CHAPTER 2

LITERATURE REVIEW

2.1 Classification of Edible-nest Swiftlets

Edible-nest Swiftlets are classified within the taxonomic order as follows :

Superorder Apodimorphae

Order Apodiformes

Family Apodidae

Genus *Aerodramus*

Aerodramus fuciphagus produces white nest so it is commonly called the White-nest Swiftlet whereas *A. maximus*, producing black nest, it is called the Black-nest Swiftlet. Another species, *A. unicolor*, produces nest with saliva incoporate with moss, is called the Indian Swiftlet

2.2 General description of Family Apodidae

Within the Family Apodidae, all species are small and medium birds, the bill is short and broad with a deeply cleft gape and nostrils that open vertically, saliva glands are large and the sizes increase during the breeding season (Chantler and Driessens, 2000). Apodidae species are resemble swallows, but have longer, thinner, usually crecent-sharped wing, fly with rapid wing beats, interspersed with long glides. Many species have screamly call and *Aerodramus* species have ability to ecolocate. They are aerial insectivores. They never perch on trees or wires like swallow but with their short claws can only hang from the vertical surface. Normally, birds spend much of their time on the wing. The large species are among the fastest flying birds in the world. Swiftlets nest in group and sexes are similar. There are 80 species around the world and 4 species, White-nest Swiftlet; Black-nest Swiftlet ; Himalayan Swiftlet *Aerodramus brevirostris* (McClellant,1840) and Glossy Swiftlet *Collocalia esculenta* (Linnaeus,1758) are found in Thailand (Lekagul and Round,1991).

For genera *Aerodramus* and *Collocalia*, birds have small and medium sizes and fluttering flight on bowed wings. Their tails are slightly notched rather than forked, appearing almost squar-ended. They nest in huge numbers in caves or sometimes in buildings. Edible-nest species build cup nests incorporating hardened saliva, and other species build nests using saliva with other materials (Lekagul and Round, 1991; Eve and Guigue, 1996; Chantler, 1999; Wells, 1999; Chantler and Driessens, 2000)

A. fuciphagus builds wholly nest from its saliva, so it is renowned as an important species regarding its valuable nest, which is most highly prized. *A. maximus* uses saliva mixed with its feathers and *A. unicolor* uses saliva incorporated with vegetable matters for its nest (Kang and Lee,1991; Rodelphe, 1992; Chantler,1999; Wells, 1999).

2.3 Morphology of the White-nest Swiftlet

White-nest Swiftlet is medium size with body length of 110-120 mm and its body mass ranges between10-15 g. It has glossy plumage, almost black-brown on upper parts with slightly greyer on the rump, underpart of the throat is paler and greyer. Upperwing is blackish with strong gloss while underwing is paler. The tail covert is blackish. It has naked-tarsi. The color of the rump shows variation throughtout its range (Smythies, 1975; Well, 1999).

2.4 Composition of the white nest

Nests of the White-nest Swiftlet compose mainly of pure saliva. This saliva is a kind of mucin-like glycoprotien, composing of 50-60% protein, 25% carbohydrate, 10% water with small amounts of minerals, mainly calcium, phosphorus, potassium and sulphur (Kang et al, 1991; Lau and Melville, 1994)

2.5 Habitat and distribution of the Edible-nest Swiftlet

White-nest Swiftlet is common and resides mainly in limestone caves on islands or on the mainland coast. Its distribution is in the oriental region, ranging from the Andaman and Nicobar Islands in the Indian Ocean to South East Asia (Myanmar, Thailand, Peninsular Malaysia, Vietnam, and extending to Sumatra, Java, Bali, Sarawak,

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Sabah, Borneo) and the Lesser Sunda Islands. The Black-nest Swiftlet is also found along this distribution line. For the Indian Swiftlet, it is abundant in caves of western Ghats on the islands off Malabar coast. This species is restricted to the southwest coast of the Indian Subcontinent and Sri Lanka (Glenister, 1971; Smythies, 1975; Medway, 1962; Cranbrook, Somadikarta, and Kartikasari, 1996; Chantler, 1999; Kenneth, 1999). The distribution lines of these three species are shown in Figure 2.1.

A. fuciphagus and *A. maximus* are residents in Thailand, living in sea caves, islands offshore along the coastlines in Prachuap Khiri Khan, Chumphon, Surat Thani, Phatthalung, Satun, Trang, Phuket, Phang-nga and Trat Provinces (Lekagul and Round, 1991; Royal Forestry Department of Thailand, 1999).

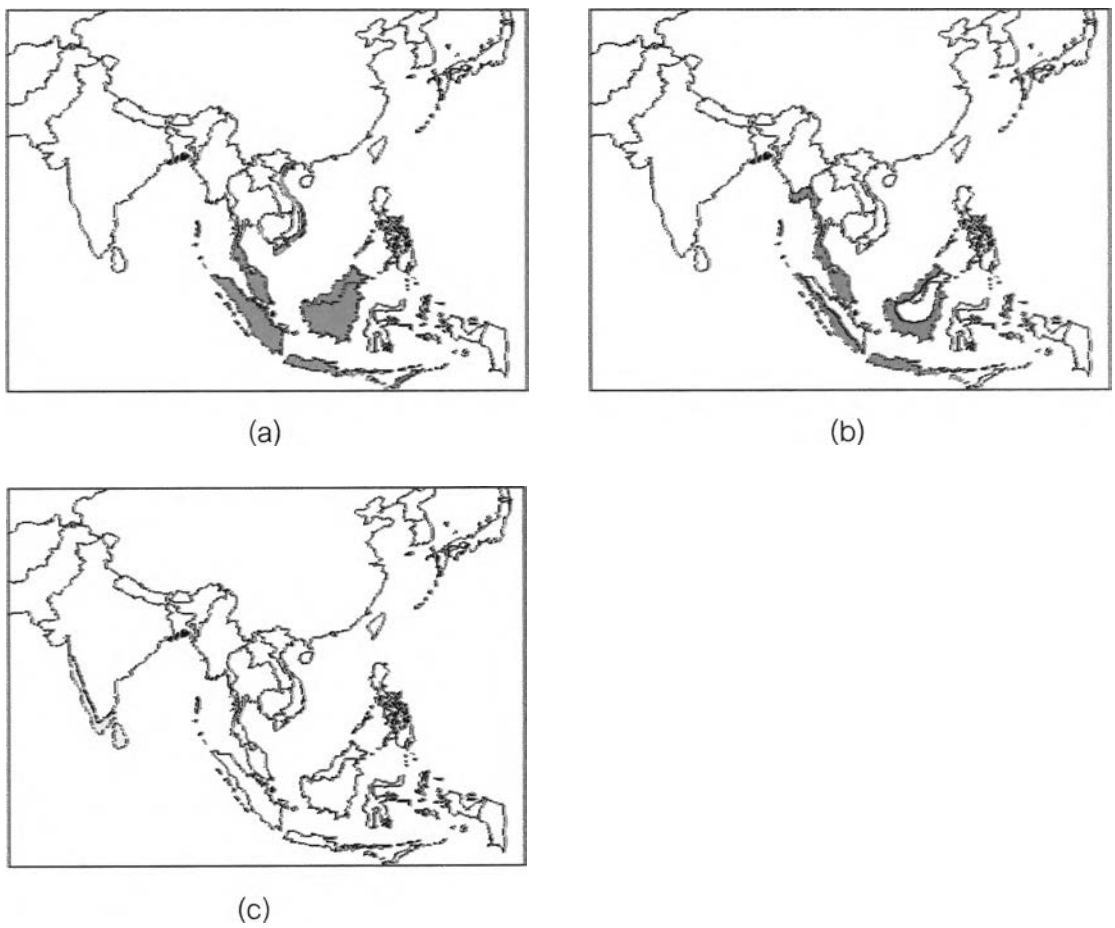

Figure 2.1 Distribution map of the Edible-nest Swiftlet : (a) *A. fuciphagus*; (b) *A. maximus*; and (c) *A. unicolor* . The map was modified from Chantler, 1999.

2.6 History of nest trade and the Act.

Saliva cement of birds' nests has been used for nest soup and Chiness cuisine since Ming Dynasty (1318-1644 AD)(Cranbrook et al., 1996; Kenneth,1999). The Edible-nest birds have provided an enormous income to the local and countries across their ranges.

A history of edible-nest harvesting in Thailand dated back to the reign of King Taksin the Great. It was recorded when his majesty went down to Songkhla Province (BE 2312,1769 AD). At that time, his majesty gave the unofficial permit to the governor to collect edible nests at See-Ha Islands (or Ko Si Ko Ha)(Giles, 1963). Dunlap (1907) stated that the official permit to collect nests on the islands probably was first released in the reign of King Rama the third (BE 2367, 1824 AD). After 115 years, the Bird Nest Harvest Act BE 2482 (1935 AD) was first announced by the governor. Ten years later, it was first improved. Thereafter, the second amendment was done in BE 2540 (1997 AD). Besides the Bird Nest Harvest Act, the Wildlife Conservation and Protection Act BE 2503 (1960 AD) was released by the Royal Forestry Department, which was amended in BE 2535 (1992 AD) (RFDT, 1999). These two Acts have brought about the conflict concerning the Edible-nest Swiftlet conservation and management. The Wildlife Act provides total protection to the swiftlets while the Bird Nest Harvest Act allows the granting of concession to the highest bidder. Despite the fact that nests have been harvested for many decades, neither concessionaires nor the government sector who issued the harvesting rules have a true understanding of the ecology and breeding biology of the White-nest Swiftlet. Therefore, the information on ecology and breeding biology of this bird are still less known in Thailand.

2.7 Taxonomy of the Edible-nest Swiftlet

The nomenclature of the edible-nest species has created many debates and remains unsolved. Early taxonomists classified birds producing edible nests in a group of " the swallow " (now is known in Family Hirundinidae), using the Genus *Hirundo* (Cranbrook et al., 1996). From the zoological explorations and bird collections in the 19th and 20th centuries, the distinguished characters between the swift and the swallow

were revealed. The two groups differ in the material and structure of the nests. The swallow uses mud and straws with a little of its saliva for the construction of the nest but the edible-nest species mainly uses the saliva to build nest. For this reason, the ornithologist later placed swiftlets in Subfamily Chaeturinae in Family Apodidae.

Gray (1840) separated members of the Indo-pacific group (including Edible-nest species) from other swifts and placed in the Genus *Collocalia*. He selected *Hirundo esculenta* Linnaeus as the type species (Peter, 1940), after that Wallace (1863, cited in Cranbrook et al., 1996 : 4) indicated that *C. esculenta* did not produce edible nests, therefore *C. esculenta* should not be in the same Genus with other edible-nest species.

In 1906, Oberholser divided the genus *Collocalia*, selecting *Collocalia innominata* Hume as a type of Genus *Aerodramus* that was characterized by the presence of tarsal feathers (Peter,1940).

Brooke (1972, cited in Cranbrook et al., 1996 : 5) suggested that the Glossy Swiftlets including *C. esculenta* (Linn.) and the dull, gray-brown plumaged swiftlets (e.g. *A. innominata)* should belong to the Genus *Aerodramus* Oberholser. Based on the nesting behavior, nest types and the echolocation ability, he split *Collocalia* Gray into three genera as follows: *Collocalia* Gray; *Aerodramus* Oberholser; and *Hydrochous* Brooke, of which *C. fuciphaga* (Thunberg), *C. fuciphaga germani* Oustalet and *C. maxima* Hume were classified to Genus *Aerodramus.* This classification was supported by Pratt (1986, cited in Kenneth, 1999 : 5) with additional suggestion that these species also exhibited the same characteristics of using salivary cement for their nests (Medway,1962; Kang and Lee,1991; Lee and Kang, 1994).

Based on molecular genetics study, Sibley and Monroe (1990) regrouped all species in Genus *Areodramus* Oberholser and in Genus *Hydrochous* Brooke under the Genus *Collocalia* Gray. They listed the name of Edible-nest Swiftlets as *C.[fuciphaga] fuciphaga* (Gmelin) 1789. In 1993, they named the Edible-nest Swiftlets as *C. fuciphaga* and listed these subspecies of edible-nest birds as *C. (f.) inexpectata* : Edible-nest

Swiftet; *C. (f.) vestita* : Brown-rumped Swiftels; *C. (f.) fuciphaga* : Thunberg's Swiftlets and also elevated *C. fuciphaga germani* to *C. germani.*

Cranbrook et al. (1996) proposed that Edible-nest Swiftlets should be classified in the Genus *Areodramus* Oberholser and considered *C. fuciphaga germani* as a subspecies of *Areodramus fuciphagus* (Thunberg, 1812). This was on the basis of the geographical isolation, differences in morphology and behavior among the species and the new evidence from the molecular study. By the analysis and enzyme assay, Lim (1993, cited in Cranbrook et al.,1996 : 7) also showed that the Edible-nest Swiftlet was closer to *Areodramus* Oberholser than *Collocalia* Gray.

Lee, et al. (1996) using 406-bp cytochrom b mt DNA analysis, showed that *Collocalia* Gray was not monophyletic and *Areodramus* Oberholser and *Collocalia* Gray were not sister taxa.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) pointed out that Edible-nest Swiftlets were in the Genus *Collocalia* Gray 1840. It listed the four species producing edible nests as follows : the White-nest Swiftlets *C. fuciphaga* (Gmelin) and *C. germani* Oustalet, the Black-nest Swiftlets *C. maxima* Hume, and the Indian Swiftlet *C. unicolor* (Jerdon) (Cranbrook et al., 1996).

Dunlap (1907) called birds produced white nests in See-Ha islands, Phatthalung Province as "*Collocalia* species" while the same population was called as *"Collocalia francica"* by Quate (1952), *C. fuciphaga* Thunberg 1812 by Medway (1963) and *C. francica germani* by Brandt (1966). Boswell and Kanwanich (1978) reported that the Edible-nest Swiftlet in Phi Phi Le was *Aerodramus fuciphaga*. Lekagul and Round (1991) named edible-nest species as *A. fuciphagus*. RFDT (1999) called *C. fuciphaga* (Gmelin) and *C. germani* Oustalet for edible-nest species and *C. maxima* for black-nest species. Wells (1999) called the Edible-nest Swiftlet as *A. fuciphacus* (Thunberg) 1812 and the Black-nest Swiftlet as *A. maximus* (Hume) 1878, this concordant to the report of

Chantler (1999) who called Edible-nest Swiftlets as *A. fuciphagus* and the Black-nest Swiftlets as *A. maximus*.

Chantler and Driessens (2000) retained *C. germani* as a subspecies of *C. fuciphaga* and named Edible-nest Swiftlets as *C. fuciphaga* (Thunberg) 1812. Robson (2000) listed the birds produced white-nests as *C. fuciphaca* and *C. germani* and he noted that the latter distributes extreme south of Thailand, Malaysia and Singapore.

In this study, the studied species will be named as *A. fuciphagus* (Thunberg,1812) as recognized by Lekagul and Round (1991); Chantler (1999) and Wells (1999).

2.8 Population size of the Edible-nest Swiftlet

Population size is defined as the number of individuals that live together in one place at one period of time. The population size of White-nest Swiftlets has been indirectly estimated from the amount of harvesting. Banks (1935, cited in Er et al.,1997 : 2) estimated *C. maxima* number from the harvested yield of the Niah Cave in Sarawak. Lau and Melville (1994) used an average of 8 g per nest to estimate the amount of exported nests. Er et al. (1997) estimated the population size of the Edible-nest Swiftlet in South East Asia (i.e. Malaysia, Indonesia, Thailand, Vietnam and Myanmar) at 50.6 million birds and gave the average recruitment of 12.2 %. The accuracy of this method is subject to the variation brought about by the harvested yield report.

Unlike the previous method, the use of bird censusing techniques such as direct bird count, direct nest count and capture-mark-recapture method to estimate the population size of this species has not been popular with fieldworks. Good (1993, cited in Er et al.,1997 : 3) used for *C. maxima* in Niah Cave, where an observer counted the number of birds flying out of the cave entrance at fixed time interval. This method is subject to the variation brought about by the movements of swiftlets in and out of the caves in the evening and morning, the multiple entrances to some caves; and the different species (e.g. bat) inhabiting the caves. Basir et al. (1996) also reported the use of capture-mark-recapture method. However, they did not elaborate on its effectiveness.

2.9 Diet and foraging area of the Edible-nest Swiftlet

White-nest Swiftlets are insectivores. Aerial insects are main items of prey. Adults feed on wings and nestlings are fed at the nest with "food-balls" or "food bolous". The food-ball consists of a mass of insects bound together by saliva. The parents catch preys, keep in mouths, and return to their nests to feed directly to their young, one by one. Langham (1980) analyzed food items in 13 regurgitated food-balls collected from nestlings and adults of Edible-nest Swiftlets in shop house at Penang, Malaysia. He found that the mean weight of food-balls was 0.57 ± 0.09 g with a range of 0.13 to 1.08g. Almost half of the prey items in food-balls were hymenopterans especially chalcidoid wasps, followed in numerical importance by mayflies (0rder Ephemeroptera), Homopteran bugs and true flies (0rder Diptera). Chantler and Driessens (2000) indicated that these insects are important preys for swiftlets in both temperate and topical regions.

Foraging areas are the area that birds find and catch preys. Birds exit from the roost sites at dawn and return at dusk, they feed on wings and forage over all kinds of open and forest areas, rice fields or other wetland types, including crop and coastal areas (Mardiastuti and Mranata, 1996). Comparing to other swifts, White-nest Swiftlets fly at the middle height, lower than *Apus* and *Hirundapus* species (Wells, 1999). Waugh and Hails (1983, cited in Kenneth, 1999 :17) found that this species was commoner in primary forest than open habitats such as plantations and agricultural fields. To date, there is no research on the distance between the foraging areas and the nesting sites of White-nest Swiftlets.

2.10 Breeding season and breeding duration of the Edible-nest Swiftlet

Breeding season of a population is a time period from the first day the nest is built to the last day when the last nestling is fledged. Breeding time of a breeding pair is indicated by the appearance of breeding activities, for instance, the activities of nest building, incubation, nestling feeding and other signs such as nest defense. A time period, which covers all of breeding activities (from nest buiding to fledging), is defined as the breeding duration

The literature on the breeding biology of the White-nest Swiftlet has been reviewed (e.g. Medway, 1962; Langham, 1980; Francis, 1987; Kang et al., 1991; Lau and Melville, 1994; Nguyen, 1994; Er et al., 1997; Mardiastuti and Mranata, 1996; Wells, 1999; Chantler and Driessens, 2000). Many researchers stated that breeding activities of the White-nest Swiftlet coincide with the time of insect abundance in the inter-monsoon dry season (Kang and Lee, 1991; Chantler and Driessens, 2000). However, the breeding time of populations can be varied due to localities, especially when they are under the different environmental conditions. For example, Langham (1980) found that birds in Malaysia, under the harvesting condition, showed two laying peaks, the first was in October to December and the second was in February. In Thailand, under the 3 times harvesting a year, birds started nesting in January and ended up in August (RFDT, 1999). Under the natural condition, birds in Vietnam started nesting activities in December to April and the breeding season was timed by climate (Nguyen,1994). Breeding activities of birds in Singapore reduced in August to September (Kang and Lee, 1991).

Other studies on the congener for example *Aerodramus spondiopygius* by Busst (1956); Smyth et al.(1980) and Tarburton (1988, cited in Cranbrook et al., 1996 : 9) and *A. salangana* by Medway,1962 and *A. leucphaeus sawtelli* by Tarburton (1986) showed the same pattern in periods of incubation and fledging. The data also indicated the variation caused by location and climatic conditions.

The incubation period (the number of days from laying to hatching) and the nestling feeding period (the number of days from hatching to fledging) have been reported by many researchers. Medway (1969) studied on other species of this group and showed that it took 93 days for the total hatching-fledging period in the Black-nest Swiftlet *C. maximus* and 71 days for those of the Mossy-nest Swiftlet *C. salangana*. The periods of nest building and incubation of Edible-nest Swiftlets in Vietnam were 31-40 days and 23-30 days, respectively (Nguyen, 1994). Kang and Lee (1991) reported that White-nest Swiftlets in Singapore fed their nestling for 40 days.

The precise knowledge in the periods of nest building, incubation and nestling rearing of the White-nest Swiftlet is crucial important for the management of the sustainable harvesting. Therefore, detailed studies should be carried out for each breeding colony.

2.11 Breeding success of the Edible-nest swiftlet

The reproductive success is mostly considered as the number of young that survive to become breeding adults (Weatherhead and Dufour, 2000). However, the measurement of this parameter is often difficult because it takes time and most of fledglings often disperse before they are mature. For example in White-nest Swiftlets, once fledglings leave nests, there is no evidence that they comeback to live with their parents. For this reason, most researchers have to use other parameters (e.g. fledging success) instead of the true reproductive success.

In general, there are several parameters to determine the breeding success for birds and other animals. First is the clutch size (the number of eggs laid in one clutch). Second is the hatching success or hatchability (the number of hatched eggs in a clutch). Third is the fledging success or breeding success at fledging, BSF (the number of fledged chicks in a clutch). Forth is the production or fledgling production (the number of fledgling per pair per year) and the fifth is the nesting success (the number of nests that eggs hatched divided by the number of nests performing nesting attempts throughout the breeding season). To determine the breeding success of a bird species, researchers may select parameters depending on their purposes. For examples, Bukacinska, Bukacinski, and Spaans (1996) collected the data of the fledging success in Herring Gulls *Larus argentatus* in Netherlands to test the patterns of parental care and diet on the breeding success when a given colony was under the food limiting and high predation. Burger et al. (1996) determined breeding success of Roseate Tern *Sterna dougallii* in New York and Massachusetts in relation to the effect of adults' age, food availability and time of breeding using the data of clutch size, hatching success and production. Yogev, Ar, and Yom-Tov (1996) recorded clutch size and hatching success of Spur-winged Plover *Vanellus spinosus* in Israel for the study on the

determination of clutch size and breeding biology. Bennetts et al. (2000) recorded clutch size, brood size and nesting success of Little Egrets *Egretta grazetta* in order to evaluate the influence of environmental and density-dependent factors on the reproductive parameters. Ahumada (2001) measured clutch size, nesting success, time of breeding and renesting attempts to determine the strategy in breeding biology of Neotropical Wrens in an unpredictable environment of Northeastern Colombia. Larison, Layman, and William (2001) used the clutch size and fledging success in the Song Sparrow *Melaspisa melodia* to evaluate the quality of the habitat in the restored stand and natural areas in California.

For the White-rumped Swiftlet *Aerodramus spondiopygius* in Fiji. This species is cogeneric to the White-nest Swiftlet. Tarburton (1986) recorded its clutch size, hatching success and fledging success to test for the feeding ability of a breeding pair and demonstrated the inability of this species to raise more young than that was normal.

In the White-nest Swiftlet, Kang et al. (1991) recorded the nesting success to determine the effect of harvesting on the breeding success and reported that the reproductive success of re-nesting in *C. fuciphaga* declined significantly from 71% after the first harvest to 41% after the second harvest. In Vietnam, Nguyen (1996) found that the reproductive success of renesting *C. germani* Oustalet was 71%, in which the range of overall breeding success was between 45-63% after the first harvesting and he suggested that this might be due to marked variation in climate. However, under the natural condition, Langham (1980) found that the breeding success of *C. fuciphaga* did not differ significantly between the three subsequent clutches.

2.12 Parental care, loyalty in pair and nest-site fidelity of the Edible-nest Swiftlet

Parental care is the allocation on time and energy for breeding activities(e.g. nest building, incubation, nestling feeding, nest defense, etc.) during the breeding cycle. Many authors claimed that both sexes of the Edible-nest Swiftlets allocating in the nest building and incubation (i.e. Nugroho and Whendrato, 1999; Wells, 1999; Chantler and Driessens, 2000).

The White-nest Swiftlet is monogamous (one male and one female form a pair bond and breeding activities are shared by both sexes). It is also believed that the White-nest Swiftlet is faithful to its nest-site, which is called "nest-site fidelity", and its pair which is called as "royalty in pair" (Nugroho and Whendrato, 1999). This manner has been found in other swifts such as Common Swifts *Apus apus* (Chantler and Driessens, 2000). However, There has been little information on the parental care in the White-nest Swiftlet and the previous assumptions remain untested.

2.13 Nest-site characteristics of the Edible-nest Swiftlet

White-nest Swiftlets are cave dwellers, roosting and nesting in the dark or totally dark places in limestone caves off the mainland coast. Somewhere inland, this species can be found living in houses (i.e. abondoned or cultivated houses in Malaysia, Indonesia and Thailand) and in other man-made buildings (e.g. tunnels in Sentosa, Republic of Singapore). Wells (1999) reported that the White-nest Swiftlet prefered to choose higher and inner nest-site in caves than the Black-nest Swiftlet. However, he did not mention in more detail between the two species. A few researchers have been trying to reveal the nest-site characteristic of cave swiftlets (i.e. Robiah,1998; Risman, 1996, cited in Mardiastuti, 1999 : 4) examined the habitat and the morphology of the Black-nest Swiftlet at Misiu Cave, West Sumatra. However, this study did not concentrate on the nest-site characteristics. Therefore, the information of nest-site characteristics is less known.