



UNIVERSITI PUTRA MALAYSIA

***COMPARATIVE MORPHOLOGY OF THE GASTROINTESTINAL
TRACT OF WHITE EDIBLE BIRD'S NEST SWIFTLET
(*Aerodramus fuciphagus* [Thunberg]) AND
HOUSE SWIFT (*Apus nipalensis* [Hodgson])***

FHAISOL MAT AMIN

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**MASTER OF VETERINARY SCIENCE
UNIVERSITI PUTRA MALAYSIA**

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AND HOUSE SWIFT (*Apus nipalensis* [Hodgson])**

By

FHAISOL MAT AMIN

**Thesis submitted to the School of Graduate Studies, University Putra
Malaysia**

**in Fulfilment of the Requirements for the Degree of
Master of Veterinary Science.**

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Masters of Veterinary Science.

**COMPARATIVE MORPHOLOGY OF THE GASTROINTESTINAL
TRACT OF WHITE EDIBLE BIRD'S NEST SWIFTLET
(*Aerodramus fuciphagus* [Thunberg]) AND
HOUSE SWIFT (*Apus nipalensis* [Hodgson])**

By

Fhaisol Mat Amin

Chairman : Intan Shameha Binti Abd Razak, Ph.D
Faculty : Veterinary Medicine

A. fuciphagus or White Edible bird's-nest Swiftlet (EBN Swiftlet) and *A. nipalensis* or House swift belong to Apodidae family. *A. fuciphagus* is the only bird in the world constructing its nest using saliva, whereas *A. nipalensis* builds its nest using grass and saliva as adhesive materials. The objective of this study is to evaluate the macro and microscopic morphology of the gastrointestinal tract of six selected male *A. fuciphagus* and four selected male *A. nipalensis*. The birds were caught in Kuala Terengganu, Terengganu, and in FELDA Redong, Segamat, Johore, using mist net according to the FAO standards, and were transported and immediately euthanized by injecting pentobarbital sodium (Nembutal®) at 80 mg/kg body weight through a brachial ulnar vein upon arrival at the Anatomy Laboratory, Faculty of Veterinary Medicine UPM. The body weight and length and the gastrointestinal tract (GIT) weight and length of each bird were measured, recorded and calculated into relative GIT weight and length. These values were analyzed using Mann-Whitney U Test for non-parametric data. The GIT specimens were then fixed in Bouin's solution and underwent various processes for histomorphological and histomorphometrical evaluations. The histological evaluations include the used of H&E, Masson trichrome, Van Gieson, Gomori trichrome. Periodic acid-Schiff (PAS), Aldehyde fuchsin, Alcian blue pH 1.0 and pH 2.5, Aldehyde fuchsin-Alcian blue (AF-AB) and Periodic acid-Schiff-Alcian blue (PAS-AB) were used to determine and classify the type of mucins. Histomorphometric evaluations were also conducted on koilin thickness, villus height, and crypt depth, thickness of the tunica muscularis externa and goblet cell of the intestines. It was observed that the tongue had a sharp burficated apex, the esophagus was an elongated tubular structure with absence of crop and it continuously connected to the proventriculus, ventriculus and small intestine. The ventriculus was formed by a thick and strong muscle, whereas the intestines lacked both a cecum and *Meckel's diverticulum*. All the recorded weight and length of the GIT and its glandular organs of *A.fuciphagus* were found to be smaller ($P \leq 0.05$) than those of *A.nipalensis*, except for the esophagus and pancreas. However, when calculated based on the relative weight and length, all the GIT and

its glandular organs of *A.fuciphagus* were found to be significantly greater ($P\leq 0.05$) than those of *A.nipalensis*, except for the esophagus and pancreas. The tissue arrangement of the GIT in both *Apodidae* species consisted of mucosa at the innermost layer, with absent of the muscularis mucosa. It was followed by a submucosa rich in glandular structure, the tunica muscularis externa, comprised of inner longitudinal and outer circular muscle, and finally the serosa as the outermost layer. The tongue of both species of birds was comprised of a keratinized squamous epithelium, which was found to be thicker in the dorsal than ventral region. The submucosa layer consisted of a massive glandular structure, absent in the apical region of the tongue. The mucins were detected in the glands of the tongue and also along the GIT of *A. fuciphagus* and *A. nipalensis*. The lingual and esophageal glands of *A. fuciphagus* consist of acid carboxylated mucins, but *A. nipalensis* had a mixture of carboxylated and sulfated mucins. Along the GIT, the type of mucins was considerably similar. In turn, the thickness of koilin, height of the villus, crypt depth, thickness of the tunica muscularis externa and goblet cells in the intestinal segments were found to be significantly different ($P\leq 0.05$) in both *A. fuciphagus* and *A. nipalensis*. As a conclusion, the significant differences ($P\leq 0.05$) in the morphology of the GIT of *A. fuciphagus* and *A. nipalensis* are related to both the type of diet and the nest building ability.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia Sebagai memenuhi keperluan ijazah Sarjana Sains Veterinar

**PERBANDINGAN MORFOLOGI TRAKUS GASTROUSUS BURUNG
WALIT SARANG PUTIH (*Aerodramus fuciphagus* [Thunberg]) DAN
BURUNG LAYANG – LAYANG RUMAH (*Apus nipalensis* [Hodgson])**

Oleh

FHAISOL MAT AMIN

Pengerusi : Dr Intan Shameha Binti Abd Razak, Ph.D
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A.fuciphagus atau Burung Walit Sarang Putih (EBN walit) dan *A. nipalensis* atau Layang – Layang Rumah tergolong dalam keluarga Apodidae. *A. fuciphagus* merupakan satu-satunya burung di dunia yang membuat sarang dengan menggunakan air liur manakala *A.nipalensis* membina sarangnya menggunakan rumput dan air liur sebagai bahan pelekat. Objektif kajian ini adalah untuk menilai morfologi makro dan mikroskopik saluran gastrousus ke atas enam ekor jantan *A. fuciphagus* dan empat ekor *A. nipalensis* terpilih. Burung – burung itu ditangkap di Kuala Terengganu, Terengganu dan di FELDA Redong, Segamat, Johor menggunakan pukat mengikut piawaian FAO yang kemudiannya dibawa dan dimatikan dengan menyuntik sodium pentobarbital (Nembutal®) pada kadar 80mg/kg berat badan melalui vena ulnar brakial sejurus tiba di Makmal Anatomi, Fakulti Perubatan Veterinar UPM. Berat dan panjang badan; berat dan panjang saluran gastrousus setiap burung diukur dan direkodkan. Ia kemudiannya dikira berdasarkan kepada berat dan panjang relatif. Data-data ini dianalisis dengan menggunakan Ujian Mann -Whitney U untuk data bukan parametrik . Spesimen GIT kemudiannya ditetapkan ke dalam larutan Bouin dan menjalani pelbagai proses untuk penilaian histomorfologi dan histomorfometrik. Penilaian histologi termasuk pewarnaan ‘H&E’, ‘Masson trichrome’, ‘Van Gieson’, ‘Gomori trichrome’ telah digunakan. Pewarnaan ‘Periodic acid-Schiff’ (PAS), aldehid fuksin , alcian biru pH 1.0 dan pH 2.5, Aldehid fuksin - ‘Alcian blue’ (AF- AB) dan ‘Periodic acid-Schiff’ – ‘Alcian blue’ (PAS- AB) telah digunakan untuk menentu dan mengkelaskan jenis mucins. Penilaian histomorfometrik juga telah dijalankan ke atas ketebalan koilin, ketinggian vilus, kedalaman krip, ketebalan maskularis eksterna dan sel goblet usus. Diperhatikan bahawa lidah mempunyai hujung bercabang yang tajam, esofagus berbentuk tiub panjang dengan ketiadaan tembolok dan ia bersambung ke proventrikulus, ventrikulus dan usus kecil. Ventrikulus terbentuk daripada otot yang tebal dan kuat, usus pula didapati tiada sekum dan ‘Meckel’s diverticulum’. Berat sebenar semua organ trakus gastrousus dan organ kelenjar di dalam *A.fuciphagus* yang direkodkan didapati rendah dengan ketara ($P\leq 0.05$) berbanding *A.nipalensis* kecuali esofagus dan pancreas. Walau bagaimanapun, apabila perkiraan dibuat berdasarkan berat dan panjang relatif, Walau bagaimanapun, apabila ia telah dikira

berdasarkan berat relatif dan panjang, semua organs trakus gastrousus dan organ kelenjar di dalam *A.fuciphagus* didapati lebih tinggi dengan ketara ($P \leq 0.05$) daripada *A.nipalensis* kecuali esofagus dan pankreas. Susunan tisu GIT dalam kedua-dua spesies Apodidae ini terdiri daripada mukosa di lapisan terdalam dengan tidak mukosa maskularis. Ia diikuti oleh submukosa yang kaya dengan struktur kelenjar; selaput muskularis eksterna terdiri daripada otot bulat membujur dalaman dan otot melintang luar dan akhirnya lapisan serosa di bahagian paling luar. Lidah kedua-dua spesies burung ini terdiri daripada epitelium skuamus berkeratin yang didapati tebal pada bahagian dorsal berbanding bahagian ventral. Lapisan submukosa pula terdiri daripada struktur kelenjar yang banyak tetapi tiada pada bahagian apeks lidah. Mucins dikesan di kelenjar lidah dan juga di sepanjang trakus gastrousus *A.fuciphagus* dan *A.nipalensis*. Kelenjar lidah esophagus *A.fuciphagus* terdiri daripada mucins berasid berkarboksilat tetapi dalam *A.nipalensis* adalah campuran mucins berkarboksilat dan bersulfat. Dalam GIT lain, jenis mucins adalah sama. Ketebalan koilin, ketinggian vilus, kedalaman krip, ketebalan muskularis eksterna dan sel goblet dalam usus didapati berbeza dengan ketara ($P \leq 0.05$) dalam kedua-dua spesies *A.fuciphagus* dan *A.nipalensis* yang dikaji. Sebagai kesimpulannya, perbezaan yang ketara dalam morfologi trakus gastrousus *A.fuciphagus* dan *A.nipalensis* dipengaruhi oleh jenis diet dan juga keupayaan membina sarang.

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I certify that a Thesis Examination Committee has met on 7th January 2014 to conduct the final examination of Fhaisol Bin Mat Amin on his thesis entitled "Comparative morphology of the gastrointestinal tract of the White Edible Bird's nest Swiftlet (*Aerodramus fuciphagus* [Thunberg]) and House Swift (*Apus nipalensis* [Hodgson])" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Veterinary Science.

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LIST OF ABBREVIATIONS

AB-PAS	Alcian blue- Periodic acid-Schiff stain
AB-PAS	Alcian blue- Periodic acid-Schiff stain
AF-AB	Aldehyde fuchsin-Alcian blue stain
ANOVA	Analysis of Variance
AD	Anno Domini
cm	Centimeter
°C	Degree Celsius
ETP	Economic Transformation Program
EBN	Edible bird's-nest
FAO	Food and Agricultural Organization
GIT	Gastrointestinal tract
g	Gram
H&E	Haematoxylin and Eosin
HCL	Hydrochloric acid
kg	Kilogram
µm	Microgram
ml	Milimeter
mg/kg	Milligram per kilogram
%	Percentage
PEMANDU	Performance Management Delivery Unit
PAS	Periodic acid-Schiff stain
RM	Ringgit Malaysia
SE	Standard error
SPSS	Statistical Package for the Social Sciences
UPM	Universiti Putra Malaysia

CHAPTER 1

INTRODUCTION

Toward the goal of becoming a high-income country by 2020, Malaysia has recognized swiftlet farming as one of the major projects under the Economic Transformation Program (ETP) (Pemandu, 2011). In the 2011 budget, the Government of Malaysia has allocated a total of RM 135 million to promote the participation of farmers in the high-value agriculture cluster (swiftlet farming, herbs, ornamental fish, seaweed and aquaculture) (Razak, 2010). Currently, there are about 50,000 active premises of swiftlet houses in Malaysia, mainly in Sabah and Sarawak, making Malaysia the second largest producer in the world of Edible Bird's-nest (EBN) after Indonesia (Hobbs, 2004), with 10% of world market and approximately 375 metric tons annually (Kadir, 2012). In 2001, Hong Kong and North America were the world's largest importer and consumer of the processed nests, respectively (Goh *et al.*, 2001). In 2020, EBN are expected to generate approximately RM 4.5 billion for Gross National Income (GNI) with 20,800 jobs created and an additional increased revenue from RM 0.5 billion to 4.5 billion. (Pemandu, 2011).

All members of Apodidae family are able to produce saliva in feeding and as nest cement (Camfield, 2004). However, due to their medicinal value, three species from Apodidae, namely *A. fuciphagus* (white edible bird's-nest swiftlet), *A. maxima* (black edible bird's-nest swiftlet) and *A. unicolor* (Indian swiftlet), were reported to be highly exploited for human consumption, especially by the Chinese community (Nguyen and Voisin, 1993; Lau and Melville, 1994). *A. fuciphagus* constructs its nests using their saliva, occasionally in combination with feathers (Lee *et al.*, 1996). In turn, around 10% of the nest of *A. maxima* is normally composed of feathers, while the nest of *A. unicolor* contains saliva, vegetation and feathers (Kang and Lee, 1991; Kang *et al.*, 1991; Lau and Melville, 1994).

Both the House Swift (*A. nipalensis*) and the White Edible Bird's-nest Swiftlet (*A. fuciphagus*) belong to the order Apodiformes, suborder Apodi and family Apodidae (Figure 1.1) (Chantler and Driessen, 1995; 2000; Packert *et al.*, 2012; Bird Life International, 2013). These two species are aerial insectivorous birds where the insects their diet (Zhou, 2002). Unlike the White edible bird's-nest, the House Swift, also known as Malay House Swift (*A. nipalensis*), is categorized as the least concerned bird (Camfield, 2004; BirdLife Int. 2013) and is a native bird of the country in South East Asia and East Asia (BirdLife Int. 2013). There are also some similarities and differences between *A. fuciphagus* and *A. nipalensis*. For instance, both of these two species have long hand-wing., *A. fuciphagus* has dull plumage without white color on their back and the nest of *A. nipalensis* is made from grass and feathers (Figure 1.2).

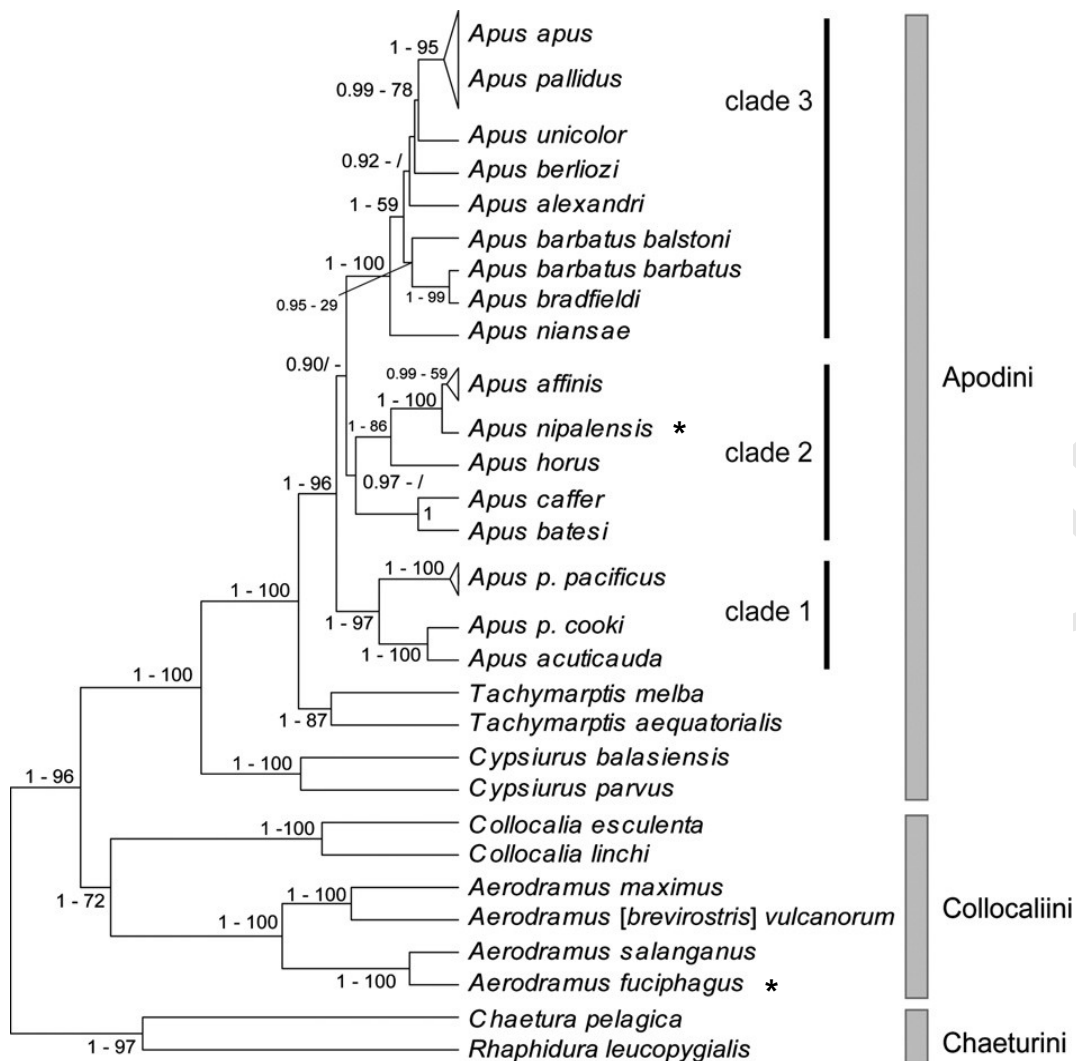


Figure 1.1: Phylogenetic tree of Apodidae family: Note the position of the *A. nipalensis* and *A. fuciphagus* (*) (Source: Packert *et al.*, 2012).



Figure 1.2: Photograph showing similarities and differences between *A. fuciphagus* (A) and *A. nipalensis* (B). Both of these two species have long hand wing. Note that the differences on plumage, *A. fuciphagus* is dull without white colour on their back and the nest of *A. nipalensis* is made from grass and feathers.

The Edible Bird's Nest (EBN) has been used since Tang's dynasty (618 AD).. Considered the 'Caviar of the East', it became an important item not only in Chinese cuisine but also in pharmacy (Marcone, 2005). The Chinese cook this tonic food, which is commonly known as "bird's nest soup". The nests are doubly cook with-steamed and sugar to produce the gastronomic delicacy (Hobbs, 2004; Ma and Liu, 2012) and as an alternative medicine in dissolving phlegm, improving the voice, relieving gastric troubles, aiding renal functions, raising libido, enhancing complexion, alleviating asthma, suppressing cough, curing tuberculosis, strengthening the immune system, speeding recovery from illness and surgery, increasing energy and metabolism, and improving concentration (Francis 1987; Jong *et al*, 2013). EBN is scientifically proven to have hemagglutination inhibiting activities against influenza virus and to contain epidermal growth factor (Marcone, 2005; Wu *et al* 2010).

Although the Edible Bird's Swiftlets belong to the family of another type of swiftlet and share approximately similar diet (Nguyen *et al.*, 2006), the nest construction materials used by these species are totally different (Lourie and Thompkin, 2000; Nguyen *et al*, 2006). To date, there was very limited information regarding the gastrointestinal tract morphology of these insectivorous birds and to our knowledge the morphology of GIT in EBN Swiftlets and House Swift hasis never been reported. Most of the previous studies conducted only focused on the insectivorous birds from passerine families (Klasing, 1998; Kaspari, 1991; Kaspari and Joern, 1993). Many studies suggested that the GIT morphology are well-correlated with the diet consumed (McLelland 1975; Bailey, 1997; Denbow, 2000). By understanding the gastrointestinal tract of these species will enable us to correlate their morphological structures to the diet. The House Swift and the White EBN Swiftlet can the studied together, to explore and investigate the similarities and differences within the Apodidae family. In this study, the working hypothesis is that the morphology of the GIT in *A. fuciphagus* and *A. nipalensis* are not significantly different.

The objectives of this work were to describe and compare the following features of the White EBN Swiftlet (*A.fuciphagus*) and the House Swift (*A.nipalensis*)

- The gross morphology of the gastrointestinal tract;
- The histological structures of the gastrointestinal tract;
- The histomorphometric of the ventriculus and intestines.

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