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REVIEW ARTICLE

INSECTS AS FOOD IN SUB-SAHARAN AFRICA

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Abstract—Data on insects as food in sub-Saharan Africa were collected by reviewing the literature and conducting interviews in a number of African countries. A list of about 250 edible insect species from Africa was compiled. Of these, 78 percent are Lepidoptera (30%), Orthoptera (29%) and Coleoptera (19%), and 22 percent Isoptera, Homoptera, Hymenoptera, Heteroptera, Diptera and Odonota. Insects are rich in protein, vitamins and minerals, and a good source of iron and B-vitamins. Examples of insects being toxic are given, but often traditional methods are used to remove the poison. Whether or not insects are eaten depends not only on taste and nutritional value, but also on customs, ethnic preferences or prohibitions. The harvesting of insects is often done by women. The way of collecting depends on insects' behaviour. For example, inactivity at low temperatures enables easy catching of locusts and grasshoppers in the morning. Night flyers (termites, some grasshoppers) can be lured into traps by light and some insects like palm weevils can be attracted to artificially created breeding sites. Some species (crickets, cicadas) can be located by the sound they make. A number of tools are used to facilitate capturing such as glue, sticks, nets and baskets. Because most insects are only seasonally available, preservation by drying is often practised. Some examples of how to prepare them as food are given from important insect groups.

To manage insects in the interest of food security more attention should be given to environmentally sustainable harvesting methods. They should be made better available throughout the year by developing improved conservation methods or by farming this minilivestock. Considering the economic, nutritional and ecological advantages of this traditional food source, its promotion deserves more attention both from national governments and assistance programmes.

Key Words: sub-Saharan Africa, entomophagy, edible insects, insects as food

Résumé—Des données sur le rôle des insectes dans l'alimentation humaine ont été collectées dans la littérature et lors d'enquêtes effectuées dans un certain nombre de pays africains. Une liste d'environ 250 insectes comestibles a été établie. Soixante dix-huit pour cent sont des Lépidoptères (30%), Orthoptères (29%) et Coléoptères (19%) et 22% sont des Isoptères, Homoptères, Hyménoptères, Hétéroptères, Diptères et Odonotes. Les insectes sont riches en protéines, vitamines et minéraux et sont des sources importantes de fer et de vitamine B. Des examples d'insectes toxiques sont cités mais dans de nombreux cas des méthodes traditionnelles sont utilisées pour éliminer les toxines. Les insectes sont consommés ou non en fonction des traditions, des préférences ethniques ou des interdictions. La récolte des insectes est souvent effectuée par les femmes. La façon de récolter dépend du comportement des insectes, par exemple, l'inactivité de certains insectes à basse température (criquets et sauterelles) les rend vulnérables à la récolte le matin; les insectes nocturnes volants

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(termites, certaines sauterelles) peuvent être piégés avec la lumière; certains insectes tels que les vers du palmier peuvent être attirés par des sites de pontes artificiels; les insectes chanteurs (criquet, cigales) peuvent être localisés par les sons qu'ils produisent. Un certain nombre d'outils, tels que la glue, des bâtons, des filets et des paniers peuvent être utilisés pour faciliter la capture. Certains insectes étant disponibles seulement à certaines saisons, la conservation par séchage et souvent pratiquée. Des exemples de recettes d'insectes sont donnés pour les groupes d'insectes les plus importants.

L'exploitation des insectes dans une optique de sécurité alimentaire demande qu'une attention particulière soit portée aux méthodes de récolte respectueuses de l'environnement. Les insectes comestibles devraient être disponibles tout au long de l'année par l'amélioration des méthodes de conservation ou par création de mini élevages de ces arthropodes. Au vu des avantages tant économiques, nutritionnels qu'écologiques, la promotion de cette source alimentaire traditionnelle mérite une attention plus grande de la part des gouvernements nationaux et des programmes de coopération pour le développement.

Mots Clés: insectes comestibles, Afrique sub-saharienne, entomophagie

Introduction

Insects are eaten as a delicacy in many parts of the world, particularly in the tropics. In contrast, people in most of the Western world tend to see human entomophagy as an aberration. They are very reluctant to even consider eating insects, and often associate it with primitive or barbaric attitudes. This may be the reason that such traditional foods have received very little attention in assistance programmes on food security. DeFoliart (1999) mentioned in his overview of insects as food that "Westerners should become aware of the fact that their bias against insects as food has an adverse impact, resulting in a gradual reduction in the use of insects without replacement of lost nutrition and other benefits". Ramos-Elorduy (1990) also indicated that "Insects have long been a significant dietary factor in the poorer regions of the world, and it is high time that scientists recognise this fact and begin to build on it, rather than discouraging or ignoring the practice".

One of the reasons that entomophagy in the Western civilisation is rare may be that only in tropical zones are insects available seasonally in large numbers and can therefore be gathered; in temperate zones there are too few of them. In the event that they are more plentiful, they may be more readily consumed in temperate zones as well. One example exists in the Netherlands: when outbreaks of the oak processionary caterpillar (*Thaumetopoea processionea* Linn.) occurred in 1995 and 1996 (Stigter et al., 1997), it was put on the menu of one restaurant. The prejudice against eating insects is not justified from a nutritional point of view. Insects are not inferior to other sources of protein such as fish, chicken or beef. The bias has caused people in Western civilisations to believe that the eating of insects in the developing world is prompted by starvation—that overcoming the aversion to use insects as food is a survival tactic.

In this article we argue that the eating of insects is common practice in sub-Saharan Africa, and that this traditional food source deserves more attention. It deals with the history of eating of insects in Africa, the large variety of species eaten, the toxicity of some edible insects, the importance of edible insects in the diet, their nutritional value, the gathering techniques, and the preparation, conservation and marketing in different parts of Africa. It is also argued that this local traditional food source has been neglected in the past and should receive more attention in the future, in particular on how to manage this sustainable food source in the interest of food security.

Materials and Methods

The information presented here was collected by reviewing the literature and by personal interviews. The interviews were conducted in the years 1995 and 2000 and concentrated on the traditional, nutritional and medical uses of arthropods and their products as well as on their role in religion, witchcraft, art, song, music, dance, children's games, mythology and literature. Some of the results obtained in 1995 have been published (van Huis, 1996). In total, 308 persons from 27 countries in West, East and southern Africa were interviewed: Benin 19 persons (6

ethnic groups or tribes / sub-tribes), Burundi 2 (2), Burkina Faso 5 (2); Cameroun 30 (14), Central African Republic 2 (2), Congo 2 (2), Chad 17 (10); Gambia 2 (2); Guinea Bissau 1; Kenya 13 (5); Madagascar 24; Malawi 1; Mali 10 (7); Mozambique 8 (7); Namibia 1; Niger 15 (6); Nigeria 18 (4); Rwanda 1; Senegal 17 (7); South Africa 6 (1); Sudan 23 (11); Togo 11 (5); Uganda 15 (8); Zambia 23 (9); Zanzibar 9 (1); and Zimbabwe 13 (3). To avoid misunderstandings about the identity of the arthropod species or taxa, most of the people interviewed were scientists or technicians trained in entomology. When there was doubt, pictures from books were used or insect museum collections were consulted. Twenty-two of those interviewed acted as resource persons on specialised areas (e.g. termites, insects as food or medicine). These included 2 from Cameroon, 2 Kenya, 5 from South Africa, 8 from Sudan, 3 from Togo, 3 from Zambia, and 1 from Zimbabwe. In these cases the ethnic origin of the information was not considered relevant. The remaining 286 persons came from about 125 different ethnic groups or (sub)tribes (which at times crossed political borders).

Findings for a particular country or tribe were only specified if information was received from more than one informant, or if the information given during interviews was confirmed in the literature. When a country and tribe are mentioned, it is just an indication that an informant from that tribe provided this information. Therefore, generalisations for tribes or countries cannot and should not be made. The qualitative character of the information provided is emphasised. When literature sources used local insect names, these records were not taken into account.

A number of insects are eaten for medical purposes. Such practices have not been included in this overview. Some insect products which are eaten (honey, termite soil, lerp), are only mentioned a few times. The use of insects as food for livestock has not been included.

For the taxonomic status (order, family) of the insect species mentioned in this article, see Table 1. When no literature reference is indicated in this table, it means that information was collected by the author. Bergier (1941), Bodenheimer (1951), Netolitzky (1919) and Silow (1976) are used in the table as reference when they cite very early references from difficult accessible sources. Valid (most recent) species names are used, and only for some well-known species, old names are added in brackets. Contrary to International Code of Zoological Nomenclature convention, the names of the authors are not parenthesised to indicate a species and genus combination that is different from the one used for the original description, as it would have required an inordinate amount of bibliographic searching to ascertain the historical status of names and accurate use of parentheses. For some insect species encountered in the literature an author name could not be found. In the table only one superfamily (Acridoidea) is mentioned (in parentheses); subfamilies are indented.

History

Early hominids, either *Homo* or *Australopithecus robustus* in southern Africa, used bones as tools to harvest termites from their nests for nearly a million years (Blackwell and d'Errico, 2001). This was concluded from wear patterns on the purported bone tools. They drove the bones down into the termite hills, forcing the termites to come out, then collected them. Although capture by destruction of the termite hill is also possible, Joulian and Roulon-Doko (1994) describe more sophisticated techniques used by the Gbaya in the Central African Republic and by chimpanzees (*Pan troglodytes*) in Tanzania. Quin (1959, p. 111–112) states that termites appear to be of greater significance in primitive diets than ants. Ledger (1971) also found at Melville koppies in South Africa, that from 100.000 BC till recent termites and bees were of possible food value to man. He listed two termites species, *Trinivitermes trinervoides* and *Hodotermes mossambicus*, and the wild honeybee *Apis mellifera unicolor*.

The greek historian Diodorus described an Ethiopian community of acridophagi (locust eaters) in the first century BC and recalls that this group attempted to preserve the locusts in salt for times of scarcity (Brothwell and Brothwell, 1998). Sutton (1990) asked the question why females eat more insects than males in human populations and higher primates. He argues that early hominid males controlled the procurement of vertebrate meat. Therefore, females having less access to vertebrate protein and needing it because of their childbearing responsibilities, compensated by collecting edible insects as part of their normal gathering routine.

That insects were an important food resource for early hominids is beginning to be appreciated,

and that they still are for humans is increasingly being recognised.

How Many Insect Species Are Eaten?

DeFoliart (1997) assumed the number of insect species to be eaten worldwide to be about 1000, of which in African countries: 30 in Congo, 22 in Madagascar, 36 in South Africa, 62 in the Democratic Republic of Congo (D.R. Congo), and 32 in Zimbabwe. Ramos-Elorduy (1997) mentioned 1391 insect species eaten worldwide, of which 524 are eaten in 34 countries of Africa representing 38% of all species consumed. She listed as most important countries the Central Republic of Africa with 185 species, D.R. Congo with 51, and Zambia with 33. Probably these are conservative estimates as little research on human entomophagy has been conducted in sub-Saharan Africa. In countries where intensive research has taken place, the numbers are impressive. For example, Ramos-Elorduy (1997) in Mexico listed 348 species, which is the highest number recorded for one country in the world. Similarly, Malaisse (1997), after intensive studies in the region inhabited by the Bemba (Bantu-speaking people inhabiting the northeastern plateau of Zambia and neighbouring areas of the D.R. Congo and Zimbabwe), listed only 38 different species of caterpillars. The first systematic studies in Africa were carried out by Bodenheimer (1951) and Silow (1976), with the latter concentrating on mid-western Zambia. The higher number of edible insect species (524) mentioned by Ramos-Elorduy (1997) for Africa compared to the number mentioned in this article (246) is that we only took into account records of scientific names.

From the 1391 species listed by Ramos-Elorduy (1997), most belong to the Coleoptera (24%), followed by the Hymenoptera (22%), Orthoptera (17%), Lepidoptera (16%), Heteroptera (7%), Homoptera (5%), Isoptera (3%), Diptera (2%), and others (4%). By reviewing the literature and from our own observation we arrived at a list of 246 species (most at species and only a few at genus or family level) eaten in sub-Saharan Africa (Table 1). Of these, the majority are Lepidoptera (30%), Orthoptera (29%) and Coleoptera (19%); below 10% are the Homoptera (7%), Isoptera (6%), Hymenoptera (5%), Heteroptera (3%), Diptera and Odonota (1%) (Fig. 1). For the Gbaya in the Central African Republic with 96 edible insect species, the Orthoptera and the Lepidoptera were also the most important, viz.: locusts and grasshoppers (40%), caterpillars (36%), termites (10%), beetles (6%), and others such as cicadas and crickets (8%) (Roulon-Doko, 1998). Comparing our data of the percentage of edible insect species recorded for sub-Saharan Africa (Fig. 1) with those recorded worldwide (Ramos-Elorduy, 1997), we find differences in the sense that in sub-Saharan Africa the Coleoptera and Lepidoptera are almost twice as frequently recorded, and the hymenopterous species more than four times less so.

How Nutritious Are Insects?

The nutritional value (amount of proteins, fat, vitamins and calories) of insects compares very favourably with that of meat and fish (Nkouka, 1987). Insects contain a high amount of crude protein. In g/100 g dry weight, caterpillars contain 50–60, palm weevil larvae 23–36, Orthoptera 41–91, ants 7–25, and termites 35–65 (Bukkens, 1997). One hundred grams of caterpillars provide 76%

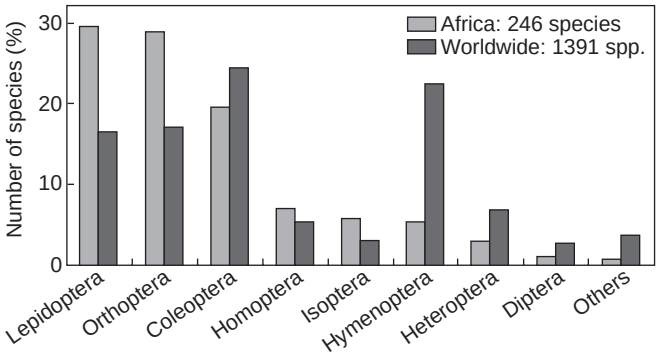

Fig. 1. The percentage of insect species per order eaten worldwide. (Source: Ramos-Elorduy (1997) and in sub-Saharan Africa (this article)

Table 1. List of arthropod species consumed in sub-Saharan Africa

Order/Family/ Subfamily	Species	Countries and Reference
Coleoptera:		
Curculionidae	*Eugnoristus monachus* Oliv.	Madagascar (Bodenheimer, 1951)
	Rhyna sp.	Madagascar (Bodenheimer, 1951)
	Rhynchophorus sp.	Madagascar (Bodenheimer, 1951)
	Rhynchophorus phoenicis Fabr.	Angola (Santos Oliveira et al., 1976), Cameroun (Bodenheimer, 1951), Congo (Bani, 1995; Nkouka, 1987; Takeda, 1990), Nigeria (Fasoranti and Ajiboye, 1993)
	Polyclaeis equestris Boheman	South Africa (Quin, 1959)
	P. plumbeus Guerin	South Africa (Quin, 1959)
	Sipalinus aloysii-sabaudiae Camerano	Tanzania (Bodenheimer, 1951; Harris, 1940)
Carabidae	*Scarites* sp.	Angola (Bergier, 1941), Madagascar (Decary, 1937)
Buprestidae	*Sternocera funebris* Boheman	Zimbabwe (Chavanduka, 1976; Gelfand, 1971)
	S. interrupta Oliv.	Cameroun (Seignobos et al., 1996)
	S. orissa Buq.	Botswana (Nonaka, 1996), South Africa (Bodenheimer, 1951; Quin, 1959), Zimbabwe (Chavanduka, 1976; Gelfand, 1971)
Cerambycidae	*Acanthophorus maculatus* Lameere	Zambia (Mbata, 1995)
	A. capensis White	Zambia (Mbata, 1995)
	A. confinis Laporte	Zambia (Mbata, 1995)
	Ancylonotus tribulus Fabr.	Gabon and Senegal (Netolitzky, 1919), West Africa (Bergier, 1941)
	Ceroplesis burgeoni Breuning	Southern Africa (Malaisse, 1997)
	Dorysthenes forficatus Fabr.	North Africa (Ghesquière, 1947)
	Mallodon downesi Hope	Central Africa (Bergier, 1941), South Africa (Bodenheimer, 1951)
	Macrotoma edulis Karsch	Sao Tomé and Principe (Netolitzky, 1919)
	M. natala Thomson	Botswana (Roodt, 1993)
	Petrognatha gigas Fabr.	Gabon (Bergier, 1941), Senegal (Netolitzky, 1919)
	Plocaederus frenatus Fåhraeus	Central Africa (Bergier, 1941)
	Pycnopsis brachyptera Thomson	D.R. Congo (Malaisse, 1997)
	Sternotomis itzingeri katangensis Allard	D.R. Congo (Malaisse, 1997)
	Zographus aulicus Bertolini	D.R. Congo (Malaisse, 1997)
Dytiscidae	*Cybister hova* Fairm.	Madagascar (Decary, 1937)
Elateridae	*Tetralobus flabellicornis* Linn.	Central Africa (Bodenheimer, 1951)
Lucanidae	*Cladognathus serricornis* Latr.	Madagascar (Decary, 1937)
Passalidae	sp.	Madagascar (Bodenheimer, 1951)
Scarabaeidae		
Cetoniinae	*Goliathus cacicus* Voet	Central Africa (Bergier, 1941)
	G. regius Klug	Central Africa (Bergier, 1941)
	G. cameronensis	Central Africa (Bergier, 1941)
	G. goliathus D.R.ury	Central Africa (Bergier, 1941)
Dynastinae	*Augosoma centaurus* Fabr.	Cameroun (Bodenheimer, 1951), Congo (Bani, 1995; Nkouka, 1987), D.R. Congo (Takeda, 1990)
	Oryctes boas Fabr.	Congo (Bani, 1995; Nkouka, 1987), Nigeria (Fasoranti and Ajiboye, 1993), South Africa (Bergier, 1941; Netolitzky, 1919)
	O. monocerus Oliv.	South Africa (Bergier, 1941; Netolitzky, 1919)
	O. nasicornis Linn.	Madagascar (Bergier, 1941)
	O. owariensis Palisot	Congo (Bani, 1995; Nkouka, 1987), South Africa (Bergier, 1941; Netolitzky, 1919)
Melolonthinae	*Lepidiota mashona* Arrow	Zimbabwe (Chavanduka, 1976; Gelfand, 1971; Weaving, 1973)

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Order / Family / Subfamily	Species	Countries and Reference
	L. anatina Brenske	Zimbabwe (Chavanduka, 1976)
	L. nitidicollis Kolbe	Zimbabwe (Chavanduka, 1976)
	Proagosternus sp.	Madagascar (Decary, 1937)
	Tricholespis sp.	Madagascar (Decary, 1937)
Rutelinae	*Popillia femoralis* Klug	Cameroun (Bodenheimer, 1951)
Scarabaeinae	*Pachylomera femoralis* Kirby	Zambia (Mbata, 1995)
Trichiinae	*Platygenia* spp.	Africa (Ghesquière, 1947)
	P. barbata Afzelius	D.R. Congo (AD.R.iaens, 1951)
Tenebrionidae	xylophagus insects	Congo (Nkouka, 1987)
Diptera:		
Chaoboridae	*Chaoborus edulis* Edwards	East African lakes (Bergier, 1941; Owen, 1973), Tanzania (Bodenheimer, 1951; Harris, 1940), Uganda, Kenya
	C. pallidipes Theob.	Uganda (Bergier, 1941)
	Chaoborus sp.	East African lakes (Bergier, 1941)
Heteroptera:		
Belostomatidae	*Belostoma* sp.	Congo (Bani, 1995; Nkouka, 1987)
Coreidae	*Petascelis remipes* Signoret	Zimbabwe (Chavanduka, 1976; Weaving, 1973)
	P. wahlbergi Stål	Zimbabwe (Chavanduka, 1976)
Nepidae	*Nepa* sp.	Madagascar (Decary, 1937)
Pentatomidae	*Agonoscelis versicolor* Fabr.	Sudan
Tessaratomidae	*Natalicola delegorguei* Spin.	South Africa (Faure, 1944), Zimbabwe (Chavanduka, 1976; Bodenheimer, 1951)
	N. pallidus Westwood	Zimbabwe (author, Weaving, 1973)
Homoptera:		
Cicadidae	*Afzeliada* sp.	Congo (Nkouka, 1987)
	Afzeliada afzelii Stål	D.R. Congo (Malaisse, 1997)
	Afzeliada duplex Diabola	D.R. Congo (Malaisse, 1997)
	Ioba horizontalis Karsch	D.R. Congo (Malaisse, 1997)
	I. leopardina Distant	D.R. Congo (Malaisse, 1997), Zambia (Mbata, 1995), Zimbabwe (Chavanduka, 1976; Malaisse, 1997)
	Monomatapa insignis Distant	Botswana (Roodt, 1993)
	Munza furva Distant	D.R. Congo (Malaisse, 1997)
	Orapa sp.	Botswana (Roodt, 1993)
	Platypleura adouma Distant	Congo (Nkouka, 1987)
	P. stridula Linn.	Zambia (Mbata, 1995)
	Sadaka radiata Karsch	D.R. Congo (Malaisse, 1997)
	Ugada limbalis Karsch	Congo (Nkouka, 1987), D.R. Congo (Malaisse, 1997), Zambia (Mbata, 1995)
	U. giovanninae Boulard	Congo (Nkouka, 1987)
	U. limbimaculata Karsch	Congo (Nkouka, 1987), D.R. Congo (Malaisse, 1997)
Flatidae	*Phromnia rubra* Signoret[1]	Madagascar (Decary, 1937)
Fulgoridae	*Pyrops tenebrosa* Fabr.	Madagascar (Decary, 1937)
Psyllidae	*Arytaina mopane* Pettey[1]	Botswana (Sekhwela, 1988), Zimbabwe (Weaving, 1973)
Hymenoptera:		
Apidae	*Apis adansoni* Latr.	D.R. Congo (Takeda, 1990), Tanzania (Harris, 1940), Zambia (Mbata, 1995)
	Apis mellifira Linn.	Senegal (Gessain and Kinzler, 1975), Zambia (Mbata, 1995)
	Dactylurina staudingeri Gribodo	D.R. Congo (Takeda, 1990)
	Trigona sp.	D.R. Congo (Takeda, 1990)
	T. ferruginea gambiensis Moure	Senegal (Gessain and Kinzler, 1975)
	T. occidentalis Darchen	Senegal (Gessain and Kinzler, 1975)
	T. ruspolii Mag.	Senegal (Gessain and Kinzler, 1975)
	T. senegalensis Darchen	Senegal (Gessain and Kinzler, 1975)

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Order/Family/ Subfamily	Species	Countries and Reference
Formicidae	*Anomma nigricans* Illiger (eggs)	Cameroun (author)
	Oecophylla spp.	Cameroun, Congo (Bani, 1995; Nkouka, 1987)
	Camponotus sp.	Botswana (Nonaka, 1996)
	Carebara vidua Smith	South Africa (Bodenheimer, 1951; Quin, 1959), Zambia (Mbata, 1995; Silow, 1983), Zimbabwe (Chavanduka, 1976; Jackson, 1954 in Gelfand, 1971)
	C. lignata Westwood	Southern Africa (author)
Isoptera:		
Macrotermitidae	*Acanthotermes* spp.	Tanzania (Bodenheimer, 1951; Harris, 1940)
	A. militaris Hagen	Angola (Silow, 1983)
	A. spiniger Sjöstedt	D.R. Congo (Bequaert, 1921), Zambia (Silow, 1983)
	Hodotermes mossambicus Hagen	Botswana (Grivetti, 1979; Nonaka, 1996)
	Macrotermes spp.	D.R. Congo (Takeda, 1990), Tanzania (Bodenheimer, 1951; Harris, 1940), Zimbabwe (Jackson,1954 in Gelfand, 1971)
	M. bellicosus Smeathman	CAR (Roulon-Doko, 1998), Congo (Nkouka, 1987), Malaisse (1997), D.R. Congo (Bequaert, 1921), Nigeria (Fasoranti and Ajiboye, 1993)
	M. falciger Gerstäcker	Zambia (Mbata, 1995; Silow, 1983), Malaisse (1997), Zimbabwe (Chavanduka, 1976)
	M. subhyalinus Rambur	Angola (Santos Oliveira et al., 1976), Zambia (Mbata, 1995; Silow, 1983), Malaisse (1997)
	M. swaziae Full	South Africa (Bodenheimer, 1951)
	M. vitrialatus Sjöstedt	Zambia (Mbata, 1995; Silow, 1983)
	Microhodotermes viator Latr.	South Africa (Bodenheimer, 1951)
	Odontotermes sp.	Zimbabwe (Weaving, 1973)
	O. badius Haviland	South Africa (Quin, 1959), Zambia (Silow, 1983)
	Termes spp.	Tanzania (Bodenheimer, 1951; Harris, 1940)
Lepidoptera:		
Eupterotidae	*Strichnopteryx edulis* Boisduval	Southern Africa (Bergier, 1941)
Hesperidae	*Coeliades libeon* Druce	Congo (Bani, 1995; Nkouka, 1987)
Lasiocampidae	*Catalebeda jamesoni* B.-Bak.	Zambia (Silow, 1976)
	Bombycomorpha pallida Distant	South Africa (Quin, 1959),
	Borocera madagascariensis Boisduval	Madagascar (Decary, 1937)
	Brachiostegia sp.	Zimbabwe (Bodenheimer, 1951)
	Gonometa postica Walker	South Africa (Quin, 1959), Zambia (Silow, 1976)
	Mimopacha aff. *knoblauchi* Dew.	Central Africa (Silow, 1976)
	Pachypasa bilinea Walker	Zambia (Silow, 1976)
Limacodidae	sp.	D.R. Congo (Malaisse and Parent, 1980)
Noctuidae	*Nyodes prasidones* Prout	D.R. Congo (Malaisse and Parent, 1980)
	Sphingomorpha chlorea Cr.	Zambia (Silow, 1976)
	Spodoptera exempta Walker	Zambia (Mbata, 1995)
	S. exigua Hübner	Zambia (Mbata, 1995)
Notodontidae	*Antheua insignata* Gaede	D.R. Congo (Malaisse and Parent, 1980),
	Elaphrodes lactea Gaede	D.R. Congo (Malaisse, 1997; Malaisse and Parent, 1980)
	Desmeocraera sp.	Zambia (Silow, 1976)
	D.R.apetides uniformis Swinhoe	D.R. Congo (Malaisse and Parent, 1980)
Notodontinae	*Amerila madagacariensis*	Madagascar (Decary, 1937)
	Nephela comma Hopffer	Zambia (Silow, 1976)

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Order/Family/ Subfamily	Species	Countries and Reference
	Rhenea mediata Walker	D.R. Congo (Malaisse and Parent, 1980)
	spp. (2)	D.R. Congo (Malaisse and Parent, 1980)
Thaumetopoeinae	*Anaphe* sp.	Congo (Bani, 1995), D.R. Congo (Latham, 1999; Takeda, 1990), Equatorial Africa (Bergier, 1941)
	A. gribodoi	D.R. Congo (Takeda, 1990)
	A. panda Boisduval	D.R. Congo (Malaisse and Parent, 1980; Takeda, 1990), Tanzania
	(*A. infracta*)	(Bodenheimer, 1951; Harris, 1940), Zambia (Silow, 1976)
	A. venata Butler	Nigeria (Ashiru, 1988), Zambia (Silow, 1976)
	Hypsoïdes cajani Vinson	Madagascar (Decary, 1937)
	H. diego Coquerel	Madagascar (Decary, 1937)
	H. radama Coquerel	Madagascar (Decary, 1937)
	spp. (2)	D.R. Congo (Malaisse and Parent, 1980)
Psychidae	*Deborrea malgassa* Heylaerts	Madagascar (Decary, 1937)
	Eumeta cervina Druce. (=*Clania moddermanni*)	Equatorial Africa (Bergier, 1941)
Saturniidae	*Anthocera teffraria*	Gabon (Bergier, 1941)
	Athletas gigas Sonthonnax	D.R. Congo (Malaisse and Parent, 1980)
	Athletas semialba Sonthonnax	D.R. Congo (Malaisse and Parent, 1980)
	Bunaea alcinoë Stoll	Cameroun/D.R. Congo/Gabon/Zambia (Silow, 1976),
	(=*B. caffraria* Stoll)	D.R. Congo (Malaisse and Parent, 1980), Tanzania (Bodenheimer, 1951; Harris, 1940), Zimbabwe (Chavanduka, 1976; Weaving, 1973), Zambia (Silow, 1976), southern Africa
	Cinabra hyperbius Westwood	D.R. Congo (Malaisse and Parent, 1980), Zambia (Silow, 1976)
	Cirina forda Westwood	Burkina Faso, D.R. Congo (Latham, 1999; Leleup and Daems, 1969), Zambia (Mbata, 2002)
	(=*C. butyrospermi* Vuillot)	Malaisse and Parent (1980), Mali (Bergier, 1941), Nigeria (Fasoranti and Ajiboye, 1993), South Africa (Quin, 1959), Southern Africa (Oberprieler, 1995), Zambia (Silow, 1976), Zimbabwe (Chavanduka, 1976)
	Gonimbrasia aurantiaca Rothschild	D.R. Congo (Leleup and Daems, 1969; Malaisse and Parent, 1980), Zambia (Silow, 1976)
	G. belina Westwood	Malawi (Munthali and Mughogho, 1992), South Africa (Bodenheimer, 1951; Quin, 1959), Southern Africa (Oberprieler, 1995), Zambia (Mbata, 1995; Silow, 1976), Zimbabwe (Chavanduka, 1976)
	G. hecate Rougeot	D.R. Congo (Malaisse and Parent, 1980)
	G. tyrrhea Cramer	Namibia (Oberprieler, 1995)
	G. zambesina Walker	D.R. Congo (Malaisse and Parent, 1980), Zambia (Mbata, 2002; Silow, 1976)
	Goodia kuntzei Dewitz	D.R. Congo (Malaisse and Parent, 1980)
	Gynanisa ata Strand	D.R. Congo (Malaisse and Parent, 1980)
	G. maia Klug.	Malawi (Munthali and Mughogho, 1992), Namibia (Oberprieler, 1995), South Africa (Quin, 1959), Zambia (Mbata, 2002; Oberprieler, 1995; Silow, 1976)
	Heniocha dyops Maassen and Weymar	Southern Africa (Marais, 1996; in Illgner and Nel, 2000)

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Order/Family/ Subfamily	Species	Countries and Reference
	Holocerina agomensis Karsch	Zambia (Silow, 1976)
	Imbrasia dione Fabr.	D.R. Congo (Malaisse and Parent, 1980; Takeda, 1990)
	I. cytherea Fabr.	Zambia (Silow, 1976)
	I. epimethia Drury	Congo (Bani, 1995), D.R. Congo (Kodondi et al., 1987; Malaisse and Parent, 1980), Zambia (Mbata, 2002; Silow, 1976), Zimbabwe (Gelfand, 1971; Weaving, 1973),
	I. ertli Rebel	Angola (Santos Oliveira et al., 1976), D.R. Congo (Latham, 1999), Southern Africa (Oberprieler, 1995)
	I. macrothyris Rothchild	D.R. Congo (Malaisse and Parent, 1980)
	I. obscura Butler	Congo (Bani, 1995)
	I. (=Nudaurelia) oyemensis	Congo (Bani, 1995), D.R. Congo (Kodondi et al., 1987)
	I. rectilineata Sonthoanax (=*Gonimbrasia richelmanni* Weymer)	D.R. Congo (Malaisse, 1997; Malaisse and Parent, 1980)
	I. rubra Bouvier	D.R. Congo (Malaisse and Parent, 1980), Zambia (Mbata, 2002)
	I. truncata Aurivillius	Congo (Bani, 1995), D.R. Congo (Kodondi et al., 1987)
	Lobobunaea goodi Holland	D.R. Congo (Takeda, 1990)
	L. phaedusa Drury	D.R. Congo (Latham, 1999)
	L. angasana Westwood	D.R. Congo (Malaisse and Parent, 1980), Zambia (Silow, 1976)
	Melanocera menippe Westwood	Gabon (Bergier, 1941)
	M. parva Rothchild	D.R. Congo (Malaisse and Parent, 1980), Zambia (Silow, 1976)
	Micragone ansorgei Rothchild	D.R. Congo (Malaisse, 1997), Zambia (Silow, 1976)
	M. herilla Westwood	Cameroun (Bodenheimer, 1951)
	M. cana Aurivillius	D.R. Congo (Malaisse and Parent, 1980)
	Micragone sp.	Equatorial Africa (Bergier, 1941)
	Pseudantheraea discrepans Butler	D.R. Congo (Leleup and Daems, 1969; Silow, 1976; Takeda, 1990)
	Saturnia marchii	Gabon (Bergier, 1941)
	Saturnia sp.	D.R. Congo (Takeda, 1990)
	Tagoropsis flavinata Walker	D.R. Congo (Malaisse and Parent, 1980)
	Urota sinope Westwood	D.R. Congo (Malaisse and Parent, 1980), Gabon (Bergier, 1941), southern Africa
	Usta wallengrennii Felder	Namibia (Oberprieler, 1995)
	U. terpsichore Maassen and Weymer	Angola (Santos Oliveira et al., 1976), D.R. Congo (Malaisse and Parent, 1980)
Sphingidae	*Herse convolvuli* Linn.	Botswana (Nonaka, 1996), South Africa (Quin, 1959), Zambia (Silow, 1976)
Odonata:	larvae	Madagascar (Decary, 1937)
	adults	Nigeria (Bodenheimer, 1951)
	Trithemis arteriosa Burmeister	D.R. Congo (Malaisse, 1997)
Orthoptera:		
Acrididae (Acridoidea)	*Acanthacris ruficornis* Fabr.	Sahel, Congo (Bani, 1995, Nkouka, 1987), Niger (Lévy-Luxereau, 1980), Zambia (Mbata, 1995), Zimbabwe (Chavanduka, 1976)
	A. ruficornis citrina Serville	Cameroun (Barreteau, 1999)
	Acorypha clara Walker	Cameroun (Barreteau, 1999)
	A. nigrovariegata Bolivar	Zambia (Mbata, 1995)

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Order / Family / Subfamily	Species	Countries and Reference
	A. glaucopsis Walker	Cameroun (Barreteau, 1999)
	A. picta Krauss	Cameroun (Barreteau, 1999)
	Acrida bicolor Thunberg	Cameroun (Barreteau, 1999), Zimbabwe (Chavanduka, 1976)
	A. sulphuripennis Gerstäcker	Zambia (Mbata, 1995)
	A. turrita Linn.	Cameroun (Barreteau, 1999)
	Acridoderus strenuus Walker	Niger (Lévy-Luxereau, 1980), Sahel
	Acrotylus blondeli Saussure	Niger (Lévy-Luxereau, 1980)
	A. longipes Charpentier	Niger (Lévy-Luxereau, 1980)
	Afroxyrrhepes procera Burmeister	Congo (Nkouka, 1987)
	Anacridium burri Dirsh	Southern Africa (Malaisse, 1997)
	Anacridium melanorhodon Walker	Cameroun (Barreteau, 1999), Niger (Lévy-Luxereau, 1980), Sahel
	A. wernerellum Karny	Niger (Lévy-Luxereau, 1980), Sahel
	Brachycrotaphus tryxalicerus Fischer	Cameroun (Barreteau, 1999)
	Cataloipus fuscocoeruleipus Sjöstedt	Sahel
	C. haemorrhoidalis Krauss	Niger (Lévy-Luxereau, 1980)
	C. cymbiferus Krauss	Cameroun (Barreteau, 1999)
	Chirista compta Walker	Congo (Nkouka, 1987)
	Cyathosternum spp.	Zimbabwe (Gelfand, 1971)
	Cyrtacanthacris aeruginosas Stoll	Nigeria (Fasoranti and Ajiboye, 1993), Zambia (Mbata, 1995)
	C. tatarica Linn.	Botswana (Nonaka, 1996), Zambia (Mbata, 1995)
	Diabolocatantops axillaris Thunberg	Cameroun (Barreteau, 1999), Niger (Lévy-Luxereau, 1980), Sahel
	Exopropacris modica Karsch	Cameroun (Barreteau, 1999)
	Gastrimargus africanus Saussure	Cameroun (Barreteau, 1999), Congo (Nkouka, 1987), Niger (Lévy-Luxereau, 1980), Sahel
	G. procerus Gerstäcker	Cameroun (Barreteau, 1999), Niger (Lévy-Luxereau, 1980)
	Harpezocatantops stylifer Krauss	Cameroun (Barreteau, 1999), Niger (Lévy-Luxereau, 1980)
	Heteracris pulchripes guineensis Krauss	Congo (Nkouka, 1987)
	Hieroglyphus daganensis Krauss	Sahel Africa
	Homoxyrrhepes punctipennis Walker	Cameroun (Barreteau, 1999)
	Humbe tenuicornis Schaum	Niger (Lévy-Luxereau, 1980)
	Kraussaria angulifera Krauss	Cameroun (Barreteau, 1999), Sahel
	Krausella amabile Krauss	Cameroun (Barreteau, 1999)
	Lamarckiana cucullata Stoll	Botswana (Nonaka, 1996)
	Locusta migratoria capito Sauss.	Madagascar (Decary, 1937)
	Locusta migratoria migratoriodis	Cameroun (Barreteau, 1999), Congo (Nkouka, 1987), Tanzania (Bodenheimer, 1951; Harris, 1940), Zambia (Mbata, 1995), Zimbabwe (Chavanduka, 1976; Gelfand, 1971)
	Locustana pardalina Walker	South Africa (Quin, 1959), southern Africa, Zambia (Mbata, 1995)
	Mesopsis abbreviatus Palisot de Beauvois	Cameroun (Barreteau, 1999)
	Nomadacris septemfasciata Serville	Congo (Nkouka, 1987), South Africa (Quin, 1959), Tanzania (Bodenheimer, 1951; Harris, 1940), Zambia (Mbata, 1995), Zimbabwe (Chavanduka, 1976; Gelfand, 1971), eastern Africa
	Oedaleus nigeriensis Uvarov	Cameroun (Barreteau, 1999)

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Order/Family/ Subfamily	Species	Countries and Reference
	O. nigrofasciatus De Geer	Zambia (Mbata, 1995)
	O. senegalensis Krauss	Niger (Lévy-Luxereau, 1980)
	Ornithacris sp.	Zimbabwe (Weaving, 1973)
	O. cyanea Stoll	Zimbabwe (Gelfand, 1971)
	O. turbida cavroisi Finot	Congo (Bani, 1995), Niger (Lévy-Luxereau, 1980), Sahel
	Orthacanthacris humilicrus Karsch	Niger (Lévy-Luxereau, 1980)
	Orthochtha venosa Ramme	Cameroun (Barreteau, 1999)
	Oxycatantops congoensis Sjöstedt	Congo (Bani, 1995; Nkouka, 1987)
	O. spissus Walker	Cameroun (Barreteau, 1999), Congo (Bani, 1995; Nkouka, 1987), Sahel
	Paracinema tricolor Thunberg	Cameroun (Barreteau, 1999)
	Schistocerca gregaria Forskål	Africa, Congo (Nkouka, 1987), Cameroun (Barreteau, 1999), Tanzania (Bodenheimer, 1951; Harris, 1940), Zambia (Mbata, 1995)
	Sherifuria haningtoni Uvarov	Cameroun (Barreteau, 1999)
	Truxalis johnstoni Dirsh	Cameroun (Barreteau, 1999)
	Truxaloides constrictus Schaum	Zimbabwe (Gelfand, 1971)
	Tylotropidius gracilipes Brancsik	Cameroun (Barreteau, 1999)
Pyrgomorphidae (Acricoidea)	*Chrotogonus senegalensis* Krauss	Cameroun (Barreteau, 1999)
	Phymateus viridipes Stål (=*Borborothis brunneri* Bolivar)	Congo (Bergier, 1941), southern Africa (Malaisse, 1997)
	Pyrgomorpha cognata Krauss	Cameroun (Barreteau, 1999)
	Zonocerus variegatus Linn.	Central African Republic (Barreteau, 1999), Nigeria (Fasoranti and Ajiboye, 1993)
	Z. elegans Thunberg	Mozambique, South Africa (Quin, 1959)
Blattidae	sp.	Cameroun (Bergier, 1941)
Gryllidae	*Acanthoplus* sp.	Botswana (Nonaka, 1996)
	Acheta sp.	Zambia (Mbata, 1995), Zimbabwe (Chavanduka, 1976)
	Brachytrupes membranaceus Drury	Congo (Bani, 1995; Nkouka, 1987), D.R. Congo (AD.R.iaens, 1951), Nigeria (Fasoranti and Ajiboye, 1993), Tanzania (Bodenheimer, 1951; Harris, 1940), (East, central and southern Africa), Zambia (Mbata, 1995), Zimbabwe (Chavanduka, 1976;Gelfand, 1971; Weaving, 1973)
	Gryllus bimaculatus DeGeer	Zambia (Mbata, 1995)
Gryllotalpidae	*Gryllotalpa africana* Palisot	Uganda (Bodenheimer, 1951), Zimbabwe (Chavanduka, 1976; Gelfand, 1971; Weaving, 1973)
Mantidae	*Tarachodes saussurei* Giglio-Tos	Cameroun (Barreteau, 1999)
Tettigoniidae	*Ruspolia differens* Serville [= *Homococoryphus nitidulus vicinus* Walker	The whole of East (Owen, 1973) and southern Africa D.R. Congo (Bergier, 1941; Bequaert, 1921), Tanzania (Bodenheimer, 1951); Harris, 1940), Zambia (Mbata, 1995), Zimbabwe (Chavanduka, 1976; Gelfand, 1971; Weaving, 1973)
Thespidae	*Hoplocorypha garuana* Giglio-Tos	Cameroun (Barreteau, 1999)
Class Arachnida	*Epeira nigra* Vinson	Madagascar (Decary, 1937)
	Nephila madagscariensis Vinson	Madagascar (Decary, 1937)

For explanations: see Materials and Methods.
[1]From these homopterans the secreted product is eaten (that of *Arytaina mopane* is called 'lerp').

of an individual's daily protein requirement, and more than 100% of the daily requirements for many of the vitamins and minerals (Santos Oliveira et al., 1976). In the majority of food insects, either tryptophan or lysine is the first limiting amino acid (Bukkens, 1997). However, three caterpillars in the D.R. Congo proved to be a rich source of lysine, important in complementing lysine-poor staple cereals (Kodondi et al., 1987). Also *Macrotermes bellicosus*, collected in Nigeria, is probably also valuable in complementing maize protein, while others, like *Macrotermes subhyalinus* from Angola were not (Bukkens, 1997). The nitrogen in chitin, main component of the exoskeleton of insects, is not available, because of the absence of the enzyme chitinase in the human digestive tract. Insects in general are rich in fat, in particular caterpillars, palm weevil larvae and termites (Bukkens, 1997). Of the micronutrients, iron and vitamin A deficiency affects about 50 percent of the children in Africa (ACC/SCN, 2000). Insects are a good source of iron (Fe), and the A- and B-vitamins are well represented (Bukkens, 1997). Being an animal food, they contain even more bio-efficacious micronutrients than vegetables. There are quite a number of studies dealing with the nutritional and calorific value of several insect species in Africa (Chitsiku, 1989; Bukkens, 1997, Kitsa, 1989; Malaisse, 1997; Santos Oliveira et al., 1976), including caterpillars (Latham, 1999), *Anaphe* sp. (Ashiru, 1988); the mopane worm *Gonimbrasia belina* (Dreyer and Wehmeyer, 1982; Hobane, 1995), termites (Phelps et al., 1975; Tihon, 1946), and the secretion (mopane bread) of the mopane psyllid *Arytaina mopane* (Ernst and Sekhwela, 1987; Sekhwela, 1988). Bukkens (1997) concludes that given the high nutritional value of insects, efforts should be made to retain the tradition of entomophagy where it is still alive.

How Important Are Insects As Food?

There are only a few systematic studies on the importance of insects as food, and most are not too recent. Simmonds (cited in Bodenheimer, 1951, p. 202) mentioned in 1885 that the inhabitants of Madagascar are ill fed for half the year. Insects probably met only a part of their food requirements, but not to the dislike of the people, as he adds, "they are fond of fried grasshoppers and silkworm, esteeming the latter a great delicacy". It is a misconception to believe that insects are only eaten because of lack of alternatives or because people are hungry. Often my interviewees indicated that they eat insects because they are just delicious, in particular termites, the cricket *Brachytrypes membranaceous*, the palm larvae *Rynchophorus* sp., and the tettigoniid *Ruspolia differens* [vernacular name "edible grasshopper"; see reference to this species also in Mors, (1958)].

In the period before the harvest (during the rainy season), main staples are scarce. Insects are then abundant and can become an important food item. For example, in Madagascar, this is the period when there is not much rice (Decary, 1937). In the Central African Republic (Bahuchet, 1975, 1990) and in the D.R. Congo (Pagezy, 1975) caterpillars are a very important food item for the pygmies during a period between July to October. However, Schebesta (1957), studying the Bambuti-pygmies in the Ituri forest of the D.R. Congo, stated that insects were eaten only as a supplement to other meat sources, although their importance in nutrition should not be underestimated.

In Malawi, Mikkola (1997) interviewed 110 persons: 86% consume termites, 68% caterpillars, 46% grasshoppers, and 17% lake flies, but they were not considered a very important protein source. Five percent of the food of the Gbaya in the Central African Republic consists of invertebrates (96 different insect species), which is about 15 percent of their meat diet (Roulon-Doko, 1998). The Nganda in the D.R. Congo recognised 128 insect species, of which 39% are considered edible (Takeda and Sato, 1993). In six provinces of the D.R. Congo, insects constituted 10% of the animal protein in the human diet (being the highest in the two western provinces, viz. 15 and 22%), similar to beef (also 10%). However, fish was the most important part of the diet (47%), followed by game meat (30%) (Gomez et al., 1961). In the city Kananga, in the south west of the D.R. Congo, 28% of the inhabitants eat insects, mainly termites, caterpillars and beetle larvae (Kitsa, 1989). This amount was considered low, probably due to a deficient market infrastructure. The average monthly consumption was 2.4 kg per person. On the market it appeared that only palm beetle larvae and soldier termites (20% of the edible insect species) were found throughout the year, while the rest (in particular caterpillars and flying termites) were only seasonally available (December to April). Adriaens (1951) indicated

from the southwest of the D.R. Congo that animal protein in the dry season is obtained from eating large game, crickets and grasshoppers, during the rainy season from caterpillars, and throughout the year from fish, rodents, reptiles and various insect larvae. The estimate for the district of Kwango in the D.R. Congo between 1954 and 1958 was close to 300 tonnes a year of dried caterpillars.

In southern Africa, emperor moth caterpillars (Saturniidae) are widely consumed during one of the most food-deficient periods of the year—the months preceding the harvest. Fortunately during this period caterpillars can be harvested from forest trees which put forth leaves before the start of the rainy season. Their larvae can be dried and stored. The most well known emperor moth is *Gonimbrasia belina*, the so-called 'mopane worm'. Large quantities are harvested annually (in the early 1980s the annual sales in South Africa were estimated to be 1600 tonnes; Dreyer and Wehmeijer, 1982), and sometimes exported to other countries. A mopane worm canning factory was set up in South Africa years ago. However, the unpredictable nature of their occurrence and numbers, and the as yet unsuccessful attempts to farm them on a large scale, has made this and other similar enterprises unprofitable (Oberprieler, 1995). The population dynamics of the species are studied in order to obtain a more predictable and sustainable harvest with consequent economic stability (Frears, 1995).

When honey is harvested, the honey, wax, combs and larvae can be separated, but often mixtures are consumed, including the honeybee larvae (Gessain and Kinzler, 1975).

Toxicity of Edible Insects

Although some insects are considered toxic, they are still eaten. For instance *Zonocerus variegatus* in Cameroun (Barreteau, 1999) and Nigeria. The larvae have to be prepared specially, such as by repeated cooking. The tessaratomid *Natalicola delagorguei* in Zimbabwe and South Africa excretes a pungent fluid (Bodenheimer, 1951; Faure, 1944) which can cause severe pain and even temporary blindness if it comes in contact with the eyes (Scholtz, 1984). Therefore, the fluid is removed by squeezing the thorax and by diluting the 'poison' by putting the insect in hot water. The consumption of caterpillars with hairs containing toxic substances can be very dangerous and these have to be burned off by shaking them in a recipient with glowing coals (Tango Muyay, 1981).

There have also been reports of seasonal ataxic syndrome after people consumed the silkworm *Anaphe venata* in southwest Nigeria (Adamolekun, 1993). This may occur in poorly nourished people who are marginally thiamine deficient as a result of a mainly carbohydrate diet containing thiamine-binding cyanogenetic glycosides, and who experience seasonal exacerbation of their thiamine deficiency from thiaminases in seasonal foods. The silkworm contains such thiaminases.

Bouvier (1945) observed in D.R. Congo that when grasshoppers and locusts are consumed without removing the legs, intestinal constipation may occur, caused by the large spines on the tibia. Surgical removal of locust legs is then often the only remedy. Autopsy of dead monkeys during locust invasions also proved that the consumption of locusts proved to be fatal for the same reason.

Another problem is the pesticide applications against locusts and grasshoppers, which can cause problems because of their toxic residues.

Ethnic Preferences and Prohibitions in Entomophagy

The publications of Barreteau (1999) and Lévi-Luxereau (1980) give a detailed account of the Latin names of locusts that are eaten. Both deal with locusts from the Sahelian region, the first in the extreme north of Cameroun and the second from the Maradi area in Niger. It appears that the different ethnic groups have different preferences, for example the Mofu-Gudur in Cameroun eat a number of grasshopper species (*Acorypha picta*, *A. glaucopsis*, *Acrida bicolor*, *Oedaleus senegalensis*, *Pyrgomorpha cognata*, *Truxalis johnstoni*), which are not eaten by the Haussa in Niger, and vice versa (*Humbe tenuicornis*).

There are also prohibitions to eat insects, for example the Pygmies eat the larvae and the nymphs of the Goliath beetle, but not the adult which is considered sacred and used in fetishes (Bergier, 1941: p. 60). Members of termite clans in Malawi, Tanzania, Mozambique, Zambia and Zimbabwe have certain termite species as totems, and members are forbidden to eat winged termites (Silow, 1983: p. 115). The Logo-Avokaya in north-central Africa have rules determining the consumption of termites, which take into account the state of being married or pregnant, as well as the swarming behaviour of the termites (Costermans, 1955). Members of the Ire clan of the Yoruba tribe in Nigeria (predominantly

blacksmiths) do not eat crickets, because the worshipped Iron God Ogun does not accept animals that have no blood (Fasoranti and Ajiboye, 1993). Any woman of the grasshopper clan of the Baganda in Uganda may catch and cook the edible grasshopper *R. differens* for her husband, though she is not allowed to eat any herself (Roscoe, 1965). The Bahaya in Tanzania also seem to have a number of rules related to the eating of this particular insect (Mors, 1958). Pagezy (1975) mentions for the Oto and Twa in the D.R. Congo quite a number of prohibitory rules relating to eating beetle larvae, termites and caterpillars depending on the person's sex, age, physiological status (e.g. pregnancy), and/or being a twin.

Collection and Capture of Edible Insects

The ways in which insects are caught have to do with their behaviour (e.g. resting places, response to light), which is often influenced by environmental factors such as temperature. They can be collected by using tools, such as traps, sticks with glue, nets, bow and arrow, or by hand. Their location can sometimes be detected by the sound they make.

Use of glue

For some insects found in trees or in bushes, glue which is smeared on the tip of a branch, twig, stick or stem may be used. The Mofu-Gudur in northern Cameroun use as glue the sap from *Diospyros mespiliformis* or from the mistletoe (Barreteau, 1999). The Gbaya in the Central African Republic use a stick from *Lantana rhodesianus* or grass stems of *Andropogon gayanus* with glue at the end, to collect edible flower beetles (Cetoniinae), cicadas and grasshoppers (Roulon-Doko, 1998). In southern Africa children trap cicadas by climbing trees or by using long poles, the ends of which have been dipped in glue (Malaisse, 1997) fabricated from certain plant galls and tree resins. Pemberton (1995) mentions this method, using latex from a jackfruit tree (*Artocarpus* spp.) for catching edible dragonflies in Bali, Indonesia. In northern Cameroun, children insert a stick with glue at one end to catch crickets in their holes (Seignobos et al., 1996).

Capturing devices

To capture insects on the soil the San women in the Central Kalahari use small brooms, and beetles are trapped using nets attached to the ends of millet stems (Nonaka, 1996). In Maghreb countries locusts have been collected with the aid of an eight-by-four-metre cloth into which they are driven (Bergier, 1941). The appearance of the East African Lake fly *Chaoborus edulis* producing the 'Kungu' cake (already mentioned by Livingstone; see also Cotterril, 1968, p. 415–418), drifting in masses over the lake, is according to lunar cycles (Owen, 1973; MacDonald, 1956). Clouds of these flies move to the lakesides, where they are collected in whirling baskets attached to long handles (Armitage et al., 1995; Harris, 1940; Owen, 1973, p. 135). Bouvier (1945) mentions from the D.R. Congo that grasshoppers are caught using a bow and arrow, the latter made from bamboo with divergent points. Some crickets are caught in traps baited with certain fruits (Seignobos et al., 1996).

Capturing early in the morning

The San women in the Central Kalahari collect the grasshoppers *Cyrtacanthacris tatarica* and *Lamarckiana cucullata* by hand in the morning and the evening from trees and huts (Nonaka, 1996). To collect locust and grasshoppers, Gbaya women in the Central African Republic, very early in the morning use brooms made from leaves or branches to sweep the savanna vegetation which has been cut the day before, in order to catch the jumping insects (Roulon-Doko, 1998). At this time of day the insects are easy to catch because of their low body temperature. In Madagascar there is a proverb "how can you capture ovipositing grasshoppers and have a late morning at the same time?". It indicates that you can only catch the very much appreciated gravid female grasshoppers very early in the morning (Houlder, 1960). In Tanzania, in addition to collecting the edible grasshopper *R. differens* early in the morning, people lit fires so the smoke keeps down the flyers (Mors, 1958).

Use of light

The tettigoniid *R. differens* is eaten as a delicacy in the whole of central, eastern and southern Africa. There are two ways of collecting them (Harris, 1940): (1) small boys herding cattle, catch them and impale them on skewers, usually grass stems;

(2) during their mass flight in November, large numbers of people can be seen in the cities collecting these insects from electric street lights (Owen, 1973: p. 132).

Use of sound

People in the D.R. Congo have a peculiar way of finding out the appropriate moment to harvest edible larvae of weevil, longhorn and scarab beetles, which occur in standing or rotting *Elaeis*, *Raphia*, *Chamaerops* and *Cocos nucifera* palm trees (Ghesquière, 1947). They do this by listening to the sound made by the nibbling beetle by putting their ears against the palm tree. In Cameroun my informants indicated that they used this method in order to harvest the right instar of *Rhynchophorus* larvae from the palm tree. From the Central African Republic, Roulon-Doko (1998) also mentions that women listen at the trunk of the tree in order to collect beetle larvae. Adriaens (1951) mentioned from the D.R. Congo that children at darkness locate the cricket *Brachytrupes membranaceus* by its sound. Then they either dazzle the insect with a straw torch and/or block the nearby hole with a hoe or knife after which they capture the insect. During the day crickets can be dug out from their holes.

Collecting at resting places

The pentatomid *Agonoscelis versicolor*, a pest of sorghum in Sudan, is collected during the dry season, when they amass in mountain cracks (Delmet, 1975). Seignobos et al. (1996) also mention such a heteropterous insect in North Cameroun. An edible oil is extracted from the insects which can also be used for cooking and as a dermatological product for horses and sheep. Another heteropterous insect, *Natalicola delegorguei*, eaten in South Africa and Zimbabwe, congregates in large numbers at the end of the rainy season (Bodenheimer, 1951).

Collecting beetle larvae

To collect some cerambycids, the Gbaya in the Central African Republic cut several *Burkea africana* trees around the village. A few days later the cerambycids arrive to attack the tree, and a waiting person near the trunk is then able to collect them (Roulon-Doko, 1998). The same tribe earlier collected the dung beetles by searching in the excrements of buffaloes. However, in the seventies the buffaloes were replaced by cattle, and the method can no longer be used.

Collecting caterpillars

Tango Muyay (1981) mentioned from the D.R. Congo that when somebody finds a tree with edible caterpillars ready to be harvested in the forest, this person automatically becomes the owner. Women climb the trees to collect them (Roulon-Doko, 1998; Tango Muyay, 1981). Sometimes branches or even whole trees are cut in order to facilitate collecting. However, this practice is now often prohibited by law (Tango Muyay, 1981). It is also possible to make a fire below the tree. By adding green leaves there will be so much smoke that the caterpillars drop to the soil. Some of the caterpillars are collected when they come down from the trees in order to pupate in the soil, and at that moment they do not have any excrements in their body.

For the Gbaya in the Central African Republic, Roulon-Doko (1998) mentions 59 different caterpillar species that are eaten. Twenty-five species live isolated (not more than 4 per plant) and those are not systematically collected. About 16 species are found in densities of up to 30 per plant, and 14 species are found in even greater numbers per plant. The local names given to these caterpillars often refer to the plant they are found on. They are mainly harvested during the first months of the dry season or in the middle of the rainy season.

When a nest of caterpillars is found, it can also be transferred to certain host trees nearer home where they can further develop (Adriaens, 1951; Chavanduka, 1976).

Collecting termites

Winged termites are collected in various ways. In urban areas, they are attracted to electric light and are trapped in a receptacle with water which is placed under or near the light source. In rural areas, they are often caught at the termite mound itself. When emerging they are attracted by the light of a grass torch and then swept with a broom into a dug-out hole. In parts of the DRC a basket is put upside down over an emergence hole and the termites which cling to the bottom of the basket are then detached every few minutes by shaking the basket (Bergier, 1941: p. 56). Another method is to build a dome-shaped framework of sticks or elephant grass covered with banana,

Maranta leaves or a blanket to cover part of the emergence holes (Bergier, 1941: p. 54; Osmaston, 1951; Roulon-Doko, 1998: pp. 269–270). Other emergence holes outside the structure are closed, forcing the termites to emerge from the holes within the tent structure. The tent structure has an opening at one side to which the flying termites are attracted by light (from the sun, moon, torch or fire) and near this opening there is a receptacle into which they are collected (Bergier, 1941: p. 50; Harris, 1940; Ogutu, 1986). Osmaston (1951) mentions from Uganda a complicated structure of clay pipes constructed over the emergence holes which leads them to the receptacle. Ogutu (1986), Owen (1973, p. 131), Roulon-Doko (1998, p. 268) and several of my informants reported that continuous beating and drumming on the ground around the hill triggers certain termite species to emerge.

Soldiers from the larger termite species are also eaten (D.R. Congo: Bequaert, 1921; Bergier, 1941: p. 54; Owen, 1973, p. 131. Central African Republic: Roulon-Doko, 1998, pp. 260–263. Zimbabwe: Chavanduka, 1976). To extract them from the mounds, women or children lower saliva wetted grass blades (Uganda), often of *Imperata cylindrica* (Roulon-Doko, 1998: p. 261), or parts of tree pods or barks (Takeda, 1990) into the shafts of termite mounds opened by machete. The Ngandu from the D.R. Congo also blow smoke from charcoal from certain trees into the opening (Takeda, 1990). In defence, the soldiers bite into the grass blades, which are then pulled out and the soldiers stripped into a container. The inside of the basket may be lined with the slippery leaves from the *Sarcophrynium shweinfurthianum* tree to prevent the termites from climbing out (Takeda, 1990).

As the nest of the harvester termite *H. mossambicus* is undetectable, the San women in Botswana dash out in the direction of the swarm, to identify the site of the nest (Nonaka, 1996).

Who Collects Edible Insects?

It depends often on how important the catch is, whether the women, men or children that collect the insects and whether it is done on an individual or community basis. When the catch is considerable the men also collect insects, such as in the case of locusts, the edible grasshopper or winged termites. Normally however, the women are responsible for catching insects. When the catch is very small (cicadas, termite soldiers, some grasshopper species) or difficult (cicadas, crickets) then it is only the children who do the collection. For example, cicadas are difficult to catch as they are attached to the bark, often high in the tree (Bergier, 1941: p. 76). The same is true for hunting crickets, which requires quite some patience and skills for a small catch.

Roulon-Doko (1998) mentions 16 edible beetle species whose larvae are collected by the Gbaya in the Central African Republic. However, only five are deliberately looked for by adults, another five by children and the rest are collected when accidentally found. Although 17 locust and grasshopper species are eaten in this country, the women actively search for only seven species. The 29 caterpillar species from the D.R. Congo are normally collected by the women (Tango Muyay, 1981).

Female farmers in Niger recognised more locusts and grasshopper species than men, probably because they are responsible for the capture and preparation of the insects (A. de Groot, pers. commun.). The Azande and Mangbetu in the Uele district in northwestern D.R. Congo consider termite hills as private property (Bequaert, 1921). Also in East Africa termite mounds are often owned and protected by individual families (Owen, 173: p. 131). The reproductive form of the termites, whose individuals emerge from the termite nest with the first rains after the dry season, is collected by everyone in the village. Chavanduka (1976) also mentions that if a woman finds a tree with young caterpillars, she ties a piece of bark around the trunk of the tree to establish her right to harvest.

Termite soldiers can only be collected in small quantities. Therefore, they are only collected by women or children (Roulon-Doko, 1998: p. 261). Unlike the winged reproductives, the soldiers can be gathered any time during the year. Only small quantities of the harvester termite, *H. mossambicus*, can be collected. Therefore, the capture is often carried out by children or young women (Roulon-Doko, 1998).

Preparation, Preservation and Marketing

Because many insects are only seasonally available, they are frequently conserved for later consumption. This is often done by drying insects in the sun, over ashes or in the oven. Preservation

with salt after boiling is also common. Some insects are not prepared at all and are eaten alive. For example, in most parts of Africa a small quantity of termites is eaten alive as a relish during collection. In South Africa, the heteropteran insect *N. delegorguei* is also eaten alive. In discussing the preparation, preservation and marketing of insects, the insect groups will be treated in order of importance.

Lepidoptera

There are several ways of getting the excrements out of caterpillars. They can be squeezed or purged out (Adriaens, 1951; Chavanduka, 1976), kept alive without food for a number of days, or washed in water (Tango Muyay, 1981). The irritating hairs on the body of caterpillars are often burned off, for example by the Azande (Bergier, 1941: p. 70). Caterpillars are often cooked in salted water until all the water has evaporated (Tango Muyay, 1981). They can also be smoked after being boiled. To store them, or before taking them to the market, they are then dried in the sun.

Large outbreaks of the hawk moth, *Herse convovuli* on *Ipomoea* sp. occur in January/February in the central Kalahari (Nonaka, 1996). San women collect the caterpillars, squeeze out the intestines and roast them in hot ash and sand. After sun-drying they are stored in bags in the hut and eaten for several months. They can also be pounded into powder and mixed together with stewed watermelon.

The Bambaras in Mali and Burkina Faso eat the caterpillar *Cirina forda* which is a pest of the karité tree, *Butyrospermum parkii*. Before being fried in karité butter, the caterpillars are boiled in water (Bergier, 1941: p. 66).

In Tanzania the caterpillars of the wild silk moth *Anaphe panda* are sought and eaten (Harris, 1940). These caterpillars are gregarious and build communal nests of strong yellow silk in the branches of the trees on which they feed (generally, if not exclusively, on *Bridelia micrantha*). The caterpillars are cooked fresh, or dried and powdered for storage.

In Madagascar, the chrysalids of a psychid and several bombycid silk worms are killed in hot water then eaten (Decary, 1937).

The Zulus and the Bushmen reportedly also eat butterflies (Bergier, 1941: p. 72).

Orthoptera

Both the adult and hopper stages of all locust species (the brown, desert, migratory and red locust) are consumed when and wherever they occur (Harris, 1940). Many univoltine adult grasshopper species are also eaten, in particular in the Sahel. The larger species, in particular the females, are preferred (Barreteau, 1999). At the end of the rainy season they contain a lot of fat and the females hold many eggs. In the Sahelian region the sale of harvested and marketed grasshoppers and locusts may yield more revenue for farmers than millet. This is one of the reasons that farmers prefer not to treat their crops with pesticides. The spiny legs and wings of hoppers are removed. Some tribes also remove the head together with the intestines, and sometimes only the thorax is eaten (Sudan). The insects are cooked, fried or roasted. The San women in the central Kalahari roast them in hot ash and sand (Nonaka, 1996) after picking off the heads and removing the internal organs, which are considered to be excrement. Flying locusts and grasshoppers (and to a greater extent hoppers) are sun-dried before storage, pounded in a mortar to powder, and eaten with porridge.

The tettigoniid *R. differens* is considered a delicacy in the whole of central, eastern and southern Africa. In Uganda, the tettigoniid is called 'nsenene' which is in Ganda the word for the month of November during which the grasshopper appears in large numbers. Butchery owners and fishmongers are affected because few customers go then for meat or fish (Mulissa, 1997). Before frying them, the antenna, legs and wings are removed.

The Naro in D'kar make grasshopper powder by pounding them in a mortar, to mix it with maize flour in porridge.

From the Cameroun there are records that stinking blattid cockroaches are eaten (Bergier, 1941, p. 80). After removing the elythra they are fried and mixed with a porridge of vegetables or fruits.

Coleoptera

Larvae of the palm weevil *Rynchophorus* spp. (Col.: Curculionidae) are eaten in Asia, Africa and the Americas. The African species is *R. phoenicis*, which is often grilled or fried in ashes. From other beetles, such as flower beetles or cerambycids, both the larvae and the adults are eaten, often

grilled. The elytra are removed from the adults. Larvae can also be prepared by squashing them in a mortar with different condiments, then cooking them (Bergier, 1941: p. 61).

The San in the central Kalahari collect the buprestid beetle *Sternocera orissa* in January during outbreaks from the leaves of *Acacia mellifera* and *Kyllinga alba* (Nonaka, 1996). The quarry is roasted in hot ash and sand and then the hind wings are removed. The heads are picked off if they are eaten directly. It can also be pounded and mixed with fruits or wild plants to form a paste. Especially liked are females containing eggs.

Isoptera

Of termites, the queen, the soldiers and the reproductive form are eaten. The most popular are the sexual winged forms of the larger species (Macrotermitinae) which emerge from holes at the mound after the first rains, often during the night. The termites are killed by boiling or roasting for a few minutes the morning after the swarming, and then they are sun-dried or smoke-dried, or both, depending on the weather (Silow, 1983: p. 127). Sometimes they are then crushed to a mush with a pestle and motar and eaten with honey (Ogutu, 1986). Termites are fried in their own fat. This fat can also be used to fry meat (Bequaert, 1921), as by the Azande and pygmies in the D.R. Congo (Bergier, 1941: p. 51). The pygmies also use the oil to treat their body and hair. The oil is also obtained by pressing dried termites in a tube (Costermans, 1955). Termites can also be steamed or smoked in banana leaves (Uganda). In many East African towns and villages, sun-dried termites can be bought at the local market at the right season of the year (Osmaston, 1951; Owen, 1973: p. 131).

Fried or dried termites contain 32–36% protein (Nkouka, 1987; Tihon, 1946) and in most parts of Africa they are considered a delicacy. The queen in particular is considered an exquisite dish and often reserved for special occasions (Owen, 1973, p. 131). Queens are often fed to children (Uganda and Zambia).

Of the harvester termite, *H. mossambicus*, the San women in Botswana collect the winged reproductives and roast them in hot ash and sand (Nonaka, 1996). The workers and soldiers are not collected as they taste bitter.

Soldiers from the larger termite species are either fried or pounded into a cake. Sometimes only the heads are eaten (Uganda).

Hymenoptera

In southern and East Africa the queens of the thief ant, *Carebara* spp. are eaten. These ants live in the earthen walls separating the roomy galleries and chambers of termites. The worker ants are small enough to slip unobtrusively in and out of the termite nest chambers, feeding on the termites and their larvae. The males and females are vastly larger than the workers, the weight differential being a factor 4000 (Wheeler, 1927; Hölldobler and Wilson, 1990). These reproductive forms emerge during their nuptial flight during the day. They are caught in large numbers, their gasters torn off, and eaten raw or fried with salt (Skaife, 1979).

Roulon-Doko (1998) mentions that the Gbaya in the Central African Republic use ants as a spice. The women pierce the nest in a tree after which they are brushed into a receptacle. She also indicates that children eat ant eggs. Of one species they just collect and eat the raw eggs which are brought outside the nest by the ants. From another ant species they collect the stored eggs by digging out the nest. These eggs are fried before being eaten. In Cameroun several informants also indicated that dug-out eggs are fried and eaten.

The San in the central Kalahari collect *Camponotus* sp. by poking a nest with a digging stick and tapping the ground by hand around the nest (Nonaka, 1996). At home they pound wild plants and when well pounded, the ants are mixed in. This adds a sweet-sour flavour to the mixture which enhances the taste of the plants.

To alleviate thirst the pygmies in the D.R. Congo seek ant nests (probably an *Oecophylla* sp.) in the trees, and the nymphs from the nest are pressed in order to obtain a sweet-sour liquid (Bergier, 1941, p. 66).

Nests of wild bees are exploited not just for honey; bee larvae are also collected for food (Owen, 1973: p. 135). In Tanzania, the larvae are generally eaten raw in their combs (Harris, 1940). They can also be shaken out and added with honey to porridge. In the D.R. Congo, bee larvae and pupae are preferably grilled (Bergier, 1941: p. 76).

As earlier reported by Decary (1937), larvae of wasps were eaten in Madagascar. However, by that time the custom was already disappearing.

Heteroptera

In Sudan, the local people roast the pentatomid *A. versicolor*, which is a serious pest of rainfed

sorghum. Oil is also made from these insects for use in food preparation and for treating the scab disease in camels.

Diptera

Clouds of the aquatic fly *Chaoborus edulis* emerging from the East African lakes are collected by whirling baskets. They are ground and dried in the sun and the resulting cake is an important source of protein in Uganda and elsewhere in East Africa.

Odonata

The larvae of several *Odonata* species are collected from abandoned rice fields or in marshes in the highlands of Madagascar (Decary, 1937). The Pangwe in Cameroun also eat *Odonata* larvae for their diuretic properties (Bergier, 1941, p. 76).

Other arthropods

In Madagascar two spider species are eaten, both are fried in oil or fat (Decary, 1937). In the Central African Republic ground-dwelling bird spiders are eaten by children (Roulon-Doko, 1998). Spiders were the only arthropods other than insects encountered as food. Scorpions and millipedes are taken orally but only as medicine.

Maintaining and Developing the Insect Food Resource Base

The development of rearing methods for edible insects, rather than relying on natural harvesting, would allow a continuous supply (Fasoranti and Ajiboye, 1993). Is it possible to farm edible insects and to treat them as mini-livestock (DeFoliart, 1995)? Cerda et al. (2001) gave suggestions of how to rear the South American palm weevil *Rhynchophorus palmarum* on other crops and even on artificial diet. Munyuli Bin Mushambanyi (2000) started to mass-rear *A. panda* in cages on leaves of *Bridelia micrantha*, because of the revenues realisable from the sale of edible insects. For instance, in the D.R. Congo edible insects are more expensive than other kinds of protein (fish and beef). On the Bukavu market, 100 caterpillars weighing 0.25 kg fetched 3 US$ in March 1999, the same as 1 kg of beef. In the *A. panda* mass rearing, twelve pairs of adult butterflies could produce 9.3 kg of caterpillars. The life cycle is about 140 days, making possible at least two generations a year; in nature there is only one generation a year. The last larval stage is about 5 cm long. The mean weight gain in 49 days of caterpillar's feeding is 2.7 g for a 400 g of total food consumed. To exploit such resources, agro-zoological techniques have to be developed concentrating on issues like food regimes, pathology, parasitism, bio-ecology and reproduction.

Several lepidopteran species cannot only be utilised as a food resource but also for silkworm production. These include such representatives of the genera *Borocera*, *Gonometa*, *Mimopacha*, *Pachypasa* (Lasiocampidae), *Anaphe* (Notodontidae) and *Goodia* (Saturniidae). The International Centre of Insect Physiology and Ecology (ICIPE) in Nairobi has explored the possibilities of increasing the survival of these silkworms, and protective measures include the use of fine net sleeves which reduce the high natural mortality rate (about 80%) of *Gonometa* sp. by about 60 percent (ICIPE, 1998). Another silkworm, *A. panda,* also has potential for silk production and as human consumption; its huge silk nests are commonly woven by 20–105 silkworms. The host tree *Bridelia micrantha* is widely distributed in Kenya, Tanzania and Uganda (ICIPE, 1998).

The supply of edible insects is dependent on the season. However, the abundance of insects may vary widely from year to year, as a result of overexploitation (Ferreira, 1995) or other factors. This variation was mentioned as one of the problems with setting up a canning factory for the mopane worm in South Africa (Oberprieler, 1995). The abundance / scarcity of certain edible arboreal caterpillars was also investigated in the Kwango region of the D.R. Congo by Leleup and Daems (1969). They mentioned as reasons for the fluctuations in caterpillar abundance the effect of parasitoids and the timing of bush fires. The latter factor had a great influence on the life cycle of the insect, either by destroying the insects or by disrupting the coincidence of the appearance of the larvae and the right stage of tree foliage. They mentioned that before 1938 it was prohibited to cut trees for the purpose of harvesting *Cirina forda* caterpillars from the upper parts of the trees. Besides, there was a strict regulation that the bush fires were only allowed in June. These practices vanished with the gradual loss of authority by the traditional chiefs in favour of colonial

administration. In addition to the above measures, Leleup and Daems (1969) also proposed to inoculate trees with *C. forda* eggs after the bush fires.

Most of the caterpillar species live on trees. In Africa, there are 42 trees species with edible caterpillars (Turk, 1990). The author has suggested a number of ways to manage forests to protect the caterpillars. The demand for land in the face of growing human population and wood exploitation have degraded forests to Savanna, which is accompanied by a loss in edible caterpillar species. Forests have also been mismanaged by overexploitation, as caterpillars are an important source of food and income (Ferreira, 1995). In Malawi, farmers adjacent to Kasungu National Park, have now been allowed to harvest at certain times in the Park to diversify their income base and to win their support for wildlife conservation programmes (Munthali and Mughogho, 1992). By allowing rural people to use the parks and reserves sustainably, the preservation of the country's biodiversity is enhanced. A management programme involved the adoption of a rotation burning policy that promotes vegetation coppicing, eases harvesting and promotes high caterpillar yields. Mbata et al. (2002) mentioned that in Zambia two popular commercial caterpillar species, *Gynanisa maia* and *Gonimbrasia zambesina,* are traditionally harvested. This involves: (i) monitoring 20 tree species for caterpillar development and abundance and for changes in caterpillar habitats; (ii) protection of host plants and moth eggs against late bush fires through the use of a special fire technology; and (iii) temporal restriction of edible caterpillar harvesting.

In recent years a number of insect cookbooks have been published (Gordon, 1998; Ramos-Elorduy, 1998; Taylor and Carter, 1996; Thémis, 1997). African insect recipes are found in Grimaldi and Bikia (1985).

The use of traditional food is sustainable and has economic, nutritional and ecological benefits for rural communities in sub-Saharan Africa. Future studies should focus on sustainable ways of harvesting wild populations, the use of improved conservation practices, the enhancement of cottage industries for farming insects and the development of economically feasible ways of mass-rearing edible species.

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