the *Scarabaeidae* family ranged between 40 and 47 individuals in H1 to H5 with no statistical difference ($P > 0.05$). The same pattern of the average repartition in the habitats H1 to H5 was recorded in *Geotrupidae* (47-59 individuals) and in *Cicindelidae* families (57-61 individuals) with no significant differences ($P > 0.05$) within the family. The exception was observed in the *Aphodiidae* family where the number of individuals in the habitat H3 (Grassy and shrubby savannahs with a few Shea trees) dropped to 41.7 ± 27 but still significantly higher than that recorded in the habitat H6 (Grassy and shrubby savannahs dominated by *Imperata cylindrica*). In spite of the difference in numbers observed for the habitat H6, only the repartition of individuals in the *Geotrupidae* family follow uniform distribution over the 6 habitats surveyed (X-square = 7.9, df = 5, $P = 0.16$; Table 2). This means that even if the number of individuals

in the habitat H6 is relatively low, the repartition tends to be the same over the 6 habitats surveyed for the *Geotrupidae* family. In the others Coprophagous families, the uniform distribution fit test failed ($P < 0.05$; Table 2) showing no trend to equal repartition over the 6 habitats.

3.3. Repartition of Xylophagous Coleopterans in the habitats

The repartition of Xylophagous Coleopterans in the habitats was different from that observed in Coprophagous in the way that numbers of individuals in the habitat H6 were not statistically different from all the others habitats. Indeed, statistical differences were established only in H5 and H6 (29.4 ± 19.9 and 15.7 ± 2 individuals, respectively; $P < 0.05$) for the *Cerambycidae* Family and only in H4 and H6 (36.7 ± 10.7 and 25.6 ± 16.2 , respectively; $P < 0.05$) for the *Tenebrionidae* family (Table 1). In the *Bruprestidae* family, the average numbers of individuals in the 6 habitats ranged from 21 to 28 and no significant differences was established ($P > 0.05$). The *Scolytidae* family was the only one where we recorded a higher number of individuals in the habitat H6 (30 ± 10 individuals) compared to the other habitats (19.9-25.9 individuals). However, uniform distribution fit tests have established trends to equal repartition in all the Xylophagous families ($P > 0.05$; Table 2).

Table 2. Statistical comparison of numbers (means \pm SD) of Coprophagous and Xylophagous Coleopterans according to the habitats within each family

Different ecological habitat	Coprophagous Coleopterans				Xylophagous Coleopterans				Total of individuals/habitat
	<i>Scarabaeid</i>	<i>Geotrupidae</i>	<i>Aphodiidae</i>	<i>Cicindelida</i>	<i>Cerambycidae</i>	<i>Bruprestida</i>	<i>Scolytidae</i>	<i>Tenebrionida</i>	
H1	46 \pm 13.2 ^a	47.4 \pm 34.2 ^a	46.5 \pm 28.3 ^{ab}	60.4 \pm 23.7 ^a	19.7 \pm 17.9 ^b	22.6 \pm 14.1 ^a	21.6 \pm 13.4 ^b	34.9 \pm 14.7 ^{ab}	3590
H2	47.4 \pm 15.5 ^a	51.9 \pm 33.1 ^a	54.4 \pm 25.8 ^a	60.1 \pm 17.8 ^a	19.8 \pm 18.4 ^b	21.9 \pm 12.6 ^a	20.4 \pm 1 ^b	31.2 \pm 9.1 ^{ab}	3686
H3	47.2 \pm 15.6 ^a	53.1 \pm 32.1 ^a	41.7 \pm 27 ^b	57.3 \pm 23 ^a	24.5 \pm 19.3 ^{ab}	28.8\pm18.9^a	25.9 \pm 18.7 ^{ab}	31.3 \pm 17.9 ^{ab}	3717
H4	40 \pm 15.9 ^a	59.3\pm43.9^a	52 \pm 23.5 ^a	61.1\pm22^a	23.5 \pm 19.5 ^{ab}	24.4 \pm 11.6 ^a	19.9 \pm 13.1 ^b	36.7\pm10.7^a	3803
H5	44.4\pm15.6^a	55 \pm 38.9 ^a	56.7\pm24.9^a	57.9 \pm 20.5 ^a	29.4\pm19.9^a	25.2 \pm 2 ^a	22.3 \pm 17.3 ^{ab}	30.9 \pm 15.4 ^{ab}	3861
H6	6.85 \pm 2.7 ^b	33.7 \pm 30 ^b	21 \pm 14.7 ^c	31 \pm 17.2 ^b	15.7 \pm 2 ^b	21.2 \pm 8.7 ^a	30\pm10^a	25.6 \pm 16.2 ^b	1905

Means followed by different letters are statistically different (ANOVA followed by the Tukey's HSD test, $P < 0.05$); in bold the biggest means.

Table 3. Uniform distribution fit test with the average repartition of individuals within each family over the 6 habitats

Statistical	Coprophagous Coleopteran				Xylophagous Coleopteran			
	<i>Scarabaeidae</i>	<i>Geotrupidae</i>	<i>Aphodiidae</i>	<i>Cicindelidae</i>	<i>Cerambycidae</i>	<i>Bruprestidae</i>	<i>Scolytidae</i>	<i>Tenebrionidae</i>
Chi-square value	32.3	7.9	19	12.4	5	1.6	3.25	2.3
P-value	5.10 ⁻⁶	0.16	0.002	0.03	0.41	0.9	0.66	0.8

P-values in bold are superior to 0.5 indicating a trend to an equal repartition of individuals over the 6 habitats within the family.

Discussion

The present work is the first step to the identification of coleopterans in different habitats existing in the CAR. The National Park of Bamingui-Bangoran is by excellence an ecosystem that bring together all types of biotopes that can be found across the country. Thus, we retained 6 pilot habitats where this study was performed.

Trapping tools employed allowed to collected several coleopterans divided into 2 groups (Coprophagous and Xylophagous) over the 6 habitats surveyed. The Coprophagous group was represented by 4 families (*Scarabeidae*, *Geotrupidae*, *Aphodiidae* and *Cicindelidae*) totalizing 13318 individuals (64.76%). Each of these families are a higher number of individuals compared to families in the Xylophagous group. This tend to confirm the fact that none of Coprophagous beetles is considered rare species (Miessen et al, 2005).

The Xylophagous group was represented also by 4 families with an abundance of 7244 individuals (35.23%). Such a result is in accordance with that of Talbi and Bouhraoua (2015) who found also 4 xylophagous families with an abundance representing 32,14% of the total of collected individuals in the Algerian Atlas. The low abundance of individuals in the xylophagous group may be explained by the fact that wood is extensively used as source of energy in households and field burns for cropping, thus directly impacts the density vegetal covert. Indeed, coprophagous and xylophagous coleopterans pooled together were much abounded in the habitats H1 – H5 (3590 – 3861 individuals) than in the habitat H6 (1905 individuals) characterized by grassy and shrubby savannahs dominated by *Imperata cylindrica*. The plant cover strongly modifies the parameters near the ground, thus influencing the distribution of beetles (Mecherihadjer et al, 2014).

The burrowers bring together several species of the *Scarabeidae* family and the *Geotrupidae*. The individuals dig a burrow under the excrement and lay their eggs in cells filled with feces and laid out below the surface. They mix the excrement with the surface layer of the soil. Such behavior, highly adaptive, allows the larvae to have enough reserves to accomplish all their development, the adults compete in order to accumulate the reserves (Lumaret 1989).

The family of *Cicindelidae* is most abundant H1 in (Dense to thorny thickets, very difficult to penetrate), H2 (herbaceous stratum dominated by *Imperata cylindrica*), H3 (Grassy and shrubby savannahs with a few Shea trees) and H4 (Grassy savannahs with much mixing trees with *Imperata cylindrica*).

The *Cerambycidae*, commonly called beetles or capricorns because of the length of their antennae often exceeding that of the body, are a family of insects of the order Coleoptera. *Cerambycidae* beetles belong to the phytophagoidea superfamily (sensu

Comment [AM8]: Family name should not in italic

Comment [AM9]: A bit misleading. In previous sentence mentioned only about the families groups, but in this sentence mentioned about species level. So, which taxa group the author(s) intend to discuss? The whole manuscript does not mentioned in detail the species collected in numbers, I think if the specimens are arranged to species level, some rarity should be found. Plus, species rarity also can be statistically tested.

Comment [AM10]: Should be a dot, not a comma.

Comment [AM11]: The correct term is "dominated"

Comment [AM12]: Should not in italic. Please check for the whole manuscript.

Comment [AM13]: This paragraph does not really discussed the finding. This is just a literature review. Either remove it, or move it to Introduction with a proper continuation between the paragraph.

Comment [AM14]: The correct term is "dominated"

Comment [AM15]: Longhorn beetle

Comment [AM16]: Sentence are not properly written. Please paraphrase this sentence. Also, this paragraph does not discussed the finding.

Jeanne and Paulian, entomologists). Most of the insects of this family are sylvicultural living in deadwoods with the exception of a few species living in hot and dry places or even deserts.

The Scolytidae family According to Benhalima (2006), this family is composed of xylophagous species and is placed at the forefront of the natural enemies of coniferous forests, and is responsible for 90% of the damage caused. Balachowsky in 1962, indicated that most species of the genus *Scolytus* colonize every weakened, fallen or felled tree. Some Scolytidae can change their behavior toward their host. In fact, they have a polyphagy that allows them to live on both Conifers and Hardwoods. Bark beetles practice gallery systems composed of a corridor that the female practices during spawning, this corridor is dotted on both sides by larval galleries which start from notch whose eggs are deposited by the female. Adults are small, cylindrical, fairly good fliers. The larvae of most species are xylophagous, digging their galleries from the one made by the adults (oviposition gallery or maternal gallery) in the bark or between wood and bark. Some bark beetles are dependent on symbiotic "Ambrosia" fungi which they sow in their galleries and which they consume once they have digested the wood.

Conclusion

The cluster analysis showed that the herbaceous stratum dominated by *Imperata cylindrica* and the grassy and shrubby savannahs with a few Shea trees are the most similar in relation to species composition and abundance, yet different from the Dense to thorny thickets, very difficult to penetrate with herbaceous stratum dominated by *Imperata cylindrica* and the Grassy and shrubby savannahs with a few Shea trees.

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Comment [AM17]: In general, the Discussion are weakly elaborated the findings. The author(s) should highlighted the "why" and the "how" such results obtained from the sampling processes. This manuscript has the potential, but need a proper constructive discussion based on the findings.

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