



## The marketing of *Imbrasia* edible caterpillars in the Republic of the Congo

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### ABSTRACT

After highlighting the importance of marketing *Imbrasia* caterpillars in Africa and even in Europe (Paris and Brussels) and Asia (Bangkok), various aspects of their marketing in the Republic of the Congo are developed. The objective of this study was to assess the value chain of caterpillars in the Republic of the Congo. To achieve this, three cross-sectional caterpillar marketing surveys and field missions were conducted. The results show that caterpillar marketing is mainly a women's activity. This trade is more beneficial for wholesalers than for retailers and enables wholesalers and semi-wholesalers to meet their vital needs. Thus, this activity contributes significantly to improving the living conditions of wholesalers and semi-wholesalers. However, it fluctuates according to demand and availability, making revenues unstable throughout the year. *Imbrasia* caterpillars sold in the Republic of the Congo are largely imported from Equateur Province and South Ubangi in the D.R. Congo; the quantity from Likouala and Sangha is very small. This indicates the existence of a cross-border trade in caterpillars between the Republic of the Congo and the D.R. Congo. However, this trade could not be evaluated because it is still illegal and no statistical data exist at the level of cross-border markets and ports of embarkation.

**Keywords:** Entomophagy, edible caterpillars, value chain, import-exports, food security, Congo-Brazzaville.

## La commercialisation des chenilles comestibles d'*Imbrasia* en République du Congo

Après avoir souligné l'importance de la commercialisation des chenilles d'*Imbrasia* en Afrique et même en Europe (Paris et Bruxelles) et en Asie (Bangkok), différents aspects de leur commercialisation en République du Congo sont développés. L'objectif de cette étude était d'évaluer la chaîne de valeur des chenilles en République du Congo. Pour ce faire, trois enquêtes transversales sur la commercialisation des chenilles et des missions de terrain ont été réalisées. Les résultats montrent que la commercialisation des chenilles est principalement une activité féminine. Ce commerce est plus bénéfique pour les grossistes que pour les détaillants et permet aux grossistes et semi-grossistes de satisfaire leurs besoins vitaux. Ainsi, cette activité contribue fortement à l'amélioration des conditions de vie des grossistes et semi-grossistes. Cependant, elle fluctue en fonction de la demande et de la disponibilité, rendant les revenus instables tout au long de l'année. Les chenilles d'*Imbrasia* vendues en République du Congo sont en grande partie importées de la province de l'Équateur et du Sud-Oubangui en R.D. Congo ; la quantité en provenance de la Likouala et de la Sangha est très faible. Ceci indique l'existence d'un commerce transfrontalier de chenilles entre la République du Congo et la R.D. Congo. Cependant, ce commerce n'a pas pu être évalué car il est encore illégal et aucune donnée statistique n'existe au niveau des marchés transfrontaliers et des ports d'embarquement.

**Mots-clés :** Entomophagie, chenilles comestibles, chaîne de valeur, exportations, sécurité alimentaire, Congo-Brazzaville.

## INTRODUCTION

For a large number of urban dwellers in many great African cities, caterpillars are a popular food and even a delicacy (Mabossy-Mobouna et al., 2013). The availability of caterpillars is seasonal, and their supply and marketing have attracted the attention of several researchers. The cities of Kinshasa (Mbemba and Remacle, 1992; Mapunzu, 2002; Nsevolo, 2012), Ibadan (Akinnawo and Ketiku, 2000; Ivbijaro, 2012), Abidjan (Akpossan et al, 2009), Yaoundé (Balinga, 2003), Lubumbashi (Leblanc and Malaisse, 1978; Malaisse and Parent, 1980), Libreville (Yembi, 1999), Harare (Hobane, 1994), Kananga (Katia-Kitsa, 1989), Brazzaville (Moussa, 2002; Mabossy-Mobouna et al., 2013), Kisangani (Kakonda and Wetsi, 1992), Bangui (N'Gasse, 2003; Mbétid-Bessane, 2005), Ilorin (Fasoranti and Ajiboye, 1993), Ndola (Siulapwa et al., 2014), Kikwit (Ndoye and Awono, 2005), Mbandaka (Ndoye and Awono, 2005), and Makurdi (Agdidye and Tyokever, 1999) are good examples. *Saturniidae* caterpillars are frequently consumed and are the subject of a significant trade. This trade is flourishing in some cities such as Bangkok and Kinshasa and is in high demand by urban consumers.

In Southern Africa, 1,600 tons of dried *Imbrasia belina* caterpillars are traded annually (Malaisse and Lognay, 2003; 2004). Annual production of dried caterpillars in the Kwango district of D.R. Congo is estimated at 300 tons. More than half of the production, 185 tons, is traded (De Foliart, 1991). This annual trade amounted to 280 tons of dried edible caterpillars between 1954 and 1958 for the Kwango District (Leleup and Daems, 1969) and was reported to be 1,600 tons in the Transvaal in 1981 (De Foliart, 1995). The Democratic Republic of Congo (DRC) exports about 3 and 5 tons of dried caterpillars per year to the African diaspora like in France and Belgium respectively, at a cost of USD106,000, or about CFAF 58,300,000 (Tabuna, 2002). In Brazzaville, dried *Imbrasia* caterpillars from the Likouala department for sale in the markets represent an annual monetary value of over 80 million CFA francs (Dzono, 2002). Values of 40g/person/day of smoked caterpillars have been reported, representing an annual trade of several hundred tons (Malaisse, 1997). The sale of these caterpillars can bring wholesalers an average monthly profit of between 400,000 and 600,000 CFAF, or an average

value of 763.5 euros (Mabossy-Mobouna, et al., 2013).

In Bangui, when supplies of bush meat and fish decrease, dried *Imbrasia* caterpillars sell for up to USD14 per kilogram. This becomes the main source of cash income for rural women (FAO, 2004). In Zambia, the annual income from the marketing of caterpillars is greater than the sale of crops (Chidumayo and Mbata, 2002). In Botswana, income from the sale of *Imbrasia belina* accounts for 13% of total household income in nature in a year. Hours worked on this activity account for only 5.7% of all income-generating activities. The sale of *Imbrasia belina* is in third place after wooden stakes and livestock. Cunningham (1996) reports a capacity of 80,000 "Mopane caterpillars" per bag, a selling price of 120-150 rand (USD75 in 1995) and individual earnings of 2,500 rand in seven weeks for some harvesters. This sale is of vital importance to the livelihoods of families (Zitzmann, 1999). The caterpillar is marketed in many European cities such as London, Paris, Amsterdam, Berlin, Marseille, Montpellier, Dortmund, Lille and Brussels (Malaisse and Lognay, 2003; 2004). According to these authors, in October 2000, a kilo of dried caterpillars was selling for 20 euros in France.

In many families, the collection and resale of caterpillars helps to finance the schooling and health costs of household members. These activities are estimated to provide a bonus of USD25 per month for farmers in Equateur province in D.R. Congo (Dounias, 2012). In the Central African Republic, the income generated by the sale of caterpillars has enabled some collectors to set up as fruit and vegetable traders (Mbétid-Bessane, 2005). The importance of dried *Imbrasia* caterpillars from the Likouala department for sale in the Brazzaville markets has been highlighted by Dzono (2002). He estimates the annual monetary value of this sale at 80 million CFA francs (USD14, 4007). Mabossy-Mobouna et al. (2013) showed the existence of a cross-border trade in *Imbrasia* caterpillars between the Republic of the Congo, Central African Republic (CAR) and DRC. This cross-border trade in edible insects is significant not only in Central African countries, but also in Sudan and Nigeria (FAO, 2004). In addition, the existence of significant trafficking from southern Burkina Faso to Benin and Nigeria has been reported (Ouedraogo, 2001). Johnson (2010) has shown that cross-border trade in edible insects occurs regularly between a few countries in Southeast Asia, such as the People's

Democratic Republic of LAOS, Thailand and Vietnam.

However, no in-depth study on the marketing of edible caterpillars in the different departments of the Republic of the Congo has been carried out. It is this gap that this article aims to fill.

## MATERIALS AND METHODS

### Field materials

Survey sheets were used to determine: the social characteristics of caterpillar-consuming households.

A Samsung brand digital camera was used to take the caterpillars' picture at the sales points. The scales used were SECA brand electronic scales with a weighing capacity of 1 to 150 kg in 100 g divisions with an accuracy of  $\pm 100$  g.

### Type of study

This was a prospective study based on a cross-sectional survey to assess the marketing of edible caterpillars in the Republic of the Congo, using a direct interview technique.

### Types of variables

The variables describing the marketing of caterpillars were the mode of acquisition, the mode of sale, the purchase price, the sale price, the annual frequency of sale and the place of origin. In this paper, the purchase and sale prices of caterpillars were converted into US dollars (USD1 = CFA francs 555.55).

### Study sites

The study took place in the cities of Brazzaville and Pointe-Noire, and in the locality of Pokola. The surveys were conducted in selected markets and households in these three locations. The choice of these localities was justified by the following criteria:

- Pokola has the status of a cosmopolitan urban community. It is a place of large-scale caterpillar production;
- the city of Brazzaville, capital of the Republic of the Congo, is a major consumer of local products and a large consumer of caterpillars;
- the city of Pointe-Noire, a cosmopolitan city located more than 1,200 km from the main caterpillar production site. The choice of this city made it possible to better evaluate the influence of

distance on the price and quantity of caterpillars sold.

The marketing survey took place from 4 June to 30 August 2012 in Brazzaville, from 3 July to 14 August 2014 in Pokola and finally from 20 August to 30 September 2014 in Pointe-Noire. Field missions were carried out in Bétou, Impfondo and Liranga in the Likouala Department, in Makotimpoko in the Plateau Department, and in Oyo in the Cuvette Department until 2015. Data collection to acquire information from traders on the origin of caterpillars sold in border markets with the DRC continued up to 2017.

### Study population

The population covered by this study was that of certain households in Brazzaville, Pokola and Pointe-Noire, and caterpillar sellers in the towns of Brazzaville, Pokola and Pointe-Noire, not forgetting the indigenous and Bantu harvesters in these towns. It was made up of adults in professional activity whose age ranged from 18 to 70 years. All respondents under 18 years and over 70 years old, and all subjects who refused to participate in the survey were excluded from the total sample.

### Sampling

Sampling was carried out using the simple random selection method. In the markets, the selection of stalls to be surveyed was done according to the following methodology:

- visit to the block where caterpillars are sold;
- determining the first stall to start the interview by the coin toss method;
- survey the stalls in a stepwise fashion, with 2 stalls on the left and 3 stalls on the right, up to a maximum of 14 vendors for large markets or landing sites. In markets where there were no more than three *Imbrasia* vendors, such as Maman Mboulé, Massa and Ta Ngoma in Brazzaville, and Nkouikou in Pointe-Noire, we interviewed them all.

The marketing survey involved a sample of 79 randomly selected vendors, 59 of whom were in the markets of Poto-poto I (4), Tembè na Babanda (5), Sukisa (5), Massa (2), Ouenzé (5), Commission (2), Ta-Ngoma (1), Bourreau (5), Bouemba bus station (9), Bamako (5), Maman Mboulé (2) and Total (14). These markets were also selected at random, and the other 20 vendors were selected from the markets of: Tié-Tié (2), Fond Tié-Tié (11), Nkouikou (1) and Central (6) in the city of Pointe-

Noire. In Pokola, the survey was conducted directly with caterpillar collectors, including 15 indigenous people and 10 Bantu. Two field missions were carried out in Liranga and Makotimpoko in order to conduct surveys of caterpillar boats to find out where they came from.

### Duration of the study

The study was structured over four years, starting on 23 July 2012 in the cities of Brazzaville, Pointe-Noire and the randomly selected city of Pokola.

### Data processing and statistical analysis

Data processing was carried out with SPSS version 20 and Excel 2013. Data entry and production of raw tables were done with SPSS and Excel. Quantitative variables were expressed as mean ( $\bar{x}$ )  $\pm$  standard deviation (s) while indicating extreme values (minimum and maximum). Categorical variables were expressed as numbers and percentages. The  $\chi^2$ -test was used for the comparison of variables, with a significance level of 5%. The ANOVA test was used for the comparison of calculated means.

## RESULTS

Among the caterpillars consumed by the Congolese population, the genus *Imbrasia* is the one that is the object of a large trade. Thus, only the marketing of

caterpillars of this genus will be considered in this article.

### Traders' supply locations

Results indicated in Table 1 show that in the Republic of the Congo, *Imbrasia* caterpillars traded come from the Likouala (37.3%) and Sangha (5.1%) departments. The main source of supply in Brazzaville is the Bouemba bus station, where traders from the Liranga and Makotimpoko markets sell their products. A fairly large quantity arrives via the Brazzaville city autonomous port and a small quantity via the Maya-Maya international airport. The respondents did not mention any supplies from the Brazzaville railway station while in Pointe-noire Department, these caterpillars are mainly sold in two markets: the Fond Tié-Tié market and the central market. The sellers buy either directly from Brazzaville or from wholesalers coming from Brazzaville. In the other markets, there is either only one female vendor, as in the case of the Nkouikou market, or none at all. The sellers in these small markets buy from the Fond Tié-Tié market.

No department in the southern part of Congo was indicated as the place of origin of these caterpillars. In addition, all vendors stated that Brazzaville city is only a place where these caterpillars are sold, supplied by the departments of Likouala and Sangha, and the D.R. Congo (Table 1).

**Table 1.** Place of origin of *Imbrasia* caterpillars sold in in the different markets of Brazzaville

Variables	Characteristics	Effectives (n)	%	IC (95%)	Statistics
Place of origin	Sangha	3	5.1	1.1-14.1	$\chi^2=25.268$ ddl=58 p<0.001
	Likouala	22	37.3	25.0-50.9	
	D.R. Congo	29	49.2	35.9-62.5	
	CAR	4	6.8	1.9-16.5	
	Don't know	1	1.7	0.0-9.1	

### Imports

According to the wholesalers and semi-wholesalers interviewed at the Bouemba bus station and the Bourreau market, the smoked *Imbrasia* caterpillars sold in Brazzaville come mainly from the markets of Liranga (in the Likouala department) and Makotimpoko (in the Plateau department). These two cross-border markets are supplied with caterpillars by traders from the Equateur and Sud-Ubangi Provinces in the DRC (49.2%), particularly from the surrounding localities of Mbandaka and

Gemena. The quantity from the Central African Republic (CAR) is low (6.8%). In addition, a fairly large quantity of caterpillars from the DRC enters the Congo via Bétou and Lanza. Field missions to Bétou revealed that *Imbrasia* caterpillars do not come from CAR but from the South Ubangi Province in DRC. It follows that *Imbrasia* caterpillars sold in the Republic of the Congo are largely imported from the DRC (Table 1).

### Estimated imported quantities and sales prices

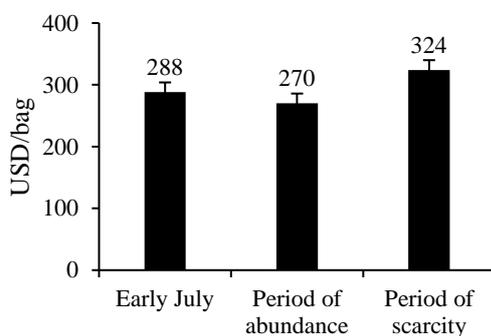
The field missions to Makotimpoko, Oyo and Liranga made it possible to make some estimates of the average quantity of caterpillars coming from the DRC. At the Liranga market, it is about 250 bags of 55 kg, i.e., 14 tons per market during the period of July to September. As the Liranga market is held twice a month, this quantity can be estimated at 84

tons during the production period. The quantity entering the Makotimpoko market is estimated at a monthly average of 200 bags of 55 kg or 11 tons. However, surveys of the authorities at these markets and at the secondary port of Oyo did not reveal any statistical data on the quantity of bags of caterpillars sold or transiting through these localities (Table 2).

**Table 2.** Estimated quantity of edible caterpillars vended on the Republic of the Congo's markets imported from D.R. Congo

Quantities imported per market (bags of 55kg)	Imported from:	Point of sale	%
250 (14 tons or 84 tons during the production period)	DRC	Liranga	55.56
200 (11 tons)	DRC	Makotimpoko	44.44

In early July 2015, a 55 kg bag was sold at CFAF 160,000 (USD288 or USD5.24/kg) in Liranga and Makotimpoko. This price drops to 150,000 CFA francs (USD270 or USD4.9/kg) during the period of abundance of the product on the market; it then rises again during the period of scarcity, reaching 180,000 CFA francs (USD 324 or USD 5.89/kg; Fig. 1).



**Figure 1.** Average quantity and price per bag of edible caterpillars imported from the D.R. Congo.

### Storage and preservation

The caterpillars are collected alive and placed in containers during the harvest. Once the harvesters return to the village or camp, the caterpillars were lightly boiled in large pots and then spread out on racks where they were smoked for two to three days. The smoked caterpillars were stored in sacks called locally 'green bands' and then taken to the places where they were sold.

In towns such as Impfondo and Ouesso, the fresh caterpillars were lightly boiled in salt water and flown to Brazzaville the next day.

Surveys in Brazzaville city and Pointe-Noire Department showed that there are no

adequate structures at market level to store and preserve *Imbrasia* caterpillars for a long time so that they can be sold throughout the year.



**Figure 2.** A wholesaler from Liranga (right) selling "green band" bags of *Imbrasia truncata* caterpillars at the Brazzaville bus station on 8<sup>th</sup> August 2012.

### Movement of production

Caterpillars harvested in Sangha and Likouala were largely transported to Brazzaville (70%) and other major cities in the southern part of Congo (25%) such as Pointe-Noire, Dolisie and Nkayi for sale in the markets of these cities. Small quantities (5%) of smoked caterpillars were sold in towns in the central part of Congo such as Oyo, Owando, Gamboma and Djambala (Table 3).

### Mode of transport

Four modes of transport are involved in the movement of *Imbrasia* caterpillar food production: transport by air (5%), transport by boat (15%), transport by motorboat (20%) and transport by vehicle (60%) (Table 4).

**Table 3.** Source of supply and point of sale of edible caterpillars in the Republic of the Congo

Source of supply	Destination	%
Likouala and Sangha	Brazzaville	70
	Pointe-Noire, Dolisie, Nkayi	25
	Central part of the Congo	5

Fresh caterpillars from Impfondo arrive in Brazzaville via Maya-Maya airport with a frequency of four days per week during the production period (July to September). The quantity of these caterpillars is not too large. The caterpillars of the same condition from Ouesso are transported to Brazzaville either by plane with low frequency (once or twice a week), or by vehicle from the Océan du Nord companies and others with high frequency. Motorized boats transport the smoked caterpillars from the cross-border markets of

Liranga and Makotimpoko to the places where they are loaded into vehicles for transport to Brazzaville. Those from Liranga arrive at the secondary port of Oyo and those from Makotimpoko arrive at the village of Bouemba or at Gamboma. A significant proportion of the smoked caterpillars from Liranga and other localities in Likouala are transported by boat to the autonomous port of Brazzaville.

Once in Brazzaville, the caterpillars are transported by train or plane to Pointe-Noire and other cities and towns in southern Congo.

**Table 4.** Mode of transport of edible caterpillars in the Republic of the Congo

Mode of transport	Source of supply	Caterpillars' condition	%
Air	Impfondo and Ouesso	Fresh, smoked	5
Boat	Impfondo and Liranga	Smoked	15
Motorboat	Liranga	Smoked	20
Motor boat and Vehicle	Makotimpoko and Liranga	Smoked	60

## Food availability

### Storage

According to surveys conducted in Pokola, Ibolo (Epéna district) and Impfondo among the indigenous and Bantu populations, the harvest of *Imbrasia* caterpillars lasts at most three months, from July to September. The harvested product was gradually sold at the point of sale. There were no suitable storage facilities for these caterpillars, which limited their consumption to about two months after the harvest period. The sale of *Imbrasia* caterpillars in Brazzaville city also begun in July and was usually completed by January of the following year. It could continue until May. However, the products sold in the period from January to May were often in a state of decomposition due to the lack of conservation structures. According to some sellers (95%), the good product ends in December; in the following months, the product is moldy and often has an unpleasant taste.

In Pointe-Noire Department, the sale of *Imbrasia* caterpillars begins at the end of July and ended in November for the majority of sellers (85%)

contacted at the Central Market (large market) and the Fond Tié-Tié market. A small proportion of sellers (5%) continue to sell them until the end of February of the following year and another (2%) until March. However, from January onwards the product begins to decompose due to the lack of suitable storage facilities (Table 5).

### National production and imports

The quantity marketed from national production was insufficient to meet the demand of *Imbrasia* consumers in the Republic of the Congo. Indeed, surveys of wholesalers at the secondary port of Oyo, the autonomous port of Brazzaville and the Bouemba bus station showed that national production was 42.4% and imports represented 57.6%, especially caterpillars from Equateur Province in the DRC (Table 1). However, observations made during our field missions in Liranga, Makotimpoko and Impfondo showed that national production is very low (less than 20%) and Equateur Province in DRC was the major supplier of *Imbrasia* caterpillars sold in the Republic of the Congo.

**Table 5.** Marketing modalities of *Imbrasia* caterpillars in Pointe-Noire Department

Variables	Characteristics	Effectives (n)	%	IC (95%)	Statistics
Place of supply	Fond Tié-Tié	17	85.0	62.1-96.8	$\chi^2=7.935$ ddl=19 p<0.001
	Brazzaville	3	15.0	3.2-37.9	
Purchasing terms and conditions	Sacs	5	25.0	8.7-49.1	$\chi^2=12.583$ ddl=19 p<0.001
	Pots	15	75.0	50.9-91.3	
Terms of sale	Retail	16	80.0	56.5-94.3	$\chi^2=21.354$ ddl=19 p<0.001
	Semi-wholesale	2	10.0	1.2-31.7	
	Wholesale	2	10.0	1.2-31.7	
Purchase price per 4.6kg pot (in F CFA)	18000	1	5.0	0.1-24.9	$\chi^2=27.568$ ddl=19 p<0.001
	20000	18	90.0	68.3-98.8	
	25000	1	5.0	0.1-24.9	
Selling price of 4.6kg pot (F CFA)	25000	17	85.0	62.1-96.8	$\chi^2=26.246$ ddl=19 p<0.001
	>25000	3	15.0	3.2-37.9	
Average quantity of sales per week	≤1 pot	13	65.0	40.8-84.6	$\chi^2=6.476$ ddl=19 p<0.001
	2 pots	3	15.0	3.2-37.9	
	3 pots	0	0	0	
	≥4 pots	4	20.0	5.7-43.7	

Sellers, whose main activity was the sale of *Imbrasia* caterpillars, manage to build up stocks during the May-June break period or source them from Kinshasa.

### Methods of selling caterpillars

The sale of *Imbrasia* caterpillars in Brazzaville was almost exclusively a female activity (98.3%). The surveys showed that 89.8% of the *Imbrasia* caterpillar sellers surveyed in Brazzaville were used to sell these caterpillars. The main form of caterpillar sold was the smoked form, which accounts for 94.9% of cases. 52.3% of the sellers surveyed were selling caterpillars for at least five years. However, the proportion of sellers who have recently adopted this trade was somewhat considerable (23.7% of cases, Table 6).

The annual frequency of sales varied in 98.3% of cases. The main factor explaining this variation was the seasonality of the product (98.3%). For 61.6% of the sellers surveyed, the sale of *Imbrasia* caterpillars was their main source of income, compared to 37.3% who had other sources of income apart from the sale of *Imbrasia* caterpillars. The sale of *Imbrasia* caterpillars was sufficient to cover household expenses for 66.1% of sellers. On the other hand, 32.2% of the sellers had

resort to other sources of income. Of the *Imbrasia* caterpillar sellers surveyed, 81.4% were retailers, 16.9% were semi-wholesalers and 1.7% were wholesalers. The lowest selling unit price was 250 CFA francs (USD0.45) in 42.4% of cases, compared to 100 CFA francs (USD0.18) in 32.5% of cases. The unit of sale was either the heap, the small pot or the 4.6 kg pot. The bag of *Imbrasia truncata* caterpillars weighed 46 to 56 kg and contained 10 to 12 pots of 4.6 kg on average.

The price per bag fluctuated according to the demand and availability of *Imbrasia* caterpillars. Indeed, the purchase price of the 46 kg bag was 200,000 CFA francs (USD360) at the beginning of the harvest in July (USD7.83/kg) and dropped to 180,000 CFA francs (USD324) at the end of September (USD7.04) due to the abundance of the product on the market. The differences between the variable characteristics of *Imbrasia truncata* caterpillar marketing in Brazzaville were highly significant ( $p<0.001$ ).

The sale of *Imbrasia* caterpillars in Pointe-Noire was an exclusively female activity (100%) and 75% of the female *Imbrasia* caterpillar sellers surveyed were used to selling these caterpillars. The smoked form of these caterpillars was the only sold in the various markets of this cosmopolitan city (100%).

**Table 6.** Characteristics of *Imbrasia* caterpillar sellers in Brazzaville city

Variables	Characteristics	Effectives (n)	%	IC (95%)	Statistics
Gender of interviewed (N=59)	Male	1	1.7	0.0-9.1	$\chi^2=58.000$ ddl=58 p<0.001
	Female	58	98.3	90.9-100.0	
Sales habit	Yes	53	89.8	79.2-96.2	$\chi^2=26.097$ ddl=58 p<0.001
	No	6	10.2	3.8-20.7	
Form of sale	Fresh	3	5.1	1.1-14.1	$\chi^2=41.917$ ddl=58 p<0.001
	Smoked	56	94.9	85.9-98.9	
Length of time in trade of <i>Imbrasia truncata</i> caterpillars (in years)	1	14	23.7	13.6-36.6	$\chi^2=15.582$ ddl=58 p<0.001
	2	3	5.1	1.1-14.1	
	3	5	8.5	2.8-18.7	
	4	5	8.5	2.8-18.7	
	≥5	31	52.5	39.1-65.5	
Consistency of sales frequency	Don't know	1	1.7	0.0-9.1	$\chi^2=58.000$ ddl=58 p<0.001
	No	58	98.3	90.9-100.0	
	Don't know	1	1.7	0.0-9.1	

40% of the women surveyed have been selling caterpillars for more than 5 years and 75% for at least 3 years. However, the proportion of women

vendors who have been in the trade for no more than one year was 25% (Table 7).

**Table 7.** Characteristics of caterpillar sellers in Pointe-Noire Department

Variables	Characteristics	Effectives (n)	%	IC (95%)	Statistics
Gender of interviewed (N=20)	Male	0	0		$\chi^2=12.583$ ddl=19 p<0.001
	Female	20	100	83.2-100.0	
<i>Imbrasia</i> caterpillars' sales habit	Yes	15	75.0	50.9-91.3	$\chi^2=12.583$ ddl=19 p<0.001
	No	5	25.0	8.7-49.1	
Form of sale	Fresh	0	0	1.1-14.1	$\chi^2=8.611$ ddl=19 p<0.001
	Smoked	100	100	83.2-100.0	
Length of time in trade of <i>Imbrasia</i> caterpillars (in years)	≤1	5	25.0	8.7-49.1	$\chi^2=8.611$ ddl=19 p<0.001
	2	0	0		
	3	3	15.0	3.2-37.9	
	4	2	10.0	1.2-31.7	
	5	2	10.0	1.2-31.7	
Consistency of sales frequency	Yes	0	0		$\chi^2=6.582$ ddl=19 p<0.001
	No	20	100.0	83.2-100.0	
Factors for variation in frequency of sale	Scarcity	12	60.0	36.1-80.9	$\chi^2=19.170$ ddl=19 p<0.001
	Overabundance	1	5.0	0.1-24.9	
	Other	7	35.0	15.4-59.2	
Sale of caterpillars as main source of income?	Yes	6	30.0	11.9-54.3	$\chi^2=19.170$ ddl=19 p<0.001
	No	14	70.0	45.7-88.1	

The annual frequency of sales varied in 100% of cases. The main factor explaining this variation was

the seasonality of the product, leading to its scarcity on the market (60%). However, other factors (35%)

such as the difficulty of obtaining a rail ticket and the high cost of air transport explained the variation in the annual frequency of sale of these caterpillars. For 30% of the sellers surveyed, the sale of *Imbrasia truncata* caterpillars was their main source of income, while 70% have other sources of income besides the sale of *Imbrasia* caterpillars. The sale of *Imbrasia* caterpillars was sufficient to cover the household expenses of 35% of the women sellers. However, 65% of the sellers had resort to other sources of income to make up the shortfall.

Of the women selling *Imbrasia truncata* caterpillars surveyed, 80% were retailers and 20% were semi-wholesalers (10%) and wholesalers (10%). Most of these sellers (85%) obtained their caterpillars in the Fond Tié-Tié market from wholesalers and semi-wholesalers from Brazzaville. On the other hand, 25% of the vendors bought directly from the Bouemba bus station in Brazzaville. The most common way of buying caterpillars was in 4.6kg pots (75%); the purchase of 46-55kg bags represented only 25%. The weekly quantity of caterpillars sold does not exceed one 4.6 kg pot for 65% of sellers. It reached 2 pots for 15% of the sellers and exceeded 3 pots for 20%. A pot of caterpillars was bought from semi-wholesalers at 20,000 CFA francs (USD36) for 90% of the women surveyed and resold to retailers in small markets at 25,000 CFA francs (USD45) for 85% of the women surveyed.

During the period of production disruption, the 4.6kg pot could be sold for more than 25,000F CFA (USD45) for 15% of the women surveyed and the number of caterpillars decreased considerably. The differences between the characteristic variables of the marketing methods for *Imbrasia* caterpillars in Pointe-Noire were highly significant ( $P < 0.001$ , Table 7).

### Marketing channels

In the marketing of *Imbrasia* caterpillars, five types of actors were involved. These were harvesters, wholesalers, semi-wholesalers, retailers and consumers.

In the production areas, two commercial channels were used: the direct harvester-consumer channel and the indirect harvester-retailer-consumer channel. In both cases, the price does not have a negative influence on the consumption of caterpillars, the product was available and accessible to all households. This situation was observed in departments such as Sangha and Likouala.

In areas that do not produce *Imbrasia* caterpillars, wholesalers went to harvesters in the production areas by plane, boat, motorboat, vehicle or train. On their return, they can sell their products to other wholesalers and semi-wholesalers or to retailers. The semi-wholesalers in turn sold the product to retailers who sold at the market level where consumers come to buy. In this commercial circuit, the product passes through several intermediaries, from the harvester to the consumer, each of whom has requirements due to the endogenous factors they experience along the way. These factors can be transport, taxes and handling. All these factors influenced the price increase on the market and consequently the product was no longer accessible to all households.

### Profitability of selling *Imbrasia truncata* caterpillars

The Bantu bought smoked caterpillars from indigenous harvesters at CFAF 3,500 (USD6.3) per 4.6 kg pot (i.e., USD1.3/kg) and resold them at CFAF 7,000 (USD12.6 or USD2.74/kg) or even CFAF 8,000 (USD14.4 or USD3.13/kg) from Pokola wholesalers or retailers. The same quantity of caterpillars was sold in Impfondo at 10,000 CFA francs (USD18), 18,000 (USD32.4) to 20,000 CFA francs (USD36) in Brazzaville and 25,000 CFA francs (USD45) in Pointe-Noire. Pokola dealers store the caterpillars at home and pay almost no taxes. They have a 100% profit. The same was true for those in Impfondo.

The wholesalers in Brazzaville at the beginning of the caterpillar harvest had a profit of 17% per sale. In mid-August, production increased, prices fell, and profit increased to 28% or even 42% of the cost price of each bag. However, retailers in the Brazzaville markets had a profit of 3,000 CFA francs (USD5.4) to 4,000 CFA francs (USD7.2) per 4.6 kg pot (USD1.2 to 1.6/kg), i.e., 17% to 22%; those in Pointe-Noire had a profit of 5,000 CFA francs per pot, i.e., 25% of the cost price of each pot (Table 5).

### DISCUSSION

The caterpillar trade was almost entirely a female activity (100% of sellers in Pointe-Noire Department and 98.3% in Brazzaville city). This result is similar to that of Mbétid-Bessane (2005) where the resale of caterpillars in CAR was an activity carried out by women (100%). It was often a secondary activity for the 100% of women

resellers in Pointe-Noire Department and 88.1% in Brazzaville city who were smoked fish traders, but it could become the main activity for 61% of women resellers in Brazzaville and 30% of those in Pointe-Noire during the collection period. This result is similar to that of Mbétid-Bessane (2005) where the resale of caterpillars in CAR becomes the main activity of 25% of the resellers during the collection period.

In this trade, there was usually one or more intermediaries between the harvesters and the consumers. This situation contributed significantly to price increases. The same observation was made by Mbétid-Bessane (2005) in CAR and by Badanaro et al. (2014) in Togo. A kilogram of caterpillars was sold on average at 3500 F CFA (USD6.3/kg) in Brazzaville at the same price as a kilogram of beef in butcher shops. This price was about three times that of a kilogram of *Cirina forda* caterpillars in Togo (Badanaro et al., 2014) and *Elaphrodes lactea* caterpillars sold in Lubumbashi during the production period (Bomolo et al., 2019), and higher than that of a kilogram of caterpillars sold in CAR (Mbétid-Bessane, 2005).

Profit margins were higher upstream (wholesalers) than downstream (retailers). This finding corroborates the observations made by Badanaro et al. (2014) during a study conducted on the marketing of *Cirina forda* caterpillars in Togo. This trade is therefore more beneficial for wholesalers than for retailers. They had a monthly profit of around 400,000 (USD720.03) to 600,000 F CFA (USD1,080) against 36,000 (USD64.8) to 48,000 F CFA (USD86.4) for retailers. This trade enables wholesalers and semi-wholesalers to meet their basic needs. Thus, this activity contributes significantly to improving the living conditions of wholesalers and semi-wholesalers. However, this activity fluctuated according to demand and availability, making revenues unstable throughout the year. This finding is similar to that of Balinga (2003) who made the same observations in Cameroon and recently by Bomolo et al. (2019) on *Elaphrodes lactea* edible caterpillar in Lubumbashi, DR Congo reported that the indirect mode of trade of *E. lactea* is the most commonly used, with the average price/kg varying between USD2.32 (during in-season = production period for caterpillars) and USD5.24 (during dry season = off-season, mainly pupae). During the peak season of caterpillar production, the harvester's average income per day varied between USD1.6 and USD3.0 whereas it

varied between USD2.2 and USD5.2 during the pupal season.

*Imbrasia* caterpillars sold in the Republic of the Congo were largely imported from Equateur Province in the DRC, particularly from the surrounding localities of Mbandaka and Gemena; the quantity from Likouala and Sangha was very small. This indicates the existence of a cross-border trade in caterpillars between the Republic of the Congo and the DRC. However, this trade could not be evaluated because it was illegal and no statistical data exist at the level of cross-border markets and ports of embarkation. This observation is in line with that made by Badanaro et al. (2014) who highlighted the existence of an illicit trade in caterpillars between Togo, Nigeria and Ghana.

## CONCLUSION

*Imbrasia* caterpillars are traded more by women whose main occupation is trading. The main source of caterpillars is the market and the smoked form is the most traded. The annual frequency of sale of these caterpillars is variable. The main factor explaining this variation is the seasonality of the product leading to its scarcity on the market. The quantity and frequency of weekly sales varies both according to the supply of caterpillars and the demand on the market. Profit margins are higher upstream (wholesalers) than downstream (retailers).

Although perceived as an alternative solution to poverty in different departments and localities of the Republic of the Congo, the business of the *Imbrasia* caterpillars is, however, not very lucrative. The exploitation of the caterpillar remains basic, the combined harvesting of various player and anthropogenic activities such as charcoal production puts the species at heavy disappearance risk. The value chain of *Imbrasia* caterpillars is similar to that of Mopane worm *Imbrasia belina* in Southern Africa and measures for sustainable management of this important insect have been studied and implemented in the region. This study, therefore, calls on a concerted action from all stakeholders to increase awareness and the development of sustainable *Imbrasia* edible caterpillars harvesting models through community participation to preserve the ecosystem and reduce the pressure on the forest.

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### Conflicts of Interest

The authors declare no conflict of interest.

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