Classified into Class of Insect, crickets, so called “jumping insect”, the G. testaceus (cliring crickets), G. mitratus (cendawang crickets) and G. bimaculatus (kalung crickets) are widely cultivated by farmers in Indonesia. Crickets preferred hiding in dark places and are sensitive to light, farmers use egg trays, dried banana leaves and cardboards of tissue rolls to provide them comfort. They active at night to forage, mate, sing and laying eggs. Practicing polygamy one male could mate 1-5 females, and females laying eggs within 7-10 days after mating. The average egg production between 3,154 - 4,128 eggs/cycle. Wild crickets mate in the middle of rainy seasons when males produced unique sounds to attract females. Crickets eat leaves, vegetables and fruits. Feed containing 20%-22% protein could reduce cannibalism and accelerate growth. Providing high protein content (60%-70%) serve as alternatives in-feeds conventional ingredients for ruminants. Use of unproductive old crickets to replace soybean meals in lamb rations, revealed that utilization of cricket meals achieved up to 100%. Small or medium crickets enterprises provide significant revenue and benefit to farmers

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CRICKET FARMING IN INDONESIA: Challenge and Opportunity

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CRICKET FARMING IN INDONESIA: Challenge and Opportunity

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Aknowledgement

It is a great pleasure to have this book entitled: **"Cricket Farming in Indonesia: Challenge and Opportunity",** ready to be reviewed and pulished. First of all, thanks God for His Grace and Mercy, so that we could finalize this monograpy. On behalf of our research team, I would like to extend our great thanks and appreciation to Lambert Academic Publishing, wich had shown a high interest on cricket topics, requested us to write this book for a broad readers and and to those who are of interest. This opportunity opened our mind to see insect from a different anggle, as a unique and important creature to be working on, of wich have high benefits to small farmers.

It has been a long way of preparation carried out on research, trials, data collection and review of all pieces of reports on crickets within almost past eight years. Data were obtained and adopted from various sources: series of experiments conducted at the farm laboratory of Faculty of Animal Science, Bogor Agricultural University, surveys, reports and literatures reviews. A number of visits to cricket farms were also done to enrich our understanding and knowledge on urban cricket farming practices. As research team, Ir Hotnida C.H. Siregar, M.Si; Yuni C. Endrawati, S.Pt. M.Si.; Prof. Dr. Dewi A. Astuti, and myself, supported by our technician, Winarno, SP., all have been involved with crickets by doing lots of academic and research activities. We became interested in this insect since firstly introduced about ten years ago by Prof. Dr. D.T.H. Sihombing, (he passed away 2011), used to be a great innovative researcher and effective writer with his brillian ideas, concepts and works on insects. In this regards, this book is dedicated to him as a remembrance for his dedication and passion to science and education.

This book could only be accomplished because of such great contributions, help and supports we received from many parties and people. Firstly, from our institution: The Faculty of Animal Science, Bogor Agricultural University, which provided and facilitated us with all facilities for education, research, and practical classes. Secondly, all writers including Lilis Khotijah, Andika Sunyoto and students, who participated in the preparation, data collection and drafting, to make this editing process was possible. With different background and fields of interest of writers, the content of this book comprised all aspects of cricket farming in Indonesia including how cricket could survive in their ecological zones, capacity of production and reproduction,

management and feeds and feeding practices, cricket as source of livestock feed, economic potencial, contraints and strategies for a sustainable cricket production. Recommendations for future work and programs are outlined. We realized that cricket had potency to be developed for several aims: initially, at present, as animal feeds (birds, fish, reptiles and small ruminants); in the future, it might be possible to develop cricket enterprises focused on producing materials or products to be used for cosmetics, and possibly, human consumption.

Last but not least, we would also like to aknowledge and extend our thanks to cricket farmers, and Mr. Achmad as farm group leader in Bekasi-Indonesia. His extensive experiences and understanding has provided us with important data and information on urban cricket farming. We realized that information presented in this book did not covered all related aspects yet, due to some limitation in terms of time and resources. There is an open window for future collaboration with related parties and institutions to develop an integrated research approach and development, including creating business on crickets. Any suggestion and advices from readers for enriching and making this book usefull, would be very much appreciated.

Bogor, March 2016
Editor,

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CHAPTER 1.
GENERAL INTRODUCTION

Raising non-livestock animals such as bees, worms, silkworms, crickets, mouses, butterflies, birds and other prospective animals is now starting to be recognized since they have several advantages compared to other conventional animals. Insects become something to consider as a new business in urban areas with low input for farming activities. To run business on insects, a person does not need a big capital since it does not require a large area or special care. The animals are not only easy to raise, but the operational costs are also quite low, making this business would be economically potential. One of those is crickets, which commonly become important sources of feed for other animals such as birds, reptiles and fish, and providing important components in the preparation of animal feed. There is a belief that birds fed crickets will produce a distinct and unique sound. These caharacteristics give a kind of excitement to the bird owner who keep birds as hobbies or has higher price for sale. In fact, crickets are generally used as a source of alternative protein for both, whether birds or conventional livestock, and human consumption in some regions in Central Java. Reported that crickets had high protein content (61.58%) with a fairly complete amino acids contents. The protein content is even capable to substitute a number of protein material sources such as soybean meal and fish meal which are commonly used in animal feed.

There were more than 100 species of crickets in Indonesia (Paimin *et al*. 1999), but only a few species that have been cultivated by farmers included *Cliring* cricket (*Gryllus mitratus*), *Cendawang* cricket (*Gryllus testaceus*) and *Kalung* cricket (*Gryllus bimaculatus*), and a bit rarely, German crickets. According to Sukarno (1999), local crickets in Indonesia generally lived and adapted well to any environments with a temperature ranged between 22-32^{0}C and a humidity range from 65-80%. One female *G. bimaculatus* could lay 1,375-4,123 eggs at one time, *G. testaceus* could produce 1,164-1,565 eggs for 45 days, German crickets produced 1.200-1400 eggs/cycle. The life cycle of crickets was fairly short, about 51-99 days for German crickets and 74-120 days for local crickets. Crickets belonged to phitophagous insects, alike other members of the Orthoptera (Chapman, 1975), the insect could survive in a variety of places with limited sources of feed and harsh environments. Crickets adapted well to their habitats and in suitable natural environments since they were able to eat all kinds of fruits, vegetables, assorted leaves, dead insects and so on (Walker, 1987; Hasegawa and Kubo, 1996; Siregar *et al*., 2014)). Our study, which was similar to Paimin *et al.* (1999), revealed that crickets preferred eating young leaves that contained lots of water like lettuce, cabbage, spinach, papaya leafs, According to Ueckert and Hansen (1970), feed preference of crickets was very much influenced by seasons and feed availability. Research findings revealed that the productivity of crickets reared by breeder community was not quite optimal in terms of egg production, hatchability and mortality rates because those cricket enteprises were categorized small to medium scale, and were not supported by an appropriate farming management and supportive environment. On the other hand, low access of farmers to a diverse market with good prices, unavailability of appropriate technology for breeding and feeding management and high mortality rates became obstacles in improving business scale. The availability of such a big variety and types of local feeds in Indonesia which are not in competition with human consumption could become supporting factors for cricket rearing.

Why choose crickets?? Based on the general characteristics of crickets which are easy to raise with very low input, short life cycle with relatively high production per cicle, and the growing demands for the insect and its products, possibility to develop cricket enterprises in urban areas may involve land-less farmers of low capital. Fuah, *et al.* (2015), had shown the benefits of crickets to improve income of small farmers, and might become the driving force for raising crickets as choice of prospective business. To our understanding, several regions in Indonesia have been recognized as the centers for cricket cultivation in term of business activities. According to Kurniawan (2010), the economic analysis of cricket productivity can be classified into both, technically and economically. Technically; the productivity was calculated as the ratio between output and input through increased productivity. This implies to an cricket production and a significant improvement of any methods used to run the business. Whereas, economically productivity is an effort to obtain maximum results with the smallest use of resources. Therefore, considering the great potency, it is no doubt if cricket farming could become an alternative business for a significant cash income to small farmers. Further studies on cricket farming, and information at down-stream levels, especially on processing and marketing need to be done for local cricket development. Supports from government and any related research institutions could help to develop various topics for research on crickets as feed and as alternative business opportunity.

CHAPTER 2.
CRICKET FARMING IN INDONESIA

Yuni Cahya Endrawati and Andika Sunyoto

2.1. Geographycal Distribution and Habitat

Crickets could be found in almost all parts of the world except in the polar region. The highest number of crickets were found in most tropical countries, the number of species found in a certain places depended upon local environmental conditions (Linsemaier (1972). Beside their morphological differences found in the subfamily of Gryllidae family, there were also some differences related to each habitat in where they usually live. Among all cricket families, there were: sub-family of Oceanthinae as tree crickets; sub-family of Eneopterinae as shrub crickets; sub-family of Mogoplistinae as scaly crickets; sub-family of Myrmecophilinae as ant lover crickets; sub-family of Nemobiinae as soil crickets; and sub-family of Gryllinae as house crickets and field crickets. House crickets and field crickets were commonly lived in meadows, open fields, along roadsides, in the yards and some go into the house (Borror et al 1992).

There were about 1.000 species of crickets belonged to Gryllidae family, of those, approximately 123 species spreaded almost all over Indonesia, mostly found in dry areas with a temperature of 20-30°C and humidity of 65-80%, even on areas of having loose soil or sand and shrubs (Paimin, *et al*, 1999). *Gryllus testaceus* (*Cliring* crickets), *Gryllus mitratus* (*Cendawang* crickets) and *Gryllus bimaculatus* (*Kalung* crickets) are now widely cultivated by farmers and have special markets. According to Esa (1998), the great harvest of rice field crickets occured from December to April during the dry season, the very suitable season for crickets to adapt and might reach high rate of population in a very short time. News cited from Kompas (2015), the spread of crickets in almost all the territory of Indonesia was much related to the suitable climatic conditions, temperatures, and humidity for the growth of crickets. Apart from those that still live in their original habitats, the three domesticated crickets have been widely cultivated in Java islands for business purposes. The production centers become the major suppliers of crickets and breeding eggs to meet the increasing market demand of buyers in Indonesia. Several cities in Central Java known as cricket cultivation centers are Demak, Kudus, Purwodadi, and Yogyakarta, in East Java were Tulungagung, Kediri, and Porong. Whereas, in West Java the production centers of crickets are located in Bekasi and Cirebon. It was stated that the daily production in Cirebon reached 200 kg young crickets and 8 kg eggs per day.

Crickets preferred to live in colony, as nocturnal species they were mostly hiding to avoid areas with high light intensity, found in hidden dark places or shadow areas. That is why, they were often found under rocks, wood piles, crevices of furniture, and in the shade of foliages or grasses such as under pastures, farm fields, and so on. Crickets lived on land--in trees, bushes, cave, even in the hole in the grouceports. According to Walker (1978), they hid in the folds of dry leaves or chunks of soil, among the leaf litter and plant debris, on the trunks of trees or shrubs, even in the houses, grass, fields or gardens, depending on species. The dried leaves are commonly used by farmers in Indonesia to suit cricket nature in wild teritory such as teak leaves, banana leaves, *ilalang* leaves, sugar cane leaves, and dried soybean stems, as also reported by Adihendro (1999). According to Sukarno (1999), crickets could live in cold or hot air, with high or low humidity, but they generally preferred to live in the regions with temperature ranged from 20-32°C and a humidity of 65-80%. Booth and Kiddell (2007), found that house crickets (Achetta domesticus) grew faster at 28°C than when kept at 25°C, while Purwanti (1991), showed that cricket activities decreased at a low temperature (20°C) and rose at high temperatures (30-35°C). For crickets kept in a cages, the humidity could be maintained by spraying clean water around the cages using a spray or a fine sprayer or by placing a cotton/damp cloth inside cricket cages. As stated by Bursell (1970), insects lived in the environments with high humidity tended to lower the water content of their bodies by reducing feed intake. As long as the variation of temperature and humidity were still between comfort ranges, it will be suitable for stable production and longer life cycle of crickets. In their nature, during the day crickets hide under rocks, tree debris or in the soil, at night the animals move out in search of food and mates. Crickets cannot always be found in nature because they appear only in certain months i.e. in June-July and November-December. Paimin (1999), stated that crickets were difficult to find from January to May and August to October because of the limited numbers, and seasonal effects.

Based on the study results obtained on how crickets could adapt in their natural environment, some strategies for cultivation could be made. Before setting any programs for cricket cultivation and sustainable production, it is necessary to understand more detail about all related aspects associated with management and technology to support higher production and strategy for success in the insect business. The cultivation of crickets in efficient ways need good cages representing their damp and dark natural habitat. The common materials used for cricket raising in Indonesia are mostly of woods, plywoods, plastics, or bamboos, of which easy to find and cheap. Generally, cages are placed in an area that free from direct sunlight and equipped with a hiding place in the form of egg tray, dried banana leaves, used cardboard of tissue rolls, or other materials that serve to provide comfort and increase the surface area of the cage. **Figure 2.1** shows the most representative cages used by farmers for rearing crickets. Until now, very seldom to find any other alternative caging systems which are efficient and economically fiable for cricket farming.

Figure 2.1. Type of cage for cricket rearing (Source: Bekasi Farm)

CHAPTER 3.
BIOLOGICAL ASPECTS

Hotnida C.H. Siregar, Asnath M. Fuah and Winarno

3.1. Classification and Morfology of Crickets

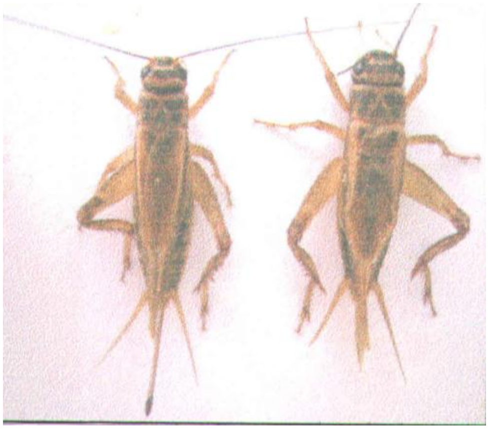
According to Borror et al., (1992) crickets could , hierarchically, be classified as follows:

Kingdom	: Animalia
Phylum	: Arthropods
Class	: Insecta
Order	: Orthoptera
Sub order	: Ensifera
Family	: Gryllidae
Sub-family	: Gryllinae
Genus	: *Gryllus*
Species	: varies within and between regions

A number of studies have been done on the three well known species of crickets raised by farmers in Indonesia, namely, *Gryllus mitratus* (*Cliring* Cricket), *Gryllus testaceus* (*Cendawang* Cricket), and *Gryllus bimaculatus* (*Kalung* Cricket). View research on the German crickets were also carried out, and being introduced to farmers, however, because of some problems arose from the cultivation practices, the species was no longger raised by farmers. High mortality rate found in Jerman cricket aged 10-40 days was 14.81%, and increased significantly to 43% within 41-70 days of age. Cricket was normally called jumping insect related to grasshopper and bush cricket or cicada, it had hind legs used for jumping, two pairs of wings, and a pair of thread-like antennae that sometimes exceedsed the length of its body. *Gryllus bimaculatus* or *Kalung* cricket had a softer body skin with a faster growth rate than the two other crickets. Its body size was about 2-3 cm. The body skin and outer wings were black or reddish, and there was a thick yellow line resembling a necklace around its back neck. Widyaningrum (2009) stated that this species was relatively calm, but if there was any threath or predators, they became aggressive and pugnacious, similar report by cricket farmers that extra care was needed, including types of feed given. *Kalung* crickets have more advantages compared with other species of crickets, especially in the growth rate and feed conversion. Provided with softer body skin, making crickets are more desirable by birds and other insect-eating animals. Borror et el (1992) and Hasegawa and Kubo (1996), stated that cricket body consisted of three major parts, namely, head (anterior), chest (thorax) and abdomen (posterior). On the head part, there were compound eye. On the head there was a part, stated as the antennas, according to Sukarno (1999), normally used to detect odors up to the distance of 1.5 m and two pairs of whiskers near the mouth served as a food feeler. On the chest there were three pairs of legs and two pairs of wings, located at the back. The hind legs which were larger in size and had sharp spikes on them served to jump for long distances. At the front of the legs, there were hearing organs (tympanum), of ellipse-shaped and white in color. According to the Editorial Team of National Encyclopedia Indonesia (1994), cricket legs consised of segments, namely, the basic segment (subcoxa), the second segment (coxa), the third segment (trochanter), the fourth segment (femur), the fifth segment (tibia), the sixth segment (tarsus). Cricket wings which served to fly and produced sound were in their full development after reaching adulthood. In the abdomen there were respiratory organ, digestive organ and reproductive organ (Corey et al., 2000). According to Borror et al. (1992), cricket abdomen consisted of 11 segments and the external genital was located on segments 8 or 9. At the end of the abdomen there was a pair of cerci which served to detect danger and the presence of rear movements.

Figure 3.1. *Kalung* Cricket (*G. Bimaculatus)*

Figure 3.2. Adult *Cliring* Cricket (G. *mitratus*)



(a) (b)

Figure 3.3. Jerman Cricket (*Gryllus sp)*: Male (a) and Adult Female (b)
(Source: Septyka, 2004)

Wild cricket / *jeliring* cricket / *seliring* cricket / *alas* cricket is a kind of "gryllidae" which belongs to the type of insect almost similar to grasshopper, spreaded extensively in Indonesia. This cricket is very popular to cultivate due to its big body size and become the favorite feed for bird and fish. Its body is not only smaller and longer, but it contains a lot of water. This wild species of crickets / *seliring* crickets are mostly found in the western part of Java and Sumatra, especially in rice fields and spacious damp land area and characterized by its yellowish brown color.

3.2. Cricket Behaviors

Crickets as nocturnal insect which is sensitive to light, are only active at night to forage, mate and sing. The behaviors that can be observed are when they are singing, mating and nesting. **Singing behavior;** Matthews (1978) stated that only male crickets could sing, because they had jagged or wavy wings. The sounds were produced by rubbing the right wing back and forth with the left wing simultaneously. The sounds were not only used to call for gathering, social purpose, and agresivity sign, but also to attract the opposite sex and isolate other animals. Paimin *et al*., (1999), stated that every cricket had different types of voices, and the characteristics made the male is easier to find a partner of its kind. **Mating Behavior;** Crickets practiced polygamy; one male in the wild could only mate 1-5 females. The process begins with the sound made by a male cricket, signaling that he was ready to mate. The female crickets which were attracted by the sound would find the source of the sound and approached it (Sukarno, 1999). The male would release liquid (seducin) from the base of its wings to attract female cricket which was approaching. A female then climbed onto the back of the male cricket, licking the liquid (seducin) released by the male, along with the copulation process made by the male cricket (Matthews, 1978; Oda and Kubo, 1987). By recognizing these behaviors, appropriate mating systems could be more efective.

Figure 3.4. Mating behavior of *Kalung* Cricket
(sumber: Hasegawa dan Kubo, 1996)

Egg-laying Behavior; Female crickets could lay eggs without mating, but the eggs produced were not fertile. A female would layed eggs within 7-10 days after mating and produced fertile eggs. Matheson (1951) stated that the egg-laying behavior was started by making a small hole by moving its ovipositor into egg-laying media until a sufficient area forms, and then the female cricket will drop its feces near the hole. Then, the female insect deposited its eggs by moving its ovipositor into the hole. The egg-laying process was ended with picking up the feces and put it on the surface on where the eggs were laid. Our observation revealed that under some limit circumstances, crickets would still laying eggs with or without any availability of media. The eggs were released in between the food or laid scattered on the bottom of the cage.

Figure 3.5. Female *Kalung* cricket is laying eggs on sand media
(Source: Bekasi Farm)

CHAPTER 4.
MANAGEMENT PRACTICES IN CRICKETS FARMING

Asnath M. Fuah, Hotnida C.H. Siregar and Andika Sunyoto

4.1. Production and Reproduction

The life cycle of crickets was relatively short, and some studies revealed the differences found between species; *Kalung* crickets ranged from 75 to 84 days with a production period of 20-24 days (Jamal 2000). The time for a female cricket to hatch eggs into nymphs (young insects) was ranged within 13-25 days. Nymphs grew into young *clondo* or crickets within the range of 30-40 days, and might reach adulthood (growth of wings) at the age of ± 50 days. Of the three species, *Gryllus bimaculatus* or *Kalung* cricket is more popular in the market. This type of cricket is more attractive to bird lovers because of their softer bodies as compared to the wild crickets.

Wild crickets mated in the middle of the rainy season when the male crickets produced a distinctive sound to attract females of which would be approaching the male crickets that emitting loud noises, before they finally mated. In general, one female cricket produced as many as 50-100 eggs. It was not too difficult to cultivate this type of cricket, due to the easiness to adjust itself to new surroundings, unfortunately, it needed a longer time to reach the harvest time. The age of wild crickets to reach harvest time was around 40-55 days of age (Paimin, et al. 1999). The common signs when a cricket was in heat period were indicated by the shiny look of its back fur and the long size of ovipositor (**Figure 4.1**), stiff, black and the tip of the lower abdomen became pouch-like shape (Sridadi and Rachmanto 1999). A male cricket which was ready for mating had the following signs: a complete wings, age had reached 60 days, the voice iwa loud and showed agile movements (Sukarno 1999). Widyaningrum (2009) reported that the males could mate several females with an ideal and efficient sex ratio of 1:5 with 57.25% hatchability, in line with Paimin *et al.* (1999). Whereas, by applying sex ratio of 1:9, the hatchability lower down to approximately 55%.

The external genital organ of a female cricket so called ovipositor was a needle-like shape located at the tip of the abdomen, normally used to lay eggs. A female cricket had a pair of ovaries which were located in the middle of the back on the digestive tract (Budi, 1999). A male cricket had a pair of creamy white testis located on the digestive tract. Each testis consisted of several follicles thinly related, extending to the back part until it reached ejaculator channel. A pair of accessory glands consisted of seminali vesicle and a long convoluted vessel located on the ejaculator channel (Youdeowai,1974). Male genital organ called clasper, functioning as a tool for copulation that moves sperm to the female genital tract (Budi, 1999).

Figure 4.1. A sandy container containing ready-to-hatch *Kalung* crickets (Source: Bekasi Farm)

The eggs of the genus Gryllus looked like a banana, a clear pale yellow with an average length of 2.5-3 mm. The top of the egg was protrusion so called operculum, from where the nymph gone out from the egg. The cricket eggshell was very tough and strong to protect the inside part of the eggs (Paimin *et al*., 1999). A good egg looked translucent yellow and shiny. Eggs with a growing embryo were translucent and glossy brownish (Raharjo 1999). An adult female of *Kalung* cricket could produce 1,375 eggs (Widiyaningrum et al., 2009), even student experiment showed that egg production might reach up to 3,154 - 4,128 eggs/cycle of cricket kept in damp cages covered by muds. Egg production varied between species, widely influenced by various factors including genetics and environmental factors, with the proportion of 30% genetics and 70% environmental factors. Female crickets had the ability to lay eggs even without male crickets, but the eggs produced would be infertile (sterile) and will not hatch (Paimin et al. 1999). A female cricket layed eggs by inserting ovipositor into the soil or sand at a depth of 1.25 cm, the eggs in the soil needed natural warmth to hatch (Sridadi and Rachmanto 1999). The relative humidity required for hatching eggs ranged between 65% -80% with an air temperature of 26° C (Sukarno, 1999). Crickets needed media to lay eggs and hatch the eggs. Damp sandy media was very effective in stimulating egg laying to produce a higher number of eggs. Hatching media can be sand, soil, a mixture of sand and soil, cotton, and linen (Paimin *et al*., 1999). Difference in hatching media influenced the hatching time of *Kalung* crickets. The eggs placed on cotton media hatched faster than in sand. Local cricket eggs hatched into nymphs in the wild within a period of 15-17 days;

(13-14 days; Paimin *et al*., 1999); (10-14 days; Patton 1963), counted from the parents begin mating until the eggs hatch. **Table 4.1** presents the productive caharacteristics of *Kalung* crickets (*G. bimaculatus*).

Table 4.1. Production and Reproduction Charasteristics of *G. bimaculatus*, *Gryllus sp and* G. *Testaceus*

No	Characteristics	Average/Range				
		[1]*G. bimaculatus*	[1]*G. mitratus*	[1]*G. testaceus*	[2]*Gryllus sp*	[3]G. *Testaceus*
1	10 days body weight (mg)	-	-	-	-	-
2	50 days body weight (mg)	501.47	306.13	228.86	-	-
3	Adult male body weight (mg)	0.86	-	-	-	-
4	Adult female body weight (mg)	0.88	-	-	-	-
5	Body weight gain(mg/cricket/day)	12.50	7.62	5.69	-	-
6	Feed consumption (mg/cricket/day)	11.19	7.29	5.42	0.46	1.58
7	Feed conversion	0.89	0.96	0.95	0.04	1.59
8	Laying period (day)	32-36	56	56	-	-
9	Eggs production (eggs/cricket)	1.375	2.576	1.961	464	122
10	Hatchability (%)	60.23	63.56	39.66	80.48	36.56
11	Mortality of egg laying females (%)	45.86	33.99	28.41	2.97	2.26
12	Mortality of young cricket (%)	-	-	-	3.71	54.72

Source: [1)]Widiyaningrum (Thesis 2001); [2)]Septyka A. (Thesis, 2004); [3)]Retno S. (Thesis, 2005)

4.2. Cricket Rearing Management

Types and materials used for cricket cages are essential in cricket cultivation. The cricket farmers in Indonesia usually use wood, plywood, cardboard, plastic or bamboo for making the insect cages. There are no difference in the shape and type of cages for each species of crickets. Box-shaped cricket cages are made of plywood and wooden laths as the main framework. Cricket breeders have provided several boxes in one big unit for cultivation. The cage size was approximately 3 meters long, 2 meters wide, and 30-50 cm high. Like its wild environment, the inside part of the cages should be dark. The base of the cage was made by putting egg trays (egg crates) on the bottom part of cages, which are arranged vertically or horizontally, coupled with dry banana leaves (klaras) above it (**Figure 4.2**). Both of these materials were used to create such a comfortable environmental condition with suitable temperatures for cricket growth and production. Farmers are easy to find materials for cricket egg-laying media such as sand, with fine form, stoneless and clean. The sands were used by farmers as media for hatcing eggs, by placing it inside a plastic container or plywood board as many as necessary. It was recommended that the spread of the sand in the container should be equal, with a thickness of 3-4 cm. The container was filled with sand before being inserted into the cage after the age of crickets has reached ± 53 days, when crickets enter the egg-laying period. The cage design used in the study is presented in **Figure 4.2.**

Figure 4.2. Cricket Cage System (source: Bekasi farm)

The results revealed from a number of on-farm studies, experiment conducted at the university's farm laboratory and student final tasks, suggested that fast harvest time and high market demand became a driving force to develop cricket business in an efficient way. From economic point of view, in relation with its high production, this insect has potencial market and high demand. Every 3 ounces of cricket eggs is capable of producing 30 kg crickets each harvest with a raising period of 29-33 days.

In cricket raising management, normally several steps of procedure are applied. To prepare their cages, first of all, the rectangular cricket cages need to be cleaned in order to remove dusts or dirts, and then the inside of the cages were cleaned by washing it with soap and water. The cricket eggs which are ready to hatch are placed in the hatchary cage using a piece of cloth as the base. The newly hatched crickets will walk to find food. Feeds are given *add libitum* (always available). Regularly, at each feeding time, the remains of the previous food are taken out to prevent decay and fungal that can bring a disease to crickets. Once a week, the boxes are cleaned and the klaras replaced without removing crickets from inside the boxes. Washing boxes is conducted every time the harvest is done.

In cricket cultivation, one important thing to which attention should be paid is harvest time. Borror *et al*., (1992) showed that a cricket could be said to have entered adulthood when wings had grown on its body, at the age of 45-50 days. The right time for harvesting crickets is when they still have no wings (35-45 days). This is because the majority of cricket consumers are ornamental bird enthusiasts. Ornamental birds are known to like wingless crickets because the wings are hard, sharp, and harsh, and are dangerous for ornamental birds to consume. The experience of cricket farmers in Perwira sub-district, North Bekasi, they often disposed the culling or unsale crickets due to the delay in harvest time.

The observations and interviews with farmers in the urban area of Bekasi, showed that the crickets used parents were kept alive until the egg-laying period ends from the beginning of lay eggs at age ± 50 days, and lasted for 20-24 days. In practice, eggs were layed on sand media, and the sand container containing eggs were removed every 3-5 days. The eggs in the sand were then separated from the sand by a filtering process. Some breeders had a different technique of separating the cricket eggs from the sand. For example, the breeders in Bekasi, separated the cricket eggs from the sand by soaking the sand containing cricket eggs in a container filled with water. Because the cricket eggs were lighter than the sand, when stirred gently, the cricket eggs rised to the surface, and that was when the cricket eggs were taken out using a sieve **(Figure 4.3).** Cricket eggs were hatched within 10-14 days after the mating time. The eggs released by females were golden yellow, but the color would turn into whitish when the cricket eggs were about to hatch.

Figure 4.3. Newly separated cricket eggs from sand media, are ready to hatch (location: laboratory farm, Faclulty of Animal Science, IPB)

4.3. Feed and Feeding Management

Feed availability in good quality and sufficient quantity is one important factor in the cultivation of crickets since feed can affect reproduction, growth, development, behavior, and other morphological properties. A big variety of feeds that can be consumed by crickets, are found in their living habitat, as Hasegawa and Kubo (1996), stated that adult crickets ate everythings they could find. Unlike young crickets which eat in order to grow up, adult crickets eat to obtain energy for mating and reproduction process. As plant-eating animals (herbivores), crickets eat leaves, vegetables and fruits that contain lots of water, because this insect do not drink water as most animals. According to Widyaningrum (2009), crickets fed forage consisting of a combination of concentrate with mustard leaf were preferable to concentrate combination with papaya leaves. In terms of feed, Paimin *et al*. (1999), and Widyaningrum *et al*. (2001), revealed that the palatability of crickets was determined by the water content and the types of leaves given. Because crickets never drink water, the water needed was obtained from the leaves given.

Feeding is regularly administered three times a day, or when the crickets are considered hungry again. Chinery (1986), stated that if their feeds were reduced or hard to find in sufficient quantity, cannibalism may occur. A regular feeding system can reduce cannibalism. Commonly, the types of feed used by farmers are banana stalk, squash, pumpkin, cabbage leaves, field glass, mustard green, fruit and papaya trunk. The amount of foliage feeding depends on the age of crickets. Upon hatching, baby crickets do not need any food, because they will eat the rest of their egg liquid. At the age of two days, young crickets start eating vegetables. The amount of foliage given follows their age increase, because the older the crickets, the more food they need. Cricket breeders administer greenery variously since it is adapted to the natural resources and the greenery which is generally given in their respective area. However, most cricket farmers obtained green feed from buying simply because of limited space and practical reasons (efficient). In addition, beside the feed in form of greenery, breeders also give concentrate to the crickets reared. Concentrate is very good to be used to accelerate the growth of crickets, but the feed can only be given after the crickets have been seven days old, and this feed can be given until the crickets reach adulthood. Lumowo (2001), reported that feed consumed by crickets was concentrate with protein content of 20%-22%; according to Sridadi and Rachmanto (1999), primarily, given during the enlargement period, which was 10 days after the eggs hatched. The purpose of giving the concentrate was to accelerate the growth, making crickets became agile, nymphs became soft, and crickets were not easily die (Tim GN 1999). Lumowo (2001) found that crickets fed artificial feed with a protein content of 20% -22%, performed better in production growth and breeding performance, than those given feed with lower protein content.

One alternative feed that always available for crickets in Indonesia are cassava leaf and stem, and all parts of a cassava plant can be utilized. The tuber is consumed as food by the community in several areas as alternative to substitute for rice. The young leaves are often processed as a side dish accompanying rice. When young leaves are still available, the old leaves and the leaf stems are not consumed by crickets. Up to now, the old leaves and the leaf stems have not been used optimally.

In fact, when consumed by crickets, their productivity can increase. This potential is an opportunity in the culture of crickets. According to statistical data, the planting area of cassava in Indonesia in 2014 was about 1,003 million hectares (BPS 2014). Lebdosukoyo (1983), reported that the production of cassava leaves of 0.92 tons/ha in Indonesia, was definetely abundant raw material for cricket feeding. There are many more types of leaves and vegetables available and is not in competition with human consumption, of which could be utilized as a raw materials for cricket feed.

4.4. Environmental Support

When viewed from the astronomical position, Indonesia is located in the tropical climate in the eastern hemisphere of the earth. Due to thigeographical position, Indonesia is always exposed to the sun throughout the year, with only two seasons, the dry season and the rainy season. Generally, tropical countries are blessed with rich natural resources. The high rainfall makes their land fertile and rich in diverse flora and fauna. The temperatures and humidity conditions of each province of Indonesia are shown in **Table 4.2.**

Table 4.2 Temperature and humidity in all provinces of Indonesia

Province/region	Temperature (°C)			Humidity (%)
	Minimum	Maximum	Average	
Sumatera	21,9	30,85	26,81	81,30
DKI Jakarta	22.40	35.80	28.20	77.43
Jawa Barat	18.50	30.10	23.50	77.00
Jawa Tengah	24.64	32.05	28.02	78.18
DI Yogyakarta	18.40	35.70	26.20	86.20
Jawa Timur	20.60	35.80	27.90	79.17
Banten	22.70	32.90	27.00	83.00
Bali	23.40	31.50	27.40	80.00
Nusa Tenggara Barat	20.80	35.20	28.25	80.00
Nusa Tenggara Timur	21.50	34.20	27.50	74.90
Kalimantan	22,64	34,48	27,17	84,08
Sulawesi	22,2	33,95	27,13833	85,44
Maluku	23.00	32.00	27.00	84.00
Papua Barat	22.80	32.60	27.30	83.00
Papua	25.30	31.70	27.90	80.60

Source: Central Bureau of Statistics 2015 (in average)

Based on the existing environmental condition, temperature and humidity variations, Indonesia regions consisted of regional divisions and provinces, are very much suitable for cricket cultivation and breeding. According to Sukarno (1999), crickets could live in the cold or heat, in high or low humidity, but generally crickets prefered to live in the region with temperatures was around 20-32°C with humidity of 65-80%. Data in **Table 4.2**, shows the average temperature and humidity in all the provinces of Indonesia ranged from 23.50°C - 28.77°C and 74.90% - 105.15% respectively. Although crickets can adapt to diverse natural environments, the condition inside and the surrounding of cages is important aspect in the cultivation of crickets, which is at least, similar their natural conditions, Booth and Kiddell (2007), found that house crickets (Achetta domesticus) grew faster at 28° C than if raised at 25°C, while Purwanti (1991) showed a decrease activities if crickets were kept in low temperature (20°C) and increased at high temperatures (30°C and 35°C).

To keep comfort environment for crickets, common materials used by breeders inside the cages were egg trays (egg crates) and dry banana leaves so called *"klaras"* The egg trays were placed stacking as a pad in a cage, generally in a vertical position to facilitate the farmers in the harvesting process, and *klaras* was placed exactly above the egg trays. The egg trays and *klaras* were to create a natural atmosphere like in the wild environment. According to Paimin (1999), both materials created dark atmosphere for crickets so that they could do daily activities such as eating, chirping and mating. During the day crickets seeked refuge in the passageway / hole, under a pile of leaves, under logs and rocks.

By understanding cricket behaviors and their adaptation to various environmental conditions, in areas with a range of temperature and humidity outside the comfort zone for cricket growth, it requires an appropriate technology to optimize the cricket growth. When cage temperatures are under a comfortable ranges, there should be an effective systems of cage management. For a cage with a too cold temperature, there should be an additional media in a cage, such as providing klaras (dry banana leaf) which functions not only as a hiding and mating place, but it can also keep the temperature inside the cage warm. To create warm temperatures, warming tools can be used, such as light bulb that is hung inside the cage box. The problem that has not been solved up to now is how to cope with the cage temperature above 35°C. There is still a lack of information and research on how to cope with the high temperatures in relation with the production of crickets.

4.5. Diseases and Predator Control

Food remains and accumulated feces reduced comforts and caused disease problems. The most common disease that have been identified was diarrhea, mainly caused by unclean environment of cages or boxes used for rearing. For example, unclean food or cricket feces could attract all unuseful bacteria. Paimin *et al*. (1999), stated that crickets suffered from diarrhea were characterized by some symptoms: the body was weak; did not move much; loose appetite, eyes began to close; fluid came out of its mouth; had mushy droppings. The infected crickets would not last long and would die within one day. There was no medical treatment found to prevent cricket diseases, so the common way of farmers to solve the problems was separateing the sick crickets by taking it out of the cage and then threw it away or to bury it. The main reasons behind this practice was the believe that the sick cricket would spread the disease the other crickets in the cage.

Predator is a main threat in the rearing crickets because it can lead to a high mortality rate. When crickets are just 1 to 2 weeks old, they are vulnerable to predator attack since the crickets are still very weak, making them become an easy target for predators. Young crickets always become food for ants and other animals such as lizards and mice. To overcome the attacks of ants, the cage should be equipped with a good security system, for example, by applying oil to the feet of the cage, so that the ants or other predators that are on the floor cannot climb up and attack the small crickets. Adult crickets cannot always be separated from predators, such as rats or mice. To prevent rats from entering the cage, the cage needs to be covered with a small diameter of netting wires and is given a heavy object on it so that predators cannot open and get into it. The crickets rearing carried out in the farm laboratory, showed that despite getting a pretty good handling, the mortality rate was still high, reaching up to 70%. Regular monitoring and control need to be done because of the high mortality rate. In addition to the effects of unfavorable temperature and humidity, predators have become the enemies that have to be watched out.

Figure 4.4. Cage type cricket rearing at the laboratory of Faculty of Animal Science, IPB

Categorized as insects with a short life cycle, the mortality rate of male *Kalung* crickets was higher than *Cliring* crickets, started from the age of 35 days. Mortality often occured due to molting failure which is characterized by the death of the crickets that have not finished their molting process. High humidity in the cage results in frequent failure of molting (Zuhriyah 2015). Molting periods are vulnerable for crickets to getting any kind of attack. Crickets will remove their outer skin and replace them with new skin. At this stage, the cricket body is vulnerable to attacks from other crickets because the molting crickets are weaker than usual. Cannibalism is common among crickets. Especially the crickets entering the mating stage, they are very aggressive. Clifford *et al*., (1977) stated that cannibalism occured when food availability was less, particularly when strong large crickets and weak small crickets lived in one box with high dense population, thus, the cages were over crowded. During molting period, when the crickets were in weak condition (**Figure 4.5**), there is no doubt that cannibalism may increase mortality. Cannibalism could be avoided by providing adequate hiding places inside the cage, comfort environment and enough feed provided for crickets in the cages. Also, simple management that commonly applied is by providing separate cages for crickets based on age stages. This will need many cages for cultivation, according to the target of production and types of production required.

Figure 4.5. Skin-changing (molting process) of crickets
(Source: Sunyoto)

Owning a small piece of land is not an obstacle in the cultivation of crickets, because the land can be maximized through cage models. Cricket cages are made of plywood and covered with netting wires so that predators cannot get into the cages. The inside of the cages is dark, filled with dry banana leaves where crickets are hiding and mating. A suitable cage model in a small piece of land is a stacked cage. When there are too many crickets kept in a cage, the percentage of inbreeding (mating within one offspring) is very high. Inbreeding can lead to a high rate of mortality. After one year of inbreeding, it can make cricket eggs smaller in size. One common way to overcome the problem of inbreeding is by bringing in the male crickets from outside the farm, meaning that breeders should look for male crickets from other cricket breeders. Actually, there is still a way to prevent high inbreeding in crickets, but unfortunately the research is in the process and will be carried out at the farm laboratory of Faculty of Animal Science, Bogor Agricultural University.

4.6. Institutional Development in Cricket Enterprises

Most farmers in Indonesia are categorized as small farmers with the following characteristics: They have limited access to a political base, assets of production and markets, local community income resources, including technology; they have low incomes, mainly from agricultural production; they are landowners, tenants and laborers; the land they own is not optimally cultivated (due to its small size); the labor used is family members; their primary needs are rarely met; they feel insecure with their property (fear of losing it); they have a small business scale which is a household business in nature (low input, low income); they are poor and geographically isolated; they always have their hunger and destitute period; they are used to hard life; they resist change because of their incapability of using new technology; they are illiterate and are not interested in counseling; the women tend to be more involved in the family business, not a commercial venture; they use local resources at family level, not commercial farming multipurposes; the services related to information, marketing, product transportation, storage, processing, and communication of information are still very limited. In general, most farmers in Indonesia run a small-scale farming, with limited capital and land area (<0.5 ha) and some employ an agricultural business model of integrating crop and livestock. Their commodities are adapted to their limited land area, the commodity developed, the scale and objectives of business, and available family workforce (Fuah *et al*., 2015). Cricket farming does not require a large piece of land, big capital and many workers compared to other livestock businesses. Fuah et al. (2015) reported that the income obtained from cricket farming can contribute to the farmer family income, be it a major business or just as a sideline. The support of the donor agencies is indispensable to facilitate cricket breeders to increase their business scale to be the main business.

LEISA (Low External Input Sustainable Agriculture) is a sustainable agriculture with low external inputs that optimizes the use of natural resources (soil, water, vegetation, plants and animals) and human resources (labor, knowledge and skills) locally available, economically viable, ecologically steady, socially equitable and culturally appropriate. LEISA concept as a new direction for conventional farming is very suitable to be conducted in the farming systems implemented in developing countries, including Indonesia as a country rich of natural resources. LEISA was a concept of the future agriculture, aiming to improve products sustainably and reduced negative environmental as well as social impacts by minimizing external inputs (Fuah et al., 2014). LEISA did not aim to achieve maximum production in the short term, but to achieve a stable level of production and adequate in the long term, refers to these characteristics:

1. Optimizing the utilization of local resources by combining the various components of farming systems (crops, animals, soil, water, climate and human) that are complementary and provide a great synergy effect.
2. Searching for ways of utilizing external inputs only when needed to complement the elements lacking in the ecosystem and improve the biological, physical and human resources. In making use of external inputs, the emphasis is on maximizing recycling and minimizing environmental damage.

Based on statistical`data, around 7 million Indonesian labor forces were either fully unemployed or working part-time, particularly those with low education that range from 50-74% having primary and secondary education (Central Bureau Statistics of Indonesia, 2015), which can be seen in (**Tables 4.3 and 4.4)** and this shows that the employment in the real sectors cannot accommodate the working people who do not have job yet. Insect farming can serve as an alternative business, which can provide job opportunities for those who are interested and have no formal higher education. This figures indicates that beside the huge job opportunities available in main real sectors such as mining, big companies and industries, and agriculture, insect business could answer the need for workers with less land and low formal education providing good skill in the insect rearing.

Table 4.3. Population of age 15 or older according to the types of main activities, 2013-2015.

Types of main activities/unit	2013	2014		2015	
	August	February	August	February	August
1. Labor force (million)	120.17	125.32	121.87	128.30	122.38
Employed	112.76	118.17	114.63	120.85	114.82
Unemployed	7.41	7.15	7.24	7.45	7.56
2. Participation level of labor force (%)	66.77	69.17	66.6	69.5	65.76
3. Level of open unemployment (%)	6.17	5.7	5.94	5.81	6.18
4. Disguished unemployment (million)	37.74	36.97	35.77	35.68	34.31
Under unemployed (million)	11.00	10.57	9.68	10.04	9.74
Part-time workers (million)	26.74	26.4	26.09	25.64	24.57

Source: Central Bureau of Statistics of Indonesia, 2015

Table 4.4. Population of age 15 or older who worked in line with their highest levels of education (million people), 2014-2015.

The Highest Education Level Completed	Year	
	2014	2015
Elementary School or lower	54.63	52.72
Junior High School	20.70	21.08
Senior High School	18.74	19.81
Vocational High School	10.71	11.32
Diploma I/II/III	3.04	3.11
University	8.55	9.79
Total	116.4	117.83

Source: Central Bureau of Statistics 2015

Viewed from the 2015 census data, most Indonesian people who worked in this cricket business were elementary school graduates or not complete elementary school. This makes the distribution of knowledge and information on how to run and manage cricket culture become minimal. According to data, the total labor force in August 2015 was 122.38 million, 7.56 million of whom were unemployed or have not got a job. And, of the total labor force, 34.31 million were not full-time workers—they were either part-timer or underemployed. That means they have spare time after work. Cricket culture is one of the business opportunities to boost economy. Cricket raising does not require a lot of time. In one day, it only takes 3-4 hours for farmers to do the raising process.

In August 2015, 5.272 millions people were the population aged over 15 years old who worked according to the highest educational background, and this is half of the total workforce in Indonesia. The level local culture. The higher the level of education, the broader the knowledge and mindset of that person will be. In other words, the higher the level of education, the better the managerial skills of a person. To increase knowledge about the culture of crickets can be done through training taking into account gender roles and participation. The training is important to develop the cultivation of crickets through farming management, application of technology, increased production and marketing expansion.

A business scale is the cricket populations raised daily, which are divided into three types: small, medium and large. Business scales directly affect the income obtained. Economically, the larger the business scale, the greater the income will be, especially if supported by good farming management. The three types of business scales were described by Rahmawati (2010) as follows:

1. The small scale; the enterprises had only a few boxes, where farmers just raised for their own need, or some bird buyers, or someone elses
2. The medium scale was categorized as a well-established business. For example, the farmers in as traders or middle men. However, the marketing coverage is still limited.
3. The large-scale has belonged to a business venture. In Central Java, the centers of *Kalung* cricket cultivation are Demak, Kudus, and Purwodadi with an average production of 9.78 tons per year, while in East Java the centers are Tulungagung, Kediri, and Porong with an average production of 12.69 tons per year.

CHAPTER 5.
CRICKETS AS SOURCES OF FEED FOR SMALL RUMINANT

Dewi Apri Astuti and Lilis Khotijah

Introduction

Feeding management in traditional farming system face many problems, especially for finding the protein sources. Cereals as conventional ingredient is more expensive as protein source for fattening ration, compare to legumes. It is necessary to find alternative protein sources especially for poultry and ruminant ration before and just after weaning period (1-4 month) with low price, high quality and save to consume. Sheep was one of small ruminant which have potential to produce meat. Sheep population in 2010 was 10,725 heads and increased by 2014 became 15,715 heads (BPS, 2014). Problem with high population is how to overcome the feed. It was reported that around 100 000 ton dry matter concentrate and 7.5 million ton dry matter forage per year were needed to produce sheep in Indonesia (Directorate General Livestock and Animal Health Services, 2011). Nutrient requirement for post-weaning lamb or growing sheep with ADG 100 g/d was around 14% CP and 52.50% TDN (NRC, 2007). One of plant protein was soybean meal with crude protein content around 49%. Dendi (2012) reported that utilization of 15% soybean meal in the ration has increased performance of growing lamb, but the feed cost was also high. Other alternative protein sources from plant or animal with low price, high quality and easy to produce was required.

Insect as a feed is now being introduced to many sectors, including in animal feeding management as a protein source, and might become one of the alternatives in-feed conventional ingredient which has high protein content. Since declaration of *Insect to Fed The World* at Wageningen University Netherland Conference last May, 2014, many kinds of insects were introduced as protein resources, including crickes. Insects contained of 60% to 70% protein and a fairly low of carbohydrates. After producing eggs within 5 - 6 times layer crickets would be wasted due to their low productivity (50%). The wastes produced is very potential as non conventional ingredient and can be used as protein source for animals. The average waste products obtained by one farmer was 2-10 kg per week (private data, 2014). Novianti (2003) reported that Indonesia cricket meal contained 56-74% protein and potential to be used as protein source in concentrate for growing sheep. Protein of the insect is one of the alternative ingredients to be used either as milk replacer or concentrate for pre and post weaning lamb. Wang *et al*. (2005) reported that in 100 g of cricket meal contained 58.30% protein, and chitin of 8.70% could disturb the nutrient absorption by animals.

Sustainable use of insects as a means to produce *protein* for *livestock, poultry, and aquacultured species* has been proven over 30 years. Cricket had high protein content (48.84% - 56.02%), fat (24.41% - 32.84%) and gross energy 4610 Kal/kg (Sinaga et al, 2010). Tiesnamurti *et al*. (2002) reported that milk production of Garut Ewes with single and twin litter size has only 10% by different. FAO (2011) reported that milk replacer had 24 % of protein, 22 % of fat and 1.2 % of calcium. Utilization of cricket meal for pre-weaning lamb should consider the high chitin content which could decrease nutrient digestibility

Ruminant have ability to convert nutrient in the ration to the product of VFA. However ruminant also produce methane (CH_4) another main greenhouse gas (GHG) that contribute to global warming after Carbon Dioxide (CO_2). Protein and its effect to rumen fermentation will contribute to the methane formation. (Jayanegara et al., 2015).

Figure 5.1. Cricket is eating the green leaf

Cricket Meal As Lamb Ration

Research on ruminants fed cricket meals was conducted using twelve pre weaning lambs (3- 10 kg, a week old) and post weaning lambs (11.24 ± 1,62 kg BW, 2 months old) placed on a Completely Randomized Design method, allotted in individual pens for two months. They fed concentrate containing 15% of soybean meal (C), concentrate containing cricket meal with 50% replace of soybean meal (CM-50) and concentrate containing cricket meal with 100% replace of soybean meal (CM-100). The concentrate was iso protein (17%) and TDN (63%). All animals were fed ration containing 40% of forage *Brachiaria humidicola* and 60% of concentrate. The nutrient composition of ration is shown in **Table 5.1.** During study, some parameters were evaluated to make sure that cricket meal can be used as part of milk replacer and also can replace soybean meal until 100% in the lamb ration. Feed intake, blood parameters and rumen profiles (VFA and methan) are the major data that can give information of the utilization cricket meal in the ration. Total VFA and its partial was analyzed by using gas chromatography equipment (GC 8-Schmidzu). Methane emission was estimated by stoichiometry from VFA partial by following Moss et al. (2000) equation :

$$CH_4 \text{ (mmol)} = 0.42\ C2 - 0.275\ C3 + 0.40\ C4$$

Table 5.1. Nutrient composition of the concentrate containing cricket meal (% DM)

Nutrient	C	CM-50	CM-100
Crude Protein	17	16.77	17.27
Lipid	2.50	3.19	3.99
Crude fiber	23.89	24.47	24.79
NFE	44.36	43.18	42.68
TDN	62.72	62.77	63.35

C= concentrate containing 15% of soybean meal, CM-50 = concentrate containing cricket meal with 50% replace of soybean meal and CM-100 = concentrate containing cricket meal with 100% replace of soybean meal.

5.1. Blood Profiles of Lambs fed Cricket Meal

Data of hematology profiles of pre-weaning and post-weaning lamb fed with cricket meal are shown at **Table 5.2 and 5.3**. The hematological data of pre-weaning and post-weaning lamb showed no significant difference, meaning that the utilization of cricket meal as milk replacer or substitute of soybean meal in the lamb ration have no effect to the health condition of the animals. The PCV value in the post-weaning lamb showed significant difference between treatments, where the ration containing soybean meal has higher value ($P<0.05$) than other treatments. Percentage of PCV had correlation with water intake. More protein intake will increase higher water intake which will dilute the blood in the body so that the high water intake will reduce percentage of PCV. Astuti *et al*. (2008, reported that lamb blood profile which suckling from their mother by grazing at tropical rain forest had 7.57 trillion/mm^3 of RBC, 7.21 g.dL^{-1} hemoglobin and 28.10% of PCV.

Table 5.2. Hematology profile of **pre-weaning** lamb fed cricket meal

Parameters	C	M	CM
RBC (x $10^6 \cdot mm^{-3}$)	7.54 ± 1.48	7.55 ± 1.19	7.37 ± 1.33
Hemoglobin (g.dL^{-1})	11.63 ± 0.90	10.27 ± 0.70	9.87 ± 0.31
PCV (%)	28.67 ± 2.08	28.67 ± 2.52	27.83 ± 2.57
WBC (x 10^3 mm^{-3})	12.73 ± 1.95	12.92 ± 1.83	15.27 ±1.00

C = control suckling from their mother; M= MR 100% of cow milk; CM = MR containing cricket meal

Table 5.3. Hematology profile of **post-weaning** lamb fed cricket meal

Parameters	MR (SB)	MR (SB+CM)	MR (CM)
RBC (x 10^6mm^{-3})	9.43 ±1.38	9.11 ± 0.49	9.09 ± 0.23
Hemoglobin (g.dL^{-1})	11.23 ± 0.87	11.13 ± 0.98	11.05± 0.41
PCV (%)	30.75 ± 1.71b	28.25 ± 2.06a	27.25 ± 0.50a
WBC (x 10^3 mm^{-3})	12.38 ±1.07	13.76 ± 0.91	13.98 ± 2.12
- Netrophil (%)	39.32 ± 5.58	39.75 ± 1.50	41.05 ± 2.31
- Eosinophil (%)	3.66 ±1.50	6.25 ± 1.26	5.23 ± 0.98
-Limphosit (%)	52.89 ± 6.14	49.25 ± 0.96	49.49 ± 2.73
- Monosit (%)	2.91 ± 0.19	3.25 ± 0.50	2.74 ± 0.51
- Basophil (%)	1.22 ± 0.48	1.50 ± 0.58	1.49 ± 0.57

MR (SB)= milk replacer containing soybean meal; MR (SB+CM) = milk replacer containing soybean meal and cricket meal; MR (CM) = milk replacer containing cricket meal

Metabolite blood profiles such as glucose, triglyceride and total protein plasma are relate to nutrient status. In pre-weaning lambs, blood glucose, triglyceride and total protein were the same in all treatments (**Table 5.4**). Cow milk and milk replacer (MR) containing cricket meal had similar effect to the nutrient status of pre-weaning lambs compare to control (doe milk). This means that cricket meal in part of milk replacer ingredient would not give any disturbance to the metabolite status. Kaneko *et al.* (1989) reported that normal blood glucose in lamb was around 50-100 mg/dL. Meanwhile Smith and Mangkoewidjojo (1988) reported that protein plasma was around 6.0 – 7.59 g dl^{-1}. Gani *et al*.(2013) reported that the normal blood triglyceride in lamb was around 26-145 mg/dL. It showed that the lamb had normal triglyceride concentration so far.

Table 5.4. Glucose, triglyceride and total protein plasma of pre-weaning lamb fed cricket meal

Parameters	C	M	CM
Glucose (mg/dL)	118.18 ±14.93	126.32 ± 19.31	144.01 ± 14.62
Triglyceride (mg/dL)	47.51 ± 5.70	26.62 ± 3.76	39.30 ± 7.09
Total protein (mg/dL)	5.52 ± 0.49	6.03 ± 0.50	6.14 ± 0.71

C = control suckling from their mother; M= MR 100% of cow milk; CM = MR containing cricket meal and PM= MR containing pupae meal

The study revealed that metabolite status of post-weaning lamb fed different level of cricket meal were similar between all treatments (**Table 5.5**). Cricket meal in the ration could substitute soybean meal until 100% without any problems with the nutrient absorption and status of metabolite glucose and protein. Some chitin from cricket meal seemed to reduce the absorption due to the low digestibility. Protein which was absorbed through the blood system could be as ammonia, albumin or globulin (Frandson 1992). This protein will distribute to whole body for support nutrient requirement of the animal. So it can be suggested that protein status in blood will relate to protein intake. This also happen for all other nutrients status in the body.

Table 5.5. Glucose and total protein plasma of post-weaning lamb fed cricket meal

Parameters	MR (SB)	MR (SB+CM)	MR (CM)
Glucose (mg/dL)	66.22 ± 7.52	58.68 ± 8.70	58.04 ± 7.98
Total protein (mg/dL)	6.76 ± 0.24	8.32 ± 1.29	6.09 ± 0.62

MR (SB)= milk replacer containing soybean meal; MR (SB+CM) = milk replacer containing soybean meal and cricket meal; MR (CM) = milk replacer containing cricket meal

5.2. Utilization of Nutrient and Rumen Fermentation of Lambs fed Cricket Meal

Data of dry matter, protein and energy consumptions in lambs fed cricket meal in the ration showed similar results compared to the control. It means that cricket meal had good palatability for lamb. The total dry matter intake was around 2.80% of BW. These results are comparable with NRC (2006) recommendation that lambs with 10-20 kg BW required dry matter intake about 2.85% of BW. Meanwhile, the protein and energy intake were around 8.73 -9.72 $g.kg^{-1}.BW^{0.75}$ and 0.21 – 0,23 $Mkal.kg^{-1}.BW^{0.75}$ respectively, which is enough for growing lambs. The digestibility of DM and protein were also similar in all treatments, but tended to decrease along with the age. There was a decrease in digestibility of energy in the treatment using 100% cricket meal (CM-100) as compared to other treatments (**Table 5.6**). The reoprt by Mc Donald et al. (2002), suggested that cricket meal with 8% of chitin affected to the nutrient digestibility. The digestibility feed is affected by physiological status of the animal, age, rate of passage of diet and quality of the ration.

Table 5.6. Consumption and digestibility nutrient of lamb fed different level of cricket meal

Parameters	C	CM-50	CM-100
Consumption (g.lamb^{-1}.d^{-1}):			
Dry matter	383.53±8.64	368.90±45.55	338.53±45.45
Protein	64.98±1.80	57.99±9.05	57.27±9.92
Energy (Mkal.**lamb^{-1}.d^{-1}**)	1.43±0.05	1.36±0.04	1.27±0.04
Digestibility (%):			
Dry matter	64.39±2.43	66.72±4.41	62.28±3.31
Protein	77.09±3.87	74.53±2.73	73.99±2.22
Energy (Mkal)	1.02±0.03^{ab}	1.04±0.06^{a}	0.89±0.10^{b}

C= concentrate containing 15% of soybean meal, CM-50 = concentrate containing cricket meal with 50% replace of soybean meal and CM-100 = concentrate containing cricket meal with 100% replace of soybean meal. Mean in the same row with different superscript differ P<0.05

Volatile Fatty Acids (VFA) were the primary energy substrate of mature ruminants with upwards of 70% of the energetic requirements of the animal being met from ruminally absorbed VFA (Bergman, 1990). Thus, understanding the control of ruminal growth and differentiation is essential to the development of improved feeding regimes. Concentration of total VFA in 50% cricket meal (CM-50) was 106.33 mM which was lower than control (113 mmol.L^{-1}) and 100% cricket meal (CM-100, 135 mmol.L^{-1}). High total VFA in CM-100 is due to the accumulation of VFA partial especially from acetic and butyric acid. On the other hand, treatment with creaked meal replace 100% of soybean meal (CM-100) have lower energy intake so that the crude fiber and protein source of the ration were fermented and produced VFA with dominantly acetic and butyric acids, to cover the energy requirement for the lamb. Ration with high fiber will produce acetic acid higher than propionic acid. VFA was a major energy source for ruminant, so the ratio of acetic, propionic and butyric acids was in a balance proportion of 60 ; 30 and 10 % from the rumen fermentation profiles (Jayanegara et al., 2013). In this experiment, the ratio of acetic acid, propionic acid and butyric acid were 60-65%, 27-28% and 9-12%, respectively. On the other hand Lane *et al.* (2000), reported that rumen VFA concentrations did not change with age in lambs given milk replacer. At 84 d of age, intraruminal VFA concentrations were elevated in lambs consuming solid feed compared to 84-d-old lambs given milk replacer. In this study, lamb was started to be fed solid feed since 60 days of age and resulted in high ruminal VFA concentration (106 – 135 mmol.L^{-1}) compared to those fedwith milk replacer.

Methane from agriculture is typically produced from 2 sources, ie. the fermentation of feed in the rumen (enteric emissions) and the management of manure. A significant proportion of methane emissions from sheep was in the form of enteric methane emissions from fermentation of feed in the rumen. There were different methods for reducing enteric methane emissions including nutritional approaches (Rheidol et al, 2011). Increasing productivity could reduce methane emissions per kg of output.

Estimation of methane emission by using VFA profiles had accurate result with a high coefficient of determination (Jayanegara et al., 2015). Methane estimated from VFA partial (Moss et al, 2000) in CM-50 (25.22 mmol) was significantly lower than CM-100 (33.93 mmol). The high acetic acid and butyric acid production caused the high methane production. The increasing concentration of acetic acid and butyric acid at treatment CM-100 lead to methanogenesis since fermentation of glucose and protein to acetic and butyric acid yields H2, a main compound of methane (Jayanegara et al., 2015). Data of VFA and methane are presented at **Table 5.7**.

Tabel 5.7. Rumen fermentation profiles of lamb fed different level of cricket meal

Parameters	C	CM-50	CM-100
Total VFA (mmol.L^{-1})	113.42± 13.93^{b}	106.33± 17.74^{b}	135.60± 15.05^{a}
- Acetic acid	71.88± 17.91^{ab}	62.99± 5.75^{b}	87.47± 6.87^{a}
- Propionic acid	31.45± 9.12	30.32± 9.28	36.56± 5.69
- Butyric acid	10.08± 2.89	13.02± 2.70	11.53± 2.46
Methane (CH4) (mmol)	27.73± 1.23^{b}	25.22±2.01^{b}	33.93±1.72^{a}
CH4/DMI	0.07±0.008^{b}	0.068± 0.01^{b}	0.10±0.009^{a}
CH4/VFA total	24.45±2.22	23.71± 3.11	25.02±3.51
CH4/kgBW	0.41±0.02	0.43±0.02	0.62±0.03

C= concentrate containing 15% of soybean meal, CM-50 = concentrate containing cricket meal with 50% replace of soybean meal and CM-100 = concentrate containing cricket meal with 100% replace of soybean meal. Mean in the same row with different superscript differ P<0.05

The average daily gain of those lamb ranged from 55 – 66 g.lamb^{-1}.d^{-1}, with feed efficiency values ranged from 15 – 17%. Astuti and Sastradipradja (1999) reported that ADG of sheep reared in individual cage was 50 g.d^{-1} compared to 45 g.d^{-1} when reared in pasture. Meanwhile it was reported that data of ADG was 66.7 g.d^{-1} with feed consumption 370 g.d^{-1} and ME intake (BW$^{0.75}$) was 0.75 Mj.d^{-1} (Baldwin, 2000). The higher the feed efficiency values, the most efficient the feed utilization by animals. This study revealed that the feed efficiency was around 17 %. And similar between treatments, **Figure 5.2** showed the ADG and feed efficiency of lamb fed with level of cricket meal substituted of soybean meal.

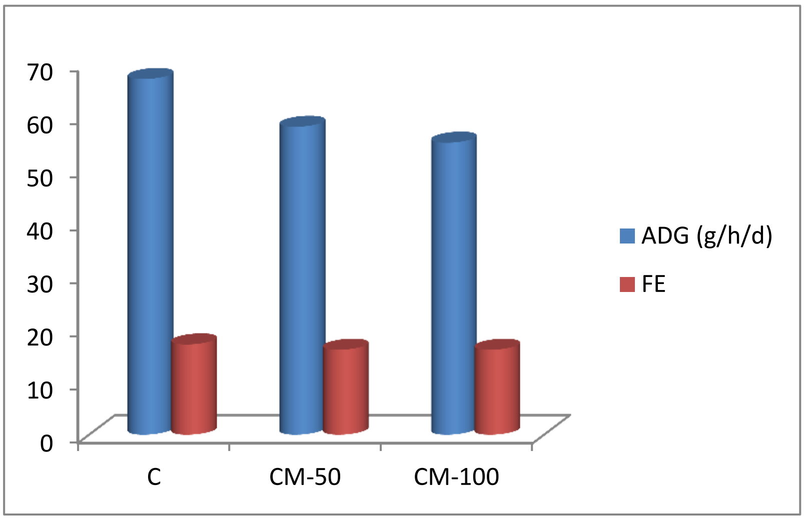


Figure 5.2. ADG and FE value of lamb

Conclusion

It was concluded that cricket meal could be used as protein source as milk replacer for pre-weaning lamb and in the concentrate ration for the post-weaning or growing lamb. The utilization of cricket meal could achieved up to 100% as replacement to subtitute soybean meal for feeding growing lamb without any problems with palatability, blood parameters and rumen fermentation profiles.

CHAPTER 6.
ECONOMIC POTENCIAL, CONSTRAINTS AND STRATEGY TOWARD SUSTAINABLE PRODUCTION

Asnath M. Fuah and Winarno

In Indonesia crickets are spreading almost throughout the territory in accordance with their original habitats, but not all types of crickets are cultured by people. The three types of crickets often raised by the community: G. mitratus, G. Testacius, and *G. bimaculatus*. *G. bimaculatus* has biolocial advantage of softer body skin with a faster growth rate but more aggressive compared to G. mitratus and G. testacius. G. testacius is characterized by a large body, thick skin, so it looks sturdy but is still wild. Meanwhile, G. mitratus is characterized by thick skin, dark color and relatively small body, a line forming a letter V in the head, more calm and adaptable. Crickets have become a farming animal for cash income, because the capital needed is relatively small, the raising period is short, and the market opportunity is still wide open. Cricket raising in Indonesia has not widely developed, so the opportunity for cricket business is still very challenging.

The potential and benefits of crickets for animal feed birds, fish, reptiles, and pets have been fairly known by the public. In some parts of Indonesia and some countries, crickets are also consumed by humans. Crickets are potential to be developed since these insects (1) contain high protein, (2) have a high reproduction capacity with a short life cycle, and (3) are easy to feed on (De Foliart et al., 1982). Cricket products sold in the market are eggs, *clondo* and parents. The target market of cricket eggs and parents is cricket farmers, while *clondo* are sold to fans of chirping birds or arwana fish. *Clondo* as the feed of chirping birds will make the birds have excellent songs, and as feed arowana fish will make the fish body have more brilliant colors. In addition to the three products, there is also cricket flour used as feed for shrimp and catfish (Paimin et al., 1999). Crickets are also known as human food in some countries. According to Bodenheimer (1951), crickets were one type of insect consumed by people in countries such as India, the Philippines, Thailand and Indonesia. These insects are consumed not only in time of emergency but rather as complementary food as an alternative protein source throughout the year. De Foliart et al. (1982), stated that crickets were very potential to be raised as a food ingredient and feed since they have palatability and a high protein content. In Jogyakarta, especially in the urban areas, crickets were traditionally processed by household family as human food or to be various snack or crackers for sale.

Crickets can be processed into flour and have the potential as an alternative source of animal protein because they contain nutrients, particularly amino acids that are complete enough to be able to partially replace soybean meal and fish meal in broiler feed mixture. The protein content of cricket flour based on wet material ranged from 56.02% to 61.58%. When compared with protein content of food consumed by humans, cricket flour could be used as an alternative food source of protein (Napitupulu, 2003). Novianti (2003) showed that the flour of *Kalung* cricket (*G. bimaculatus*) contains protein and fat that is relatively high, ranging from 56.02% to 74.5% and 15.47% to 32.84% respectively. Syaiful (2003) stated that linoleic acid is the most dominant fatty acid in cricket flour, which is essential for humans and animals, primarily to prevent dermatitis (skin drying and flaking) in children.

6.1. Productivity of Cricket Raising

Cricket productivity can be defined as the ratio between production and the products derived from crickets and the overall resources allocated to the production process per cycle, or an increased production per time unit, Simanjuntak (1998) and Reksohadiprodjo (1995). Technically, cricket productivity is formulated as the ratio between the output produced by cricket culture and all inputs to increase productivity in the improvement of production methods that can economically deliver the results as much as possible at the expense of the smallest resource. Cricket productivity is influenced by three main factors as genetics, environment, and the interaction between genetic factor and environmental all factors should be optimized (Kurniawan, 2010). Egg production, hatchability, mortality rate as well as survival rate per cycle are an important aspect to be considered in relation to genetics (cricket species) and interaction with the environment. Temperature, humidity and season have an influence on the production and growth of crickets, especially in the dry season the cricket mortality rate is very high. According to Herdiana, (2001), the mortality rate of crickets could reach 89.35% in the dry season. Food availability, both the type and the amount, is highly influential on the level of preference and cricket productivity (Resh and Carde, 2006). Economic factors also play an important role in developing the culture of crickets which include demand, market, pricing and promotion, and marketing.

6.2. Factors Affecting Cricket Productivity

Egg Quality and Hatchability

The quality of cricket eggs decreases or more infertile eggs are found due to unsuitable environmental conditions such as long drought. Humid environment can also degrade the egg quality, making it susceptible to a disease attack or to be overgrown by fungal. All crooked eggs or black eggs indicate that the eggs are bad. The relative humidity required for hatching eggs ranged from 65% to 80%, with an air temperature of 26° C (Paimin et al., 1999). Eggs do not hatch all at once but gradually (Sridadi and Rachmanto, 1999). The time required for the eggs of *Kalung* crickets (*G. bimaculatus*) which have been released to hatch was 15-17 days after mating (Rifadah, 2000). Short reproductive cycle was a critical for cricket breeders to generate income in a short time during 6-8 periods per year, particularly when the environmental conditions favor the cricket raising business (Rifadah, 2000). In addition, the number and the quality of eggs produced should meet market needs. According to Widyaningrum (2001), the hatchability of *Kalung* cricket is considered very high, when it is above 95%, but the quality is considered bad if the hatchability is under 50%.

Feed management

Good quality feed can improve the productivity and performance of crickets which resulted in the increased sales value of the crickets. As plant-eating animals (herbivores), crickets generally eat many kinds of leaves, vegetables and fruits that contain lots of water, because they do not drink any water. Cricket feed consists of two types: foliage and concentrate feed. Foliage should be the one available throughout the year, have sufficient amount, and contain nutrition to meet cricket needs. Avoid choosing foliage that makes crickets compete with other animals. Feed in form of leaves is taken from nature, so it is efficient and economical. The crickets given extra feed concentrate can grow faster than the crickets fed leaves (Praditya, 2003). Using low-priced feed resources which have adequate nutrition can improve the efficiency to increase the income from cricket raising. According to Widyaningrum, 2001, the combination of cultured cricket feed consisting of foliage, when added to chicken concentrate, can increase growth and egg production.

Cage System and Density

The crickets need a raising cage almost similar to the natural habitat in the wild in order to improve comfort for the crickets. A comfortable cage for crickets must meet the following criteria: smooth air circulation, controlled temperature and humidity, hiding place, sufficient darkness, and the materials used to protect the crickets from predators (Sukarno, 1999). Hiding places serve to minimize the risk of cannibalism and enlarge the space for crickets to move about (Paimin, et.al, 1999). Cricket cultivation in Indonesia generally use wood, plywood, or bamboo as the materials to make cricket cages. Those materials are chosen because they are relatively inexpensive and fairly durable. When crickets are kept in a cage, the humidity can be maintained by spraying water around or putting wet cotton in the cage, Booth and Kiddell (2007). Facility in the cage that should be provided is a nesting media, especially for adult crickets. In creating a cage like the original habitat in nature, some cage types are made of wood and plywood that can significantly reduce the risk of death and improve the productivity of the crickets.

Cricket cage density is closely related with mortality, thee higher the density is, the higher the mortality will be. Cages that are too dense can trigger cannibalism and slow down the growth and development of crickets (Clifford et al., 1977). Widyaningrum (2001) reported that *Kalung* crickets reared in a cage measuring 60x45x30cm with a density of 500 crickets experienced a mortality of 35%. This situation is due to the fact that crickets require adequate space for their activities: eating, mating, molting and nesting. An overcrowded cage is not only uncomfortable but it can also trigger cannibalism, which in turn causes high mortality and low productivity. This often happens in the culture of crickets mainly carried out by the society, making their income level relatively low, (Fuah, et.al., 2015).

Promotion and Marketing

In general, the cricket cultivation carried out by the farmers in Indonesia is still in traditional way without any specific strategy for the marketing of their products. This is because for some farmers, the cricket cultivation are only a sideline activity to meet a limited market, particularly for the feed of birds, fish and reptiles. Meanwhile, the number of companies which are involved in cricket breeding dan raising is still limited, so there is still a gap between supply and demand. The marketing strategies in several regions in Indonesia may be categorized as (1) marketing via retailers, (2) marketing through direct consumers, (3) service delivery directly by farmers, (4) postponing harvest time to obtain an appropriate price in the market while still keeping the quality, (5) marketing crickets in the areas where the selling price is high, (6) surveying the market before selling. Cricket breeder communities usually gain market information from their collector traders and other breeders. The cricket market potential includes between regencies, provinces and islands. The target market of cricket breeders is collector traders, retailers and direct consumers. Promotion is usually conducted through the internet and by offering directly to the consumers.

In marketing their crickets, breeders usually have set a certain price, but under certain circumstances it will experience price fluctuations, depending on the number of crickets in the market. The harvest price will be high when the number of crickets in the market is small, and vice versa. The results of the research conducted by Rahmawati (2010) showed that over one year period of cricket culture the prices of crickets underwent three kinds of price change: twice low, once at breakeven point, and twice high. The supply of crickets in the market is a major cause of price fluctuations. The results of the same study by Rahmawati (2010), showed that the prices of crickets in Central Java ranged from Rp 4,500 to Rp 35,000 per kg with an average price of Rp 19,000 per kg, while in East Java, the price ranged from Rp 5,000 to Rp 40,000 per kg with an average price of Rp 19,500 per kg. In the meantime, in West Java the cricket price ranged from Rp 20,000 to 50,000 per kg with an average price of Rp. 25,000 per kg. Payment system was usually in cash with the delayed time ranges from 3-7 days. The difference in payment systems depended upon agreement between the breeder and the buyer. This condition was influenced by a trust system and farmer's low bargaining position. Sometimes, breeders had to wait long enough to get paid. The length of the delayed payment disturbed the smoothness, product availability and sustainability, particularly with regard to the provision of cricket parents, feed and cage maintenance and labor.

6.3. Dominant Factors in Cricket Business

Factors that determine the success of cricket business can be classified into two things: (1) technical-biological factors, such as breeding, feeding, raising, caging and disease control; and, (2) non-technical factors (bio-economic and social) such as socio-cultural condition, purchasing power, marketing, infrastructure and transportation (Basuki, 1985; Fuah et al., 2014). Three factors affecting the spread of crickets in Indonesia are (1) social culture factors, which include customs, experience and level of education; (2) economic factors, which include labor, capital, marketing and product processing; (3) biotic environment or nature, which includes diverse geographical and topographical elements in Indonesia (Atmadilaga, 1977). Based on these factors, the development of cricket farming in Indonesia is also very diverse, from small scale to industrial scale, which have been growing rapidly and are still concentrated in Java. In Java, the factors related to macro environment are highly favorable, particularly because the people's economic conditions are quite supporting, the demand for the cricket products are relatively high, there are opportunities for exports, and the availability of food is quite diverse (Mukson et al., 2005).

6.4. Analysis of Income and Revenue of Cricket Business

The rate of profit in the cricket business is measured by breeder revenue, which is commonly used to evaluate the activities of a business with the aim to help improve the management of the business. An analysis of revenue in the cricket business aims to describe the current state of the work done and describe the future situation (Hernanto, 1993). In calculating for the purpose of analyzing the income and revenue of the cricket culture business, the following formula approach can be employed:

$$\pi = TR-TC = TR-(TVC+TFC)$$
$$\pi = Px.Y-(Px.X+TFC)$$
$$\pi = Py.Y-Px.X-TFC$$

Total Revenue (TR) is production quantity multiplied by output price (Py). Production Cost (Total Cost / TC) is total variable cost (Total Variable Cost / TVC) plus total fixed cost (Total Fix Cost / TFC). TVC is input quantity (x) multiplied by input prices (Px).

Revenues include three things: product sales (crickets and eggs), consumed product (if any) and the increase in the value of cricket cultivation inventory. The analysis of business income is done by considering the factors in a business, among other things, the cricket cultivation business, production costs (variable costs and fixed costs), gross margin, and cricket business income. An analysis of cricket business income is presented seen in **Table 6.1.**

Here is an example of farming income analysis crickets in Bekasi with 17 famers and the average production capacity of 175 kg/month.

Table 6.1. Analysis of Cricket Cultivation Business Income

No	Description	Total (IDR)
1	Revenue of cricket cultivation business	124.050.000
2	Production cost	
	a. Variable cost	37.215.000
	b. Fix cost	24.810.000
3	Gross Margin	86.835.000
4	Income of cricket cultivation business	62.025.000

The results of the analysis of the business obtained R/C ratio 2, this shows that the cultivation of crickets highly prospective and profitable. Cash revenue is defined as the value of money received from the sale of cricket cultivation products (crickets or eggs). Cash spending of cricket cultivation business is defined as the amount of money paid for the purchase of goods and services to run the cricket business. Income is the difference between total revenue and costs. Costs can be classified into fixed costs and variable costs (Soekartawi et al., 1986). Fixed costs are the expenses whose values do not depend on production volume, such as rent or land interest in the form of money. Variable costs are the expenses whose values are directly related to production volume, such as expenditures for cricket parents and feed.

6.5. Characteristics of Cricket Business

Business Typology

Typology of cricket breeders can be divided into two: as a main business and as a sideline business. As the main job, breeders make cricket cultivation business as their main source of income, and this type of breeders can generally be found in urban or suburban areas, close to production inputs and markets. As a sideline, breeders generally have a primary income source from other businesses, and raising crickets is only as an extra or as a hobby. Rahmawati (2010) stated that some breeders run cricket cultivation as their main business and others as a sideline, depending on the purpose of production and the available market, namely, permanent markets which already have long-term cooperation contract. In Central Java, the breeders who made cricket cultivation business as their main job were only 33.33% compared to 66.67% breeders who considered cricket cultivation as a side job. Meanwhile, in East Java and West Java, about 86% breeders made cricket cultivation as the main activity, the remaining 14% as a sideline business. The cricket breeders who considered cricket raising sideline activity generally had rice fields to cultivate, while cricket cultivation was just to complete their daily needs. On the contrary, the breeders who made cricket cultivation as their main job normally did not have other business or rice fields or farmland to cultivate. Of course, there were rice farmers who prefered cricket breeders as their main job to being rice farmers. At present, when seasonal changes are quite unpredictable, many farmers have switched their activity from agricultural farming to animal cultivation, such as raising bees, silkworms, Hongkong caterpillars, weaver ants, including crickets.

In carrying out their cricket cultivation, most breeders have not applied modern technology. This can be seen from the use of facilities and equipment that are still traditional and simple (**Figure 6.1**). Business efficiency is still done by hiring cheap labor and using simple facilities to meet a limited market demand. To improve the productivity of cricket cultivation and breeder income, it is necessary for the local government and related agencies to play a role in developing this business by providing training on good farming management, information system, promotion, and effective marketing. In addition, support from universities by preparing a wholistic research and development using Farming System Research approach , and by involving related experts on crickets farming is essential. This strategy would help providing small farmers with appropriate technology and capacity in cricket business development.

Figure 6.1. Types of cages and facilities used to rearing crickets
(Source: Bekasi farm)

Business Scales

A business scale is the number of cricket populations raised daily. Business scales are divided into three businesses: small, medium and large. Business scales directly affect the income obtained. Economically, the larger the business scale, the greater the income will be, especially if supported by good farming management (Rahmat, 2008). This is consistent with the statement made by Astuti et al. (2000) that the number of crickets owned determines the level of income, because the greater the number of crickets, the more efficient the business, thus increasing revenues and lowering the total cost of production. In general, many cricket breeders in Indonesia start a small or medium scale cricket cultivation business with their own capital. According to Rahmawati, (2010), cricket business scales are classified based on the number of boxes owned: small (5-10 boxes), medium (10-20 boxes) and large (> 20 boxes). Business scales are influenced by such factors as the amount of capital, land size, marketing strategy and farming management. The increase in business scale varies greatly in each region, ranging from 60 to 500% (Rahmawati, 2010).

The increase in business scale indicates that the cricket cultivation business run has contributed profits so that the business is able to develop well. The increase in business scale is also associated with the revenue that the breeders obtain from their business activity. The cricket breeders market their products directly to consumers can enjoy relatively higher selling prices. On the contrary, the breeders who just rely on collector traders to market their products cannot determine the price of their own crickets, so that the income earned is not optimal. Breeder’s revenue has a significant effect on the continuity and development of the cricket cultivation business.

Analysis of Income and Revenue from Cricket Business

Income and revenue are very important in cricket raising business, because they are indications whether the business has made a profit or not. Income can be defined as the difference between the revenue and the production cost, while revenue is the value obtained from output or product because the breeder has sold it to the buyer. The income of cricket cultivation business is greatly influenced by the cricket price fluctuations in the market and the productivity of cricket cultivation.

The research results conducted by Rahmawati (2010) showed that the average income of cricket breeders in one year with a scale of 20-30 boxes, for Central Java, was Rp 134,714,300.00 with an average revenue of Rp 186,566,666.00, and East Java Rp 149,899,333.00 with an average revenue of Rp 255,960,000.00. The analysis result of the incomes indicated that the cricket cultivation run by the breeders had a positive value even though the cricket harvest price in the market is always fluctuating. Research conducted by Sidiq, 2015 showed that the average income of cricket breeders in West Java in one year for a scale of 20 boxes was Rp. 116,280,000.00 with an average revenue of Rp. 222,000,000.00.

6.6. Constraints in Cricket Enterprises

Failure in a cricket cultivation business is generally caused by several factors such as environment, feed, raising and caging management, diseases and predators, which result in lower egg production and hatching rate, and high mortality. Extreme temperatures and humidity have an effect on cricket high mortality, reaching 35,04% (Widyaningrum, 2009). According to Paimin et.al (1999), if the level of cage density is too high, especially in the phase of skin change (moulting), cannibalism will occur where the strong crickets prey on the weak. In the raising system, a cage with less air circulation will have a lack of oxygen and crickets will die of suffocation (Sridadi and Rachmanto, 1999). Inbreeding is also a constraint in raising crickets, because most breeders use cricket parents from the same brood for the purpose of reproduction which leads to the high mortality rate around 35-36% (Widyaningrum, 2011) and a low reproduction. In addition, some predators such as ants, mice, lizards often become a threat to cricket raising. The marketing aspect has also become one of the obstacles faced by most cricket breeders in Indonesia. In general, crickets are sold to collector traders at a relatively cheaper because farmers do not have access to markets at reasonable prices and due to the transportation constraint. Collector traders are one of the trading system chains that is important and dominates the cricket marketing to consumers like pet shops, bird lovers, reptiles business players and fish farmers. This causes the income received by the cricket breeders become lower than it should be. Another factor that affects the stability of cricket breeder income is fluctuating prices. When there is an oversupply, the price of crickets and cricket eggs becomes very low. On the other hands, when the demand for crickets and its eggs is high and the supply is low, the price becomes very expensive, sometimes double of factual prices. This is as normally happened to the common rules of supply and demand.

Crickets farming rarely receive attention from government to be developed because the government programs are still focusing on national commodities such as ruminants and poultry. This has an impact on the cultivation pattern and the application of technology which is still very simple, and the production objectives which are not yet commercial. In order to develop cricket farming that does not require large inputs and large areas, the support of the government, particularly the related departments / agencies, is badly required to enable cricket raising to become a source of community income, especially in urban and suburban areas. The low level of public understanding on the economic value of cricket farming should be increased through a training program on farming management and various other aspects related to the promotion and marketing.

The roles of the government and donor agencies in helping cricket farmers to increase their business scale, farming management and skills, effective marketing system and product quality are an important factor in the economic empowerment of the farmers and job creation that have an impact on increased revenues. The roles of the government in developing cricket cultivation include providing training for cricket breeders, making policies and regulations, and funding for the purpose of capital provision. Training activities to improve the skills of cricket breeders, among others, are: a) business management; b) farming management, and c) marketing management. Implementation of the organizational system and the use of labor in the cricket cultivation are still family-oriented, because some breeders still make cricket cultivation as a sideline business. The contribution of family members, especially house wives during their free times of approximately 1-2 hours feeding significant labor cost in cricket business which was very romising for a significant cash income.

CHAPTER 7.
RECOMMENDATION

There were more than 100 species of crickets in Indonesia, but only a few species that have been cultivated by farmers included *Cliring* cricket (*Gryllus mitratus*), *Cendawang* cricket (*Gryllus testaceus*) and *Kalung* cricket (*Gryllus bimaculatus*), and a bit rarely, German crickets. Apart from wild crickets which still live in their natural habitats, the three domesticated crickets have been widely cultivated in Java islands for business purposes. The production centers become the major suppliers of crickets and breeding eggs to meet the increasing market demand of buyers in Indonesia. Several factors causing the failure and big loses in cricket cultivation and business are, amongst all, environment, feed availability, management, caging systems, arises from cricket production and farming practices, there are some recommendation to be considered for future programs:

1. Provision of appropriate environmental conditions including temperature, humidity and sufficient feeds for cricket rearing according to crickets life cycle
2. Application of good management to prevent crickets from diseases or bacteria which may cause diseases or loses in production
3. Provision of appropriate design of animal cages isuited to each locality to prevent crickets from predators around the farming areas
4. Implementation of appropriate breeding programs by providing new productive males from different broods to avoid inbreeding
5. Establishment of crickets enterprises of medium and large scales may help to create job opportunities for landless farmers as alternative business. Farmers need to be trained on cricket cultivation including management, breeding strategies, marketing and animal logistics
6. Having good understanding in post harvest technology of crickets for determining the good quality of production for further product processing
7. Government supports in developing cricket enterprises and policy for marketing of cricket products would be best strategies for small farmers. This need to be provided with organizing the supply chain focusing on pricing system.
8. Strengthening institutional capacity in cricket enterprises to improve access to input, process and output.
9. Provision of appropriate technology for farmers to improve production and efficiency.

BIOGRAPHY OF AUTHORS

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