



Food and Agriculture
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United Nations



Guidance on sustainable cricket farming

A practical manual
for farmers and inspectors

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Required citation

Hanboonsong, A. and Durst, P. 2020. *Guidance on sustainable cricket farming – A practical manual*. Bangkok, FAO. <https://doi.org/10.4060/cb2446en>

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ISBN 978-92-5-133739-4
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Acknowledgements

This manual was prepared by Dr Yupa Hanboonsong, Professor of Entomology, Khon Kaen University, and Patrick Durst, Forestry and Natural Resources Consultant and former Senior Forestry Officer with the Food and Agriculture Organization of the United Nations.

Under the visionary leadership of Dr Hanboonsong and her colleagues, Khon Kaen University has pioneered the development of edible insect farming and provided effective extension services to insect farmers throughout Thailand, Lao People's Democratic Republic, and several other countries over the past two decades. Cricket farming has expanded greatly, particularly in northeast Thailand, as a result of the support and outreach provided by Khon Kaen University. Along the path of development – from essentially no organized insect farming in the early 1990s, to more than 20 000 farmers today – a great deal has been learned to make cricket farming more efficient and sustainable.

Drawing upon this practical knowledge and experience, the FAO Regional Office for Asia and the Pacific collaborated with Khon Kaen University to produce this manual. The manual is designed to provide practical guidance to cricket farmers, and those advising on cricket farming development, and a systematic framework for farm inspectors to monitor farming practices and ensure food safety and sustainability. In compiling this manual, the authors visited scores of cricket farms of various scales of to assess challenges, identify common operational and management weaknesses and confirm best practices. Detailed investigations were conducted with leading cricket farmers throughout northeast Thailand to validate the prescribed practices and operations. Consultations were also held with agricultural extension officers to identify current gaps in monitoring of insect farming and provision of extension services.

The lead compilers of this manual were supported by Dr Tasanee Jamjanya, Assistant Professor of Entomology at Khon Kaen University, who provided technical review and comments on various drafts. Mr Peter Martin, former Manager, Agribusiness Sector of the ANZ Bank of New Zealand, also provided valuable review and comments on the manual from a business perspective.

The compilers also acknowledge the support of Ms Lallalit Sukontarattanasook, Lallalit Agri Foods, Co., Ltd., for providing photographs of cricket rearing facilities and plastic breeding containers. Mr Piboon Kammumart and cricket farmer peers at Ban Bansantho, Khon Kaen, provided highly detailed information on cricket breeding and rearing operations.

We also appreciate the support of Kenichi Shono, Giulia Muir and Illias Animon in reviewing the manual and coordinating the publication process. Robin Leslie provided editing support. Lucia De Canio provided graphic design. We gratefully acknowledge the support of the Forest Products and Statistics Team at FAO Headquarters for the technical and financial support provided.

Executive summary

In 2013, the FAO publications “Six-legged livestock: edible insect farming, collection and marketing in Thailand” and “Edible insects: future prospects for food and feed” were published, each causing international media sensations in advancing the proposition that edible insects could contribute to meeting the food, nutrition and feed needs of a growing world population. The suggestion by the authors that insects could be “a future food” with the potential to contribute to global food security under certain conditions gained widespread attention and prompted much discussion around the world. Among the issues raised by the authors of these publications, however, was the remarkable lack of research-based information on best farming practices for insect production and consequently, inadequate guidance on food safety and hygiene from government agencies.

In Thailand, although there were some 20 000 cricket farmers active by 2013, most learned their farming practices through trial and error, with little science-based research guiding them and limited counselling on “best practice” to advise new entrants to the industry. New cricket farmers, particularly, make avoidable mistakes in farm management and extension agents and advisors have limited knowledge to offer by way of support.

The purpose of this publication is twofold: to help new cricket farmers get started in the business with a minimum of errors, and to provide those already farming crickets with practical management support (Part 1); and provide a framework for government agencies to monitor cricket production processes and ensure food safety (Part 2). As the most comprehensive cricket farming management guide assembled to date, this publication is expected to fill long-standing gaps that have frustrated many existing and aspiring cricket farmers, those in academia and extension services seeking to advise farmers, development organizations promoting edible insect farming, and students interested in this emerging sector. Users of the Inspector’s guidance (Part 2) should also make use of the Best Practices for Sustainable Cricket Farming (Part 1). When used together, this guidance will help close the knowledge gap and enable staff of government agencies, such as Agriculture Department advisors and Food Safety Inspectors to get “up to speed” on cricket production processes and focus clearly on issues that affect food safety.

Cricket farming is one of those rare agricultural industries that has developed rapidly and largely independently of government and research institutional support. This has left monitoring and extension bodies scrambling to catch up, especially as edible insect farming increasingly expands to supply international markets that demand food safety assurances and sustainable practices. This publication is equally vital for insect farmers and food safety inspectors to bridge knowledge gaps and provide structure for effectively engaging the industry, for the benefit of all stakeholders, including farmers, consumers, extension agents, academics, researchers, and students.

Part 1

Best practices for sustainable cricket farming



INTRODUCTION

The primary purpose of this section is to help new cricket farmers get started, while those already farming crickets will also likely find management information covered to be of practical use.

As requests for advice on how to start cricket farms, or overcome problems that were being experienced arose, the idea of collecting existing experiences and formulating guidance on cricket farming emerged. This section seeks to address this demand for more and clearer guidance and information. It systematically describes basic management techniques needed to ensure best practices in raising crickets for food production.

These techniques are based on 20 years of practical experience of cricket farming in Thailand, and previously unpublished data and knowledge collected by the authors and support team. Robust research data related to cricket farming is still lacking, but will undoubtedly increase over time. However, in the interim, the growing cricket farming sector can be enhanced through the application of known best practices and related guidance.





GOOD CRICKETS FARMING PRACTICE

Cricket farming is relatively easy to manage, requires little time and few inputs, and produces outputs quickly. The guiding principle for good cricket farming is to produce high-quality edible crickets from healthy insects, using management practices that are sustainable from economic, social and environmental perspectives.

This guideline for good cricket farming practices covers the following topics:

1. Farm assets and equipment
2. Rearing cycle management
3. Feeding crickets and nutrition
4. Farm hygiene and health management
5. Waste management
6. Heat management
7. Record keeping
8. Workers' health and safety

1. Farm assets and equipment

Farmers should address:

- 1.1 Farm location and layout
- 1.2 Rearing shed
- 1.3 Cricket rearing pens
- 1.4 Siting of water and feed containers
- 1.5 Egg collecting and containers
- 1.6 Location of processing and packaging on farm

1.1 Farm location and layout

- Large commercial cricket farms should be in rural rather than urban areas. However, small-scale and micro-farms may be compatible with urban locations;
- Cricket farms should not be located near industrial areas where there is a chance that air or water contamination may occur;
- In agricultural areas, cricket farms should not be located where there is a risk of pesticide contamination from neighbouring agricultural production activities;
- Flood-prone areas, and residential zones where periodic cricket stridulation (chirping) may be bothersome or irritating, should be avoided;
- Attention should be paid to the farm's layout, i.e. how the various buildings, pens, storage, waste and housing areas are arranged within the farm unit; and
- The farmer's house (living area) should be separate from the cricket breeding and rearing areas for health and safety reasons.



1.2 Rearing shed

The rearing shed, under good farming practices, should have the following features:

- A roof that shields the pens from sun and rain; ideally, the roof should be insulated to moderate the heat inside the rearing shed;
- The walls of the shed should allow for air movement, ventilation and moderated temperature in the shed. Net sidings, screens, or concrete blocks which also prevent the entry of pests and other insects into the shed can be used for these purposes;
- Louver windows can also be used to regulate airflow and temperature;
- The shed floor should be made of concrete and extend beyond the shed area by about 1 to 1.5 metres (m) to allow for a water-filled moat (10 centimetres [cm] wide and 5 to 10 cm deep). The concrete floor and moat help to keep pests and other insects out and the latter facilitates easy cleaning and hygiene practices;
- Crickets develop optimally if temperatures are between 28° and 32° C with 40 to 70 percent relative humidity. All rearing sheds should have at least a thermometer and ideally also instruments for measuring relative humidity. Other features should include means to control heat and humidity inside the shed such as:
 - > Ceiling fans or side-mounted fans to maintain air movement and cool the shed;
 - > Misting sprinklers, which require a high-pressure water system to generate a cooling mist (but not droplets) in the shed.
- Facilities for washing hands and a disinfectant foot bath should be installed, if possible, immediately outside the rearing shed.

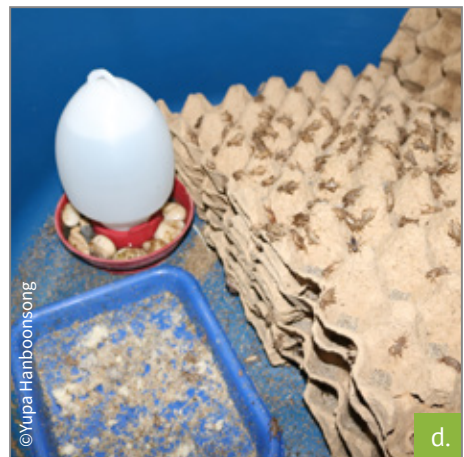
1 Part 1

Best practices for sustainable cricket farming



F.1

Best practice shed design:
a) enclosed rearing shed, b) hand-washing facility, c) foot bath for sterilization, d) insect moat, e) humidifier sprinklers.



F.2

Cricket rearing pens:
 a) rectangular rearing pens, b) egg carton blinds, c) stacked plastic basin rearing pens, d) interior arrangement of plastic basins.

1.3 Cricket rearing pens

Crickets can be reared in various structures. The purpose of the pen or enclosure is to retain and isolate the crickets in a safe and secure environment that will optimize growth.

Pens can be made from various materials and employ different styles. In the early years of cricket farm development, 80-cm-diameter cylindrical concrete well tubes were commonly used. More recently, concrete cylinder enclosures have largely given way to rectangular pens, usually 1.2 to 3.0 m in width and 2.4 to 5.0 m in length, with 0.6-m-high sides. The sides are normally made from concrete blocks, but gypsum board sheets and plywood can also be used, although they are less durable. Another option is to rear crickets in custom-

made plastic boxes or commercially-available plastic basins.

A metallic non-grip surface is needed around the top edge of the pen to prevent crawling crickets from escaping. In the past, adhesive tape was used, but nowadays for permanent concrete pens, a strip of glazed tiles is recommended for the tops of the pen walls.

Heat generation inside the pen is an important issue as overheating can cause disease outbreaks and high death rates among the crickets. Concrete absorbs and radiates heat. Pens should therefore be shaded from direct sunlight under a roofed structure with plenty of air movement above the pen.

1.3.1 Preparing the pen for rearing

Starting with an empty clean pen, the following steps should be used for setting up a breeding and rearing pen:

Prepare the floor:

The floor of the pen needs to remain clean and dry during the breeding cycle. In the past, plastic sheets or other materials such as sawdust or rice husk

were commonly used as a floor covering over the concrete base but these practices are no longer recommended. A better method is to cover the floor with rows of bamboo or small wooden poles or polyvinyl chloride (PVC) pipes about 3 cm in diameter and spaced about 30-40 cm apart. The purpose of these poles is to elevate the egg tray 'blinds' so they

do not rest directly on the concrete floor. This serves to keep the egg cartons dry and provides good air circulation.

Assembling the cricket blinds:

Crickets like to avoid direct exposure, so providing hideouts within the pen is essential. This gives the crickets a safe and comfortable habitat where they can grow and shed their exoskeletons during moulting. While it is common practice to use commercial cardboard egg cartons for the blind ('hide'), other types of boxes can also be used.

Cricket blinds are best constructed from commercial cardboard egg trays designed to hold about 30 eggs. These trays have proven ideal as cricket hiding

places since they were first used in Thailand 20 years ago. The trays should be stacked together, providing gaps from the top of the stack to the floor and allowing easy movement of the crickets throughout the blind. Trays are added until they form a row running the lengths of the pen. A gap between the rows of approximately 30 to 40 cm needs to be maintained to allow space for water dispensers.

A larger pen of 3 x 5 m can hold three rows of cricket blinds constructed with 1 500 to 1 600 cardboard trays of the 30-egg size. Narrower pens may only be able to accommodate two rows of egg carton blinds.

1.4 Siting of water and feed containers

Water dispensers used on cricket farms are usually adapted from the commercial self-feeding type used in the poultry industry. In a 3 x 5 m pen, two rows of seven water feeders are spaced out along the length of the pen. For pens of smaller dimensions, the number of water dispensers can be adjusted accordingly, with about

one water dispenser per square metre of pen space. The water dispensers should have sponges or cloth mats in the feeding tray during the early growth of the crickets to prevent the young crickets from drowning. These sponges or cloth mats need to be cleaned every one to two days and the water levels topped up regularly.

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Best practices for sustainable cricket farming

Alternative water dispenser systems:

Another method of dispensing water is through PVC pipes with sealed ends to store the water. A slit cut along the length of the pipe holds a cloth 'wick' that draws water out of the pipe as the crickets consume it. The cloth should be cleaned regularly. The cloth mats or sponges used with water feeders are very high risk reservoirs of harmful microbes, so frequent replacement and cleaning is essential.

Another alternative method of providing water is by spraying the vegetables given to the crickets as supplementary feed.

Feed containers:

Feed is generally given to crickets in shallow plastic trays or plates. The surface of the tray should be rough so the crickets can walk easily on it. The feed trays/plates are usually placed on top of the cricket blinds in three or four rows. In a 3 x 5 m pen, 40 25-cm diameter round trays can be fitted.

The cricket feed used on farm needs to be stored in a clean, dry and pest-secure location. Ideally a storage room near the rearing shed would be a good option. In larger operations, a separate

building for feed storage may be needed. Small farmers may find storing feed in plastic sealable boxes to be an effective low-cost option. Feed needs to be elevated off the ground to facilitate air movement and prevent exposure to dampness. A frame or rack arrangement is effective.

Any materials that carry the risk of containing heavy metals or hazardous chemicals, such as newspaper or chemical containers, should never be used in feed containers for cricket rearing.

Covering the pens:

In a modern purpose-built cricket rearing house with netted walls, it may not be necessary to cover the top of the box pens with netting. However, for more open structures it is recommended that the top of the pen be covered with netting, such as mosquito netting, to keep pests and predators out of the pen. The common cricket is more active at flying than the house cricket, so may require more netting to avoid individuals escaping from the pen.

1.5 Egg collecting and containers

New cricket farmers will need to purchase cricket eggs in bowls from other cricket farmers to start their operations. Farmers should always record the sources of the egg bowls they purchase and consider the history of the source farm in terms of generations bred and duration of disease-free operation when choosing where to buy cricket stock. It is important to note that after a farmer has established his or her own operation, cricket eggs can be collected on farm and used by the farmer for the subsequent breeding cycles.

It is recommended that farmers incubate their cricket egg bowls, containing newly laid eggs, before placing them in the rearing pens. Incubating can be achieved by stacking the bowls close together, covering them with plastic bags or other materials like jute sacks or cloth to increase the temperature, or even introducing an electric light bulb near the egg bowls to generate heat. At the first sign of hatching (about 7 to 14 days after the eggs have been laid by the adult females), the bowls can be moved to the rearing pens.

Having set up the rearing pens, including the positioning of the cricket blinds, the next step is to place the bowls con-

taining the cricket eggs (obtained from other farmers and suitably incubated) into the pens. In a 3 x 5 m pen, about 35 egg bowls (15 cm in diameter) are needed to fully stock the pen (i.e. about two egg bowls per square metre of pen space). The egg bowls should be placed on the floor of the pen alongside the cricket blinds.

After the first rearing cycle of crickets, eggs can be collected for use in the farm for the second cycle, and subsequent cycles. But consideration must be given to maintaining the health and vigour of the crickets and avoiding inbreeding within the colony. Accordingly, best practice calls for regularly bringing egg bowls into a pen from another pen, or even from another cricket farm. Typically, mixing the egg bowls from two or three pens for the next cycle of production is a good practice.

Egg collecting can be accomplished by providing bowls or other trays containing a suitable medium in which adult females will be encouraged to lay their eggs. Traditionally, 15-cm diameter plastic bowls have been used to for this purpose, but other shapes and types of trays can also be used.

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Clean, porous material should be placed in the egg collection bowls as a medium for mature females to lay their eggs. Rice husk ash or sterilized sand are commonly used for this purpose. Whatever medi-

um is used for egg deposit, it is essential that it is well-sterilized to prevent harmful microbes or pest species being introduced to the farm.

1.6 Location for processing and packaging on farm

Processing and packaging of harvested crickets should take place in a separate location to the rearing pens/sheds. In practical terms this will mean a separate building on the farm is used to pro-

cess and pack cricket products after harvesting the crickets in the rearing sheds. Processing and packaging should be separated from rearing facilities.



F.3

Water feeders:
a) slitted PVC pipes lined with cloth wicks;
b) commercial chicken farming water dispensers.



F.4 Egg collecting and incubation:
a,b) burned rice husks in plastic bowls for adults to lay eggs in;
c) egg incubation tank.



2. Rearing cycle management

After eggs have been laid in the egg bowls, young crickets will begin to hatch in 7 to 14 days, depending on the species of cricket and whether the eggs were carefully incubated.

Feed and water are provided based on the stage of cricket development as described below:

2.1 Nursery period (0 to 14 days old)

In the nursery period the young crickets need fine, soft feed which is high in protein. High protein feed promotes growth and sexual development. Commercial or concentrate cricket feeds are now available from agribusiness feed suppliers, but many farmers still use commercial poultry or fish concentrates. Commercial cricket feed is usually 14 to 21 percent crude protein. Feed is best provided to young crickets in very shallow trays or bowls. During this period, the young crickets do not eat much, but it is important to provide them with high-protein feeds to accelerate growth.

Water is provided in containers or by frequent spraying the surface of the enclosure or pen which should remain moist

at all times. Crickets can easily drown in deep dishes so surface spraying is preferred if the systems are in place to do so. However, if too much water is sprayed, feed can become excessively damp and this might lead to fungus contamination.



2.2 From 15 days of age until maturity

The cricket diet during this period is similar to that for early growth, but the protein content of feed can be reduced to 14 percent crude protein and green plant feed can be introduced. Thus, feed during this stage can be a mixture of green material and concentrates. There is some variation in the feed ratios that can be used. Crickets will mature faster on a diet of concentrates, but from an economic perspective, and in the context of flavour preference, a mixed diet of concentrate feed and green feed works well. Some farmers use concentrates for 10 percent of the feed offered. Others use up to 100 percent concentrates with only a small amount of green feed making up the balance. Concentrates are the more expensive option but convenient where the farmer does not have his/her own green feed supply. After crickets reach the age of 30 days, farmers should watch for mating behaviour, which normally occurs at 30 to 40 days of age, depending on the cricket species.

As the crickets mature, the focus of feeding can move towards reduced protein concentrate levels, with more feeding of chopped vegetables.

At two to three days before the adult crickets are harvested, the feed should

be changed to 100 percent fresh pumpkin. The pumpkin is cut into thin slices, the seeds are removed and the sliced pumpkin is spread around the pen so all crickets have easy access. This will minimize undesirable odours derived from commercial feeds and improve the flavour of the crickets.

Nesting bowls to encourage egg deposits are placed within the rearing pens as described above when crickets have reached maturity and prior to harvesting. Bowls can be replaced two to three times over a two- to three-day period until the desired number of eggs has been obtained. Any longer period of time will unnecessarily prolong the breeding cycle and lengthen the age variation within the colony. In addition, the egg numbers will decline as the breeding period is extended.

The nesting bowls are placed in the breeding pens for six to eight hours typically. Every day, the bowls containing deposited eggs should be removed from the rearing pen and relocated to another location for incubation.

2.3 Harvesting the adult crickets

After breeding and subsequent laying of eggs in nesting bowls, the adults are ready for harvesting. In some species, such as the common cricket, this can occur at 30 days of age, but with the house cricket, this occurs at around 45 days.

Harvesting method:

The first stage involves removal of feed trays and water sources. Then the central row of egg tray blinds (in larger rearing pens) is dismantled and the crickets are shaken into a large collecting basin and removed from the pen.

Progressively, the blinds are dismantled around the edge of the pen and the crickets are shaken into the collecting basin. At the same time, blinds are maintained around the sides of the pen as the crickets will naturally move towards the remaining egg trays to seek dark-

ness or a hiding place. This enables the farmer to collect the last of the crickets easily by shaking them into the collecting basin and replacing a few of the egg trays against the pen wall to gather more crickets. The process can be repeated until most of the crickets have been gathered. The last remaining adult crickets can be harvested using a triangular-shaped net or plastic bag attached to a handle that captures the last of the crickets crawling on the sides of the pens.

Crickets from a 3-x-5-m rearing pen can be harvested in about one hour by one person. The collector remains outside the pen, leaning over the side to gather the crickets and dismantle the cricket blinds. About 80 to 100 kg of crickets can be harvested from a 3-x-5-m pen.

2.4 Storage and processing

Once harvested, the crickets can be bagged alive immediately and sold to buyers. However, if the crickets are transported, heat generation in the bags could cause the release of an undesirable amount of hista-

mine, which can cause allergic reactions in some people. It is therefore recommended to cool the crickets by placing them in ice boxes or using layers of ice over the bags before transporting them from the farm.

Other postharvest options include boiling the crickets for 5 minutes to sterilize them. Crickets can be bagged in various sized plastic bags for transport which should be surrounded by ice packs with

layers of ice between the bags of crickets during transportation. Some processors freeze the crickets after boiling and store them in bags in cold storage for later transport to markets.



F.5

Harvesting the adult crickets:

a) The central row of egg tray hides is dismantled; b) the crickets are shaken into a large collecting basin; c,d) scoop bags for cricket harvesting.

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F.6

Postharvest and storage:
a) wash with water; b) boil for 5 minutes; c) the crickets are stored in plastic bags and put in ice boxes or a layer of ice is put over the bags.

2.5 Cleaning the pen and equipment

Collecting dry waste:

After cricket harvesting and emptying of the cardboard egg tray blinds, the floor and walls of the pens should be swept with a broom and brush to collect the dry faecal matter waste and left-over feed and other waste material which can be used as fertilizer for plants. Cricket dry waste is a high demand alternative organic fertilizer and farmers in Thailand have no difficulty in selling it to arable crop farmers. For example, a 30-kg bag of cricket dry waste sells for between 50 and 70 baht. Although, this is not a major return for the cricket farmer, but it is a reliable market and a convenient and sustainable approach to waste disposal.

A commercial inorganic fertilizer would cost ten times as much, so the cricket waste is an alternative nutrient source for crop growers.

Cleaning of the rearing equipment:

The cardboard egg trays used for the cricket blinds must also be brushed and left to air-dry in the sun. Mouldy or damaged trays should be discarded. Some farmers now heat treat the cardboard trays in a purpose-built gas fired oven that bakes them for about 30 minutes at 60 to 70° C. This sterilizes the egg trays for use in the next breeding cycle.

Feeding containers and water dispensers should be thoroughly cleaned with water and air-dried in the sun or heat treated. Other equipment used should also be cleaned between breeding cycles.

Washing the pen:

Standard practice is to wash the pens and containers with clean water and leave them to dry. Soap is usually not needed. However, if there has been a disease outbreak or there is a suspicion of disease risk, use of appropriate disinfectants is advisable. Also, if a pen has been used in multiple breeding cycles, it is advisable to use a disinfectant to kill bacteria and pathogens.

The disinfectant used should be one that is registered and approved by relevant Livestock Department or Agriculture Department regulations.

The pen should be left to air-dry for 7 to 14 days before use in a new breeding cycle.

2.6 Environmental concerns

Waste disposal:

All intensive livestock enterprises need to consider responsible disposal of waste products generated in the course of the farming operation. Cricket farming is no different and so good cricket farming practice includes environmentally safe disposal and recycling of waste products.

The type of waste generated includes dry concentrate feed leftovers, droppings or faeces produced by the crickets and liquid waste in the form of effluent from the pen cleaning process and the water used to boil the crickets postharvest.

Some of these waste products are suitable for use as a plant fertilizer, although careful management is required to avoid run off into streams, drains and waterways. Dead crickets are also routinely removed from the rearing pens during the production cycle and it is recommended that dead insects are burned to avoid the risk of potentially spreading disease to other pens.

Wise and appropriate use of chemicals:

Crickets can be sensitive to various chemicals so the farmer needs to be particularly cautious with their use.

Typically, there will be a need to use some chemicals to maintain hygiene and to prevent disease outbreaks in the colonies (e.g. for cleaning and disinfecting), but such use should be minimized. Where chemicals are used, farmers should only use chemicals that are approved for use in cricket farming by the appropriate government agencies. It is important to note that cricket products for human consumption must adhere to food safety standards. Chemicals used in sterilizing pens and equipment should only be used in accordance with the manufacturer's directions and should be stored securely and responsibly when not being used.

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3. Feeding crickets and nutrition

A high protein feed is needed to achieve good growth and development rates in crickets. Feed type can vary based on the stage of development but feeds are usually a mixture of commercially produced concentrates and fresh vegetables.

3.1 Commercially produced feeds

Commercially formulated cricket feeds that contain 21 percent crude protein are now available in some areas. But feed concentrates formulated for other farming sectors can also be fed to crickets. For example, feed for poultry and fish has been used, typically having

crude protein of between 21 and 24 percent. In the first 14-day period (nursery period), the feed needs to be high protein concentrates. During the 15-to-30-day growth period, the feed offered to the crickets can be a mix of green vegetables and concentrates.

3.2 Green vegetable feeds

Vegetable feeds can be introduced to crickets when they are 15 days' old. Vegetable plants commonly used are

- **Green cassava leaves;**
- **Morning glory;**
- **Water hyacinth;**
- **Papaya leaves;**
- **Grass of all types**, including Napier grass; and

- **Pumpkins** (cut into pieces); these are typically fed to crickets two to five days before the crickets are harvested, as pumpkin improves the odour and the flavour of the crickets after cooking.

Farmers are recommended to plant these vegetables on their own land and keep them separate from other livestock

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species to avoid cross-contamination of the feed source. Vegetables from markets or other sources might be contaminated by insecticides, so they should be washed thoroughly before being fed to crickets. Harvesting vegetables in areas accessed by cattle or pigs is not recommended for hygiene reasons.

Uneaten green vegetables should be removed from the rearing pens completely and replaced daily with fresh green plant material. To avoid pathogenesis, fresh vegetables should not be placed over old feed.

While green vegetable material is good for crickets and improves their flavour, the growth rate of crickets fed on green vegetable material is slower than those fed with commercial feed concentrate. Therefore, feeding them with large amounts of vegetable and plant material will lengthen the rearing cycle. One of the main benefits for the farmer in this context is that these feeds are much cheaper than commercial concentrate feeds. The trade-offs between cost and reduced rates of growth are a matter for individual farmers to consider, based on their cost structure and management approach.

3.3 Home-made concentrate feeds

Feed is usually the most significant cost incurred by cricket farmers and commercial feed concentrates are the most expensive of the feed options. However, farmers can formulate their own concentrate from various mixtures of grains and other ingredients, which may help to reduce the cost of cricket feed.

Commercial feeds are typically based on cereal grains with protein and vitamins added. Most commercial feeds, such as those formulated for poultry or fish, will comprise 35 percent maize meal, 20 percent wheat meal and 10 percent milk powder, the remaining 35 percent being other ingredients.

Some researchers have developed formulations that may lower feed costs for farmers. One such formulation, developed by Nakagaki and DeFoliart (1991), was modelled after commercial chicken feed, but used lower-cost ingredients. The recommended formulation was:

- **58 percent**
ground yellow corn or maize
- **35 percent**
soybean meal
- **3 percent**
corn oil
- **2 percent**
dicalcium phosphate fertilizer
- **1 percent**
calcium carbonate (agricultural lime)
- **0.5 percent**
iodized salt

The Nakagaki and DeFoliart feed mix was revealed to be 22 percent crude protein, 5.5 percent crude fat, 4.9 percent crude fibre and 4.4 percent ash, which is comparable to commercial poultry feed. Local costs of raw material vary from country to country. Other variations and mixes of inputs could also be tried as alternatives.

Farmers seeking to formulate their own cricket feed concentrates are advised to consider various grains and other components in line with local availability and relative costs to determine if such self-formulations will be more financially advantageous than commercial feeds.

3.4 Cassava pulp fermented feed recipe

In Thailand, some farmers feed crickets a feed based on pulp from cassava tubers. This formulation can be introduced

into the cricket diet from about ten days of age. The costs to cricket farmers using such a cassava pulp mix are about 50

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percent of the cost of commercial concentrates. The recipe is provided below:

1. **Mix approximately 500 grams of commercial food yeast (such as that used in baking) with 1 kilogram of raw sugar and 40 litres of water.** This mix is stirred and left for 10 to 15 minutes to allow the yeast to activate.
2. **Add 10 litres of molasses, plus 5 kilograms of urea fertilizer and 40 litres of water.** Mix the solution well and aerate with an air pump (such as that used for a fish aquarium) for 1 hour. This aerates the solution and activates the yeast.
3. **Mix the yeast-activated solution with the cassava pulp (the dry material left after the liquid starch is squeezed out) at a ratio of 80 litres of yeast-activated solution to 1 tonne of cassava pulp.** Once thoroughly mixed (a cement mixer may be used), the material is left for ten days covered with a plastic sheet, which induces fermentation. After ten days the cassava pulp will have fermented and can be packed in airtight bags and stored for a further 15 days.

Rice bran equalling 10 percent of the cassava pulp can be added and mixed to increase fibre content.



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4. Farm hygiene

Proper farm hygiene is a necessity for successful cricket farming. Crickets produced in farm operations need to be healthy and remain healthy. Good hygiene practices are thus essential. In addition, crickets as a human food product must be raised, harvested and packaged under hygienic conditions. Recommendations are listed below.

4.1 Establishing a disease-resistant farm

A key goal of cricket farmers should be to establish and maintain a disease-resistant farm. Disease-free and disease-resistant cricket stocks mean faster growth and greater survival rates. Disease-resistant cricket stocks are more profitable for farmers as they result in fewer deaths and less need for farmer interventions.

Make hygiene a priority:

Hygiene needs to be made an overriding priority on the farm. Farmers need to understand that the way they manage their farms can affect the health of their cricket stocks. Farmers also must understand that hygiene begins before the breeding and rearing cycle; it continues throughout the cycle and also during all harvesting, processing and packaging activities.

Clean the rearing and breeding pens as well as the containers between cycles:

The entire breeding and rearing cycle lasts for 30 to 45 days. At the end of the cycle the pens should be thoroughly cleaned, washed and scrubbed to leave the pen as clean as possible before the next production cycle starts. The components of the pens such as the cardboard egg trays used as cricket blinds should also be cleaned and sterilized using sun-drying or heat treatment in ovens to kill bacteria and pathogens.

All equipment such as the feed bowls and other items used must also be cleaned thoroughly before reuse. The aim is to minimize the presence of harmful pathogens in the pen at the beginning of the breeding cycle.

Avoid inbreeding:

An important aspect of farm hygiene related to breeding management is avoiding inbreeding in the cricket colony. If outside genetic material is not periodically introduced, the health, vigour and growth rates of the subsequent cricket generations will be adversely affected. Farmers typically manage this by in-

roducing egg bowls from other pens within the farm or from completely different farms and cricket populations. This will counter the risk of inbreeding but care must be taken so that outside breeding stock is sourced from known disease-free farms, otherwise diseases could be inadvertently introduced along with the outside genetic material.

4.2 Preventing disease entry to the farm

Farmers need to carefully guard against diseases from outside their farms. This can be done in various ways, but it essentially means establishing a system of biosecurity for the cricket farm.

Limit access of people and wildlife:

Visitors to cricket farms can unwittingly introduce disease risks from outside. This especially includes visitors from other cricket farms. Efforts should be made to control outside visitors or at least minimize the risks that human visitors can bring. One method is to install a footbath tray at the doorway leading into the breeding or rearing house. The footbath should be filled

with a sterilizing chemical such as formaldehyde that visitors walk through before entering. Bacteria and pathogens on the shoes can then be eliminated. Alternatively, visitors can be told to remove their footwear at the entrance to the breeding or rearing house and be provided with sterilized footwear. Animals (especially birds and lizards) can also be a biosecurity risk, especially if they establish nests in the roof of the cricket house and drop faeces into the cricket pens. Where possible, birds and lizards need to be excluded with netting. These exclusion measures also help to reduce the potential access of predators to the farm stock.

Ensure introduced cricket stock is healthy:

Farmers introducing breeding stock from other farms should be especially careful when sourcing their new stock. Farmers should assess the health status of the farm from which new stock is being procured. Prior to purchase, farmers should visit the potential source farm, paying particular attention to the quality of farm operations and the health of the crickets.

Do not use equipment from other cricket farms:

A key measure to protect the farm from unwanted disease is to avoid the use of equipment or supplies from other cricket farms. It is better to start a new cricket farm with new egg trays, feed contain-

ers and so forth rather than acquiring these items second hand from an existing farm. Even equipment from a seemingly healthy farm can pose an unnecessary risk of introducing diseases to a new farm and should be avoided.

Be careful after visiting other cricket farms:

Farmers typically learn farming techniques from each other and by visiting other cricket farms. But for biosecurity reasons, after visiting other cricket farms, it is advisable to immediately wash footwear on arrival home before entering the cricket rearing house. It is even advisable to change the clothes worn for the visit.

4.3 Developing a health management programme

Proactive cricket farmers develop sound health management programmes for their farms. Such programmes entail:

Monitoring crickets for signs of disease:

Alert farmers will become aware of disease presence in the farm by daily ob-

servicing the cricket pens and the level of activity and feeding of the crickets. Experienced farmers will quickly learn to recognize signs that disease is present. Early identification of problems allows for quick and effective responses to the disease and hopefully limited damage.

Quickly removing sick crickets from pens:

There will always be some insect mortality, but as sick and dead crickets can be sources of disease, a key management strategy should be to remove such individuals as quickly as possible. All dead crickets observed in the pens should be quickly removed and burned. Crickets that are slow or inactive may also be diseased and should also be removed and destroyed.

Keep written records of treatments used:

Very little can be done in terms of treating sick crickets and there are even fewer cures. However, it is important for farmers to record outbreak dates in a farm record book, the details of the disease or suspected disease outbreaks, symptoms and what action was taken. This is both a wise management tool and a possible future food safety requirement of national authorities.

4.4 Using chemicals only as directed and approved

While there are few options currently to treat diseased crickets, other than separation from the healthy population and subsequent destruction, the pen and rearing environment where the disease or suspected disease occurred can and should be cleaned with approved chemical agents.

Only use chemicals approved for use:

There must be clear recognition of crickets being produced as a human food source, with corresponding awareness of food safety issues. Therefore, only chem-

icals approved for use in cricket rearing and for human food situations should be used to sterilize pens or blinds. Calcium oxide or glutaraldehyde have been recommended for use for cleaning concrete walls and floors in Thailand, but farmers should refer to specific regulations within their own countries.

Use chemicals only according to directions:

All chemical products used to clean farm pens and equipment must be used according to the manufacturer's direc-

tions, including safety recommendations for the person using the chemicals.

Store chemicals securely and responsibly: Cleaning chemicals used on cricket farms should be stored in a safe and

secure place where children and other people and animals cannot readily gain access to them. Chemicals should always be stored only in the original containers with clear labels. This is a public safety requirement in most countries.



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5. Waste management

Good cricket farming practice includes the environmentally responsible disposal of waste generated on the cricket farm. Waste can consist of cricket faeces, left-over food scraps and the water runoff from cleaning pens and equipment.

5.1 Cricket faeces

The cricket faeces that can be swept up after a breeding and rearing cycle should be retained and used as an organic fertilizer on the farm itself, provided there are cropping or pasture areas where it can be applied. Care needs to be taken

in large operations that the quantity applied to land is not excessive. If larger quantities of dung waste are generated on the farm than can be used appropriately on the farm, it should be bagged and sold to other farmers.

5.2 Food scraps

Ideally, food scraps should be separated from the cricket faeces. This can be achieved by using a sieve. Food scraps should not be reused with another pen

or batch of crickets as there is a risk of disease transfer. Food scraps should be used as a composting material and later applied around plants.

5.3 Water effluent

After the pens are washed down and cleaned, the water should be drained and collected rather than allowed to enter a drain, waterway or stream.

If the water is piped to a pond on the farm this will allow the waste solids to

settle in the pond and the water itself can later be pumped out and spray-irrigated onto pasture or cropping areas.



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6. Heat management

Successful cricket farming requires a favourable climate for the crickets to grow at optimum rates and reproduce efficiently.

The ideal conditions for rearing crickets are temperatures between 28°-32° C with 40 to 70 percent humidity. Temperature and humidity above or below these ranges are likely to see slow cricket development and possibly lead to death at extreme levels. The farmer should therefore monitor the daily conditions in the cricket rearing shed and pens. Thermometers and hydrometers are essential tools to monitor heat and humidity.

Depending where the crickets are being farmed, achieving these ideal conditions may or may not be easy. In some areas with a pronounced cool season, the temperature may drop below this ideal range. This could result in slower growth and feeding activity in the pens. It could also result in uneven or slow hatching of eggs and even death of young crickets.

Excessive heat can also lead to low activity and possible death of crickets. Farmers can use management practices to minimize the detrimental effects of heat on the cricket farm. In a cricket

rearing shed, heat buildup can be reduced using various strategies such as open walls and sides that encourage good air circulation. Fans can be installed in sheds to circulate air and in some cases misting sprayers can be installed under the shed roof to humidify the air. Shed roofs can radiate heat, so under-roof insulation can lessen the entry of outside heat.

During the cold season, if temperatures fall below the ideal range, it may be advisable to delay production until a warmer month. Growth and incubation in egg bowls are slower in the cold season. Hatching of eggs in cold weather is also difficult, but heat lamps or covering of pens with plastic sheets, will conserve heat. Farmers need to make temperature-management decisions based on local conditions and situations.



7. Record keeping

Record keeping is an essential tool to facilitate analyses of various management practices, production history, production efficiency and other decisions made by farmers.

Records can indicate what went right and what went wrong in a farmer's management system. They are an important tool for the farmer as well as for extension officers, advisors and government agencies.

Farmers should keep records about various processes related to the production cycle. Good records can help guide future decisions and can identify improper management practices when production problems occur, such as at the time of disease outbreaks. Good records will help cricket farmers make decisions based on past experiences and assist in planning for the future.

Suggested record-keeping data are:

Production cycle:

Key processes and timing should be recorded, such as:

- Origin of cricket eggs (i.e. where the eggs came from, where they were purchased or collected from on-farm production);

- How many egg bowls used per pen;
- Date hatching began;
- Dates of maturity and breeding;
- Dates of egg collection; and
- Dates of harvesting.

Feed:

Records showing the feed used in the production cycle such as:

- Type of commercial feed used;
- Percentage protein content;
- Bags or kilograms of commercial feed used; and
- Types of vegetables used, dates vegetables were introduced.

Water:

Water records should note the water source used and any tests of water quality.

Cricket growth:

Cricket growth records should note weekly issues relating to the production cycle such as problems encountered and the health and vitality of the crickets.

Disease:

An important part of the record-keeping process should relate to recording any disease issues or outbreaks on the farm. Where this has occurred, the management processes followed to control the disease should be logged. Special note

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should be made of the date and type of disease, how the pens were cleaned and what chemicals were used.

Egg collection:

The breeding stage should be recorded and the management processes used should be noted. For example, farmers should record what type of egg-laying bowls and medium were used and whether the crickets were commercially bought or bred on the farm. Regarding egg incubation, records should note whether the eggs were heat incubated and, if so, the details of the process used.

Yields:

Record the dates when pens were harvested and the quantity of crickets collected; the weight of harvested crickets per pen and the total production figures for the farm. Note the date the crickets were harvested.

Postharvest:

Postharvest records should show what type of processing was used on the farm at harvest. Note whether the crickets were washed in water or not and whether the crickets were boiled or frozen.

Sales records:

It is useful for farmers to record where and to whom they sold their products. Records should be kept of where, when and at what prices the batches of crickets were sold. This can be useful in future years for monitoring year-to-year market prices and profitability.



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RECORD SHEET

CRICKET INFORMATION

- a) Species name.....
 b) Start of breeding cycle date.....
 c) Breeding cycle number.....
 d) Cricket eggs came from.....

NUMBER OF EGG BOWLS USED AND DATE OF EGG HATCHING

Pen number	Pen size	Number of egg bowls/pens	Date of hatching	Egg purchase cost

FEED

Pen number	% protein from commercial feed							Trade name	Date of purchase	Total cost of feed
	wk1	wk2	wk3	wk4	wk5	wk6	wk7			
Pen number	√ vegetables added							Vegetable type	Obtained	Note
	wk1	wk2	wk3	wk4	wk5	wk6	wk7			
Pen number	√ Other feed used							Trade name	Details	Note
	wk1	wk2	wk3	wk4	wk5	wk6	wk7			

Food cost:

Total cost of commercial feed for cycle:

Total cost of vegetable feed purchased:

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WATER

Type of equipment:

Water used came from:

Pen number	Date of water dispensers cleaned							Remark/note
	wk1	wk2	wk3	wk4	wk5	wk6	wk7	

GROWTH DEVELOPMENT AND PROBLEMS

Pen number	Date of water dispensers cleaned							Remark/note
	wk1	wk2	wk3	wk4	wk5	wk6	wk7	

DISEASE MANAGEMENT

Pen number	Date of sick crickets observed	Symptoms	Management

CLEANING AND SANITARY MANAGEMENT FOR DISEASE-FREE PENS

Pen number	Date of pen cleaning	Date of rearing shed cleaning	Chemical used	How diseased crickets were destroyed

EGG COLLECTING

Containers used for egg collecting:

Materials used for egg laying:

Pen number	Starting date for collecting	Finishing date to remove egg bowls	Number of egg bowls collected per pen

EGG INCUBATION

Method used	Starting incubation date	Transfer date of egg bowls to rearing pen

TRANSFER OF EMERGING CRICKETS TO THE REARING PEN

- Directly deposited onto pen's floor
- Put egg bowls on the supporting materials on the rearing pen (give details)
.....
- Other

PRODUCTION YIELD

Pen number	Date of harvesting	Yield (kilograms)	Remark/note

Total yield per harvesting:

Sale price per kilogram:

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POSTHARVEST

Cleaning after harvesting		Packing		Treatment for transportation	
No wash	Wash with water (time)	Fresh	Boiled	On ice	Without ice



8. Workers' health and safety

Making the workplace a safe and healthy environment is wise business practice and may be a legal requirement in many countries. It will lead to many benefits, such as:

- **Helping to retain good staff;**
- **Maximizing worker productivity;**
- **Ensuring the employer complies with legal requirements and responsibilities; and**
- **Reducing costs of injuries and risks associated with worker compensation.**

As business owners, cricket farmers should implement health and safety practices on the farm. The farm owners need to make sure that their farming operation do not create health and safety problems for their workers, visitors, family members, customers or other members of the public. Most workplace laws are framed around the following responsibilities the owners of the cricket farms have such as:

1. **Providing a safe workplace.**
2. **Assessing risks and implementing measures to control them.**
3. **Providing and maintaining safe materials and machinery.**

4. **Making sure goods and substances are handled safely.**
5. **Assessing the layout of the workplace and providing safe working systems.**
6. **Providing a suitable working environment.**
7. **Providing adequate insurance to cover workers' compensation.**

Farm assets and equipment

Cricket farmers and workers need to develop a safe workplace culture. This means all workers as well as the owner proactively think about minimizing hazards that make the workplace unsafe. Workers should be properly trained in the use of equipment used on the farm. This involves demonstrat-

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ing and explaining safe practices, particularly in the operation of machinery.

The use of chemicals in the cleaning stage of the cricket farming cycle is also potentially a hazard. The cricket farm owner must ensure appropriate chemicals are used to sterilize areas. The workers using the chemicals should be provided with protective clothing and trained in safe use of the chemicals. Chemicals should be stored in a locked cupboard.

Frequently asked questions

Q: How long does it take for a female cricket to mature and start producing eggs?

A: Three to five days after reaching the adult stage.

Q: How many eggs does a single cricket produce? Do they produce continually or only one large batch at a time?

A: Egg production varies depending on species. A single female house cricket can produce an average of 1 800 eggs (range 1 100 to 2 400 eggs/female). Female common crickets produce about 1 000 eggs. Females produce eggs continually for two weeks.

Q: How many days does it take for eggs to hatch into baby crickets?

A: Approximately 10 to 14 days for house crickets and about 7 to 10 days for common crickets.

Q: How many days are needed for baby crickets to become adult crickets ready for harvesting and breeding?

A: Depends on the species: the house cricket takes an average of 45 days (range 42 to 55 days) while the common crickets mature more quickly (30 to 35 days)

Q: Do the crickets need any special encouragement to lay their eggs in the egg bowls or will they only lay them there as opposed to other areas of their enclosure?

A: In natural habitats, females lay eggs in the soil after mating, so if they are provided with similar materials, such as a mixture of burned rice husks and sand (in egg bowls), they will readily lay their eggs in such a medium.

Q: At what point should the egg bowls be moved to a separate enclosure to start a new generation? How does one know enough eggs have been laid in the egg bowl before moving to a separate enclosure?

A: As soon as the male crickets stridulate (chirp), bowls containing egg-lay-

ing materials should be placed in the breeding enclosure for the crickets to lay eggs in. After one to two days, the bowls should be moved to another breeding pen for incubation and hatching.

Q: What is the best way to collect adult crickets for harvesting?

A: Crickets always hide in the egg cartons, so by tapping those cartons into a basin or bucket, crickets can be collected.

Q: How should the crickets be killed before cooking or processing?

A: Boiling for 5 minutes after harvesting. Then they can be cooked in many kinds of dishes.

Q: What is the ideal temperature and humidity for optimum cricket growth?

A: 28 to 30°C with 40 to 70 percent relative humidity.

Q: What special management techniques are needed for cold and hot seasons?

A: In the cold season it may be necessary to cover pens to conserve heat. In the hot season they may need extra ventilation such as fans, misting sprays or reduced numbers of egg

bowls to lower the population size.

Q: What does cricket fighting or cannibalism indicate?

A: Insufficient food or lack of hideouts.

Q: Can other materials apart from egg trays be used for the cricket blinds?

A: Yes, for example cardboard rolls, cardboard boxes, sections of bamboo. However, for commercial production, egg trays are best.

Q: What are the signs of disease in a cricket farm?

A: The crickets will be inactive, move slowly or stop feeding. Dead crickets in the pen are a sure sign of disease.

Q: What should farmers do when they suspect disease in their pens?

A: Isolate the suspect pen immediately, destroy the cricket colony, disinfect the pen and burn materials used in the pen. Do not use the pen for at least two weeks.

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Appendix 1

Biology of crickets

Cricket life cycle

There are many different species of crickets but the two most popular cricket species for commercial farming and home consumption are the common cricket, also known as the field cricket or two-spotted cricket (*Gryllus bimaculatus* De Geer), and the house cricket (*Acheta domestica* Linnaeus).

Each species has the same three main life cycle stages: egg, nymph and adult. The time needed to complete each stage varies slightly according to the species. Crickets have incomplete metamorphosis development and therefore do not enter a pupal stage, but hatch from the egg into a nymph that resembles the adult.

Eggs:

Eggs are laid about 10 millimetres (mm) deep in soil or under other materials such as rice husks or sawdust. The eggs are oval, usually creamy or yellow in colour. Hatching occurs in about 7 to 14 days, depending on the species, and the nymphs emerge.

Nymphs:

Nymph crickets are very small and white in colour when they first emerge from

the eggs. The cricket nymphs are very similar to adult crickets in many ways, but they initially do not have wings and females do not have ovipositors. In order to grow, a nymph has to shed its exoskeleton by moulting eight to ten times. A nymph will begin growing wings after about a month and upon reaching the adult stage.

Adults:

Once a cricket reaches maturity its wings are fully developed. The female has a long needle-like egg-laying organ called an ovipositor. After three to four days, mating occurs. Adults can live an additional 30 to 50 days after reaching adulthood, depending on the species.

Mating:

Male crickets stridulate (chirp) to female crickets during the mating season by scraping their wings together. Females are generally attracted to males by their calls. After the pair has made antennal contact, a courtship period occurs. The female may mate on several occasions with different males. After mating, a female will look for suitable places to lay her eggs.

Common cricket: *Gryllus bimaculatus* De Geer

The common cricket's body is black or dark brown. The insect is about 30 to 40 mm long and 7 mm wide. The head is round and black. This species is distinguished by yellow spots at the base of its wings.

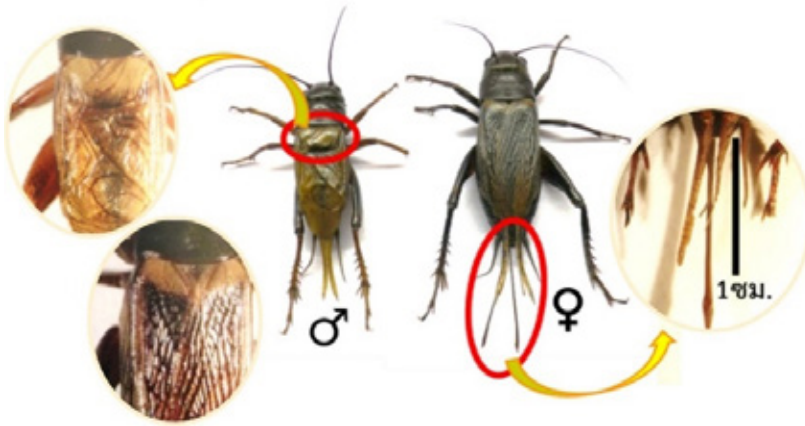
The life cycle of the common cricket is about 37 to 45 days from egg until adult. After mating, females lay approximately 1000 eggs. The eggs are yellowish or creamy in colour and are 3 to 4 mm

long. The egg-hatching period lasts for about 7 to 10 days, during which time the nymphs emerge from hatching. The young nymphs are white and gradually turn black after each moulting. The nymph stage lasts for about 30 to 35 days, with eight moulting periods, before becoming adult crickets with developed wings. The adult crickets take two to three days to start mating before laying their eggs. Adults live for approximately 30 to 40 days.



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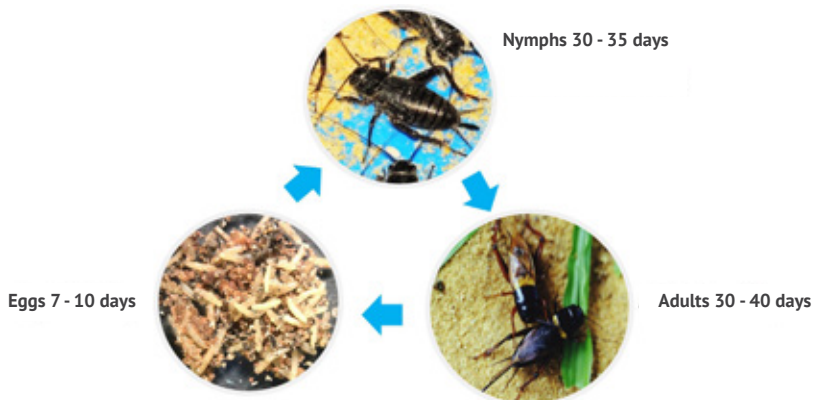
Biology of crickets



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F.A1

Adult male and female of the common cricket



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F.A2

Life cycle of the common cricket

House cricket: *Acheta domesticus* Linnaeus

The house cricket is a naturally ground-dwelling insect. The body is 16 to 21 mm in length and light yellowish-brown. The head is light brown with three black transverse bands on the top, between the eyes and a third horseshoe-shaped band between the antennae. The wings are long, extending beyond the abdomen, and are brown or black. Males are smaller than females. The female's

ovipositor for egg laying is straight, thin and shorter than the length of the abdomen. Each female can lay about 1 700 eggs which are creamy in colour and 2 to 3 mm long. Eggs take 10 to 14 days to hatch into the nymph stage. The nymphs live between 40 and 45 days after moulting to become adults. The adults can live for 40 to 55 days.

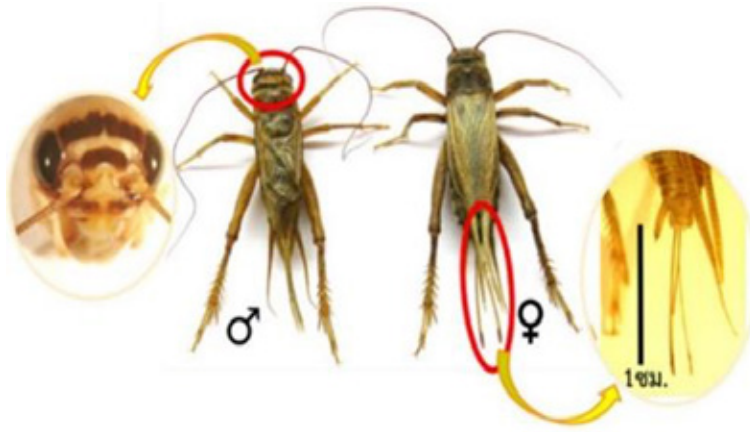


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Acheta domesticus Linnaeus

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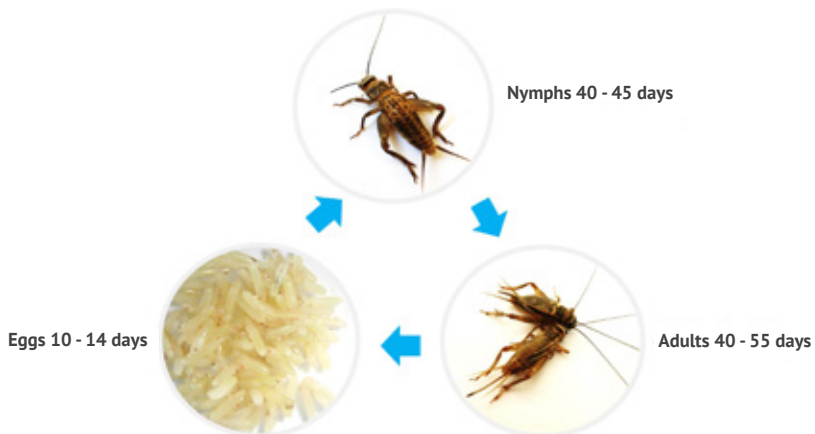
Biology of crickets



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F.A4

Adult male and female house cricket



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F.A5

Life cycle of the house cricket

Part 2

Cricket farm inspection





1. Introduction

This section promotes best practice inspections fostering a spirit of co-operation with cricket farmers.

This approach aims to benefit all in the food supply chain, from farmers and end consumers, to the regulatory bodies themselves.

The lack of published information on cricket production practices and related research findings has left government agencies and food regulatory bodies largely uninformed of best practices and management. As a result, government agencies and monitoring bodies have been limited what they can contribute by way of advice to farmers, and in their ability to protect the interests of consumers by ensuring “safe food” is being produced. This section outlines a sequential plan of inspection of production facilities. It begins with reviewing the philosophy behind the inspection approach and details in chronological order a hypothetical visit to a cricket farm. The section provides guidance for inspectors from pre-visit planning to how to conducting an inspection after arriving on site. The focus is on food safety and hygiene but environmental and worker safety issues that should be considered by national authorities are also covered.



2. Inspection objectives

- Evaluate the management practices used in the production of crickets for food and identify potential areas of risk;
- Assess whether controls and practices on cricket farms adequately address all known food safety risk factors;
- Evaluate quality and safety management practices and ways to improve them;
- Take samples where necessary and conduct laboratory analyses; and
- Document findings and initiate compliance actions as necessary.

3. Inspection approach

The inspection should be focused overall on identifying and addressing all food safety risks. It should also be conducted in a sense of partnership with the farmer, as this is the best approach to foster cooperation and improvement of practices to ensure quality and food safety for consumers.

Key points:

- Base the inspection on identifying food safety risks; and

- Aim for a high level of partnership with cricket farmers to achieve food safety goals and production of high-quality food products.

The inspector should prepare carefully for the inspection of the cricket farm. Among other preparations, the inspector should notify the cricket farmer in advance of the visit and negotiate an agreed date and time for the inspection.



4. Pre-inspection planning

Prior to the visit, the inspector should obtain a copy of any previous inspection reports and note the findings.

Particular attention should be paid to any previous violations/deficiencies or non-compliance of regulations noted during the previous inspection.

Pre-inspection planning should also include selection of appropriate clothing, such as coveralls, rubber boots and rubber gloves, and tools such as a calibrated thermometer, sterile bags, ice and a cooler box, labels and markers, and sample containers.

In the interest of providing a good food safety example, the inspector should not

attempt to conduct an inspection visit while sick (i.e. inspection visits should not be made to cricket farms when illness could expose the farm to risk of contamination).

Key points:

- Be prepared before the visit;
- Inform the farmer about the inspection;
- Agree on the time and date of the visit;
- Review past inspection reports before the visit; and
- Conduct the visit in a spirit of partnership.

5. Inspection day

The inspection should be conducted in a professional manner. This begins with the inspector arriving on time and tidily dressed. The inspection should start with the inspector identifying him/herself and showing official identification.

This establishes the credentials and authority of the inspector.

There should be an opening meeting with the cricket farmer during which introductions are made and the objectives

of the inspection are clearly explained. The farmer must fully understand why the inspector is there and what the process will be during the inspection.

The inspector should be careful to discuss matters in a friendly manner with the farmer and request cooperation during the inspection.

Key points:

- The inspector identifies him/herself and members of the team (if any);
- Inspection objectives are clearly explained;
- Sign the farm/visitor register if available;
- Outline the inspection procedures; and
- Ask for cooperation from the farmer.

6. 'Walkabout' inspection

The walkabout inspection should be just that. All areas of the farm operation should be visited on foot, observed and where necessary samples should be taken.

The inspection should be sequential, that is, follow the process of production through all stages, until harvest and postharvest treatment and handling of food products.

The inspector should be accompanied by the farmer or supervisor during the

walkabout so questions can be asked as the inspector reviews the system. This also ensures important points are not missed and reduces the need for note taking and extensive discussions at the closing meeting.

The inspector should also talk to staff to ask how they conduct specific operations in the farming system and to measure their awareness of health and safety issues, particularly with regard to hygiene.



Key points:

- The walkabout should cover all parts of the farming operation;
- The inspector should be accompanied by the farmer or supervisor;
- Other staff should be questioned about management practices;
- Emphasis should be placed on food-borne disease risk factors; and
- Workplace safety issues should be noted.

7. On-site inspection checklist

The following should receive special attention during the walkabout inspection:

7.1 Cricket farm assessment

a) Farm location

Assessment focus:

Location of the farm and surrounding area, with special attention to risks of contamination and threats to the safety of the crickets and downstream product consumers.

Recommendations:

Commercial cricket farms should be located in rural rather than urban areas.

However, microfarms can be compatible with urban locations.

Cricket farms should not be located near industrial areas where there is a chance that contamination of air or water may occur.

In agricultural areas, cricket farms should not be located where there is a risk of pesticide contamination from neighbouring agricultural fields.

For all locations, consideration should be given to avoiding flood-prone sites or residential areas where periodic cricket stridulation ('chirping') is unwelcome.

b) Buildings and structures

Assessment focus:

Standard and suitability of buildings used for the cricket farm. The farm should be a suitable size, not overly crowded and without threats to the health of the crickets and the environment.

Recommendations:

The farm should be suitably laid out so that pens, cricket feed storage and waste collection facilities are separated from housing areas.

Cricket housing units should be structurally durable and easy to clean, maintain and ventilate.

The buildings and structures should be well designed and maintained. Ideally floors, walls and other surfaces should be smooth and without cracks for easy cleaning and sanitizing. The floors in wet areas should be concrete or tiled with good drainage.

The roof should be waterproof and con-

vey rain water away from the farmed area. Ceilings should be designed to avoid product contamination.

The site's location should consider natural drainage and risks of flooding.

Following cleaning of the rearing sheds, water effluent should be appropriately drained.

The buildings and sheds used in the cricket rearing and breeding cycles should be kept clean and free of weeds, dust and materials that could harbour pests, or contribute to contamination of harvested cricket products.

Particular attention should be given to preventing birds from nesting in the cricket farming pen areas.

c) Equipment used

Assessment focus:

Equipment used, including pens, water and food containers, cricket hiding spaces (blinds), containers for egg collection, and areas for egg incubation.

Recommendations:

The design and type of equipment used in the farm operation should be inspected. The guiding principle is that equip-

ment in direct contact with cricket food products should not contribute to product contamination. Such equipment should be easy to clean and kept clean to avoid risk of contamination that could harm crickets and consumers.

The inspector should seek information on management practices related to cleaning and sanitizing equipment. The inspector should inquire about schedules and plans used for assigning responsibility for cleaning and maintaining equipment. There should be logs for recording the cleaning and maintenance schedules for equipment.

d) Ventilation in the cricket sheds

Assessment focus:

Ventilation methods used and suitability.

Recommendations:

The cricket rearing house or shed should be well ventilated by natural or mechanical means. The key objective is to maintain a suitable temperature for cricket rearing, while not contributing to food product contamination by dust, odour or condensation.

e) Sanitation, maintenance and pest control

Assessment focus:

Schedules and procedures for cleaning, sanitizing and disposal of waste hygienically with no negative environmental impacts.

Recommendations:

The cricket farm buildings, rearing pens and equipment used must be adequately maintained to prevent contamination of the harvested cricket products.

There should be well-established procedures and schedules for cleaning and sanitizing the farm operation. Farm workers should be properly trained on how to clean the farm equipment and structures.

Immediately outside the rearing shed, facilities for washing hands and a disinfectant foot bath should be installed. This is particularly important when visitors come to the farm. There should be a record of visitors who have entered and left the farm.

Cleaning and sanitizing chemicals must be approved by a food authority and stored separately, away from the cricket

products. If there is any doubt about the type of disinfectants used for sterilizing equipment, samples should be taken for laboratory tests and the registered disinfectants should be recorded.

Attention should be given to solid waste, such as dead crickets, which must not be allowed to accumulate inside the farm premises and rearing pens. Waste must be put in containers and regularly removed from the farm. It may be possible to dispose of some organic waste on farm or to use it as fertilizer.

Likewise, liquid waste, such as water used in washing and cleaning, must be disposed of in accordance with the local environmental regulations and laws. Wastewater from the farm should be treated properly before being discharged.

It is important to prevent pests and other wildlife from entering the cricket rearing and breeding areas. They are not only predators but also pose pathogen risks. This applies particularly to rats, mice, birds, snakes and lizards.

Accumulation of rubbish or waste material around the farm should be avoided as this attracts pests.

f) Staff facilities

Assessment focus:

Provision of toilets and a hand washing area, separate from the rearing pens.

Recommendations:

If the cricket farm employs workers other than the owner and his/her family, staff toilets should be provided. These must be kept clean and have a hand washing area separate from the food handling areas. Hand washing after use of the toilet should be mandatory for workers.

Staff should not eat, drink or smoke in the cricket rearing area. Separate facilities should be provided for these purposes.

Staff on the cricket farm must wear appropriate clean clothing.

Any workplace features that may affect staff safety should be noted.

Assessment focus:

Provision of high-quality, clean feed and water to maintain the health and growth of the crickets.

7.2 Cricket rearing management

Recommendations:

On-farm feed storage facilities should be noted and feed should be checked to determine if it is kept clean and free from contamination. Sacks of feed should be elevated above the ground. The inspector should check the effectiveness of excluding pests from accessing the feed and open feed sacks to look for any sign of dampness or mould.

Record the type of water supply used for the farm, cricket hydration needs and how pens and equipment are cleaned. Water used should be clean and potable or otherwise treated before use.

Any water reservoir for use on farm should not be located near a site where there is a risk of contamination. If there is any doubt, a water sample must be taken for further laboratory analysis.

Records of water quality and chemical analyses results from laboratories should be maintained on site.

Water that is used to wash harvested crickets for human food must be 'potable' water. The inspector needs to determine the source of the water used on

farm in the final washing stage before the products are sent to markets. This is important where water comes from a well or rainwater storage tank. In this situation the water quality needs to be tested periodically.

There should be a contingency plan if water is found to be unpotable.

If water used to wash cricket products is boiled, details of the duration of the boiling phase should be recorded.



7.3 Harvesting practices

Assessment focus:

Procedure and equipment used for the harvesting of crickets. The harvesting practices should ensure that the product is safe for consumers and is free from pathogens and chemical contamination.

Recommendations:

Good harvesting practices feature:

- Harvested products safe for consumers and free from pathogenic micro-organisms and chemical contaminants;

- Pest-free harvesting and processing areas;
- Toilet facilities for staff and mandatory hand washing in place;
- Absence of sick staff on farm;
- Appropriate cooling and sterilization of harvested cricket products prior to packaging; and
- Harvested products stored in areas that are effectively cooled.

7.4 Packaging and labelling

Assessment focus:

The labelling practice used meets national food labelling standards. Labels clearly identify the product, bear the producer's name and indicate the date of production and harvesting.

Recommendations:

Boxes and crates should be new or, if re-used, sanitized. Any plastic bags used should be new.

The labelling of cricket products must comply with the legal requirements and regulations of the national authority. In all cases the labels must clearly identify the product and must bear the producer's name and address as well as a code indicating the date of production or harvest.

"Lot" numbers should be affixed on all product packages and should allow for clear traceability.

7.5 Storage and transport of cricket products

Assessment focus:

Storage and transportation of cricket products in a manner that avoids contamination or damage. Records of the procedures and equipment used for storage and transport of products.

Recommendations:

Products should be stored properly to prevent contamination. In this context, there is a need to minimize moisture and wet areas, reduce dust generation and avoid contact with floors or other unclean surfaces.

Refrigerated storage, with temperature control, may be necessary in some situations. In other circumstances, packing

products with ice may be adequate. National authority regulations will determine specific requirements.

Commercial-scale farms should have a back-up power supply if products are to be stored before marketing.

Transportation to markets or customers must be done in a way that prevents exposure to pests, dust, fumes or residual contaminants of previous shipments.

Transportation vehicles should be clean and able to transport food products safely; they should not be used to transport waste or toxic materials on other occasions.

7.6 Record keeping

Assessment focus:

Record keeping of information related to breeding species, breeding stock sources, breeding generation, farm management, and productivity. Records on chemical use for control and prevention of pests and diseases.

Recommendations:

It is good business practice for farmers to keep records of their farming operations. Countries will have differing national regulations, but farmers may be required to keep the following records:

- Visitor records;
- Cleaning and sanitation records;
- Production records;
- Staff training records;
- Records of disease outbreaks on farm and corrective actions taken; and
- Records of accidents that have occurred in the workplace.

7.7 Training of staff

Assessment focus:

Staff employed receive adequate training to produce safe cricket products for consumption.

Recommendations:

It is the farm owner's responsibility to provide all workers on the cricket farm with sufficient training to produce safe food.

Staff must be aware of the importance of complying with the farm's quality and safety management systems. They should be aware of the potential consequences of failure to comply for the well-being of consumers and the

farm itself. As such, the workers must be willing to operate in ways that ensure food safety and quality.

Training provided must include issues on hygiene as well as technical aspects. Systems should be in place to measure the efficiency of training and to review training methods used.

The inspector should ask workers about the safe use of chemicals and discuss normal practices with chemicals used in the cricket farm workplace to determine if chemicals are used appropriately and safely.



8. Corrective actions and recall procedures

Assessment focus:

The farm has a plan for corrective actions in the event of deficiencies in the management system. Records should be kept documenting aspects of production failures, disease outbreaks and subsequent actions taken.

Recommendations:

All food production businesses should have a plan for corrective actions in the event of failures or shortcomings within the systems.

This also pertains to cricket farming. On-farm records should be available

to document elements of production failures, disease outbreaks and details of corrective actions taken by the farmer.

In addition, there must be a plan for initiating a product 'recall' in the event a serious product failure or contamination is discovered. This underscores the importance of suitable product coding, dating, lot and batch numbering. Moreover, records should detail the product's market destinations and distribution. The recall plan should also include procedures for safe disposal of recalled products.

9. The closing meeting

After thorough inspection of the cricket farm, the inspector should conclude with a closing meeting with the cricket farmer, owner or manager.

The purpose of the closing meeting is to give early feedback to the farmer and discuss positive and negative findings. Any non-compliance with regulations

or violations detected during the inspection should be highlighted in the closing meeting.

The inspector should clearly explain the food safety implications of any elements of non-compliance, as this will improve the cricket farmer's understanding of food safety issues. It will also assist in

achieving prompt remedial action by the farmer.

Positive aspects of the cricket farm should be highlighted and reinforced. It is good practice to begin with outlining the good aspects of management before drawing attention to areas that need correction or improvement.

In the case of non-compliance and violations, a time frame needs to be agreed upon between the inspector and the farmer for resolving issues.

The inspector should complete the inspection report on site, sign it and have the manager of the cricket farm co-sign. A copy should be left with the farmer.

The closing meeting should also aim to build a spirit of partnership between the inspecting authority and the farmer. The inspector must try to win the farmer's support with regard to the importance of food safety and ongoing cooperation.

On return to his/her office, the inspector should file the report. If non-compliances or violations were discovered and a time frame for correction was agreed upon, a copy of the report should be kept in

a 'pending' file to enable timely follow up. The follow-up inspection should be unannounced and aim to verify that agreed corrections have been made.

Key points: Closing meeting

- Mention positive aspects of the farm's operation;
- Discuss findings of non-compliance/violations of regulations;
- Explain food safety implications to the farmer;
- Agree on a correctional time frame with the farmer;
- Discuss other possible improvements to enhancing product quality and safety;
- Sign the report and leave a copy with the farmer/manager;
- File the report on return to the office; and
- Schedule a follow-up visit if needed.

Appendix 1

Cricket farm inspection flow chart

Appendix 1 Cricket farm inspection flow chart

1 Preparing for inspection

- Announce the visit to the farmer;
- Understand key risk factors;
- Prepare for inspection;
- Arrange an opening meeting; and
- Review earlier records.

2 Inspection day: opening meeting

- Inspector's introduction to the farmer;
- Objectives and process explained; and
- Inspector requests the farmer's cooperation.

3 Walkabout inspection

- Buildings and structures;
- Equipment used;
- Water supply;
- Ventilation;
- Sanitation, maintenance and pest control;
- Staff facilities;
- Record keeping;
- Training;
- Harvesting practices and transport;
- Packaging and labelling;
- Storage; and
- Recall action.

4 Closing meeting

- Discuss any findings of non-compliance;
- Explain food safety implications;
- Mention positive aspects of the farm;
- Agree on a correctional time frame;
- Discuss other improvements;
- Sign the report, give a copy to the farmer;
- File the report on return to office;
- Schedule a follow-up visit if warranted.

5 Follow-up inspection

Appendix 2

Checklist for cricket farm evaluation

Appendix 2 Checklist for cricket farm evaluation

A) Farm information

1. Farm name:.....
2. Farm address:
-
- Phone.....E-mail:.....
3. Farm manager/owner
Name:.....Phone:.....

B) Farm information

1. Cricket species.....
2. Total pen numbers.....
Pen size.....
Pen made from.....
3. Farm in production years.....

C) Inspection information

1. Inspected by.....
2. Date.....

D) Farm and cricket management

Classification (Note: If the answer is NO, please explain in remarks)	Meets standard			Remarks
	Yes	No	N/A	
A. Farm assets and equipment				
1. Farm location				
The farm is located where there is no risk of contamination from chemicals/biohazards and is at a distance from residential and industrial areas.				
2. Buildings and structures				
2.1 The buildings and structures are well designed and well maintained.				
Focus points:				
a) The rearing house is built with durable materials, is easy to clean and has good maintenance and ventilation.				
b) Floors and walls are smooth, without cracks.				

Classification (Note: If the answer is NO, please explain in remarks)	Meets standard			Remarks
	Yes	No	N/A	
c) The floors in wet areas are concrete or tiled and have good drainage.				
d) The roof is waterproof and conveys rainwater away from the farmed area.				
e) Ceilings are designed to avoid product contamination.				
f) Pest entry to the building is prevented by netting or solid walls.				
2.2 Farm layout is divided properly for specific use such as pens, storage for cricket feed, waste collecting; housing areas are separate from the farm unit.				
3. Cricket rearing equipment Equipment used is clean, and there is no risk of contamination that would harm crickets and consumers. A cleaning and maintenance schedule for equipment in the cricket farm is used. Focus points				
3.1 Rearing pens				
a) Pens are durable and made of non-toxic materials.				
b) Pens are shaded from direct sunlight under a roofed structure.				
c) The top edge of the pen is durable and composed of non-toxic material that prevents crickets from escaping.				
d) The cleaning and maintenance schedule is recorded.				
3.2 Cricket hiding materials				
a) Materials are clean with no risk of contamination.				
b) They are cleaned regularly.				
c) Origin of materials used is known.				
4. Siting of water and feed containers				
a) Water and feed containers are made of non-toxic materials and are regularly cleaned.				
b) Water used comes from clean reservoirs.				
c) Water quality is good (odour, colour by visual assessment).				

2 Appendix 2

Checklist for cricket farm evaluation

Classification (Note: If the answer is NO, please explain in remarks)	Meets standard			Remarks
	Yes	No	N/A	
5. Egg containers, collection and incubation				
a) Containers are clean and non-toxic materials are used.				
b) Egg-collecting material used, such as rice or coconut husks, is clean and sterile before use to prevent contamination.				
c) Egg incubation is done hygienically with clean pens and separated in plastic bags or other clean materials like jute sacks or cloth.				
B. Rearing cycle management				
1. Parent stock				
a) Selection of good quality cricket parent stock (good body size, healthy and active crickets).				
b) Origin of the parent stock is recorded.				
2. Feed used on the farm				
2.1 Commercially produced feed.				
a) Quality of feed observed is good. (Note: normal colour, odour free and no contamination from pests and mould).				
b) Source of feed is known				
c) Feed is stored in a clean and dry room.				
d) Feed sacks are elevated off the ground or floor.				
2.2 Green vegetable feed.				
a) The basic examination of vegetable feed used confirms good quality (Note: no rotten or diseased leaves or fungus)				
b) The source of vegetable feed is known.				
3. Water supply				
a) Water used is supplied from a clean and safe source.				
b) Has water been tested in the past?				
c) Is water testing recommended?				

Classification	Meets standard			Remarks
	Yes	No	N/A	
(Note: If the answer is NO, please explain in remarks)				
4. Storage and processing				
a) Boiling water is used for postharvest sterilization.				
b) Cricket products are kept in cool storage (ice boxes or a refrigerator, comment on type).				
5. Cleaning the pen and equipment				
5.1 Cleaning of rearing equipment				
a) Does the farmer practise good cleaning of equipment and hygiene such as using clean water, heat treatment or air-drying in the sun?				
- Cardboard egg trays				
- Feeding containers				
- Water containers				
5.2 Cleaning of rearing pens				
a) Pens are washed at the end of each rearing cycle with clean water and left to dry				
b) An approved disinfectant is used to clean the pens after each rearing cycle				
C. Environmental concerns				
1. Dry waste and wet waste disposal				
a) Dry waste of faeces and left-over feed are removed from rearing pens after the harvest of the crickets.				
b) Collected dry waste is used as fertilizer for plants or for sale.				
c) Water from washing enters a drain leaving the farm.				
d) Liquid waste is held in a tank or pond.				
2. Dead crickets				
a) Dead crickets are routinely removed from the rearing pens during the production cycle.				
b) Dead insects are burned to avoid the risk of potentially spreading disease to other pens.				
3. Chemicals used				
The inspector has checked all chemical products used in farm operation.				
a) Approved chemicals are used in sterilizing pens and equipment.				

2 Appendix 2

Checklist for cricket farm evaluation

Classification	Meets standard			Remarks
	Yes	No	N/A	
(Note: If the answer is NO, please explain in remarks)				
b) Chemicals used are stored in a safe and secure place.				
D. Farm hygiene				
Preventing disease entry to the farm is practised.				
a) A footbath tray with disinfectant chemicals is installed at the doorway for visitors to walk through before entering.				
b) Visitors are required to remove their footwear at the entrance to the breeding or rearing house and are provided with sterilized footwear.				
c) Netting for protection from animals is installed in the roof of the cricket house.				
d) Sick crickets are quickly removed from pens and burned; pens are then cleaned with approved chemical agents.				
e) Food scraps are not reused with another pen or batch of crickets to prevent risk of disease transfer.				
E. Record keeping on farm				
a) Names of visitors to the farm (when, where from and numbers) are recorded in a visitors' book.				
b). There are records relating to cricket production (e.g. yield).				
c) Any production problems are recorded (e.g. an outbreak of disease or management failure).				
F. Staff health and safety				
The farming operation does not create health and safety problems for workers.				
a) Provision of toilets and hand washing facilities.				
b) Separate eating area away from the cricket rearing area for staff to use.				
c) Staff on the cricket farm wear appropriate clean clothing.				
d) 'Do not eat, drink or smoke in the cricket rearing pen areas' signage is present.				
e) Workers are properly trained and know about risks and safety.				

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