UNIVERSITI
MALAYSIA
KELANTAN

IDENTIFICATION OF ECTOPARASITES IN BUDGERIGARS (*MELOPSITTACUS UNDULATUS*) AND THEIR ASSOCIATED RISK FACTORS IN THREE SELECTED ZOOS IN MALAYSIA

By

KU NUR AFIFATIN BINTI KU HARIZAN

A RESEARCH PAPER SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF DOCTOR OF VETERINARY MEDICINE

FACULTY OF VETERINARY MEDICINE
UNIVERSITI MALAYSIA KELANTAN

2025

ORIGINAL LITERARY WORK DECLARATION

I hereby certify that the work embodied in this thesis is the result of the original research and has not been submitted for a higher degree to any other University or Institution.

/	**OPEN ACCESS**	I agree that my thesis is to be made immediately available as hardcopy or online open access (full text).
	EMBARGOES	I agree that my thesis is to be made available as hardcopy or online (full text) for a period approved by the Post Graduate Committee. Dated from_______ until_______.
	CONFIDENTIAL	(Contains confidential information under the Official Secret Act 1972) *
	RESTRICTED	(Contains restricted information as specified by the organization where research was done) *

I acknowledge that Universiti Malaysia Kelantan reserves the right as follows.

1. The thesis is the property of Universiti Malaysia Kelantan.
2. The library of University Malaysia Kelantan has the right to make copies for the purpose of research only.
3. The library has the right to make copies of the thesis for academic exchange.

SIGNATURE OF CANDIDATE	SIGNATURE OF SUPERVISOR
NRIC/PASSPORT NO. 000407090010	DR. GOH SOON HENG
DATE: 29/11/2025	DATE: 29/11/2025

Note: * If the thesis is CONFIDENTIAL OR RESTRICTED, please attract the letter from the organization stating the period and reasons for confidentiality and restriction.

ABSTRACT

An abstract of the research paper presented to the Faculty of Veterinary Medicine, University Malaysia Kelantan, in partial requirement of the course DVT 55204 - Research Project.

Ectoparasitic infestation is one of the major causes of morbidity and mortality in captive bird populations, yet limited research has been conducted on the ectoparasites affecting budgerigars in Malaysia. This study was conducted to determine the presence of ectoparasite infestation, identify the genera present and assess the associated risk factors among budgerigars in three zoos in Malaysia. A total of 50 budgerigars were sampled randomly via feather plucking and acetate tape methods. The ectoparasites identified were examined under an Olympus CX21FS1 microscope for identification using the available taxonomic keys and reported morphological features. The result showed a 100% detection percentage, with all 50 budgerigars testing positive for feather mites that were tentatively identified as *Kramerella* spp., *Eustathia* spp., *Analges* spp., *Proctophyllodes* spp., *Sokoloviana* spp., *Ptiloxenoides* spp., *Syringophilus* spp., *Pandionacarus* spp., *Ardeacarus* spp., *Pelargolichus* spp., and *Fainalges* spp. No lice or ticks were identified. Findings were presented descriptively as the statistical association could not be determined between the infestation status and risk factors. The universal presence of ectoparasites was due to their ability to survive long-term on birds, spread widely within zoo settings, and survive on fallen feathers. Advanced molecular analysis is required for further identification of the mites down to the species level. More extensive screening of the budgerigars is needed to fully assess the risk factors and zoonotic potential associated with the presence of the feather mites.

Keywords: *Budgerigars, Captive bird, Ectoparasite, Feather mites, Zoos*

ABSTRAK

Abstrak kertas penyelidikan dibentangkan kepada Fakulti Perubatan Veterinar, Universiti Malaysia Kelantan sebagai keperluan daripada kursus DVT 55204 - Projek Penyelidikan.

Infestasi ektoparasit merupakan salah satu punca utama kepada peningkatan kadar penyakit dan kadar kematian dalam populasi burung dan kajian berkaitan infestasi ektoparasit terhadap burung baji di Malaysia sangat terhad. Oleh itu, kajian ini dijalankan untuk menentukan kadar infestasi ektoparasit, mengenal pasti genera dan menilai faktor-faktor risiko yang berpotensi dikaitkan dengan infestasi dalam burung baji di tiga zoo di Malaysia. Sebanyak 50 ekor burung baji telah di sampel secara rawak dan sampel telah diambil melalui kaedah potongan bulu dan pita pelekat. Ektoparasit yang diperoleh diperiksa di bawah mikroskop untuk tujuan pengecaman berdasarkan taksonomi dan ciri morfologi yang telah dilaporkan. Hasil kajian menunjukkan kadar infestasi adalah 100%, di mana kesemua 50 ekor burung baji positif dengan hama bulu yang dikenal pasti secara tentatif seperti *Kramerella* spp., *Eustathia* spp., *Analges* spp., *Proctophyllodes* spp., *Sokoloviana* spp., *Ptiloxenoides* spp., *Syringophilus* spp., *Pandionacarus* spp., *Ardeacarus* spp., *Pelargolichus* spp., dan *Fainalges* spp. Tiada kutu atau tungau dikesan dan tiada hubungan statistik dapat ditentukan dan hanya statistik deskriptif dapat digunakan dalam kajian ini. Infestasi ektoparasit secara menyeluruh ini dikaitkan dengan kemampuan hama untuk bertahan lama pada burung, hidup pada bulu yang gugur serta merebak dengan meluas dalam persekitaran zoo. Risiko zoonotik hama ini masih belum diketahui. Untuk memperoleh pengecaman spesies yang tepat, analisis molekular, saiz sampel yang lebih besar dan seimbang perlu dilakukan bagi menilai hubungan antara faktor risiko.

Kata kunci: *Burung baji, Burung dalam kurungan, Ektoparasit, Hama bulu, Zoo*

CERTIFICATION

This is to certify that we have read this research paper entitled 'Identification of Ectoparasites in Budgerigars (*Melopsittacus undulatus*) and Their Associated Risk Factors in Three Selected Zoos in Malaysia' by Ku Nur Afifatin Binti Ku Harizan and in our opinion, it is satisfactory in terms of scope, quality and presentation as partial fulfillment of the requirement for the course DVT 55204 - Research Project.

Dr. Goh Soon Heng

DVM (UMK), PhD in Epidemiology and Public Health (UPM)

Senior Lecturer

Faculty of Veterinary Medicine, Universiti Malaysia Kelantan

(Supervisor)

Dr. Tan Li Peng

BSc of Forestry (UPM), PhD in Entomology (UPM)

Senior Lecturer

Faculty of Veterinary Medicine, Universiti Malaysia Kelantan

(Co-Supervisor)

ACKNOWLEDGEMENTS

Special thanks to those who have given their support, guidance, advice and aid for the completion of this project paper:

Dr. Goh Soon Heng

Dr. Tan Li Peng

Puan Zalhasrah Binti Ahmad Fathillah

Dr. Suhailiza Hanie Suroya

Dr. Wong Pei Ting

Dr. Eve Foong Yee Wei

Cik Hasimah Binti Hassan

Fikrie Bin Fakharoll Rodziee

Family

Lycans

Thank You

DEDICATIONS

First and foremost, I would like to praise Alhamdulillah and express my gratitude for the health and strength granted to me throughout the research project, which enabled me to complete it successfully without any difficulties.

I want to express my sincerest gratitude to my main supervisor, Dr Goh Soon Heng. His commitment, time and support are always inspiring. Deepest thanks to my co-supervisor, Dr Tan Li Peng, for the guidance and advice for the completion of this research project. My appreciation also goes to the parasitology laboratory staff, Puan Hasimah Binti Hassan, for helping throughout my research. Also, I would like to extend my gratitude to the veterinarians, Dr. Suhailiza Hanie Suroya, Dr. Wong Pei Ting and Dr. Eve Foong Yee Wei for granting me permission and assisting me in collecting the samples at the zoos.

I want to extend my deepest gratitude towards my loving parents, who always gave me words of encouragement and utmost support throughout this process and also my Final Year Project partner, Fikrie Bin Fakharoll Rodziee, who have always been with me and provided any means necessary to help and support me throughout this research project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

IM - Intramuscular

IBM - International Business Machine

kg - kilogram

mg - milligram

PO - Per Os

SPSS - Statistical Package for the Social Sciences

spp. - Species pluralis

No. – Number

p - probability

LIST OF SYMBOLS

% = Percentage

n = Sample size

CHAPTER 1

1.0 INTRODUCTION

Zoo is classified as an ex-situ form of conservation where the animals are kept in cages or enclosures for aesthetic, educational, research or conservation purposes (Ombugadu *et al*., 2019), Today, walk-through aviaries are a common feature and a popular sight at many zoos in Malaysia. These enclosures are specially designed to mimic the natural habitat of birds, providing a safe, comfortable, and spacious area to house a variety of bird species for exhibition. This allows them to fly freely, and visitors can also enter (Science, 2019). A common bird species typically housed in an aviary is the budgerigar, which belongs to the Psittacidae family. Budgerigar (*Melopsittacus undulatus*) is a small-sized parrot, commonly known as a parakeet. These birds are highly social creatures that enjoy companionship, making them a great choice for placement in the aviary at the zoo (Farnsworth, 2023). However, these captive birds are prone to being attacked by parasites, which poses a serious threat to them. In addition, as some zoos permit direct physical contact between visitors and birds, such as holding, petting, and feeding them, this can pose a risk of infection or disease transmission with zoonotic pathogens carried by ectoparasites (Isler *et al*., 2020).

Ectoparasitic infestation is one of the major causes of the birds' morbidity and mortality. According to Ombugadu *et al*. (2019), captive birds are more prone to parasites infestation as compared to wild birds who leave unfavorable environment and naturally can handle the health challenges compared to the captive birds which might suffer the consequences of poor and mismanagement protocol such as incorrect ectoparasite control regime or improper hygiene practices leading to high level of environmental contamination as well as a possible zoonotic potential. According to Baron *et al*. (n.d.), common ectoparasites that affect budgerigars are *Cnemidocoptes* spp. mites, *Mallophaga* spp. lice, feather and quill mites. Birds are easily infested with ectoparasites due to their fitness, foraging behaviour, nesting cavities, micro- and macro-habitats (Asrif *et al*., 2018). The parasitic arthropods are responsible for restlessness, skin damage, restricted growth, and reduced body weight in infected birds, resulting from the ectoparasites' bites, which are commonly found on the skin or feathers of the birds. In addition, they can enhance their living and existence on the birds by having the ability for morphological and physiological adaptation to the host (Bala *et al*., 2011). Besides, their size and shape are also different, where some are microscopic, like mites, and some can be seen with the naked eye, like lice (Agbede *et al*., 2010).

According to a study conducted by Daud *et al*. (2017) at Exotic Animal Veterinary Practice, Taman Melawati, Kuala Lumpur and Farm in The City, Seri Kembangan, Selangor, Malaysia, budgerigars were mostly treated for scaly leg mite infection, *Cnemidocoptes pilae*. This suggests that budgerigars in Malaysia are infested with parasites. However, the identification of ectoparasite infestations on budgerigars in zoos in Malaysia is largely unknown. In addition, several studies have been conducted by researchers in other countries on the prevalence of ectoparasites in budgerigars, but such research is lacking in Malaysia. Next, with the variety of other bird species housed in the aviary, there may be many ectoparasites that have not been recorded or described due to the limited research performed on the prevalence and identification of ectoparasite infestations. Therefore, this research is conducted to identify the ectoparasites in budgerigars (*Melopsittacus undulatus*) and their associated risk factors in three selected zoos in Malaysia. This study is important as the results will provide baseline data on the current ectoparasitic infestations in budgerigars, aiding veterinary practitioners and researchers in recognising the potential health implications of these parasites on the host birds, other avian species, and humans.

1.1 RESEARCH PROBLEM STATEMENT

Despite the growing popularity of budgerigars as exotic animals in aviaries at zoos across Malaysia, there remains a lack of scientific research on the identification of ectoparasites affecting these birds in Malaysia. Current information is more anecdotal, with no comprehensive studies addressing the type of ectoparasites involved and the effectiveness of ectoparasite control measures and management practices. This knowledge gap raises concerns about the potential for persistent infestations and, more importantly, the zoonotic risks to humans through direct contact with infected birds at the zoo.

1.2 RESEARCH QUESTIONS

1. What are the ectoparasites that can be identified among budgerigars in three selected zoos in Malaysia?
2. What are the potential associated risk factors of ectoparasite infestation among budgerigars in three selected zoos in Malaysia?

1.3 RESEARCH HYPOTHESIS

1. *Mallophaga* spp., *Cnemidocoptes* spp., *Analges* spp., *Proctophyllodes* spp., and *Syringophilus* spp. are ectoparasites that can be identified among budgerigars in three selected zoos in Malaysia.
2. The age, sex, and ectoparasite control practice are the potential associated risk factors of ectoparasite infestation among budgerigars in three selected zoos in Malaysia.

1.4 RESEARCH OBJECTIVES

1. To identify the ectoparasites present among budgerigars in three selected zoos in Malaysia.
2. To investigate the associated risk factors of ectoparasite infestation among budgerigars in three selected zoos in Malaysia.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 COMMON ECTOPARASITES OF BUDGERIGARS

Several common ectoparasites can be found on budgerigars. Firstly, *Cnemidocoptes* spp., also known as scaly leg and face mites, are characterised by the round bodies and short legs which barely protrude from the margin of the body (Patel *et al*., 2025). They are very common in budgerigars and rare in all other psittacine species and are transmitted mainly through direct contact between birds. Moving on to the second most common ectoparasites that can be found is the feather lice (*Mallophaga* spp.), from the suborders Ischnocera and Amblycera of the Phthiraptera order, which have a characteristic of chewing mouthparts, allowing them to chew on the feather barbules and shaft. Morphologically, they have six legs and their bodies are elongated, slender. Fully grown bird lice can be seen with the naked eye. Additionally, the lice eggs can be seen attached in clusters around the feather shaft. Lice are classified as obligate permanent ectoparasites, meaning they cannot survive independently of their host. Therefore, the entire life cycle must be completed on the host (Ombugadu *et al*., 2019). They are usually found clustered in different parts of the body, with many species being specific to each niche, such as the head and neck, the dorsal or ventral part of the wings, or the rump or tail.

Next, feather and quill mites that live between the barbs on the ventral surface of feathers and spend their entire life cycle on the bird. As with lice, they are also host-specific and prefer certain niches on the bird due to different species preferring different types of feathers or even different areas of feathers and are commonly transmitted through direct physical contact such as preening. According to Baron *et al*. (n.d.), there are lots of feather and quill mite species that need to be further investigated with regard to their involvement in feather loss. Families Analgidae, Proctophyllodidae and Syringophilidae are the most common feather and quill mites found on birds (Eren & Acici, 2022). Genus *Analges* spp. morphological features include a body surface with numerous macrosetae and spine-like processes on the tibiae and tarsi of the first two pairs of legs. Next, for the Proctophyllodidae family, the genus *Proctophyllodes* spp. is also one of the richest among all feather mites, characterised by a well-defined gnathosoma, laterally compressed chelicerae, a prodorsal shield covering almost the entire dorsal surface, and setae with a depressed edge (Janiga *et al*., 2025). Moving on, mites of the family Syringophilidae have a general morphology of the propodonotal shield that is well sclerotised, rectangular in shape, with short setae, smooth and subequal length propodonotal setae with striated cuticular body. Avian parasitologists frequently face numerous obstacles and difficulties in their studies due to an insufficient understanding of the ecological peculiarities and distribution patterns of these mites, as well as a limited number of high-level taxonomists (Negm *et al*., 2019). Thus, available morphological descriptions, taxonomic keys, and published descriptions of feather mites are commonly used to identify them.

Furthermore, *Dermanyssus gallinae*, also known as the red mite, is a free-living mite that inhabits housing and is typically found in nest boxes (Hoppes, 2024). Morphologically, they have styliform chelicerae, the sternal shield is narrow in height and very wide, and the pedipalp reaches the apex of the tarsus with a triangular anal shield (Moretta *et al*., 2025). They breed off the host and have the ability to survive in the environment and transmission occurs mainly via contaminated nest boxes, perches and enclosure structures. *Dermanyssus gallinae* is a blood sucking ectoparasite, especially fed at night, from a very wide range of hosts such as chicken, pigeon, house sparrow, starling, pet canaries, parakeets, rarely cat, dog, rodent, horse and even humans (Mullen and Oconnor, 2002; Marchiondo and Endris, 2019).

2.2 CLINICAL SIGNS OF ECTOPARASITES INFESTATION IN BUDGERIGARS

Ectoparasite infestation in budgerigars may result in a wide range of clinical manifestations, depending on the parasite species, infestation intensity, and host immune status. Firstly, for *Cnemidocoptes* spp. mites, it will burrow into the skin to lay their eggs, causing white, porous, proliferative encrustations, and hyperkeratosis at the non-feathered skin, especially around the beak, cere, periorbital area, legs, and vent. In addition, prolonged infection can lead to severe distortion of the beak and enlargement of the legs and feet, which could result in necrosis. These clinical appearances are generally pathognomonic signs in infected budgerigars (Hoppes, 2024).

Next, chewing lice, *Mallophaga* spp. will chew on the feather barbules and shaft, causing feather damage (Yildiz *et al*., 2023) and deteriorating the plumage quality by causing small holes in feathers, which further reduce the thermoregulatory capacity (Akawasi *et al*., 2018). For feather and quill mites, birds have the ability to keep the mite burden low by beating their wings. However, in cases where they are too debilitated to flap their wings, large numbers of mites can accumulate, potentially migrating from the feathers to the skin and causing considerable irritation. Moving on, infected budgerigars with red mites, *Dermanyssus gallinae* may show signs of intense irritation and restlessness as well as debility if the mite burden is high, and can cause mortality in young birds (Moretta *et al*., 2025).

2.3 ASSOCIATED RISK FACTORS OF ECTOPARASITE INFESTATION IN BUDGERIGARS IN ZOOS IN MALAYSIA

Several risk factors are associated with ectoparasite infestation in budgerigars, including sex, age, and ectoparasite control practice (Mayer *et al*., 2012). Captive birds in zoos are more prone to parasite infestations, which pose serious threats to their health. These parasites can affect their growth, reproduction, and long-term survival, ultimately leading to mortality, significant population declines, and local extinction events. Age is one of the factors that can affect budgerigars' susceptibility to ectoparasite infestation. Young budgerigars, less than one year of age, are more prone to infestation due to their underdeveloped immune systems. *Cnemidocoptes* spp. infestations are notably common in this age group, as the affected birds will have crusty lesions on the cere, feet and vent (Margaret *et al*., n.d.). Meanwhile, in older budgerigars, mite infestation typically occurs if they have underlying health issues, such as hepatic lipidosis, a very common disease in budgerigars due to their high-fat seed diet (Sakas, 2002). This condition can compromise their immune system, making them more susceptible to ectoparasite infestation.

Moving on, appropriate ectoparasite control practices in budgerigars are required to prevent them from being infested with the ectoparasites. This is because failure to follow the correct protocol, such as administering the wrong dosage or failing to retreat the birds at recommended intervals, can lead to persistent ectoparasite infestation. The examples of ectoparasite control that are widely used include ivermectin (0.2 mg/kg, PO or IM) or moxidectin (0.2 mg/kg, PO or topically), repeated every two weeks. This treatment is commonly used to treat scaly face mite. Next, budgerigars infested with feather mites may be treated with pyrethrin sprays, 5% carbaryl powder, or ivermectin (0.2 mg/kg, PO or IM), repeated in two weeks. Failing to follow the correct treatment regimen will increase the risk of the birds being easily infested with ectoparasites (Hoppes, 2024). Lastly, sex-based risk factors in budgerigars are usually influenced by hormonal status. For example, female budgerigars will undergo hormonal changes during the breeding season that can suppress their immune system, resulting in increased susceptibility toward the ectoparasite infestation compared to male budgerigars.

2.4 ONE HEALTH IMPLICATIONS OF ECTOPARASITES IN BUDGERIGARS

The ectoparasites identified in budgerigars may pose potential health concerns for humans, animals, and the environment, aligning with the One Health concept. In humans, it can lead to swelling and a rash, as the bite can cause intense itching and some irritation, which is a result of the saliva they produce when they bite human skin (Bird Mite - Pest Control ENVU, n.d.). In addition, they are also known to be a potential cause of allergic diseases in humans (Arias *et al*., 2007). According to a study by V. Patel *et al*. (2022), feather mites of budgerigars can act as allergens, causing skin allergies in humans. Meanwhile, a study conducted in Turkey by Yildiz and Köse in 2023 found that *Dermanyssus gallinae* can be a carrier of several vector-borne pathogens. For instance, transmission of bacteria and viruses such as *Salmonella enteritidis*, *Pasteurella multocida*, *Coxiella burnetii* and Fowl pox virus via *Dermanyssus gallinae* to another host has been demonstrated. Their ability to feed on human blood and transmit the pathogens underscores the risk to public health. Next, in multi species zoo settings, these mites can spread between birds and potentially to other susceptible species via direct contact, shared enclosures or contaminated environments such as feathers and nesting materials in which can be supported by a study conducted by Moro *et al*., 2019, birds can acquire the mites from other infected birds held in the same or neighboring cages via vertical transmission. Furthermore, live mites have the ability to attach to and survive on fallen feathers found in the field for a relatively long time, becoming a source of mechanical vectors to other hosts (Janiga *et al*., 2025). Thus, this environmental resilience means that ectoparasite infestations can be established within zoo ecosystems, which enables them to continue circulating even after treatment, contributing to reinfestation cycles. In addition, with their ability to suck blood from humans and their potential role of being a vector to various pathogens for both animals and humans, the preventive measures and studies should be carried out more about this ectoparasite and also other ectoparasites in budgerigars in zoos in Malaysia, to prevent the cross-sectoral health impacts.

2.5 CHALLENGES IN IDENTIFICATION

The most significant challenges in identification of the ectoparasite is due to the limited availability of published literature on ectoparasites affecting budgerigars in Malaysia, resulting in a lack of comprehensive baseline data for comparison and references. These limit the accuracy of ectoparasite identification presence. Available morphological descriptions, taxonomic keys, and published descriptions reported in other avian host species in other countries are commonly used as references for the tentative classification, however, it may differ morphologically from those infesting budgerigars. To emphasize the accuracy of the identification to the species level, specialised taxonomic expertise and molecular analysis need to be performed. This highlights the importance of more extensive further studies including the molecular based research that needs to be established as a foundation or reference for ectoparasite identification infesting budgerigars in Malaysia.

CHAPTER 3

3.0 MATERIALS AND METHODS

3.1 ETHICAL CONSIDERATION

Ethical approval for using animals in the current study was obtained from the Animal Ethics Committee of Universiti Malaysia Kelantan (UMK/FPV/ACUE/FYP/018/2025).

3.2 STUDY AREA

This study was conducted in three selected zoos in different regions of Peninsular Malaysia, referred to as Zoo A, Zoo B, and Zoo C. The zoos were purposely selected based on the presence of captive budgerigars housed in the enclosure, accessibility for sampling, and approval from zoo management to conduct the study. In addition, these zoos represent typical zoo management systems in Malaysia, where multiple bird species are kept in shared enclosures and also different bird species housed in different enclosures but close to each other with varying population densities. The inclusion of three different zoos in this study was intended to capture potential variations in ectoparasite presence associated with environmental conditions, management practices and regional differences in zoo operations. Such conditions are considered conducive to the transmission and persistence of ectoparasites, making these locations scientifically appropriate for investigating identification of ectoparasite and associated risk factors in captive budgerigars.

3.3 STUDY DESIGN

A cross-sectional study was employed in this study as it is appropriate for determining the presence of ectoparasite infestation and describing the distribution of ectoparasite and associated risk factors in a defined population at a single point in time. Additionally, this study design allows for rapid data collection without the need for long-term follow up, making it suitable for studies conducted in zoo settings where repeated handling of birds may cause stress and welfare concerns. Next, cross-sectional study design is commonly used in parasitological and epidemiological studies to establish baseline prevalence data, particularly in populations where limited prior information is available.

Additionally, a multistage sampling method was employed in this study. First, the zoos were conveniently identified, and then, from each selected zoo, budgerigars were randomly selected using simple random sampling without replacement within the study.

3.4 STUDY POPULATION

The study population consisted exclusively of captive budgerigars housed in selected zoos in Malaysia. Budgerigars (*Melopsittacus undulatus*) were chosen as the focus species due to their common presence in the enclosure at the zoo and their social behavior that allows them to be mixed with other bird species. In addition, budgerigars are not listed as protected wildlife species under Malaysian wildlife legislation and do not require special permits for handling for research purposes when conducted with institutional ethical approval. This made them a practical and ethically appropriate species for sampling in zoo settings without regulatory constraints that could limit access or sample size.

The selection of zoos was based on the presence of an established budgerigars population within aviary enclosures, which form the basis of the sampling technique. Only zoos housing budgerigars under similar captive management systems were included in the study to ensure species specific consistency of the study population. In this study, no other bird species were housed within the budgerigars enclosures, however, the enclosures were located in close proximity to enclosures housing other bird species. Within each selected zoo, a multistage sampling method was employed in this study. First, the zoos were conveniently identified, and then, from each selected zoo, budgerigars were randomly selected using simple random sampling without replacement within the study to minimise selection bias and to ensure that each individual bird had an equal probability of being included in the study. A total of 50 budgerigars were included in the study, consisting of 25 birds from Zoo A, 20 birds from Zoo B and 5 birds from Zoo C, as shown in Table 3.1.

Table 3.1: Number of samples collected from three zoos in Malaysia.

Zoo	Number of Samples (n)
A	25
B	20
C	5
Total	**50**

3.5 SELECTION CRITERIA

3.5.1 INCLUSION CRITERIA

Samples selected were presented as free range in the bird enclosure and collected prior to their scheduled ectoparasite control treatment.

3.5.2 EXCLUSION CRITERIA

Birds that have recently received the ectoparasite control treatment.

3.6 SAMPLING PROCEDURES

All budgerigars were captured by using a net and were handled for a thorough ectoparasite examination using the Ringer's grip technique, in which the bird’s neck was held between the index and middle fingers while the wings and body were gently restrained with the closed hand (Harcourt *et al*., 2005). After sampling, all the birds were released back into the enclosure, while those that had not yet undergone examination for ectoparasites remained in the carry cage to prevent resampling. Before each bird was released, it was examined for any injuries that might have occurred during the sampling process, and iodine was applied to any injuries that were detected.

3.6.1 FEATHER PLUCK

This method is an excellent way to identify parasites, such as lice and feather mites, that live deep within the follicle or those that often attach to feathers. It is recommended to conduct this method in addition to skin scrapings, as it is a valuable method for lesion areas that are difficult to scrape, such as the interdigital area, around the face, and eyes (Dacvd, 2023). Firstly, feathers that showed visible signs of lice or mite infestation were identified based on the presence of damaged or dirty feather surfaces. These infested feathers were carefully cut using scissors and placed into individually labelled ziplock plastic bags, along with their sex and age information, for proper identification and record-keeping. Next, by using a pair of forceps, each feather sample was brushed in the opposite direction of its natural growth to ensure that all attached ectoparasites were dislodged onto a petri dish. This step was performed gently to avoid damaging the ectoparasites and to ensure complete removal from the feather surfaces. A clean piece of acetate tape was then pressed onto the petri dish with the sticky side facing downward to pick up the ectoparasites. The tape was lifted and placed onto a clean glass slide, and was observed under an Olympus CX21FS1 microscope for identification of the ectoparasites. The results were interpreted and documented in the form of digital images. Identification was carried out according to available morphological descriptions, taxonomic keys, and published descriptions of ectoparasites reported in the literature.

3.6.2 ACETATE TAPE STRIP

Tape strip tests are a convenient and cost-effective method for skin cytology, particularly in areas that are difficult to reach, such as skin folds and interdigital spaces, for identifying ectoparasites (University of Bristol, 2017). Firstly, the acetate tape was cut to match the length of the glass slide. It was crucial to avoid getting fingerprints and to ensure no dust contaminated the adhesive side. The tape was then firmly pressed onto the birds' feet and interdigital spaces. Adequate pressure was applied to ensure good contact between the tape and the skin surface, while still avoiding excessive force that could injure the bird. The tape application was repeated several times over the same area to ensure that any ectoparasites present on the skin adhered securely to the tape. Then, the tape was carefully placed onto a clean glass slide and stored in individually labelled ziplock plastic bags, along with their sex and age information, for proper identification and record-keeping. The slides were examined under an Olympus CX21FS1 microscope for the identification of ectoparasites. The results were interpreted and documented in the form of digital images. Identification was carried out according to available morphological descriptions, taxonomic keys, and published descriptions of ectoparasites reported in the literature.

3.7 DATA COLLECTION TOOLS FOR RISK FACTORS

Data related to ectoparasite infestation and associated risk factors were collected using a structured data collection form during the sampling process. Information recorded for each budgerigars included zoo location, age category (young or adult), sex (male or female), and ectoparasite control practice (given or not given). Age and sex of the birds were determined based on physical characteristics observed during handling.

3.8 DATA ANALYSIS

All data were recorded and entered into Microsoft Excel, and then analysed using the Statistical Package for the Social Sciences (SPSS) version 27 developed by the International Business Machine (IBM) Corporation. Data cleaning was performed to ensure accuracy and avoid errors. Descriptive statistics of the population were generated to summarise the data, and the results were tabulated using frequencies and percentages for categorical variables such as age, sex and ectoparasite control practice. The association between various risk factors and the outcomes of this study was determined using Pearson's chi-square with the level of significance less than 0.05.

CHAPTER 4

4.0 RESULTS

4.1 OCCURRENCE OF ECTOPARASITES INFESTATION

Table 4.1: Occurrence of ectoparasites in budgerigars in three selected zoos in Malaysia

Zoo	Sample Size (n)	Positive	Negative	Detection Percentage (%)
A	25	25	0	100
B	20	20	0	100
C	5	5	0	100
Total	**50**	**50**	**0**	**100**

A total of 50 budgerigars from three selected zoos were examined for ectoparasite infestation. All birds sampled, 25 from Zoo A, 20 from Zoo B, and 5 from Zoo C, were found to be infested, resulting in a detection percentage of 100% (n=50/50) in all locations. No negative cases were recorded in any of the zoos.

4.2 DISTRIBUTION OF THE ASSOCIATED RISK FACTORS FOR ECTOPARASITE INFESTATION

Table 4.2: Distribution of the associated risk factors for ectoparasite infestation

Risk Factors Category	Sub-category	Number of Birds (n)	Positive	Negative	Detection Percentage (%)

Age	Young	22	22	0	100
	Adult	28	28	0	100
Sex	Male	21	21	0	100
	Female	29	29	0	100
Ectoparasite control practice	Given	5	5	0	100
	Not given	45	45	0	100

The distribution of ectoparasite infestation according to different risk factors, such as age, sex, and ectoparasite control practices, is presented in Table 4.2. All budgerigars examined, regardless of age category, sex, or whether an ectoparasite control practice given or not given, were positive for ectoparasite infestation. This resulted in a 100% detection percentage across all associated risk factors. No negative cases were recorded for any of the risk factors, indicating that the infestation was uniformly distributed across all groups. Among the 50 sampled budgerigars, age distribution showed that 44% (n=22/50) were classified as young, whereas 56% (n=28/50) were classified as adults. Next, 42% (n=21/50) were classified as male and 58% (n=29/50) were classified as female. Meanwhile for ectoparasite control practice, 10% (n=5/50) of budgerigars were given ectoparasite control, whereas 90% (n=45/50) budgerigars did not receive any ectoparasite treatment. Due to all budgerigars in this study being positive for ectoparasite infestation, the outcome variable showed no variation. Inferential statistics tests such as Pearson's chi-square test or Fisher's exact test could not be performed to assess the associations between risk factors and infestation status. Therefore, the results were presented descriptively.

4.3 ECTOPARASITE IDENTIFICATION

Table 4.3: Types of ectoparasites identified in each zoo

Ectoparasite Type	Zoo A (n=25)	Zoo B (n=20)	Zoo C (n=5)	Total (n=50)	Total Percentage (%)
Mites	25	20	5	50	100
Lice	0	0	0	0	0
Ticks	0	0	0	0	0
Unidentified species	1	1	0	2	4

Microscopic examination revealed that mites were the only confirmed ectoparasite identified in all budgerigars, 100% (n=50/50). No lice or ticks were observed in any of the samples. However, two budgerigars, one from Zoo A and one from Zoo B, were presented with unidentified ectoparasite specimens that could not be classified into mite, lice, or tick categories, representing 4% (n=2/50) of the sampled population. The number and percentage of birds with each type of ectoparasite are presented in Table 4.3.

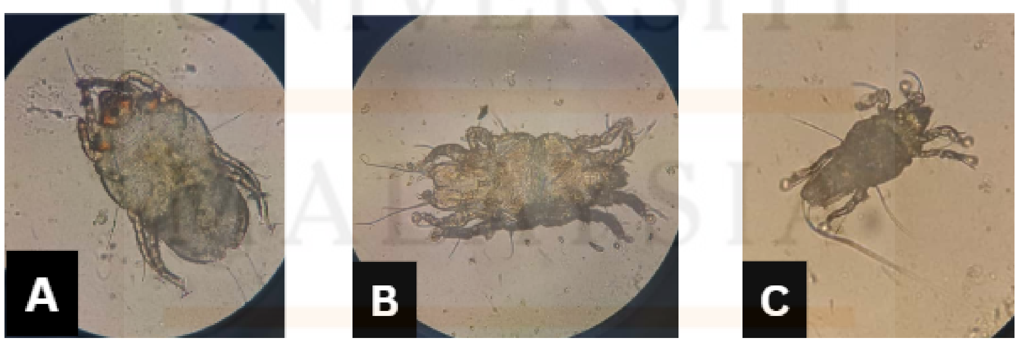

Figure 4.1: Tentative identification of feather mites. A. *Kramerella* spp., B. *Eustathia* spp., C. *Analges* spp. (Magnification x40)

Figure 4.2: Tentative identification of feather mites. D. *Proctophyllodes* spp., E. *Sokoloviana* spp., F. *Ptiloxenoides* spp. (Magnification x40)

Figure 4.3: Tentative identification of feather mites. G. *Syringophilu*s spp., H. *Pandionacarus* spp., I. *Ardeacarus* spp. (Magnification x40)

Figure 4.4: Tentative identification of feather mites. J. *Pelargolichus* spp., K. *Fainalges* spp., L. *Analges* spp. (Magnification x40)

Figure 4.5: Unidentified genus of feather mites (Magnification x40)

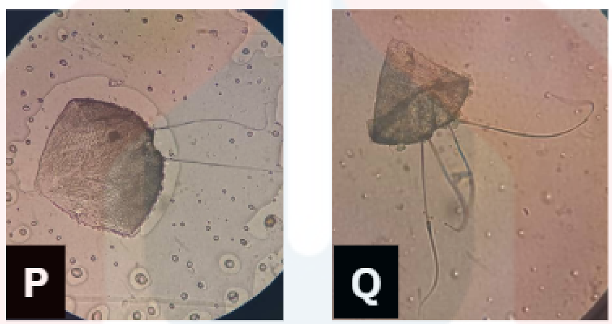

Figure 4.6: Unidentified ectoparasite species (Magnification x40)

Microscopic examination showed multiple morphological features of feather mites, shown in Figures 4.1 to 4.5. The mites were tentatively identified as belonging to several genera based on available morphological descriptions, taxonomic keys, and published descriptions of feather mites reported from other avian hosts. Due to the scarcity of published data on ectoparasites on budgerigars, most available references pertain to mites found on other avian species. Therefore, the morphological similarity to published descriptions was used as the primary basis for tentative genus classification. Hence, the identifications in this study should be considered provisional at the species level, and even genus-level diagnosis of feather mites would require molecular analysis, specialised taxonomic expertise and comparison with type specimens. Figure 4.5 showed several ectoparasite specimens that could not be assigned to any known genus of feather mite, and also unidentified ectoparasite specimens that did not match the characteristics of mite, lice or tick were also recorded as shown in Figure 4.6. All the budgerigars in this study have mixed infestation with the feather mites listed.

CHAPTER 5

5.0 DISCUSSION

In this study, the detection percentage of ectoparasite infestation reached 100%, with all 50 budgerigars from the three zoos testing positive. This high percentage indicates a widespread and persistent infestation within the captive environment. Mites, specifically feather mites, were the only ectoparasites identified in this study, with no lice or ticks found, indicating that feather mites were the predominant ectoparasites affecting these captive birds. Feather mites are large and consist of a diverse group of persistent, highly specialised ectoparasites on birds, and they are permanent ectosymbionts, meaning they spend their entire life cycle on the host body, and their prevalence can be quite high can reaching up to 100% among different bird species (Melnychuk *et al*., 2024). Budgerigars that are infested with feather mites will have skin or feather damage and the quill interior will have yellowish to grey or brownish powder appearance and more severe infestation will cause itches and lesions that can interfere with the flight. Additionally, these feather mites usually feed on feather fragments, lipids than blood or sebaceous fluid, which results in some infested budgerigars may not exhibit any clinical signs except in heavy infestation (Prathipa, 2015).

Cnemidocoptes spp. mites and *Mallophaga* spp. lice are the other common ectoparasites of budgerigars (Yildiz *et al*., 2023; Hoppes, 2024). However, neither was identified in this study, primarily due to the sampling location of the birds and the method used. Feather plucking, mainly the secondary covert feathers and the acetate tape method of the budgerigars' feet and interdigital digits were conducted in this study. These are the predilection sites of the feather mites, as they mainly live on these feathers. However, according to Prathipa (2025), they can also move to the skin in excess. Hence, this explains why both sampling on the feathers and skin of the feet in this study can successfully isolate the feather mites. Moreover, deep skin scraping is necessary to identify *Cnemidocoptes* spp. because they are burrowing mites (Hoppes, 2024), while feather plucking, specifically the flight feathers, is required to identify the *Mallophaga* spp. lice. Additionally, ticks tend to attach to areas that are difficult for birds to preen, such as around the eyes, ear canals, and crown, which allows them to feed successfully on blood. These areas were not included in the sampling site in this study due to the tight restrictions on examining the birds without causing physical harm to them, as budgerigars are highly sensitive birds that can easily become stressed when handled for extended periods. Thus, this limits the sampling procedures that can be performed on the birds and also explains why only feather mites were identified in this study.

According to Mironov and Tolstenkov (2013), there are approximately 2,500 species in 450 genera and 38 families known from representatives of all bird orders. They also mention that, for all countries in the Indo-Malayan region, the feather mites have been explored quite poorly so far. In this study, a wide diversity of feather mites genera were tentatively identified such as *Kramerella* spp., *Eustathia* spp., *Analges* spp., *Proctophyllodes* spp., *Sokoloviana* spp., *Ptiloxenoides* spp., *Syringophilus* spp., *Pandionacarus* spp., *Ardeacarus* spp., *Pelargolichus* spp., *Fainalges* spp. and also some unidentified feather mites and unknown ectoparasite species. Findings from this study also showed that all the budgerigars have mixed infestation with the feather mites listed. The most significant limitation when interpreting the findings is the scarcity of published studies on ectoparasites of budgerigars, especially in Malaysia. This limited the ability to compare the findings obtained from this study with established baseline data, which further restricts the interpretation of the ecological and epidemiological significance of the ectoparasites identified, as well as the accuracy of the taxonomic classification. Hence, the ectoparasites were tentatively identified only at the genus level based on the available morphological descriptions, taxonomic keys, and published descriptions of feather mites reported mainly from other avian hosts. However, for a definitive genus-level or even species-level diagnosis of feather mites, molecular analysis and specialised taxonomic expertise would be required, which cannot be performed in this study.

Firstly, according to Eren *et al*. (2023), the genus *Kramerella* is typically associated with birds of the order Strigiformes and has been reported from several owl species, such as *Otus scops* and *Tyto alba,* which are commonly found in Malaysia. Next, the genus *Eustathia* includes species associated with birds of the order Apodiformes, primarily swifts such as the one that is commonly found in Malaysia is the little swift *Apus affinis.* Moving on, *Analges* and *Fainalges* species are predominantly found on members of the order Passeriformes. Additionally, this mite has been recorded from the Psittaciformes order, which includes the budgerigar species (Mironov, 2019). The genus *Proctophyllodes* is the most species-rich genus among all feather mite families. These mites were commonly found on hosts from the orders Passeriformes, Apodiformes, Charadriiformes and Piciformes (Eren & Açici, 2022). Next, the *Sokoloviana* and *Ptiloxenoides* genera were reported to belong to the family Ptiloxenidae, which inhabits water birds, such as those in the Charadriiformes order (Siepel *et al*., 2016). Besides, mites of the family Syringophilidae were also identified in this study. According to Prathipa *et al*. (2014), they conducted a study to investigate the presence of feather mites in psittacine birds, specifically in budgerigars, *Syringophilus* spp. mites were encountered in 11.43% of the feather samples. This aligns with the results of this study, indicating that mite infestations in budgerigars are common.

Another genus found in this study was *Pandionacarus* spp., which is one of the largest feather mites at about 1.2 to 1.3 mm in length and commonly associated with the osprey but was recently reported on a toucan (Moro *et al*., 2019). Next, the genus *Ardeacarus* has been reported on Pelecaniformes, a large and diverse group of aquatic birds, including pelicans. A new feather mite *Pelargolichus* spp. that was tentatively identified in this study also had been described on stork birds based on a study conducted by Waki *et al*. (2023). Aside from that, several mites identified in this study could not be tentatively identified to the genus level as the morphological characteristic did not match any features described in published papers or textbooks. Additionally, some ectoparasite specimens isolated in this study that were found on budgerigars in Zoo A and Zoo B were unable to be categorised as tick, mite or lice as its morphological characteristic did not correspond to any known ectoparasite group. Notably, the specimen has a flagellum like structure with no legs and triangle in shape, which is atypical and not characteristic of ectoparasites. All the different bird species mentioned above, which have been reported to be associated with the feather mites found in this study, are common bird species that are housed in zoos in Malaysia. Hence, with the ability for the vertical transmission of these feather mites, the opportunity for them to transfer between different host species increases, especially in the zoo settings, making their presence on budgerigars, like in this study, is biologically plausible.

The zoonotic potential of mites identified in this study still remains unknown. According to Moretta *et al*. (2025), the red mite, *Dermanyssus gallinae* is a blood feeding ectoparasite commonly found in budgerigars is known to cause zoonotic disease as their impact goes beyond affecting birds because humans also affected, especially the ones that directly come into contact with the infested birds leading to dermatitis. However, this red mite was not identified in this study because the sampling method used was not suitable for isolating them. Effective identification typically requires environmental sampling at night. Furthermore, one of the feather mites identified in this study which is the *Syringophilus* spp., has been reported to act as a vector for *Anaplasma phagocytophilum*, an obligate intracellular parasite (Marcisova *et al*., 2024). These findings raise important considerations for future research, as other mites identified in this study may also carry pathogens with potential implications for the One Health triad.

In terms of the associated risk factors, all budgerigars had a 100% detection percentage regardless of the variables; there was no variation in the dependent variables, and no statistically significant difference could be determined due to the absence of the negative group causing the restriction on the use of inferential statistical tests, such as Pearson's chi-square or Fisher's exact test. Additionally, the unequal sample sizes obtained from the selected three zoos, with Zoo A contributing 25 budgerigars, Zoo B contributing 20 budgerigars, and Zoo C contributing only 5 budgerigars was dependent on the ability to capture them, as it was challenging and time-consuming. Thus, this also limits the representativeness of the sampled population and weakens the comparisons across the zoos. Furthermore, since all the budgerigars in this study were selected using simple random sampling without replacement and not in a balanced group, the distribution of birds across each risk factor group could not be controlled, resulting in an inability to conduct a comparison between these categories.

As such, the relationship between the risk factors including sex, age, and ectoparasite control practice with the infestation status in this study can only be performed via descriptive statistics. Several factors may explain this uniform infestation. First, some infested budgerigars with feather mites may not show obvious clinical signs such as skin or feather damage except in heavily infested birds (Prathipa, 2015). Next, according to Mironov *et al*. (2018), who explained that feather mites can persist on captive hosts for more than 40 years, thereby contributing to the long-term maintenance of infestations in a flock. Similarly, another study conducted by Hernandes (2017) reported that Psittaciformes bred in captivity and frequently treated for parasites can still harbour feather mites from their place of origin. Additionally, these mites also have the ability to live and attach to fallen feathers for a long time, enabling transmission when the infested budgerigars shed feathers into the environment. Furthermore, the feather mites have also been reported to be found on a variety of bird species besides their natural host, indicating the possibility of vertical transmission within different host species.

In zoo settings, budgerigars are usually sourced from breeders and undergo quarantine to observe any clinical signs of development before being introduced into the flock inside the enclosure. However, if the mites already persist in the environment or present on the feathers regardless of the clinical sign that may or may not be shown, they can still be introduced into the flock even if the budgerigars have been treated for ectoparasites leading to both horizontal and vertical transmission within the flock resulting in uniform infestation. Several mite genera tentatively identified in this study were uncommon or previously unreported in Malaysia, suggesting the possibility that these mites may have originated from other regions, such as from the breeder that persisted on the budgerigars and also from other bird species within the zoos. These biological traits of the feather mites such as long-term survival on the host even with ectoparasite treatment, persistence on fallen feathers, the asymptomatic infestation and ability to be transmitted from different host species explained the 100% detection percentage in this study irrespective of the risk factors such as age, sex or ectoparasite control practices. Additionally, since the mite infestation was encountered in plenty, then the enclosure floors, walls and nests should be treated with ectoparasite control to prevent the persistent infestation together with identifying the source of the budgerigars and their management from the breeders. In addition, sampling from the other bird species in the zoo settings are also required to improve knowledge about the transmission status of the feather mites within different host species and also examination of a few representative budgerigars of each enclosure should be carried out in a periodical manner.

CHAPTER 6

6.0 CONCLUSION

This study successfully determined the identification and associated risk factors of ectoparasite infestation in budgerigars from three zoos in Malaysia. The findings revealed a 100% detection percentage among all 50 birds examined, with mites being the only confirmed ectoparasite species identified. Several feather mite genera were tentatively identified, and they are rarely reported in Malaysia. As infestation was uniformly present across all groups of risk factors, no association could be established between them. Only descriptive statistics can be applied in this study, and inferential statistical analysis was not feasible. Additionally, studies on feather mites collected from birds kept in captivity are still scarce in Malaysia.

6.1 RECOMMENDATIONS

Further studies are needed to be conducted, as valuable information can be obtained from these birds, such as confirmation of host-parasite associations, discovery of new species, collection of rare ectoparasites species, new records and hosts, and information on microhabitats, which will also provide a better understanding of epidemiological case studies. Increasing the sample size is strongly recommended to improve the representativeness and reliability of the findings for better assessment of the risk factors associated with the ectoparasite infestation or introduce a new group of truly negative to serve as a control group as it the only way for the inferential statistic in order to compare the associated risk factors. Additionally, stratified sampling methods can be employed to mitigate the limitations identified in this study and minimise sampling bias. For example, stratification may be performed at the zoo level by including a larger number of zoos from different geographical regions across Malaysia and with varying aviary management systems, ensuring broader representation of captive budgerigars populations. Next, in order to complement the morphological analysis, molecular identification methods should be incorporated in the future study to enhance the species level accuracy and provide stronger insights into the phylogenetic relationship.

7.0 APPENDIX

Table 7.1: List of equipment for sampling procedure.

NO.	EQUIPMENT	QUANTITY	INDICATION
1.	Glove	1 box	Biosafety purposes
2.	Polystyrene box	1 box	Put all the samples collected
3.	Ziplock bag	100 pieces	Put feather sample
4.	Scotch tape	2 unit	For acetate tape sampling
5.	Glass slide	2 boxes	For acetate tape method
6.	Face mask	1 box	Biosafety purposes
7.	Scissors	1 unit	For feather and tape cutting

Figure 7.1: Equipments used for sampling procedure

Figure 7.2: Bird restraining using Ringer's grip technique

Figure 7.3: Sampling procedure by feather plucking and acetate tape technique

Figure 7.4: Budgerigars' enclosure

8.0 REFERENCES

Agbede, R. I. S. (2010).Survey of ectoparasites and their predilection site on chicken. Journal of Agricultural and Veterinary Sciences, 2: 70-74.

Akwashiki Ombugadu, Department of Zoology, Faculty of Science, Federal University Lafia. (2018, February 13). Impact of Parasites in Captive birds: A review. Retrieved May 27, 2025, from https://phthiraptera.myspecies.info/sites/phthiraptera.info/files/95341.pdf

Asrif, N. A., Nurqamareena, K., & Chong, Y. L. (2018). Ectoparasites of Birds from a Rice Field in Samarahan Division, Sarawa. Trends in Undergraduate Research, 1(1), a45-51. https://doi.org/10.33736/tur.1240.2018

Bala, A. Y., Anka, S. A., Waziri, A. and Shehu, H. (2011). Preliminary Survey of Ectoparasites Infesting Chickens (Gallus domesticus) in Four Areas of Sokoto Metropolis. Nigerian Journal of Basic and Applied Science, 19(2): 173-180.

Baron, H., Avian Reptile and Exotic Pet Hospital, & University of Sydney. (n.d.). Parasites of budgerigars. *Parasites of Budgerigars*. https://nzbudgerigarsociety.co.nz/wp-content/uploads/2014/10/Budgerigar-PARASITES.pdf

Barreto, M., Burbano, M. E., Proctor, H. C., Mironov, S. V., & Wauthy, G. (2012). Feather mites (Acariformes: Psoroptidia) from Colombia: Preliminary list with new records. *Zootaxa*, *3516*(1). https://doi.org/10.11646/zootaxa.3516.1.

Bird mite - Pest Control ENVU. (n.d.). https://www.my.envu.com/Pest-Management/WhatToControl/Bird-Mite

Brawijaya, U. (2024, March 7). A rapid protocol for clearing, staining, and mounting of arthropoda : Siphonaptera and Phthiraptera.

Clayton, D. H., Koop, J. A., Harbison, C. W., Moyer, B. R., & Bush, S. E. (2010). How birds combat ectoparasites. The Open Ornithology Journal, 3(1), 41–71. https://doi.org/10.2174/1874453201003010041

Cravens, E. (n.d.). Focus on catching and transporting of parrots. https://parrots.org/wp-content/uploads/2025/02/Focus-on-Catching-and-Transporting-of-Parrots.pdf

Dacvd, D. J. D. D. (2023, February 28). Skin scraping for external parasites. Clinician's Brief. https://www.cliniciansbrief.com/article/skin-scraping-external-parasites?eid=290699332&bid=1389041

Dacvd, K. S. C. D. (2020, April 27). Obtaining a skin scraping. DVM 360. https://www.dvm360.com/view/obtaining-skin-scraping

Eren, G., & Açici, M. (2022). A contribution to avian ectoparasite fauna of Turkey: the reports of feather mites and tick on the Great tit (Parus major L.). *Acarological Studies*, *4*(1), 21–27. https://doi.org/10.47121/acarolstud.970440

Eren, G., Öztürk, M., Mironov, S. V., NiSbet, H. Ö., & Açici, M. (2023). New records of feather mites (Sarcoptiformes: Astigmata) from some birds in Türkiye. Acarological Studies, 5(2), 58–68. https://doi.org/10.47121/acarolstud.1244323

Farnsworth, M. (2023, November 29). 27 Aviary birds you should know - the worlds rarest birds. The Worlds Rarest Birds. https://theworldsrarestbirds.com/birds/birds-in-aviary/

Harcourt-Brown, N., & Chitty, J. (2005). BSAVA Manual of Psittacine Birds. BSAVA.

Hoppes, S. M. (2024, September 17). Parasitic diseases of pet birds. MSD Veterinary Manual. https://www.msdvetmanual.com/exotic-and-laboratory-animals/pet-birds/parasitic-diseases-of-pet-birds?utm_source=chatgpt.com#Scaly-Face-(Leg)-Mite_v3305743

Isler, M., Wissmann, R., Morach, M., Zurfluh, K., Stephan, R., & Nüesch‐Inderbinen, M. (2020). Animal petting zoos as sources of Shiga toxin‐producing Escherichia coli, Salmonella and extended‐spectrum β‐lactamase (ESBL)‐producing Enterobacteriaceae. Zoonoses and Public Health, 68(2), 79–87. https://doi.org/10.1111/zph.1279

Janiga, M., Marčanová, N., & Ballová, Z. K. (2025). Prevalence and size variation of feather mite, Analges slovakiensis Dabert, Mironov & Janiga, 2018, on the host Alpine accentor, Prunella collaris (Scopoli, 1769). *The European Zoological Journal*, *92*(1), 227–237. https://doi.org/10.1080/24750263.2025.2451773

Marcisova, I., Skoracki, M., Patan, M., Hromada, M., & Sikora, B. (2024). Quill mites of the subfamily Syringophilinae (Acariformes: syringophilidae) parasitising starlings (Passeriformes: sturnidae). *Animals*, *14*(15), 2239. https://doi.org/10.3390/ani14152239

Margaret A. Wissman, D.V.M., D.A.B.V.P. (n.d.). Exotic pet veterinarian. Margaret a. Wissman, D.V.M., D.A.B.V.P. https://www.exoticpetvet.net/avian/

Mayer, J., & Donnelly, T. M. (2012). Clinical Veterinary Advisor: Birds and Exotic Pets. https://espace.library.uq.edu.au/view/UQ:715922

Melnychuk, V., Yevstafieva, V., Kolomak, I., Muzyka, D., Chaplygina, A., Filonenko, S.,

& Opara, N. (2024). Description of feather mite Proctophyllodes musicus (Acariformes, Proctophyllodidae) obtained from Turdus merula. *Biosystems Diversity*, *32*(2), 246–251. https://doi.org/10.15421/012426

Mironov, S., & Tolstenkov, O. (2013). Three new feather mites of the sbfamily Pterodectinae (Acari: Proctophyllodidae) from passerines (Aves: Passeriformes) in Vietnam. *Proceedings of the Zoological Institute RAS*, *317*(1), 11–29. https://doi.org/10.31610/trudyzin/2013.317.1.11

Moretta, I., Principato, S., Brustenga, L., & Principato, M. A. (2025). Poultry mites contributing to human dermatitis: A retrospective study in Italy (2010–2024). Poultry, 4(2), 21. https://doi.org/10.3390/poultry4020021

Moro, M. M. L. A., Waquim, E. C., De Melo Evangelista, L. S., & Hernandes, F. A. (2019). Feather mites (Acari: Astigmata) of the Zoobotanical State Park in Teresina, Brazil. Acarologia, 59(4), 424–432. https://doi.org/10.24349/acarologia/20194345

Mullen, G. R. & Oconnor, B. M. (2002). Mites (Acari). In: L. A. Durden & G. R. Mullan (Eds.). Medical and Veterinary Entomology (pp. 449-516), Elsevier.

Negm, M., Mohamed, A., El-Gepaly, H. & Abdelaziz, S. (2018). Mesostigmata mites (Acari: Parasitiformes) associated with birds and their nests from. Turkish Journal of Zoology, 42(6), 722-731. https://doi.org/10.3906/zoo-1801-24

Negm, M. W., Hernandes, F. A., Nasser, M. G. E., Ahmad, A. M. A., & Shobrak, M. (2019). New records of feather mites (Astigmata: Analgidae, Avenzoariidae, Proctophyllodidae) from the blackcap, Saunders's tern and osprey in Saudi Arabia. *International Journal of Acarology*, *45*(3), 113–118.

https://doi.org/10.1080/01647954.2018.1561752

Paré, J. A., & Veterinarian, S. (2008). BSAVA Manual of Psittacine Birds, 2nd ed. Canadian Veterinary Journal, 49(3), 268. http://europepmc.org/articles/PMC2249719

Patel, U., Patond, C., Dev, R., & Mukherjee, S. (2025). Therapeutic management of Knemidocoptes pilae infestation in budgerigars (Melopsittacus undulates): Case Reports. International Journal of Veterinary Sciences and Animal Husbandry, 10(4), 221–224. https://doi.org/10.22271/veterinary.2025.v10.i4d.2201

Patel, V., Bhadesiya, C., Gajjar, P., Anikar, M., Dadawala, A., Makwana, P., & Lende, S. (2022). Prevalence of Endoparasites and Ectoparasites in Pet Budgerigars (Melopsittacus undulatus) of Gujarat, India. Ecology Environment and Conservation, S233–S239. https://doi.org/10.53550/eec.2022.v28i06s.039

Prathipa, A., Jayathangaraj, M., Gomathinayagam, S., & Thangavelu, A. (2014). Feather mites of psittacine birds [Journal-article]. *International Journal of Veterinary Science*, 30–32. https://www.ijvets.com/pdf-files/Volume-4-no-1-2015/30-32.pdf

Proctor, H. & Owens, I. (2000). Mites and birds: diversity, parasitism, and coevolution. Trends in Ecology and Evolution, 15(9), 358-364. https://doi.org/10.1016/s0169-5347(00)01924-8

Sakas, P. S. (2002). Essentials of avian medicine: A Guide for Practitioners. American Animal Hospital Association.

Samuel, P. P., 1, Govindarajan, R., 1, Krishnamoorthi, R., 2, & Ayyakani Venkatesh. (2020). A rapid protocol for clearing, staining, and mounting of Arthropoda: Trombiculidae, Pediculidae and Pulicidae. In NORTH-WESTERN JOURNAL

OF ZOOLOGY (Vol. 17, Issue 1, pp. 1–5). NWJZ, Oradea, Romania. https://biozoojournals.ro/nwjz/content/v17n1/nwjz_e201104_PhilipSamuel.pdf

Saranya, K., Prathaban, S., Senthilkumar, K., Srithar, A., & Gomathinayagam, S. (2018). Prevalence of ectoparasites and its identification in captive wild birds. International Journal of Current Microbiology and Applied Sciences, 7(08), 1093–1100. https://doi.org/10.20546/ijcmas.2018.708.124

Science, D. (2019). Zookeeper Assistant Program. https://www.animalbehaviorcollege.com/wp-content/uploads/2020/09/zap-sneak-peak.pdf

Siepel, H., Cremers, H., & Vierbergen, B. (2016). Provisional checklist of the astigmatic mites of the Netherlands (Acari: Oribatida: Astigmatina). Wageningen University and Researchcenter Publications (Wageningen University & Research), 47, 49–88. https://research.wur.nl/en/publications/provisional-checklist-of-the-astigmatic-mites-of-the-netherlands-

University of Bristol. (2017). Skin scrape. Retrieved May 27, 2025, from https://www.bristol.ac.uk/media-library/sites/vetscience/documents/clinical-skills/Skin%20Scrape.pdf

Waki, T., Mironov, S. V., Nakajima, A., & Shimano, S. (2023). A new feather mite of the genus Pelargolichus (Acariformes: Pterolichidae) from the Oriental White Stork Ciconia boyciana (Ciconiiformes: Ciconiidae) in Japan. Systematic and Applied Acarology. https://doi.org/10.11158/saa.28.3.5

Yildiz, Ö., & Köse, O. (2023). Investigation of ectoparasites in budgerigar and canaries in

Burdur city of Turkey. Mehmet Akif Ersoy Üniversitesi Veteriner Fakültesi Dergisi, 8(2), 89–94. https://doi.org/10.24880/maeuvfd.1243440