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Concerning some taxonomic confusions in African edible caterpillars

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ABSTRACT

Edible insects, and in particular edible caterpillars, occupy a strategic place in the fight against hunger and malnutrition on a global scale. It is essential that the different species are correctly identified to ensure their exploitation and sustainable conservation. This article raises examples of the taxonomic confusions found in the scientific literature regarding the edible caterpillars of Africa. This study indicates that these taxonomic confusions follow identification based on the comparison of morphological features using photos taken from previous articles that used the same method of identification. Hence there is a repetition of taxonomic errors in the online scientific literature. To put an end to these confusions, the authors plead for molecular identification of edible caterpillars, which should be extended to all known and available species in order to constitute a real data bank as a reference for all future studies of edible caterpillars.

Keywords: Taxonomic confusion, DNA test, realistic identification, edible caterpillars, Africa.

RESUME

A propos de certaines confusions taxonomiques concernant les chenilles comestibles Africaines

L'intérêt alimentaire des insectes dont les chenilles comestibles occupe aujourd'hui une place stratégique dans la lutte contre la faim et la malnutrition à l'échelle mondiale. Ainsi, il est indispensable de bien maitriser les différentes espèces à valoriser afin d'en assurer une exploitation et une conservation durable. Le présent article soulève quelques cas des confusions taxonomiques diffusées dans la littérature scientifique sur les chenilles comestibles d'Afrique. Notre étude indique que ces confusions taxonomiques font suite à une identification basée sur la comparaison des traits morphologiques

avec des photos tirées dans les articles précédents ayant utilisé la même méthode d'identification. D'où une répétition de ces erreurs taxonomiques dans la littérature scientifique en ligne. Pour mettre fin à ces confusions taxonomiques, les auteurs plaident pour une identification moléculaire des chenilles comestibles, élargie à toutes les espèces connues et disponibles afin de constituer une véritable banque de données comme référence pour toutes les études futures d'identification des chenilles comestibles.

Mots-clés : Confusion taxonomie, test ADN, identification, chenilles comestibles, Afrique.

INTRODUCTION

The population of sub-Saharan Africa will reach approximately 2.2 billion people by 2050 (Suzuki, 2019), requiring food production to be significantly increased. People currently cannot afford sufficient nutritious food for a healthy life. Meat is still not within the reach of all social s. The simplest way to address the issue of malnutrition would be to consider insect farming. Insects are everywhere and reproduce quickly with high growth and feed conversion rates (Van Huis, 2013) and can grow in small spaces with low environmental impact. They are nutritious, rich in proteins, fats and minerals (Rumpold and Schlüter, 2013a,b). They are capable of transforming organic (food) waste into proteins (FAO, 2013; 2014).

The consumption of insects has a long history in all continents, North and South America, Europe, Africa, Southeast Asia and Oceania. Before addressing aspects of taxonomic errors concerning the Lepidoptera, it should be remembered that the consumption of insects belonging to this order has been the subject of an abundant literature. For Africa, Malaisse (2005) and Malaisse & Latham (2014) list 350 articles addressing this theme. This theme is further addressed for Mexico by Ramos-Elorduy et al. (2011), for South America by Paoletti & Dufour (2005), for Southeast Asia by Barennes et al. (2015), for Australia by Yen (2015) and Meyer-Rochow (2005). Africans consume about 20% of the 2,100 species of insects recognized as edible in the world. Insects are considered today as a new circular food economy whose breeding in addition to improving access to nutritious food, intended for human and animal consumption could create millions of jobs, have a positive impact on climate, the environment and strengthening national economies (Verner et al., 2021). It is advisable to take advantage of this renewable natural resource to solve the serious problem of malnutrition in Africa and that the new entomological research strategies focus on this new vision of food production compatible both with the standard of living of the populations, respectful of natural resources. and the environment (Malaisse, 2022).

The exploitation of edible insects requires a knowledge of the taxonomy of the species in order to better conduct studies on their massive breeding, their nutritional values and their conservation in the wild. Taxonomic confusion of edible caterpillars in Africa has been circulating in the scientific literature published in several journals for some time. On this subject, Dr. Thierry Bouyer, one of the specialists in African Lepidoptera, raised this problem in an article which should appear in the first issue of the first volume of the scientific Journal, African Journal of Tropical Entomology Research. published on February 08, 2022 (Personal communication).

In order to solve this problem and prevent confusion from spreading widely in the scientific literature, this study establishes a history of the identification of edible caterpillars, an analysis of the identification methods used in the various publications and presents the potential taxonomic confusions of some edible caterpillars.

MATERIAL AND METHODS

The methodology followed in this study was based on documentary research relating to articles on entomophagy in sub-Saharan Africa. The documentary research made it possible to become acquainted with the various studies and publications relating to edible caterpillars in Africa. We then collected testimonies from certain authors with previous research experience on edible caterpillars in Africa, including François Malaisse, Paul Latham, Thierry Bouyer and Augustin Konda Ku Mbuta.

RESULTS AND DISCUSSION

Identification history of African edible caterpillars

At a time when current possibilities were not available, a rigorous way of identifying caterpillars was as follows according to information collected from Malaisse and Latham in June 2022, whose work is among the oldest publications on the identification of African edible caterpillars and who have been in contact with collaborators and some of the first authors who have worked on edible caterpillars in Africa.

Young caterpillars of second, or especially third stage, were collected and reared in a very fine mesh cage so that it was impossible for parasites to enterinside. Fresh leaves from the food tree were provided daily. Photos of each stadium were taken; at least three perfect photos, of the dorsal, lateral and ventral sides. The pupae were kept in conditions analogous to those in nature. Detailed descriptions were made; especially with regard to the spiracles. At hatching photos were again taken; and the dried insects were preserved and deposited in institutions in Europe, for example, in occurrence, in Belgium, at the RMCA (Royal Museum for Central Africa) which is located in Tervuren

Analysis of identification methods and potential taxonomic confusions

The first identifications were based on keys based on morphological characteristics (Oberprieler, 1995; Bouyer, 1999; Schintlmeister 2013; Mabossy-Mobouna et al., 2016). Among these there are keys based on the consideration of many characters such as: the general colour of the body of the caterpillars, the presence or absence of spines and/or hairs, the presence of spines on the mesothorax and the metathorax, the colour of the cephalic capsule and the anal shield, the density of the hairs, sometimes the spiracles are the subject of special attention.

More recently several authors have identified caterpillars using photos comparing the morphological details of their specimens. Note that the photos are an additional means of identification and not an absolute reference. Attention should be paid to the fact that the morphology and the coloured patterns of the caterpillar can vary significantly from one larval stage to another (Malaisse et al., 2016, and illustrated in Jurgen Vanhoudt's website www.silkmothsandmore.com). This fact was illustrated by Mabossy-Mobouna et al. (2016) for the caterpillars of *Imbrasia truncata*, *Imbrasia epimethaea*, *Bunaea alcinoe*, *Gonimbrasia petiveri* and *Imbrasia forda*. Obviously, problems with correctly naming these Lepidoptera from photos of specimens are not uncommon. The articles by Lisingo et al. (2010) and Okangola et al. (2016) are examples that contain multiple photographs of caterpillars with incorrect names as per the following examples.

1. *Cirina forda*

The genus *Cirina* is often associated (sometimes confused) with the genus *Imbrasia*. The problem therefore exists among the highly gregarious caterpillars which together provide the most important species of food and economic interest. Okangola et al. (2016) in a study on the nutritional values of edible caterpillars from the city of Kisangani and its surroundings (Tshopo Province, Democratic Republic of Congo) published a photo of *Cirina forda* under the name of *Bunaeopsis aurantiaca* in the International Journal of Innovation and Scientific Research 25(1): 278-286. From a morphological point of view these two species are totally different and cannot be confused, simply because *Bunaeopsis aurantiaca* caterpillars have spines while *Cirina forda* do not.

Figure 1a. Chenille de Kilueka © KONDA KU MBUTA

Figure 1b .Chenilles de Voka (Boko) © MABOSSY-MOBOUNA.

Figure 1c : Chenilles du Kongo Central © LATHAM

Figure 1d : Chenilles du Kongo Central © LATHAM

Figure 1e : Chenilles du Kongo Central © LATHAM

Figure 1f : Chenilles du Kongo Central © LATHAM

Figure 1g : Chenilles de Masi-Manimba © MADAMO MALASI

The photo of *Bunaeopsis aurantiaca* below (figure 2) was taken by Louise Nkulu Ngoie near Lubumbashi in D.R. Congo and another photo of this caterpillar (not included in this article) was taken by Paul Latham. The caterpillar was identified by Thierry Bouyer. The name of this caterpillar is attributed erroneously to other species in the literature. For example Okangola et al. (2016) "Edible caterpillars of Kisangani and its surroundings", presents on page 280, Figure 1, six photos in which one (f) is named *Bunaeopsis aurantiaca*. Page 281 of the same article continues, illustrating four photos with photo (h) showing another caterpillar also with the name *Bunaeopsis aurantiaca*. Thus, in this article the authors attribute the same name *Bunaeopsis aurantiaca* to two distinctly different species of edible caterpillar, neither of which corresponds to *Bunaeopsis aurantiaca*. The caterpillar shown in photo (f) figure 1 of Okangola et al (2016) is definitely *Cirina forda* while that in photo (h) is a *Pseudantheraea discrepans*

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Figure 2. *Bunaeopsis aurantiaca* (Rothschild, 1895) © Louise Nkulu Ngoie

2. ***Pseudantheraea discrepans***

The caterpillar of *Pseudantheraea discrepans* (figure 3) is also misnamed in the scientific literature. This

caterpillar was called *Bunaeopsis aurantiaca* by Lisingo et al. (2010), Muvundja et al. (2013), Ombeni & Munyuli (2017), Ombeni & Munyuli (2019) and Okangola et al. (2016). Moreover, the consumption of the caterpillar species *B. aurantiaca* in the province of South Kivu in the DRC (Muvundja et al., 2013; Ombeni & Munyuli, 2017) is questionable. According to Dr. Thierry Bouyer, indicates that it may be *Pseudanthaea* sp. whose ecology we do not yet know because the *B. aurantiaca* caterpillar feeds on grasses and probably does not exist in South Kivu (Thierry Bouyer, February 6, 2019, personal communication). However, the caterpillar of *Bunaeopsis aurantiaca* (figure 2) is morphologically very different from that of *Pseudantheraea discrepans*.

Figure 3. Two photos of *Pseudantheraea discrepans (*Butler 1878?) © Lucien Mballa.

Two caterpillars (figure 4) which are almost identical to the two photos of *Pseudantheraea discrepans* (figure 3) belong to another species and feed on different plants. One of the caterpillars has *Mangifera indica* as host plant and the other has *Trichilia gilgiana*. The people of Kilueka (Kongo Central, in

DRC) call them Munsongo and differentiate them by their host plant: Munsongo from *Mangifera indica* (figure 4a) and Munsongo from *Trichilia gilgiana* (figure 4b).

Figure 4. Two photos of *Gonimbrasia rhodophila* © Augustin Konda Ku Mbuta.

Although the two caterpillars feed on different plants, Rolf Oberprieler and Thierry Bouyer suggest that they are both *Gonimbrasia rhodophila*. The caterpillars of *Gonimbrasia rhodophila* and those of *Pseudantheraea discrepans* are often confused in the scientific literature. There are however two anatomical characters allowing them to be easily distinguished: the thoracic scutellum and the dorsal spine. The thoracic scutellum in *G. rhodophila* is normal whereas it is bituberculate in *P. discrepans*. The fused dorsal spine of the penultimate segment is bifid in *G. rhodophila* and simple in *P. discrepans*.

Furthermore, the white caterpillar designated by Lisingo et al. (2010) and Okangola et al. (2016) as *Pseudantheraea discrepans* is quite different morphologically from *P. discrepans* (figure 3) identified by Bouyer et al. (2004), Lautenschläger et al. (2017), Bocquet et al. (2020) and Mabossy-Mobouna et al. (2016, 2022). This caterpillar, see photo below (figure 5), is called Bitombo in Topoke (DRC), Sombotele in Mbole (Lisingo et al., 2010), Mimpemba in Laari and Kongo and Pululu in Baaka (Mabossy-Mobouna et al., 2022). To our knowledge, this caterpillar has not yet been determined although known for some time. In the young stage, the caterpillar has hairs that it loses with age until in the last stage it is completely hairless. Its host plant in the Republic of the Congo is *Albizia ferruginea (Guill.& Perr.) Benth.*

Figure 5. "Mimpemba" a caterpillar whose scientific name is not yet known. © Germain Mabossy-Mobouna, Photo taken at Loumou, south of Republic of the Congo (04°08'S, 15°07'E, altitude 365 m), on 29th July 2019.

The caterpillar in photo (h) figure 1 in Okangola et al. (2016) named *Bunaeopsis aurantiaca* probably corresponds to the caterpillar in figure 11 of Bocquet et al. (2020) published in the journal Geo-Eco-Trop, vol. 44 (1) and those of Mabossy-Mobouna et al. (2022)(see page 21) named *Pseudantheraea*

discrepans. On the other hand, the caterpillar named *Pseudantheraea discrepans* in figure 1, photo (h) page 281 of Okangola et al. (2016), a white caterpillar, is quite different from the *Pseudantheraea discrepans* in figure 11 of Bocquet et al. (2020) page 118 and on page 20 in Mabossy-Mobouna et al. (2022) published in African Journal of Tropical Entomology Research, Vol. 1 (1):3-27.

Note that the *Pseudantheraea discrepans* of Okangola et al. (2016) already bears the same name in the publication by Lisingo et al. (2010) who cite Malaisse (1997), Rougeot (1962), Oberprieler (1995) and Latham (2003) as references consulted to identify their caterpillars. These works have been consulted and we have not seen anywhere that these authors designate this species *Bunaeopsis aurantiaca*. For more information on this subject, we contacted two of the authors, François Malaisse, Professor Emeritus at the University of Liège and Paul Latham, former missionary of the Salvation Army in Central Africa. These two authors did not name this species *Bunaeopsis aurantiaca* in their publications on the edible caterpillars of Africa. Also, the same caterpillar would not have been published by Looli et al. (2021) in the Yangambi region without determining the name correctly, because of the confusion that exists in the literature they consulted.

3. *Imbrasia obscura*

The caterpillar of *Imbrasia obscura* (fig. 6) is often confused with the caterpillar of *Gonimbrasia hecate* and *Imbrasia jamesoni*. In the article by Okangola et al. (2016), a species that the authors named *Gonimbrasia hecate* (c on page 280) is more likely to be *Imbrasia obscura*, as illustrated in the publication by Bocquet et al. (2020) and Mabossy-Mobouna et al. (2022). Bocquet et al. (2020) had already noticed this taxonomic confusion on this species of caterpillar and made the following comments: "The consumption of this species has been reported on at least twelve occasions: Bahuchet (1985), Pagezy (1988), Hladik (1994), Latham (2003, 2008, 2016), Meutchieye et al. (2016), Okangola et al. (2016), Mabossy-Mobouna et al. (2016a-b), Lautenschläger et al. (2017), Mabossy-Mobouna et al. (2018). These reports are from five countries: Cameroon, the Central African Republic, the Republic of the Congo, the Democratic Republic of Congo and Angola. One of the aforementioned articles publishes a good photo of the caterpillar, but without determination (Meutchieye et al., 2016), another article publishes a good photo of the caterpillar, but names it *Gonimbrasia hecate* (Okangola et al., 2016). " (sic).

Figure 6. Caterpillars of *Imbrasia obscura* Butler (species n° 11) photo taken on August 20, 2016, in Pokola (North of the Republic of the Congo), © Germain Mabossy-Mobouna.

Figure 7. *Gonimbrasia hecate,* © Jurgen Vanhoudt. http://www.silkmothsandmore.com

Note also that the caterpillar of *Gonimbrasia hecate* (Figure 7) looks much more like the caterpillars of *Gonimbrasia melanops* (Figure 8) though they are two totally different species.

Figure 8. Caterpillar of *Gonimbrasia melanops* © Germain Mabossy-Mobouna.

Figure 9. Caterpillar of *Gonimbrasia jamesoni* © Paul Latham

Other confusion exist. Thus, Malaisse and Parent (1980) report the consumption of *Tagoropis flavinata* (Walker, 1865) from Katanga. However, this species only exists in southern Africa (Oberprieler pers. comm.). Furthermore, there is now molecular evidence (although unpublished and in need of verification) that the *Imbrasia* complex splits into a number of genera, the main ones being *Imbrasia, Cirina, Gonimbrasia* and *Nudaurelia* but also *Bunaeoides, Pinheyella* and apparently a few undescribed (despite Cooper's many new names). This also seems to agree with the morphological differences, although again no one has done a proper and comprehensive study so far. But we either have to deal with all these genres separately or group them all into *Imbrasia* (sensu lato). Other authors to be certain of the name of the caterpillar were based on the breeding of caterpillars to obtain the imago (Bouyer et al., 2004).

There are many Journals that accept articles without offering them to expert peer reviewers for effective review and expressly publish these articles, so long as the authors pay. These articles very often have pictures of caterpillars with completely wrong names. Several species have erroneous names in several published papers. Worse still, there are cases of exchange of sometimes erroneous names between two species either in the same article, or even from one article to another. As long as authors rely on identification from published photos without submitting their specimens to specialists before publication, these errors will be increasingly present in the scientific literature. The scientist must fight to have the value of his scientific production recognized. It is therefore necessary to take into account the number of articles published, but also the impact factor (Lognay, 2004).

Need for molecular identification

The problem discussed above clearly shows the need for an effective method of identifying edible caterpillars, including molecular identification. The molecular identification of African edible caterpillars should use following steps. 1) tissue preparation, insect genomic DNA extraction, 2) insect identification, PCR by using general insect DNA barcoding LepF1/LepR1 primers (LEP F1-5' ATTCAACCAATCATAAAGATATTGG 3'; LEP R1-5' TAAACTTCTGGATGTCCAAAAAATCA 3') (Hebert et al., 2004), 3) Agarose Gel Electrophoresis, PCR Product Purification and Sequencing, and 4) Sequence Analysis. To hammer home this situation, we take up here the case of *Cirina forda*, whose caterpillar called “Ngwanda” in various languages of the Republic of the Congo, indisputably belongs to the old concept of “*Cirina forda*”, sensu lato. The taxon present in Central Africa certainly does not belong to *Cirina butyrospermi*, sensu stricto, with a north-western distribution (from Senegal to Chad) and which feeds on *Vitellaria paradoxa* C.F. Gaertn.

The latter has been the subject of various studies, including Odebiyi et al. (2003a,b; 2009). The status of the taxon present in the Congo Basin poses a problem and requires additional study that goes

beyond the scope of morphological determination alone. It is very probably the *Cirina forda amiti* Darge, 1975 described from southern Cameroon, but doubt persists as to the name and status. The recent description of this taxon, its relative rarity in old collections or old publications and the fact that it is now present in large populations (sometimes pullulative) throughout the central forest block as far as South Africa, suggests that it is a recent invasive colonizing species. Ideally, a study program of the genus *Cirina* should be initiated based on genetic and ecological data, the only means of access to a reliable determination of the various taxa incriminated and to the history of the genus. Where possible, researchers should make the effort after capture, to rear the caterpillars to the imago stage. Endeed, the determination from an adult. This study may seem anecdotal but in the state may seem easier. At our knowledge, nothing suggests that the interest in the entomophagy of the different taxa of *Cirina* is identical or even equivalent. The determination of the moths being inaccurate in certain articles poses a major problem for the reliability of these determinations. Several authors refer to *C. forda* feeding on *Vitellaria paradoxa* in West Africa. If the larvae feed on *Vitellaria paradoxa* in West Africa, then it is *Cirina butyrospermii*, although Rolf Oberprieler in a personal communication says they are all *Cirina forda*.

The authors should work with a specialized systematist rather than relying on the comparison of photos from articles that have used the same identification method. This results in the continued repetition of the same taxonomic confusions in several online articles. It is therefore necessary to put an end to this taxonomic haemorrhage, by an extended study of molecular identification of all known and available species in order to constitute a real database as a reference for all future studies of identification of edible caterpillars. Thus by taking a sample of caterpillar (or egg or chrysalis) we can know with certainty to which species it belongs without necessarily carrying out breeding to the imago. Obviously this is subject to the same treatment and the same hazards as those for adults (therefore in terms of contamination, wolfbachia, etc.).

The tests can be performed on both dried and alcohol samples, and both give reliable results. The most commonly used gene is the one popularized by the Barcode which is a mitochondrial CO1 (cytochrome C oxidase 1) gene for which we have primaries.

CONCLUSION

This article clearly indicates that it is now necessary to take into consideration an indispensable rigor in naming the edible caterpillars of Africa. The comparison of the caterpillars collected with the photos already identified has been a source of confusions because some caterpillars are morphologically similar. It is necessary to use a realistic identification key for each species needing identification. Therefore, recourse to molecular identification is essential. This will allow an exact identification of each species of edible caterpillar and the establishment of a biological database of edible caterpillars in Africa at the service of taxonomists. This finding fully justifies this article and recalls the expression "the habit does not make the monk"!

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