Exploring Entomophagy in Northern Benin - Practices, Perceptions and Possibilities

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Abstract

Food security is a critical issue for many low income countries across the African continent. In such areas unsuited for intensive agricultural production, local natural resources assume an increasingly important role, particularly those which are environmentally sustainable and which people have relied on for centuries. Insects have been traditionally consumed for generations in many regions of the world and represent an important source of animal proteins that could improve nutritional intake among populations subject to malnutrition. Data on insects as food in the Wama communities of North Benin were collected by conducting interviews in two Wama villages, Kosso and Cotiakou. Eighteen edible insect species were recorded, predominantly Coleoptera (52%) and Orthoptera (29%). This project has found a further eleven arthropod species that eaten in the region. These include new groups of insect including Hemiptera (family: Coreidae); and Acari (family: Ixodidae) in addition to several new species of Coleoptera from the Cetoniinae family. One insect documented of particular interest was the bush cricket, *Gymnoproctus sculpturatus,* which was the first recorded presence in Benin. Insect collection is an ancestral tradition in the Wama community and, interestingly, the collecting is mostly carried out by children. In light of malnutrition in North Benin being a major problem among children, promoting this tradition as well as implementing small scale captive rearing of selected species could be a promising opportunity to further develop regional and national food security. The potential and barriers of developing village scale rearing for entomophagy in Benin are discussed.

Table of Contents

I. Introduction

As the global population continues to rise, attempts to increase arable land area come into conflict with other land uses. As a result, the regional food shortages that we are already experiencing are likely to become a recurrent phenomenon. In particular, this increasing pressure on land is making meat production from livestock extremely unsustainable. Food security is a critical issue for low income countries across the African continent that already struggle to meet their nutritional needs. Issues of chronic poverty, landlessness and/or land-grabbing, alongside increasing environmental degradation, as well as the disruption of local alimentary culture by the Western imported food products and "fast-food" culture are all contributing factors (Premalatha, 2011). In such areas unsuited for intensive agricultural production, regional food resources can assume an important role, particularly those which are environmentally sustainable and which people have relied on for centuries. Insects, which have been traditionally consumed in many regions of the world, represent an important source of animal proteins that could considerably improve nutritional intake among populations subject to undernourishment and malnutrition.

Research has established that over a thousand insect species have been used as traditional foods by humans and many still form an important part of the diet and economy of many societies (Merle, 1958; Katya Kitsa, 1989; DeFoliart, 1995). In addition, over the last two decades, the potential of insects as a commodity has been increasingly recognized (DeFoliart, 1999; van Huis, 2003) and insects are now regarded as a class of mini-livestock (Hardouin, 1995, 2003). These activities are attracting increasing attention and support from international organizations such as the Centre Technique de Cooperation Rurale et Agricole (CTA) and the Food and Agricultural Organizations (FAO).

Sub-Saharan Africa has the lowest average animal protein intake per capita per day in the world (Grigg, 1995). The consumption of insects is widespread through-out the African continent with some 250 species being consumed, either as delicacies or as important components of the daily diet (van Huis, 2003) (Figure 1). In parts of the Democratic Republic of Congo, insects constitute up to 64% of the animal protein consumed by humans (Paulin, 1963; DeFoliart, 1999), while many populations in Zambia prefer winged termites to the meat of mammals (DeFoliart, 1999). In addition, even many agricultural pests, which cost billions to control and can cause serious environmental damage, are edible and are utilized as food in some countries (Ramos-Elorduy, 1997; FAO, 2008; Premalatha *et al*., 2011). The potential of entomophagy is further illustrated through the mopane caterpillar (*Imbrassia belina*) industry in South Africa which forms the basis of a multi-million dollar trade in edible insects, providing livelihood for many harvesters, traders and their families (Dreyer and Wehemeyer, 1982; Munthali and Mughogho, 1992; Menzel and D'Aluisio, 1998; FAO, 2004). This industry shows that the potential income from sale of edible insects is not insignificant.

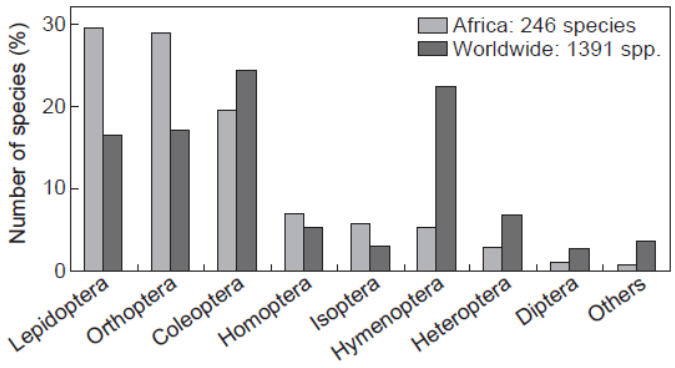

Figure 1: The percentage of insect species of each order eaten worldwide. (Source: van Huis, 2003)

Insects have been - and still are - consumed in Benin. However, their consumption is currently not very common. The biggest consumers of insects are the Nagot, Pobè, Kétou, Wama, and some Fon groups (most of whom have lived in Nigeria) (Tchibozo *et al*., 2005). However, the edible arthropods of Benin are not yet very well known, with only a preliminary study listing the insects consumed in some regions in South Benin (Tchibozo *et al*., 2005). Nonetheless, they

have been shown to be an important source of animal protein in the South, improving the health of malnourished children (Tchibonzo *et al*., 2005). While the potential benefit of entomophagy is apparent, little is known about how to realise the full potential of insects as a food crop, and much remains to be explored across large areas of Benin.

The report focuses specifically on the understudied Atakora region in the North of Benin where food security is a serious issue (UNIDEA, 2006). The report concentrates on the Wama ethnic group as their consumption of insects is poorly documented. The different species eaten regionally are listed, along with collection methods. Their significance to people's livelihoods, from subsistence collection to the evaluation of the potential for farming insects, are also explored. Finally, the wider possibilities and barriers to the expansion of entomophagy in Benin are discussed.

II. Background Information

a. Value of Insects as food

While current livestock production, including feed-crop production, occupies 70% of the world's agricultural land (or 30% of the earth's land), and consumes 77 million tonnes of plant or animal protein to produce just 58 million tonnes of protein for human consumption annually (Pimental *et al*., 1975), farming insects offer many valuable benefit in contrast. Insects can offer higher or similar nutritional quality compared to current available meat products (Table 1 and 2) (Ruddle, 1973; van Huis 2003; FAO 2010a,b). Van Huis (2003) mentioned in his overview of insects as food that "insects are not inferior to other sources of protein such as fish, chicken or beef" (pp1). In addition, a much lower consumption of energy and natural resources of insect farming (Lindroth, 1993; Nakagaki *et al.*, 1991), alongside high fecundity and a faster growth rate, make insect farming an option which deserves urgent global attention.

Table 1: B-Vitamins in 100 g servings of chicken and beans dishes in comparison to the contents of some insects (From Premalatha, 2011).

	Thiamine	Riboflavin	Niacin
Daily human requirement	1.5 mg	1.7 mg	20 mg
Fraction met by roasted chicken	5.4%	–	45%
Fraction met by backed beans	10.8%	–	3%
Fraction met by termites	8.7%	67.4%	47.7%
Fraction met by silkmoth larvae	224.7%	112.2%	26%
Fraction met by palm weevil	201.3%	131.7%	38.9%

Table 2: Protein and iron in 100 g servings of beef and of two insects (From Premalatha, 2011).

Food	Protein, g	Iron, mg
Beef (broiled)	22.3	2.9
Silkmoth larvae (boiled)	28.2	35.5
Grasshoppers (fried)	61.1	–

b. Benin: Country Overview

i. Population and Trends

Benin has a population of around 9.5 million inhabitants (CIA Factbook, 2012), with an increasing urban population, which now stands at of 42% (BTI, 2012). The population is very young, with 44% of the population between the age of 0 and 14 (CIA Factbook, 2012), and life expectancy stands at 55 (BTI, 2012), which is amongst the lowest in West Africa. The country has significant regional variation in terms of culture and traditions, many of which are still practiced and transmitted today, particularly in rural environments. Religion is also varied, with 27.1% of Catholics, 24.4% Muslim, 10.4% Protestants and 5.3% other Christian. Benin is also the birthplace of Vodoun, which is still practiced by 17.3% of the population along with other animist religions (2002 Census in CIA Factbook, 2012).

ii. Economic Profile

Despite recent economic and social improvements over the last decade, characterised by a rise in development indicators and a GDP growth rates averaging 4% per annum (World Bank, 2012), Benin remains among the poorest countries in the world (Rank 167 of 187 Human development index (HDI)), and 51.6% of the population live on less than $1 a day (BTI, 2012). The economy relies strongly on agriculture, which represents 32% of the GDP and employs 70% of the workforce. In fact, a large part of the population depends on subsistence farming for their livelihoods. The main cultivated food products are maize, millet, sorghum, rice, yams, cassava, beans, fruits such as pineapples, mangos and oranges, and vegetables such as tomatoes, aubergines and okra. Exports are dominated by cotton, which represents between 25 to 40% of total exports (FCO, 2012), and is followed by products such as cashews and shea butter, textiles and palm products (CIA Factbook, 2012). Due to a lack of diversity in economy sectors, Benin is very vulnerable to external shocks and price volatility, and has suffered economically during the

global economic crises, as well as from severe floods in 2010 which depressed agriculture and cotton exports (World Bank, 2012).

iii. Regional Variations

Poverty-related issues and food insecurity is not evenly distributed across the country. The North has always been the poorer, as a result of Benin spanning two very different climatic zones. The South is endowed with a tropical climate, with two rainy seasons, which result a in a lush landscape and fertile ground for agriculture, with the possibility of two harvests. In contrast, the North remains arid, and oscillates between an extensive dry season spanning from October to May and abundant rains from June to October, making agriculture much more unreliable. In addition, although the Southern ports thrive through import/export activities, the benefits and products from trade do not necessarily reach the rest of the country, partially due to inadequate infrastructure. As a result of these inequalities, malnutrition is far more severe in the North. These regions lag behind in terms of agricultural diversification - and crop failures and limited access to affordable fortified products lead to widespread nutritional inadequacies. The hardest period is called the *soudure* - the time before the first rains and the first harvest, between February and April, when food is scarce.

iv. Food Security

Benin struggles to resolve poverty-related issues which affect the country, one of which is the problem of food security. Child malnutrition in particular is very severe, with studies over the last years showing that moderate and severe stunting is increasing (from 25% in 1996 to 27% in 2001 and then 35% in 2006) (UNICEF, 2006). To tackle these issues, the IMF and World Bank have pushed for the formulation of a 'Growth and Poverty Reduction Strategy' (IMF, 2011) to guide growth strategies. Among those strategies, food security via sustainable agriculture is vital to poverty alleviation (Gangnibo *et al*., 2010). In fact, the greatest increases in poverty between 2007 and 2009 occurred in the agriculture-livestock-fisheries-forest sector (5.46%

increase) - which illustrates the urgency to tackle this sector in order to address chronic poverty (INSAE, EMICoV, 2010, in IMF, 2011). Benin has also launched the 'Strategic Plan of Agricultural Sector Revival' in 2008 (MAEP, 2008) to make Benin food secure by 2015 (Gangnibo *et al*., 2010). With the help of international donors such as UNICEF, there are also various initiatives specifically aimed at combatting child malnutrition, such as the Minimum Package of Essential Nutrition Actions ("PMA/Nut" Project) (UNICEF, 2009).

c. Background to the Area of Study

i. The Atakora and the Commune of Tanguieta

Our study focused on the Atakora department, located in the North West of the country, bordering Burkina Faso and Togo, and contains the Atakora mountain range. It has a population of 550 thousand inhabitants (ANCB, nd), spread across nine *communes* (districts). This study specifically investigated the *commune* of Tanguieta. The main ethnic groups present in the area are Ditamnari, Berba, Wama, Natemba, Peulh and Gourmanché (UNIDEA, 2006). The landscape in the *commune* is composed of rocky mountains, and a scrub savannah to the North of Tanguieta. 80% of the population depend on agricultural activities to support their households, consisting of either subsistence agriculture (maize, millet, sorghum, rice, beans, peanuts, and yams) or cultivation as a source of income, for example cotton. During the period of *soudure*, petty commerce and cattle selling are the main activities pursued to breach the gap before the harvest (UNIDEA, 2006).

ii. The Issue of Malnutrition

As stated previously, malnutrition is a major problem in the area. A study conducted in the *commune* of Tanguieta by UNIDEA (2006), found that about 10% of the surveyed children under the age of five suffered from acute malnutrition, and up to 50% of the surveyed children

presented signs of chronic malnutrition, with detrimental effects on growth rates resulting in stunting. 24% of the cases where categorised as severe stunting, whereby malnutrition significantly hampered their development. Malnutrition was found to be most acute in the months where children depend on breast-feeding, which indicates that the mother's nutritional intake is often inadequate. There is limited literature on food security in the area, but Dr Aouanou Guy Basile, the director of the Centre for Nutrition, and Dr Priuli G.B. Fr. Florent, the Director of the Hospital Saint Jean de Dieu Fatebenefratelli of Tanguieta confirmed that food insecurity is a significant problem in the area, and has often resulted in widespread famine.

iii. The Wama Settlements of Kosso and Kotiakou

The research was conducted in the town of Kotiakou and the village of Kosso, both under the *arrondissement* of Kotiakou,. These are both Wama settlements. They mainly live off non-mechanised subsistence agriculture and livestock rearing, while selling surpluses in Tanguieta. Most of their land is very rocky, which is poor for agriculture, but allows for a secondary source of income: the breaking of rocks, which are sold to cement producers. While Kotiakou has a health centre, a church, a primary school, and has opened a secondary school in 2010, Kosso does not have such facilities, and both settlements are without electricity. A large part of the adult population has not been to school or has had limited exposure to the formal education system, especially in Kosso, but indigenous knowledge is extensive in terms of agricultural practices and the uses of plants and animals for medicinal and practical uses. Current school attendance is high at primary school level, and is improving at secondary school level since the facilities were opened in Kotiakou. In addition, some children walk to Tanguieta to attend school there. The population is mainly Catholic, but animism is intertwined with religious beliefs to varying degrees.

The Wama are strongly attached to traditions transmitted from one generation to the other. Family bonds are considered extremely important, and the houses are built so that family

groups live next to each other, surrounded by their fields. Housing is organised in *concessions,* each owned by one head of family, which are composed of a series of circular rooms built out of mud and straw, with different functions, along with pens and granaries, all connected in a circle by a mud wall. Their diet is largely composed of rice, maize products and yams, while meat and eggs are scarce, and imported fortified products remain unaffordable and are unusual in their diet.

Photo of the Atakora landscape near Tanguieta

Photo of a family *concession* in Kosso

III. Materials & Methods

The information presented in the results section was collected by field interviews and participatory insect collection conducted during the months of October and November 2012. The interviews concentrated on the traditional, nutritional and medical uses of arthropods. Two Wama villages were visited, Kosso and Kotiakou, situated between Tanguieta and Natitingou (Fig2). The initial contact with the two Wama settlements was made through our local partner, Séverin Tchibonzo, who had previously worked with a Wama. Interviews were mostly lead with the *délégué* or administrative representative of Kosso, the director of the secondary school of Kotiakou and focus groups were held with certain members of the communities mostly men between the ages of 25 and 45, most of which had a limited exposure to formal education, and generally involved in agricultural activities. Communication occurred either in French or by means of translation done by those who were more fluent in French.

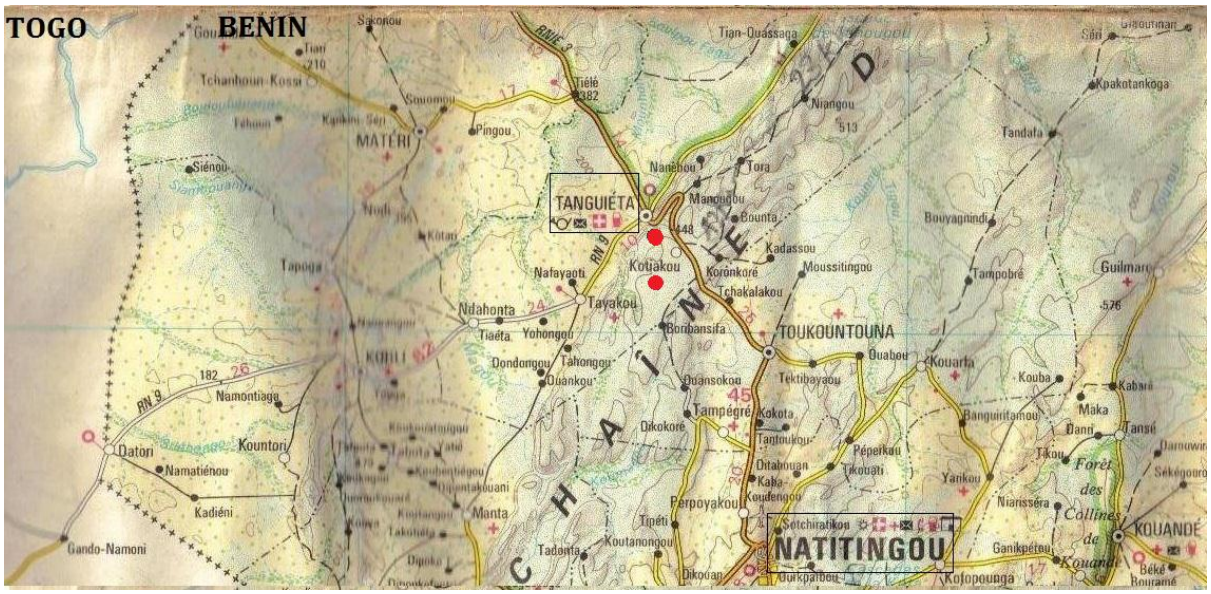

Figure 2: Map of the Atakora Region (scale 1:600000). The red dots represent the locations of Kosso and Kotiakou.

Collections of insects were carried by the children as it is custom in the Wama. In addition to the traditional "hunting" of insects, a trap with fermenting fruits (pineapple, bananas) was used to attract some Coleoptera. This method consisted in hanging a bucked filled

with fermenting pineapple and bananas with water to a high branch of a tree; the bucket was then collected 24hours later. This method was successfully used once to collect adult chafers. When possible four specimens of each insect were kept and killed using ethanol and then pinned. The location, local name, host plant, habitat and temporal distribution of each morphospecies were noted. When possible specimens were subsequently identified by a specialist at the IITA (International Institute of Tropical Agriculture) Research Institute in Cotonou. Specimens were also kept to document preparation, cooking, and eating. While insects are used for honey production and to a small degree for animal feed, only insects used for direct human consumption are dealt with in the report.

To investigate the potential of developing entomophagy in Benin various specialist were interviewed. The Director of the Hospital Saint Jean de Dieu of Tanguieta Fatebenefratelli and the Director of the Centre for Nutrition of the hospital were both interviewed on the question of malnutrition and nutritional deficiencies in the region. In addition food scientists at the University of Abomey Calavi (UAC) of Cotonou and specialist agricultural economists of the IITA were approached about how the production of selected insects can be enhanced and incorporated into food security plans in Benin.

Limitations of the project include the length of time we were in the area, which allowed the collection of most but not all insects due to seasonal variation in abundance. For example the termites winged stage are only observed and collected in August. This problem was addressed through interviews and creating a calendar of species availability. Language and cultural barriers also occasionally created misunderstandings, but through repeated visits and work with a translator, the significance of this problem reduced considerably with time. Initially camera equipment was distracting, especially for young children, and could have affected the way the collections were carried out, however over time this curiosity noticeably decreased. The research could be influenced by a gender bias, as it was very hard to interact with the women due to the nature of the Wama societal organisation.

IV. Results

a. Which insect species are eaten?

Previous research by Tchibozo (2005) had found that the Wama communities consumed six species of insects (Table 3). This project has found a further eleven arthropod species that are or were recently eaten. These include new groups of insect including Hemiptera (family: Coreidae) and Acari (family: Ixodidae) in addition to several new species of Coleoptera from the Cetoniinae family. One insect documented of particular interest was the bush cricket, *Gymnoproctus sculpturatus,* which was the first recorded presence in Benin and it has only recently been recently described from Kenya. With the present record, there are only 3 genera and species known from West Africa. Table 3 fully lists the arthropods consumed by the Wama communities. The most abundant and preferred for their taste were the Coleoptera (52%), especially *Pachnoda cordata*, followed by the Orthoptera (29%). Comparing our data on edible insects to the percentage data worldwide (Ramos-Elorduy, 1997) and of Sub-Saharan Africa (van Huis, 2003) we can find similarities in the fact that Coleoptera and Orthoptera are in the top three major eaten groups, however, Hymenoptera and Lepidoptera, which are both frequently recorded by both authors, are not present in our data. In addition, our data suggests a very different insect diet between the North and the South of Benin (Tchibozo, 2005) linked to the presence of different species as well as ethnic preferences, prohibitions and necessity. In the North, where the Wama live, we can find a greater diversity and abundance of edible insects that in the more developed South. In addition, as Figure 3 shows, the temporal distribution of the collected arthropods, some can be found all year round, however, most of the eaten insects, such as many Orthopterans and all Coleopterans are seasonal.

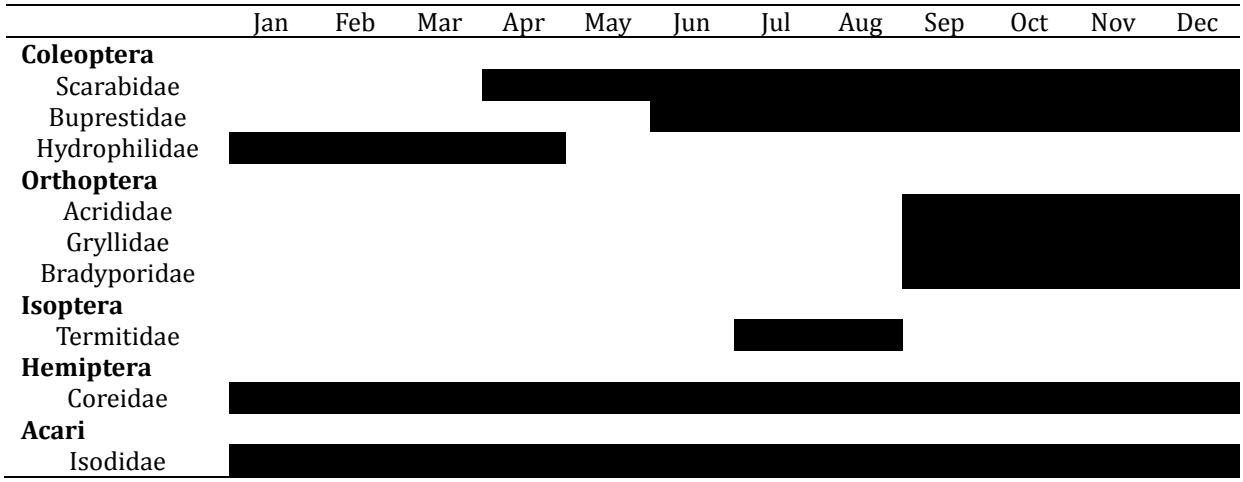

Figure 3: Seasonal distribution of the collected arthropods

Two particularly interesting findings are that of edible ticks found on cattle and water beetles of the family Hydrophilidae. These are the first reports we know of for these species being eaten in Africa. Although the Wama do not rear cows themselves, the Peulh group, who is the major cattle herders in the region, often travel with their cows from pasture to pasture. Some Peulh are settled in Kotiakou. The Wama gather the blood filled ticks to eat, almost like a mini black pudding, when the Peulh come to their village or when they have come back from the fields. However, this tradition is getting lost due to the increasing use of chemicals to prevent these ticks settling on the cattle. The water beetles, on the other hand, are collected in pockets of water at the beginning of the dry season and roasted. Similarly, in Asia the giant water bug (Belostomatidae) is collected by the farmers and eaten as a delicacy (Srivastava *et al*., 2009).

Interestingly, the use of a species of leaf footed bug, from the family is Coreidae, for a medical purpose was also documented. The stink bug is traditionally mixed with spices turned into a powder and then eaten to cure migraines. However, the bad smell of this arthropod and the existence of alternative methods to deal with migraines mean that today it is used less and less. Therefore, the use of the leaf footed bug as medicine, although interesting, will not be discussed with further.

Overall, the Wama mostly consume insects that can be gathered in the fields and high grasses around their village, predominantly phytophagous species. Some of them are potential crop pests such as grasshoppers (*Hieroglyphus africanus, Acanthacris ruficornis citrina, Ornithacris turbida cavroisi*), crickets (*Brachytrupes membranaceus, Gymnoproctus sculpturatus*), locusts (*Locusta migratoria*) -who can be major defoliators of crops- and chafers (*Pachnoda cordata*) - whose larvae live in the soil and damage to cereal and sugarcane roots. The table below gives further information on the species collected and previously found to be eaten by the Wama.

Table3: List of arthropod species consumed by the Wama in North Benin (* species previously collected by S. Tchibozo, all the others are new specimens)

Local Name	Locality	Family	Species Name	Collected from	Photo
Nagitasambi	Kotiakou	Bradyporidae	*Gymnoproctus sculpturatus*	Bush Grass, Millet	
Chaubafranca	Kosso & Kotiakou	Acrididae	*Truxalis spp.*	Bush Grass	
Sosoré	Kosso & Kotiakou	Acrididae	H*ieroglyphus africanus**	Bush Grass	
Manchougou	Kosso & Kotiakou	Acrididae	*Acanthacris ruficornis citrina*	Bush Grass, Okra	
Manchougou	Kosso & Kotiakou	Acrididae	*Ornithacris turbida cavroisi*	Bush Grass, Okra	
Baga	Kosso	Grillydae	*Brachytrupes membranaceus*	Under mango trees	
Pipiru	Kosso & Kotiakou	Scarabidae	*Pachnoda cordata**	Bush Grass, Maize, Millet	
Fapipiru	Kosso	Scarabidae	*Gnathocera impressa*	Bush Grass, Maize, Millet	
Fapipiru	Kosso & Kotiakou	Scarabidae	*Rhabdotis buchardi*	Bush Grass, Maize, Millet	

Sopipiru	Kosso & Kotiakou	Scarabidae	*Gnathocera varians*	Bush Grass, Maize, Millet	
Pipisae	Kosso & Kotiakou	Scarabidae	*Pachnoda vossi*	Bush Grass, Maize, Millet	
Pipirundi	Kosso	Scarabidae	*Chondrorrhina abreviata*	Bush Grass, Maize, Millet	
Kokouaré	Kosso	Buprestidae	*Sternocera interrupta**	Acacia trees	
Kokouaré	Kosso	Buprestidae	*Steraspis castanea**	Acacia trees	
Cotondousre	Kosso	Hydrophilidae	*Cybister sp.**	In still water pools	
Iiriiri	Kosso	Termitidae	*Macrotermes falciger**	Termite mounds	
Nagkopta	Kotiakou	Ixodidae	*Unknown*	On cattle	
Como Como	Kosso & Kotiakou	Coreidae	*Unknown*	Bush Grass	

b. Collection of Edible Insects

Insects in the Wama communities are collected and cooked mostly by children between the age of 5 and 15 who practice this activity mostly in groups (Fig4). Children generally use their hands, sometimes with the help of sticks, to move the vegetation or to dig in the ground to collect the different insects. The insects are collected alive, sometimes with the removal of legs, and kept containers such as empty bottles or jars. They are brought to the *concessions* where they are cooked all together in a pan with shea butter and chilli or grilled directly on charcoal. Insects are shared amongst the group and are also distributed to smaller kids that did not participate in the collection. Insect capturing is mostly done in the mornings and in the evenings when temperatures are low and insects less active. This activity is traditionally a game where insects are considered a snack food rather than a meal as such, and are not considered comparable to other animal proteins such as chicken, beef or guinea fowl.

Figure 4: Collection and cooking of edible insects by group of children In Kotiakou (collection) and Kosso (cooking)

This is in sharp contrast to many Sub-Saharan countries, where insect gathering is mostly a female activity (van Huis, 2003). One exception in the Wama groups is when the catch is considerable, as is the case for the emergence of the winged termites in August. Here, the women as well as the men collect the insects using mass collection techniques (van Huis, 2003) involving leaving large buckets of water under a light source at night. The winged termites are attracted to the light, but remain stuck to the water as they fall in the bucket. The collectors then dry them or prepare them into sauces, and sometimes sell them on the market. Another exception is the collection of termites to feed the chickens and the guinea fowl. This is usually done by adults that collect termites in their field where damage to the millet and corn by these arthropods can be observed (uprooted plants) and collect them using buckets to feed to their animals.

No methods of mass collection are used for other insects than termites in the Wama communities. Although methods had been introduced in the 1990s by the CRGB (Centre de Recherche et de Gestion de la Biodiversité) in Kosso to catch chafers using buckets of pineapple and bananas, this method was dropped over time because of the cost and unavailability of such products in the North of Benin. In addition this was considered time consuming, whereas insect collection is mainly seen as a children's game. The increasing number of children attending primary school also means that they have increasingly less the time to pursue this activity, now only possible on Wednesdays and weekends, when school is closed.

In the Wama communities, insects are eaten directly after collection with very little preparation. Marketing of insects products seems to be developed only with termites, where mass capturing techniques are available and therefore there are enough insects to dry for snacks or mix with sauces and can be found on the market. Many people in Sub-Saharan Africa consider them a delicacy. However, more often, insect eating and preparation remains very localised.

V. Discussion

a. Review of the insects consumed by the Wama communities and exploring future potentials

From the data collected across Benin we can observe that different ethnic groups have distinct insect preferences. In the South the main insect consumed across different localities are larvae of *Oryctes* spp and *Rhynchophrus phoenicis* (Tchibozo, 2005). In both cases the larvae are directly collected by the adults in palm trees. In contrast, the Wama from the North have a much more varied assemblage of edible insects, although they avoid eating any larvae. This local aversion for the soft and usually most nutritious stage of the insect (van Huis, 2003) reveals the barriers of local traditions preferences for the commercial development of certain insect species. These differences could also be related to the differences in climate between the North and the South of Benin, with grasshoppers and crickets being more common in the North of Benin, where high grass and bush savannahs dominate the landscape; whereas palm trees, where larvae of *R. phoenicis* and *Oryctes* dwell, are predominantly found in the warmer South.

Nevertheless, similarities exist across Benin as well as across Africa. One such example is termites (*Macrotermes falciger*).Termites have been part of the human diet since prehistoric times (van Huis, 2003), with their sexual winged forms being the most popular today (Fig 5). These swarm out of the mound after the first rains, which in North Benin correspond to the month of August. Fried or dried termites contain 32-36% proteins (van Huis, 2003), they are also high in fat (48%) and iron (5.80 mg/100g) (Mumba and McDonald, 2006). The widespread practice of eating termites as well as their high nutritional value would make them a good starting point to develop edible insects in the area. However, the seasonality of the preferred stage and its ecology would make it hard to rear in captivity. Interestingly, in East Africa, termite mounds are often owned and protected by individual families (van Huis, 2003). Ownership of termite mounds could be an interesting prospective to explore in Benin. However care should be

taken to avoid conflicts and a good understanding of how many termite mounds are in the area and how to sustainable harvest them is essential as termite mounds are related to trees and deforestation could affect them.

Figure 5: Illustration of sexual winged termite (*Macrotermes falciger*) (Photo of S. Tchibozo).

b. Mass rearing of edible insects

The mass rearing of insects for consumption or sustainable harvesting from the wild is an important hurdle that needs to be overcome. The Wama generally eat the food they collect or catch on the same day or not long after. There are only a few recorded examples of preserving insect food to eat later. These include the preservation of termites into sauces or dry snacks. Two factors work against mass harvest of edible insects from the wild: unreliability of supply and the potential for habitat destruction.

The development of rearing methods for edible insects, rather than relying on natural harvesting would allow a continuous supply and a better integration of this rich source of nutrients into the daily diet. In fact, although children consume insects, they are often not consumed in adequate amounts or frequency to have an effect on the nutritional status of the child. Methods to mass rear insects in captivity already exist for biological control (*Macrolophus* spp), waste management (*Hermetia illucens*), blue-sky research (*Drosophila* spp) and for pet

food (*Tenebrio molitor, Zophobas morio, Galleria mellonella*, *Acheta domestica*). However not all insects can be easily reared in captivity at a low budget.

Firstly, life history of the insect is an important point to consider. Holometabolous development (complete metamorphosis) common in coleopterans (Chafers, Buprestidae), means that the adult stage and the offspring won't have the same ecological niche. These insects will require more investment to rear in captivity compared to hemimetabolous insects that have no pupae stage (Orthopterans, Hemiptera). For example in Thailand, farmers use cement tanks or wooden containers covered with a nylon nets filled with sandy loam soil and grasses and weeds for cricket farming (Gahukar, 2011). All stages are mixed together and adult crickets are partly harvested to keep the rearing going. Insects with short life cycles will also be more suitable for rearing than insects with a long development period.

Another point to consider is the insects' diet. For a successful village scale rearing host plants or alternative diets should be easily available and not costly. Even in the presence of an artificial diet, such as is the case for the South American palm weevil (Cerda *et al*., 2001), the cost of buying or manufacturing it will not be viable for many villages in Africa. Therefore ease of access to the insect diet is a necessity. Orthopterans are mostly generalist phytophagous who can feed on organic waste as well as wild gasses and weeds and offer an interesting avenue to pursue small scale farming.

Third important point to consider is the seasonality and abiotic factors that may affect the fecundity and growth of the insects. Insects are typically seasonal due to food availability and temperatures. To successfully rear seasonal insects and have a continuous supply rather than relying on natural harvest it is therefore essential to know what is the range of temperatures the insect can sustain. This information will allow to build efficient cages or place the rearing facilities in adequate areas (indoors/outdoors).

Finally, nutritional value and consumer preference should be considered before implanting captive rearing projects. As mentioned above ethnic preference can vary at a very fine scale and therefore village traditions and preferences should be considered before implementing such programs. In addition, not all insects offer the same nutritional quality, and protein content may vary significantly between groups and species (Banjo *et al.*, 2005; Mumba and McDoald, 2006) (Fig6). Therefore it is important to promote traditional insect gathering on top of captive rearing of one species. Development of rearing facilities should not replace traditions, as lack of diversity in the diet as well as quantity is the main cause of deficiencies in Benin (UNIDEA, 2006).

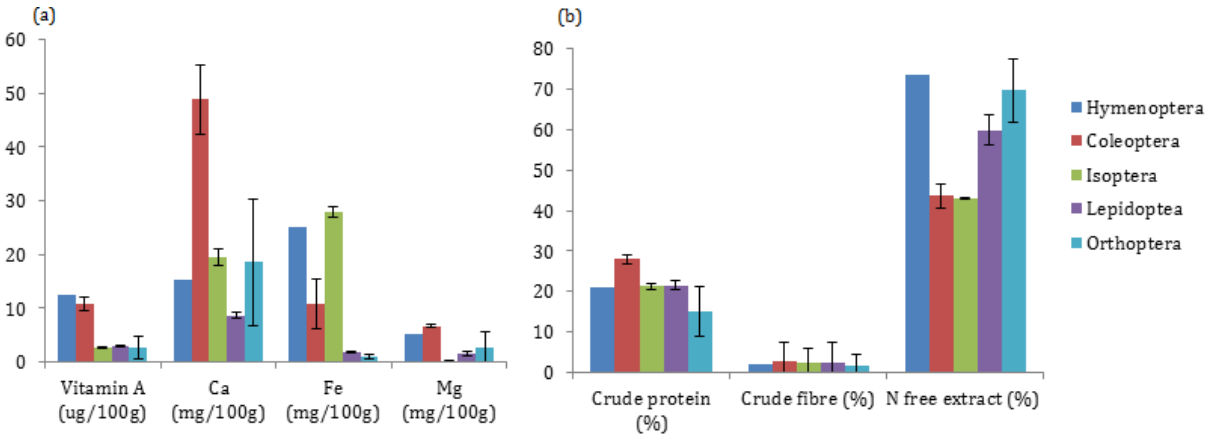

Figure 6: (a) Average Vitamin and mineral content and (b) Average proximate analysis (%) of major insects groups consumed in Nigeria (±1SE)(Hymenoptera n=1; Coleoptera n=3, Isoptera n=2; Lepidoptera n=5 and Orthoptera n=3) (Data modified from Banjo *et al.*, 2005).

The Wama traditionally do not consume larvae or caterpillars, therefore rearing development should focus on Orthopterans for which low cost mass rearing technologies have already been developed in China, Korea, and Thailand (FAO 2010b, 2012) as well as in Europe and in the United States by pet food companies. Small scale farming of one of the three species of grasshoppers (*Hieroglyphus africanus, Acanthacris ruficornis citrina and Ornithacris turbida*) eaten by the Wama could be considered. However, because orthopterans tend to be generalist defoliators care should be taken to secure rearing and to avoid any escape into crops where they

could become serious pests. However, better management of the harvesting of wild populations and more dependable supplies based on mass rearing will only be possible with more information about the biology of these species.

From the results collected we can conclude that entomophagy in the Wama communities although widespread among the children, is a tradition that is progressively weakened by changing lifestyles. Collection and preparation of insects is mostly considered a children activity in the Wama, and ordinarily insects are not included as a planned part of the diet like in other places, for example in Southern Nigeria, edible insects are conceived as food and source of nutrient and the Pedi of South Africa prefer certain of their traditional insects to meat (Banjo *et al*., 2006). Although entomophagy is not as well structured and integrated in the Wama as it is in other groups, since children are the most vulnerable group in terms of nutritional deficiencies, this activity may still have an important impact on the children who practice it, especially by diversifying their diet in times of food shortage. There is certainly an opportunity to research mass rearing of selected insects and should be conducted in conjunction with research on food quality and safety. If mini-livestock enterprises are to be established in Benin, it is necessary to consider the design, location and integration of these enterprises with other production systems and consider how farmers could augment their agricultural income.

c. Potential Applications

i. Edible insects as a response to food insecurity, particularly child malnutrition

Edible insects can be seen as a way to respond to the problem of inadequate nutritional intake. This can occur at different levels, with small scale and large scale propositions.

At the small community level, there are two solutions that could be encouraged. The first one is to develop awareness campaigns in order to maintain the tradition of entomophagy where it already exists. In fact, it would seem that entomophagy is practiced as a tradition, with limited knowledge of the nutritional benefits of the insects – although in the Wama communities there was a general belief that the insects were 'good for the children' and especially 'good for their growth'. These awareness initiatives can take the form of seminars or focus groups directed to the mothers, such as the focus groups concerning nutrition which are currently being established in Kotiakou by the Peace Corps. They could be designed to include the transmission of knowledge concerning the benefits of edible insects, hopefully translating into encouragement of entomophagy. Educational campaigns can also be addressed to children directly at school, in relation to subjects such as nutrition, health and/or traditions.

The second possibility could be to develop captive rearing facilities, in order to support consumption at local level. This could be supported by the faculty Agronomy, in the department of Nutrition and Food Sciences of the University of Abomey Calavi (UAC), which is interested in developing small scale projects, or under national or international entities aiming to expand entomophagy for local consumption. Nonetheless, this solution does not necessarily fit all insect consuming communities as they function today. For example, today, for the Wama people of Kosso and Kotiakou developing rearing facilities was not a priority. Dr Gbangboche of the Faculty of agronomy of the UAC suggests that it would be appealing to start pursuing these small scale projects in communities which have shown an interest in insect rearing, as has been found in the area of Lokoli, South of Benin. These could serve as pilot projects to demonstrate the feasibility of localised insect farms, and lessons learned from these experiences could inform future projects in other areas.

On a larger scale, there is an opportunity to develop an advanced insect industry. This would include steps such as a conducting a market research on the insects that would work better for expected and targeted consumers in order to fit different preferences. Hence, specific

species would be considered on the basis of the extent to of their acceptance by the consumers in terms of taste, appearance, and cultural acceptability. This aspect is particularly important, since the main adversity to insect is usually to its presentation as something that is unusual to their diets, as explained by Dr Gbangboche from the UAC. Based on these results, certain products can be designed, produced, packaged, marketed and distributed. Developing a supply chain of edible insects would be a complex issue, and would have to be complemented by a successful campaign promoting edible insects to overcome issues of perception.

Nonetheless, there also has to be a choice of products to develop in accordance with the established target groups. Will the establishment of an industry aim to serve the general population, or will it have specific objectives such as combating child malnutrition? For example, one of the most appealing suggested products aimed at malnourished children is an insect flour conceived to be integrated into the maize based gruel which is given in health clinics re-establishment of the children. It is currently fortified with peanuts or dry fish, but this could be replaced or complemented by protein rich insect flour. This is one of the ideas that might be pursued by the IITA, which has an interest in establishing an edible insect industry in the scope of combatting food insecurity. The flour would be sold or distributed to hospitals and medical centres. Hypothetically, hospitals could also have their own insect rearing and processing units. This idea nonetheless depends on whether the costs of the new insect flour or setting up the rearing facilities would be competitive.

ii. Edible insects as a means for agricultural diversification

On a small scale, collecting or rearing insects can be a source of agricultural diversification, and provide an additional source of income, as is demonstrated by the case of the termites. As described above, termites are the only insect currently sold in the *commune* of Tanguieta, and are found in many other places. They are appreciated for being high in lipids, but

on top of their culinary properties, they are also a source of income for the household, contributing to economic diversification. In fact, termite sellers do not depend solely on this activity, but this forms a complementary source of profit when available. This is particularly beneficial because it occurs in a period where crops are not yet ready for harvesting. This is made possible due to the fact that they are found in abundance, and therefore the volume of the termites collected is large enough to be sold at markets. Therefore, for economic benefits to be made from edible insects, quantity is essential, which can be achieved through rearing.

On the large scale, edible insects can also be a source of revenue, hence allowing some economic diversification in a country that strongly suffers from over-reliance on few sectors. Nonetheless, for the industry to be profitable, economies of scale have to be made, which calls for mass production, along with the possibility of preserving the products, and adequate storing facilities. This calls for large scale investments to cover the initial start-up costs. Fortunately, other countries, for example neighbouring Burkina Faso, have proved that the commercialisation of edible insects in Africa is possible and can be remunerative. It is therefore important for the private sector to get involved, in addition to other interested institutions, as the profitability of the project could generate a push for investment and innovation.

iii. Edible insects as a pest management solution

As stated above, in the literature entomophagy have been claimed as a potential means to help manage pests on agricultural crops. For example, in Thailand, insect consumption is also used as a strategy for insect pest control, the Patanga locust (*Patanga succincta* L.) is one of the best known and most popular edible insects. Consequently, this species is no longer a major pest for farmers, the high demand and price for *Patanga* locust lead some farmers to grow maize to feed this insect, rather than to harvest the maize (FAO, 2010b).

In the case of the Wama settlements, although most of the insects consumed were pests, these did not seem to be considered a major problem. None of the pests damaged crops to a significant extent; this is probably due to the mosaic structure and small scale of the local agriculture. When asked whether the insects where eaten in order to keep the numbers down, the answer was negative. In fact, one interviewee explained that, on the contrary, there had to be an effort to keep enough insects alive so that there can be enough to consume in the future. In the past the insect population had dwindled, and this had been seen as a problem by the community. Therefore, the Wama consider insects as a resource to be protected, and is managed communally by restraining depletion.

An example of pest management through - or complemented by - entomophagy is that of eating locusts, as occurs in many African countries where the sale of harvested and marketed locusts may yield more revenue for farmers than millet (van Huis, 2003). When asked whether the Wama had experienced locust invasions, the *délégué* of the village was not familiar with the French word for locusts, but seemed said that 'very big crickets' had arrived in large quantities only rarely in his lifetime[1], and had not been eaten. It would seem that locust invasions are not frequent enough to have developed a transmissible tradition around it. Hence, entomophagy as a pest control system does not seem to be applicable in the case of Northern Benin. Although locust invasions have been documented in other areas and *Locusta migratoria* is eaten in Pénélan (locality in central Benin) (LINCAOCNET, 2012), insect consumption does not seem to be used as a strategy for insect pest control in Benin.

[1] In fact, Benin escaped the Desert Locust invasion in 2004 which caused significant damage across West Africa, including neighbouring countries (IRIN, 2004)

VI. Barriers to the Development of Entomophagy

a. Loss of Tradition in Insect-eating Communities

One of the barriers to consider is the tendency of many Beninese to detach themselves from traditions which are not seen as 'modern'. As the majority of the Beninese population does not practice entomophagy, there is a certain degree of stigmatisation attached to the consumption of insects. It is seen as a 'rural' or 'backwards' practice, born out of times of poverty and isolation from 'modern life'. van Huis (2012) describes the phenomenon of not being proud of certain traditions as a 'minority complex', whereby certain cultures look up to Western lifestyles and hope to discard local practices. Interviewees claimed that, although in the village people felt comfortable eating insects, they did not necessarily feel at ease in telling non-insect consumers this. As urbanisation increases, insect-eating is often dropped when people migrate to the city. Out migration of young men is high within the Wama settlements, either to other Beninese cities or to neighbouring countries, mainly Nigeria, as there is not enough food to support all members of the family. This means that many will live in non-Wama communities, and might not educate their children to eat insects, either in the fear of attracting prejudice, or due to the lack of ownership or availability of fields and land where collection can take place.

b. Cultural Barriers Linked to Culinary Habits

As mentioned above, entomophagy is not practiced by the majority of the population, and many feel a certain aversion to the idea of eating insects. Even in the areas where entomophagy is practiced, each ethnic group is very specific about what species of insects they are willing to eat and in which way. Hence, there are significant cultural barriers preventing the expansion of edible insects. Nonetheless, there are examples of countries where entomophagy

has gained in popularity when appropriate approaches were followed (FAO, 2010b). It has been found that public demonstrations and trials of edible insects can be quite an effective way to promote these practices. For example, Dr Gbangboche of the UAC speaks of a very successful event held in Lokoli (South Benin) in the occasion of the International Woman's Day, where the group that ate *Rhychorphorus* larvae demonstrated of how they were collected and cooked, and were then made available for public to try. This attracted attention not only locally, but led different government members to follow up on the UAC's project on entomophagy. This can be done through information campaigns, but raising awareness on nutritional factors needs to be coupled with elements that make the products appealing. Benin is undergoing many changes, and in the last years has seen a vast range of new products enter the market. The successful ones were those that managed to meet expectations while remaining compatible with culinary uses. With appropriate market researches, appropriate products can be designed and promoted, to ensure coherent and successful results.

c. Government Involvement

Advocacy for entomophagy needs a concerted effort. This can be at several levels involving: (1) scientists and conservationists on the potential benefits of entomophagy from an energy and conservation perspective; (2) nutritionists on dietary advantages; (3) farmers to establish mini-livestock activities and (4) governments to implement policies and encourage the use of insects in feed and food.

At government level efforts are needed to include edible insects in their agenda on food security. Governments need to recognise the importance of entomophagy, and respond accordingly in terms of promoting research, involving relevant actors, and based on these efforts, formulate legislation relating to the handling of insects for consumption. This would permit the adoption of insects in national food policies. First of all, the government needs to

promote research on the value of entomophagy. For this further stimulation and facilitation of scientific research in cooperation with experts (agribusiness, research Institutes and hospitals) is required. An up-to-date inventory of entomophagous insects is required. This will involve both working with traditional landowners to obtain more information on which species they consider edible as well as information on their biology, collecting, preservation and cooking techniques. This has to be complemented with research on risks, rearing options, nutritional properties and other relevant aspects for the insects which are specific to Benin. Establishment of a global bank of edible insects may open new avenues in research and development, ultimately proving advantageous for food security projects. There is an urgent need to document information and traditional stories because the loss of local knowledge is a major issue.

Secondly, another important role of the government is to raise awareness and promote active involvement of stakeholders through the formulation of adequate policies. There are four main groups of stakeholders that can be identified: (1) traditional owners; (2) landowners (whether government or private); (3) industry (food production, processing and marketing); and (4) consumers. Promoting educational campaigns as well as concentrating efforts of popularising entomophagy through collaboration between nations as well as the local level should be initiated. Our experience in Benin points to the need for greater public-private partnership in research and development. Government could provide incentives to investors that come up with business ideas on the production/transformation/marketing of edible insects and encourage local development of on-farm production of such insects by collaborating with NGO's. For example in Australia the government has funded research on the breeding of the exotic snail *Helix aspera* for the restaurant trade and for personal consumption (Begg, 2006). In addition regulatory authorities and Universities in Laos encourage local farmers to develop on-farm insect rearing by teaching them how to build low cost mass rearing facilities.

From a legislative point of view, governments need to address aspects such as health and safety, environmental and animal welfare standards, availability and accessibility, and quality.

New standards have to be investigated and set due to dealing with a novel field of food production. Insects are still not considered a safe source of proteins for humans or livestock by the Standard Food Agency and the EU Commission (European Food Safety Authority). Novel food safety assessments and guidelines are required before a new protein source can be developed and transformed into a sellable product. It is the role of the governments to promote such research and push legislation to accept insects. Eventually, entomophagy could be included in the formulation of national scale policies of food security.

VII. Conclusions & Recommendations

The consumption of insects is not a major component of the diet in Benin today. It is confined to some groups, where it is in decline due to changing lifestyles as illustrated by this case study. The Wama eat a diverse and rich assembly of insects as identified by this study; however these are not integrated into their diet but rather considered a children snack.

There are enormous opportunities to develop and expand entomophagy in Benin on two levels: (1) human consumption of selected species; and (2) as a nutritive supplement in food for humans especially for malnourished children. Most edible insects are difficult to collect in large numbers, are unpredictable in their occurrence and inappropriate harvesting could result in significant damage to both their population numbers and their habitats. Mass rearing of edible insects would be the most appropriate solution to increase their availability. This involves research in raising insects from different habitats. Mass rearing and preparation of edible insects is a research area that could facilitate more cross-continental collaboration. There is an urgent need to document further information from Benin due to the progressive decline of traditional local knowledge, that could eventually be lost forever. There could be more edible species, and it is necessary to learn how the various groups found, collected and cooked them.

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