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Vulnerability of Host Tree Species with Edible Caterpillars in the Yangambi Biosphere Reserve (Tshopo Province, DRC)

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ABSTRACT

The study on the vulnerability of edible caterpillar host tree species in the Yangambi Biosphere Reserve (Tshopo Province, DRC), led to the identification of 35 edible caterpillar host tree species, belonging to 17 families, mainly dominated by *Fabaceae*. These tree species were generally used as medicinal plants and timber trees (71,4% each); the most used organ was wood (85,7%); the analyses showed that there is a moderately positive correlation between the number of uses and the number of organs used of the caterpillar host tree species ($\boldsymbol{\tau}$: 0.61, p-value: 0,000); to collect the organs of the edible caterpillar host tree species, the population resorted more to felling (85,7%); all edible caterpillar host tree species were used at the adult stage. The floristic analysis of bioecological characteristics revealed that 62,9% of edible caterpillar host tree species had secondary forests as habitat, 61,1% were mesophanerophytes, 65,7% were sarcochores, 57,1% were Omniguineo-Congolese, 51,4% were evergreen and 74,3% were heliophiles. The vulnerability analysis revealed that 88,57% of edible caterpillar host tree species are moderately vulnerable to the high demand of the population for ecosystem goods and services.

Keywords: specie, host tree, edible caterpillar, vulnerability, Yangambi

1. INTRODUCTION

Edible insects have, for a very long time, been integrated into the dietary habits of populations living in and around the tropical forest of Tshopo province (Okangola *et al*., 2007). In addition to timber, this forest provides interesting potential in terms of non-timber forest products (NTFPs) to ensure the economy and even the survival of local populations. Among these non-timber forest products, edible caterpillars are consumed while their host tree species are exploited by different communities in the region (Lisingo *et al.,* 2010).

These tree species, which serve as habitat and food support for edible caterpillars, are exploited irrationally and exclusively for multiple uses (medicinal, wood production, wood trade, timber and food plants) (Okangola *et al.,* 2019). This negligent exploitation therefore leads to the continuous degradation of the vegetation cover and the erosion of the plant heritage. These lead to the reduction of edible caterpillar host tree species, and consequently, to the destruction of the edible caterpillar habitat and the reduction of their population (Traoré *et al.,* 2011, Bomolo, 2017).

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Given the ecological and socio-economic value of caterpillar host tree species, it is important to assess the ecological impact of the uses of these species on the basis of vulnerability index. Vulnerability assessment, taking into account anthropogenic factors, is a major imperative for the success of sustainable management actions for edible caterpillar host tree species.

It is with this in mind that this study aims to analyze the vulnerability of edible caterpillar host tree species in the Yangambi Biosphere Reserve.

2. ENVIRONMENT, MATERIALS AND METHODS

2.1. Environment

2.1.1. Location and period of the research

The research was carried out in the Yangambi Biosphere Reserve, which is located in the northeast of the DRC, in the province of Tshopo, approximately 100 km west of the city of Kisangani, the provincial capital (Kyale *et al.,* 2019), with local members residing in the Lusambila, Ekutshu, Likango, Lomboto and Mandikala districts, during the period from April to July 2024, i.e. 4 months of research.

Figure 1 below shows the location and boundaries of the Yangambi Biosphere Reserve.

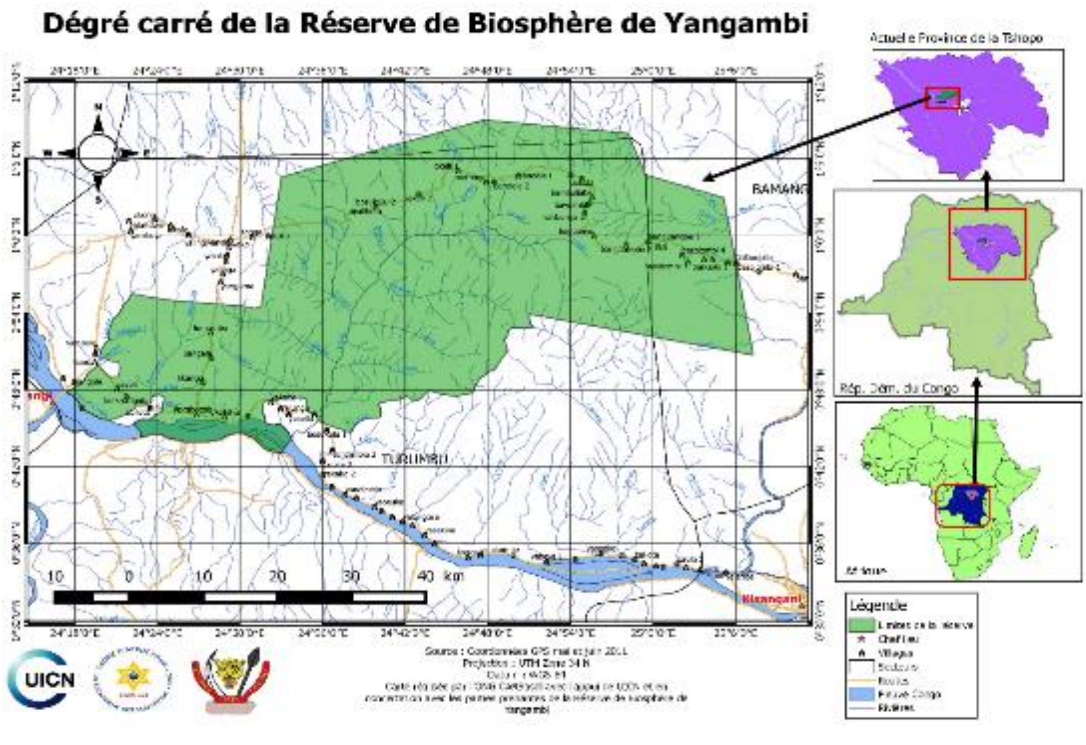

Figure 1: Location and boundaries of the Yangambi Biosphere Reserve (MECNT, 2020)

2.2. Materials

To better conduct this research and achieve the expected results, the use of edible caterpillars, caterpillar host tree species and respondents as biological material for this study was made. We used the following non-biological materials: a GPS device, for collecting the geographical coordinates of the study site; questionnaire sheets, to sort information on the subject of the survey; a smart phone, for taking images of edible caterpillars and caterpillar host plants, as well as browsing the Internet; a computer, for text entry, data processing and plotting tables, histograms and sectors.

2.3. Methods

In relation to the objectives of this work, we used participatory and empirical methods, which were supported by the survey technique (ethnozoological and ethnobotanical), which made it possible to establish the vernacular names of edible caterpillars, as well as those of their host tree species, to determine the types of uses, the organs used, the methods of collecting the organs used, the stages of development of the host tree species for edible caterpillars; the documentary technique helped to collect the bioecological characteristics of the host tree species for edible caterpillars and other information; direct observation, from which hikes in the forest were carried out for field observations and sample collection.

To identify the species of edible caterpillars, we showed the respondents, during the surveys, the photos of the edible caterpillars of Tshopo, found in the works of LISINGO *et al.* (2010), ONGAGOLA *et al.* (2019) and LOOLI *et al.* (2021) and from these photos, they gave the vernacular names of each edible caterpillar.

The tree species were determined at the Herbarium of the Faculty of Agronomy Institute in Yangambi based on local collections and the work of TAILFER (1989), PAUWELS (1993) and WILKS and ISSEMBE (2000).

2.4. Data processing and statistical analyses

To statistically analyze the socio-demographic aspects, ethnobotanical aspects, uses, organs used, sampling methods, stages of development and floristic analysis of the bioecological characteristics of the host tree species for edible caterpillars, we used the calculations of: percentage, mean, standard deviation and variance.

To calculate the vulnerability of host tree species to edible caterpillars, the Species Vulnerability Risk Index (*IVi*) calculation adapted from Betti (2001) and Traoré *et al.* (2011) was used.

The vulnerability scale has three levels, from 1 to 3. A value of 1 designated a species with low vulnerability for the indicated parameters, a value of 2 represented medium vulnerability, and a value of 3 characterized a species with high vulnerability. The vulnerability indices were calculated from the following parameters:

1. **Number of uses of the species (N1):** The value 1 is assigned to caterpillar host tree species with a number of uses less than 2, the value 2 to caterpillar host tree species with a number of uses greater than or equal to 2 and less than or equal to 4 and the value 3 to caterpillar host tree species with a number of uses greater than 5.
2. **Organs used (N2)**: The value 1 is assigned to caterpillar host tree species whose plant organs collected are leaves, latex, seeds and flowers; value 2 to caterpillar host tree species whose plant organs are fruits and branches and value 3 to caterpillar host tree species whose plant organs are wood, bark, stems and roots.
3. **Sampling method (N3)**: Value 1 is assigned to caterpillar host tree species whose sampling method is collection, value 2 to caterpillar host tree species whose sampling method is leaf picking and value 3 to caterpillar host tree species whose sampling method is felling, uprooting, fruit picking, bark stripping and limbing.
4. **Development stage (N4)**: Value 1 is assigned to caterpillar host tree species harvested in old age or senescence, value 2 is assigned to caterpillar host tree species harvested in the adult stage and value 3 is assigned to caterpillar host tree species harvested in the young stage.
5. **Habitat type (N5)**: Value 1 is assigned to caterpillar host tree species in rangelands, gardens and crops; value 2 is assigned to caterpillar host tree species in secondary forests and value 3 is assigned to caterpillar host tree species in primary and disturbed forests.
6. **Biological types (N6)**: Value 1 is assigned to Hemicryptophyte species, value 2 is assigned to Chamaephyte species and value 3 is assigned to Phanerophyte species.

7. **Diaspore types (N7)**: Value 1 is assigned to caterpillar host tree species whose diaspores are dispersed by autochory (ballochory, barochory), value 2 to caterpillar host tree species whose diaspores are dispersed by anemochory (pterochory, pogochory, sclerochory, pleiochory) and value 3 to caterpillar host tree species whose diaspores are dispersed by sarcochory or desmochory and zoochory.
8. **Phytogeographic distribution (N8)**: Value 1 is assigned to cosmopolitan caterpillar host tree species; the value 1.5 to the host tree species for caterpillars with a wide geographical distribution: Afro-American species (AA): species represented in Africa and tropical America, pantropical species (Pan): species found in all tropical regions of the world (Africa, America, Asia and Oceania), paleotropical species (Pal): species found in Africa and tropical Asia as well as in Madagascar and Australia, Afro-Malagasy species (AM): species distributed in Africa and Madagascar and the African pluriregional species (PRA); the value 2 to the host tree species for Sudano-Zambézian caterpillars; the value 2.5 to the endemic caterpillar host tree species of the Guinean-Congolese endemism center: omniguinean species (OGC): Guinean-Congolese species, found throughout the Guinean-Congolese regional endemism center, bas-guinéo-congolaise species (BGC): Central Guinean species whose geographical distribution extends from Cameroon to Congo and the Congolese Central Forest species (CFC): confined to the central forest sector; and the value 3 to the endemic caterpillar host tree species.
9. **Foliage behavior (N9)**: The value 1 is assigned to the evergreen foliage caterpillar host tree species, the value 2 to the semi-deciduous foliage caterpillar host tree species and the value 3 to the deciduous foliage caterpillar host tree species.
10. **Tree temperaments (N10):** The value 1 is assigned to host tree species for heliophilous caterpillars, the value 2 to host tree species for tolerant caterpillars and the value 3 to host tree species for sciaphilous caterpillars.

All woody host species for edible caterpillars used were observed directly in the field. Since the existence of all the species from the surveys is effective, those that were not encountered during the hikes carried out in the forest were considered as species with low frequency in the environment.

When several parts of a plant are requested and several sampling methods are used, only those with the highest value from the vulnerability scale were taken into account in the calculation of the indices.

Thus, the calculation of the vulnerability index of the caterpillar host tree species *i* (*IVi*), followed the following formula:

$$IVi = \frac{N1 + N2 + N3 + N4 + N5 + N6 + N7 + N8 + N9 + N10}{10}$$

If $IVi < 2$, the edible caterpillar host tree species is said to be low vulnerable; if $2 \leq IVi <$ 2,5, the edible caterpillar host tree species is said to be moderately vulnerable; if $IVi \geq 2{,}5$, the edible caterpillar host tree species is said to be highly vulnerable.

To calculate the correlation between the number of uses of caterpillar host tree species and their organs used, we used Kendall's Tau correlation. The Shapiro-Wilk normality test was used to determine which correlation coefficient to use.

3. RESULTS

3.1. Ethnobotanical aspects

3.1.1. Host tree species and their edible caterpillars

A total of 35 host tree species for edible caterpillars and 12 edible caterpillar species were recorded during the survey. *Amphimas pterocarpoides, Erythrophleum suaveolens, Uapaca guineensis* are each colonized by 3 edible caterpillar species, or 25%. They are followed by *Millettia laurentii, Petersianthus macrocarpus* and *Ricinodendron heudelotii* with 2 species each, or 16,7%. The other host tree species for edible caterpillars are each conquered by 1 species, or 8,3%.

3.1.2. Taxonomic identification of edible caterpillar host tree species

The 35 edible caterpillar host tree species recorded in the study area belong to 17 families, 8 orders, 2 classes, 2 sub-phyla and 1 phylum. These species show a predominance of *Fabaceae* with 34,4% of genera and 33,3% of species.

3.2. Uses of edible caterpillar host tree species

25 edible caterpillar host tree species in the Yangambi Biosphere Reserve, or 71,4% are used, ex-aequo, as medicinal plants and timber trees; 16 species, or 45,7% are used as fuelwood trees; 9 species, or 25,7%, are used as food plants and finally, 1 species, or 2,9% is used as an ichthyotoxic tree.

Note that the average use of caterpillar host tree species is 2,17 uses, the standard deviation is 1,043 uses and the variance is 1,087 uses, this implies that there is a moderate dispersion or variability of uses of caterpillar host tree species compared to the average, because the values are close to each other.

Figure 2 shows the distribution of edible caterpillar host tree species according to number of uses.

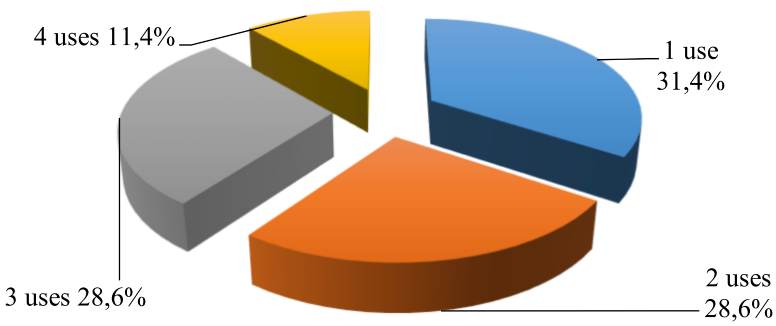

Figure 2: Distribution of edible caterpillar host tree species according to number of uses

It appears in this figure 2 that 31,4% of edible caterpillar host tree species have 1 use, 28,6% have, ex-aequo, 3 uses and 2 uses and 11,4% have 4 uses.

3.3. Organs used by edible caterpillar host trees

The most used organ of edible caterpillar host tree species in the Yangambi Biosphere Reserve is wood with 30 species, or 85,7%; followed by bark with 20 species, or 57,1%; leaf and fruit with 12 species, or 34,3% each; root with 3 species, or 8,6% and finally, seed with 2 species, or 5,7%.

It should be noted that the average organs used by caterpillar host tree species is 2,26 organs, the standard deviation is 1,039 uses and the variance is 1,079 uses, which shows low heterogeneity, that is, the organs used are weakly dispersed around the average, as they vary little from one tree to another.

Figure 3 shows the distribution of edible caterpillar host tree species according to the number of organs used.

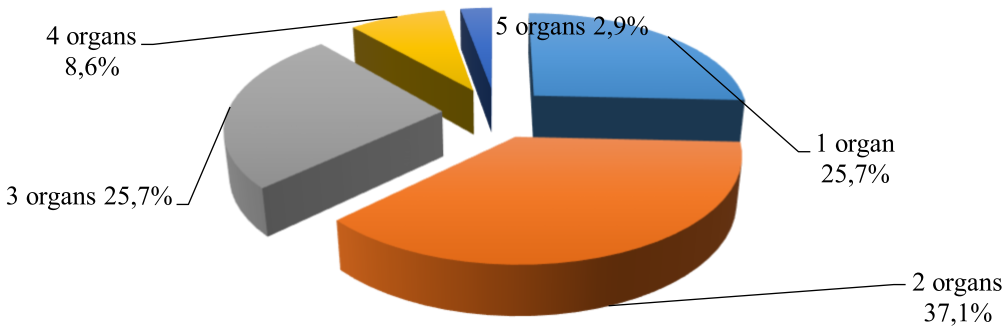

Figure 3: Distribution of edible caterpillar host tree species according to the number of organs used

Figure 3 shows that 37,1% of edible caterpillar host tree species in the Yangambi Biosphere Reserve have 1 organ used, 25,7% have, ex-aequo, 2 organs and 3 organs used, 8,6% have 4 organs used and 2,9% have 5 organs used.

3.4. Correlation between the number of uses and organs used of caterpillar host tree species

Figure 4 shows the correlation between the number of uses and organs used of caterpillar host tree species in the Yangambi Biosphere Reserve.

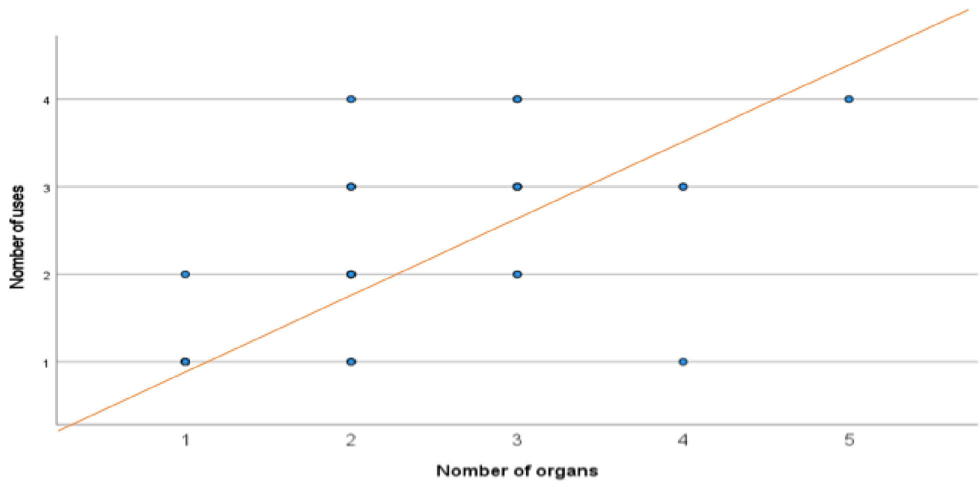

Figure 4: Correlation between the number of uses and the organs used of the caterpillar host tree species

The analyses showed that there is a moderately positive correlation between the number of uses and the organs used of the caterpillar host tree species in the Yangambi Biosphere Reserve (τ: 0,601, p-value: 0,000), that is to say that the number of organs used evolves weakly in the same direction as the number of uses.

3.5. Methods of harvesting organs of edible caterpillar host tree species

The results reveal that the most predominant method of harvesting organ species of edible caterpillar host trees in the Yangambi Biosphere Reserve is felling with 30 species, or 85,7%; followed by bark stripping with 20 species, or 57,1%; leaf picking and fruit picking with 12 species, or 34,3% each; uprooting with 3 species, or 8,6% and finally seed picking with 2 species, or 5,7%.

3.6. Development stage of edible caterpillar host tree species

It is shown in this research that all edible caterpillar host tree species in the Yangambi Biosphere Reserve are used at the adult stage.

3.7. Floristic analysis of bioecological characteristics of edible caterpillar host tree species

3.7.1. Habitat types of edible caterpillar host tree species

The results reveal that 62,9% of edible caterpillar host tree species in the Yangambi Biosphere Reserve have secondary forests as habitat, 31,4% have primary forests as habitat and 5,7% are cultivated trees.

3.7.2. Biological types of edible caterpillar host tree species

The results show the predominance of mesophanerophytes with 61,1% of edible caterpillar host tree species, followed by macrophanerophytes with 30,6% and finally, microphanerophytes with 8,3%.

3.7.3. Diaspore types of edible caterpillar host tree species

The analysis of diaspore types reveals the predominance of sarcochores edible caterpillar host tree species with 65,7%, followed by barochores and ballochores with 11,4% each, pterochores with 8,6% and finally, pogochores which are poorly represented with 2,9%.

3.7.4. Phytogeographic distribution of edible caterpillar host tree species

The detailed analysis of the phytogeographic affiliation of edible caterpillar host tree species shows the dominance of Omniguinéo-Congolaise species (57,1%). Bas-Guineo-Congolaise and Afrotropicales tree species are respectively represented with 17,1% each. Congolese tree species from the Central and Pantropical Forests are poorly represented with 5,7% and 2,9% respectively.

3.7.5. Foliage behavior of edible caterpillar host tree species

The results show that 18 edible caterpillar host tree species, or 51,4%, are evergreen species and 17 species, or 48,6%, are deciduous species.

3.7.6. Temperaments of edible caterpillar host tree species

The results highlight the preponderance of heliophilous edible caterpillar host tree species with 74,3%, followed by sciaphilous edible caterpillar host tree species with 14,3% and tolerant edible caterpillar host tree species with 11,4%.

3.8. Vulnerability of edible caterpillar host tree species

Figure 5 illustrates the vulnerability of edible caterpillar host tree species in the Yangambi Biosphere Reserve.

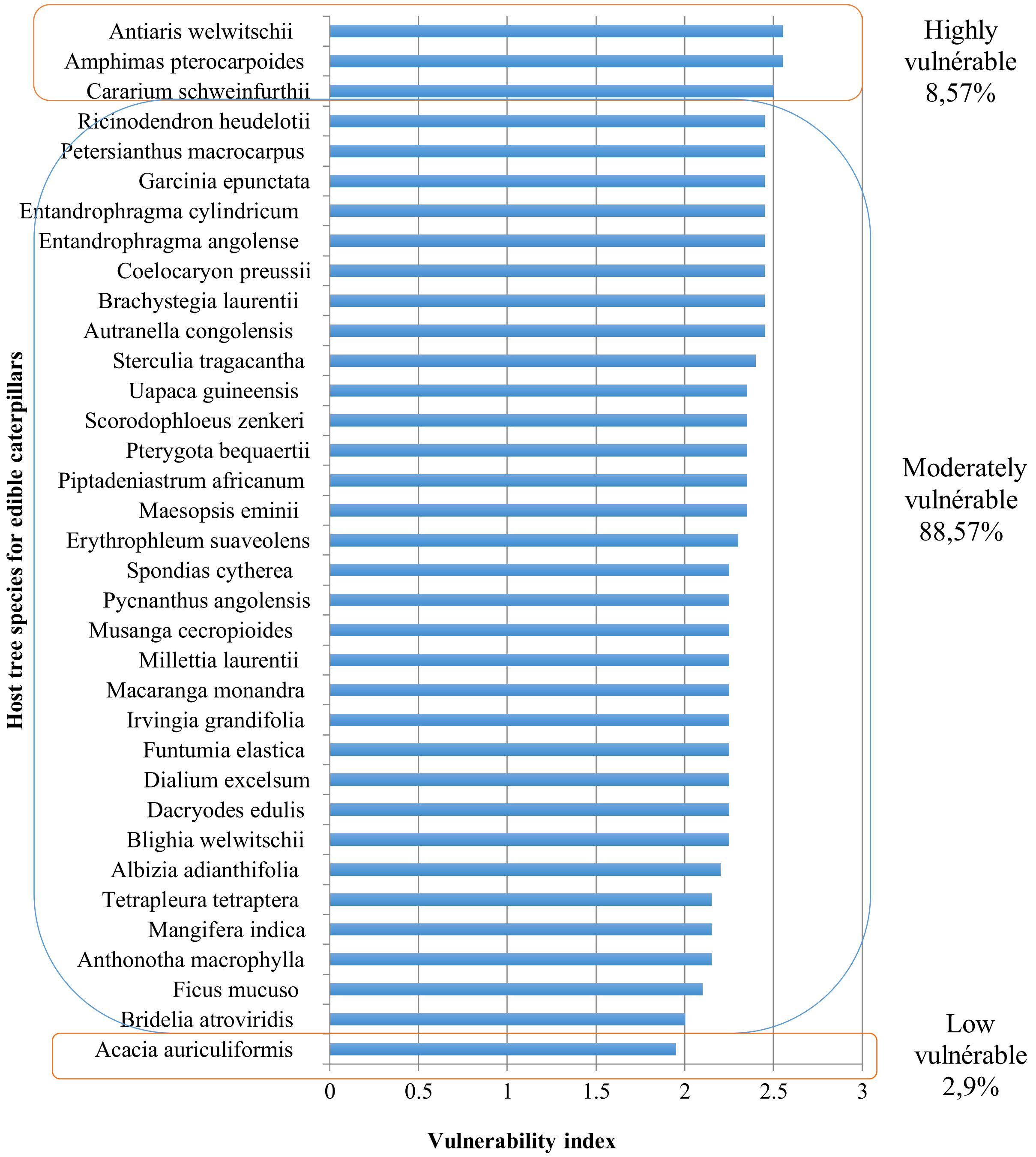

Figure 5: Vulnerability spectrum of edible caterpillar host tree species

The analysis of the results recorded in Figure 5 reveals that 31 edible caterpillar host tree species in the Yangambi Biosphere Reserve, or 88,57%, are moderately vulnerable to the population's high demand for ecosystem goods and services; 3 species, or 8,57%, are highly vulnerable and finally, only 1 species, 2,9%, is low vulnerable.

4. DISCUSSION OF RESULTS

The results of this study reveal that 31 edible caterpillar host tree species in the Yangambi Biosphere Reserve, or 88,57%, are moderately vulnerable to the population's high demand for ecosystem goods and services; 3 species, or 8,57%, are highly vulnerable and finally, only 1 species, 2,9%, is low vulnerable.

These results are in line with those found by Beriname *et al*. (2018), which reveal that 55,70% of woody species used have a medium vulnerability risk, 28,19% have a high vulnerability risk and 16,11% of species have a relatively low vulnerability risk. These results are somewhat different from those found by Yaovi *et al.* (2021), which show that 31,25% of woody species used in their study environment are respectively low vulnerable and medium vulnerable, 17,5% are very vulnerable.

The predominance of caterpillar host tree species with a medium vulnerability index could be explained by their development stage, organ used, method of organ harvesting and temperament. Among these parameters, the development stage is the main cause of their vulnerability, because 100% of edible caterpillar host tree species are used at the adult stage (value 3); followed by the organ used, because 82,9% of edible caterpillar host tree species have wood as the organ used (value 3); the method of organ harvesting, because 82,9% of edible caterpillar host tree species are completely felled (value 3) and finally the temperament, because 74,3% of edible caterpillar host tree species are heliophilous (value 3).

5. CONCLUSION

This study focused on the vulnerability of edible caterpillar host tree species in the Yangambi Biosphere Reserve (Tshopo Province, DRC).

The main objective of this study was to analyze the vulnerability of edible caterpillar host tree species in the Yangambi Biosphere Reserve.

At the end of this study, we can retain the following: a total of 35 species of host trees for edible caterpillars were listed in the study environment, belonging to 17 families, 8 orders, 2 classes, 2 sub-phyla and 1 phylum. These species, in majority were essentially dominated by *Fabaceae* with 34.4% of different species; the species of host trees for edible caterpillars offered great potential for the local population, they were generally used as medicinal plants and timber trees (71,4% each), energy wood trees (45,7%); the most used organ was wood (85,7%); the analyses showed that there is a moderately positive correlation between the number of uses and the number of organs used of the species of host trees for caterpillars (τ: 0,61, p-value: 0,000); to harvest the organs of edible caterpillar host tree species, the population resorted more to felling (85,7%); all edible caterpillar host tree species were used at the adult stage; the floristic analysis of bioecological characteristics revealed that 62,9% of edible caterpillar host tree species had secondary forests as habitat, 61,1% were mesophanerophytes, 65,7% were sarcochores, 57,1% were Omniguineo-Congolese, 51,4% were evergreen and 74,3% were heliophiles; the vulnerability analysis revealed that 88,57% of edible caterpillar host tree species are moderately vulnerable to the population's high demand for ecosystem goods and services.

REFERENCES

Beriname, B., Kouami, K., Nadedjo, B., Dabitora, K., Ayitre, A., Macomba, B., & Georges, A. (2018). Ethnobotanical study of woody species of dry savannahs in Northern Togo: diversity, uses, importance and vulnerability. *Biotechnol. Agron. Soc. Environ., 22*(3), 152-171.

Betti, J.L. (2001). Vulnerability of plants used as antimalarials in the Mintom district south of the Dja Biosphere Reserve (Cameroon). *Syst. Geogr. Pl., 71*, 661-678.

Bomolo, O. (2017). *Entomophagy, ecology and exploitation system of the edible caterpillar "Elaphodes lactea (Gaede 1932) from the Miombo-type open forest of the Lubumbashi plain, Haut-Katanga (D.R. Congo)".* Thesis, University of Lubumbashi, Democratic Republic of Congo. 115p.

Kyale, J., Maindo, A. & Andrew, W.D. (2019). Yangambi Biosphere Reserve tested by the crystallization of local survival practices: a response to the failure of the State in the Democratic Republic of Congo. *VertigO - the electronic journal in environmental sciences, 19*(1), 1-32.

Lisingo, J, Wetsi, J.L. & Ntahobavuka, H. (2010). Survey on edible caterpillars and the various uses of their host plants in the districts of Kisangani and Tshopo (D.R. Congo). *Geo-Eco-Trop., 34*, 139-146.

Looli, B.L., Dowiya, B, Bosela, O., Salumu, P., Monzenga, J.C., Posho, B., Mabossy-Mobouna, G., Latham, P. & Malaisse, F. (2021). Harvesting techniques and sustainable exploitation of edible caterpillars in the Yangambi region, D.R. Congo. *Geo-Eco-Trop, 45*(1), 113-130.

MECNT (2020). *General management plan of the Yangambi biosphere reserve*. 56p.

Okangola, E., Dudu, A. & Upoki, A. (2019). *The bioecology of edible caterpillars and screening of host plants.* European University Editions, Mauritius, Republic of Moldova. 257p.

Ongagola, E. (2007). *Contribution to the biological and ecological study of edible caterpillars in the Kisangani Region. Case of the Yoko Reserve. (Ubundu, Democratic Republic of Congo).* DEA thesis in Ecology and Animal Resources Management. University of Kisangani, DRC. 99p.

Pauwels, L. (1993). *Guide to trees and shrubs in the Kinshasa-Brazzaville region*. Jard. Bot. Nat. of Belgium. 493 p.

Tailfer, Y. (1989). *The dense forest of Central Africa. Practical identification of the main trees.* Cultural and Technical Cooperation Agency & CTA, Wageningen, Volume 1 (456 p) and 2 (1271 p).

Traore, L., Ouedraogo, I., Ouedraogo, A., & Thiombiano, A. (2011). Perceptions, uses and vulnerability of woody plant resources in the Southwest of Burkina Faso. *Int. J. Biol. Chem. Sci., 5*(1), 258-278.

Wilks, M.C. & Issembé, Y.A. (2000). *Practical identification guide: trees of Equatorial Guinea, Continental Region*. CUREF Project, Bata, Equatorial Guinea, 546 p.

Yaovi, C.R., Hien, M., Kabore, S.A., Sehoubo, Y.J. & Somda, I. (2021). Use and vulnerability of plant species and adaptation strategies of populations living near the Kou Classified Forest (Burkina Faso). *Int. J. Biol. Chem. Sci., 15*(3), 1140-1157.