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# Caterpillars consumed in Masi-Manimba territory (Kwilu), Democratic Republic of the Congo

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**RESEARCH ARTICLE**

## Abstract

Caterpillars are a favourite traditional food that potentially represents the largest proportion of total animal protein consumed by people in Masi-Manimba, Kwilu Province, Democratic Republic of Congo. However, caterpillars are becoming increasingly scarce, with no inventory data existing for this region. This study aims to contribute to the valorisation of edible caterpillars in Masi-Manimba through their inventory and identification. A questionnaire was completed by 212 people representing the four main ethnic groups in the territory and seven peripheral sectors. The caterpillars were collected in 2020 and 2021 in the township. Eighty two species were listed by the four main ethnic groups but only 63 species were scientifically confirmed at least to the family level. The main family was Saturniidae, followed by Notodontidae and Sphingidae. The genus *Imbrasia* is the most represented in the territory. Overall, 46% of caterpillars are found in forests, 19% in savannah, and 35% across multiple habitats. Surveyed people considered 64% of caterpillars to be very tasty. Large numbers were harvested during the rainy season (November and January). Respondents observed that there has been a major decline in caterpillars, with just 22% of species being readily available. Due to this major decline in caterpillars, it is urgent to study their biology and relationship with food plants, to farm them successfully.

**Keywords:** Masi-Manimba, Democratic Republic of Congo, entomophagy, caterpillars eaten

## 1. Introduction

The number of Lepidoptera species consumed by humans in the world is more than 400, belonging to 35 families, of which 28% are Saturniidae. Caterpillar consumption is particularly widespread in sub-Saharan Africa, where 31% of edible insect species are caterpillars (Jongema, 2017). More than 370 studies have been published on this subject in Africa (Malaisse and Latham, 2014). To date 146 species of Lepidoptera have been inventoried in Africa, of which 55% belong to Saturniidae (Jongema, 2017). Moreover Latham *et al.* (unpublished data) gives plenty of information for 133 species. Finally, Malaise (unpublished data) has listed 158 different taxa of Lepidoptera for Africa. The species of this family are abundant in the forest regions of Central Africa during the wet season (Balinga *et al.*, 2004; Mabossy *et al.*, 2021; Malaisse, 1997; Van Huis, 2003).

These edible caterpillars are mainly collected in the wild (92%) using different techniques adapted to specific ecosystems, ranging from simple collection on detection to the cutting of trunks and branches of trees, or even climbing, lopping and felling of host trees (Tamesse *et al.*, 2018; Van Huis, 2003; Vantomme *et al.*, 2004). Caterpillars, like others insects, can also be partially reared (i.e. entomoculture) in different systems, such as improved natural production, which is sometimes used in the Democratic Republic of Congo (DRC). In this system, caterpillars of certain species (such as *Cirina forda* and *Imbrasia epimethea*; the full names of the genera and species are given in Supplementary Table S1) are collected from the natural habitat when young

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and are reared to maturity on village trees (Muyay, 1981). Other types of insect farming systems include family mini-farming, which is often practiced in a vivarium, allowing limited production and factory farming, allowing mass production (Vandermeersch, 2018; Van Huis *et al.*, 2014).

Some studies showed that 85% of the human population in DRC (80% of Congolese living in the capital Kinshasa) eat edible caterpillars regularly, out of habit and for their state. In particular, caterpillars account for up to 40% of total animal protein consumption (Balinga *et al.*, 2004; Latham, 2003; Nsevolo *et al.*, 2016). The main provinces supplying caterpillars are Equateur, Kwango, and Kwilu (Balinga *et al.*, 2004). The latter two provinces are considered territories that support the highest diversity of caterpillar species, with more than 30 species being consumed (Leleup and Daems, 1969).

Bocquet *et al.* (2020) and Hulstaert (1966) indicated that the population of Equateur Province consume 22 species of caterpillars, of which only eight species have been scientifically identified that belong to the family Saturniidae (e.g. *C. forda*, *I. epimethea*, *Imbrasia obscura*, *Gonimbrasia anthinoides*) and the Notodontidae (e.g. *Anaphe panda*).

People of Kwango Province consume caterpillars belonging to various families, including Hesperiidae, Noctuidae, Notodontidae, Nymphalidae, Sphingidae, and especially Saturniidae (Adriaens, 1951). The most important species are *C. forda*, *I. epimethea*, *I. obscura,* and *Coeliades libeon* (Adriaens, 1951; Leleup and Daems, 1969). However, Lunga (2017) reported that over 85% of caterpillars recorded in this province have disappeared, especially those found in forest habitats.

Thirty-three species of caterpillars consumed by the Yansi ethnic group in Kwilu Province have been described, most belong to the families Saturniidae, Notodontidae, and Sphingidae (Muyay, 1981). Caterpillars of the genera *Achaea, Bunaea, Elaphrodes, Epidonta,* and *Imbrasia* include species such as *Achaea catocaloides*, *Elaphrodes lactea,* and *I. epimethea*, which are among the most widely consumed by the Yansi ethnic group.

Very little data on edible caterpillars is available for Kwilu Province, one of the poorest regions in the country in terms of protein resources, and no inventory data have been recorded for the Masi-Manimba territory (Figure 1). This territory is one of the most populated territories in Kwilu, with 1,758,847 inhabitants at a density of 122 inhabitants/km$^2$ across 14,327 km$^2$ (Administration du Territoire, 2020).

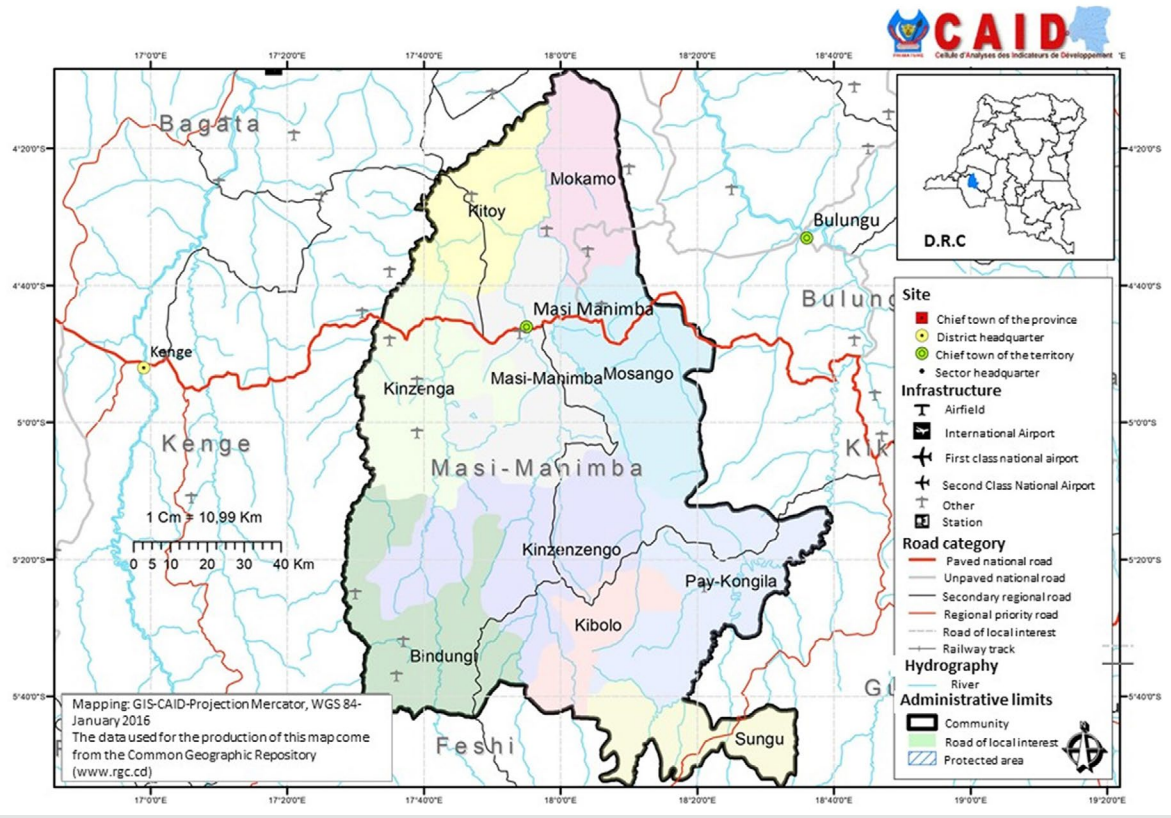


**Figure 1. Administrative map of Masi-Manimba territory (CAID, 2016).**

It is located in the humid tropical climate zone 'type AW (i.e. savannah climate with dry winter or winter dry season), characterised by two contrasting rainy seasons and relatively cool nights. The average annual rainfall is 1,500 to 1,700 mm, the relative atmospheric humidity remains high throughout the year, and its elevation varies from 600 m in the south to 300 m in the north (CAID, 2021; Fehr, 1990). The local populations fall into nine ethnolinguistic groups (ethnic groups), namely: Mbala (45%), Ngongo (35%), Suku (10%), Yansi (4%), Hungana (2%), Tsamba (1.5%), and the other groups including Lua and Téké (0.5%) (Anonymous, 2005; CAID, 2021).

In this territory, as elsewhere in the country, food resources are becoming increasingly scarce and food imports are becoming more expensive. According to the Congo's central bank, imports are valued at nearly 1.5 billion US dollars (USD) per year, or a quarter of the national food budget (Anonymous, 2019; Essolomwa, 2017). Therefore, it is urgent to identify the number and extent of caterpillar species present before this local resource disappears completely, focusing on identifying species suitable for sustainable management to alleviate the current food shortage.

This study aims to contribute to the valorisation of edible caterpillars from Masi-Manimba, through an inventory and identification. A list of caterpillars consumed by the population will be developed, including their ecology, phenology, availability, appreciation. The level of entomological knowledge of the population will also be established. Our results are expected to contribute towards identifying ideal species for cultivation to generate a sustainable protein resource for the population and stop the depletion of species in the natural environment.

## 2. Materials and methods

### Collection of samples

The caterpillars were collected and photographed in the outskirts of the city of Masi-Manimba, in a radius of 50-150 km from January 16 to March 20, 2020 (short dry season) and December 16, 2020, to April 12, 2021 (rainy season and short dry season). For each sample of caterpillars collected, five caterpillars of 6.0-9.0 cm body length and 1.5-2.0 cm diameter and 10 caterpillars of 3.0-5.9 cm length and 0.5-1.4 cm diameter were placed in ethanol (70%) for subsequent identification. Also, 500 g of each species was stored after drying under cover at a maximum temperature of 40 °C for biochemical analysis. Geographical coordinates (latitude, longitude, and altitude) were obtained for each sample using a global positioning system (GPS) MAP 66S (Garmin; Olathe, Kansas, USA) and those of the Masi-Manimba Territory are: 4°46'0" South (-4.76667), 17°55'0" East (17.9167), 498 m (chief town of the territory).

### Morphological identification of caterpillars

The collected samples were identified using binocular loupe (Zeiss; Stemi 305, Paris, France). The determination keys established by Mabossy *et al.* (2016a), Malaisse and Parent (1980) and Pinhey (1956) were used with photographs from the available literature, including Bocquet *et al.* (2020), Kusia *et al.* (2021), Lautenschläger *et al.* (2017b) and online databases (De Prins and De Prins, 2011-2021).

### Ethno-entomological surveys

A questionnaire (Supplementary Material Annex) was given to 212 people representing the four main ethnic groups in the area (i.e. Mbala, Ngongo, Suku, and Yansi; n=53) and seven peripheral sectors (i.e. Bindungi, Kinzenzengo, Kitoy, Masi-Manimba, and Mosango; n=30; Kinzenga, Mokamo; n=31). Villages recognised by the territorial authority as 'reservoirs' of edible caterpillar species were selected, and contact was made with village chiefs to target the caterpillar farmers. Interviews focused on the vernacular names of caterpillars that were consumed, as well as information on their habitats, phenology, availability, taste value (appreciation), and potential causes of decline. The age, gender and education level of respondents were also recorded.

### Statistical analysis

All statistical analyses were performed using SPSS 25 Windows software (Armonk, NY, USA). Significance was set at 5%. Quantitative data was presented by calculating the means and standard deviations. Categorical variables were calculated from the percentages of each modality. Comparisons of the number of caterpillars cited by respondents were made using Student's *t*-test for independent samples, to assess the influence of age, gender, and ethnic group of respondents on the number of edible caterpillars identified. The Fisher test was performed by analysing the variance of the four ethnic groups. When the *P*-value of the Fisher test was less than 5%, Bonferroni post-hoc multiple comparisons were performed to identify the ethnic groups that differed significantly. For the comparison of percentages, the Pearson chi-square test was used. Principal component analysis was used to determine the different relationships between caterpillar species and their habitats.

## 3. Results and discussion

### Demographic characteristics of the study population

Men represented 54% (114) and women 46% (98) of the whole sample. All respondents were divided into two age groups: people under 40 years old (55 people; 26%) and over 40 years old (157 people; 74%). In terms of education

level, 15 were illiterate, 57 had primary education, 124 had secondary education, and 16 had higher education.

### Inventory of caterpillars consumed in the Masi-Manimba territory

A list of 82 species of edible caterpillars known locally by the population of the four main ethnic groups of Masi-Manimba were listed. Of these, 63 species could be scientifically identified, of which nine were identified to the taxonomic family level, 16 to the genus level, and 38 to the species level (Supplementary Table S1). Sixty-three taxa were scientifically identified similar to the 65 caterpillar species identified by Nowak (2014) as being consumed in the DRC. This value represented 56.2% of the total number (146) of caterpillar species consumed in Africa, which were identified by Jongema (2017). The high representation of caterpillars in this territory is probably related to the climate and host plants that allow development. The high identification rate might be associated with the high rate of consumption of these caterpillars (Twine *et al.*, 2003; Van Huis *et al.*, 2014).

Regarding the diversity of caterpillars eaten by a single tribe, two examples may be given. Roulon-Doko (1998) points out that the Gbaya-Bodoé consume 59 different species; whilst in second position Malaisse (2010) gives 40 different species for the Bemba population of Katanga (DRC).

### Richness and diversity of caterpillars consumed in Masi-Manimba

The identified taxa belonged to 11 families (Supplementary Table S1), of which Saturniidae (25 species, 40%), Notodontidae (12 species, 19%), and Sphingidae (12 species, 19%) dominated. Among these families, Saturniidae (Supplementary Figure S3-S5) and Notodontidae (Supplementary Figure S1-S2) are considered important, in terms of diversity, in several provinces of the DRC, including Central Kongo, Equateur, Kwango, Kwilu, Mai-Ndombe; North-Ubangi, South-Kivu, and Tshopo (Adriaens, 1951; Bocquet *et al.*, 2020; Konda ku Mbuta and Ambühl, 2019; Latham, 2008; Leleup et Daems 1969; Lisingo *et al.*, 2010; Looli *et al.*, 2021; Malaisse 1997; Malaisse and Lognay, 2003; Okangola, 2007; Payne *et al.*, 2016; Yabunda *et al.*, 2019). This high diversity is explained by the fact that these caterpillars are widely harvested at the time of their appearance, and so are easy to identify. In comparison, Sphingidae were collected in very small quantities, and were rarely identified, due to their lower representation. The consumption of Sphingidae (Supplementary Figure S3), generally by children, is more anecdotal, and tends to arise in areas where food resources are less available, as is the case in the Masi-Manimba territory (Muyay, 1981).

The most represented genera, due to their polyphagy, were *Imbrasia*, *Epidonta*, *Gonimbrasia,* and *Lobobunaea*, with the genus *Imbrasia* dominating. There was low specific diversity per genus, supporting existing studies (Bocquet *et al.*, 2020; Looli *et al.*, 2021; Malaisse, 1997).

### Local knowledge on caterpillars consumed in the Masi-Manimba territory

#### *Vernacular names of caterpillars*

The populations of the Masi-Manimba territory often identify caterpillars in their dialects in reference to the name of the food plant, as observed by Latham (2005) and Malaisse (2010) for the whole of Africa. For example, the species *Cymothoe caenis* has different vernacular names, namely Mibamba in Mbala and Suku, Mibamb in Ngongo, and Mibaam in Yansi. All these different names mean the caterpillar of the plant '*Oncoba welwitshii* Oliv.' Caterpillars are sometimes identified in reference to certain morphological characteristics (e.g. *Aletis* sp. these names as follows 'Angayi' in Mbala or 'Bangayi' in Ngongo, which means the shape of a cat) or in reference to alleged physiological effects on the consumer (e.g. some *Imbrasia* sp. is called Miwur in Yansi, which induces a feeling of satiety).

Even though the vernacular names of caterpillars vary from one ethnic group to another, they are often similar for the main ethnic groups of the Masi-Manimba territory, such as 'Mindanda' in Mbala and Suku, 'Mindan' in Ngongo, and 'Mindaan' in Yansi for the caterpillar *Epidonta brunneomixta* (Supplementary Table S1). Finally, in all ethnic groups, some species of caterpillars belonging to the same family have the same vernacular name; for example, the Mbala call all species of Sphingidae 'Gidishi.'

#### *Frequency of citation of caterpillars*

Most caterpillar species consumed by the respondents (86%) were cited by them at frequencies >50% (Supplementary Table S1). Out of these species, 11 were cited with a frequency of >80% by respondents (i.e. *C. forda, C. caenis, I. epimethea, I. obscura, E. lactea, A. catocaloides, A. panda, E. brunneomixta, Bunaea alcinoe, Gonimbrasia petiveri, Haplozana nigrolineata*). These species had easily identifiable morphology and were the most popular throughout the DRC, as well as the main caterpillar-consuming countries of Africa. They have been listed in more than 36 countries, and more than 370 scientific publications (Kelemu *et al.*, 2015; Lautenschläger *et al.*, 2017b; Malaisse and Latham, 2014). Among the caterpillars less frequently consumed, the presence of certain representatives of the Notodontidae family are worth mentioning ('Mimbim' in Ngongo and 'Mipepepe' in Mbala), including Pieridae (*Catopsilia florella*), Psychidae

(*Eumeta* sp.), and Lymantriidae ('Mipepi' in Mbala and 'Mibangubangu' in Ngongo). Their low representation is explained by their larval development, which takes place in very localised and specific biotopes, as well as lower harvesting abundance, and being primarily consumed by children (Malaisse, 1997; Mignon, 2002; Roulon-Doko, 1998).

Among the interviewees in the Masi-Manimba territory, women and the Mbala, Ngongo and Suku ethnic groups identified more caterpillars that are consumed (Table 1). This greater knowledge of women might be explained by the fact that caterpillar harvesting is culturally a female activity in Kwilu Province (Muyay, 1981). The Yansi group identified fewer caterpillars compared to the other ethnic groups, which was also observed by Muyay (33 species). This difference is explained by the ethnic areas of exploitation. The Yansi group prefer to exploit forests, whereas the other three ethnic groups exploit both forests and savannahs, the vegetation of which accommodates a higher diversity of caterpillars (Administration du Territoire, 2020; MAPED, 2009).

### Availability of caterpillars

Most respondents considered that the caterpillar harvest is currently very fragile throughout the territory. Only 22% of caterpillar species are considered relatively available, whereas 59% are considered rare and 19% almost extinct. Out of the potential causes for the decline in caterpillar abundance, respondents identified the practice of slash-and-burn agriculture, exacerbated by poverty, felling of trees during harvesting or logging, bush fires, failure to comply with prohibitions or restrictions (e.g. harvesting young caterpillars is prohibited, only the last larval stage is allowed to be harvested and no one may cut the caterpillar host plant down), and global warming.

The abandonment of fallow land in the practice of slash-and-burn agriculture, as a result of declining land availability and increasing human population size, is degrading the environment and causing deforestation (Bahuchet and Betsch, 2012; Demaze and Manusset, 2008; FAO, 2016; Lunga, 2017). In particular, the disappearance of host trees is associated with a long-term gradual decline in caterpillars, especially those that only inhabit specific host plants (Ashton and Hall, 2011; Asseng, 2008; Lunga, 2017; N'Gasse, 2003; Vantomme *et al.*, 2004). Indirectly, deforestation may alter local micro-climates in the short run, and contribute to climate changes in the long run, both of which could disrupt the insect lifecycles (Vantomme *et al.*, 2004). The FAO (2016) also suggest that climate change is impacting caterpillars, due to variation in temperature and precipitation. However, estimating this impact is difficult. Leleup and Daems (1969) and Lunga (2017) also identified burning the savannah at inappropriate times, thus destroying eggs and chrysalises, as contributors to caterpillar decline, as is the case of *Platylesches moritili*. Ancestral practices that protected natural resources are now abandoned, in place of modern practices, pressure of population and Christianity, which very early on questioned traditional values (Kyale and Maindo, 2017).

Yet caterpillars, like all insects, are part of the food chain of several birds and other small animals which are hunted for bushmeat. Thus, their reduced availability also affects the stocks of their predators. The resulting loss of biodiversity directly affects food supplies and livelihoods for local people as well as the fructification potential of plant species by reducing their pollination (Vantomme *et al.*, 2004).

**Table 1. Number of caterpillars identified by age, sex and ethnic group.[1]**

| Variables | Mean ± standard deviation | Statistical analysis | *P*-value |
|---|---|---|---|
| Age group | | t(210)=1.421 | 0.157 |
| Under 40 years | 42±6 | | |
| Greater than or equal to 40 years | 41±7 | | |
| Sex | | t(210)=2.367 | 0.019 |
| Male | 41±6 | | |
| Female | 43±6 | | |
| Ethnic group | | $F_{3.208}$=9.325 | 0.001 |
| Mbala | 43±6[a] | | |
| Ngongo | 43±6[a] | | |
| Suku | 43±5[a] | | |
| Yansi | 38±6[b] | | |

[1] The letter 'a' in the rows indicates a non-significant difference between the three groups. The letter 'b' indicates the significant difference for the number of caterpillars cited by the Yansi ethnic group.

All respondents agreed that the decline in caterpillar production is greater in the northern sectors (i.e. Kitoy, Mokamo, Masi-Manimba, and Mosango), which have a higher percentage of rare and extinct species compared to the southern sectors (i.e. Kinzenzengo, Kinzenga, and Bindungi) (Figure 2). Respondents considered Kinzenzengo to have the highest caterpillar diversity, due to the population's respect for prohibitions and rich forest galleries (forests along the rivers), despite the decline in abundance. For example, *A. panda* and *E. lactea* caterpillars could still be harvested in this territory, but have disappeared completely elsewhere (MAPED, 2009). Although there is a lack of detailed analysis on the decline in caterpillar production, several studies have confirmed that there has been a reduction in caterpillar populations in Central Africa, and specifically in some provinces of the DRC. Eighteen species of caterpillars are now considered extinct, and three endangered, in Kwango Province (Leleup and Daems, 1969; Lisingo, 2010; Lunga, 2017; Van Huis *et al.*, 2014). Faced with this threat, the FAO is encouraging the rearing of insects, including caterpillars, to ensure their sustainability. However, this initiative requires in-depth knowledge of their biology and ecology (Van Huis *et al.*, 2014).

Two caterpillar species, *C. forda* and *H. nigrolineata*, are particularly collected in the Bindungi, Kinzenga, and Kinzenzengo areas (Figure 2). This is because the environment in these areas is dominated by savannah (both woodland and shrubland), which is the preferred habitat of these species. The annual production of *C. forda* throughout the whole territory is 1,522,370 tons constituting a very important source of income for households (CAID, 2016).

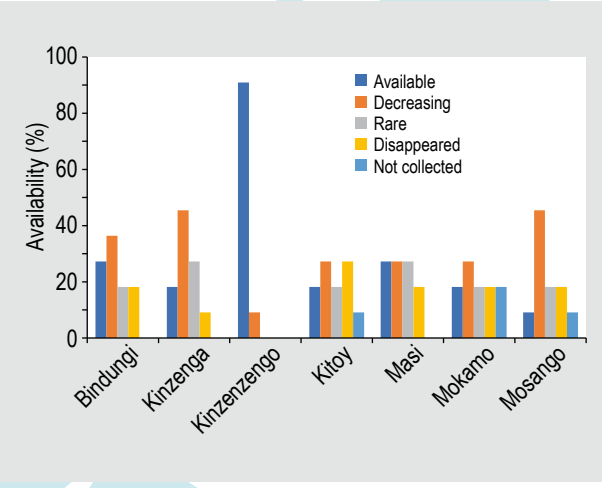


**Figure 2. Availability of popular caterpillars consumed by sector in Masi-Manimba territory.**

## Preference of caterpillars for consumption

All respondents identified themselves as regular consumers of one or more caterpillar species. Respondents indicated that 91% of identified caterpillars were preferred, of which 64% were highly valued, including *A. catocaloides*, *A. panda*, *C. forda*, *E. lactea*, *I. epimethea*, and *Imbrasia ertli*. These species were the most popular caterpillars in the region (Figure 3). Caterpillars constituted a delicate and refined dish for the population, providing gustatory pleasure, supporting the findings of Malaisse *et al.* (2016). The consumption of caterpillars is part of the cultural heritage of the region, being traditional foods (Leleup and Daems, 1969; Malaisse, 1997).

Almost all respondents from all ethnic groups acknowledged the high taste value of certain caterpillars, including *I. epimethea*, *C. forda*, *E. lactea*, *A. catocaloides*, *I. obscura*, *A. panda*, and *H. nigrolineata* (Figure 3). Their gustatory advantages are attributed to the fats that they contain and the advantage of having a thinner cuticle and less crunchiness in the mouth (Ande and Fasoranti, 1998; Malaisse, 1997; Mignon, 2002). Respondents also noted the low value of *C. caenis* because of its bitter taste, supporting Balinga *et al.* (2004) and Muyay (1981) (Figure 3). This species is consumed because other sources of protein are not available at the beginning of every season, in addition to it having alleged therapeutic value (Muyay, 1981).

The appearance of certain caterpillars, e.g. *I. epimethea* and *C. forda*, makes them more attractive. These two species are highly valued in most sub-Saharan African countries (Mabossy *et al.*, 2016b). Respondents indicated that the lack of gut contents in *I. epimethea* and other late-stage *Imbrasia* species makes them tastier. However,

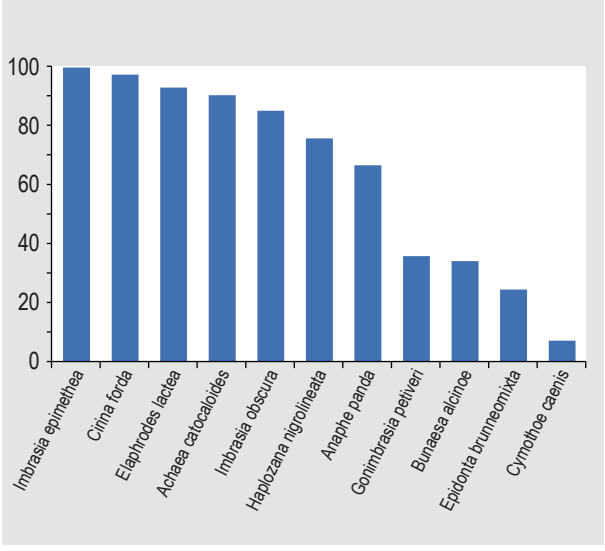


**Figure 3. Preference of the most popular caterpillars in the Masi-Manimba territory.**

before cooking the younger ones, the gut must be removed, because it may contain toxic substances from the host plant, as for example with the Euphorbiaceae, that alter their taste (Lautenschläger *et al.*, 2017a; Malaisse, 1997). Thus, studies investigating the interactions of caterpillars and their food plants would be interesting to document. Respondents identified *I. obscura* as having an intermediate position for taste and value because of its spines, which frighten some consumers; though it is widely consumed in other African countries (Bocquet *et al.*, 2020; Mabossy *et al.*, 2018).

The most preferred caterpillar species in Haut-Katanga Province (DRC) is *E. lactea*. Its chrysalises are appreciated because of the absence of gut contents, giving it a pleasant taste, and offering consumers exceptional eating quality (Bomolo *et al.*, 2019; Malaisse, 1997). *Anaphe* caterpillars, especially *A. panda*, are a local delicacy in West African countries (Kebede *et al.*, 2014).

### Ecological characteristics of caterpillars consumed in Masi-Manimba

Throughout the territory, caterpillars were identified by respondents as inhabiting forests (46%) or multiple habitats, including forests (35%) and savannah (19%). The most popular caterpillars primarily inhabited forests (81.8%). Principal component analysis was used to construct three groups of habitats (Figure 4).

The first grouping was combined 'primary and secondary forest' habitat, where *C. caenis*, *E. brunneomixta*, *I. epimethea,* and *I. obscura* are found (36.4%). The second group is primary forest, where *A. catocaloides* and *E. lactea* occur (18.2%). The last category is a mix of habitats, each of which was represented by only one species (e.g. secondary forest, marsh, secondary forest, shrub savannah [Arboreal savannah], and wooded savannah).

This preference of caterpillars for forests as habitats is explained by the polyphagy of most species consumed in this area, requiring a diversity of forest plants for their diet (Bocquet *et al.*, 2020; Latham, 2016; Lisingo *et al.*, 2010; Muyay, 1981). As identified by Emberger *et al. (*2013), the faunal richness of forests is evidence of an incredible floristic richness.

### Period of appearance of caterpillars consumed in Masi-Manimba

Almost all caterpillars in the Masi-Manimba territory were harvested during the rainy season (Table 2).

All respondents agreed that the caterpillar harvest is abundant between November and January, except for *C. forda*, which has the highest abundance in August. These results were consistent with those of Balinga *et al.* (2004), Lunga (2017) and Muyay (1981), who indicate the same period of relative caterpillar abundance in the provinces of Grand Bandundu (i.e. Kwango, Kwilu and Mai-Ndombe) in the west of the DRC. Our results also supported those of Bascoulerges and Bergot (1959), who report the importance

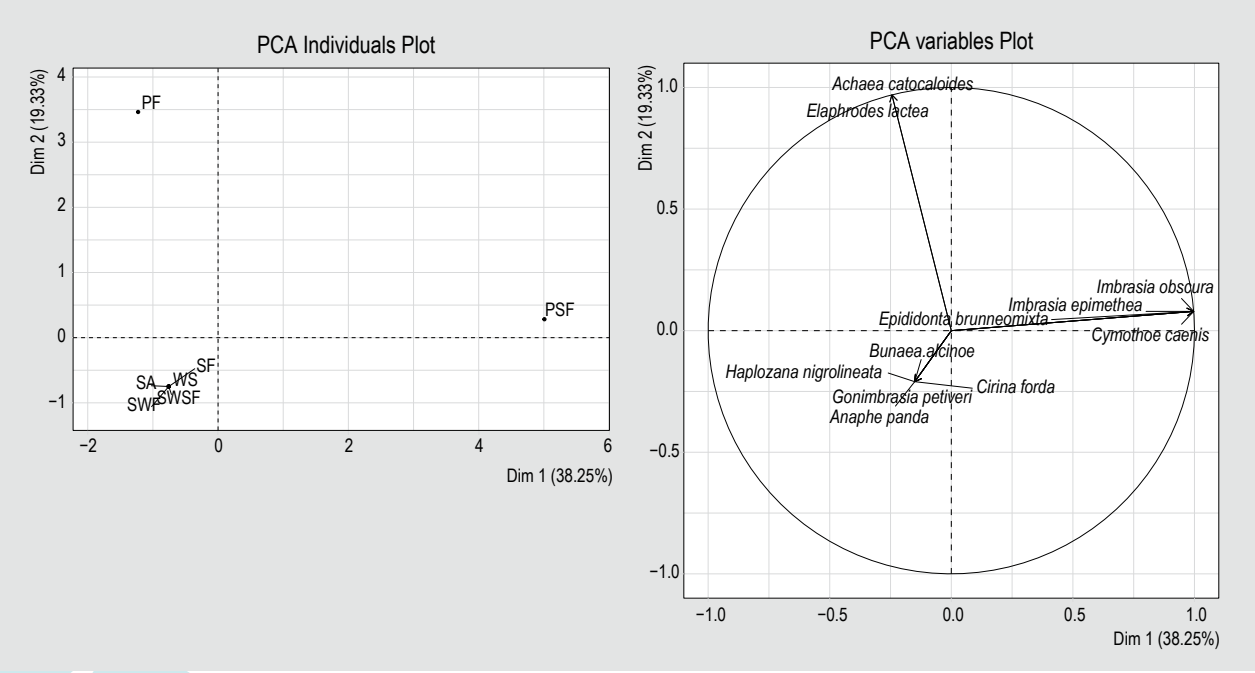


**Figure 4. Principal component analysis of species by habitat. PF = primary forest; PSF = primary and secondary forests; SA = arboreal savannah; SF = secondary forest; SWF = swamp forest; SWSF = swamp and secondary forests; WS = wooded savannah.**

**Table 2. Period of appearance of caterpillars consumed in the Masi-Manimba territory.**

| Species | Months | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | March | April | May | June | July |
| *Achaea. catocaloides* | | | | x | x | | | x | x | x | x | |
| *Anaphe panda* | | | | x | x | x | x | | | | | |
| *Bunaea alcinoe* | | | | x | x | x | x | | | | | |
| *Cirina forda* | x | | | | | | | | | | | x |
| *Cymothoe caenis* | | x | x | x | | | | | | x | x | |
| *Elaphrodes lactea* | | | | | x | x | | | | | | |
| *Epidonta brunneomixta* | | | | x | x | x | | | | | | |
| *Gonimbrasia petiveri* | | x | x | x | x | x | x | | | | | |
| *Haplozana nigrolineata* | | | | | x | x | x | | | | | |
| *Imbrasia epimethea* | x | x | x | x | x | x | x | | x | x | x | x |
| *Imbrasia obscura* | x | | | x | x | x | | | | | | |

of caterpillar consumption in November, December, and January in the vicinity of Brazzaville.

This phenomenon is attributed to caterpillars being dependent on fast-growing host plants (Muvundja *et al.*, 2013; Van Huis, 2003). In contrast, early burning (June) causes the regrowth of young leaves that facilitate the development of the last larval stages of *C. forda* (Adriaems, 1951; Muvundja *et al.*, 2013), which is harvested towards the end of the dry season.

The availability of caterpillars varies within each country depending on local climatic conditions (Vantomme *et al.*, 2004). Due to staggered rainfall in the DRC, the period of caterpillar abundance in the Kasai region occurs between June and September, whereas in the Equateur region, where rainfall is relatively constant throughout the year, the peak period occurs from June of the previous year to March of the following year (Balinga *et al.*, 2004; Omasombo *et al.*, 2016). This variation is also very important for *C. forda*, which is harvested from March to May in Katanga (Malaisse, 1997), November to January in central Congo (Latham, 2016), July to September in Cameroon (Ngute *et al.*, 2019), and October to November in Zimbabwe (Dube *et al.*, 2013). Despite this variation according to the geographical area of the region, the climatic conditions for the development of this species remains the same (i.e. low sunshine, temperatures of 22-27 °C, and a relative air humidity of 80-100%) (Ande and Fasoranti, 1998).

## 4. Conclusions

Caterpillars are an important part of the traditional diet of the people in the Masi-Manimba territory of Kwilu Province, where the diet is very low in protein. Eighty-two taxa were listed by the four main ethnic groups (Mbala, Ngongo, Suku, and Yansi), from which 63 species were scientifically confirmed. This diversity of caterpillars inventoried exceeds all that has been reported previously (Malaisse, 2010; Roulon-Doko, 1998). These caterpillar species were dominated by Saturniidae, followed by Notondotidae and Sphingidae. The genus *Imbrasia* was the most represented in the territory. People have a good level of knowledge about the caterpillars they consume. In general, 46% of caterpillars were from forests, 19% were from savannah, and 35% were from a variety of other habitats (i.e. forest, savannah, home gardens, and agricultural areas).

Caterpillars are considered a tasty food in Masi-Manimba territory, with 64% being considered very tasty. For instance, almost all respondents (>90%) recognised the high taste value of *I. epimethea*, *C. forda*, which are widely consumed in the DRC and other sub-Saharan African countries, *E. lactea*, which has highly valued chrysalises, and *A. catocaloides*. The taste quality is very high for late stage *Imbrasia* caterpillars, due to the absence of intestinal contents. Respondents were aware of a sharp decrease in the availability of caterpillars, identifying just 22% of species as being relatively available, 59% as rare, and 19% as having almost disappeared. Species considered to have disappeared included *A. panda* and *E. lactea* in studied sectors, with the exception Kinzenzengo. Respondents considered that this gradual disappearance of caterpillars is mainly caused by slash-and-burn agriculture, deforestation, felling of host trees during caterpillar harvesting, and non-compliance with prohibitions. This situation varies across areas within the territory. The decline in caterpillars tends to be very advanced in areas located between the centre and north of the territory (i.e. Kitoy, Masi-Manimba, Mokamo, Mosango). In contrast, Kinzenzengo (to the south) supports the highest quantity and diversity of caterpillars, because of the presence of well-preserved forest galleries as people respect regulations. The caterpillar harvest is abundant during the rainy season, between November and January,

due to the influence of humidity, which favors the regrowth of tree foliage on which the caterpillars feed.

The human populations in the Masi-Manimba have a high level of entomological knowledge, recognising the caterpillars that they eat, and name them in their dialects based on the plant on which the caterpillars feed and/or their morphological characteristics. Women have the best knowledge of caterpillars. In contrast to the Mbala, Ngongo, and Suku, the Yansi could not identify as many caterpillars, probably due to their limited use of savannahs, which contain a high diversity of caterpillars. Many caterpillars well known by most populations, were cited at very high frequencies (termed 'star' caterpillars). The caterpillars cited by almost all respondents from all ethnic groups (more than 90%) included *C. forda*, *C. caenis*, *I. epimethea*, *I. obscura*, *E. lactea*, *A. catocaloides*, *A. panda*, and *E. brunneomixta*. This list is proof of the wide distribution of caterpillars in the territory and country. A less known and appreciated species was *H. nigrolineata*, which was not collected in the Kitoy and Mokamo sectors; however, this species, together with *C. forda*, was emblematic for the Suku and Ngongo in the southern sectors of the territory.

Finally, there is need for research on the biology of edible caterpillars and associated food plants to develop sustainable cultivation through domestication to ensure a continuous supply.

## Supplementary material

Supplementary material can be found online at https://doi.org/10.3920/JIFF2022.0032

**Table S1.** Caterpillars consumed in Masi-Manimba territory.

**Figure S1-S5.** Images of some edible caterpillars from Masi-Manimba.

**Supplementary Material Annex.** Survey questionnaire / Kwilu.

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