

Edible *Cirina forda* (Westwood, 1849) (Lepidoptera: Saturniidae) caterpillar among Moba people of the Savannah Region in North Togo: from collector to consumer

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ABSTRACT

Cirina forda (Westwood, 1849) (Lepidoptera: Saturniidae) is a Lepidoptera species whose larvae are eaten in West Africa. In Togo, larvae of *C. forda* are eaten and sold in northern part of the country, by Moba people. However no scientific information was recorded on this practice. The objective of this study is to increase the value of this edible unconventional resource to ensure food security. The research was carried out in three villages in the study area and 300 actors were surveyed in two main markets of the Savannah Region in order to obtain information about the availability of caterpillars in a year period; their collection, cooking and conservation techniques; financial income and distribution channels. The nutritional value of *C. forda* larva was also evaluated through biochemical analyses. The period of availability of *C. forda* larva goes from July to September and mostly during the rainy season. The collection, conversion and sale of *C. forda* larva are activities occurred in all surveyed villagers. People of different sexes and ages carry out this activity. However, resale strictly involves women. Wholesalers buy *C. forda* caterpillars from collectors and sell them to middlemen who, on their turn, sell them to retailers. The average price of *C. forda* caterpillar increases from collectors to wholesalers, from wholesalers to middlemen and from middlemen to retailers, but the margins of profit are in the reverse order. The margins of profit on one kilogram are 600 F CFA, 287.5 F CFA, 187.5 F CFA and 125 F CFA for collectors, wholesalers, middlemen and retailers respectively. As far as the nutritional value is concerned, raw as well as converted *C. forda* caterpillar contains less water, but a lot of ashes, proteins, high in crude fibers and minerals with significant differences sometimes. Consequently, *C. forda* caterpillar is a good food resource and provides significant incomes for poor people in the north of Togo. This study lays the foundation of a program aimed at increasing the economic value of this unconventional food resource in Togo.

Key words: *Cirina forda*, collection, trading, nutritional value, Togo.

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INTRODUCTION

Edible insects are of great importance in the development of poor populations who exploit them. Unfortunately, this unconventional resource is often minimized or ignored by both development program agents and the scientific community. In fact, insects are important sources of protein, fat, vitamins and minerals (Malaisse and Parent, 1980; Ramos-Elorduy *et al.*, 1997). Some are eaten for their healing properties (DeFoliart, 1992; Mignon, 2002). They also provide economic advantages. Edible insects create profitable activities based on their collection, processing and sale on national and international markets (Tabuna, 1999; Mbétid - Bessane, 2005). Despite the numerous advantages they provide, edible insects are less known especially, in tropical ecosystems where new species are yet to be discovered. Almost 2000 insect species are edible worldwide (Malaisse *et al.*, 2003). Within the insect orders, Coleoptera (beetles), Hymenoptera (bees, wasps and ants), Orthoptera (locusts, grasshoppers, crickets) and Lepidoptera (caterpillars) represent 80% of edible species (Ramos-Elorduy, 2005). Moreover, specific studies on African edible caterpillars have been carried out. Saturniidae, Notodontidae and Sphingidae are the three major families of Lepidoptera of which caterpillars are edible (Malaisse *et al.*, 2003). Many Africans are fond of big and abundant Saturniidae larvae. Harvested in huge quantities when they appear, they are much appreciated and are exported not only to the sub-region, but also towards diasporas settled in Europe (Tabuna, 1999). Among the edible Saturniidae species, the *Cirina forda* (Westwood, 1849) (Lepidoptera: Saturniidae) caterpillar is well accepted as food in Africa, especially in Nigeria, Zambia, Zimbabwe, South Africa, Centrafrican Republic and the Democratic Republic of Congo (Quin, 1959; Brandon, 1987; Holden, 1991; DeFoliart, 1995; Malaise, 1997). In Nigeria, especially, this caterpillar is in great demand and has become the most commercialized species (Fasoranti and Ajiboye, 1993). In Togo, the Savannah Region is involved in the consumption and selling of the caterpillar locally known as “Salantonda” by the Moba ethnic group. Despite the flourishing trade in caterpillars in this region, no research has been done regarding this food resource in order to promote it. To increase the value of the caterpillar, it's important to analyze the traditional trade based on the endogenous knowledge of local populations. The general objective of this study is to increase the value of this edible unconventional resource to ensure food security. Specifically, the study provides information on the annual period of availability, harvesting techniques, conversion and preservation, trade channels, financial income of activities for the different actors involved and the nutritional value of *C. forda* caterpillar in the north of Togo (Savannah Region).

MATERIAL AND METHODS

Study area

The study was carried out in the Savannah Region in the north of Togo (Figure 1) located between 0° and 1° E longitude and 10° and 11° N latitude and covers an area of 8533 km². It has 776710 inhabitants in a flat region in a sudanese climatic zone. This ecological zone is

characterized by two seasons: a rainy season (from May to September) with poor and ill-divided rainfall and a long dry season (from October-April). The monthly average temperature varies from 26,4 to 28,3 °C during the year and the annual mean precipitation is close to 1 000 to 1 302 mm and relative humidity that varies from 56 to 67 % RH in the year.

The soils of this region are poor (Tiwome, 2009), fragile, less varied and overexploited. These conditions are a hindrance to agricultural activities. The Savannah Region of Togo is mostly inhabited by the Anoufo, Bissa, Gangan, Gourmantché, Mamproussi, Moba, Fulani, Yanga and Mossi. However, this study was carried out only on the Moba ethnic group which eats and sells *C. forda* caterpillars. Thus our research area covered the prefectures of Tône and Tandjoaré, mostly populated by the Moba. Field research was carried out in 03 villages (Bogou, Tampialime, Tamongue) where *C. forda* caterpillar is collected (Figure 1). Surveys were carried out the Nano market (rural area) in the prefecture of Tandjoaré and in Dapaong (urban area) in the prefecture of Tône which are the main centers of *C. forda* trading in the Savannah Region.

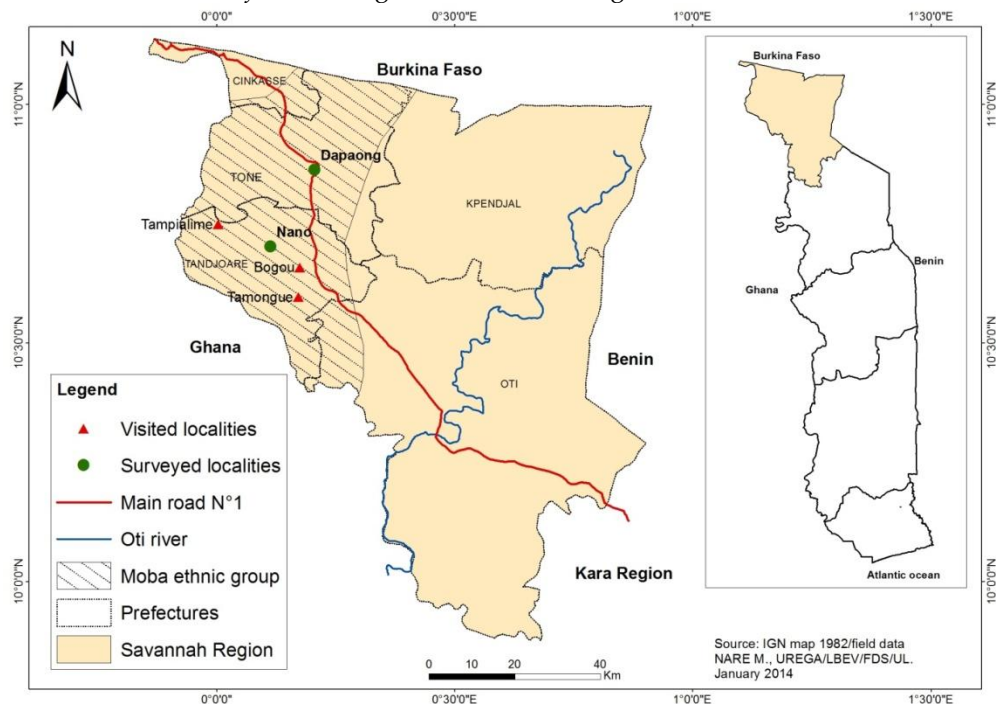


Figure 1: Study area and surveyed localities

Sample collection and data analysis

The collection of data lasted one year (from October 2012 to September 2013). The Field research helped us to collect caterpillars under Shea trees, *Vitellaria paradoxa* C. F. Gaertn (Sapotaceae) in nature in the best season. The confirmation of insect identity was carried out in the Laboratory of Entomology in the Faculty of Science at the University of Lomé (Togo). Field research permitted to identify the different techniques of collection and conversion of the caterpillar. Surveys provided information on the annual period of availability of caterpillars, the social status of the actors involved in the collection and sale

of *C. forda*, the trade channels and the costs of each activity. The sample for this study consists of 300 actors: 100 collectors, 100 sellers (wholesalers, middlemen and retailers) and 100 consumers. In each actor category the people involved, were randomly selected in the market on the day of the interview. Percentages of the total number of persons interviewed were calculated with the different data collected. The profit margin of *C. forda* channel was expressed by the difference between the sale price and the cost price. The profit margin percentage (PMP) was estimated using Blanchette's (2012) formula:

$$PMP = \frac{\text{Sale price} - \text{Cost price}}{\text{Sale price}} \times 100$$

Costs have included conversion expenses during purchase and caterpillar transport. Taxes were not taken into account in this study because no taxes were paid in the area as far as caterpillar sale is concerned. Various measurements of caterpillar sale were found in the study area (unit of caterpillar, a handful caterpillar, bowl caterpillars and a sack caterpillar). In order to have the same calculation base, a kilogram was chosen as measurement units.

Chemical analysis

Fresh samples of *C. forda* caterpillars were collected in August 2013 in 03 villages (Bogou, Tampialime, Tamongue). They were killed by putting them in an icebox with ice cubes (Finke *et al.*, 1989) and brought to the laboratory. Other samples of *C. forda* caterpillars, boiled, roasted and sold in markets in these same villages were bought in the same period. An electronic dampness analyzer SCALTEC (SM01 Instrument GmbH) was used to determine moisture content in fresh and converted caterpillars. Five grams of fresh caterpillar from each village was weighed and mixed to get an average sample. The same manipulation was done with converted bought caterpillars. The average sample was dried at 40°C in an incubator and ground in a mill for ash, mineral substance, crude protein and crude fiber analysis. Ashes were obtained by incinerating samples in an oven at 550°C for 5 hours. Using the following formula, the total percentage of ash was calculated:

$$CT = \frac{\text{Ash weight after incineration}}{\text{Sample weight}} \times 100$$

Crude protein was estimated by measuring the nitrogen using Kjeldahl's method. The total quantity of protein was estimated by multiplying the quantity of nitrogen by 6.25. Minerals (sodium, potassium, calcium, magnesium, iron, zinc, copper and manganese) were analyzed through the atomic absorption spectrographic method. Phosphorus content was determined using the phosphovanado molybdate method (AOAC, 1995). Finally, crude fiber content was determined through Weende's method (AFNOR, 1985). Experiments were done in triplicate. The SPSS.16.0 software was used to analyze the different results obtained in our experiment. Comparisons of the mean numbers were made using analysis of variance (ANOVA-1) at the 5% level.

RESULTS

Annual availability period of *C. forda* caterpillar

Ninety four percent of the actors replied that collection of *C. forda* caterpillars takes place between July and September (Table I). Caterpillars are therefore collected during three months.

Table I: Collecting period of *C. forda* caterpillars during the quarters of the year according to the actors involved in its trading channel

| Informants | Number of involved actors (%) | | | |
|------------|-------------------------------|------------|----------------|------------------|
| | January-March | April-June | July-September | October-December |
| Collectors | 0 (0) | 0 (0) | 100 (33.34) | 0 (0) |
| Resalers | 0 (0) | 0 (0) | 97 (32.3) | 3 (1) |
| Consumers | 0 (0) | 6 (2) | 85 (28.34) | 9 (3) |
| Total | 0 (0) | 6 (2) | 282 (94) | 12 (4) |

According to 76.67% of the actors, *C. forda* caterpillar trade and consumption take place from June to September, whereas 22.33% say that the two activities take place from October to December (table II). In fact, 99% of the actors think that the trade and consumption of *C. forda* caterpillars last from July to December. Indeed, the collected caterpillars are converted on the same day and either eaten or sold right away by the collectors in village markets. Wholesalers buy *C. forda* caterpillars from these markets and retailing to the consumer follows in the same period. The sale and consumption of caterpillars decline during the quarters that follow harvest time (October to December). Therefore, *C. forda* caterpillars are not preserved for a long period.

Table II: Period of sale and consumption of the *C. forda* caterpillars during the quarters of the year according to the actors

| Informants | Number of actors involved in the sale and trade per quarters (%) | | | |
|------------|--|------------|----------------|------------------|
| | January-March | April-June | July-September | October-December |
| Collectors | 0 (0) | 2 (0.67) | 81 (27) | 17 (5.67) |
| Resalers | 0 (0) | 0 (0) | 79 (26.33) | 21 (7) |
| Consumers | 0 (0) | 1 (0.33) | 70 (23.33) | 29 (9.67) |
| Total | 0 (0) | 6 (2) | 230 (76.67) | 67 (22.33) |

Social status of the actors in the *C. forda* trade channels

In the study area, there is no age or sex restriction on the collection of *C. forda* caterpillars. According to the informants, everybody, men (50%), women (50%) and children (51%) carry out this activity in rural areas (Table III). However, there is no full-time specialist in the activity during harvest periods.

Table III: Variations in number (Nb) and percentages of the actors involved in *C. forda* collection and resale according to their sex and age

| Informants | Nb and % according to sex and age of actors involved in collection | | | | Nb and % according to sex and age of actors involved in resale | | | |
|------------|--|------------|-----------------|------------|--|-----------|-----------------|------------|
| | Nb of men (%) | | Nb of women (%) | | Nb of men (%) | | Nb of women (%) | |
| | 10-17 years | ≥18 years | 10-17 years | ≥18 years | 10-17 years | ≥18 years | 10-17 years | ≥18 years |
| Collectors | 25 (8.33) | 25 (8.33) | 25 (8.33) | 25 (8.33) | 0 (0) | 0 (0) | 48 (16) | 52 (17.33) |
| Resalers | 26 (8.67) | 25 (8.33) | 24 (8) | 25 (8.33) | 0 (0) | 0 (0) | 49 (16.33) | 51 (17) |
| Consumers | 26 (8.67) | 23 (7.67) | 27 (9) | 24 (8) | 0 (0) | 0 (0) | 50 (16.67) | 50 (16.67) |
| Total | 77 (25.67) | 73 (24.33) | 76 (25.33) | 74 (24.67) | 0 (0) | 0 (0) | 147 (49) | 153 (51) |

The collectors are men, usually farmers and students on holidays that help their parents on farms. They are also women who prepare and sell either local beer or meals at road sides. Almost all these women are farmers. The collectors are the first actors in the resale

chain. Contrary to the collection, caterpillar resale is exclusively (100%) carried out by women (Table III). According to their role in the resale chain, we have: wholesalers, middlemen, retailers and exporters. The wholesalers are women who sell foodstuff (maize, millet, beans...) and go to villages where *C. forda* caterpillars are collected. They buy from collectors (with foodstuff) and sell in towns. Caterpillar resale is not the main activity of these women. Middlemen are also women who usually buy foodstuff from wholesalers to resell in town. Selling caterpillars is also a second activity for resellers. Retailers are sellers (women and young girls of 10 to 17 years old), who sell caterpillars in heaps. Young girls hawk caterpillars through the markets and neighborhoods, while women display them on market stalls, sidewalks along the avenues and in front of houses. Caterpillars are also sold by women in inns with local beer. Finally, consumers of *C. forda* caterpillars are men, women and children.

Caterpillar collection techniques

The collectors mentioned that the smell of *C. forda* caterpillar faeces and the defoliation done while eating the leaves of Shea trees inform them about their presence. Caterpillars are collected at the moment when they are ready to become nymphs. In that period, they climb down from *V. paradoxa* trees to the ground for metamorphosis. Collection is manual. It's done either individually or collectively at dawn. Collectors set out at around 3 a.m. for the bush with basins and buckets. Travel time at collection sites varies depending on the place of harvest. Harvesting is usually done between 4 and 5:30 a.m using flashlights. Collection time depends on the availability of caterpillars under a Shea tree. It lasts an hour or hour and a half. Each collector moves to a Shea tree and collects all the caterpillars found on the ground. Back home, around 6 a.m *C. forda* caterpillars freshly collected are converted for consumption and sale. Collectors who have to perform pastoral work can still do their work before returning to carry out the conversion. During field observations and during investigations, there has been no mention of tree cutting for collecting caterpillars. According to collectors, the best caterpillars are those collected on the ground. Collected quantities vary because they are based on the scope of infested host plants and duration of work. On average, collectors fill a bucket of 32 liters with fresh *C. forda* caterpillars per day per person.

Conversion techniques

Collected caterpillars are soaked in boiling water to kill them and then seasoned with salt. Then, they are roasted and can be consumed immediately. To ensure their preservation, roasted caterpillars are moistened with potash liquid prepared from the ashes of Palmyra palm *Borassus aethiopum* Mart. (Arecaceae). Then, they are dried in the sun and can be stored until the next harvest period (one year). Roasted and dried caterpillars are stocked in sacks for future use (consumption or for sale).

TRADING OF *C. FORDA* CATERPILLAR

Caterpillar market organization

The caterpillar market is not organized as such. The sale is individual. The sellers use their own means to deliver the ware; this helps them to get much profit. Collectors who deal with caterpillars before sale in the market are the first in the trade chain. Between collector and consumer, there are middlemen. Three trading channels are distinguished: the direct channel (caterpillars are directly sold to consumers), the indirect short channel (caterpillars

are directly bought by retailers and sold to consumers) and the long channel (which involves at least three middlemen: the wholesaler, the half-wholesaler, the retailer).

The direct channel: the minority of informants (5%) affirm that caterpillars are directly sold to consumers (table IV). These consumers are officials that pass weekends in villages and take the opportunity to buy caterpillars directly from collectors.

The short indirect channel: 12% of the informants think that *C. forda* caterpillars are bought from collectors and sold to consumers directly without passing through wholesalers. It is often local beer sellers from villages and rural areas where collection is practiced who retail them in small market sheds.

The long indirect channel: It is the most common. The majority of informants (83%) reported that caterpillars are sent to consumers only through this channel. *C. forda* caterpillar trade is thus ruled by wholesalers. They buy from collectors and sell to middlemen who sell to retailers. Retailers are at the end of the trade chain. Through them, caterpillars reach consumers.

Table IV: Number and percentage of the actors involved in the *C. forda* caterpillar network in the north of Togo

| Informants | Number of actors involved (%) | | |
|------------|-------------------------------|------------------------|-----------------------|
| | Direct channel | Short indirect channel | Long indirect channel |
| Collectors | 5 (1.67) | 12 (4) | 83 (27.67) |
| Resalers | 0 (0) | 7 (2.33) | 93 (31) |
| Consumers | 10 (3.33) | 17 (5.67) | 73 (24.33) |
| Total | 15 (5) | 36 (12) | 249 (83) |

At the end of daily activity, collectors sell dry caterpillars to both wholesalers and retailers and/or rarely to consumers who wait at the village markets. Wholesalers go to village markets using different means of transport (bush taxi or other means of light transport) where collectors wait to haggle over the product. Once they return to town, wholesalers deliver the ware to middlemen. But some wholesalers reserve caterpillars for themselves in order to raise prices in times of scarcity (dry season). During the shortage period, prices increase and may even double. The sellers whose number varies from 10 to 12 are scattered all over Dapaong market where retailers buy.

Financial profitability of caterpillars

In order to assess profitability in caterpillar selling activities, an outline of the operating account was established. The purchase prices prevailing during the survey in the period of abundance were given by informants. They vary depending on the measures used: the price of 1 caterpillar varies between 5 and 10 F CFA; that of a handful containing 6-9 caterpillars costs 25 to 50 F CFA depending on the point of sale (village or town); a bowl of 1.6 kg and a bag of 64 kg cost 1000 and 40.000 F CFA respectively at the collector level. Considering a quantity of 1 kg of caterpillars, costs and profit margins vary according to the different actors in the marketing chain (Table V). The purchase price increase from wholesalers to retailers. The profit margin for a collector is 96% per kg. The profit margin is 30.67%, 16.67% and 10% for wholesalers, middlemen and retailers respectively.

Table V: Prices and profit margins for 1 kg of caterpillar sold by different *C. forda* channel actors in the north of Togo

| Informants | Purchase price (F CFA) | Conversion cost (F CFA) | Distribution cost (F CFA) | Cost price (F CFA) | Sale price (F CFA) | Profit margin | |
|-------------|------------------------|-------------------------|---------------------------|--------------------|--------------------|---------------|----------|
| | | | | | | Gross (F CFA) | PMP (%)* |
| Collectors | 0 | 25 | 0 | 25 | 625 | 600 | 96 |
| Wholesalers | 625 | 0 | 25 | 650 | 937,5 | 287,5 | 30,67 |
| Middlemen | 937,5 | 0 | 0 | 937,5 | 1125 | 187,5 | 16,67 |
| Retailers | 1125 | 0 | 0 | 1125 | 1250 | 125 | 10 |

* Profit Margin Percentage

C. forda caterpillar nutritional value

Raw *C. forda* caterpillars are richer in water than converted ones (Table VI).

Table VI: Water, ash, crude protein, crude fiber (%) and minerals (mg/100g) contents of fresh and converted *C. forda*

| Analyzed parameters | Average content (\pm SD)* | | Statistics |
|----------------------|--------------------------------|---------------------------------|--------------------------------|
| | Raw caterpillars | Converted caterpillars | |
| Moisture (%) | 10.06 \pm 0.12 ^a | 3.94 \pm 0.14 ^b | F = 2955; df = 1; P < 0.001 |
| Proteins (%) | 51.43a \pm 3.81 ^a | 52.39 \pm 3.16 ^a | F = 0.112; df = 1; P = 0.755 |
| Fibers (%) | 8.42 \pm 0.45 ^a | 8.92 \pm 0.40 ^a | F = 2.03; df = 1; P = 0.227 |
| Ashes (%) | 18.43 \pm 0.15 ^a | 16.48 \pm 0.56 ^b | F = 31.855; df = 1; P = 0.005 |
| Sodium (mg/100g) | 35.035 \pm 0.38 ^a | 39.838 \pm 0.303 ^b | F = 285.904; df = 1; P < 0.001 |
| Potassium (mg/100g) | 67.386 \pm 0.22 ^a | 43.124 \pm 0.22 ^b | F = 18010; df = 1; P < 0.001 |
| Calcium (mg/100g) | 28.531 \pm 0.25 ^a | 28.356 \pm 0.39 ^a | F = 0.418; df = 1; P = 0.553 |
| Magnesium (mg/100g) | 24.472 \pm 0.37 ^a | 23.638 \pm 0.25 ^b | F = 10.267; df = 1; P = 0.033 |
| Iron (mg/100g) | 6.929 \pm 0.12 ^a | 5.061 \pm 0.03 ^b | F = 618.375; df = 1; P < 0.001 |
| Zinc (mg/100g) | 1.068 \pm 0.061 ^a | 0.734 \pm 0.01 ^b | F = 88.347; df = 1; P = 0.001 |
| Manganese (mg/100g) | 1.751 \pm 0.15 ^a | 0.972 \pm 0.06 ^b | F = 69.129; df = 1; P = 0.001 |
| Copper (mg/100g) | 0.454 \pm 0.02 ^a | 0.341 \pm 0.02 ^b | F = 32.291; df = 1; P = 0.005 |
| Phosphorus (mg/100g) | 233.09 \pm 0.19 ^a | 232.87 \pm 0.38 ^a | F = 0.804; df = 1; P = 0.421 |

*Means followed by different letters in the same line are significantly different (ANOVA-1 comparison tests, P < 0.05).

The differences in average water content are statistically significant (F = 2955; df = 1, P < 0.001). Raw or converted caterpillars are also rich in protein and fiber. There are no statistically significant differences between the protein and fiber in the two types of caterpillar. Converted or not, the caterpillars are rich in ashes, however raw *C. forda* caterpillars are richer in ash than the converted ones (F = 31.855; df = 1, P = 0.005). Caterpillars are rich in minerals like sodium, potassium, iron, magnesium, calcium and phosphorus. However, raw caterpillars are less rich in sodium with Sodium/Potassium ratio less than for those converted. They are low in manganese, copper and zinc (Table VI). The average contents in minerals like sodium, potassium, iron, zinc, manganese magnesium and copper in the raw caterpillars are significantly higher than for converted caterpillars (Table VI). However differences in calcium and phosphorus between converted caterpillars and raw caterpillars are not statistically significant. Converted or not, *C. forda* caterpillars are a good source of protein and minerals.

DISCUSSION

C. forda caterpillar locally known as Salantonda is a delicious and very popular dish of the Moba people of Togo. The availability of this edible insect in northern Togo is seasonal. They are available from July to September each year. This period corresponds to the rainy season which goes from May to September in this region. Contrary to Togo, the availability period of *C. forda* in Congo goes from November to January which

corresponds partly to the rainy season (October-May) in that country (Balinga *et al.*, 2004). Although annual periods of availability of *C. forda* caterpillars vary with geographical area, climatic conditions for their development remain the same: temperatures ranging from 22-27° C, relative humidity around 80 to 100% and little sunshine (Ande and Fasoranti, 1998). These conditions are signals for the beginning of reproduction because female of *C. forda* lay their eggs on Shea tree leaves at the beginning of each rainy season and larvae appear one or two months later (Ande and Fasoranti, 1997).

Nowadays caterpillar collection in the Savannah Region of Togo has become a lucrative business for people. Children, men and women are involved in the collection and sale of *C. forda* caterpillars. Contrary to this result, the majority of collectors are men in the Central African Republic (Mbétid - Bessane, 2005). In Togo, only a minority of the population eats *C. forda* caterpillars as opposed to the Central African Republic where all people consume not only this species but also several other species of caterpillar belonging to the family of Saturniidae (Mbétid -Bessane, 2005).

Caterpillars in general and especially *C. forda* are known as defoliators through their nutritional activity. Concrete measures should be taken to maintain the biodiversity of the host plant. In Togo, collection of *C. forda* caterpillars is manual and selective. People in this country collect *C. forda* caterpillars on the ground without damaging the host plant and without using chemicals. This practice is a good way to control outbreaks of *C. forda* caterpillars that are harmful to the development of *V. paradoxa*, the host tree. There is also no risk of chemical pollution of the environment and it helps to regulate their biodiversity while maintaining that of their host plant. Unfortunately in some countries such as Cameroon, Congo and Central Africa Republic, collection methods are unorthodox and do not respect the environment. Indeed, some collectors of *Imbrasia epimethea* (Drury, 1773), *Imbrasia ertli* Rebel, 1904 and *Imbrasia oyemensis* Rougeot 1955 (Lepidoptera: Saturniidae) caterpillars in these countries shake branches and sometimes do not hesitate to cut them off to improve harvest (Pomel and Solomon, 1998; Balinga *et al.*, 2004). These practices are harmful to biodiversity and are not advisable. In the north of Togo, collection of caterpillar is done in nature and requires no investment or land ownership. Nobody pays when collection takes place on the land on others. But this method is increasingly challenged in recent years. Only caterpillar conversion requires minimal cost. It's therefore easy for poor populations to make profit from this collection activity. The resale of caterpillars by successive traders is profitable. Caterpillar commercialization is an appreciable economic activity, but due to the informal nature of this activity, it's difficult to know the converted and sold quantities in villages and in Dapaong the main town of the locality. Caterpillar collection, conversion and commercialization provide both rural and urban populations of the savannah Region of Togo with additional income. This result confirms many authors' opinions (DeFoliart, 1999; Latham, 1999; Balinga *et al.*, 2004). In Togo and in the Central Africa Republic, caterpillar sale is an additional activity (Mbétid-Bessane, 2005). In general, there are one or more intermediaries between collectors and consumers and this situation significantly contributes to price increase. This profitability is reflected in northern Togo by sizeable margins generated by wholesalers, and semi-wholesalers. The conclusion that emerges from this study is that profit margins are higher upstream (collectors) than downstream (retailers). A kilogram of caterpillar is more expensive in the Central African Republic and Congo than in Togo (Balinga *et al.*, 2004; Mbétid -Bessane, 2005). This situation is probably because the majority of Togolese are not interested in the commercialization of caterpillars. However, the retail price of 1250 F CFA per kilogram is

more competitive with regard to cow meat and fish which cost 1400 F CFA per kilogram in Dapaong. There is a *C. forda* caterpillar cross - border trade nowadays. Caterpillars are sold to costumers from Nigeria and Ghana. This trade could not be assessed because it's still illicit, but we think that people in the Savannah Region of Togo have great interest in it.

Raw or converted *C. forda* caterpillar from northern Togo contains much protein, fiber and minerals. Water content of raw *C. forda* collected in Togo and in Nigeria is low compared to conventional meat and fish that contain on average 65 to 75% water (Stadlmayr *et al.*, 2012). This characteristic is advantageous for the conservation of the caterpillar. When a food item contains less water, its preservation is easier because microbial growth is slowed, chemical reactions are limited and enzymes are less effective (Desrosier, 2014). The difference in the average water content between the raw and converted caterpillars is probably due to the dehydration that occurs during roasting and drying. Analyses reveal that raw and converted *C. forda* caterpillars of the Savannah Region in Togo are very rich in protein. These results are different from those found in Nigeria (Akinawa and Ketiku, 2000; Omotoso, 2006), but these protein contents are within the range of 15-60% reported in edible Lepidoptera of the State of Oaxaca in Mexico (Ramos Elorduy *et al.*, 1997). Protein content in converted *C. forda* caterpillar is significantly higher than in raw caterpillars and this result confirms DeFoliart's (1992) observations which noted that the dry forms of most insects are known to be richer in crude protein than fresh forms. Crude fiber value of *C. forda* caterpillars from the Savannah Region in Togo look like those found in Nigeria (Akinawa and Ketiku, 2000). The presence of these fibers could be due to the presence of chitin, a common substance in all insects (Majeti and Kumar, 2000). Chitin is able to stop the body from absorbing cholesterol and be efficient in preventing cancer (Goodman, 1989). The proportion of minerals (ashes) in raw *C. forda* caterpillar of the Savannah Region in Togo is higher than that found in Ibadan and Ado - Ekiti in Nigeria (Omotoso, 2006). These results can be understood because proportions of minerals change according to localities (Akinawa and Ketiku, 2000) and probably according to the nutritional substances of the host tree *V. paradoxa* or larval stages analyzed. Caterpillars analyzed are rich in sodium, potassium, iron, magnesium and copper, minerals that play key roles in many biological functions (Favier and Maljournal, 1980). Thus calcium and potassium help to regulate heart rate and reduce the risk of cerebral vascular accidents (Kirsten *et al.*, 2010). They guarantee the maintenance of osmotic pressure and acid-base balance (Eaton and Konner 1985). Phosphorus, sodium and calcium enter into the formation and strengthening of bones and teeth (Schapira, 1981). The balance between sodium and potassium is essential. The difference observed in the Sodium/Potassium ratio between raw and converted caterpillars could be explained by the fact that salt (Sodium Chloride) was added during processing. When the Sodium/Potassium ratio in a food is less than 1, as is the case with converted or not converted, *C. forda* caterpillars in the Savannah Region in Togo, the contribution of these elements are beneficial to health. When the Sodium/Potassium ratio is favorable, it decreases blood pressure, reduces cardiovascular mortality, protects renal function and prevents of urolithiasis and osteoporosis (He and MacGregor, 2008). Given their higher nutritional value (richness in protein, fiber and mineral) than other meats such as veal and fish (Jacquot, 1957) larvae of *C. forda* contribute to strengthening food security in northern Togo.

CONCLUSION

The collection and marketing of *C. forda* caterpillars are still informal and traditional in Togo. It involves people of different ages and sexes. Many women are involved at all levels of the industry especially in trade. Although it's a seasonal activity, it provides poor populations with good income. It contributes significantly to improving food security and living conditions of the people involved and therefore contributes to the reduction of poverty. Trading is at the local scale, from rural areas to towns and even at the international scale at the borders of Togo. This study provides information on the collection periods, collection techniques and processing, actors, trade channels and the type of income generated through the *C. forda* activity in Northern Togo. Research should continue to find out the biological cycle of this caterpillar and aim at the possibility of caterpillar rearing in all seasons. Moreover, it's desirable to look for better methods to improve caterpillar packaging in order to make them more attractive to traditional buyers and therefore help to open up the market to new consumers.

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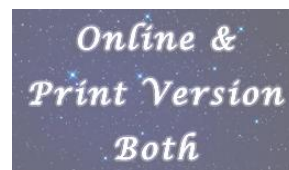
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