ISSN 1819-1894

Asian Journal of Agricultural Research

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Asian Journal of Agricultural Research 8 (1): 1-16, 2014
ISSN 1819-1894 / DOI: 10.3923/ajar.2014.1.16

An Overview of the Study of the Right Habitat and Suitable Environmental Factors that Influence the Success of Edible Bird Nest Production in Malaysia

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ABSTRACT

The estimated value of the world Edible Bird Nest (EBN) production business is worth more than a staggering MYR 10 billion. Despite the huge demand for EBN, the present supply is still less than 50% of the global demand. Numerous factors are responsible for the success of this industry. Habitat and environmental factors have significant impact on the productivity EBN production. The objective of this study is to identify the right habitat and suitable environmental factors that influence successful EBN production. The study will be conducted in two phases. The inital part of the first phase is to identify the habitat and environmental factors extracted through review of literature and supporting documents from the stakeholders of the EBN industry. The last part of the first phase of the study is by interviewing the stakeholders of the industry. The stakeholders of the swiftlet industry are EBN producers, consultants of swiftlet houses, associations of the EBN producers, the key personnel from the Federal and State Department of Veterinary Services and the Local Government Authorities. For the second phase of the study, experimental works will be conducted in 15 swiftlet houses. Several environmental factors such as air and surface temperatures, Relative Humidity (RH), air velocity and light intensity will be observed in the swiftlet houses. The expected findings will reveal the right habitat and the list of suitable and conducive envirommental factors that lead to productive EBN production. It is envisaged that these findings would provide an invaluable insight for stakeholders of the industry regarding the most appropriate habitat and suitable environment for sucessful EBN production ventures.

Key words: Habitat, environmental factors, edible bird nest production, edible bird nest industry

INTRODUCTION

Is the EBN industry blessed with *Aerodramus fuciphagus*? Swiftlets are birds similar to swallows, sparrows and house swifts but they are not closely related to each other (Merikle, 1998). Swiftlets have short legs and are not ground birds (Merikle, 1998). They perch vertically on surfaces or their nesting planks (Ibrahim *et al.*, 2009). Currently, there are 24 species of swiftlets recorded in the world (Ibrahim *et al.*, 2009). Swiftlets are insectivorous, feeding on hymenopterans and dipterans (Lourie and Tompkins, 2000). The five most common species of swiftlets found in Malaysia and the Borneo Island are *Hydrochus gigas*, *Collocalia esculent* (White Belly Swifts), *Cypsiurus balasiensis* (Asian Palm Swift), *Aerodramus maximus* and *Aerodramus fuciphagus* (Ibrahim *et al.*, 2009).

The swiftlets (genera *Aerodramus*, *Collocalia* and *Hydrochous*) are species of birds that can orientate in complete darkness using echolocation (Price *et al*., 2005). Swiftlets roost and nest in caves, often place their nests in areas of complete darkness and are able to navigate using ecolocation (Griffin, 1958). The nests of four species of swiftlets have been harvested for human benefit. These species are 'White-nest Swiftlet', Edible Nest Swiftlet (*Aerododramus Fuciphagus*) and Germain's Swiftlets (*Aerodramus Germani*) which form their nest entirely from their saliva (AgroMedia, 2007). Black Nest Swiftlets (*Aerodramus maximus*) include up to 10% dry weight of feathers (Kang *et al*., 1991) and those of Indian Swiftlets (*Aerodramus Unicolor*) also include feathers and some vegetation.

The EBN industry has the potential to grow into a multi-million ringgit industry due to the industry's relatively profitable risk return profile as well as a continuously growing demand for EBN by wealthy overseas customers (Merican, 2007). The EBN-producing swiftlets (*Aerodramus fuciphagus*) have been receiving more attention nowadays because of the fact that this species of birds can produce EBN which have high value in the international market (Iswanto, 2002). The natural nesting habitat of this bird is in limestone caves. This species is only found in the Southeast Asian Region (Ibrahim *et al*., 2009). Since, approximately a hundred year ago, the people of Java have successfully farmed the EBN swiftlets in houses managed in such a way to resemble their natural cave habitat (Mardiastuti and Soehartono, 1996). This species is also of concern today because of the high market value for their nest. The EBN is built entirely from saliva (Mardiastuti and Soehartono, 1996; Ibrahim *et al*., 2009; Iswanto, 2002) and is a very important item for both cuisine and medicine. It is an exotic item for delicacies and can also be used as material for medications that improves physical strength (Oktorina *et al*., 2005).

The EBN-producing swiftlets used to nest exclusively in caves (Mardiastuti *et al*., 1997). In order to encourage these swiftlets to nest away from caves, people have been building structures to create a cave-like atmosphere, conducive for the swiftlet to breed (Mardiastuti *et al*., 1997). The EBN-producing swiftlet houses, as they are often referred to, were first set up close to the coast, but as the bird population grows, they can now be found far inland (Lim and Cranbrook, 2002). The selection of location for man-made habitat for the swiflet houses is one of the very important factors for successful EBN industry. A suitable location for building swiftlet houses is very important to prevent EBN producers from losing money in their investment. The available local swiftlet population, their feeding areas (garden, paddy-field and garbage disposal areas), swiftlet track and areas that are easy to control swiflet houses are the most important factors. All these factors have to be considered before deciding on the site to build a swiftlet house (Nasir Salekat, 2009).

Also, in order to create suitable environmental conditions to attract the swiftlets to the swiftlet's houses, several factors must be closely controlled. Air and surface temperatures, RH, air velocity and light intensity are some of the most important environmental factors required in swiftlet houses (Ibrahim *et al*., 2009). Light must be very low inside the structure to provide the swiftlets with a nesting place similar to a dark cave (Nasir Salekat, 2009). To do this, the main entrance hole, usually near the top of the structure, must be positioned so as to prevent direct sunlight from entering deep inside the buildings (Nasir Salekat, 2009). Temperatures between 26 and 35°C are within the range for EBN production (Ibrahim *et al*., 2009). Temperature is controlled by allowing sufficient ventilation in the buildings (Ibrahim *et al*., 2009). This is often achieved by using 'L' shaped elbow pipes placed in the walls which allow air to flow without at the same time allowing light by Ibrahim *et al*. (2009). Relative Humidity is also another very important factor to a swiftlet house (Nasir Salekat, 2009). A high RH environment can cause fungal growth and swiftlets will not nest on fungus covered surfaces (Nasir Salekat, 2009). On the other hand, low RH in swiftlet houses reduces the adhering ability of the nests to the wall surfaces (Nasir Salekat, 2009). However, the best RH for swiftlet rearing is in the range of 80-90% (Nasir Salekat, 2009). This can be controlled by installing humidifiers or building pools of water inside the swiftlet house (Ibrahim *et al*., 2009).

ISSUES ON EBN INDUSTRY

Edible bird nest industry is very popular among businesses in the South-east Asian region. The estimated value of the world EBN industry exceeds Ringgit Malaysia 10 billion. Despite the huge demand for EBN, more than 50% of the global market has not been met (Abdullah *et al*., 2011). This scenerio, coupled with the attractive passive income aided by the low maintenance cost, has motivated many individuals into this industry (Abdullah *et al*., 2011). This business seems as an easy entry but many individuals who embark on this business are finding out that after three years, they are not even able recover their investment.

There are numerous factors contributing to the success of this industry that the players and would-be players should know before entering into this venture. Among the important factors for the success of EBN production are habitat and environment. Lack of knowledge and thus the failure to choose the right habitat and suitable environment will make productive and profitable EBN production difficult if not impossible. Right habitat means choosing a suitable location before investing on the usually expensive construction of swiftlet houses. Many first time EBN producers are so eager to invest in the industry without first knowing well the appropariate air and surface temperature, RH, air velocity and light intensity that should be provided in swiftlet houses. These specific environmental factors should be conducive for swiftles to come in and build their nests in.

Nothwithstanding the high risk and attractive returns of the EBN industry, habitat and environmental factors should be addressed first to swiftlet producers before building costly swiftlet houses. Otherwise, many EBN producers and investors will not even get back a single sen from the money invested.

WHY THIS STUDY IS CRUCIAL TO EBN INDUSTRY?

In recent years, the EBN Industry has grown rapidly (Anonym, 2000). These EBNs can produce a host of products including lotions, drinks and concentrated liquids, all of which are claimed to have health benefits (Winarno, 1994). In Malaysia, EBN is one of the main agricultural export products (Winarno, 1994). Harvesting EBN is biggest in the South-East Asian region besides Indonesia (Winarno, 1994). There is very high demard for EBN from countries in Asia such as Taiwan, China and Hong Kong (Iswanto, 2002). Hong Kong is the largest consumer and user of EBN and EBN products (Lim and Cranbrook, 2002). Thus, it is very important to make sure that swiftlet houses built are successful in attracting swiftlets to prevent the producers from losing money. Fulfilling the ever-increasing demand, EBN-producing houses have been built for the birds to build their nests and the nests can be harvested early (Mahmud *et al*., 2012). Habitat and environmental factors are very important factors that need to be considerd before building swiftlet houses (Nasir Salekat, 2009). This is because swiftlets will only adapt in swiftlet houses that pose habitats and environments similar to their natural habitat and environment. Swiftlet populations can provide a sustainable natural resource (Langham, 1980).

RESEARCH OBJECTIVE AND QUESTIONS

The current problem faced by most first time EBN producers and investors is not knowing or lacking knowledge of the right factors contributing to the success of EBN production. Therefore, the purpose of this study to achieve two objectives:

- To identify the list of habitat and environmental factors of EBN production
- To establish the habitat and environmental factors as success factors of EBN production

One of the most crucial aspects for EBN producers is to recover their investment's worth. The difficulty of having the right habitat and suitable environment is an issue that need to be addressed. Therefore, the following two research questions that are raised to address the issues in EBN industry are:

- What are right habitat for successful EBN production?
- What are the various suitable environmental parameters conducive for profitable EBN production?

REVIEW OF LITERATURE

The review of the literatures elegantly covers fours main parts. The first part of the review highlights the related section pertaining to swiftlets; feeding behavior, reproductive and breeding cycle, echolocation and the birds' predators. The second part talks briefly on EBN-producing swiftlets. The third part of the review discusses about the specific swiftlets that produce EBN and EBN products many health and beauty benefits. The fourth part of the review will cover a detailed discussion on the two most important factors that influence successful swiftlet ranching. These factors are the right habitat and suitable environment. The last part of the review discusses the combination of these two factors that require great attention by Malaysian swiftlet producers of today.

Overview on EBN-producing swiftlets

***Aerodramus fuciphagus*:** Before dwelling on the right habitat and suitable environment for successful EBN production, it is crucial to overview EBN-producing swiftlets. These type of swiftlets currently contribute to billions of dollars' worth of global businesses. According to Lim and Cranbrook (2002), the scientific name *Aerodramus fuciphagus* comes from a genus name which is *Aerodramus* (the group of grey-brown echolocating swiftlet) followed by a species name which is *fuciphagus* (the builder of white nests).

Historically, *Aerodramus fuciphagus* is a small sized bird around 12 cm (Hume, 1873). Their body is black-brown in colour. This species can be found in the South East Asia region. *Aerodramus fuciphagus* has the ability to fly much faster and are stronger than other bird species (Merikle, 1998). The nest produced by *Aerodramus fuciphagus* is built from saliva (AgroMedia, 2007). It can be assumed that more nutrients and energy are saved for making bigger nests due to surplus from less flying or physical activity (Kassim, 2011). Other behaviour of swiftlets are their inablity to perch, their more rapid and different wing strokes in flight, being smaller than the house swifts and super eyesights (Lim and Cranbrook, 2002). The other prominent behaviour of swiftlets is that they breed inside caves or cavern-like spaces and cling to the surface of walls as well as on ceilings, roosting with their self-supporting bracket-shaped nests (Ford and Cullingford, 1976).

Feeding behaviour of swiftlets: The feeding behaviour of swiftlets is important. Edible bird nest producers have to feed swiftlets with the correct type of food. Primarily, edible swiftlets feed on insects (AgroMedia, 2007). Swiftlet are insectivorous birds in nature, tracking and capturing airborne insects and their prey are from a diversity of arthropods, ranging in weight from 0.01-0.69 g (Lim and Cranbrook, 2002). According to Lourie and Tompkins (2000), in his dietary study of four sympatric swiftlets in Malaysia, ants and fig wasps made up most of their diet.

According to Lim (1999), adult swiftlets do not feed their young regularly. One observation from 9.00 a.m till 5.00 p.m on 11 June 1997 inside Lubang Salai revealed that only a small number of nestlings were fed during the day. Swiftlets are very important to the world ecology. As such, swiftlets have helped maintaining the ecological integrity of an area by controlling insects population (Lim and Cranbrook, 2002).

Reproduction energetics and control of breeding cycle of swiftlets: The next behaviour of relevance to EBN production are reproduction energetics and breeding cycle of the swiftlets. These behaviour patterns are important as they determine the EBN harvesting time. The duration of nest building for *Aerodramus fuciphagus* is 30 days on the average from the first deposition of nest at the start of the breeding season until the nest reaches a sufficient size to hold the eggs (Kang *et al*., 1991; Lim, 1999). According to Lim (1999), from this point, another 7-10 days may be required before the first egg is laid. If a nest is removed before the lay, the birds immediately begin rebuilding a replacement nest on the same spot (Lim, 1999). If it is taken when the eggs or young are present, there is a delay of 10-14 days before fresh saliva is deposited again (Lim, 1999). The rate of deposition of replacement nests is fairly uniform within a colony but the delay before a new clutch is laid varies greatly (Lim and Cranbrook, 2002).

Both sexes produce saliva for the construction of EBN (Kang *et al*., 1991). However, the formation of eggs are by the female counterpart and requires considerable demand of bodily reserves (Kang *et al*., 1991). Nest building normally takes place at night when the birds are roosting (Lim and Cranbrook, 2002). They need to build up their energy reserves to a level sufficient for another attempt after completing one round of breeding (Lim and Cranbrook, 2002). In Vietnam, the commencement of the *Aerodramus fuciphagus's* nest building is during the dry season and breeding normally starts during the first rainy season, at the time when there is an abundance of aerial insects (Nguyen Quang, 1994).

Echolocation of swiftlets: It is interesting to note that the most demarcated behaviour which promotes roosting and nesting of swiftlets is echolocation. The ability of echolocation of swiftlets has evolved in only two groups of birds which is the Neotropical Oilbird (Steatornithidae) and Paleotropical Swiftlets (Apodidae) (Price *et al*., 2004). These two groups of birds, when are in caves, produce clear audible clicks while flying in complete darkness or in dim light (Griffin, 1958; Medway, 1959). Studies have shown that swiftlets use echoes in the form of clicks primarily to avoid obstacles during flight rather than for capturing insect prey, similar to insectivorous bats (Medway, 1962).

Echolocation also provides unique advantage for swiftlets in that it permits them to roost and nest in the dark recesses of caves, free from competitors or visually orienting predators (Fenton, 1975). The difference between swiflets and the ultrasonic cries of bats is that the echolocation clicks of swiftlets are well within the human range of hearing (Cranbrook and Medway, 1965). Such a difference would not allow acuity required for swiftlets to be identified by aerial insect prey. The other relevant infomation here is that the echolocating species of swiftlets, *Aerodramus* spp., are not closely related to non-echolocating species, *Collocalia* spp. (Lee *et al*., 1996).

Unlike the oilbird, whose orientation sounds are single discreet pulses, most echolocating swiftlets emit double clicks during echolocation (Suthers and Hector, 1982). Each of this double clicks consists of two broadband pulses separated by a short pause. The second click is typically louder than the first, with acoustic energy between 2 and 8 kHz (Suthers and Hector, 1982). The intraclick pause of the second click can vary somewhat within swiftlets individual click and even taxa.

According to Fullard *et al*. (1993), only two swiftlet species are known to produce single clicks rather than doublets which are the black-nest swiftlet (*Aerodramus maximus*) and the Atiu swiftlet (*Aerodramus sawtelli*). Whether these single clicks represent an ancestral condition during the evolution of echolocation or a more recent specialization in these species has not been investigated previously (Price *et al*., 2004).

According to Chantler and Driessens (1995), swiftlet taxa are well known for their remarkable lack of distinguishing morphological characteristics. Characteristics of swiftlet nests also provide little information about phylogeny (Lee *et al*., 1996). The presence of echolocation is considered a relatively informative character and has been used to delineate the genus *Aerodramus* which includes the echolocating species, from other swiftlet taxa in the genre *Collocalia* and *Hydrochous* (Medway and Pye, 1977). This scheme largely depends on echolocation's first appearance in the immediate ancestors of the *Aerodramus* clade (Fenton, 1975). However, only two of the three species currently recognized as *Collocalia* have been shown to lack the ability of echolocating (Fenton, 1975). It is a known fact that the presence or absence of echolocation is in the third species, *Collocalia troglodytes* (Chantler *et al*., 2000). However, it is crucial to understand how echolocation evolved in the swiftlet species or avian group (Medway and Pye, 1977). This understanding gives insights that only specific swiftlets actually have the ability to echlocate, the pre-requiste to nesting during roosting.

Predators of swiftlets: Predators of swiftlets include both vertebrates (owls, raptors, snakes, geckoes, bats, cats, rats) and invertebrates (cockroaches, lice, flies, giant crickets and centipedes) (Naguyen *et al*., 2002).

Swiftlets can avoid predators in many ways. One of the ways is by proper nest-site selection (Manchi, 2009). The other way is by foiling the specialised search strategies of the potential predators (Martin, 1995). Predators can also be avoided by documenting the behaviour of nest predators. It is also of great interest to understand the nest-site selection of the species as this benefits the swiftlets' adaptation in the presence of predators (Manchi and Sankaran, 2009a,b). The echolocation of swiftlets is an inert strategy of the members of genus *Aerodramus* to avoid predators (Medway and Pye, 1977). This strategy enables swiftlets to roost and nest in the dark zones of caves, free from competitors or visually orienting predators (Medway and Pye, 1977).

Edible bird nest-producing swiftlets: In Malaysia, there are several types of wild swiftlets nesting in caves. Only two species can produce nests with their saliva (Merikle, 1998). The EBN-producing swiftlets use echolocation to navigate in the dark (Merikle, 1998). This species has the ability to build its nest deeper inside the caves (Merikle, 1998). The EBNs produced are white because they are made almost entirely from saliva with only a few feathers mixed in it (Wells, 1999). This species is one of the very few wild animals gives very high economic benefit to humans in the human made swiftlet houses (Merikle, 1998). In addtion, harvesting EBN is also an environmentally sound practice (Merikle, 1998). The demand for EBN has also supported the increased population of these swiftlets (Iswanto, 2002). Over the past twenty years, the high demand for EBNs has directly affect ed the increase in the birds' population globally (Hobbs, 2004).

Uses of EBN: Edible bird nests have two primary uses. They serve both as an exotic delicacy and also as materials for medicinal products which are believed to improve physical strength (Winarno, 1994). Swiftlet nests can be damaged as the result of contamination from pesticide residues, animal drugs and heavy metals and also from other contaminants such bacteria, viruses, yeasts and fungi that may cause food-borne diseases (Budiman, 2002). When first introduced, EBNs were consumed as an exotic food, but now they are considered both as tonic and medicine (Amy and David, 1994). In medical history, EBNs have long been regarded by the Chinese as a tonic, albeit of secondary importance to their native ginseng which is *Panax ginseng* (Reid, 1932). Wootton (1910) recorded EBN being listed in a Seventeenth Century London Pharmacopoeia. According to Lim and Cranbrook (2002), EBN may be taken for medication and rehabilitation purposes. What is more interesting is that there were untested claims made regarding its beneficial effects on patients suffering from cancer or AIDS (Lim and Cranbrook, 2002).

In addition, previous studies have shown that EBNs have a negative effect on *Influenza virus*. In many early studies, EBN extracts were used as a substrate to investigate viral sialidase activity and it was found that haemagglutination inhibited actions against the *Influenza virus* (Howe *et al*., 1960). It is also found that the first avian Epidermal Growth Factor (EGF) is derived from the activity in partially purified EBN extract (Ng *et al*., 1986; Kong *et al*., 1987).

Chemical composition and biosecurity of EBN: The determining characteristics present in EBN are its chemical compositon and biosecurity. These characteristics are unique in EBN, making it suitable for human consumption and useful as medicine.

Chemical composition of EBN: The chemical composition for EBNs determines the complexity of the process required to purify them. This process is important as it will assist EBN producers to devise methods of cleaning up the harvested nests from traces of chemicals. Studies have shown that EBN is composed of about 50-60% protein, 25% carbohydrate and 10% water, with small amounts of minerals, mainly calcium, phosphorus, potassium and sulphur (Wang, 1921). Banks (1986) also found arsenic in the nests. Analysis using high performance liquid chromatography has revealed that the protein in EBN edible consists of 17 amino acids in various quantities. They are aspartic acid, glutamic acid, serine, glycine, histidine, threonine, arginine, alanine, isoleucine, leucine, phenylalanine and lysine (Lim, 1999).

Biosecurity of EBN: Biosecurity of EBNs is critically important to ensure their safe human consumption and usage. Nests produced should be free from disease vectors or carriers and handled by operators practicing top hygiene (Kassim, 2011). Any slack in biosecurity can shorten the life span of swiftlets because of constant exposure to contaminants (Kassim, 2011). Unhygenic conditions may invite flies which can be disease carriers and these flying insects may be caught and consumed by the caged swiftlets (Kassim, 2011). One of the ways to have top biosecurity conditions is by using the value added designer nests from special swiftlet hybrids in controlled environments which are proven contaminant free (Kassim, 2011).

Habitat and environmental factors influence successful EBN production: The two important factors influencing successful EBN productionare right habitat and suitable environment.

Right habitat for swiftlet house: Having the right habitat is important in the success of EBN production. Habitat refers to the place in which an organism lives and is characterized by its physical features or by the dominant plant types (ODB, 2004). The natural habitat for swiftlets is limestone caves (Ibrahim *et al.*, 2009). However, to encourage nesting away from caves, building structures mimicking a cave-like atmosphere are built (Mardiastuti *et al.*, 1997).

Location selection is a very important factor before building any swiftlet home. This factor has to be addressed first, otherwise swiftlet nest producers will not cover the return of investment on building swiftlet houses. Building swiftlet houses in unsuitable locations can lead to economically devastating failure (AgroMedia, 2007).

Selecting the right location for building swiftlet houses is based on the swiftlet population density of area, feeding area, swiftlet track area and areas that are allocated for easy control of swiftlet houses (Nasir Salekat, 2009). A location containing a high swiftlet population has a greater probability of more birds coming into and nesting in the houses built (AgroMedia, 2007). Smart investors will choose high swiftlet population area for their investment (Nasir Salekat, 2009). This is because 20% of swiftlet chicks in swiftlet houses will search for a new location not far from their previous breeding place (AgroMedia, 2007). The swiftlets move to other places because of overcrowding which causes discomfort to the chicks. By building swiftlet houses in the right location or area, 90% successful swiftlet ranching will be achieved (AgroMedia, 2007).

The other aspect of choosing the right location is where the feeding area of swiftlets is reachable from swiftlet houses. Swiftlets feed on flying insects (Budiman, 2002). Swiftlest track areas in another location that is important before building swiftlet houses. By having the right track area, 40% successful swiftlet ranching is achievable (Nasir Salekat, 2009).

Suitable environment in swiftlet houses: The second most important factor that influences the success of EBN productions is suitable enivironment. Most of the time, swiftlet ranching involves the conversion of people-centric buildings into *Aerodramus fuciphagus*-centric houses (Merican, 2007). These converted houses can only be found in the South East Asia region. New well-designed buildings are constructed for the purposes of accomodating such swiftlet populations.

Other environmental factors for swiftlet ranching are; air temperature, RH, air velocity and light intensity (Ibrahim *et al.*, 2009). The recommended temperature range is between 26-35°C (Ibrahim *et al.*, 2009). Low air temperature would reduce the productivity of EBN production (Budiman, 2002). Swiftlet entrances should be constructed with South North orientation to avoid exposure to direct sunlight as it will increase cause the internal temperature and the light intensity (Nasir Salekat, 2009). Provision of an additional layer of agricultural netting to the surface wall may also decrease the surface temperature (Ibrahim *et al.*, 2009).

Relative humidity in the range of 80-90% is recommended to maximize the productivity of EBN production (AgroMedia, 2007). Higher RH breeds fungus on nesting planks and dampness usually leads to stagnant water pools and mosquito breeding (Ibrahim *et al.*, 2009). Swiftlets will not build their nests on planks full of fungus. A humidifier should be provided in the swiftlet houses to control the desirable range of RH.

Air ventilation is crucial in EBN production to provide air movement in the building (AgroMedia, 2007). An 'L-elbow' pipe connector is recommended to promote air movement (Ibrahim *et al.*, 2009). This prevents direct exposure to sunlight (AgroMedia, 2007). The distance between ventilation holes is recommended at a minimum of 1 m from the netting plank level and should be constructed in the walls opposite to the direction of nesting planks (Nasir Salekat, 2009). Installation of exhaust fans to the ventilation wall is recommended to promote ventilation and at the same time controls the evaporation (Ibrahim *et al.*, 2009).

Sustainability of EBN production: The ever increasing swiftlet population has great impact on ecology. So do their conservation. To a certain extent, by conserving swiftlets, the enivironment is protected. In lieu of that, the swiftlets' role in enhancing the ecology and the environment provide sustainablity of the world eco-system.

Ecological importance of swiftlets: Swiftlets play an important role in the cave ecosystem. They constitute the central food web in a cave ecosystem (Lim and Cranbrook, 2002). Swiftlets are efficient fliers and forage over considerable distances outside these caves. As they return to the cave to roost, their dropping are deposited as guano on th cave floor (Lim and Cranbrook, 2002). Swiftlets continuously supply the input of external energy into the cave ecosystem which in turn supports millions of tiny detritus-feeding animals that depend directly or indirectly on the guano (Lim and Cranbrook, 2002). They also help to maintain the ecological integrity of the area by controlling insect population (Lim and Cranbrook, 2002). Swiftlets, both in the cave and man-made houses, have significantly contributed to a sustainable ecosystem.

Conservation of swiftlets: The conservation of swiftlets has a direct impact to a sustainable ecosystem. Conservation refers to the sensible use of the earth's natural resources in order to avoid excessive degradation and impoverishment of the environment (ODB, 2004). According to Lim and Cranbrook (2002), the conservation of wild populations of EBN-producing swiftlets requires observance of three rules, namely, installation of a management system based on a full understanding of the natural breeding seasons at each locality; allowing at least one natural roosting cave af natural vegetation and providing the customary food resources, with its mixed composition and natural cycles of productivity reflecting climate and local weather.

Sabah and Sarawak have old Control Systems to regulate the taking of EBN, dating back to early this century, but in neither State has it been possible to control harvests adequately (Cranbrook, 1984). Amy and David (1994) mentioned that it merits a more concerted International effort to monitor the status of the species and trade in their nests, such as would occur if EBN-producing swiftlets were collectively listed in Appendix II of the Conservation on International Trade in Endangered Species of Wild Fauna anf Flora (CITES). CITES which came into force in 1975, has a membership of 122 Parties which agreed to control trade in the wild animals and plants listed in its two principal Appendices.

Appendix 1 lists species which are threatened with extinction and the treaty largely prohibits their commercial trade. Appendix 2 lists species of some conservation concern, trade in which is allowed to continue under a Permit System which aims to prevent over exploitation and allows for trade monitoring. Appendix 2 controls would provide for international support of harvest control measures adopted by producing countries. However, it is important to recognize that the implementation of a CITES Appendix II listing would not be straight forward owing to the difficulty of establishing which swiftlet species produced any particular sample of nest material.

Sustainable management of EBN-producing swiftlets: Conservation of EBN-producing swiftlets is related to its sustainable management. Such sustainable management of the swiftlets is crucial in ensuring the balance between EBN industry needs and the conservation of the ecosystem. Understanding the right meaning of sustainable is important towards the clarification of sustainable management. Sustainable refers to a condition of balance, interconnectedness and resilience which allows human society to satisfy their needs (Morelli, 2011). These needs shall neither exceed the capacity of its supporting continuous regeneration of ecosystems of the services neccesssary meet these needs nor mankind actions of diminishing biological diversity. In order to achieve sustainable management of EBN-producing swiftlets, balancing repetitive harvest of the nests is required to ensure that the colonies' productivity and viability are maintained while supplying a lucrative EBN industry (Lim and Cranbrook, 2002). Unlike other wildlife utilisation, it is relatively easy to manage the sustainability of EBN-producing swiftlets as it only involves the harvested nests and not the animals (Lim and Cranbrook, 2002).

METHODOLOGY

There are two phases for this study. The first phase is the social science whilst the second phase invovles the experimental part of the research. This study only covers the pilot test of the first phase of the research.

First phase of the study

Inital part of the first phase: The first part of the first Phase 1 is the gathering of information, derived review of literatures and the supporting documents from the stakeholders of the swiftlet industry. The information related to swiftlet nesting habitat and environment are gathered from several sources. The said sources are journals, articles, websites and consultants. The other key sources of habitat and environment information are the Veterinary Department, Ministry of Agriculture and Primary Industry. These information will be gathered and analysed to identify both the habitat and environmental factors that influence successful swiftlet ranching.

Final part of the first phase: The final part of the study is to determine the right habitat and suitable environment for successful swiftlet ranching. The study will be conducted in states in Malaysia with the highest swiftlet nesting homes. Trengganu meet this requirement.

Sampling design: The population is the swiftlet houses in Terengganu. The samples of this phase is the stakeholders of the swiftlet industry in the state. The samples comprised of the producers, consultants, contractors, authorities, related ministries, associations, suppliers, financiers, exporter as well as the importers.

Design of interview questions: In this phase, the habitats and environmental factors of success for swiftlet nesting are further explored through interviewing the stakeholders of the swiftlet industry. The data is collected from two sources. Once from the respondents who are going to be interviewed. The other source from the documents from the twelve stakeholders of the swiftlet industry as deliberated in the literature review. For the second part of the Phase 1 is an interview of the stakeholders of the swiftlet industry in the context of habitat and environment.

The questions are designed based on the information extracted from the review of literatures and available industry background information. The stakeholders are producers of swiftlet nesting, consultants of swiftlet houses, association of the producers of swiftlet nesting, the key personnel from the federal government veterinary division, the director of the state veterinary department and finally the director from the state local authority. In this part of the study, 17 respondents from stakeholders of the swiftlet industry are to be interviewed. The interview deals with several issues related to swiftlet ranching and areas related to it. A structured interview will be used to explore the habitat and environmental factors of swiftlet ranching.

Pilot study: Five producers of swiftlet ranching and two consultants for swiftlet houses are interviewed. The interview questions are checked and readjusted to ensure clarity before the main interview is conducted.

Data collection: A total of at least 17 main stakeholders of swiftlet ranching are interviewed to elicit the information on factors and elements of the success factors. The main stakeholders are six producers of swiftlet ranching, three consultants of swiftlet houses, two Federal Government key staffs from the Ministry of Agriculture, three State Department of Veterinary Directors, two state local authority staff and two Presidents from the Association of the Producers of Swiftlet Ranching.

Method of analysis: The detailed elements of the habitat and environmental factors in swiftlet ranching are also established first from the interviews. The data is analyzed thematically, i.e., by identifying the themes and patterns derived after transcribing the data. The habitat and environmental factors of swiftlet ranching are identified. Secondly, the documents gathered from the respondents are analyzed to establish the elements of habitat and environmental factors in swiftlet ranching.

Second phase of study: For the second part of the research process, experimental works will be conducted in swiftlet houses. Air temperature, surface temperature, relative humidity, air velocity and light intensity will be taken from 10 swiftlets houses in the state of Kuala Terengganu, Malaysia.

Experimental works: Experimental works will be conducted in 3 swiftlet house that are rented in the state in Malaysia with the highest swiftlet nesting homes. Equipment used in this study are the globe thermometer, thermal hygrometer, anemometer, data logger and photometer. Equipment will be placed at several locations in the swiftlet houses for data collection during the experimental works as recommended by Ibrahim *et al.* (2009). In order to investigate the factors that may affect the internal environment of the swiftlet houses, several different monitoring configuration will be undertaken. Data on building related environment will be collected and analysed based on each swiftlet house.

Thermocouples connected to a data logger are used to collect air temperature and selected wall surface temperature within 1 h intervals (Ibrahim *et al.*, 2009; Ishak *et al.*, 2011). Relative humidity, air velocity and light intensity are also recorded in 1 h intervals (Ibrahim *et al.*, 2009). A humidifier is installed in the swiftlet house to control RH in the area. Light intensity reading will also be taken using a photometer during the day time to indicate light intensity in LUX unit (Ibrahim *et al.*, 2009; Hudzari *et al.*, 2013). Data was collected 25 h after each conditions of the building were set-up. This duration is important for condition settlement time (Ibrahim *et al.*, 2009).

The suitable time to record the data on air and surface temperature, RH, air velocity and light intensity is between 10:30 a.m to 3.30 p.m (Oktorina *et al*., 2005). The swiftlet house is vacant and the swiftlets are out searching for food and will be back around 3:30 p.m (Oktorina *et al*., 2005). The swiftlet will be scared away if frequently disturbed by visits to the inside of the swiftlet house (Oktorina *et al*., 2005). Therefore, the best time should be chosen to refrain from entering the swiftlet house unnecessarily.

Data analysis: All the data obtained from the swiftlet house had been analyzed to evaluate the relationship between air temperature, relative humidity, air velocity and light intensity. This is important to create and suggest the list of the most suitable and conducive environment for swiftlet ranching.

RESULTS

Habitat and environmental factors are the succcess factors in the swiftlet ranching business in Malaysia.The list of this success of both factors will be identified as an output of this empirical study.

The selection of the location selection of habitat factors to build swiftlet houses are population area of swiftlet, feeding area (garden area, paddy-field area, garbage area), swiftlet track area and areas that are easy to control. It is expected that some from this list which lead to the success of the swiftlet house.

Subsequently, the environmental factors in swiftlet houses are air temperature, surface temperature, relative humidity, air velocity and light intensity. Similarly, it is expected that some from this list of environment factors will lead to success of swiftlet houses at the end of this study.

DISCUSSION

To avoid from the producers of swiftlet houses losing money in their investment, the habitat and environmental factors of a swiftlet house need to be determined before constructing the swiftlet house. Swiftlets will breed reproductively in a conducive habitat and environmental (Mardiastuti and Soehartono, 1996).

In contrast, unsuitable location selection in building the swiftlet house as a man-made habitat for swiftlet adaptation and survival may cause failure in the swiftlet ranching business (Langham, 1980). The strategic habitat area to build swiftlet houses are the population area of swiftlets, feeding areas (garden area, paddy-field area, garbage area), swiftlet track areas and areas that are easy to control the swiftlet houses (Nasir Salekat, 2009).

Generally, populated areas of swiftlets pose a high population of swiftlets. In this area, the big number of swiftlet houses present over a long time have very high reproductive capacity. Normally, new investors of swiftlet ranching will choose this populated area for their investment (Nasir Salekat, 2009). The rational behind this choice is that 20% of swiftlet chicks in the populated swiftlet houses will search for new homes at locations not far from their previous place (Hendri, 2007). The reason why the swiftlets move to other places is because their previous place is crowded and cause discomfort to their chicks' survival. As such, constructing new swiftlet houses in this area will guarantee a 90% success (Nasir Salekat, 2009).

Getting the right feeding area is one of the characteristics for swiftlet habitat. Therefore, before constructing swiftlet houses, it is critical to choose the closest site to the new swiftlet house. Commonly, swiftlets feed on flying insects. Many insects can be found in the garden area, paddy field area and garbage area (Nasir Salekat, 2009). In the garden area, many fruits and flowers from trees are attracted to many insects. It is one of the reasons why swiftlets prefer to search food at the garden area (Nasir Salekat, 2009). The paddy-field is another area that attracts flying insects, especially if this area is not sprayed with insecticide (Nasir Salekat, 2009). Therefore, there are so many insects attracted to this area. The presence of these insects found in the paddy-area will also draw swiftlets to search for food in this area. Besides, the garbage area with its ordour is also another area that attracts many insects like mosquitoes, flies and hermites (Nasir Salekat, 2009). This draws swiftlets to come to this area for insects during feeding time (Nasir Salekat, 2009).

The swiftlets can adapt well and are suitable to temperature ranging from 26-35°C and relative humidity from 75-90% (Ibrahim *et al.*, 2009). Howerver, swiftlets will feel uncomfortable with high temperatures that exceed the suitable range. This condition will cause damage to the swiftlet eggs (Budiman, 2002). Likewisse, lower RH will cause the swiftlet nest to be dried out because it is made from the swiftlet's saliva (Ibrahim *et al.*, 2009). The dry condition will cause cracking of the swiftlet nest. Any form of deformed nest will produce a lower class nest for the swiftlet market (Ibrahim *et al.*, 2009). This deformed nest affect the young swiftlets and eggs due to the non-supportive characteristic of a shrunk nest. This characteristic also makes the nest fall to the ground very easily (Ibrahim *et al.*, 2009).

The other factor derived from the environment is evaporation. The evaporation process happens when air movement is available in the swiftlet house (Ibrahim *et al.*, 2009). It will reduce the level of relative humidity and air temperature inside the swiftlet house (Ibrahim *et al.*, 2009). It is important to maintain a suitable range of air temperature and relative humidity. These conditions will affect the health conditons of featherless young swiftlets in higher velocity environments (Ibrahim *et al.*, 2009).

CONCLUSION

The right habitat location and suitable environment are the key factors for a successful swiftlet ranching business in Malaysia. The right habitat location that is very strategic in building swiftlet houses are: Highly populated swiftlet area; most attractive feeding area like the garden area, paddy-field area and garbage area and swiftlet tracks and areas that are easy to control the swiftlet house. The list of suitable environmental factors for swiftlet houses are air temperature, surface temperature, RH and light intensity. The air temperature in swiftlet houses should be maintained between 26-35°C, relative humidity from 80-90%, a low air velocity, and light intensity less than 5 LUX. A proper ventilation and installation of a humidifier could also assist swiftlet houses to achieve a conducive environment. It is envisaged that the findings of this study will provide insight to the stakeholders of swiftlet ranching (swiftlet house owners or producers, key personnel of ministry and department of agriculture, consultants of swiftlet house and association of the swiftlet nesting) the right habitat and suitable environment during and after construction of swiftlet houses. Therefore, having these two factors addresssed will ensure a more successful business venture in the edible swiftlet industry.

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