Imbrasia obscura, an Edible Caterpillar of Tropical Africa: Chemical Composition and Nutritional Value

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Summary

The consumption of Imbrasia obscura *(Butler, 1878) has been quoted in a dozen books and papers in five different countries, namely Cameroon, Central African Republic, Congo Republic, Democratic Republic of the Congo and Angola. This study presents, for the first time, information concerning two unknown subjects, the chemical composition and the nutritional value of the species. The chemical composition shows that it is a good source of proteins and lipids with the presence of five essential amino-acids (threonine, tyrosine+phenylalanine, histidine and tryptophan) and important amounts of essential fatty acids. The mineral elements such as calcium, phosphorus, magnesium and potassium are also present in good amounts. There is little sodium for which human consumption is frequently but not always excessive. The very high proportion of alpha-linolenic acid contributes very significantly to the low ω-6/ω-3 ratio. Consequently, this caterpillar is a food that may be recommended for human consumption. Farming this species should be encouraged because of its high nutritional value and its good commercial potential especially in areas where malnutrition is common.*

Résumé

Imbrasia obscura, une chenille comestible d'Afrique tropicale: composition chimique et valeur alimentaire

*La consommation d'*Imbrasia obscura *(Butler, 1878) a été citée dans une douzaine de livres et d'articles concernant cinq pays différents, à savoir le Cameroun, la République Centrafricaine, la République du Congo, la République Démocratique du Congo et l'Angola. Cette étude présente, pour la première fois, une information concernant deux thèmes méconnus, la composition chimique et la valeur alimentaire de l'espèce. La composition chimique montre que c'est une bonne source de protéines et de lipides ayant cinq acides aminés essentiels (thréonine, tyrosine+phénylalanine, histidine et tryptophane) et d'importantes quantités d'acides gras essentiels. Les éléments minéraux comme le calcium, le phosphore, le magnésium et le potassium sont également présents en quantité appréciable. Il y a peu de sodium dont la consommation humaine est souvent, mais pas toujours en excès. La très haute teneur en acide alpha-linolénique contribue très significativement au faible rapport ω-6/ω-3. Par conséquent, cette chenille est un aliment qui peut être recommandé pour la consommation humaine. Compte-tenu de sa haute valeur nutritionnelle et de ses bonnes potentialités commerciales dans les zones où la malnutrition est commune, l'élevage de cette espèce devrait être encouragé.*

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Introduction

The human consumption of insects or entomophagy presently constitutes an emergent domain supported by an extensive literature (16, 19, 37, 48, 51, 52, 53), and also the recent creation, in 2015, of a new review devoted to this domain, namely *Journal of Insects as Food and Feed*.

Regarding the Insecta Class, the Order Lepidoptera takes second place after Coleoptera. Indeed 659 Coleoptera and 362 Lepidoptera species have been quoted in a total of 2,111 species, making respectively 31.2% and 17.1% of the total (19).

The importance of the consumption of Lepidoptera worldwide has been emphasised in numerous papers and notably in the following (33). As far as Lepidoptera are concerned, Africa is by no means fully documented. A large number of papers and books have been published in the last 30 years. Most of them, over 300, have been recently listed (31). Currently one hundred species, together with photos have been identified and a further fifty, also with photos, but known only by their vernacular names, are in our database.

In tropical Africa, insects were largely rejected during the colonial times, being frequently considered as a food of primitive people. Today, however, insects represent a solution, at least locally, to the food needs in several countries of sub-Saharan Africa. Indeed, taking into account the shrinking food resources in the world and the expanding populations in different continents, questions of food security increasingly arise, in quantity, quality and sustainability.

For this reason, research into «new» food resources is vital. One of the «warnings» to which the wider public is susceptible is the forward movement of the «earth overshoot day» (the day under consideration relates in each case to a particular calendar year, when humanity will have consumed all the resources that the planet is able to produce in that year), which was foreseen in 2017 for 2nd August according to the «Global Footprint Network».

Taking the current global situation into account, the abundance and nutritional value of insects can be considered as an important alternative source of proteins and lipids. However, the reluctance shown by the industrialized countries, and the still fragmentary knowledge of the safe and profitable use of insects are obstacles to the expansion of entomophagy and the consumption of farmed insects. In many African countries, however, people frequently eat insects which they appreciate as a very tasty food and which they consider a status enhancing dish. Most insects are sought for and consumed during clearly defined seasons. They are eagerly sought and appreciated. Surveys and analyses of many insects have been published for more than a decade, but knowledge of the nutritional properties and composition is still very much to be explored. This is the case for *Imbrasia obscura* and for this reason this paper gives a detailed description of the last stage caterpillar.

Description of the last instar larva

The caterpillar has no dominant colour; the thorax and abdomen have a creamy white basal colour, with numerous black areas. Six spines are observed on the thoracic and the abdominal segments. There are two areas on the dorsal face, two on the upper part of the lateral face, (one on each side), and two others on the bottom of the lateral face, (also one on each side). The dorsal spines are joined in pairs on the mesothorax and metathorax; they are developed on tubercles having an orange base; the spines are red with short blackish tips, with sometimes a straight short whitish hair. The spines lean backwards at 70°. The dorsal spines on the abdominal segments as well as spines located at the upper part of the lateral face are orange on orange tubercles. The spines located at the bottom of the lateral face are black. The head capsule is dull red, the prothoracic scutellum dull red and the anal scutellum red. A transverse black band is present on each segment, this band is prolonged to a triangular spot between the pair of spines on the abdominal segments; some other small spots are present, notably before the tubercles supporting the dorsal spines. On the abdominal segments two transverse black lines are present at the rear of the segment. The black spiracles are elliptic and oblique. Long white supple hairs are present; these are more numerous on the head capsule and prothoracic scutellum. The ventral face of the thoracic segments is black, and the legs are black. When describing the ventral face of the abdominal part it is important to distinguish the segments bearing false legs from the others. The segments bearing false legs are yellowish grey and have a fine black longitudinal line along their middle. The segments without false legs are black with two groups of yellow irregular creamy spots near their middle (Photos 1 and 2).

Material and methods

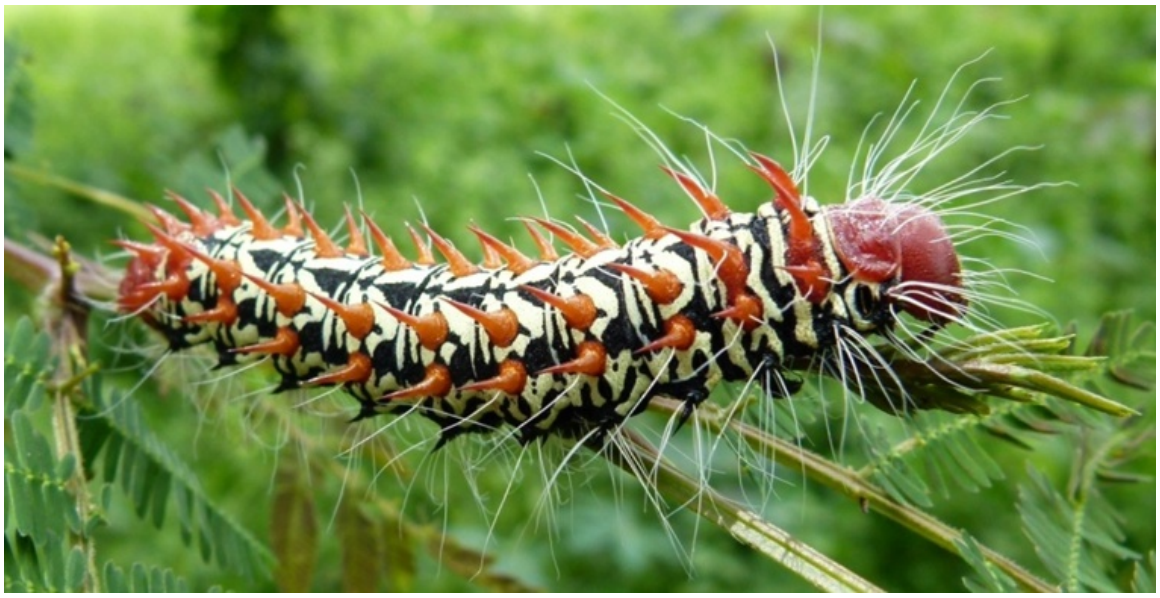


Photo 1: Last instar larva of *Imbrasia obscura*, dorsal view (© Lautenschläger T.).

Photo 2: Last instar larva of *Imbrasia obscura*, ventral view (© Madamo Malasi F.).

Final stage (5th instar) *Imbrasia obscura* caterpillars were analysed. The plant host was *Lophira alata* Banks ex Gaertn. Caterpillars were collected by G. Mabossy-Mobouna in August 2014 at Pokola (1°31'N, 16°09'E, alt. 340 m), in dense equatorial forest (27). Identification was carried out by Dr. T. Bouyer (IRSN-Belgium). The caterpillars were dried in the sun at ambient temperature.

On the one hand, a network of researchers working on the consumption of Lepidoptera in various tropical African countries (or smaller administrative units) has been consulted. This network has been established gradually over the past twenty years by one of us. On the other hand, we used the chemical analysis methods described by Paul *et al.* (43) to establish the content and composition of proteins, lipids and mineral elements.

References for *Imbrasia obscura* consumption

As indicated in our introduction, caterpillars are a product that enters in the normal constituent of a meal, as termites and mushrooms do for many people. Their consumption is confirmed by hundreds of documents.

The caterpillar of this species is a food resource among various African populations (Appendix 1) and is quoted in the recent inventory of edible insects (19). The following information is available in the literature.

Our presentation is more specific to Central Africa, i.e. Cameroon, Central African Republic, Republic of Congo, Democratic Republic of Congo and Angola due to lack of information for many of countries where *Imbrasia obscura* is present (Figure 1).

With regard to the host plants of this caterpillar and its period of harvest, the observations vary according to the regions. In particular, there are differences between the mainly savanna regions and those where the equatorial forest dominates and secondly according to the latitude of each region. *Imbrasia obscura* has a monovoltine life-cycle and the caterpillar is a polyphagous species. The list of host plants in the various regions studied is shown in Appendix 2 .

In Cameroon, the consumption of *Imbrasia obscura* has been noted on the edges of the Dja Reserve in November 1977; the local name is *milun* in the Badjoué language (Appendix 1).

For Central African Republic, we have information from several sources. The first quoting of the consumption of this caterpillar took place in 1978 (6). Furthermore in the wonderful book «Les pygmées Aka et la forêt centrafricaine», much detailed information is given (7). The figure 1 is a map of the villages investigated; these are Kenga, Bagando and Bayanga.

In August and September 1978, the author accompanied a group of Ngando people in harvesting caterpillars. He provides information on 8 species, including *Imbrasia obscura*. He observed that the fresh weight of the last stage of this caterpillar is of the order of 4.3 g. In a given site its gathering from the ground extends over a period of 29 days and that the period of abundance is limited to one week. The maximum quantity observed on 7 September 1978 was 5 kg per km^2 and 700 caterpillars per tree. The slight difference in harvesting dates from one year to the next is pointed out. Finally, it should be remembered that large local outbreaks are rarely observed in the same place for several years, sometimes they are limited to one year (26, 30, 34).

Information on conservation techniques for several species, including *kɛ́nàkɛ́nɛ́*, namely *Imbrasia obscura* are also provided. Finally a drawing of the last stage of this caterpillar made by F. Crozier is presented (Figure 2).

An ECOFAC Report, published in 1994, deals with the NFLP and notably the edible caterpillars (13). For the Ngotto forest, the consumption of *Imbrasia obscura* is quoted, as well as the local names of *nguéguélé* in Bofi, *mokélia* in Issongo and *kènakène* in Aka are given (Appendix 1). Harvesting takes place in August.

The consumption of *Imbrasia obscura* by the Aka people of Lobaye at N'Gotto, has twice been confirmed and supported by photos (Appendix 1). We also have information on the presence and consumption of Imbrasia obscura in other villages and linguistic groups in CAR (Appendix 1) (45).

In the work «Chasse, cueillette et culture chez les Gbaya de Centrafrique» information and comments on 82 different caterpillars are presented (46). Their local names and harvesting techniques are specified; the systems of naming are discussed. These include «nàà-sáŋ-kàɗáŋ» which are caterpillars to be found in large numbers, up to 30 (page 295). From a photograph taken in the vicinity of Ndongué it has been established that this species is *Imbrasia obscura*. The local name may be translated as « the well-dressed » or « the harnessed » depending on whether (a) we look at its general appearance, especially the two colours, yellow and black, or (b) its red spines. Its consumption by the Gbaya bodoe a homogenous group of 5,000 peoples in the south-west of Bouar (6°N, 16°E), is confirmed. Women in particular search for this caterpillar in the rain season during July and August.

For the Congo Republic, the first mention of the consumption of this caterpillar is given in 1995 (8). It was followed in 1996 during an ad-hoc meeting of United Nations experts to increase the production and use of unconventional resources as a food source in Africa. This took place at Addis-Ababa from 2nd to 4th December 1996.

The consumption of this species, as well as diverse local names, have been recently studied (27, 28). The

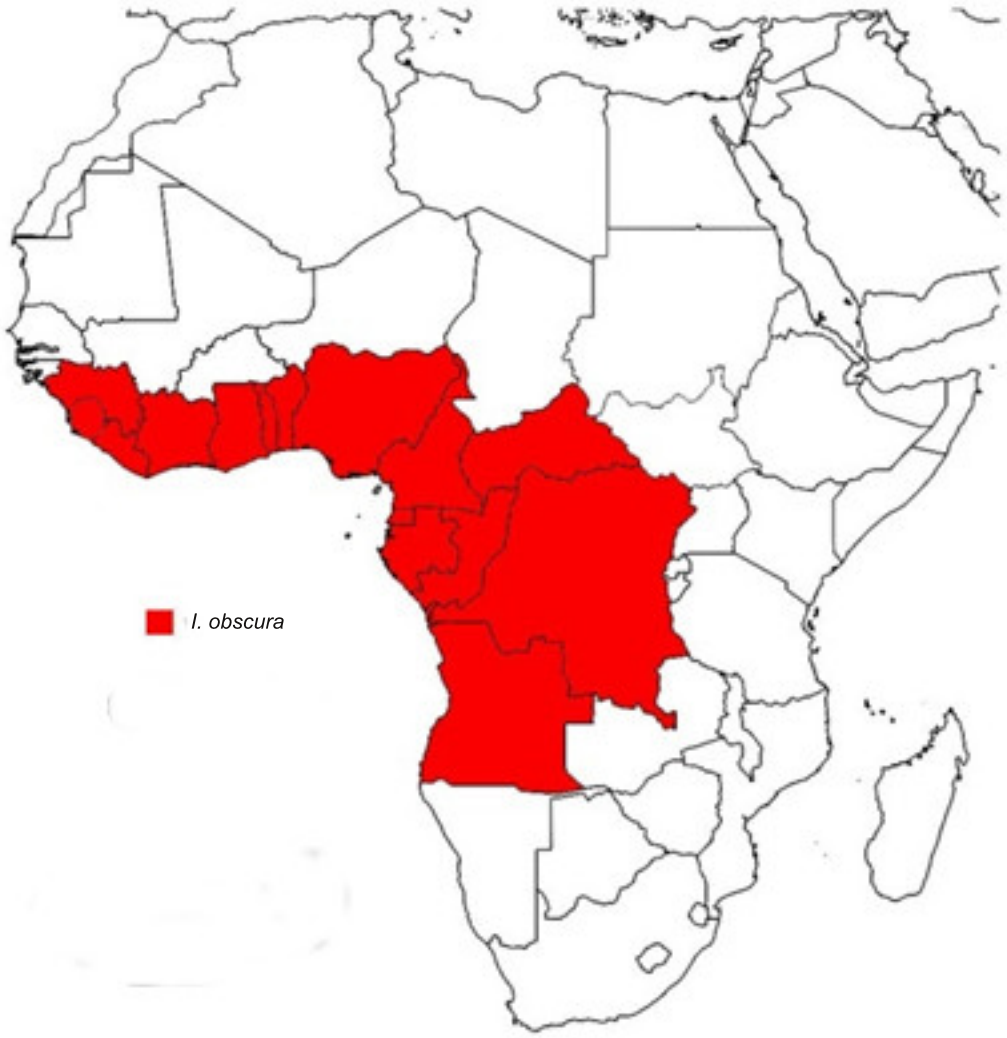
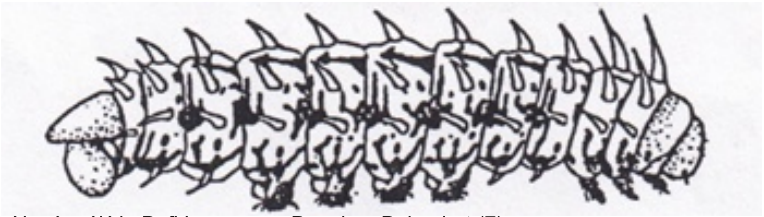


Figure 1: Distribution map of *Imbrasia obscura* (27).



Nguéguélé in Bofi Language. Drawing: Bahuchet (7).

Figure 2: *Imbrasia obscura* last stage caterpillar.

caterpillar is eaten by all the ethnic groups of the northern part of the country, as well as by the Teke and the Lari. In the main towns of the South of the country, they are frequently consumed smoked, and mixed with *Gonimbrasia melanops*, since they are put in the same bag by the traders due to the presence of spines on their body. This characteristic is the reason for the name *binkélé* by the Kongo linguistic group, and of *inkèlè* by the Mbosi, the Mbere and the Teke. The caterpillars of the last instar are mainly collected during the second half of August. These papers (27, 28) provide also local names for 25 diverse ethno-linguistic groups and present the distribution of the species. Three photographs illustrate the last stage of this caterpillar.

For the Democratic Republic of Congo, the gathering, preparation and consumption of caterpillars by the Ba-Oto and the Ba-Twa in the vicinity of Lake Tumba has been discussed (42). *Imbrasia obscura* is the most common species; *mo-pakala* is described as a black caterpillar with yellow patches, red spines and white hairs (p. 209). Several sightings during the year, with important peaks in early August, the beginning of September, in January and in February are reported (p. 287). A photograph of this caterpillar taken in the Salonga National Park in Bandundu province, where it is called *bapakala* may also be found (44).

Since 1984, when P. Latham (and his wife), first tasted caterpillars, he has researched non-timber forest products (NFTP) in Central Kongo in the Democratic Republic of the Congo. Several publications confirm the importance of the documentation he has put together with the help of his collaborators. Published in French and English, the book «Edible caterpillars and their food plants in Bas-Congo province» concerns us. *Imbrasia obscura* is one of several caterpillars called *minsendi* (20, 21, 23). The 2015 edition, for the Central Kongo Province, indicates the recent change of name of this province, made in July 2015 (22).

For Angola, its consumption in the north of the country has been noted (24); its local name is *minsende* in the kongo language and *tubula* in the kimbundu language.

Caterpillars are collected from January to March and the moths are observed from October to November each year in the forest around Uige and in Mamanje Province in Northern part of Angola.

The above data is summarized in Appendix 1. Furthermore, two photographs of this caterpillar have been published, once without name (36), once with a wrong determination (40).

The wide distribution of *Imbrasia obscura* (Figure 1) and the consumption of the last stage of the caterpillar by many people (Appendix 2) makes it an important edible species.

The species occurs in 15 countries, being eaten in at least five of them by people belonging to a total of 31 ethno-linguistics units. Moreover its polyphagous character has been established, 21 different taxa having been quoted (Appendix 2).

Preparation methods

The way in which caterpillars, are consumed varies according to different factors. On the one hand, the consumption of fresh caterpillars at the time of harvest should be distinguished from that of caterpillars that have been dried for later storage consumption. On the other hand, we must also consider the stage of the caterpillar and finally its size and thickness.

For fairly thick caterpillars, as is the case for *Imbrasia obscura*, they are washed in cold water and, if they are harvested before maturity, are emptied of their gut contents by pressing the caterpillar's body between the thumb and the forefinger to expel the excrement from the anus whilst the head of the caterpillar is held in the other hand. Salt and pepper are then added, and they are boiled in a small quantity of water.

For immediate consumption, we will compare the mode of preparation of Gbaya ɓodoe (CAR) compared to that of Enyellé (CR). In Gbaya ɓodoe as in the Enyellé, the fresh caterpillars are a complete dish that accompanies the principal base of any meal, cassava porridge for the first, or with plantain (banana) or chikwangue for the second.

The Gbaya ɓodoe use only one method of preparation, salt and pepper are added to the caterpillars of *Imbrasia obscura*, they are then boiled in water and usually eaten as the main dish served with a ball of cassava porridge.

With the Enyellé, there are three cooking techniques used for I*mbrasia obscura* caterpillars. The caterpillars can be boiled in water, or they can be cooked in packets of Marantaceae leaves (the packet is called *liboké* in lingala) (Photo 3). For this they are either broken in two in the middle of the body, either after being beheaded, the fresh caterpillars are turned inside out by pushing the anal scutellum in with a small hard stem), then salted. The packets may be cooked in embers, steamed in a pot or boiled in water. Finally, they may also be skewered onto a hard stem and grilled over a fire or fried in small quantities of palm oil (this is nevertheless an uncommon method of preparation).

To preserve the caterpillars for later preparation, all the groups that harvest them fresh, after washing them in cold water, boil them in a little water, either adding salt or not. The caterpillars are then dried using techniques that vary depending on whether one is in savannah or forest. In savannah areas, caterpillars are sun dried, spread on mats, sheets, tarpaulins or racks. This technique requires a long period of sunshine.

When sunshine is sufficient, even in the rain season, as is the case for the Gbaya in CAR, the caterpillars

may be conserved for 3 or 4 months (47). Otherwise, drying in the sun does not allow long-term storage (less than a month) and these caterpillars have to be eaten quickly.

Thus, in forest areas, where the abundant rainfall does not allow drying in the sun, the caterpillars are smoked on racks for a maximum of three to four days (Photo 4). The smoking technique allows the long-term storage (3 to 6 months) of large quantities of caterpillars, often intended for marketing.

For the preparation of these caterpillars, whether in the harvesting zone or from the dried product, the techniques are based on the cultural practices of each group with respect to dried products, and the preparations are very diverse.

When choosing a future way of consuming the caterpillars they are dried to preserve them, being first cooked in water and afterwards put out to dry in the sun on plates or on mats. This is obviously the case when the caterpillars are marketed in places at a distance from where they are harvested.

For the Gbaya ɓodoe, the dried caterpillars are reheated, and usually added to a paste of sesame seed mixed with a little water and cooked, but most often they are added to a gluey sauce, using powder obtained from the nuts of two Lauraceae species, (*Beilschmiedia anacardioides* (Engl & Krause) Robyns & Wilczek, *Beilschmiedia mannii* (Meisn.) Benth. & Hook.f.) mixed with water. One may also add them to a plate of sesame or squash balls with gluey sauce, the characteristic glutinous dish of the Gbaya kitchen. They constitute a meal, of the same value as meat, vegetables or mushrooms, that accompanies cassava porridge, the basis of all Gbaya meals. The caterpillars are never eaten with vegetable leaves, cassava leaves, leaves of *Amaranthus* spp. or *Gnetum africanum* Welw. Whereas, in the Republic of the Congo, dried caterpillars are cooked with vegetables. These include rattans (*Calamus deerratus* G.Mann & H.Wendl., *Laccosperma secundiflorum* (P.Beauv.) Kuntze), *Malabar spinach* (*Basella alba* L.), cabbage (*Brassica* spp.), *Amaranthus*, squash (*Cucurbita* sp.) or beans (*Phaseolus vulgaris* L.). Smoked fish, salted fish, prawns and smoked meat are the foods of animal origin which most frequently accompany smoked *Imbrasia obscura* caterpillars in cooking, as opposed to the foods accompanying fresh caterpillars.

In the areas where the caterpillars are not found naturally, only the smoked caterpillars of *Imbrasia*

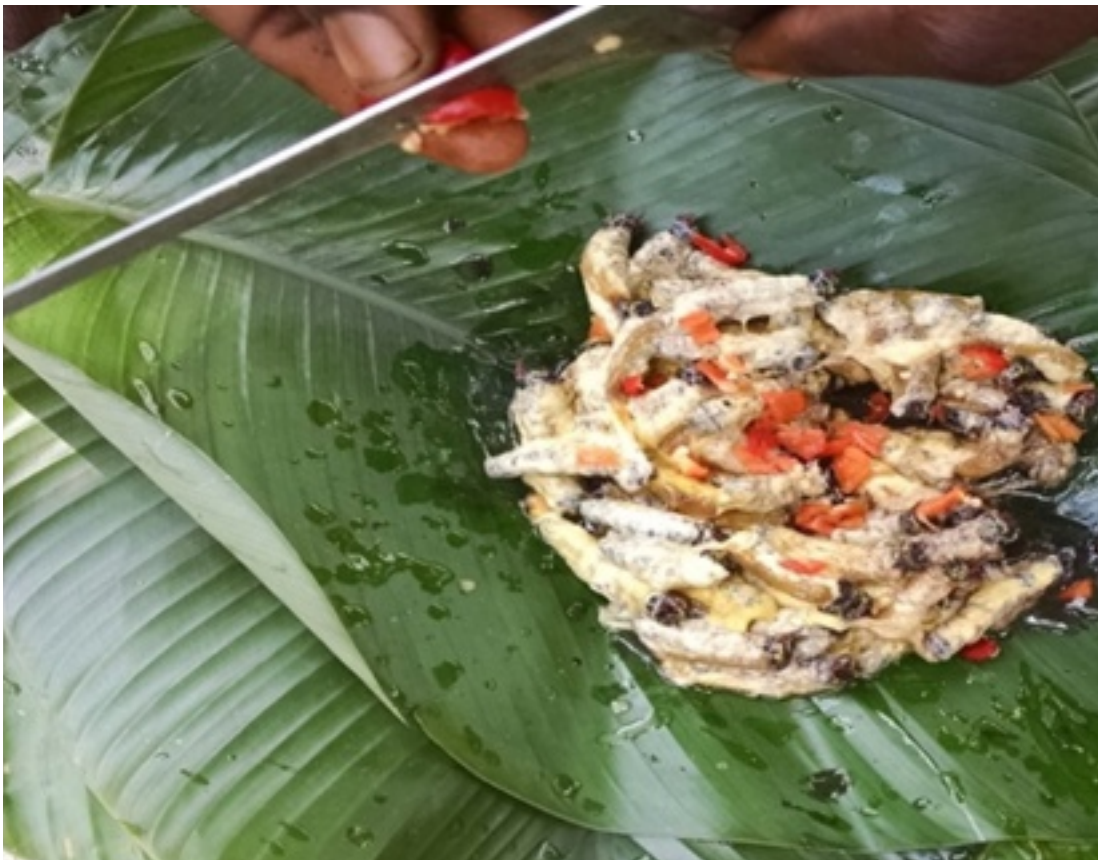


Photo 3: Preparation method for *Imbrasia obscura* caterpillars at Mokpetene (Bétou). The most commonly used leaves are from Marantaceae. These are *Megaphrynium macrostachyum* (K.Schum.) Milne-Redh., *Megaphrynium gabonense* Koechlin, *Sarcophrynium prionogonium* (K.Schum.) K.Schum. and a *Marantochloa* sp.)

Photo 4: A curing rack for smoking *Imbrasia* spp. caterpillars at Wongo-West village (Bétou, © G. Mabossy-Mobouna).)

obscura are usually prepared. They are cooked, either with water, with peanut butter (*Arachis hypogea* L.) or with palm oil (*Elaeis guineensis* Jacq.) and the same accompanying vegetables as in the areas where the caterpillars are collected. In Congo, in the different recipes, the most commonly used condiments are onion (*Allium cepa* L.) and gombo (*Abelmoschus esculentus* (L.) Moench.), followed by fresh tomatoes (*Solanum lycopersicum* L.), chives (*Allium fistulosum* L.) and garlic (*Allium sativum* L.). Peppers (*Capsicum annuum* L.) may also be added. Finally when caterpillars are marketed in sites where they are not collected, the dried caterpillars are consumed and cooked according to the local traditions. This will not be commented here.

Results and discussion

Overall chemical composition

Final stage (5th instar) *Imbrasia obscura* caterpillars contain 72% (N x 6.25) proteins, 12.17% lipids, 1.5% carbohydrates and 2.9% of ash (with an energy value of 1718.03 kJ for 100 g of Crude Material) with 11% moisture.

The comparison of the chemical composition of these caterpillars with those of other caterpillars consumed in tropical Africa indicates what they have a protein content similar to those of *Imbrasia truncata* (26), *Imbrasia epimethea* (24) and *Hadraphe ethiopica* (32). They are more rich in proteins than the caterpillars of *Bunaeopsis aurantiaca* (38, 41), *Antheua insignata* (32) and *Cirina butyrospermi* (55).

The quantity of proteins in *Imbrasia obscura* caterpillars is higher than in those of *Imbrasia oyemensis* (3), *Lepidoptara litoralia* (49), *Anaphe panda* (24), *Pseudantheraea discrepans* (24), *Elaphrodes lactea* (40), *Sciatta inconcisa* (24),

Gonimbrasia alopia (24), *Cymothoe caenis* (40), *Gonimbrasia dione* (40) and *Cirina forda* (5, 24). *Imbrasia obscura* caterpillars are among those having the highest protein content.

The fatty matter content of *Imbrasia obscura* caterpillars is slightly lower than that of *Imbrasia truncata* (26). However, the caterpillars contain less lipids that those of *Cirina butyrospermi* (55) but more than those of *Imbrasia epimethea* (24).

The amount of carbohydrates in *Imbrasia obscura* caterpillars is lower than that of *Bunaeopsis aurantica* (38), *Hadraphe ethiopica* (32), *Imbrasia oyemensis* (14) and *Cirina butyrospermi* (55).

The level of minerals in *Imbrasia obscura caterpillars* is lower than for *Cirina forda* (2), *Lepidoptara litoralia* (49) and *Cirina butyrospermi* (55). It is comparable to the level in *Anaphe reticulata* (4) and *Bunaeopsis aurantiaca* (41). It is nearly double for that of *Anaphe infracta* and *Cirina forda* (4).

The energy value of *Imbrasia obscura caterpillars* is nearly identical to that of *Bunaeopsis aurantiaca* (38), but greater than that of *Hadraphe ethiopica* (32), *Antheua insignata* (32) and *Cirina forda* (1). However, it is lower than for *Imbrasia oyemensis* (3, 14).

Essentiel amino acids composition

The proteins present in *Imbrasia obscura* caterpillars contain all the essential amino-acids in appreciable quantities, but for most of them, in lower concentrations than recommended. Indeed, in accordance with the FAO guide values quoted in Table 1,100 g of *I. obscura* provide nutritionally relevant amounts for only five essential amino acids (threonine, tyrosine+phenylalanine, histidine and tryptophan), which are highly restricted in valine, isoleucine, lysine and the sulphur amino-acids (only 69%, 80%, 73% and 79% of the recommended intake) and deficient in leucine (56 %) (54).

The essential amino-acids profile of *Imbrasia obscura* caterpillar is different to that of *Imbrasia oyemensis* which contains an important amount of lysine, followed by leucine and valine (3).

The ratio between the essential acids and the total amino-acids of *Imbrasia obscura* caterpillars is similar to that for *Imbrasia truncata* (26), but lower than that for *Cirina butyrospermi* (55).

The leucine/isoleucine and leucine/lysine ratios of *Imbrasia truncata* caterpillars are favourable and do not cause any nutritional problem. They are comparable to those of *Imbrasia oyemensis* caterpillars (14).

Fatty acids composition

The lipids (% D.M.) of this caterpillar contain

Table 1

Analysis of *Imbrasia obscura* caterpillars.

Amino-Acids	g/100g proteins			Amino- Acids	g/100g proteins		
	Imbr. obscura	RP-FAO (1)	CI (2)		*Imbr. obscura*	RP-FAO (1)	CI (2)
Asp	4.8			Met	1.1	2.2 *	79 *
Thr	2.9	2.3	126	Cys	0.6		
Ser	2.8			Leu	3.3	5.9	56
Glu	6.2			Tyr	4.1	3.8 **	190 **
Pro	3.5			Phe	3.2		
Gly	2.5			His	2.0	1.5	133
Ala	2.7			Lys	3.3	4.5	73
Val	2.7	3.9	69	Arg	2.9		
Ile	2.4	3	80	Trp	1.0	0.6	167

Fatty Acids	%	% Total Fatty Acids ***	%	Major Minerals	% DM	Others	mg/Kg DM
C14	0.2	C18	18.0	Ca	0.10	Cd	0.01
C15	0.2	C18:1	8.0	P	0.28	Cu	12.3
C15:1	0.2	C18:2 (ω-6)	9.2	Mg	0.24	Ni	1.6
C16	17.1	C18:3 (ω-3)	41.1	K	0.97	Pb	< 0.01
C16:1	0.3	C20	0.3	Na	0.02	Zn	154
C17	1.1	C20:4 (ω-6)	0.3			Hg	0.006
∑ Saturated	36.9	ω-6	9.5			Cr	1.4
∑ Mono-insaturated	8.5	ω-3	41.1			As	<0.01
∑ Poly-insaturated	50.6	ω-6 /ω-3	0.2				

(1) Reference protein (WHO/FAO/UNU, 2007).
(2) Chemical index (Amino-acid content Imbrasia/ Amino-acid protein content WHO. Reference). * Met + Cys ** Tyr + Phe *** Total non identified: 4%.

important proportions of α-linolenic, palmitic and stearic acids. The percentage of polyunsaturated fatty acids (50.56 %) is due to a very high proportion of alpha-linolenic acid, which contributes very significantly to the low ratio ω-6 / ω-3 (0.23), which is much lower than the optimal value recommended.
As an example, for Belgium, the value of this ratio is of 4 (7), of 5 for F.A.O. (13). Nevertheless, "*The ratio of ingestion of ω-6 fatty acids and ω-3 fatty acids is of little importance as long as the intake of these two groups of polyunsaturated acids is within the recommended range*" (13). Arachidonic acid is present at low levels (0.30 %). The highly polyunsaturated character, and therefore the risk of auto-oxydative lipid degradation, could be problematic, causing changes to the flavour and taste during prolonged storage.
The profile of the major lipids of *Imbrasia obscura* caterpillars (C18:3> C18:0> C16:0> C18:2> C18:1) is almost the same as those of *Imbrasia truncata* (C18:3> C16:0> C18:0> C18:2> C18:1) (26).
Imbrasia obscura caterpillars have a similar ratio of polyunsaturated fatty acids to those of *Imbrasia truncata* (26), but different to those of *Cirina butyrospermi* (55).
The ratio PUFA on SFA equal to 1.3 is similar to that for *Imbrasia truncata* (26), which indicates a very high nutritional value for lipidic level (25, 26). The ω6/ω3 ratio of *Imbrasia obscura* caterpillars (0.23) is lower than 1 and is better than the one of *Imbrasia oyemensis* caterpillars which is 8.02 (14).

Minerals composition
The mineral content of *Imbrasia obscura* includes Ca, P, Mg and K at interesting rates and a small amount of Na, of which human consumption is very often excessive. The ratio of Ca/P is much less than 1, causing poor absorption of Ca (11). In the same way, the ratio Ca/Mg is much less than 2, causing poor fixing of Ca in the organism (15). Thus, the foods that are cooked with caterpillars should have more Ca in order to correct these two ratios. The ratio of Na/K, being less than 1, is favourable for the good functioning of the organism. In fact, He and Mac Gregor's work (17) has shown that when the ratio of Na/K is inferior to 1 in a food, blood pressure is lowered, cardio-vascular mortality is reduced, renal function is protected, and urinary lithiasis (gall stones) and osteoporosis are prevented.

The low content of Na could be advantageous for hypertension. However, where people suffer from renal failure K rich food is generally absent (35, 50).
The profile of the major mineral elements in *Imbrasia obscura* caterpillars is similar to that of *Imbrasia truncata* (26) but different to that of *Cirina* butyrospermi (55). Indeed *Imbrasia obscura* and *Imbrasia truncata* caterpillars are richer in potassium followed by phosphorus whilst *Cirina butyrospermi* caterpillars are rich in calcium followed by sodium.

Conclusion

The caterpillars of *Imbrasia obscura* are an excellent provider of essential amino acids, essential fatty acids and other micronutrients. By incorporating them in the flour in Central African infant weaning pastes will improve the nutritional value of these foods and help combat malnutrition. In fact, corn and cassava flours used in the preparation of weaning pastes in Africa are poor in α-linolenic acid (39). Infants receiving only these foods have a deficit in this fatty acid, the consequences of which are dramatic because dietary deficiency in α-linolenic acid induces behavioral and cognitive problems, particularly in learning, memorization and habit forming (10).
Few works deal with solving child malnutrition in Central Africa countries (29, 41).
The results assembled in the present paper point out that *Imbrasia obscura* is a good proteins and lipids source with an interesting ratio of essential fatty acids and having only five essential amino-acids. Nevertheless the consumption of these caterpillars combined with a diverse feeding may provide a valuable alimentary supplement.

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Appendix 1

List of vernacular local names for *Imbrasia obscura*.

Linguistic group (Country)	Vernacular name	Informant	Source
Aka (CAR)	*kènakène*	Hladik	Hladik (1994)
Aka (CAR)		Jeanmart	Pers.com., photo, 1977
Aka (CAR)		Malaisse	Pers.com., photo, 2001
Baaka (CR)	*kenakènè*	Mabossy-Mobouna	Pers.com., photo
Badjoué (Cameroon)	*milun*	Bertieaux	Pers.com., photo
Bakwelé (CR)	*daswab*	Mabossy-Mobouna	Field miss.
Bangi (CR, DRC)	*mbinzu*	Mabossy-Mobouna	Pers.com., photo
Bofi (CAR)	*nguéguélé*	Hladik	Hladik (1994)
Bomitabat (CR)	*mantsèntsènè*, *mankènkènè*	Mabossy-Mobouna	Field miss., photo
Bomwali (CR)	*makèkènè*	Mabossy-Mobouna	Field miss.
Bondongo (CR)	*mankènkènè*	Mabossy-Mobouna	Field miss.
Bongili (CR)	*makèkènè*	Mabossy-Mobouna	Field miss.
Djem (CR)	*dzassuom*	Mabossy-Mobouna	Field miss.
Enyellé (CR)	*mankènkènè*	Mabossy-Mobouna	Field miss.
Gbaya ɓodoe (CAR)	*nàà-sáŋ-kàɗáŋ*	Roulon-Doko	Roulon-Doko (1998)
Issongo (CAR)	*mokélia*	Hladik	Hladik (1994)
Kaka (CR)	*gengènè, ngèlèngèlè*	Mabossy-Mobouna	Field miss.
Kimbundu (Angola)	*tubula*	Lautenschläger	Lautenschläger *et al.* (2017)
Kongo (Angola)	*minsende*	Lautenschläger	Lautenschläger *et al.* (2017)
Kongo (CR)	*binkélé*	Mabossy-Mobouna	Pers.com., photo
Kongo (DRC)	*minsendi*	Latham	Latham (2008)
Kongo (DRC)	*makangu ya mfinda*	Madamo Malasi	Pers.com., photo
Lari (CR)	*binkélé*	Mabossy-Mobouna	Pers.com., photo
Likuba (CR)	*mbindzu*	Mabossy-Mobouna	Pers.com., photo
Likwala (CR)	*mbindzu*	Mabossy-Mobouna	Pers.com., photo
Lingala (CR)	*mbinzo*	Mabossy-Mobouna	Field miss.
Lori (DRC)	*mikial*	Madamo Malasi	Pers.com., photo
Mbala (DRC)	*makangu*	Madamo Malasi	Pers.com., photo
Mbanza (CR)	*baladjah*, *blabjah*	Mabossy-Mobouna	Field miss.
Mbendjele (CR)	*(bo)kèkènè*	Mabossy-Mobouna	Field miss.
Mbere (CR)	*inkèlè*	Mabossy-Mobouna	Pers.com., photo
Mbonjo (CR)	*gègènè*	Mabossy-Mobouna	Field miss.
Mbosi (CR)	*ikèlè*	Mabossy-Mobouna	Pers.com., photo
Moi (CR)	*mbindzu*	Mabossy-Mobouna	Pers.com., photo
Monzo-Nkundu (DRC)	*bapakala*	Payne	Payne et al. (2016)
Monzombo (CR)	*gengènènè*	Mabossy-Mobouna	Field miss.
Pomo (CR)	*ngèlèngèlè*	Mabossy-Mobouna	Field miss.
Teke (CR)	*inkèlè*	Mabossy-Mobouna	Pers.com., photo
Teke western (CR)	*mayulbatsiè*	Mabossy-Mobouna	Field miss.
Teke (DRC)	*enkel*	Madamo Malasi	Pers.com., photo
Twa (DRC)	*mo-pakala*	Pagezy	Pagezy (1988)
Yansi (DRC)	*minkiel, minsiel*	Madamo Malasi	Pers.com., photo
Yasswa (CR)	*nabatèlè*	Mabossy-Mobouna	Field miss.

Appendix 2

Host plants of *Imbrasia obscura*.

Family	Species	Local name	Vegetation unit	Place (Country)	Reference
Euphorbiaceae	*Macaranga monandra* Müll.Arg.	nyensi	forest	Kinseke (DRC)	Latham (2003)
		nsasa	forest	Northern Angola	Lautenschläger *et al.* (2017)
Euphorbiaceae	*Macaranga spinosa* Müll.Arg.	lépumbâh	forest	Bétou (CR)	Mabossy-Mobouna (Field miss.)
Fabaceae (Caes.)	*Amphimas ferrugineus* Pellegr.	molinda	forest	Bétou (CR)	Mabossy-Mobouna *et al.* (2016)
Fabaceae (Caes.)	*Daniellia oliveri* (Rolfe) Hutch. & Dalz.	kéá	savannah	Ndongué (CAR)	Roulon-Doko (p.c.)
Fabaceae (Fab.)	*Millettia eetveldeana* (Micheli) Hauman		forest, but all over	LuiKotale (DRC)	Payne et al. (2016)
Fabaceae (Fab.)	*Mucuna poggei* Taub.	mbírò	all over	Ndongué (CAR)	Roulon-Doko (p.c.)
Fabaceae (Fab.)	*Pterocarpus lucens* Lepr. ex Guil. & Per.	gbɔ̀lɔ̀tà	savannah	Ndongué (CAR)	Roulon-Doko (p.c.)
Fabaceae (Mim.)	*Albizzia ferruginea* Benth.	sela	forest	Kavwaya (DRC)	Latham (2003)
		mbâmbâh	forest	Bétou (CR)	Mabossy-Mobouna (Field miss.)
Fabaceae (Mim.)	*Albizzia glaberrima* (Schumach. & Thonn.) Benth.	ndɔ̀ɛ́	savannah	Ndongué (CAR)	Roulon-Doko (p.c.)
Fabaceae (Mim.)	*Aubrevillea kerstingii* Pellegr.	sùmbù	wooded savannah, forest	Ndongué (CAR)	Roulon-Doko (p.c.)
Fabaceae (Mim.)	*Fillaeopsis discophora* Harms	elongo	forest	LuiKotale (DRC)	Payne et al. (2016)
Fabaceae (Mim.)	*Inga edulis* Mart.	banana makako	forest	Northern Angola	Lautenschläger et al. (2017)
Fabaceae (Mim.)	*Parkia clappertoniana* Keay	zìŋà	savannah	Ndongué (CAR)	Roulon-Doko (p.c.)
Fabaceae (Mim.)	*Pentaclethra macrophylla* Benth.	n'gansi	secondary forest	Mbanza Ngungu (DRC)	Latham (2003)
		mbâlah	forest	Impfondo (CR)	Mabossy-Mobouna (Field miss.)
Fabaceae (Mim.)	*Tetrapleura tetraptera* (Schumach. & Thonn.) Taub.	ekombolo	forest	Ngotto (CAR)	Bahuchet (1978)
Malvaceae (Ster.)	*Eribroma oblonga* (Mast.) Bod.	engboyo	forest	Pokola (CR)	Mabossy-Mobouna (Field miss.)
Malvaceae (Ster.)	*Triplochiton scleroxylon* K.Schum.	gbato	forest	Ngotto (CAR)	Bahuchet (1978)
Moraceae	*Ficus* sp.	mulembeira	forest	Northern Angola	Lautenschläger *et al.* (2017)
Ochnaceae	*Lophira alata* Banks ex Gaertn.	chalangbala	forest	Bétou (CR)	Mabossy-Mobouna (Field miss.)
		mokolé	forest	Pokola (CR)	Mabossy-Mobouna (Field miss.)
Ochnaceae	*Lophira lanceolata* Tiegh. ex Keay	ngòkòè	savannah	Ndongué (CAR)	Roulon-Doko (p.c.)
Rhamnaceae	*Maesopsis eminii* Engl.	bongombidzi	secondary forest	LuiKotale (DRC)	Payne *et al.* (2016)

Abbreviations: Caes.= Caesalpinoideae; CAR= Central African Republic; CR= Congo Republic; DRC= Democratic Republic of the Congo; Fab.= Faboideae; Field miss.= Field mission; Mim.= Mimosoideae; p.c.= personal communication; Ster.= Sterculioidae.

Note: *Imbrasia obscura* also feeds on *Acacia auriculiformis* A.Cunn. ex Benth., an exotic Mimosoideae frequently planted (Latham, p.c.) and for which an excellent Technical Guide of agroforestry plantation is recently available (9).