agrodok

Edible insects in Africa

An introduction to finding, using and eating insects

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Foreword

The meat crisis is prompting us to look for alternative protein sources. Since 1970, world meat consumption has increased almost threefold and is expected to double again by 2050. However, agricultural land resources will soon be depleted, as 70 per cent is already in use for livestock. In addition, industrial livestock production brings high environmental costs. Of the total greenhouse gases at least 15 per cent is derived from livestock, causing global warming. We therefore need to rethink our diets and food habits, in particular those related to meat consumption.

Only now is the Western world realising that millions of people in tropical countries have an excellent alternative: edible insects. In the West, then, people are eager to learn from tropical countries how to make use of this excellent food source. For centuries people have been collecting the nearly 2000 species of insects available for human consumption. This is not because it is a poor man's food – a Western misconception – but because it is delicious. Nutritionally, insects are no less valuable than conventional meat. Insects can contain large amounts of iron. This benefit is of particular importance considering that one billion people are anaemic, including children and pregnant women .

In the tropics, insects are mainly harvested in the wild. Examples are given in this book, such as the very popular Mopane caterpillar in southern Africa, and palm beetles and termites, which are considered absolute delicacies on all tropical continents. Included are explanations of how to collect, store and prepare them. However, if we want to promote the use of insects, then harvesting in the wild will not be enough. Therefore, examples also illustrate how to rear insects. There is experience rearing two species, the house cricket and the yellow mealworm. In Thailand there are already 20,000 households that rear crickets for domestic use and the market.

Worldwide interest in insects as human food is increasing. A number of new initiatives are being undertaken in both tropical and Western countries to explore their potential. This book is a welcome contribution to the re-evaluation of insects as to their role in ensuring food security.

Arnold van Huis

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Wageningen, 2015

Contents

1 Introduction

When you first saw the title of this book, you may have found the idea of eating insects unfamiliar or strange. Actually, we all eat insects every day without knowing it. Insects or parts of insects are present in almost all processed food. Because insects attack crops, and because we cannot use pesticides on food just before harvest, it is difficult to control them at that stage of the production chain. They often end up in food products during processing. No need to worry, though: regulations control the amount of insect particles! Most importantly, here we want to share the idea that insects, a high-protein food source, can also be eaten as part of a meal. Eating insects – also called 'entomophagy' – has been part of the human diet since the beginning of humanity, especially in the tropics.

There are more than 1900 edible insect species in the world. At least 250 species are located in Africa. Countries where entomophagy is practiced house about 2.5 billion people, which is about 35% of the total world population. Insects are collected in the wild; they are a seasonal product. In Central Africa, for example, caterpillars are very popular foods. During certain months of the year, 50% of the protein intake is from insects. The main insect groups are caterpillars, beetles (of which mainly the larvae are eaten),

bees, ants, termites, grasshoppers and crickets. Insects are included in the diet of many cultures in Africa, Asia and Latin America. It is a western misconception that insects are eaten as an emergency food. In local cookbooks they are often described as traditional delicacies. Not only can eating insects prevent malnutrition; they are a valuable part of local food culture that should be preserved.

Because insects are an affordable and local food source rich in protein, they can be used as a meat replacement. Many insect species contain relatively more protein than conventional meat sources such as chicken or pork. As well, insects contain essential fatty acids and important minerals and vitamins. For example, termites, when dried, contain up to 36% protein. Eating 100 grams of caterpillars provides nearly the daily protein and vitamin requirements for one person.

Much more feed (grain) is required to produce a single kilo of animal protein (beef, chicken, goat, fish) than to produce a kilo of insect protein. The ratio of kilos of feed for producing a kilo of animal protein is called the food conversion index. This index thus indicates how much feed is required in animal production. It expresses how efficiently an animal protein is produced. A lower index number means the meat production process is more efficient and less expensive. Several food conversion figures are available; yet in all cultures, insects have outstanding food conversion numbers.
A reason for the efficient conversion figures is that insects are cold-blooded. They do not use energy from their food to maintain their body temperature. Less land is needed to produce vegetable food for insects than for conventional livestock. Insects produce up to 100 times less greenhouse gases than do cattle. Because greenhouses gases are suspected to alter the climate in unpredictable and often unfavourable ways, eating insects instead of cattle can lessen the negative impact on the environment.

Protein quality varies depending on its source. Insect protein is higher in quality than protein from vegetable sources and is similar to that from other animal sources.

Collecting edible insects can be an important source of secondary income. After collection, the insects are sold at the market the same or the next day. The insects can be dried or canned for preservation.

The world's demand for meat has increased very rapidly in the last 40 years, and the demand is expected to double by 2050. To help meet that demand, we should replace part of our meat diet with insects because they:

- taste good
- are an important source of protein
- contribute to food security
- provide extra income
- provide good nutritional value and contribute to good health
- are environmentally less damaging than conventional meat

This book is not meant to be a reference book. Rather, it is meant to introduce and inspire the eating of insects. It is an eye-opener, a different way to look at our diet. There are plenty of insect species to choose from. Here we explore 10 insect species belonging to 5 different insect orders.

Host-plant management

It is important to be aware of the impact of harvesting methods on the local ecosystem, and on the number of insects available to collect the following season. Although it is tempting to cut down trees to facilitate the harvesting of caterpillars or other tree insects, we recommend climbing or shaking the trees instead. Also important is to respect and conserve biodiversity, and to use species in a sustainable manner. Intensive collection for use as food poses a threat to many species. Including well-selected host trees in your agricultural fields may increase access to edible insects.

Potential edible-insect toxicity and other problems

Irritants Some insect species must be prepared in special ways in order to avoid negative effects. The hairs of some caterpillars, for example, can be irritating or contain toxic substances. Always handle these caterpillars with gloves, not with bare

hands. Before eating a caterpillar, its hairs must be removed (e.g. using fire). Also remove the hind legs of grasshoppers before consumption, as they have spines which may cause constipation.

Pathogens Boiling or heating is essential in order to kill pathogenic (disease-causing) microorganisms (e.g. bacteria, fungi) which often infect the insects. Methods for preservation (boiling, smoking, canning, drying) are discussed in the following chapters. Edible insects need to be eaten soon after harvesting. Do not collect insects found already dead.

Pesticide residues Make sure that the insects that you are collecting, and their host plant, have not been sprayed with pesticides. This can be the case when collecting locusts or grasshoppers in agricultural fields or palm weevil larvae on palm plantations. After spraying, the pesticides may remain in the insect and can be toxic to humans.

Further readings

Agrodok series no. 29, *Pesticides: compounds, use and hazards*.

1.1 The structure of this guide

This Agrodok describes several insect species that you can collect, cook and eat. It provides information on collecting and preparing these selected species. The focus is on the collection of insect species in the field. For several edible insect species, cultivation is also an alternative.

The introduction chapter provides information on host plant management and on possible adverse effects of edible insect consumption. The next chapter gives a short introduction on insect biology, anatomy and taxonomy.

Following this introductory material are case studies, grouped by insect order. Each chapter starts with a description of the insect order, followed

by the description of an edible insect species, how to recognize it, and how to collect and cook it. A few recipes are presented in a final chapter.

In the appendices you will find:

- a calendar showing when to collect each of the insect species discussed
- tips for further reading
- useful addresses
- a glossary

2 Insect anatomy and taxonomy

J. Cloutier

Insects can be found in all types of environments except the oceans. They are enormously divers in both anatomy and appearance. Many features, however, are common to all. Adult insects have six legs. They all have an external skeleton: the cuticula. The hard external exoskeleton serves to protect the insect and to attach the muscles from the inside.

The hard, non-elastic exoskeleton limits the growth of the insect larva: after a period of growth, the larval exoskeleton no longer fits. It is replaced during the process of moulting. First, a new, large, chitin exoskeleton is produced from the inside out. The older, outgrown exoskeleton tears apart and the insect discards it. At first the new cuticula is soft, but within a few hours it hardens and darkens.

The insect's body is divided into three sections: the head, thorax and abdomen (Figure 1). Insects breathe through small openings along the sides of their body. The oxygen (O_2) they inhale and the carbon dioxide (CO_2) they exhale moves through small tubes throughout the body.

Insects have a blood-like fluid called haemolymph, which is usually greenish or yellow. The blood is not red (from haemoglobin): insect haemolymph does not have to transport oxygen, only sugar and fat from its food. The haemolymph is pumped around by the heart in the abdomen. It floats freely inside the body around the gut, muscles and organs.

Several sense organs are located in the head: the eyes and antennae. Insects have compound eyes, which are a number of small eyes grouped together. In addition, small single eyes can be present elsewhere on the head. Antennae allow the insect to smell and to sense the environment. The antennae can vary greatly between species. Antennae of the male and female of the same species can also differ.

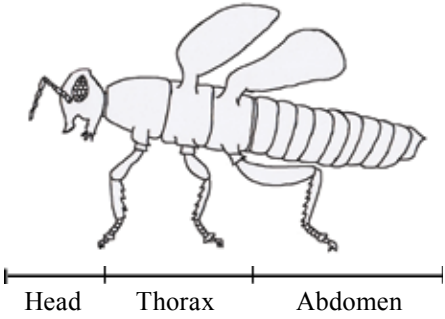

Figure 1. Insect anatomy

There is great variation in mouth types, all related to the type of food consumed by each species or insect stage. Major differences are observed between larvae and adults. For instance, caterpillars eat leaves with chewing mouthparts called mandibles, yet adult butterflies suck honey from flowers with a tube-like mouth called a proboscis.

The legs and wings are attached to the thorax. Some insect larvae – caterpillars, for example – have additional legs on the abdomen. The abdomen houses the fat reserves, the heart and, in adults, the reproductive organs (eggs or sperm).

The insect life cycle consists of several stages: egg, larvae and adult. The number of larval stages, usually 4 to 6, varies among species. Although each insect species has its specific life cycle, there are generally two types (Figure 2). In the first type, complete metamorphosis, the larva and the adult are quite different. The transition from larva to adult is a phase called pupating. The pupa is inactive and does not have functional mandibles. After a certain length of time, a mature adult emerges.

In the second type of life cycle, incomplete metamorphosis, the larva or nymph hatches from the egg and resembles the adult, except that it is smaller and may have a different colour. Its way of life and diet are similar to those of the adult. The nymph does not pupate, but rather it 'changes instar' (moves to its next developmental stage) as it moults.

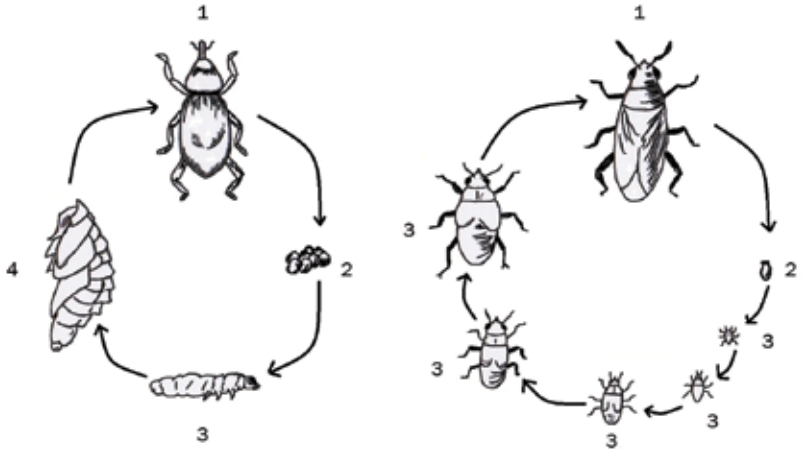

Figure 2. Complete metamorphosis(left): adult (1), eggs (2), larvae (3), pupae(4). Incomplete metamorphosis (right): adult (1), eggs (2), nymph stages (3)

3 Beetles (*Coleoptera*)

E. Kokoete, S. van Broekhoven, K. Amevoin, S. Bassan, J. Cloutier

Coleoptera is one of the largest insect orders. Commonly, these insects are known as beetles. They represent 40% of all insect species. Many economically important pests of both crops and stored products are beetles. Damage can be caused by the adult insect or the larva, or both. Fortunately, though, many beetle species are edible.

The adult beetle has two sets of wings. The elytra acts as a protective shell; it is not used for flying (Figure 3). The elytra must be raised in order to make space for the hidden wings to expand and allow the beetle to fly. After flight the rear wings are refolded under the elytra. The mouth parts and legs differ with each beetle species, as they are adapted to each specific environment and diet. Claws, called tarsi, are found at the end of the last leg segment. These claws allow the beetle to climb.

Figure 3. Adult beetle with the elytra closed (left); adult beetle with the elytra raised and wings expanded for flying (right).

The beetle undergoes complete metamorphosis: its larval stage does not resemble its adult stage. The female beetle lays its eggs near the food source. The larvae emerge and grow through different instars (larval stages). A beetle larva has short legs, and often its head is darker than the rest of its body. The larva pupates for a certain period of time before becoming an adult.

Here we'll discuss three different beetle species, their preferred habitats and the best way of collecting or rearing them. These serve as examples for other edible beetle species.

3.1 Edible palm tree insects – African palm weevil larvae – *Rhynchophorus phoenicis and Oryctes monoceros* – Nigeria

Palm trees harbour various insects, including several edible beetle species. Here we discuss two species.

Rhynchophorus phoenicis

The first of these two, the larvae of the palm beetle *Rhynchophorus phoenicis*, is a delicacy in many parts of Nigeria and other countries in Africa (Figure 4). Various ethnic groups have different names for the larvae. Locally, the larvae are valued for their high nutritious potential as well as a certain pharmaceutical potential. It is common to see the larvae being sold in many cities in the western, southern and middle belt of Nigeria. They are referred to as edible worms, larvae, grubs or maggots. The Urobhos and Ibibios in the Delta and Akwa Ibom states of Nigeria are very fond of the larvae.

Biology and identification

Palm trees under stress (for any reason) and fallen palms serve as breeding sites for this insect and can support hundreds of larvae. The palm weevil is diurnal: active during the day. The female weevil lays her eggs in palm holes and crevices made by humans or by other insects. She searches actively for cut petioles (stalks that attach leaves to stems) to serve as ovipositor (egg-positioning) sites.

Figure 4. Rhynchophorus phoenicis adult (left; © Hectonichus) and larvae (right; © Arnold van Huis)

Each female lays about 200 – 500 eggs which hatch after about three days. The larva is yellowish white or creamy in colour. It has no legs (is apodous) and moves by a wave of contraction and relaxation of the segmented body. The larva is about 7 – 10 cm long and oval in shape. At maturity it has a reddish-brown head capsule. The larval stage usually lasts 8 – 9 weeks. Pupation takes place in a cocoon of broken plant fibres. Developing from an egg to an adult insect may take from 5 to 9 months, depending on circumstances such as temperature.

Economic importance

Palm weevil larvae are of economic importance because they produce both beneficial and harmful effects. They cause harm as serious pests to oil, coconut and *Raphia* palm trees. They destroy the host plant and cause low produce yields. The larvae are voracious feeders. With their hard mouth parts, they penetrate and damage the plant tissues, causing the leaves to die. Decay follows with the formation of galleries with a moist mass of fragmented fibres and a characteristic sour odour. The trunk later becomes tunnelled and weakened and then breaks. The beneficial aspect, on the other hand, is that the larva are edible. This is a benefit for the various populations living where the larvae are found. The larvae are generally referred to as edible worms or grubs. How this food is prepared for eating differs from one locality to another. Some tribes (Urhobos and Isokos, both in Delta state) strongly recommend it for their pregnant women, probably as a source of essential nutrients. The adult insects are also eaten occasionally, when they are caught. Children usually love them.

Collecting

Collecting from young palm trees

Freshly infected young palm trees are difficult to localize. The area around the trees is wet, so it is arduous for the collector to move about. Also, the infested young palms may look very similar to the healthy trees.

Here are some tips for locating a young palm tree infested with the edible larvae:

- Look for a gallery dug by the larvae. When the gallery reaches the crown of the palm tree, the leaflets turn yellow. During the rainy season the gallery is filled with water, causing the heart of the palm tree to rot.
- Notice the distinctive sour smell released by the larvae.
- Listen for the sound of the larvae eating the inside of the tree. This can be heard by putting your ear to the tree.

Collecting from mature palm trees

Because the adult insects cannot infest healthy, mature trees, you need to locate the unhealthy trees. Usually these trees have turned grey and have no leaves left. Once you have found an infected tree, it is best to climb the tree, to look at the crown and confirm that the tree is actually infested. The tree can then be cut down and taken apart in order to collect the larvae.

Oryctes monoceros

The second edible beetle species we discuss here is the *Oryctes monoceros*. These larvae are edible as well. This insect species is not restricted to young or unhealthy trees; it is able to lay eggs into mature, healthy palm trees.

Figure 5. Oryctes monoceros Adult (left) and larvae (right) (source: Wikipedia)

In fact, damaged palm trees infested with the edible palm weevil larvae have often first been infested with *Oryctes monoceros* (Figure 5). The *Oryctes* larva is curved, and white with a tint of blue. The head is darker. The body has brown spots on the sides; these are the spiracles. The adult *Oryctes* beetle is black or dark brown, and is active at night. The beetles fly slowly and loudly.

Production

Of all the edible insects in several countries in West Africa and in Nigeria, the palm weevil, *Rhynchophorus phoenicis*, looks to have the greatest potential for production and marketing. The insect larvae are not limited to a specific season. You can recognise the best moment for collecting the right larval stage by the typical noise of the larvae nibbling away at the inner tissues of their plant host. This insect has been 'semi-cultivated' by indigenous populations in the Niger Delta regions of Nigeria. Harvest procedures vary slightly from one ethnic group to another. Basically, palms are cut down and the logs are left lying in the semi-swampy forest, with the expectation that the logs will be infested with larvae. The logs with decaying pith are ready to harvest a couple of months later. *Raphia* palms can also be left standing after being tapped for palm wine, also with the expectation that they will be infested with the insect larvae.

The adults and larvae of *Rhynchophorus phoenicis* are serious oil, coconut and *Raphia* palm pests. Efforts to control the insect include both insecticides and cultural control methods. Breeding sites are eliminated by restricting physical injury to palms; *Oryctes* beetles are controlled; infested plants are destroyed; and adult beetles are trapped. On the other hand, the larvae are gaining wider publicity as traditional yet gourmet-quality cuisine, and some restaurants in the tropics are showcasing the larvae as a tourist and urban delicacy. Awareness is increasing of economic gains which commercialisation of the insect could bring. Therefore, there are now attempts to combine increased 'Edible Palm Worm' production with more efficient recycling of dead and diseased palms. This can be part of

reduced-pesticide integrated pest management (IPM) programmes and disease control for coconut and other palm species.

Warnings

Palm weevil larvae are a delicacy and are cherished as food by certain populations. However, care must be taken during handling. The larvae have well-developed mouth parts; when they are handled carelessly, they are capable of biting and inflicting wounds. Another problem is toxicity: insects harvested from palm trees which have been treated with pesticides are not safe to eat.

3.2 Yellow Mealworm – *Tenebrio molitor* – The Netherlands

Mealworms are actually not worms, but larvae of the beetle *Tenebrio molitor* (Figure 6). In the field, they can live in such dark, moist places as the underside of rocks or rotten wood. Still, the larvae are not often found in the wild. They prefer human environments, where they can be a pest in granaries and flour-processing companies. Mealworms are also commercially produced as pet food, as fish bait and, more recently, for human consumption. Only the larval stage is suitable for consumption.

Figure 6. From left to right: Tenebrio molitor adults, larvae and pupa

Biology and identification

The beetles are black, and are 1.25 to 2 cm in length. Female beetles can lay up to 500 eggs which hatch after about 7 days. The larvae (mealworms) are initially white, yet they quickly turn a yellowish brown colour. The larval stage takes from about four weeks to several months to develop, depending on humidity and ambient temperature. Mealworms do not have a set number

of instars and can moult 9 to 20 times. They grow to about 2 to 3 cm before moulting into the pupal stage. The pupal stage lasts about 7 days before beetles emerge.

Uses

Mealworms are used as food for birds, reptiles and fish, as well as for human consumption. When freeze-dried, they can be eaten as is. When obtained live, they can be killed by freezing, and fried or toasted before consumption. Mealworms have a mild nutty flavour. They can be added to many dishes, including salads, omelettes and desserts or chocolates. They can also be eaten as snacks.

Collecting

Though the mealworm can be found in many parts of the world where grains are stored, these larvae are usually not collected in the wild, but are grown by hobbyists or commercial producers.

Production

Production allows year-round harvesting. Mealworms can be produced at home, in containers with smooth edges about 5 cm high to prevent the larvae and beetles from escaping. The beetles cannot fly. A temperature of about 25-28°C and a relative humidity of about 60% are optimal. The insects are nocturnal and prefer a dark environment. Keep the insects at their different stages separate as much as possible, as both the adults and the larvae are cannibalistic. Cover the containers with a layer of wheat bran, which serves as both feed and as substrate for hiding and laying eggs. Adding 5-10% brewer's or baker's yeast to the wheat bran supplies protein and vitamins; this will make the larvae grow faster. Supply moisture in the form of pieces of fruit or vegetables. Egg cartons can be placed in the container with beetles to provide additional shelter. Female beetles will lay eggs in the substrate. The sticky eggs cannot easily be removed from the container. It is best to regularly move the beetles to a new container to prevent the eggs from being eaten.

Pupae can be removed from the container with larvae and do not need to be kept on a substrate (Figure 6, at right). Remove emerged beetles from the pupae to prevent cannibalism.

Harvest and storage

Mealworms can be harvested when the larvae reach a size of about 2 to 3 cm. They can be killed by freezing or by immediate frying or toasting. Although freeze-drying requires special machinery and is more expensive, it has the advantage of preserving optimal flavour and allowing increased storage time. Mealworms that are killed by freezing can be kept in the freezer until use. Fried or toasted mealworms can also be dried in the sun for several days to allow longer storage time.

Warnings

In rare cases, due to overexposure, commercial insect breeders working with mealworms may develop allergy symptoms. These include asthma, redness and itching of the eyes, running nose and skin rashes.

Related species

Other species that are commercially bred for human and animal consumption are the Lesser Mealworm (*Alphitobius diaperinus*) and the Superworm (*Zophobar morio*).

3.3 Gnathocera – cetonid beetles or flower chafers – Togo

The cetonid beetles of the genus *Gnathocera* are among the various insects consumed in Togo (West Africa). In central Togo, the many *Gnathocera* species are grouped under the common name 'Îgbokpowa' in the Tem or Kotokoli language.

The several species of the genus *Gnathocera* are presented here together, according to the local habit of grouping the different species; single species of the genus are not discussed. Special attention is given to the species which are collected and consumed in the region.

Description and diversity

Cetonid beetles are more commonly known as flower beetles or flower chafers. As adults, the small beetles range in size from 1.5 to 3.5cm, and show strong variation in colour (Figure 7). Their elytra often have a tan-yellow colour. The back shield, the part between the head and abdomen, is black with three white stripes. The beetles undergo complete metamorphosis, passing through several larval stages and a pupal stage before the final adult stage. They are grass-dwelling, and feed on grasses. They are usually found on grass panicles of the savannahs and forests in the African tropics.

Eight different edible species can be found in the village of Kpéwa, Togo (Figure 7): *Gnathocera trivittata nyansana* Kolbe, the dark form of *Gnathocera trivittata aegyptiaca* Kraatz, *Gnathocera flavovirens* Kolbe, *Gnathocera impressa* Olivier, *Gnathocera varians* Gory and Percheron, *Gnathocera hyacinthina* Janssens, *Gnathocera angustata nana* Schürhoff and *Gnathocera* sp..

Collecting

The adult beetles are collected in the wild. No rearing method for these insects currently exists. They are collected at the end of the rainy season, between the months of September and November. You can best capture the various *Gnathocera* species in the early morning hours. Then, the insects are less active, although they can still fly well. After sunrise, collecting becomes more difficult, as they become very active. The slightest jarring of the beetles' resting place causes them to immediately drop to the ground. Locally, children capture them by two different methods.

Collection by beating

Carefully place a large container under a grass panicle, taking special care to avoid any disturbance. Adult beetles of the same and of different species aggregate into clumps on the panicles. Beat a loaded panicle with a stick or by hand, causing the beetles to fall into the container waiting underneath. Transfer the trapped beetles to a closed box. This method allows collection of large numbers of beetles.

Collection by hand

You can collect adult beetles of the various species by hand simply by grabbing them once they have landed on grass.

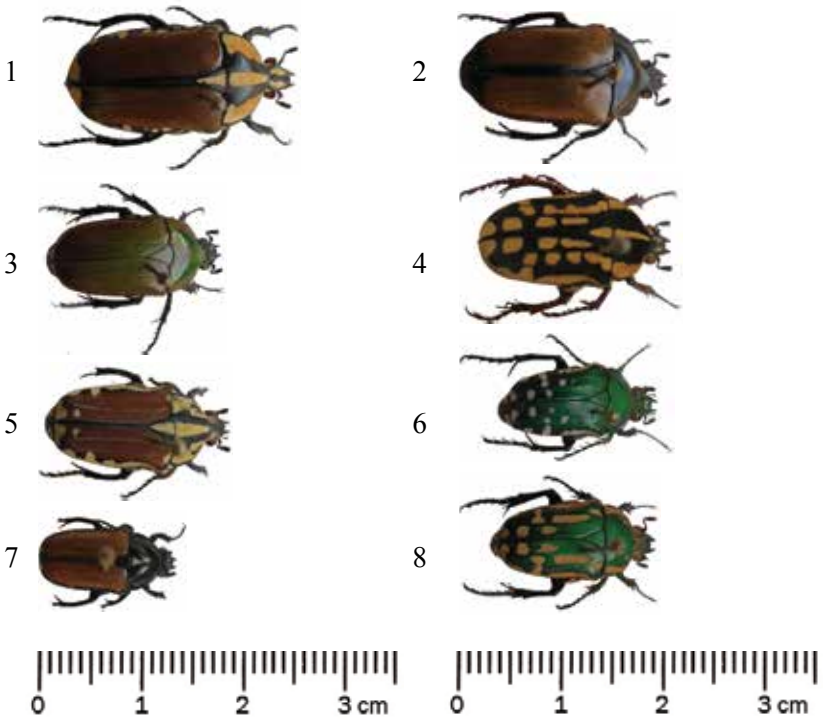

Figure 7. Edible insects of the genus Gnathocera, from the central region of Togo: Gnathocera trivittata nyansana Kolbe *(1), Gnathocera trivittata aegyptiaca* Kraatz *(2), Gnathocera flavovirens* Kolbe *(3), Gnathocera impressa* Olivier *(4), Gnathocera varians* Gory, Percheron *(5), Gnathocera hyacinthina* Janssens *(6), Gnathocera angustata nana* Schürhoff *(7), Gnathocera sp. (8).*

Cooking methods

Children of the Tem ethnic group eat the beetles especially frequently, though all Tem people consume them. The largest, and thus most succulent, are bestowed the name "îgbokpoou n'goou" in the Temir language, and are highly appreciated. There are two different ways of preparing *Gnathocera* beetles for consumption: toasting or roasting, depending on the number of insects to be prepared.

Toasting

Toasting in a pan is the preferred way of cooking when a large number of beetles has been collected. Remove the wings (both the elytra and true wings), then season the beetles with salt and a generous amount of spices. Place the pan over a slow-burning fire and turn the insects often. Toasting takes about 20 minutes.

Roasting

Roasting is preferred when only a few beetles are collected. Remove the wings and skewer the bodies on a small stick or spit. Roast them until they are thoroughly cooked.

Conclusion

Gnathocera beetles are traditionally collected in the wild and eaten by people of the central region of Togo. Sustainable exploitation of the wild insect resources deserves full attention, as does recognition of *Gnathocera* beetles as a highly appreciated food.

We believe that the local people – populations in rapid demographic development – need to become conscious of the fact that the balance of nature is very fragile. It is necessary to develop small-scale rearing practices to replace the current collection of the beetles in the wild.

4 Caterpillars (*Lepidoptera*)

R. Makhado, M. Potgieter, P. Tshikudo, K. Mawela, H. Maluleke-Nyathela, S. Tchibozo, J. Cloutier

Lepidoptera are commonly called butterflies or moths. The larvae are known as caterpillars. Most butterfly species are active during the day, while moths are usually active at night. Butterflies have antennae with knobbed ends; moths have variously shaped antennae, usually without knobs. Lepidoptera undergo complete metamorphosis: the Lepidoptera life cycle consists of the four development stages of adult, egg, larva, and chrysalis (pupa) (Figure 8).

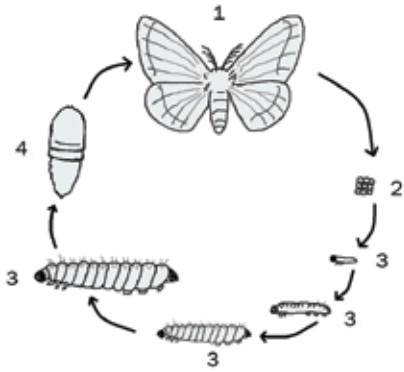

Figure 8. Life cycle of Lepidoptera : adult (1), eggs (2), the four larvae instars (caterpillar) (3), pupa (4)

The adult has two pairs of wings. They are covered with scales which produce a multitude of colour shades. The head has many sensory organs which allow the insect to sense its environment. The adult's mouth is called a proboscis; it is a tube that is unrolled for feeding. As the food source for Lepidoptera insects is nectar, they fly from one flower to another. This makes them important pollinisers.

The Lepidoptera adult and larvae (caterpillars) do not feed on the same food source, though they may feed from the same plant. The eggs are laid on the plant which has leaves eaten by the larvae. Often, the common name of a butterfly is derived from the host plant on which the caterpillar feeds.

The caterpillar is different from the adult. It does not have wings. Wings develop during pupation. When the larva has reached its maximum size, after several moults, it will make a cocoon in order to pupate. Most species pupate on or near the host plant, although a few species pupate in the soil. Adults do not live long. Their ability to fly is important: for finding a mate and then for finding a suitable location for laying eggs. In order to fly, the insect's body must be warm enough. In colder climates, the wings are used to catch the warmth of the sun. In warmer climates, butterflies are more active during the cooler period of the day, in the early morning and the early evening.

The caterpillar walks with three pairs of true legs (on the thorax) and a variable number of abdominal legs. The abdominal legs help the caterpillar to move its long, soft body. Some species have hair-like or other structures. These hairs or structures are a defence system and may be harmful to human health. You must remove these structures from the caterpillars before eating, in order to prevent irritation of the skin or the intestines.

Preserving caterpillars

You can keep caterpillars alive for two to three days after collecting if you give them enough leaves from their host plant. If they have to be stored for a longer time they are often dried.

Hairy caterpillar species usually lose their hairs during the cooking process. Alternatively, you can remove the hairs using fire. Remove the caterpillar's intestine as well before cooking. Boil the caterpillars in salted water for 30 to 45 minutes and then sun-dry or smoke.

Preservation by sun-drying

The caterpillars should be dried in the sun for one to two days. Note that sun-dried caterpillars cannot be kept for a long time.

Preservation by smoking

More common than sun-drying is smoking. Smoked caterpillars turn brown. Put the caterpillar on a grill and install it just above the fire, in the smoke, for one or two days. *Cirina forda* larvae can be deposited directly among glowing coals. The heat supports the removal of hair and grass. Unfortunately, smoking may decrease nutritional value and can cause cancer with long-term, intensive consumption. Smoke-preserved caterpillars can be kept for three months.

4.1 Mopane worms – *Imbrasia belina* – South Africa

Biology and recognition

Mopane worms – the caterpillars of the Anomalous Emperor Moth, *Imbrasia belina* – feed on fresh leaves of the mopane tree (*Colophospermum mopane*) (Figure 9). This tree is widely distributed in southern Africa. This large, vividly coloured, spiny caterpillar can generally be found where its host tree grows. These 'worms' are consumed mostly in the rural areas, and to a lesser extent in the urban areas of such countries as Namibia, Botswana, Zambia, and Zimbabwe, and the Limpopo and Mpumalanga Provinces of South Africa.

The fully mature caterpillar is about 10 cm long, and mostly black with whitish-green and yellow bands. They have short black spines covered by fine white hairs, which protect the body and help sense predators.

Figure 9. Mopane worm (Imbrasia belina). Left: Above adult female, below adult male (© David Buycott), Right: Caterpillar (© JackyR)

Uses and importance

Mopane worms are a routine part of the diet of millions of southern Africans. Mopane worms are rich in protein and crude fats. It is said that dried mopane worms can provide up to 65% of a human's daily protein needs and many of the required vitamins and minerals. They contain significant amounts of phosphorus, iron and calcium.

When available, mopane worms create seasonal employment opportunities for the majority of rural women. Many of these women depend solely on mopane worms as a source of income. Harvesters either utilise their collected mopane worms themselves or sell them. They can sell the worms in the villages and towns or to traders (mostly men). In shops, Mopane worms are sold in plastic bags; street vendors sell them by the cup. During a good year, the annual commercial value of mopane worms in neighbouring Botswana (the main source of southern Africa's mopane worms) is estimated at 330 million Rand (South Africa) or 24 million euros. These worms provide work for up to 10,000 people. Economically, this insect species is very probably the most significant in southern Africa. However, it is important to note that overharvesting in December and January is followed by lower yields in April and May. If you avoid overharvesting, you will have a more regular yield throughout the year, and you will also be protecting the species.

In addition to providing food for humans, mopane worms are critical to the ecology. They may be regarded as a 'keystone species': their activities

influence the structure of mopane woodlands in many ways. For example, the different stages of the life cycle of the Anomalous Emperor Moth provide food for predators. Some primates and birds dig up the pupae, while a number of insect species, such as ants and armoured ground crickets, prey upon the worms. Small wasps parasitise the eggs.

The caterpillars themselves are prone to virus infections that may have a significant effect on the population size. Depending on rainfall, defoliation of *Colophospermum mopane* trees by mopane worms may result in a second flush of new leaf material during autumn or early winter. This provides all-important browse for game and domestic animals when other tree species are either leafless or have senescent leaves. Furthermore, small-scale farmers use mopane worm dung as compost manure to fertilise their crops.

Seasonal outbreaks, harvesting and storage

Mopane worms are collected twice a year. The first seasonal outbreak is from December to January, the second in April to May, following good rains. Worm abundance varies annually, and is determined by the amount of rainfall and the consistent presence of fresh host tree leaves. Low rainfall affects the regeneration of host tree leaves, and so limits the number of mopane worms. The demand for mopane worms exceeds the supply in Botswana.

The ways in which mopane worms are collected, processed and consumed in southern Africa are amazingly similar despite the wide range of people and cultures. During the five- to six-week harvesting period, harvesters pick the mopane worms from their host trees from sunrise to sunset. They shake the trees or fell infested branches, or even whole trees. This cutting of trees should be discouraged at all costs! Destroying the host plants can have profound ecological consequences. Destruction affects other mopane herbivores as well as future mopane worm productivity. The worms can also be harvested by simply collecting the ones that are crawling on the ground. During a good year, an individual can harvest between 25 and 50 kg of mopane worms a day.

After the worms have been harvested from the host tree, they are squeezed with two fingers, starting from the head, to remove the guts. Relative to their size, young mopane worms have more gut contents than do the fully grown worms. The more mature worms are filled with a nourishing yellow substance that consumers like very much. After the guts are removed, the worms are washed in cold water and then boiled for about 15 minutes. Salt is added to enhance the taste. After cooling, the worms are dried in the sun for several days. Other methods of drying worms include smoking them until they are completely dry.

Mopane worm harvest is seasonal. To eat them out of season, you can preserve or store the worms for later use. Completely dried mopane worms are traditionally stored in plastic bags, metal buckets, or even clay pots. They are then sold at the market immediately , or stored carefully for selling during the off-peak season. Mopane worms are also canned and packed as snacks, and sold in the big supermarkets.

Reproduction

The Anomalous Emperor moth lives for only two to three days. In this short time it completes its reproductive processes. The moth lays a single cluster of 50 to 200 eggs around twigs or on the leaves of a host tree. After about ten days, small larvae emerge from the eggs (Figure 10). The larval stage includes five instars (stages of development) and lasts about six weeks. Larvae of instars I to III are strictly gregarious: they forage together in a group of about 20 to 200 individuals. When the larvae reach instar IV, they disperse (spread out) and become solitary.

Figure 10. Mopane worms of the first instar (© Ghazoul Jaboury (ed.), 2001-2006, Mopane Woodlands and the Mopane Worm: Enhancing rural livelihoods and resource sustainability)

Worms disperse slowly and do not go far. At the end of instar V, mature worms burrow into the soil and pupate. The pupae remain in the soil for up to six or seven months. When the environmental conditions are right, the pupae hatch as moths. During their few days of life, male and female moths mate and the females lay eggs on the host tree: the life cycle starts again.

Production

In Botswana and Zimbabwe, experiments tested the potential for mopane worm domestication. Although it is possible, piloting the research findings proved difficult. Various socio-economic and cultural challenges were present. Mainly, there was a lack of: a) long-term funds for domestication projects; b) monitoring of mopane worm harvesters; and c) cooperation, because most of the projects are on land that is considered communal.

Mopane worm production can be increased by collecting eggs and pupae in high-outbreak areas and moving them to areas with low outbreak levels. Careful selection and care of eggs and pupae is necessary as many pupal deaths can be caused by viral and parasitoid infections. The eggs can be protected from these infections by covering the egg-carrying twigs or leaves with a white sleeve. Eggs can also be stored in a white container in the house until they hatch. After hatching, they should be transported to the mopane tree. Pupae, on the other hand, can be protected from virus and parasitoid infection by placing them in a white plastic container or a wooden box filled with sandy soil. Another option is to construct a pupal pit about 30cm deep, covered with shade net.

Warnings

In the season of mopane worm outbreaks, elephants and other browsers also roam the fields where the host trees and shrubs grow. Mopane worms cause about 90% defoliation of these host plants, and thus compete with browsers. People capturing mopane worms must be aware that elephants can behave aggressively and may attack anything that moves.

Cooking

Boiling the mopane worms is essential, to kill such pathogenic bacteria and fungi as *Aspergillus*, *Rhizophus* and *Penicillium* and other microorganisms which often infect the worms. When processing the worms, it is important to wear gloves to protect the hands from the spines which can puncture the skin. Gloves also protect the hands from discolouring and irritation by the slimy green fluid from the worms' mouths. In the picture below, women are wearing gloves while squeezing mopane worms (Figure 11).

Figure 11. Women wearing gloves while squeezing mopane worms (© Ghazoul Jaboury)

4.2 Kanni larva (Shea Defoliator or Pallid Emperor Moth) – *Cirina forda* – Congo, Mali, Togo, Burkina Faso, Central African Republic, South Africa, Zimbabwe, Botswana

Biology

The Kanni larva, as it is commonly called in West Africa, is a caterpillar 5 to 7cm long with a brown head. The black body has yellow stripes and markings on each segment and is covered in white hairs (Figure 12). The adult *Cirina forda* moth has light brown wings and a darker body (Figure 12). Kanni larvae are a major pest of Shea trees. They are commonly eaten by the Pedi people, among others, in South Africa, Zimbabwe and Botswana.

This species develops through five larval stages and then a nine-month pupation period in the soil. After emergence of the adult moth, mating and oviposition (laying eggs) usually occur within three days. The first stage

(L1) caterpillars hatch after about one month and then progress through the 5 larval stages. The last stage of the caterpillar is the one harvested and eaten.

Figure 12. Cirina forda adult (left) and caterpillar (right)

Insect harvest

Although practices vary from country to country, the caterpillars are generally collected from July to October. Collection takes place in the very early hours of the morning. The caterpillars can be found on the *Vitellaria paradoxa* host plants and other native forest plants (Figure 13).

This species occurs in several African countries: DR Congo, Central African Republic, Mali, Togo and Burkina Faso. There is no known rearing method for these insects. They are collected in the wild from Shea trees and other native forest vegetation.

Figure 13. Vitellaria paradoxa host plant of Cirina forda

Storage

After harvest, the caterpillars are kept alive in tubs and sold the same day. Alternatively, the caterpillars can be sun-dried during several days and then kept in burlap bags.

Cooking

Both the freshly harvested and dried insects are washed before cooking. After washing, freshly harvested caterpillars are fried with onion in a pan (Figure 14), while dried insects are mixed with tomato sauce or leafy vegetables.

Figure 14. Example of a meal including Cirina forda caterpillars

Sale

Both fresh and dried caterpillars are sold in Central as well as West Africa. Market prices start at 100 FCFA. This food is well appreciated by the inhabitants of Bobo-Dioulasso in Burkina Faso. Exported caterpillars can also be found in Paris for the diaspora. In Bobo-Dioulasso, the Kanni larvae are honored at the 'Chitoumou' festival, which is held yearly in early August.

5 True bugs (*Hemiptera*)

C. Dzerefos, J. Cloutier

The insects of the Hemiptera order are commonly called true bugs. There are about 75,000 species worldwide. This includes aphids, cicadas, leafhoppers, shield bugs and scale insects. Many of the true bug species are pests to agricultural plants. True bugs are easy to recognise by their 'rostrum', a sucking mouth part very different to biting mandibles. It is used to pierce a plant or animal cell and suck out the contents.

Most true bug species have two pairs of wings. The wings of some species are totally membranous, or soft and transparent; other species have hard wings. On the back of many species you can see a triangle formed by the overlapping of the wings. As some species are wingsless, the defining characteristic of the true bug is the rostrum (Figure 15).

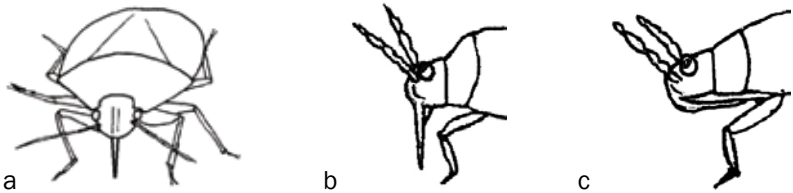

Figure 15. Example of a true bug with rostrum shown from the front (a) and the side (b). When not in use, the rostrum lies alongside the body of the insect and is therefore not visible (c).

True bugs do not undergo complete metamorphosis between the larval stage and the adult form. The young insects are called nymphs and resemble the adults. They are usually smaller than the adults, and their colour may differ. There is no pupal stage. Instead, the nymph moults several times until it reaches adult size.

5.1 Edible stinkbug – *Encosternum delegorguei* – southern Africa

This stinkbug is regarded as a culinary delicacy in South Africa, Malawi and Zimbabwe where it is a valuable winter harvest. It is known by various names including Thongolifha, Harurwa and Nkhunguni. The body of the edible stinkbug is 25 mm long (Figure 16). These are large, robust bugs with a small head and a waxy green-yellow shield-shaped body. Males have a pointed terminal abdominal segment and females have a genital orifice on the ventral abdomen. Females are slightly broader (14.9 mm) than males (13.9 mm).

Figure 16. Mating edible stinkbugs or Thongolifha (Encosternum delegorguei)

When alarmed, stinkbugs discharge an odour (also called a volatile defensive chemical or alarm pheromone) from a gland located in the metathorax. This smelly secretion irritates the eyes and stains human skin orange.

Adults copulate in October and November. During the dry winters experienced in their distribution areas the stinkbugs will migrate to higher lying mistbelt areas. Here they do not feed on plant material, though the edible stinkbug will congregate on a wide range of indigenous trees and shrubs. This is also the season when it is possible to collect them as food. In the spring, adults disperse widely in search of indigenous woody plants to feed on such as *Combretum imberbe* (Leadwood), *Combetum molle* (Velvet

bush willow) and *Peltophorum africanum* (Weeping wattle), and to a lesser degree, on *Dodonaea viscosa* (Sand olive) (Figure 17).

Figure 17. Plant species where edible stinkbugs can be found. From left to right: Combretum imberbe (© A. van den Bos), C.molle (© K Braun), Dodonaea viscosa (© J.M. Garg)

Collecting

The edible stinkbug is widely distributed in subtropical open woodland and bushveld. However, in South Africa there are only three areas, around Thohoyandou, Ga-Modjadji and Bushbuckridge, where these insects gather in sufficient quantities to be harvested. Aggregations can be on indigenous plants as well as in pine and gum plantations. Collection occurs during the cool of the night or at dawn, when the insects are inactive, during the winter months May, June and August. Protective clothing is recommended, especially gloves (see Warnings section below), as the insects can be brushed off branches with the hands into holding buckets, and then relocated to closed bags (Figure 18).

Figure 18. Collecting edible stinkbugs

Edible stinkbugs are difficult to breed because they are vulnerable to cold and desiccation (drying). Indoors, they are prone to fungal infections.

Outdoors, insectaries have been successful but the adults are sought after by birds and vervet monkeys, and parasitoids can infect the eggs. The adults can also be attacked by spiders or ants.

Consumption

Only the adults can be eaten. There are two methods to prepare them. See chapter 8 (Recipes).

Warnings

The defensive chemical from a single bug can hardly be felt. However, if it enters a cut or wound it is irritating. A direct hit of the chemical in the eyes causes a burning sensation and blurred vision for a few days. Continual exposure to bug secretions stains the hands orange-brown and causes swelling. Long-term harvesting (over a decade) caused nails to lift off the nail bed, and wart growth. Always use gloves and safety goggles to reduce the risks. Clothing should be fastened at the wrists, waist and ankles so that the bugs cannot get in.

6 Locusts and grasshoppers (*Orthoptera*)

M.A. Ayieko, J.N. Kinyuru, R. Makhado, M. Potgieter, P. Tshikudo, K. Mawela, H. Malulekе-Nyathela, D. Oonincx, J. Cloutier

There are more than 20,000 species of Orthoptera worldwide. This order includes grasshoppers, crickets and locusts. Their main characteristic is the long legs that allow them to jump great distances. They have mandible mouthparts to tear off feed plant material. They prefer to feed on grass, crops and citrus tree leaves. They have two pairs of wings which follow the insect's body. Most orthoptera species are able to produce sounds with the help of their wings. These sounds are made during the mating period and each species has its own particular songs. The antennae, used to sense predators, can be long or short but are always thin. Female locusts are larger than the males. At the end of the abdomen, the males have a single unpaired plate, while the females have two pairs of valves which are used to dig into the sand for laying eggs. Insects of the order Orthoptera undergo incomplete metamorphosis. The eggs are laid in the ground or on vegetation. The young nymphs that hatch from the egg resemble the adult, but have no wings.

Locust plagues: beat them or eat them

Locusts are capable of changing from a solitarious (alone) to a gregarious (clustering) phase. Under suitable environmental conditions – heavy rainfall in particular – the insects multiply rapidly and become gregarious and migratory. They aggregate (cluster) while changing colour and behaviour. They are capable of marching like armies during the nymph (hopper) stage and they swarm in huge numbers during the gregarious phase. Locust outbreaks have been a major concern to farmers. The insects can form very large groups or swarms that can move in coordinated migration, travel great distances, rapidly strip fields and cause massive damage to crops.

On the positive side, during the occasional plagues, locusts are easy to harvest, particularly early in the morning when their bodies are not yet warm.

In Africa there are four locust species: desert, migratory, red and brown locusts. Most locusts and grasshoppers are edible. Their consumption adds good nutritional value to the diet. Young locusts are tastier than the adults, and so are the gravid females, full of protein-rich eggs. Edible locusts and grasshoppers are eaten in many parts of the world, including Africa, Korea, The Philippines, Mexico, China and Papua New Guinea. They are fried and eaten to supplement the diet. However, it should be noted that locusts are not always available in urban markets — only during plagues, so their contribution to the human diet is not well documented. However, particularly in the Sahelian region, grasshoppers are often present, especially during the cropping season.

Reproduction and life cycle

Grasshopper and locust eggs are laid in the soil. The female drills a hole in the ground with its ovipositor and lays a 'pod' of eggs. This pod is sealed with a membranous coat that helps protect the eggs against dehydration, disease and predation. An egg pod contains several dozens of tightly packed eggs. The eggs stay in the soil throughout the winter season and hatch during suitable temperatures, particularly in the summer. After completing each instar, the nymph sheds or moults its skin in order to continue

to grow. The nymph hatches without wings, but with each moult the developing wing buds increase in size. The final moult into the adult stage is known as fledging. This is when the insect develops fully formed wings for flying. The young adult is called a fledgling. As with other insects, it takes a few weeks to become sexually mature. The time it takes for a locust or grasshopper to reach maturity greatly depends on the type of species and environmental conditions (food availability and suitable temperature).

During cool weather, the nymphs and adults often bask in the sun to increase their body temperature. (Because the insects are immobile in the morning, that is when women and children collect them.) In the temperate zones, many grasshoppers spend most of their life as eggs through the cooler months (up to 9 months), and the young and adult grasshoppers live no longer than three months.

Warnings

1. Overconsumption of the grasshopper has been associated with mild stomach aches for some people.
2. Remove the hind legs because of the spines.
3. Farmers consider locusts and grasshoppers to be major pests: outbreaks cause severe damage to agricultural crops, posing a potential threat to food security. They also increase farm operational costs.
4. Before collecting locusts, find out if pesticides have been used in the region. When in doubt, do not eat the insects.
5. Do not eat raw locusts. Uncooked locusts may contain tapeworms: parasitic worms living in the digestive tract of herbivores, including cows and goats. Cooking kills tapeworms and makes the locusts safe to eat.

6.1 Long-Horned Grasshopper – *Ruspolia spp.* – Lake Victoria region

Biology and identification

The long-horned grasshopper (*Ruspolia spp.*) has long been part of the food culture in the Lake Victoria region of East Africa. It is known as *nsenene* or *senesene* across the region. This grasshopper is most commonly green or brown, though it 'expresses colour polymorphism' (as many as six colour forms have been reported, including purple and multi-coloured) (Figure 19). The grasshopper's colouring often depends on its environment. Many are adapted to green fields and forests, and blend in well there to avoid predators. Others have adapted to drier, sandy environments and blend in with the colours of dry dirt and sand. Adult grasshoppers have wings, and they fly with a buzzing sound. The wings are actually quite pretty in flight, with flashes of bright colours. Their strong hind legs, larger than the grasshoppers themselves, facilitate the power of their flight.

Figure 19. Colour polymorphism: (left) green and (right) brown long-horned grasshoppers

Harvesting

Grasshoppers swarm during certain periods of the year, usually after the first rains following the dry seasons. The main harvest seasons are during the rainy seasons from March to May and October to December. Most of the swarms concentrate at night around street lights in urban areas, and on grasses and shrubberies, with no apparent damage. During the evenings of the swarming season, children and their parents arm themselves with saucepans, baskets and plastic bags, and fill them with thousands of the insects. Collection is easy because the insects are attracted to light in the evenings. In the mornings, hand-picking is easy because long-horned

grasshoppers are inactive at low temperatures. During the day, however, plastic nets are used for harvesting. A harvesting net with a wooden handle is swung around to trap the insects. A number of other tools are used to facilitate capturing, including glue, sticks and baskets.

Figure 20. Young long-horned grasshopper nymph

Preparation and consumption

Only the adult long-horned grasshoppers are harvested and consumed. However, there is little distinction between the younger nymph and the adult (Figures 19 and 20). The nymph is smaller, and the wings are not fully developed, but all other features are similar to those of an adult. After the wings have been pulled off, the grasshoppers may be consumed raw. Otherwise, the grasshoppers may be boiled, cleaned and fried before consumption (Figure 21). However, as the insects are only seasonally available, they are often preserved by sun drying - sometimes after frying.

Figure 21. De-winged fried and solar-dried grasshoppers ready to eat as a snack

Domestic/commercial production

Long-horned grasshoppers can be domestically produced fairly easily since the insects are not serious pests. They can be reared in netted enclosures with adequate exposure to light (Figure 22). Provide them with soft cartons

or cardboard or even sand, so they can lay their eggs in dark places. Add water at regular intervals to keep the sand/cartons moist. Feed them leaves and other edible supplements for healthy growth, e.g. bran or wheat germ. Normally they get their dietary water from their feeds. Put a source of radiant heat (light bulb or desk light) close to or, preferably, inside the cage to protect against low temperatures during cold seasons. Light should be on approximately 16 hours a day to provide the heat they need. On the other hand, if the cage is exposed to direct sunlight, providing shade is of great importance to their growth and development.

The use of insects in commercial food production has been evaluated, especially in cereal food products. One example is the addition of insects to fortify cereal-based porridges. However, as none of these ventures has become economically viable, domestic/commercial production of the insects has not been exploited.

Figure 22. Example of a rearing cage for long-horned grasshoppers (left) with its contents

6.2 Edible locusts

Various types of locusts and grasshoppers are consumed in most parts of the world. In this report we feature only brief descriptions of the desert locust (*Schistocerca gregaria*), migratory locust (*Locusta migratoria*), red locust (*Nomadacris septemfasciata*) and brown locust (*Locustana pardalina*).

Desert locust (*Schistocerca gregaria*)

Figure 23. Shistocerca gregaria (© Christiaan Kooyman)

The desert locust is large and, among farmers, much-feared because it can invade widespread geographical areas. This locust has invaded many countries worldwide: swarms have been reported to reach southern Europe, the whole of Africa north of the equator, the Arabian peninsula and the Indo-Pakistan region.

During the swarming stage, adults are first pink in colour, but may become rose, brown or orange-brown when temperatures are cool. Their colour changes during the maturity stage: the males become bright yellow and the females dull yellow (Figure 23). In the solitarious phase, the colour is greyish or brownish, but males may become yellowish when they mature. The body of the male is 40 to 50 mm long, while the female body measures 50 to 60 mm.

Migratory locust (*Locusta migratoria*)

Figure 24. Locusta migratoria gregarious phase (left) and solitary phase (right) (© Gilles San Martin)

The migratory locust is the most widespread locust species, distributed throughout Africa, Asia, the Arabian and Indo-Pakistani peninsulas, eastern Asia, Australia and New Zealand. These locusts cause large-scale destruction of agricultural crops as they migrate to suitable habitats. The gregarious adult migratory locust is brownish with a yellowish colour, while the solitary adult is brown with varying amounts of green, depending on the colour of the vegetation (Figure 24). The body of the male measures 35 to 50 mm; the female 45 to 55 mm long.

Red locust (*Nomadacris septemfasciata*)

The red locust is a large species found in south-eastern Africa. These locusts cause extensive destruction of agricultural crops as they aggressively feed on corn, rice, sugar cane, fruit and wild herbaceous species. They also feed on the leaves of citrus, acacia, eucalyptus and pine trees.

Red locusts have a longer body than do most other locusts: the male is 50 to 70 mm long, and the female measures 55 to 85 mm. Solitarious adults are larger, and chiefly reddish-brown and greyish in colour. At the base, their wings are pale red to purplish. The gregarious adults are smaller and are reddish in colour (Figure 25).

Figure 25. Nomadacris septemfasciata (© Alex Franc)

Brown locust (*Locustana pardalina*)

The brown locust is a medium-sized species that occurs in the semi-arid geographical regions of southern Africa. It survives well in adverse conditions of these regions due to a number of factors related to its eggs and their

development. The egg pod is reinforced with soil particles, forming a hard outer case that protects the eggs against soil compression and dehydration.

Intens outbreaks of brown locust occur regularly under favourable conditions (Figure 26). This species poses a potential threat to food security in southern African countries. Outbreaks are most common in the Northern Cape of South Africa and in Namibia, and they have since spread to other countries, including Zimbabwe, Botswana, Mozambique and Swaziland. As brown locust outbreaks generally arise following droughts, they have a double impact on farmers: destruction of crops by both drought and locusts.

Figure 26. Locustana pardalina (© Vincent de Boer)

Collection, storage and marketing

Locusts are collected during swarms, most often by women and children to supplement family nutrition. Children go on special catching trips as a leisure activity. Locusts are harvested when inactive: particularly early in the morning and when it is cold. To collect them, walk slowly in areas where there are grasses, and carry a piece of a tree branch. Once you spot a locust, you can then catch it by hand or kill it using the branch. Place collected locusts in a jar covered with the lid to prevent escape. Wash the harvested locusts in cold water and then boil for about 15 minutes. Salt is usually added to enhance the taste. Next, fry them for immediate consumption or expose them to the sun for several days to dry them. When the locusts are completely dry, they are traditionally stored in clay pots for future use. Locusts are collected mostly for household consumption, but they are also sold at the street market to generate income.

6.3 The house cricket (*Acheta domesticus*) – The Netherlands

Biology and recognition

There are 900 species of crickets. The house cricket may be the most commonly commercially-produced species. This species undergoes incomplete metamorphosis: young crickets look like small, wingless adults. The house cricket is medium-sized; the adult is about 2.5 cm long. It is light brown and has a black stripe between the eyes. The male is slightly smaller, and the female is easily recognised by the presence of an ovipositor about 2 cm long (Figure 27). Males stridulate: they make chirping sounds by rubbing their wings over each other. When solitary, they are quite loud, but in crowded conditions the males form a choir which does not seem as loud. House crickets are omnivores. They eat both plants and other insects, and also their eggs if food is scarce.

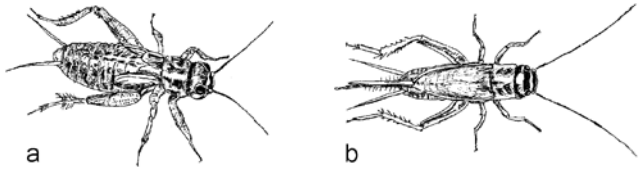

Figure 27. Male (a) and female (b) house cricket (Acheta domesticus)

Originally, the house cricket comes from northern Africa. In western Europe, however, feral (wild) populations are known to exist where it is warm enough, such as in bakeries.

Collecting

House crickets can be found in and around the house. Density depends mainly on feed availability. Large populations, suitable for sustainable harvesting, are only to be expected if there is an external source of feed. At night the crickets are active, and during the day they hide in warm and dark places. You can collect them by hand.

Production and reproduction

A holding container or pen is best made out of a smooth, non-organic material (Figure 28). This prevents the crickets from climbing out or eating through the walls. Another option is to place a strip of smooth material at least 5 cm wide at the top of the walls to prevent escape.

Figure 28. Container for the production of house crickets (left) with its contents (right)

The sides should be at least 40 cm high to keep these excellent jumpers inside. A lid should not block fresh air, so a metal screen could be used. The advantage of a lid is that it prevents flies and other animals from entering the container or pen and eating the crickets or their feed.

Production time is highly dependent on temperature. A temperature of 30˚C is optimal and will allow a full cycle to be completed within 8 weeks. At a temperature of 18˚C a full cycle can take up to 8 months. A humidity level of 50 – 70% is suitable. Higher humidity would allow the growth of mites. Good ventilation can help keep humidity levels low enough. The cage should contain materials that provide a lot of surface area. For example, stacked egg trays give the crickets places to hide underneath and inside.

For reproduction, you should put adult crickets in a separate container with a moist substrate (3 to 5cm high), such as potting soil, to allow for egg deposition. It is advisable to seal off the potting soil with a piece of metal screen. The screen should be large enough to allow the ovipositor to go through, but small enough to keep hungry crickets from eating the eggs (Figure 29).

Figure 29. Container for laying eggs

Water should always be available. You can offer it by means of a bottle of water capped with a piece of cloth so that the crickets can drink but not drown. Various types of feed are acceptable; the most common is chicken mash. This can be further varied by offering (leftover) fruits and vegetables. When working on a larger scale, you can best use different containers for the different instars. Place the eggs laid in a new container to hatch and grow. With this system you clean the container directly after harvesting.

Rearing crickets attracts other animals that prey on them. If ants are attracted, a little water runway around your rearing system will keep them out. Check your rearing system regularly to make sure it is well closed.

Harvest and storage

House crickets can be harvested as the final instar or as adults. Final instars can be eaten as is, but if adults are to be consumed, the wings should be removed first. This is because the wings consist of chitin, which has a low digestibility and does not add to the taste.

Like most insect species, house crickets are best consumed fresh. They can be killed by boiling. Crickets can be preserved either by drying or by salting. Freeze-drying and drying in the sun are acceptable. Although freeze-drying requires specialised machinery and is expensive, it is better because it preserves the taste.

Warnings

As the name implies, house crickets can sustain themselves in a house if food, temperature and humidity are adequate. This means that house crickets are a potential pest. Although they cause only limited damage, the sound the males produce can be annoying.

7 Termites (*Isoptera*)

R. Makhado, M. Potgieter, P. Tshikudo, K. Mawela, H. Maluleke-Nyathela, M.A. Ayieko, J.N. Kinyuru, J. Cloutier

The isopteran adult is mainly characterised by two pairs of membranous wings, although there are both winged and un-winged adult forms. Termites undergo incomplete metamorphosis (with egg, nymph and adult phases). Early instar nymphs are similar in form to a tiny termite. Termite larvae moult and grow into the adult stage without significant morphological (form) changes.

7.1 Termites – South Africa, Kenya

Introduction and Biology

The order *Isoptera* consists of seven families: Hodotermitidae, Kalotermitidae, Mastotermitidae, Rhinotermitidae, Termopsidae, Termitidae and Serritermitidae. The body of these insects is pale and elongate. They range in size from minute to large and have mouth parts for biting and chewing.

Termites are commonly found in tropical and subtropical regions, but are rare in temperate areas. They feed on dry or damp dead plant material such as wood and leaf litter, preferably on materials containing cellulose. Although cellulose is known to be difficult to digest, termites can digest it easily

because their gut contains symbiotic protozoa and other microbes. Protozoa are micro-organisms; symbiotic means that the protozoa cannot live without the termites and the termites cannot live without the protozoa. The protozoa can digest the wood and the termites get the energy. In exchange, the termites give the protozoa a suitable home: the termite digestive system.

Termites nest underground. However, when the nest grows above ground, beyond its initial concealing surface, it is called a mound. Some termite species make their mounds between branches in secluded forest areas (arboreal mounds). Other species nest entirely underground, making emergence holes only for the nuptial flight during swarming periods.

Soil from the mound is traditionally used by rural Africans for various purposes. For instance, the soil is collected and then spread on agricultural fields to add nutrients. It can also be used for plastering traditional structures.

There are several termite species in Kenya. Most of them are not suitable for human consumption due to their repellent smell and unappealing taste. Most locals claim that smaller species tend to be less fatty and bitter-tasting.

In the western region of the Lake Victoria region, eight termite species have been identified as potentially edible. However, as their behaviour and features are not easy to identify, there has been limited scientific characterisation. Still, some have fairly distinct features and behaviours. Three common species are described below.

Macrotermes subhyalinus (local name: Agoro)

Identifying traits:

1. Alates (winged individuals) are dark brown and are the largest of all types.
2. Alates swarm in April, between 8:00 in the evening and 3:00 in the morning. Due to changes in rain patterns, Agoro have been emerging as late as June/July, depending on adequate rainfall to facilitate nuptial swarming.
3. Soldiers and workers have light brown wings and no distinctive odour.
4. Large and medium-sized soldiers have a red head. Small females, with sour-tasting dark brown heads, are collected by only a few locals for human consumption.

Macrotermes bellicosus (local name: Riwo)

Identifying traits (Figure 30):

1. Alates are medium-sized, and dark brown with blackish wings.
2. Alates swarm from February to March between 5:00 and 7:00 in the morning, following the onset of the first rainy season.
3. Workers are medium-sized with dark brown heads.
4. Soldiers are very aggressive. Their bites tend to sting and itch much longer than bites from other species.
5. Soldiers produce a characteristically sharp smell when rubbed between thumb and first finger.

Figure 30. Macrotermes bellicosus flying (left); without wings (right) (© Hancock Wildlife)

Pseudacanthotermes militaris (local name: Sisi)

Identifying traits:

1. Nests are difficult to locate, as Sisi do not build mounds.
2. Alates are medium-sized and dark (Figure 31).
3. Alates swarm from 1:00 to 3:00 in the afternoon between September and December, depending on rainfall.
4. Soldiers are medium-sized with red heads or small and dark.
5. Workers are dark and have a swollen abdomen.
6. Sisi tend to be less fatty than Agoro.

Figure 31. Harvested winged termites (P. militaris) on banana leaves

Reproduction

Termites are social insects, living in large groups of organised colonies containing individuals from three castes: workers, soldiers and reproductives. Each caste has its own morphology (form). A colony can contain up to a million termites. Each colony is initiated and maintained by a queen and a king, the primary reproducers. The winged forms, called alates, are also reproducers. They swarm from mature colonies on warm days during the rainy season to find their mates. The winged adults emerge in huge swarms, mate while in flight, and then start new colonies (Figure 32). During the flight – known as the nuptial (wedding) flight – pairs of male and female termites isolate themselves from the others and fall to the ground. Their wings then break off, and each pair goes its own way to form a nest in a suitable spot. Usually, a termite pair starts by burrowing underground, making a few tunnels which eventually form the nest. They begin reproducing to initiate a colony.

The majority of the colony is of the non-reproductive caste. These are workers and soldiers. In general, they do not have wings. The workers have soft bodies, and have neither eyes nor well-developed mandibles. The soldiers may or may not have eyes, and have a well-developed, enlarged head with mandibles (Figures 32 and 33).

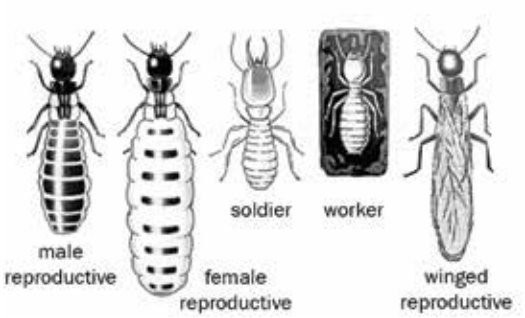

Figure 32. Members of termite castes within a nest (colony) (© Termite Web)

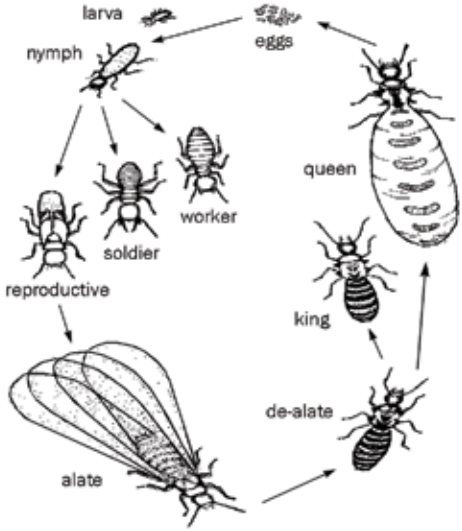

Figure 33. The termite life cycle (© Termite Web)

Termites as food

Termites are used as food in various cultures. These insects are rich in protein and fat. Eating termites provides good nutrition to a household or family. Selling termites creates seasonal employment for rural women.

Seasonal outbreaks, harvesting and storage

In most parts of Africa, termites are harvested at the beginning of the rainy season (summer). Various harvesting methods are used. For instance, winged forms are harvested by placing light traps covered by nets, or by placing a light source above a receptacle filled with water. Termites are attracted by the light shining in the water and fall into the water (Figure 34).

Figure 34. Improved light trap for Agoro (source: Ayieko et al. 2011)

Figure 35. Young children collecting termites during the season

The soldiers (un-winged form), particularly those with large mandibles, are harvested from the mound using a sliced stem of the inflorescence (complete flower head) of river sedge grass. A long sliced sedge stem is inserted into the mound opening. Soldiers bite the stem and become trapped. The sedge is then pulled out slowly with the soldier termites stuck to it. Harvesting is mostly carried out by women, both young and old (Figure 35). During a good season, an individual can harvest enough termites to fill a 5-litre bucket a day.

Harvesting depends on the type of alate. Traditionally, for the termites that build mounds (Figure 36), the insects are harvested soon after the rains begin. A hole is dug near the base of the mound. Then the mound is

knocked over and a fire is lit near the hole. The emerging winged termites are stunned by the smoke and fall into the hole. These termites are scooped out and stuffed into containers or appropriate bags. With enough oxygen in the containers, the insects can last up to 36 hours. While they are alive and active in the bag, they will be searching for an escape route.

Figure 36. Termite mound

Other termites do not build mounds. In this case, the winged termites emerge with the first rains at the end of the dry season. The alate is usually attracted to sources of light at night, and may be found around those sources in the early morning hours. In other cases, a hole is dug about 20 cm in diameter and 20 cm deep, about a metre from where the termites are expected to emerge. Traditionally, the natives line the holes with smooth, neatly overlapping leaves. In order to block the sunlight, a piece of cloth is suspended on twigs spanning the path from the termite exit hole to the pit that has been dug. The emerging alates, unable at first to use their wings, crawl towards the light at the end of the cloth-covered tunnel and fall into the pit. They cannot escape from the pit because of the smooth leaf lining (Figures 37). They are gathered in bags and taken away for home consumption.

Figure 37. Improved trap for termite collection

Preparation and Consumption

After harvesting the winged termites, the insects are fried to remove the wings and other debris, and then dried in the sun for several days. The unwinged termites are boiled in hot water in order to kill them, then dried in the sun for several days. Salt can also be added for taste. When the termites are completely dry, they are traditionally stored in bags, plastic or metal buckets, and even clay pots. They are then immediately sold at the local market or carefully stored to sell during the off-peak season.

Edible termites are collected throughout most of Africa as a kind of snack. However, in some places, especially in the semi-arid savannah zones, termites do provide an essential element of the diet among the non-livestock-keeping groups. The usual steps in the processing of the insect include wing removal, roasting and salting, or grinding into flour. The termites are usually consumed as part of a meal, or as a complete meal with tapioca, bread and roast corn — or simply eaten as snack food. Termites are often eaten straight from the holes as they emerge. In East Africa, termite mounds are considered so important that they are owned by individuals. Sometimes a mound forms part of owners' inheritance when they die.

Domestic/Commercial Production

Domestic production has not been exploited because it is a challenge to maintain nests in an artificial setting and to regulate caste development. In order to simulate the conditions within the nest (mound), you must understand the hormones that help the hatched eggs to become termites of the different castes.

Warnings

1. Sometimes agrochemicals are used to destroy termite mounds. Termites are known as pests that cause severe damage to wooden structures. The purpose of pesticide control of the mounds is to allow agricultural mechanisation and to protect cereal crops. To keep from consuming toxic pesticides, it is important not to eat termites from fields that have been sprayed with pesticides.
2. Un-winged termites must be handled carefully during harvesting as termite soldiers can bite the hands.
3. Eating too many termite alates has been associated with mild stomach aches. Locals complain of stomach upset when eating raw termites or ingesting whole termites, wings and all. The wings tend to stick in the throat and cause irritation and a mild cough. It is best to remove the wings and to use bread, potatoes or any other solid accompaniment to ensure that no wing pieces get stuck in the throat.
4. *Pseudacanthotermes militaris* has fairly light, soft wings which do not irritate the stomach, but do cause these termites to stick in the throat easily if wings are ingested. Fortunately, the wings fall off quickly during roasting.

8 Recipes

8.1 Recommendations for safe preparation of edible insects

It is important to prepare the insects properly before eating. Here are four important guidelines to follow:

1. Wash the insects.
2. Boil, steam or fry them for at least 5 minutes.
3. Eat the prepared insects directly after cooking.
4. If not eaten immediately, the insects must be preserved.
    a. Keep the insects cool: in the refrigerator at 4 to 7˚C, or in the freezer between -10 and -30˚C .
    b. It is also possible to preserve them by sun-drying for a few days.
    c. Caterpillars and larvae can be added to flour to make protein-rich bread or cakes. First, clean and boil them in salted water. Then, before adding them to the flour, either cut them in small pieces or sun-dry and grind them.

8.2 Caterpillars

Mopane worms

1. After harvesting the mopane worms, squeeze out the gut contents starting from the head.
2. Wash the mopane worms in cold water and then boil them for about 15 minutes.
3. Add salt to taste.
4. Allow mopane worms to cool and then expose them to the sun for a few days, or smoke them until they are completely dry.
5. Dried mopane worms can be eaten as snacks with or without porridge, or cooked again. These are steps for cooking dried mopane worms:
    a. Soak one cup of dried mopane worms in hot water for about 30 minutes.
    b. Rinse them in cold water.
    c. Put them in a pot with half a fried onion, 2 tomatoes, curry and green pepper.
    d. Add half a cup of water and a half teaspoon of soft salt, and mix.
    e. Boil for about 20 minutes.
    f. Make a side dish of *putu* porridge and serve.

Figure 38. Mopane worm dish (© ComQuat)

Figure 39. Stinkbugs being rinsed in cold water (method 2)

8.3 True bugs

Stinkbugs

Only the adult stinkbugs can be eaten.
They need to be prepared in one of two ways:

Preparation 1: The waterless head-removal method

1. Place a handful of live bugs in a small bowl of water to keep them from flying away.
2. Hold a bug on the middle part of the body (the thorax), just below the head.
3. Break the head off by pressing on a rock.
4. Gently squeeze until a gooey blob comes out of the opening.
5. Place the bug in a frying pan with a little water and salt to taste.
6. When you have enough bugs in the pan, fry them up until they turn golden brown.

Preparation 2: The bulk water method

1. Shake the bag of bugs in order to confuse them.
2. Drop the bugs into a 20-litre bucket with a perforated bottom.
3. Quickly pour hot water on top while stirring with a long pole for 5 minutes. This will irritate the bugs so that they release their smelly substance.
4. Rinse with cold water (Figure 39).
5. Heat a pot of water on an open fire; add bugs and simmer for 5 minutes. The bugs will change colour from green to golden-brown.
6. Drain bugs from the blackened water.
7. Spread the bugs out to dry and store for later use.
8. To eat them sauté in a pan with a little salt .

Figure 40. Cooked stinkbugs

8.4 Locusts and grasshoppers

The hind legs and the wings must first be removed from the locusts. Rinse the insects in cold water and then fry them with or without oil. Add a bit of salt or spices, and then continue to fry until they are golden brown. Make a side dish of *putu* porridge and serve.

Grasshopper snack / side dish

1. Immerse the grasshoppers in hot water for 1 minute to immobilize them and clean off excess dirt.
2. Remove the wings (optional).
3. Dry them in the sun for a few hours, or even for a few minutes, to remove excess moisture.
4. Fry in a pan for five minutes until they turn golden brown.
5. Serve as a crunchy snack or as a side dish with *Ugali* (stiff porridge).

Dry-roasted grasshoppers

1. Spread cleaned insects (fresh or frozen) on paper towels on a baking sheet.
2. Bake at 200°C for 1 to 2 hours until insects are as dry as desired.
3. Check dryness by attempting to crush an insect with a spoon.
4. Serve when hot and crunchy.

8.5 House cricket

Grilled house cricket snack

Ingredients

crickets and a few drops of sesame or olive oil

Preparation

Remove wings. Mix the crickets with a few drops of sesame or olive oil and cook under oven grill for about ten minutes until they become crispy. For alternative preparation in the pan, fry the wingless crickets in a few drops of sesame or olive oil for about ten minutes until crispy. Enjoy!

House crickets and dates

Ingredients

15 frozen crickets and 15 dates

Preparation

Cut the dates open from the side, remove the pit, and fill them with the frozen crickets. Let them defrost to allow the nutty flavour of the crickets to combine with the sweet flavour of the dates. This recipe can also be made with fresh house crickets.

8.6 Termites

Termites are best toasted or lightly fried until they are slightly crisp. Since their body is rich in oil, very little or no additional oil is needed. Termites can be dried (sun-dried), salted and then stored for future use. With winged forms, the wings are shed or can be removed just after drying. In rural areas, termites are a very important source of protein, particularly at the beginning of the rainy season when livestock is lean, the crops are at an early stage, and stored food from the previous season is running low.

Termite snack or side dish

1. Immerse the termites in water to remove excess dirt. (When termites emerge from the ground, they tend to fly out with sand and soil on their wings and legs.)
2. Fry in a pan for five minutes until they turn slightly brown and start looking more oily.
3. Blow the wings off (optional). The wings loosen and come off while frying and can easily be winnowed off in a light wind, or you can just blow with your mouth.
   You can also keep raw termites in the refrigerator overnight, and then the wings will easily fall off with a light touch. They can next be toasted without the wings.
4. Dry them in the sun for a few hours, or even dry for just a few minutes to remove excess moisture.
5. Add salt to taste.
6. Serve as a crunchy snack or as a side dish with *Ugali* (stiff porridge).

Termite spread

You can also simply put the toasted or raw de-winged termites in a blender and make a paste or bread spread to serve with potatoes or bread.

Processed termite products

Other products, such as baked buns, biscuits, crackers, muffins, sausages and meat loaf, have been prepared and tested by Ayieko and Kinyuru, two co-authors of this Agrodok.

Appendix 1
Insect availability according to the months of the year

Table 1. Availability of insect species according to the time of the year

Insect /month	January	February	March	April	May	June	July	August	September	October	November	December
Cetonids									x	x	x	
House crickets	x	x	x	x	x	x	x	x	x	x	x	x
Kanni Larvae							x	x	x	x		
Locusts and grasshoppers			x	x	x	x						
Long-horned grasshoppers			x	x	x					x	x	x
Mealworms	x	x	x	x	x	x	x	x	x	x	x	x
Mopane worms	x			x	x							x
Palm worms	x	x	x	x	x	x	x	x	x	x	x	x
Stinkbugs					x	x	x	x	x			
Termites	x	x	x	x					x	x	x	x

Appendix 2
Number of edible insects per country

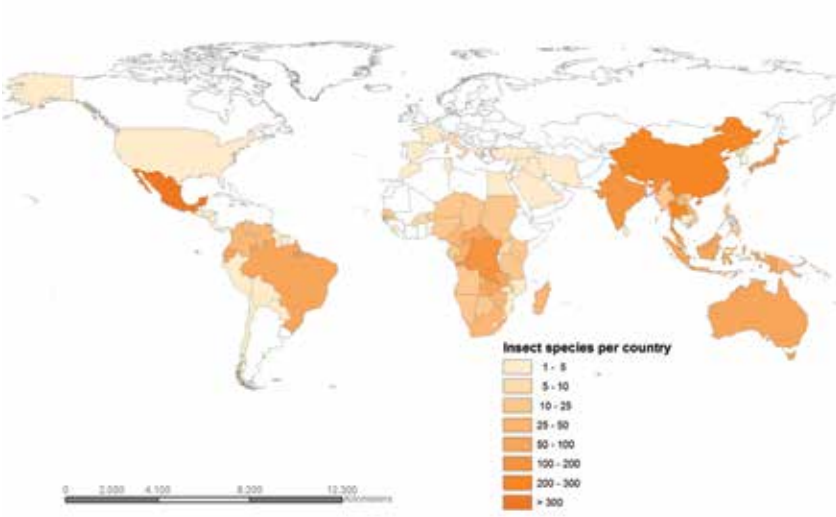

Figure A.1 Recorded edible insect species in the world (© WUR, www.ent.wur.nl)

Further readings

Huis, A. van; Gurp, H. van; Dicke M. **The insect cookbook: food for a sustainable planet.** 2014. First edition. New York. Colombia University Press. ISBN: 978-0-231-16684-3
In this book a culinary chef and two entomologists emphasise the role of insects as a protein source for humans and the role of insects in the future human diet.

Huis, A. van; Itterbeeck, J. Van; Klunder, H.; Mertens, E.; Halloran, A.; Muir, G.; Vantomme, P. **Edible insects: future prospects for food and feed security.** 2013. FAO Forestry Paper 171. ISBN 978-92-5-107595-1 (print), E-ISBN 978-92-5-107596-8 (PDF).
http://www.fao.org/docrep/018/i3253e/i3253e00.htm
This report, examines the multiple dimensions of insect gathering and rearing as a viable option for alleviating food insecurity.

Temitope, AO; Job, OO; Abiodun, A-FT; Dare, AO. **Eco-Diversity of Edible Insects of Nigeria and Its Impact on Food Security.** 2014 Journal of Biology and Life Science, 2014, Vol. 5, No. 2.
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Hundreds of species have been used as human food in Africa. Information on the list and distribution of these edible insects in Nigeria, harvesting, processing and preservation techniques, seasonality, nutritional value and potential for expanding the market.

Riggi, L.; Veronesi, M.; Verspoor, R.; MacFarlane, C. **Exploring Entomophagy in Northern Benin -Practices, Perceptions and Possibilities.** 2013.
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Elemo, BO; Elemo, GN; Makinde, MA.; Erukainure, OL. **Chemical evaluation of African palm weevil, Rhynchophorus phoenicis, larvae as a food source.** 2011. J Insect Sci. 2011; 11:146. doi: 10.1673/031.011.14601.

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Cirad. **Pest locusts: *Nomadacris septemfasciata*.** 2007. http://locust.cirad.fr/principales_especes/nse_en.html.

Further readings on stinkbugs

Dzerefos C.M. and Witkowski E.T.F. 2014. **The potential of entomophagy and the use of the stinkbug, Encosternum delegorguei Spinola (*Hem., Tessaratomidae*) in sub-Saharan Africa.** African Entomology. 22(3): 461-472.

Useful addresses

Eat less meat, more bugs: Florence Dunkel at TEDxBozeman
http://www.youtube.com/watch?v=W5GGKoYuXHs

http://labs.russell.wisc.edu/insectsasfood/the-human-use-of-insects-as-a-food-resource/
This website is an archive for a number of Dr. DeFoliart's works, including the online book, *"***The Human Use of Insects as a Food Resource: A Bibliographic Account in Progress.***"* Gene R. DeFoliart (1925-2013) was the founder and first editor of The Food Insects Newsletter (Vol. 1-8, No. 2, 1988-1995). He retired to Emeritus Professor status in 1991.

FAO
http://www.fao.org/
The Food and Agricultural Organization of the United Nations strives to achieve regular access to enough high-quality food for all people. The FAO is a major player in food security issues. In recent years the FAO initiated research and policy activities in the field of edible insects.
http://www.fao.org/forestry/edibleinsects/en/ (English, French and other languages)

Food Insect Newsletter
http://www.foodinsectsnewsletter.org/finlculinaryarts.html
Provides news, links and recipes for a diverse audience.

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Science in Africa is the first popular online science magazine for Africa, founded in 2000.

Laboratory of Entomology, Wageningen University
www.ent.wur.nl
The website of the Laboratory of Entomology, Wageningen University and Research Centre, publishes research work on edible insects and includes updated links:
http://www.wageningenur.nl/en/Expertise-Services/Chair-groups/Plant-Sciences/Laboratory-of-Entomology/Edible-insects.htm

Glossary

Acute poisoning	Immediate consequences of a single exposure to a high dose of a pesticide. This usually occurs after accidentally eating crops or insects shortly after they have been sprayed with pesticides.
Biodiversity	The variety of life forms within a given ecosystem or area.
Carbohydrates	The sugars mainly found in foods such as rice, noodles, bread and potatoes.
Caterpillar	The larval stadia of a butterfly. Caterpillars are often available during a specific season.
Ecosystem	A group of organisms – such as animals, plants, humans or microbes – living together and interacting with one another within the same environment as defined by the soil, water, air and temperature.
Foliage	The mass of leaves on plants.
Food safety	The issue of whether food is safe and 'fit for use'. Food safety involves the growing, handling, preparation and storage of food in ways that prevent health hazards.
Host-plant	A plant upon which insects can thrive.
Larvae	(Singular: Larva) The young or immature stadia of an insect species. Larvae are often available the whole year round.
Nocturnal	Describing an animal that is active at night.

Nutrients	Mineral substances, fats, carbohydrates and proteins which are essential to human health and contained in food.
Parasitoid	An insect which lays eggs in the host insect. The larva later kills and eats the inside of the host. Then it pupates inside or outside the host.
Pathogen	An organism or substance capable of causing disease.
Pathogenic	Describing something capable of causing disease.
Pesticide	A chemical used to kill pests such as weeds, fungi and insects.
Protein	The basis of many animal body structures (e.g. muscles, skin and hair), and also found in plants. Proteins are essential for good health.
Residual effect	The effect of the residue of an applied pesticide.
Vitamins	Organic substances, essential – in minute amounts – for normal growth and activity of the body, and obtained naturally from plant and animal foods.

The Agrodok series

The AGRODOK-SERIES is a series of low-priced, practical manuals on small-scale and sustainable agriculture in the tropics. AGRODOK booklets are available in English (E), French (F), Portuguese (P), Kiswahili (K) and Spanish (S). Agrodok publications can be ordered from AGROMISA or CTA.

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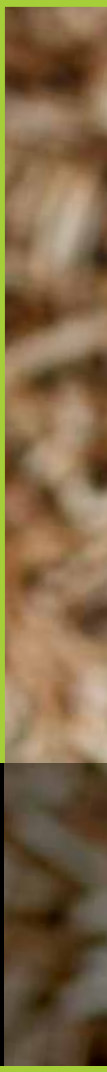
53.	Crop residues for animal feed	F, E
54.	Edible insects in Africa	F, E

Edible insects are a common ingredient in traditional dishes in many parts of Africa, a continent with more than 250 potentially edible insect species. As the world's population continues to grow, there is renewed interest in the use of insects as human food. Insects provide animal protein of good quality, and they are rich in lipids and macronutrients. The many edible insect species – an accessible and affordable source of food – can contribute to food security.

This Agrodok shows where to find, and how to collect and prepare 10 different insect species from 5 groups: caterpillars, beetles, true bugs, grasshoppers and crickets; and termites. With the information in this Agrodok, Agromisa aims to contribute to the use of edible insects as a means to securing access to sufficient quantities of nutritious food.



Agrodoks are a series of publications on small-scale agriculture. The booklets are aimed at people who work directly with small-scale farmers in the South. Each provides a theoretical background on a particular topic and then explains its practical applications extensively. All Agrodoks are published in English and French and many also in other languages. They can be ordered from Agromisa and CTA and are also available in PDF format.

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