THE FOODFACTORY PROJECT

Version 0.74

Amsterdam, August 2008

Drs. Bart T. Hogebrink – IniVention

Ir. Henk C. van Deventer - TNO

1 PROLOGUE

TNO Press release: November 30, 2007

The FoodFactory idea, conceived by Bart Hogebrink of Amsterdam,The Netherlands, is TNO's selection as winner of the 2007 Not Invented Yet (NIY) competition. FoodFactory is an idea to combat hunger in developing countries using nutritional cookies made from specially reared insects. The jury led by Alexander Ribbink of TomTom (mobile navigation systems) thought that this idea was the best for changing our future for the better. As part of the prize, TNO will be trying to get the idea launched. In addition to this, Bart Hogebrink also receives a multimedia laptop and digital HD video camera.

TNO wants to promote the power of innovation among Dutch industry and government. The competition is linked to this aim: TNO challenged young people to come up with ideas to bring about a positive change to our future. Not Invented Yet (NIY) is a web-based competition that invites the submission of original ideas. Participants were able to send in their creative ideas in the form of a two-minute video fragment between 25 April en 30 October this year to www.notinventedyet.nl. Visitors to the site were able to vote for their favorite idea. A total of 88 ideas were accepted (48 were rejected). The most viewed ideas were viewed some 10,000 times. In total the ideas were viewed 200,000 times. There were some 5,000 votes cast. The film clip of one idea was copied to another site 267 times (Youtube or the entrant's own website). The special had 38,000 unique visitors and almost a million page views.

The jury comprised Alexander Ribbink of TomTom and Peter Werkhoven, Fietje Vaas, Ben Immers and Celeste Ponsioen of TNO. The jury report reveals how impressed the members were by the quality of the ideas and the creative way the participants gave shape to their ideas in a short film clip. It was clear to the jury that the Netherlands was brimming with innovation. The jury was struck by the idea of the FoodFactory winner that world hunger could be alleviated. It may be an obvious notion but it's still new and creative. However, the next step will present significant challenges. Hunger is more a problem of logistics than it is of adequate food; the food is simply not where it needs to be. The challenge lies in getting to grips with the logistics.

2 SUMMARY

About a thousand people die from starvation every hour. The FoodFactory is an idea from the Dutch inventor Bart Hogebrink to fight world hunger by industrially rearing insects for food. Insects are highly nutritious; they generally contain more protein and less fat than traditional meats. They also have an almost 20 times higher food conversion efficiency than traditional meats. Furthermore, they reproduce much faster than cattle, are easy to raise and need far less living space.

In many parts of the world insects are already popular as food. But the current method of harvesting, by hand in the wild, makes them expensive, susceptible for extinction, droughts and natural enemies. Furthermore, they are only available in significant quantities in specific seasons.

The idea of the FoodFactory is to design highly scalable factories where insects are grown, harvested and processed in an industrial way, making the process of making insect-based food cheap and controllable. As a result, food can be produced at such low costs, that even the poorest people can obtain enough food to survive, learn and work. In this way, not only hunger, but also poverty, unemployment and environmental problems can be tackled.

3 CONTENTS

4 INTRODUCTION

4.1 WORLD FOOD SUPPLY: STILL NOT SUSTAINABLE

Human development in Africa is hampered by under-nutrition, especially micronutrient deficiency. [1] Finding new food sources to improve the food supply for the expanding world population is critical. The World Health Organization of the United Nations recently reported that more than 3 billion people in the world are malnourished as a result of a diet deficient in calories, protein, major vitamins, as well as the minerals of iron and iodine. Worldwide, around 8,7 million people die as a result of malnutrition annually.

The world food supply, especially cereal grains, has been declining for about 20 years, according to data compiled by the Food and Agriculture Organization of the United Nations. FAO has further noted that grains constitute about 80% of the world food supply. Meanwhile, the world human population now stands at more than 6.3 billion and is rapidly increasing, at about a quarter million people each day. It has been projected that the world population will double in a mere 50 years, based on the current growth rate (1.3%) of the world population. Surely all future generations of humans deserve an adequate food supply.

Although there are more than 15 million species of plants, animals, and microbes on earth, more than 90% of the world food supply comes from just 15 crop species and 8 livestock species. In the United States and other developed nations, large quantities of meat, milk, and eggs are consumed. To provide this animal protein, farmers must maintain large numbers of livestock. In fact, the US livestock population outweighs the human population by more than 5 times. Of practical concern is that these livestock consume more than 250 million metric tons of cereal grains each year. This is sufficient food grain to feed more than 800 million people.

One way to expand the human food supply is to increase the diversity of plant and animal species used as food.[2] Many programs promote home gardening, but the bioconversion of important pro-vitamins from vegetables is much less than previously thought. Animal foods contain more bio-efficacious micronutrients.[1]

4.2 IS ENTOMOPHAGY (EATING INSECTS) THE ANSWER?

Entomophagy is the practice of eating insects as food.[3] Insects are an excellent food source and have important advantages over usual livestock.

1. Insects generally have higher food conversion efficiency than traditional meats. For example, studies concerning the house cricket, when reared at 30°C or more and fed a diet of equal quality to the diet used to rear conventional livestock, show a food conversion twice as efficient as pigs and broiler chicks, four times that of sheep, and six times higher than steers when losses in carcass trim and dressing percentage are counted.

2. Insects reproduce at a faster rate than beef animals. A female cricket can lay from 1,200 to 1,500 in 3 to 4 weeks, while for beef the ratio is four breeding animals for each market animal produced, thus giving house crickets a true food conversion efficiency almost 20 times higher than beef.[3]

3. Insects have a large biodiversity. Worldwide, about 2000 insect species are reportedly eaten as human food. They form part of the traditional diet of many cultures and allow versatile preparations.

4. Insects have excellent nutritive value. They contain a high content of essential amino acids, vitamins, minerals and high quality proteins. They are also tasty, have a crunchy consistence, provide a significant quantity of energy and are generally easy to digest.

5. They accept relatively low quality food substrates of various kinds that are not used by people. Their total biomass is edible, making them excellent transformers of low nutritive elements into much richer compounds.

6. They have a short life cycle, are generally easy to breed and to conserve. Moreover, their excreta can be used as fertilizers, so no production of waste occurs.

7. They have an enormous potential in human and animal nutrition, and can be exploited for inclusion in modern food or medical products.

The U.N. Food and Agriculture Organization (FAO) has recently promoted the idea of using insects as a valuable food source during emergencies. Patrick Durst, a senior forestry officer at the FAO in Bangkok says, “In certain places, insects can very well be seen as part of the solution to hunger.” According to scientists, crickets, caterpillars, and grubs are a reliable source of protein and can be safely eaten as a reliable food source, should no other safe option be available.[4]

Although developed nations consider insects to be an emergency food or nonconventional food of low prestige, they are part of the daily diet of the greater part of humanity, where they are regarded as healthy, nutritious and tasty food. Once the suitable species are selected and the appropriate breeding methods are developed, insects would be able to provide a reliable and sustainable source of high-quality animal protein.[5]

4.3 CURRENT PRACTICES OF ENTOMOPHAGY IN AFRICA

African culture itself recognizes the value of insects as food. Insects are eaten all over the continent, particularly in central and southern Africa, where they are an important protein and micronutrient source for the rural poor, and a delicacy for urban dwellers. Around 250 edible insect species occur in Africa.

In Botswana, South Africa and Zimbabwe, strong cattle-raising traditions co-exist with entomophagy of insects. An example of a popular insect in these regions is the mopane worm. The harvesting and sale of mopane worms is a multi-million rand industry in southern Africa. The principle producers are Botswana, Namibia, South Africa and Zimbabwe. Typically, the caterpillars are not domesticated, and are hand-picked in the wild, often by women and children, wherever they occur naturally. It is the one of the region's economically most important insects.

Mopane worms are considered to be a profitable harvest, as a mere 3 kilogram of feed (mopane leaves) will generally yield 1 kilogram of mopane worms: in contrast, cattle farming requires 10 kilograms of feed to generate 1 kilogram of beef; thus the worms are a low-cost, low-maintenance, high-protein foodsource.

Traditionally, mopane worms were harvested for subsistence and nutritional purposes. The seasonal nature of the edible caterpillars meant that this was not an all-year-round food source, and was more supplementary than nutritionally sustainable in nature, although modern trends have evolved the subsistence nature of mopane worm harvesting to be more commercially-driven.

Since the 1950's, methods used in commercial farming have been applied to the mopane worm harvests, particularly in South Africa. Collectors may organize teams of hundreds of people to hand-pick the caterpillars from the trees, which are then bagged en masse, weighed and sent off to be processed. Owners of land where mopane worms are found may charge harvesters large amounts of money to enter. This commercial relationship profits both the commercial harvester and the farmer.

Nevertheless, the use of edible insects as a food in Africa is limited because of several reasons:

1. Overharvesting leads to fewer insects in the following year.

2. Insects can only be harvested during short periods of the year.
3. In Africa, edible insects were never domesticated, so rearing does not occur.
4. Insect consumption is under pressure due to Western influences.
5. Poor ecological and social management of open wild areas where insects are collected limit the wild population.
6. Collecting practices depend on insects' behavior. For example, inactivity at low temperatures enables easy catching of grasshoppers in the morning, and crickets can be located by their sound.[1]
7. There is almost no infrastructure in the countries that are most in need of food, and the challenge of transporting large quantities of these insects over great distances has not been overcome.
8. The consumption of insects is still not common everywhere, and is sometimes even a taboo in certain families.
9. The use of pesticide on crops can make insects unsuitable for human consumption.

4.4 GOAL

The goal of the FoodFactory Project is to overcome the factors that are limiting the success of entomophagy (the practice of eating insects for food) in alleviating world hunger.

The FoodFactory Projects' unique approach to reach this goal is a) the development of a nursery where insects are industrially reared for food, and b) a plan to implement these nurseries in areas with high starvation rates.

4.5 PROJECT DESIGN AND IMPLEMENTATION

The FoodFactory project addresses these problems by domesticating insects in a manner similar to silkworms. This would allow the industry to be less susceptible to the pitfalls associated with it, such as climatic change, drought, toxicity and other factors that could compromise a harvest. Furthermore, by making the insect population controllable by containing them, the insects are no longer a threat for valuable crops and trees, a reason why they are now often considered an undesirable pest.

To overcome the limited infrastructure, a version of the FoodFactory will be designed that is highly scalable, easy to maintain and easy to duplicate by the local population. This way, the insects can be farmed locally, so transporting the insects is not required.

It is not necessary to eat insects with their shape intact. When used as common foods or as an important nutrient source, they can be pulverized dry. This might eliminate the refusal reaction against insects by the majority of people that have no desire to eat insects and generally dislike them.

For a domesticated industry to succeed on a small scale and be accessible to the poorest of the poor, the costs of production would be have to be comparable with, or lower than the costs of wild or dried insects at the market.[6]

4.6 IMPLEMENTATION

Overcoming all limitations that were pointed out previously, with only one approach seems an impossible task. Therefore, the approach of the FoodFactory project is two-folded.

Approach 1: High quality, medium quantity is aimed at providing a more sustainable solution than The World Food Organization's (WFO) current method of feeding people in disaster areas, with continued supplies of external food, like grains. For this situation, a FoodFactory made from pre-fabricated building blocks will be designed, that should be delivered, built and operated by skilled WFO-employees. Of course, in time other NGO-employees or locals can be taught to operate and maintain these factories.

Approach 2: High quantity, medium quality is aimed at designing a building diagram that explains how to make a very basic FoodFactory out of scrap metal, like oil barrels, that can be made at any workplace without explanation or material from the WFO or NGO's. The idea is to convince oil-drum manufacturers to print these building diagrams on the bottom of every oil drum that is distributed in the Third World. Because of the huge quantity of these oil barrels, both the knowledge how to build a FoodFactory and the material needed to do so, is very quickly spread among all Third World countries, and can reach any community that uses oil barrels. If the FoodFactory project succeeds in developing such a FoodFactory and a simple diagram, and succeeds in getting support from oil-drum manufacturers, this approach has a greater potential to relief world hunger then any help based on an external food supply could ever have.

Fig. 1: Examples of simple FoodFactories.

4.6.1 CHOICE OF INSECTS

The choice of insect species was based on the following factors:

- Suitable for consumption
    - High nutritional value (proteins, vitamins, etc)
    - Safe
    - Tasty
- Variable diet
    - Has to eat local vegetable waste products (rotting fruit, leaves, rind, etc)
- Efficient conversion
- Fast growing
- Fast reproduction
- Easy to handle (non-flying, low space-per-insect-requirements)

- Commonly found in the wild
- Capable of living in many circumstances
- Insensitive to diseases

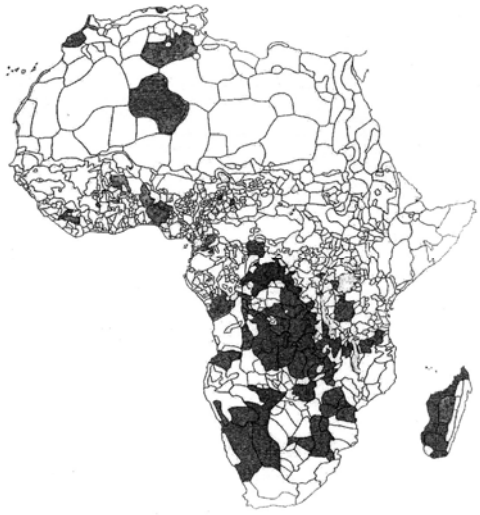
Based on these factors, the selection of insects was narrowed down to grasshoppers and non-flying crickets.

4.6.2 CHOICE OF REGION FOR PILOTPROJECT

The choice of location for a pilot project was based on the following factors:

- Significant shortage of food
- Familiar with eating insects
- Enough food available for insects
- Suitable NGO present to support the work
- Relatively safe (no active war).
- Unlikely to develop other sustainable solutions to hunger

Based on these factors was narrowed down to country in Africa. The following regions are familiar with eating grasshoppers and crickets:



[7]

The Songhai center in Porto Novo, Benin, seems like a suitable NGO to support the work. The ambition of Songhai is to consolidate the development process that links social characteristics with economic activities. To attain this goal, Songhai seeks to empower men and women by instilling in them an entrepreneurial spirit in the areas of agricultural production, food processing, craft making and training. This is in line with the approach of the FoodFactory project. Nevertheless, this preference is not final and other countries with other NGO's will still be considered.

5 APPROACH 1: HIGH QUALITY, MEDIUM QUANTITY

5.1 INTRODUCTION

Worldwide, several industrial insect farms exist, including farms where cricket and grasshopper are reared for food, usually for animals like domesticated snakes and birds. But these farms are built in western countries, with developed infrastructures, power grids, and highly skilled construction workers. They can afford to be expensive, because their customers will eventually pay for construction and maintenance costs.

In case of the FoodFactory, the main target groups are starving people and children, both unable to pay enough to return any investment needed to built a factory. Therefore, the FoodFactory needs an original approach to provide a food for the poorest and still be attractive enough to be reproduced.

5.1.1 DESIGN FOCUS

In approach 1, the design is focused on the following:

- Relatively quickly and easy to built out of Ikea-like building blocks that can be transported by planes and trucks.
- Able to make insect-rearing season-independent by controlling the temperature, humidity etc.
- Suitable for rearing numerous insect species, but specialized for one.
- Suitable for different food-sources for insects, but specialized for one diet.
- Should not rely on any power grid for operation
- Easy to operate and maintain
- Low operating costs
- Scalability
- Reliable
- Capable of killing, cleaning, conserving and processing of insects

Less important factors are:

- Initial installation costs

5.1.2 SOCIAL-ECONOMICAL IMPLEMENTATION

These factories can be constructed by WFO-employees in disaster areas or areas with a permanent food shortage. After setting them up and building a sustainable food supply, an economy should be built around it to keep an incentive for operating it after the WFO-operator leaves.

The yield can be divided into two equal parts:

- 50% is handed out for free to local schools, houses for the poor, and eventually even hospitals.

- 50% can be sold, or processed and then sold on local markets. This generates the income to keep the operator encouraged to maintain high standards in the quality and quantity of the production.

During the development of the FoodFactory and the economy around it, the WFO-employee should find out who is most likely to prolong this profitable village enterprise even after the WHO-employee leaves the village. This person should learn everything needed to provide a lasting food source for the village. He or she may exploit the FoodFactory as long as it is successful in relieving the village from hunger. This operator does not own the factory, so if during a annual inspection a WFO-employee feels that the use of the FoodFactory is not properly exploited, this employee can grant another village member to operate and exploit this factory.

6 APPROACH 2: HIGH QUANTITY, MEDIUM QUALITY

6.1 INTRODUCTION

In this day and age, oil companies like Shell are investing huge amounts of money in improving their corporate image. They also sell a product that reaches the furthest outskirts of even the Third World countries: petrol.

The idea for approach 2 is to give these oil-companies a chance to do something back for the world after all they took from it. They can turn their distribution channel of petrol into a channel that distributes all the knowledge and material that is needed to let poor villagers develop themselves.

To do so, the only thing they have to do is to allow a building diagram with essential information of how to turn an oil barrel into a FoodFactory, to be printed underneath every oil barrel that is distributed in the Third World.

This way, the knowledge of how to rear insects can be spread among the whole Third World much faster than any NGO could ever do. Moreover, this knowledge can be used immediately to build something that is able to address a very basic need: a supply of food.

However, these building diagrams should not be limited to FoodFactories. Models for other elegant uses, like simple wind-power generators like the Savonius rotor and high-efficiency woodstoves, should be distributed the same way.

Fig. 2: Savonius rotor / wind power generator made out of oil barrels.

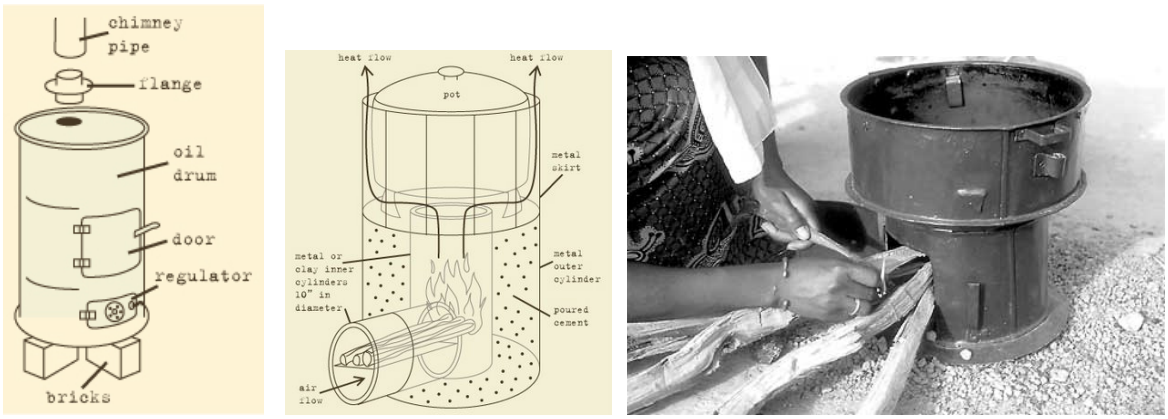


Fig. 3: Efficient woodstove made out of oil barrels.

It is not yet certain that a FoodFactory can be built from an oil barrel, and even if it can, it is unknown if all necessary knowledge to properly operate it can be distributed with information underneath an oil barrel. The lack of supervision from a professional makes this approach very precarious, but the incredible potential of this approach makes it worthwhile to design such a FoodFactory, and, when successful, thoroughly test in different settings in different countries.

6.2 TECHNICAL DESIGN

To be determined.

7 PHASE 1: TECHNICAL FEASIBILITY OF FOOD FACTORIES.

7.1 INTRODUCTION

2 approaches have been chosen:

- A high quality, medium quantity FoodFactory made from pre-fabricated building blocks to be built and operated by skilled WFO-employees
- A high quantity, medium quality and very basic FoodFactory that can be made out of scrap metal, like oil barrels, at any workplace.

In order to study the technical feasibility, it is suggested to build both FoodFactories as a pilot project to gain experience with designing, building and operating them as a nursing box for edible insects.

Nursing and growing experiments are not included in this outline, because these will be worked out in a parallel project and much is already known from literature.

7.2 GOAL

To demonstrate the feasibility of an operational FoodFactory that can be produced and operated in developing countries. In a FoodFactory insects are grown for human consumption.

7.3 PARTNERS

- IniVention, Bart Hogebrink
- TNO Quality of Life, Henk van Deventer
- Construction firm
- WUR, Arnold van Huis, Arno Hoetmer

7.4 ACTIVITIES

The following activities are foreseen:

1. Collect available data on growing of insects, especially crickets and grasshoppers, like:
    a. Growing time
    b. Optimal growing conditions, temperature, humidity, air refreshing
    c. Acceptable food, preferably not for human consumption
    d. Food conversion factor
    e. Specific growing speed
    f. Etc.
2. Basic design of a FoodFactory on the basis of:
    a. Space per insect
    b. Temperature and humidity boundaries
    c. Ventilation needed
    d. Appropriate inlet facilities for food
    e. Appropriate inlet and outlet facilities for harvesting of insects
    f. Etc.
3. Detailed construction drawing of 2 types of FoodFactories
4. Building of the two types of FoodFactories
5. Evaluation of the two types of FoodFactories, located at TNO, with respect to:
    a. Ventilation
    b. Inlet of food
    c. Inlet and outlet, harvesting, of insects
    d. Ruggedness
    e. Etc.
6. Drafting an implementation plan in phases, including go no go's.
7. Contacting NGO's for the dissemination of the FoodFactory concept
8. Contacting Foundations for financing dissemination project(s)
9. Reporting including a feasible implementation plan with potential financers

7.5 COSTS AND TIME SCHEDULE

Provisional cost calculations based on consultancy tariff for IniVention, € 80/h, and TNO tariffs (depending on classification). Costs for the construction firm and the WUR, as consultant of the project, are estimated.

Activity nr.	IniVention (cost in k€)	TNO (cost in k€)	Construction firm (cost in k€)	WUR (cost in k€)	Time (months)
1	2	2	-	1	0 – 1
2	2	5	-	1	1 – 2
3	3	3	2	-	2 – 3
4	2	2	25	-	4 – 5
5	8	15	3	2	6 – 7
6	5	5	-	1	7 – 8
7	5	3	-	1	8 – 9
8	3	2	-	-	9 – 10
9	8	5	-	-	11 – 12
Total / partner	38	42	30	6	0 – 12
Total project			**116,000 € (excl. VAT)**		**0 – 12**

8 PROJECT CHARACTERISTICS

The FoodFactory project follows the following development principles:

- **Help reduce inequities in neglected areas**
  By providing in de need for extremely cheap and possibly free food, people who are now starving can become part of the working community and develop themselves.

- **Produce measurable results**
  The number of people suffering for malnutrition is probably fairly constant in the most undeveloped areas. The main goal of the FoodFactory is decreasing this number. In all areas where this number is measured, the effect of the FoodFactory should be measurable.

- **Catalyze increased momentum, scale, and sustainability of change**
  Feeding young children enough healthy food will make it much easier for them to go to school and concentrate during their classes. This gives them the opportunity to develop themselves and the area they are living in.

- **Collaborate with government, philanthropic, private-sector, and not-for-profit partners**
  Government, philanthropic, private-sector and not-for-profit partners will be asked to build and run the first FoodFactories, maintain them and teach the locals to build and maintain them themselves.

- **Favor preventative approaches**
  Just handing out grain is generally not considered a sustainable solution for malnutrition. Once the people in these poor areas have been shown how they can actually make enough food themselves, using the FoodFactory, they will become independent of help from others.

- **Leverage support from other sources**
  Many hunger fighting projects exist. When the FoodFactory succeeds in providing enough food for a certain area, other hunger fighting projects can switch their focus to other areas.

- **Advance current strategies, accelerating current work**
  Many initiatives in Third World countries aim at reducing poverty and hunger. The FoodFactory project has the same goals and offers a new and credible method to reach those goals.

9 REFERENCES

1. Huis, A., *The Future of Edible Insects in Africa*, in *EDIBLE FOREST INSECTS; HUMAND BITE BACK*, FAO: Chiang Mai, Thailand. p. 17,18.

2. Paoletti, M.G., *Ecological implications of minilivestock: potential of insects, rodents, frogs and snails.* Ecological implications of minilivestock: potential of insects, rodents, frogs and snails, 2005: p. xiv+648pp.

3. Wikipedia, t.f.e. *Entomophagy*. 2008 [cited; Available from: http://en.wikipedia.org/wiki/Entomophagy.

4. Intern, U.-U. *Insects as a Valuable Food Source*. [cited; Available from: http://unworks.blogspot.com/2008/02/insects-as-valuable-food-source.html.

5. Ramos-Elorduy, J., *Insects: a hopeful food source.* Ecological implications of minilivestock: potential of insects, rodents, frogs and snails, 2005: p. 263-291.

6. Huis, A., *Insects eaten in Africa (Coleoptera, Hymenoptera, Diptera, Heteroptera, Homoptera).* Ecological implications of minilivestock: potential of insects, rodents, frogs and snails, 2005: p. 231-244.

7. Paoletti, M.G., *Ecological implications of minilivestock: potential of insects, rodents, frogs and snails.* Ecological implications of minilivestock: potential of insects, rodents, frogs and snails, 2005: p. 211.