MORPHOLOGICAL CHARACTERIZATION OF SWIFTLET SPECIES (COLLOCALIA SP.): BEAK, NEST AND SALIVA

by

NORAZLIN BINTI ABDUL AZIZ

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of the requirements for the degree of
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CERTIFICATE

This is to certify that this dissertation entitled

"MORPHOLOGICAL CHARACTERIZATION OF SWIFTLET SPECIES (COLLOCALIA SP.): BEAK, NEST & SALIVA"

is the bonafide record of research work done by

Norazlin Binti Abdul Aziz

During the period from August 2004 to March 2005 under our supervision:

Signature of Supervisor	:	
Name & Address of Supervisor	:	Prof. Syed Mohsin Syed Sahil Jamalullail Deputy Dean School of Health Sciences
Signature of Co-Supervisor	:	
Name & Address of Co-Supervisor	:	Associate Prof. Dr. Farid Che Ghazali Senior Lecturer School of Health Sciences
Date	:	28th April 2005

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GLOSSARY

APERTURE	An opening
APHRODISIAC	An agent that stimulate sexual excitement
EBN	Edible Bird's Nest
EDX	Energy Dispersion X-ray Scanning
H & E	Haematoxylin and Eosin
LM	Light Microscope
VERTAX	Highest point of the head
VPSEM	Variable Pressure Scanning Electron Microscope
Nok Aen	Thai terminology
Kin Rang	Thai terminology
Walet	Indonesian terminology
Sarang	Malay, Indonesian terminology
Burung layang – layang	Malay terminology
Yan wo	Chinese terminology
Tsubame no su	Japanese terminology
Liur mahal	Borneo terminology
Hnget thike	Myanmar terminology
Hnget kyi un butt	Myanmar terminology

Na	Natrium (Sodium)
Si	Silica
Ca	Calcium
C	Carbon
O	Oxygen
Mg	Magnesium
Cl	Chlorin

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ABSTRAK

Burung layang – layang ialah spesis istimewa yang dikenali sebagai pembuat sarang burung komersil yang disediakan sebagai sup. Hidangan yang terkenal sebagai 'Hidangan Timur' ini mempunyai nilai yang amat tinggi di pasaran dan disediakan menggunakan sarang burung yang terdiri daripada air liur burung layang – layang. Memandangkan tidak banyak usaha yang telah dijalankan untuk mengenalpasti ciri – ciri anatomi serta morfologi burung layang – layang dan sarangnya, kajian ini telah dilakukan sebagai langkah awal untuk membuka bidang kajian ini kepada kajian yang lebih mendalam. Kajian ini dijalankan dengan menggunakan alatan berteknologi tinggi, iaitu Mikroskop Elektron Pengimbas (VPSEM) yang dilengkapi dengan penganalisa unsur – unsur surih (EDX) untuk mendapatkan analisis topografi, morfologi serta unsur – unsur yang hadir dalam bahan kajian. Hipotesis awal kajian mengambil kira bahawa air liur yang dikeluarkan oleh burung layang – layang adalah berasal daripada kelenjar utama air liur yang berada di bahagian bawah lidah. Keputusan menunjukkan bahawa terdapat ciri – ciri penting yang lain dan mungkin menyumbang kepada maklumat untuk lebih mendalami dan memahami tingkah laku burung layang – layang semasa membuat sarang. Kesimpulannya, kajian ini telah memberikan maklumat baru yang belum pernah diterokai atau diketengahkan oleh mana – mana pengkaji yang lain.

ABSTRACT

Swiftlets are special kind of swift which is known to be the commercial edible bird's nest builder. This rare delicacy, which is famously known as the 'Caviar of the East' has very high value in the market were made up of glutinous strand of muciginous saliva secretion of the swiftlets. Seeing that not much effort has been done to characterize or properly identify the anatomical and morphological features of the bird's nest and the swiftlet, this pilot research was conducted as preliminary work towards developing this field of research into further studies. This research conducted utilized a very high tech probe, VPSEM incorporated with EDX to yield a morphological topography as well as trace element analysis of the subject concerned in the study. Before this approach was taken, we concluded to believe that the vast salivary secretions of the swiftlets actually come from the paired sublingual gland. However, results of the study showed that there are many other interesting and predominant features that may alter this fact as well as providing an insight towards understanding the nesting behaviour of the species. As a conclusion, these features found during the pilot research were bound to be suggestive of certain characteristic of the swiftlets species that may have not been discovered by any researcher before.

1.0 INTRODUCTION

Review of literatures revealed a vacuum of comparative anatomical and histological knowledge of the swiftlet's tongue. There does not seem to be any available light microscope or electron microscope or proper description of its anatomical features, with regards to taste buds, orientation of intrinsic and extrinsic muscle, and presence of minor salivary glands or tonsils. The close of any available description was of chickens, and was used early on any that described the stratified epithelium and lack of papillae. Although there are papers indicating that birds tongue are present with some structures it was not properly described whether the bone is a proper osteon formed bone or not.

The present investigation, is a pilot study to discuss the data required to determine the safe use of edible bird's nest and to try to qualitate its ingredients, with the hope to be able later to provides advice on the development of risk assessment strategies consistent with due diligence under existing food regulations on consumption of this bird nest. To achieve this goal, the pilot study integrates the morphological characterization and elemental study of the locally available edible nest swiftlet's species (*Collocalia* sp.) using its beak, nest and saliva.

The pilot study utilizes LM (integrated with image analyzer) and VPSEM (incorporated with energy dispersive x-ray scanning, EDX) as research probes for sample analysis. LM integrated with image analyzer enable images to be

snapshot and analyzed using soft imaging software more easily and comprehensively. VPSEM is a user friendly high resolution scanning electron microscope that allows the morphological inspection and probing to be undertaken in a more viable state and condition as compared to the conventional SEM. The integration of microanalysis elemental tracing (EDX) with the VPSEM hypothetically will allows microanalysis of trace elements present in the samples of nest and saliva smear.

Hence, this study is aimed to: (i) characterize and document the identity of the locally available swiftlets species (*Collocalia* sp.) based on the information from available literatures and online reviews and to extrapolate information of medicinal and pharmacological values for future research works, (ii) identify specific morphological features of the selected swiftlet's beak by histological technique, (iii) observe prepared saliva smear and nest morphology under VPSEM and (iv) to qualitate trace elements present in the saliva smear and nest using micro diffusion analysis (EDX) incorporated in the VPSEM.

To initiate a well-formed understanding of the subject of study, the first part of this paper is confined to generate and discuss broad spectrum information relating to the topic to enhance and yield a better perspective and scope of the study.

1.1 HISTORY AND BACKGROUND OF EDIBLE BIRD'S NEST

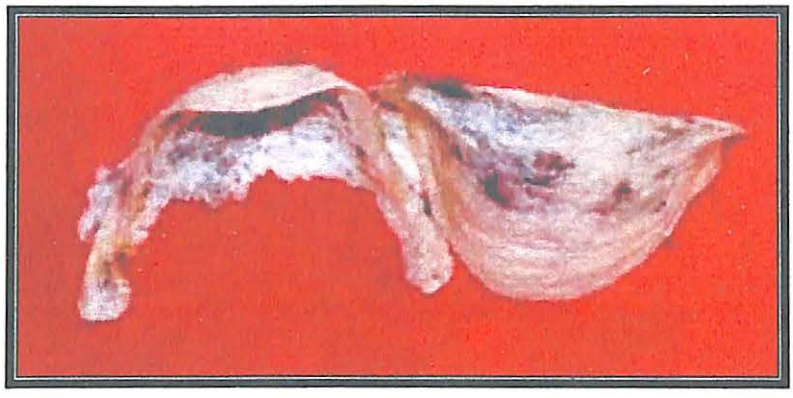

Plate 1.1.1 Edible bird's nest adapted from (http://www.e2121.com/food_db)

'Caviar of the East', as the name implies to the edible bird's nest (EBN) which resembles it's supremacy as an exquisite cuisine of the Oriental. EBN was backdated as an 'Imperial Cuisine' during the China dynasty period, about 1500 years ago. The exclusiveness of the EBN is recognized as a symbol of status and affluence in a society. The EBN is build by swifts, which is confined to only specific species of swiftlets known as the 'edible nest swiftlets'. Characteristically, these species of swiftlets construct their nest using saliva, and consequently producing the EBN.

The literature of "Ben Cao Bei Yao" (The essential notes of materia medica) (Wang, 1694) and "Ben Cao Feng Yuan" (The medicinal herbs in the wild) (Zhang, 1695) of the Qing dynasty show evidence that the ancient Chinese had the belief that the EBN did have some therapeutic effects and were used to cure disease. (http://www.naturalnest.com/the_benefical.html).

Thus, the EBN is being used as a source of medicinal herb in Chinese therapy and is classified as a cold food or "ying" according to the Chinese food concept.

The EBN carries much terminology according to the countries and region, but it is utterly important to know the local or native term of the South East Asian countries. In Chinese, the edible nest is known as '*yan wo*', whereas in Japanese language it is called '*tsubame no su*'. The Borneo people refer to it as '*liur mahal*' which stands for 'expensive saliva'. In Malay, '*sarang burung layang-layang*' is a term used to describe the swiftlet's edible nest whereby the Indonesian called it as '*sarang walet*' (walet stands for swiftlets). As the countries differ in languages, each region will have their own terminology to express the same entity. In Thailand, the EBN is known locally as '*kin rang*'. However, in Myanmar it is quite unique because two term is used referring to the EBN, '*hnget thike*' (edible nest) or '*hnget kyi un butt*' (the vomit of swiftlets). Despite of all the different languages or local name given, it still represents the EBN.

Similarly, the swiftlets are also given special names depending upon the region and languages. It is beneficial to know the local name given because whenever the topic is discussed involving these regions, we will be able to identify that these names actually implies or refer to the same species. Frankly, most people are not used to scientific names. Thus, local name will come in handy as a kick off point in any study concerning with the species that are locally available in any region of interest. Swiftlets (edible nest) species are also given unique local names based on these countries languages; '*jin si yan*'

(Chinese), '*nok aen*' (Thai), '*walet*' (Indonesian), and '*layang-layang padi*' or '*layang-layang gua*' (Malay).

Generally, the EBN is classified into two; white nest and black nest. In some literatures, it is mentioned that there are 4 species of swiftlets (*Collocalia spp.*) whose nest are commercially exploited: Collocalia *fuciphaga* and Collocalia *germani* are called White-nest Swiftlets; Collocalia *maxima* and Collocalia *unicolor* are called Black-nest Swiftlets. However, in some other literatures it is acknowledged that five species is known to build the edible nest; Collocalia *fuciphaga* (White-nest Swiftlets), Collocalia *maxima* (Black-nest Swiftlets), Collocalia *esculenta* (Grass-nest Swiftlets), or Collocalia *vanikorensis* (Mossy-nest Swiftlets). (http://www.ediblebirdnest.com/about_swiftlet.htm).

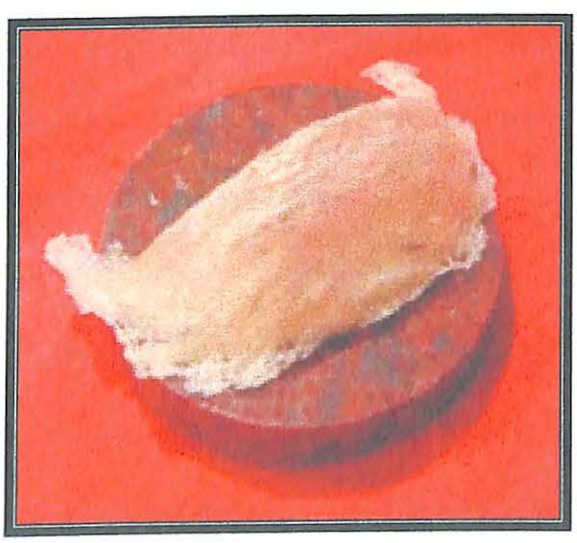

Plate 1.1.2 Collocalia *fuciphaga* nest

Plate 1.1.3 Collocalia *maximus* nest

Plate 1.1.4 Collocalia *esculenta* nest

Pictures were adapted from (http://www.ediblebirdnest.com)

The quality of nest varies dependant upon the nest construction and amount of saliva used to build the nest. The species of swiftlets that builds the nest determine the quality and value worth of the nest. Edible nest that is made purely out of saliva will yield a higher price compared to the nest with feathers and vegetation which requires much more processing yet capitulate lesser amount of pure saliva. In other perspective, the area in which the swiftlets build their nest is also taken into account and influence greatly on the quality as well as the value of the nest. Nest collected from the cave are much more expensive compare to those harvested from the 'house farmed' swiftlets. The pureness of nest also depends upon the level of contamination (air) in the area. Areas away from human inhabitant usually result in higher quality of nest and are observable by the appearance of the nest. So, much likely nests that are collected from the Gua Niah (Sarawak) are way better from the nests harvested from a building nearby urban area.

Nest building is an important and useful behavioral character of birds. No two species build identical nest. (T.P. Roger, 1963). It is an important "facility" in surviving and breeding strategy of animals, invented several times during evolution. Bird nests are more or less a synonym for all nests, from the very simple flat-bowl like scraping nests in the ground camouflaged with some natural products like grass, mosses or lichens not to attract the attention of predators over the well-known cup shaped nests of many songbirds to the ingenious hanging homes of the various types of weaverbirds. (K. Von Frisch, 1974).

Practically all birds construct their nest, resulting in a variety of bird-built architecture that is truly astounding; while some birds hardly put much effort on the nest building, others may construct their nest much more sophisticatedly. There are three main reasons for which the nest is built; to attract a mate, to provide a safe site for eggs and young, or to shelter the birds from adverse weather. (M. Hansell, 2000). Nevertheless, there is no other species of birds in this world whose nest is significantly an important trade for the economy of certain countries.

Swiftlets are believed to have built its nest entirely of glutinous strands of starched like salivary secretion. Swiftlets species were reported to construct its nests by regurgitating a protein in their saliva called mucilage, which solidifies to form the nests. The nests built by male swiftlets during breeding season are made almost entirely from saliva produced by the bird's sublingual salivary glands. Some species also include feathers in their nests, but this amounts at

most to 10% of the dry weight. The nests are composed mainly of glycoprotein. The carbohydrate component consists of 9% sialic acid, 7.2% galactosamine, 5.3% glucosamine, 16.9% galactose, and 0.7% fructose. The most abundant amino acids present are serine, threonine, aspartic acid, glutamic acid, proline, and valine.

1.2 TAXONOMICAL LINEAGE AND CHARACTERISTICS OF SWIFTS: SWIFTLETS

Swifts represent a group of small plain-colored bird that resembles a swallow and is noted for its rapid flight. (http://encyclopedia.thefreedictionary.com). They are said to be the most aerial of birds, because they spend all their active hours in the open sky. (T. P. Roger, 1963). These birds are insectivorous, and they can go miles away from their nest to hunt for insects. Usually, the swifts will leave their inhabitant as early as dawn break and will return as the dusk fall. They are migratory birds; hence they colonize almost all parts of the world except for the Arctic and Antarctic. Swiftlets on the other hand, represents the species under the Collocaliini genera, a tribe classified among the swifts. This term (swiftlets) will be used throughout the discussion to represent the subject relevant to this discussion as the topic of interest.

Taxonomical classifications of swifts are as follow; kingdom of Animalia, phylum of Chordata, class of Aves, order of Apodiformes and the families of Apodidae (swifts) and Hemiprocnidae (crested swifts). The family of Apodidae is further divided into subfamilies of Cypseloidinae (primitive American swifts) and Apodinae (swiftlets, spinetails and typical swifts).Three tribes represented the Apodinae subfamily are: Collocaliini (swiftlets), Chaeturini (spinetails) and Apodini (typical swifts) while the Cypseloidinae is represented by Streptoprocne (primitive American swifts). In our topic of discussion, we are concern only with the swiftlets (Collocaliini) species, otherwise known in layman's term as 'Cave Swiftlets'. The four genera in Collocaliini are *Collocalia, Aerodramus*, *Hydrochous* and *Schoutedenapus*. (http://encyclopedia.thefreedictionary.com). These genera are also originated from Brooke's (1970) early classification of the swiftlets species. (H. A. Thomassen, 2003). Swiftlets species are also set apart by the ability to echolocate. Several species of swiftlets utilize echolocating ability to navigate in the dark, particularly to those species that roost and nest in dark caves. In a cave ecosystem, the species that lack the ability to echolocate will nest at the cave entrance while others equipped with echolocating ability will nest in the roof of the inner caverns.

The great impact of the edible nest in the economy especially the food industry brings about the keen to knowing the swiftlets species more comprehensively. Those involved in the nest harvesting industries are being more selective in terms of selecting the most genuine swiftlets species especially for the 'swiftlets-house farming' industry. Since the beginning of

'swiftlets-house farming', the communities have become more aware towards the ecological perspectives of the swiftlets.

Swifts of the world

Pictures were adapted from (www.boafea.com/ swift_gallery.htm)

Plate 1.2.1 Whiskered Tree swift

Plate 1.2.2 Fork-tailed Swift

Plate 1.2.3 Horus Swift

Plate 1.2.4 Little Swift

Plate 1.2.5 White-rumped Swiftlet

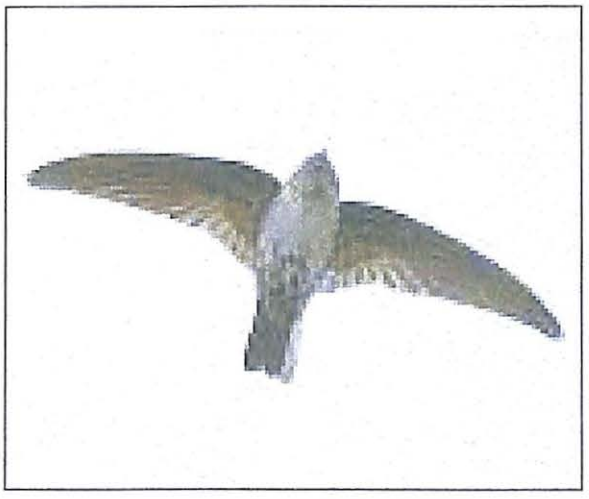

Plate 1.2.6 Glossy Swiftlet

Plate 1.2.7 Pallid Swift

Plate 1.2.8 Black Swift

Plate 1.2.9 Great Dusky Swift

1.3 MEDICAL AND GLOBAL ECONOMIC IMPORTANCE OF SWIFTLETS SPECIES TO HUMAN KIND

Economic importance of the edible nest resides to the countries of South East Asian region, which produces the commercially genuine edible nest due to the distribution of the edible nest swiftlets across the region. Currently, Indonesia is the biggest bird's nest supplier in the world (70% of supply) followed by Malaysia, Thailand and the Philippines, exporting to countries like Hong Kong, Singapore, China and Taiwan (Y. Adrian, 2002).Other exporting countries include India and Sri Lanka. EBN becomes an important economic source due to the fact that it is very highly priced and the demand for it always exceeds supply at any time. In the ultimate China market, it had been reported that a kilogram of whole large white nests can fetch up to RM26,000. As such, birds' saliva is worth two-thirds of the price of gold (http://www.borneodelights.com/exhibition.asp). Therefore the trade of EBN yields a high per capita income for the countries that supplies the edible nest.

Chinese communities all over the globe are the main target consumer of the edible nest. Since the Chinese traditionally consume edible nest as a custom in their community, certain aspect of the nest consumption such as effects and impacts of the edible nest may be seen as a pattern exclusive to the Chinese communities only. The Chinese strongly believe that the EBN have its own therapeutic values and is very essential in Chinese medicine. The EBN is usually double-boiled and prepared into soup which is sometimes cooked

with some other additional ingredients such as rock sugar, and certain types of fungus which is always being encounter in Chinese medicinal herb.

The nest cementing substance for the swiftlets (*Collocalia* spp.) is mainly constituted of sialic acid-rich *O*-glycosylproteins which contains both *N*- and *O*-glycosylproteins and represents a natural source of a carbohydrate rich material. *N*-Acetylneuraminic acid (NeuAc) is the representative of the family of sialic acids, and is a very important molecule found in the EBN. Other than that, NeuAc also the most ubiquitous sialic acid and is the biosynthetic precursor for all the other sialic acid. *In vivo,* sialic acid plays tremendous functions: (i) endowment of negative charge on cellular membrane as glycoconjugates, (ii) determination of the macromolecular structures of certain glycoproteins, (iii) information transfer between cells, and (iv) recognition of specified glycoconjugates and cells based on specific bio-activities. (I. Maru *et al*, 2002).

These tiny bird's nests are considered by some as an aphrodisiac. One study has shown the presence of a glycoprotein capable of promoting cell division, and another has demonstrated the presence of an epidermal growth factor–like protein. (Goh *et al*, 2001). The epidermal growth factor discovered is most probably related to the sialic acid compound of the edible bird's nest. Even though not yet scientifically proven, some people have claimed that the EBN is a potential remedy for treatment of certain disease as well. Recent studies in Hong Kong suggested that it may even be useful in the treatment of AIDS.

Apart from all the beneficial effects of the edible bird's nest, it has also shown to induced anaphylaxis of food derived. Food-induced anaphylaxis is a potentially lethal reaction. Deaths are related to undiagnosed allergy or to the unwitting consumption of the allergen. Bird nest allergy of children hospitalized for anaphylaxis has been reported in Singapore. (Goh *et al*, 2001).

Swiftlets also plays an important role in the ecosystem. As the nature of the swiftlets being insectivores, it feeds on wide range of insects that may as well include the destruction causing insect otherwise known as pests. The swiftlets is a very good biological control of pest because it does not feed on crops, only insects. They can become important agents in regulating the population of pests.

1.4 SELECTED SWIFTLET'S SPECIES WITH EDIBLE BIRD'S NEST POTENTIALS

1.4.1 Collocalia *fuciphaga* Species

Collocalia *fuciphaga* is a scientific name given to a species of swiftlets popularly known as the White Nest or House Nest swiftlets and also the Cave swiftlets due to its nesting habit. Aerodramus *fuciphagus* is a synonym of C. *fuciphaga*. The male birds from this species construct their creamy white nest by regurgitating their saliva, a glutinous nest-cement substance produced

by paired sublingual gland which is said to enlarge 50 times during breeding season. The nest is made into an opaque shape (cup shape), beginning with the construction of the hinge region, a U-shaped layer of saliva. Then the nest is built up gradually with layer upon layer of saliva. The dried and hardened layer of saliva constitutes the raw material of bird's nest soup and renders the nest its commercial importance. The glutinous strands substance in the nest of C. *fuciphaga* species is about 85-97% in its unprocessed form, making it the most sought after in the market as well as commanding the highest price. The higher the content of the saliva with very few feathers or vegetation will require less processing of the nest, thus placing it into a higher rank in terms of quality and price. Most if not all edible bird's nest farm cultivate this particular species commercially.

The breeding season for the swiftlets starts at late November until end of February. This is the time when nest collection or harvesting also begins. This species usually will attempt another nest building if the first nest is destroyed or collected. However, in areas where nest collection is so intense it is possible for the species to make several nests building attempt during a season, and may or may not use the same site for the next nest. (R. Sankaran, 2001).

C. *fuciphaga* measures about 12 cm in its entire length and weighs about 15 to 18 gm. This swiftlet has a band of brownish gray feathers across the rump with dark brown eyes, black beak and feet. Eggs are laid 2 at a time, slightly oval in shape and white in color. (http://www.ediblebirdnest.com/about_swiftlet.htm). The type of nest that this

species builds is the white nest, by far the most expensive type of EBN available in the market. This species is also known to echonavigate, meaning that they are able to find their way especially in total darkness by echolocation. Collocalia species are mainly distributed within the Southeast Asia including India, making their nest as an important economic trade for the countries under this region.

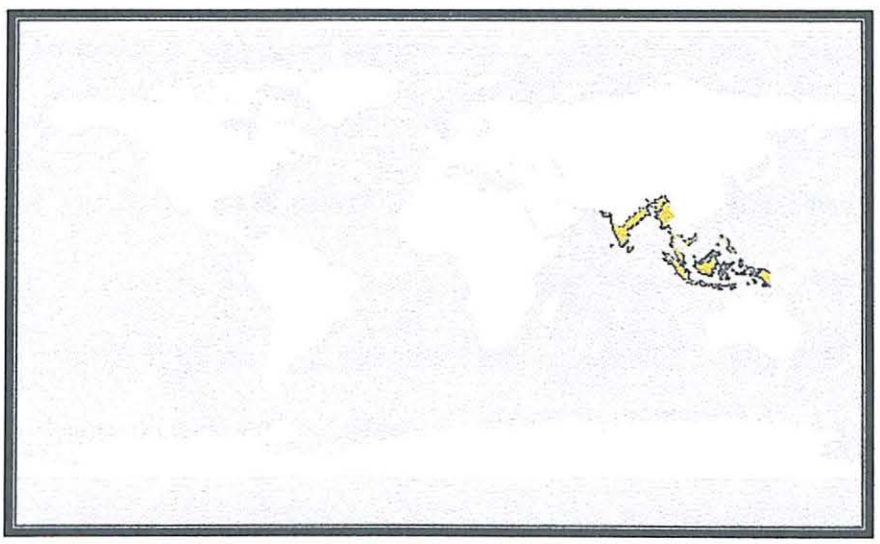

Figure 1.4.1.1 Distribution of White Nest Swiftlets (*Collocalia* spp.) adapted from (http://www.ebnresources.ebigchina.com)

Plate 1.4.1.2 Picture of Collocalia *fuciphaga* at nest site adapted from (http://www.borneodelights.com/chinese/birdsnest10.asp)

2.0 OBJECTIVES: GENERAL AND SPECIFIC

In terms to analyze and characterized the potential of the birds nest and the swiftlet itself as a global commercial therapeutic, pharmacological value entity, effort is made via this research to analyze the histological features to relate the functions of the nest by its saliva. Hypothesized questions are; (i) whether only the sublingual gland is the main gland for the saliva and production of muciginous secretion as is there other gland involved, (ii) is there existence of accessory salivary gland and their probable functional role, (iii) how is the morphology of the formed nest observed under SEM, (iv) what elements of the periodic table can be quantify from the nest and (v) is there any morphological adaptation especially in *Collocalia* associated with bird's nest formation. To analyze and characterized these questions, a light microscopic histological analysis compensated with VPSEM was undertaken.

3.0 LIMITATIONS OF THE STUDY (PRERESEARCH)

Time limitation and resources are the main concern in conducting the study. Eventhough the time duration given to prepare the thesis is 2 semesters, but due to tight schedule the study was delayed and the pending results is also delayed. Before the study is being start off, the samples have to be collected first. This is another major predicament that is being faced because the samples are not easily obtained. Since we are conducting a study on the swiftlets, we need the bird samples as well as the bird's nest. These seem to have encountered much more dilemma since a lot of people that we confronted to acquire the samples were unwilling to cooperate. Eventhough at first they agreed to help, later on after considering on the risk that they are taking which may be the migration of the birds away from their house farm, they decided not to provide us with samples. Literatures surveyed also lacking in information that is needed for the study. So, depending upon the limited sources as well as samples we were able to get on with the study.

4.0 INCLUSION AND EXCLUSION OF THE STUDY

The study includes subjects or samples of locally available swiftlets species (*Collocalia* sp.) only. The nests and the freshly dead birds were collected from the same area for control purposes. The range of species under concern is restricted to only those that are locally available in Malaysia, narrowed down to area of Kuala Besut, Terengganu. There are also nests from a few areas of Kelantan that represents nest from the house as well as from one of the local cave taken as comparative purposes. Collocalia *fuciphaga* species is our main interest in the study, thus excluding other species of swiftlets. Approximately, there are 12 species of swifts in Malaysia. Since our main concern is only the edible nest swiftlets (*Collocalia* sp.), other species which are not potential for edible bird's nest including all the common swift are excluded from the subject. In the literatures reviewed, our goal is also to find information on the same species that we use for the study as to provide better background information and enhance our knowledge of the species. However, information from a different type of species may also be incorporated and correlated into our study to form a well-rounded and more structured study.

5.0 MATERIALS AND METHODS

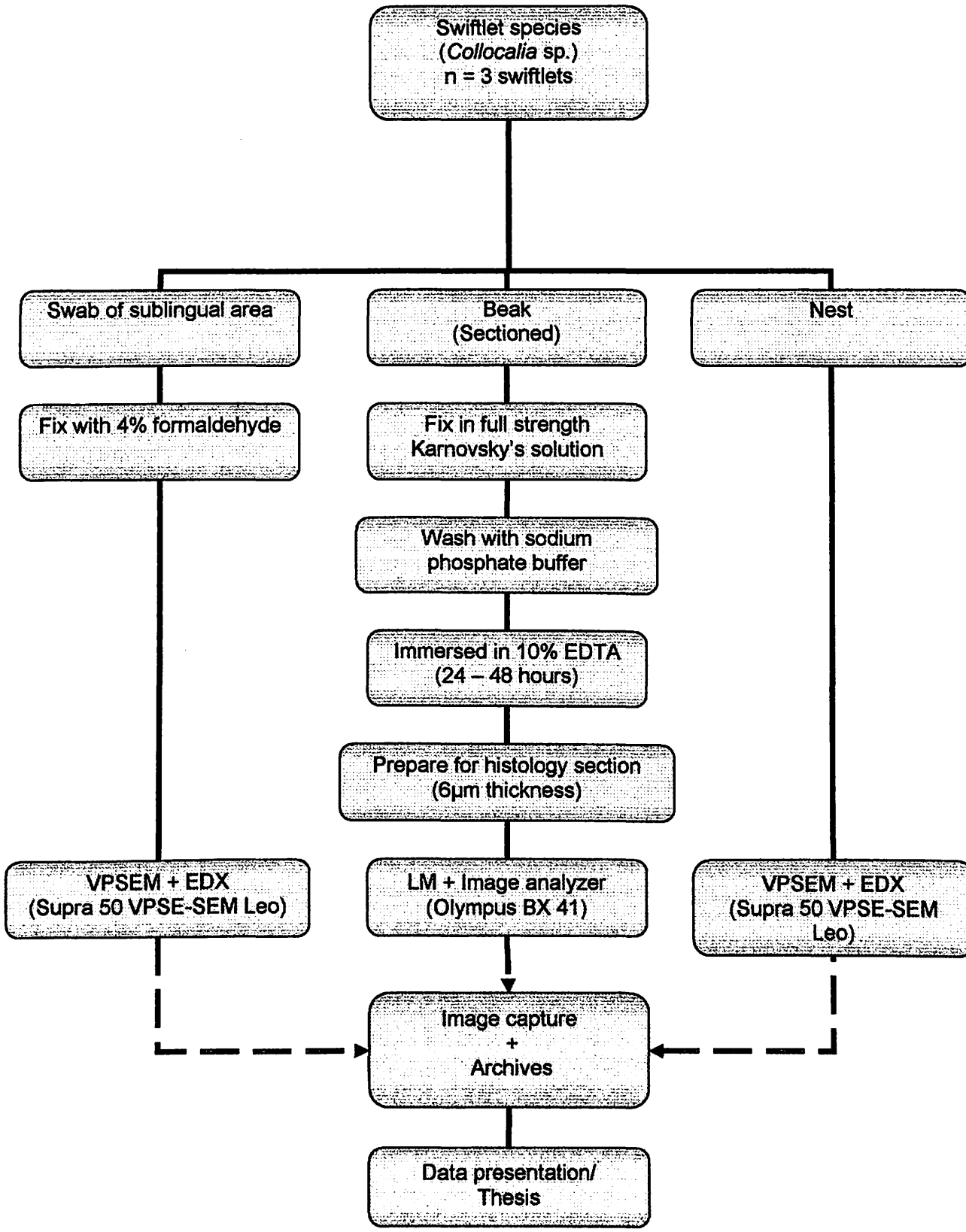

Figure 5.1 Flow chart of methodology

5.1 BEAK

To acquire the beak section, first a portion of the swiftlet's head was gently sectioned until the lower corners the eye area using saw microtome. The cut section yielded a separated upper and lower jaw of the swiftlet's beak, with the tongue kept intact and still attached to the lower jaw. Then, these sections were fixed in full strength Karnovsky's solution overnight and then washed with sodium phosphate buffer solution. Next, both of the upper and lower jaw sections are transferred into 10% EDTA solution for demineralization purpose. This process takes about 3-4 days before the sections were fully demineralized for further tissue processing.

The next step is to produce histological sections (6μm) of the cut portions, upper and lower jaw. After demineralization, the upper and lower jaw sections were processed in a tissue processor, embedded and cut into thin sections (4-6μm thickness) longitudinally. This step is followed by the preparation of tissue slides and stained using H & E (haematoxylin and eosin) stain.

Lastly, the slides prepared were observed under LM (OLYMPUS BX41) incorporated with camera (COLOR VIEW XS) for image captures via SOFT IMAGING SYSTEM image analyzer.

Longitudinal cut of swiftlet's beak

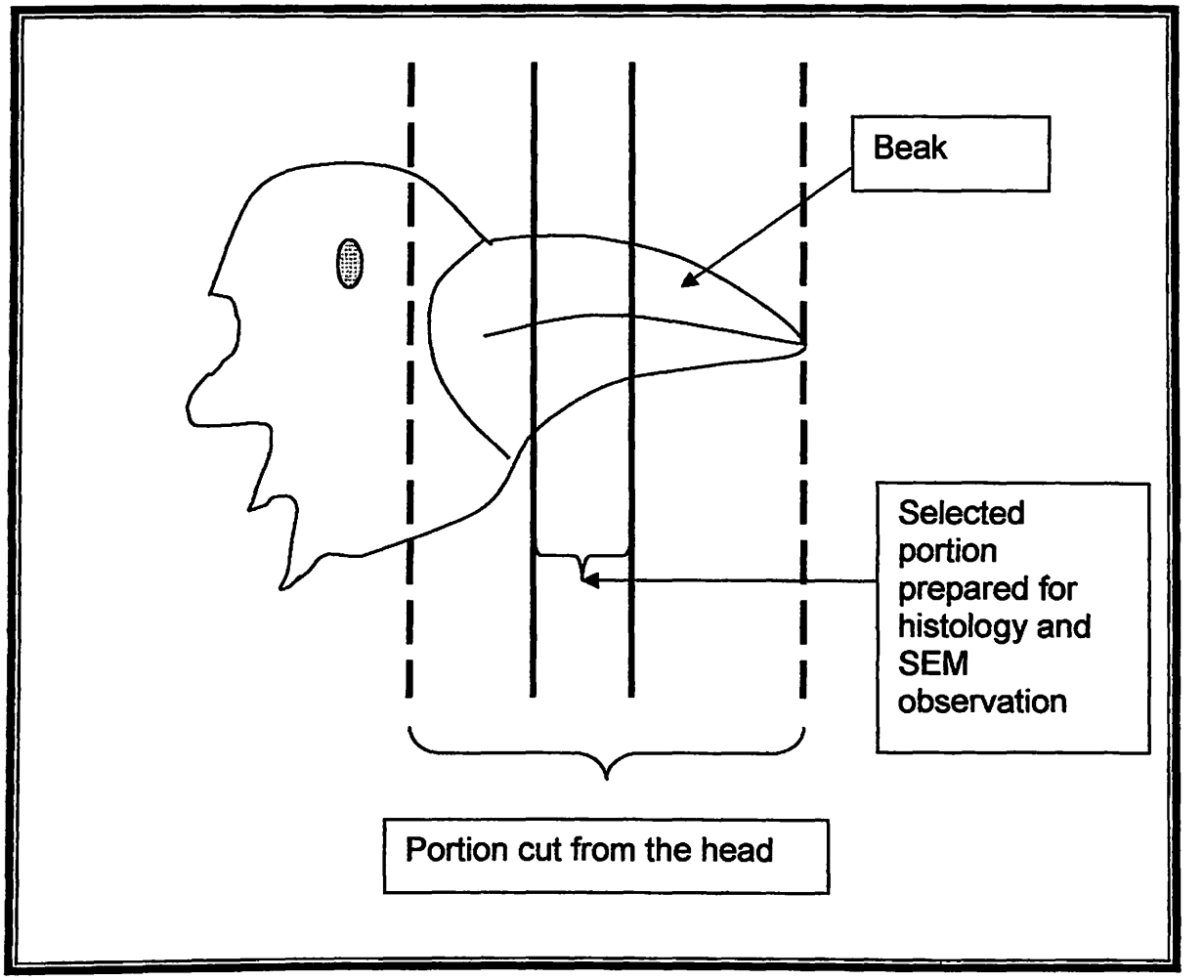

Figure 5.1.1 Artist illustration of longitudinal sectioning of the swiftlet's beak for histological and SEM observation

5.2 VPSEM OBSERVATION OF THE NEST

The nest collected from the study area (Kuala Besut, Terengganu) was not histologically processed or stained to maintain its original morphology and structure. A small portion of the nest was sectioned and observed using backscattered electron mode of the VPSEM at 27 - 35 kPa (Pascal pressure) and 8mm working distance. Then, two spots were chosen from the VPSEM observation for trace element analysis using EDX. Then, the results were recorded in the form of graph showing the trace element present in the nest. The model of VPSEM used for the study is SUPRA 50 VPSE – SEM LEO. Images were captured and kept for further analysis and interpretation.

5.3 SALIVA SMEAR

The saliva of the swiftlet was swabbed using a fine cotton bud and prepared into a smear. The saliva smear was then fixed with 4% formaldehyde and analyzed using Supra 50 VPSE – SEM and quantify under EDX.

6.0 RESULTS

The bird is glossy black, with an area of white-brown across the rump, under the chin and under the wing. The length of the bird measured from the beak to end of wing is about 12-14 cm. The under part of its body is black in color. The tail of the bird is slightly forked with extension of the wing longer than the tail. The wing is crescent shaped and the feet are covered with very few feathers. This short slightly curved beak of the swiftlets was black and very small, but its mouth when opened achieved an outstandingly wide gap. The nest was cream-whitish yellow, with some feathers stuck in between the layers and appeared to be made up of layers of hollow but rigid structure. The swiftlet's physical features are suggestive of Collocalia *fuciphaga*. Thus it is assumed that the sample that we have is a sample from this species.