UNIVERSITI
MALAYSIA
KELANTAN

IDENTIFICATION OF ECTOPARASITES IN RABBITS (*ORYCTOLAGUS CUNICULUS*) AND THEIR ASSOCIATED RISK FACTORS IN THREE SELECTED ZOOS IN MALAYSIA

BY

FIKRIE BIN FAKHAROLL RODZIEE

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 as 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 _____
☐	CONFIDENTAL	(Contains confidential information under the Official Secret Act 1972)*
☐	RESTRICTED	(Contains restricted information as specified by the organisation 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 Universiti 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

NRIC/PASSPORT NO: 020525-070393

DATE: 27.11.2025

SIGNATURE OF SUPERVISOR

DR GOH SOON HENG

DATE: 27.11.2025

Note:* If the thesis is CONFIDENTIAL OR RESTRICTED, please attach 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, Universiti Malaysia Kelantan, in partial requirement on the course DVT 55204- Research Project.

With the rising trend of zoos in Malaysia, where visitors interact with animals, there is a potential risk of ectoparasite transmission to visitors. This study aims to identify the ectoparasite, and investigate the potential associated risk factors of ectoparasites among rabbits in three selected zoos in Malaysia. The study was conducted on three selected zoos in Malaysia. The samples were selected using simple random sampling without replacement from three zoos in Malaysia. Skin scrapings, hair plucking, and tape strip techniques were used to collect samples from the selected rabbits with clinical signs. A total of 57.5% (n=23/40) of rabbits from the three zoos were identified as positive for ectoparasites. Mites presented were *Sarcoptes* spp. *Notoedres* spp. and *Leporacarus* spp. Young rabbit was found to be a potential risk factor due to its significant relationship with the presence of ectoparasites. As a conclusion, from the findings, there is importance of ectoparasite identification and surveillance among rabbits in the zoo where this will lead to a better management and control practice to prevent further infestation and transmission to other animals and humans. To achieve more accurate and precise identification of the ectoparasites to the species level, molecular identification and sequencing techniques should be implemented in the future.

Keywords: *Rabbits, Ectoparasites, Zoos, Age, Sex, Ectoparasite Control*

ABSTRAK

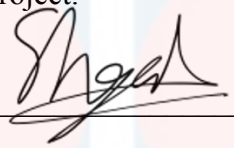
Satu abstrak kertas penyelidikan dikemukakan kepada Fakulti Perubatan Veterinar, Universiti Malaysia Kelantan, memenuhi sebahagian keperluan kursus DVT 55204–Projek Penyelidikan.

Dengan peningkatan trend zoo di Malaysia yang membenarkan interaksi antara pengunjung dan haiwan, terdapat potensi risiko penularan ektoparasit kepada pengunjung. Kajian ini dijalankan untuk menentukan kadar pengesanan ektoparasit, mengenal pasti genus yang terlibat serta menilai faktor risiko yang berpotensi berkaitan dengan jangkitan ektoparasit dalam kalangan arnab di beberapa zoo di Malaysia. Kajian ini dijalankan di tiga zoo terpilih di Malaysia. Sampel telah dipilih menggunakan kaedah persampelan rawak mudah tanpa penggantian. Teknik pengikisan kulit, cabutan bulu dan jalur pita digunakan untuk mengumpul sampel daripada arnab yang menunjukkan tanda klinikal. Sejumlah 57.5% (n-23/40) arnab daripada ketiga-tiga zoo di Malaysia telah dikesan positif. Ektoparasit yang dikesan terdiri daripada *Sarcoptes* spp., *Notoedres* spp. dan *Leporacarus* spp. Umur didapati berpotensi untuk menjadi faktor risiko kerana mempunyai hubungan yang signifikan dengan kehadiran ektoparasit. Konklusinya, berdasarkan hasil perjumpaan, ia menegaskan kepentingan pengesanan dan surveilan ektoparasit dalam kalangan arnab-arnab di zoo di Malaysia di mana ia akan menuju ke arah pengurusan dan kawalan yang lebih baik untuk mengelakkan penularan dan jangkitan ke haiwan lain dan manusia. Bagi mendapatkan identifikasi yang lebih tepat sehingga ke peringkat spesies, kaedah identifikasi molekul dan penjujukan gen perlu digunakan dalam kajian akan datang.

Kata kunci: *Arnab, Ektoparasit, Zoo, Umur, Jantina, Kawalan Ektoparasit*

CERTIFICATION

This is to certify that we have read read this research paper entitled '**Identification of Ectoparasites in Rabbits (*Oryctolagus cuniculus*) and Their Associated Risk Factor in Three Selected Zoos in Malaysia**' by Fikrie bin Fakharoll Rodziee in our opinion, it is satisfactory in terms of scope, quality, and presentation as partial fulfilment of the requirements for the course DVT 55204 – Research Project.



Dr Goh Soon Heng

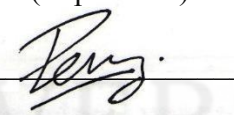
DVM (UMK), PhD in Epidemiology and Public Health (UPM)

Senior Lecturer

Faculty of Veterinary Medicine

Universiti Malaysia Kelantan

(Supervisor)



Dr Tan Li Peng

B.Sc of Forestry (UPM), PhD in Entomology (UPM)

Senior Lecturer

Faculty of Veterinary Medicine

Universiti Malaysia Kelantan

(Co-supervisor)

ACKNOWLEDGEMENT

I would like to express my heartfelt gratitude to all those who have provided their support, guidance, assistance, emotional and moral support in the completion of this project paper:

Dr Goh Soon Heng

Dr Tan Li Peng

Dr Wong Pei Ting

Dr Suhailiza Hanie Suroya

Dr Faranieyza Afiqah Binti Farzee

Puan Zalhasrah Binti Ahmad Fathillah

Cik Hasimah Binti Hassan

Parents and Family

Ku Nur Afifatin

Lycan

Thank you

DEDICATION

First and foremost, I express my gratitude to Allah (Alhamdulillah) for the health, guidance, and strength granted to me throughout this journey. With His blessings, I successfully completed this research project and overcame every challenge with resilience and perseverance.

To my lecturers and supervisor, especially Dr Goh Soon Heng and Dr Tan Li Peng, who provided not only their knowledge and expertise but also the wisdom and insight that allowed me to grow both academically and personally. I would also like to express my gratitude to the zoo veterinarians, Dr Wong, Dr Suhailiza and Dr Faranieyza for the opportunity, guidance, and assistance during the sampling process. I would also like to express my sincere appreciation to Puan Zalhasrah for her invaluable assistance throughout the sampling process, including accompanying and driving us to the various zoos involved in this study.

I would like to express my deepest gratitude to my family for their unwavering encouragement, patience, and love. I am forever grateful for your prayers, sacrifices and guidance. To my project partner, Ku Nur Afifatin, thank you for your continuous support and for helping with the many tasks and challenges we encountered throughout this project journey. Also to my classmates, Lycans, who stood by my side through every late night and moment of doubt, thank you for your constant support.

Finally, I dedicate this work to the countless researchers and scholars whose contributions laid the foundation for this study. May this work contribute, in some small way, to the collective body of knowledge and inspire future endeavours.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

µg	Microgram
b/wt	Body weight
CI	Confidence Interval
df	Degrees of freedom
GABA	Gamma-aminobutyric acid
kg	Kilogram
L	Liter
mg	Milligram
OR	Odds ratio
PCR	Polymerase Chain Reaction
pcs	Piece
spp	Species
SPSS	Statistical Package for the Social Sciences

LIST OF SYMBOLS

n	Sample size
%	Percentage
P value	Probability value
X^2	Chi square statistic
φ	Phi coefficient
>	More than
<	Less than

CHAPTER 1

INTRODUCTION

1.1 RESEARCH BACKGROUND

Rabbits (*Oryctolagus cuniculus*) are commonly kept as pets, used for meat, and also kept in enclosures, such as zoos, where visitors have the opportunity to touch and hold the animals (El-Ghany, 2022). Rabbits have been domesticated and bred for various purposes, including as pets, for medical research, for meat, and for fur (Braverman, 2014). Some rabbits in zoos are kept intensively, while others are kept semi-intensively. Animal zoos or fun fairs sometimes offer an opportunity for interaction with animals. However, on the other side, physical contact with animals and their environment also carries a risk of infection with zoonotic pathogens, especially ectoparasites. Ectoparasites are organisms that inhabit on the skin surface or inside the skin of a host, which is another animal, for a certain period of time for them to mature and multiply (Muhammad *et al.,* 2021). There are about 250 species of mites that have been identified, which cause health problems both for humans and animals (Mullen & OConnor, 2019). Visitors must be aware of the zoonotic risks when in close contact with animals (Isler *et al.*, 2020). Rabbits that are infested with ectoparasites are capable of transmitting to other rabbits and also to humans that handle them via direct or indirect contact (El-Ghany, 2022). With the increase in public contact with rabbits through visiting rabbit farms, humans can become infested with rabbits' ectoparasites, such as the common mites *Cheyletiella parasitovorax* and *Sarcoptes scabiei* (Muhammad *et al.,* 2021). Although there is limited research on ectoparasites in zoos in Malaysia, a cross-sectional study of ectoparasites in rabbits on a meat farm in Selangor had been

conducted. Based on the study, the most commonly ectoparasites that were found ectoparasites were *Sarcoptes scabiei* (25.92% ± 0.44), followed by *Cheyletiella parasitovorax* and *Psoroptes cuniculi* (9.26% ± 0.29) (Mohamad-Radzi *et al.,* 2020). It is also important to identify the associated risk factors that lead to the infestation of ectoparasites in rabbits, where these can be influenced by both treatment control regimes and intrinsic factors such as age and sex. There isa lack of data and information regarding the health risks associated when visiting zoos, especially in Malaysia. The importance of this research and results is that it will provide baseline data on the current detection percentage of ectoparasite infestation in rabbits in zoos. It also helps identify possible health implications towards rabbits and humans.

1.2 RESEARCH PROBLEM STATEMENT

With the rising trend of zoos in Malaysia, where visitors can interact with animals, there is a potential risk of ectoparasite transmission to visitors (Mohamad-Radzi *et al.,* 2020). There are fewer articles or research regarding ectoparasites in rabbits in zoos, especially in Malaysia. Ectoparasite infestation in rabbits can be a public health concern, especially for visitors when they make direct contact with the rabbits, as there is possible ectoparasite transmission from rabbits to humans, since there is a reported case of ectoparasite transmission from rabbit to human due to direct or indirect contact in Korea (Choe *et al.,* 2020). There is also limited information relating to the risk factors towards ectoparasite infestation, such as age, sex and ectoparasite control. This highlights the importance of investigating the detection percentage of ectoparasites in rabbits and their associated risk factors in Malaysian zoos.

1.3 RESEARCH QUESTIONS

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

1.4 RESEARCH HYPOTHESIS

1. *Sarcoptes scabiei, Psoroptes cuniculi* and *Cheyletiella parasitovorax* are the ectoparasites that can be identified among rabbits in three selected Malaysian zoos.
2. The age, sex and ectoparasite's control regime are potential associated risk factors of ectoparasite infestation among rabbits in three selected Malaysian zoos.

1.5 RESEARCH OBJECTIVES

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

CHAPTER 2

LITERATURE REVIEW

2.1. OVERVIEW

2.1.1 Common Ectoparasites in Rabbits

Based on an investigation of meat-farm rabbits in Selangor, *Sarcoptes scabiei* was the most frequent mite found (25.92% ± 0.44) followed by *Cheyletiella parasitovorax* and *Psoroptes cuniculi* (9.26% ± 0.29) (Mohamad-Radzi *et al.*, 2020). Although this investigation was conducted on meat-farm rabbits, it still provides valuable information, such as identifying possible or common ectoparasites that infest rabbits. Ectoparasites were identified based on morphology and observed under a light microscope (Li *et al.,* 2023). The morphology observed was referred to in the taxonomic literature where each mite had unique anatomical features that serve as important taxonomic characteristics (Mullen & OConnor, 2019). Mites were commonly transmitted and infected other hosts via direct contact between infected and healthy rabbits or indirect contact with contaminated fomites or the environment (El-Ghany, 2022).

The most commonly found ectoparasite was *Sarcoptes scabiei,* which was an important obligate ectoparasite. They are burrowing mites that live and lay eggs in the epidermis of the skin in humans and rabbits. This causes scabies disease that leads to significant morbidity and in high infestation in debilitated animals, it may lead to mortality (El-Ghany, 2022). *Sarcoptes scabiei* can be found and affect the ears, skin, limbs and corners of the mouth (Kumar *et al*., 2022). The common morphology is that it has rounded and tiny pointed spines on its dorsal

surface, long unsegmented pedicles, with the anus at the posterior edge of the body (Mullen & OConnor, 2019).

The life cycle of *Cheyletiella parasitovorax* takes place on the host for 35 days (Kim *et al*., 2013). Upon observation under microscope, *Cheyletiella parasitovorax* has the appearance of blade-like chelicerae, which used to pierce the host. Besides that, it has short and strong palps with curved claws (Mullen & OConnor, 2019).

Psoroptes cuniculi are commonly known to infect the ear, causing ear canker. 4 pairs of long legs, divided into 2 groups, the long rostrum and the regular curved posterior part of the body with unsegmented pedicles (Mullen & OConnor, 2019).

2.1.2. Clinical Signs Associated with Rabbits

Rabbits that are infested with ectoparasites come with intense pruritus, excessive scratching, desquamations, crusting and alopecia in scapular and periauricular regions (Mohamad-Radzi *et al.,* 2020). Rabbits infested with *Psoroptes cuniculi* commonly presented with signs of head shaking, and dry, crusty lesions on the inner side of the pinnae (Rodrigues *et al.*, 2024). There were also studies mentioning the lesion is not limited to the ear pinnae and canal, but may extend to the extra-auricular area and throughout the body (Mir *et al.,* 2025). These clinical signs and symptoms, especially pruritus and rash on the skin, are caused by sensitisation or a type of allergic reaction towards the proteins and faeces of the ectoparasite (El-Ghany, 2022). Severe pruritus, especially at night, is the earliest and most common symptom of scabies (Kumar *et al.,* 2022). Rabbits infested with ectoparasites experience severe economic

losses in their production system, resulting in reduced productivity, weight loss, poor leather quality, decreased conception rates, and increased mortality (El-Ghany, 2022).

2.2. ASSOCIATED RISK FACTORS OF ECTOPARASITE INFESTATION IN RABBITS IN ZOOS IN MALAYSIA

The first associated risk factor of ectoparasite infestation in rabbits in zoos is age. Juvenile rabbits, which are younger, are more prone to and susceptible to ectoparasite infestations. Usually, all ages are susceptible according to a study conducted by Mohamad-Radzi *et al.* (2020). However, according to a study by El-Ghany (2022), there is a higher incidence of mite infestations in young rabbits compared to adults, suggesting that younger rabbits are more susceptible to such ectoparasites. It is also possible that younger rabbits come into contact more frequently with adults who have been originally infested with ectoparasites (Chebet, J *et al.*, 2018).

The second associated risk factor of ectoparasite infestation in rabbits in zoos is sex. An epidemiological survey by El Shahawy *et al.* (2016) found that male rabbits had a higher prevalence of mange mites than females in rabbits. However, a study by Hajipour and Zavarshani (2020) found no significant difference in infection rates between males and females.

The third associated risk factor of ectoparasite infestation in zoo rabbits is the ectoparasitic control regime. There are several treatment protocols for ectoparasitic control in rabbits. Ivermectin administration at a dose of 0.2–0.4 mg/kg body weight (b/wt) once every 2 weeks for 2 to 3 times, 0.2–0.4 mg/kg·b/wt once every 2 weeks for 2-3 times and 400 µg/kg·b/wt

for 3 weeks at weekly intervals are very efficient in controlling *Sarcoptes scabiei* and *Psoroptes cuniculi* in rabbits (El-Ghany, 2022).

2.3.ZOONOTIC DISEASE TRANSMITTED FROM ECTOPARASITES IN RABBITS

Mite infestations are common problems reported in pets, as well as on farms and in farmed practices (Mohamad-Radzi *et al*., 2020). *Sarcoptes* sp. and *Cheyletiella* sp. could be a potential zoonosis from rabbits to humans (Mohamad-Radzi *et al*., 2020). The ectoparasites found should be concerning since they are zoonotic and raise public health concerns, especially during the handling of rabbits. In humans, children are more susceptible to scabies than adults (El-Ghany, 2022). Cheyletiellosis is a zoonosis that causes papular dermatitis in humans and may be transmissible to other species. It can lead to various clinical manifestations in humans, such as skin irritation, redness, itching, and hypersensitivity reactions; however, these signs typically do not appear after 4–8 weeks (Mohamad-Radzi *et al.*, 2020). Other than that, a report in Italy in 2013 by D'Ovidio and Santoro described two pet rabbits, and their owner was infested with *Leporacarus gibbus.* Thus, further supporting the evidence of zoonotic potential from ectoparasites to humans.

2.4. MANAGEMENT AND CONTROL STRATEGIES

Since most ectoparasite infestations have possible zoonotic transmission, wearing gloves when handling the animal can prevent direct contact transmission together with thorough cleaning of any contaminated equipment or environment (Singh *et al.,* 2024). Environmental treatments such as washing the beddings, vacuuming or physically removing ectoparasites are possible actions to eliminate possible reinfestation sources (ESCCAP, 2015). Newly arrived

rabbits should be quarantined and isolated for a period to monitor for signs of ectoparasites before introducing them to existing populations (Barrows *et al.,* 2017). This prevents possible spread to other rabbits. Rabbits also should have regular check-ups for health assessments and preventive care. The condition of the enclosure, house, or cages should be clean and hygienic to prevent rabbits from being infested with ectoparasites.

To achieve an effective treatment of mange in rabbits, proper management and the use of parasiticides or acaricides may be beneficial. Organophosphorus compounds, such as diazinon, synthetic pyrethroids like deltamethrin and permethrin, and macrolactones, including ivermectin derivatives, are the most commonly used acaricides (El-Ghany, 2022). Ivermectin can be used as an acaricide, where the drug acts on the nervous system of mites, especially *Sarcoptes scabiei,* and causes them to die (Rosumeck *et al.,* 2018). The mites will die from ivermectin, as the drug blocks the chemical transmission across nerve synapses. Mites use Gamma-aminobutyric acid (GABA) to send messages. Ivermectin blocks gamma-aminobutyric acid-gated channels, which causes the mites to become paralysed and die (Paichitrojjana & Paichitrojjana, 2024).

CHAPTER 3

RESEARCH METHODOLOGY

3.1 ANIMAL ETHICS STATEMENT

This study had obtained animal ethics approval from the Institutional Animal Care and Use Committee (IACUC) of Universiti Malaysia Kelantan, with approval reference UMK/FPV/ACUE/FYP/018/2025.

3.2 STUDY AREA

The study was conducted at three selected zoos in Malaysia.

3.3 STUDY DESIGN

The study design selected for this research was a cross-sectional study.

3.4 STUDY POPULATION

The study population was selected using simple random sampling without replacement, with 15 rabbits chosen from Zoo A, 5 rabbits from Zoo B, and 20 rabbits from Zoo C, resulting in a total sample size of 40 rabbits selected from the three zoos in Malaysia.

3.5 SELECTION CRITERIA

3.5.1 Inclusion criteria

Samples were free-range in the rabbit enclosure with clinical signs such as pruritus, alopecia and presence of scabs.

3.5.2 Exclusion criteria

Rabbits that have recently received the ectoparasite control treatment.

3.6 SAMPLING PROCEDURE

3.6.1 Skin scraping

Skin scraping was divided into superficial and deep skin scrapings. #10 scalpel blades were used, and mineral oil was applied on the blade and the skin lesion. The skin was scraped where ectoparasites were suspected to be found until the skin debris had adhered to the blade. For deep skin scrapings, the skin was scraped until capillary bleeding was seen. The blade with scrapings was kept in the urine container for transporting. Upon arrival in the laboratory, the blade was transferred onto a glass slide and a cover slip was added to it. The slide was observed under an Olympus CX21FS1 light microscope with x10 and x40 magnification. Identification was carried out according to the available morphological descriptions, taxonomic keys, and published descriptions of mites reported.

3.6.2 Hair plucking

A group of hair was grasped and held at 90° close to the base. The hair was cut with scissors and kept in a ziplock bag for transport. Upon arrival in the laboratory, the hair was transferred onto a glass slide and mounted with mineral oil. A cover slip was then added to it.

The slide was observed under an Olympus CX21FS1 light microscope with x10 and x40 magnification. Identification was carried out according to the available morphological descriptions, taxonomic keys, and published descriptions of mites reported.

3.6.3 Tape strips

A piece of 10 cm clear Scotch tape was used. It was placed at the suspected region or area with ectoparasites. At the same time, the skin was gently squeezed to ensure that any mites or other contents on the surface adhered to the tape. Then, the tape strip was removed and fixed on a glass slide. The slide was observed under an Olympus CX21FS1 light microscope with x10 and x40 magnification. Identification was carried out according to the available morphological descriptions, taxonomic keys, and published descriptions of mites reported.

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 rabbit 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 rabbits were determined based on physical characteristics observed during handling.

3.8 DATA ANALYSIS

Data entry was inserted into Microsoft Excel and was analysed using 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 from the population were determined to summarise the data by tabulating based on frequency & percentage for categorical data. The results were combined and broken down into groups according to each variable of risk factors, such as age, sex and ectoparasite control. The association between risk factors & outcomes will be determined using Chi chi-square test or Fisher's exact test, depending on whether the data meet the assumptions for each test, with a level of significance P-value less than 0.05

CHAPTER 4

RESULTS

4.1. DETECTION PERCENTAGE OF ECTOPARASITES AMONG RABBITS IN THREE SELECTED ZOOS IN MALAYSIA

Based on the results obtained, the detection percentage for Zoo A and B were 33.33% (n=5/15) and 100% (n-5/5) respectively, while Zoo C was 65% (n=13/20). A total of 57.5% (n=23/40) of rabbits sampled were positive for ectoparasites, while the remaining were negative. *Sarcoptes* spp. and *Notoedres* spp. were identified in Zoo B while *Leporacarus* spp. was identified in Zoo A and C. The results were shown in Table 4.1

Table 4.1: Detection Percentage and Ectoparasite Identification in Rabbits in Zoo A, B and C

Zoo	Total rabbits sampled (n)	Presence of ectoparasites (n)	Absence of ectoparasites (n)	Detection Percentage (%)	Ectoparasite Identified
A	15	5	10	33.33	*Leporacarus* spp.
B	5	5	0	100	*Sarcoptes* spp., *Notoedres* spp.

C	20	13	7	65	*Leporacarus* spp.
Total	40	23	17	57.5	

4.2. ECTOPARASITES IDENTIFIED AMONG RABBITS IN THREE SELECTED ZOOS IN MALAYSIA

Several ectoparasites were also identified in the rabbits. The data was represented in Table 4.2.

Table 4.2: Ectoparasite Identified, Numbers and Percentage from Rabbits in Zoo A, B and C

Ectoparasite Identified	Numbers (n=40)	Percentage (%)
Sarcoptes spp.	5	12.5
Notoedres spp.	3	7.5
Leporacarus spp.	18	45

From Table 4.2, 12.5% (n=5/40) of rabbits had *Sarcoptes* spp. identified. From Figure 4.1, the characteristic morphology of *Sarcoptes* spp. is that it had rounded and tiny, pointed

spines on its dorsal surface, and long, unsegmented pedicles with the anus located at the posterior edge of the body. On the other hand, 7.5% (n=3/40) of rabbits had *Notoedres* spp. identified among them. From Figure 4.2, it had long unsegmented pedicles, the anus is at the dorsal and subterminal surface, and it was smaller than *Sarcoptes* spp. As for *Leporacarus* spp., it had the highest detection percentage with 45% (n=18/40) of rabbits among them. From Figure 4.3, it had brown, ovoid shapes and is short, ventrally directed towards the legs.

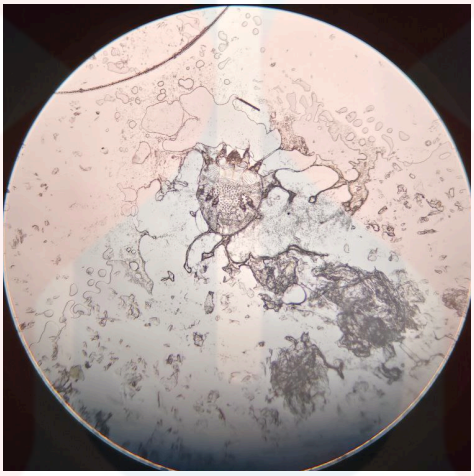


Figure 4.1: Tentative identification of *Sarcoptes* spp. under x10 magnification

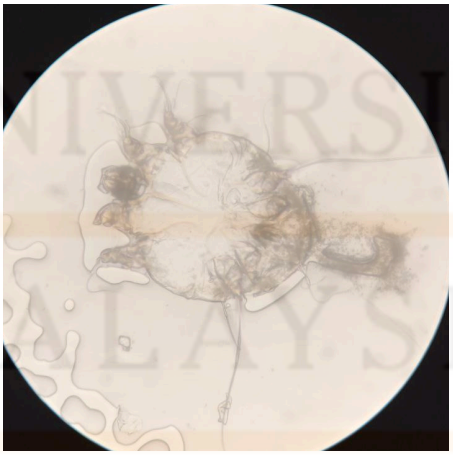


Figure 4.2: Tentative identification of *Notoedres* spp. under x40 magnification

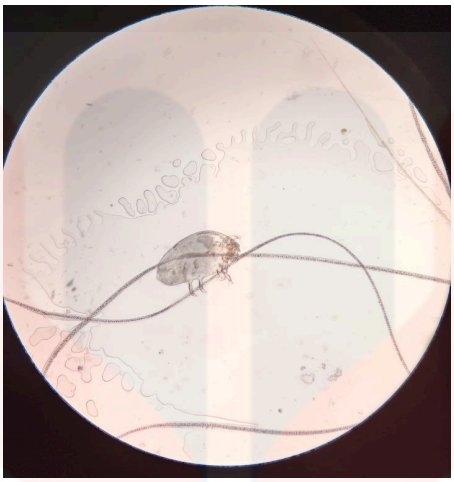


Figure 4.3 : Tentative identification of *Leporacarus* spp. under x10 magnification

4.3. ASSOCIATION OF RISK FACTORS OF ECTOPARASITES INFESTATION AMONG RABBITS

The results were combined and broken down into groups according to each variable of risk factors, which was shown in the tables below. For age, it was separated into two groups: young, which was less than 2 years old, and old, which was 2 years old or older. Besides that, the sex of the rabbits was also separated into male and female. Lastly, rabbits that had not received ectoparasite control and those that had were also separated.

Table 4.3: Association Between Age and Presence of Ectoparasites in Rabbits

Age	Positive	Negative	Total	X^2	P value	Odds Ratio	95% CI
Young	18 (72.0%)	7 (28.0%)	25 (100.0%)	5.736	0.017	5.143	1.289-20.518

Old	5 (33.3%)	10 (66.7%)	15 (100.0%)				
Total	23 (57.5%)	17 (42.5%)	40				

Based on Table 4.3, a total of 57.5% (n=23/40) of rabbits were positive for ectoparasites regardless of age. From that, there were 72.0% (n=18/25) young rabbits that were positive for ectoparasites and 33.3% (n=5/15) old rabbits that were positive for ectoparasites, indicating young rabbits had a higher percentage of ectoparasite positivity compared to old rabbits. A total of 42.5% (n=17/40) of rabbits were negative for ectoparasites regardless of age. From that, there were 28.0% (n=7/25) young rabbits that were negative for ectoparasites and 66.7% (n=10/15) old rabbits that were negative for ectoparasites. The results from Pearson Chi-Square revealed there was a significant association between age and presence of ectoparasites in rabbits (X^2=5.736, [df]= 1, P=0.017) with a moderate positive association between the relationship ($\varphi = 0.38$). The odds ratio was 5.143; since OR>1, there was a positive association. Young rabbits were 5.143 times more likely to be infested with ectoparasites compared to old rabbits. This result was statistically significant, as the p-value was less than 0.05, and the confidence interval does not include 1 (95% CI: 1.289-20.518).

Table 4.4: Association Between Sex and Presence of Ectoparasites in Rabbits

Sex	**Positive**	**Negative**	**Total**	**X^2**	**P value**	**Odds Ratio**	**95% CI**

Male	10 (58.8%)	7 (41.2%)	17 (100.0%)	0.21	0.884	1.099	0.309-3.913
Female	13 (56.5%)	10 (43.5%)	23 (100.0%)				
Total	23 (57.5%)	17 (42.5%)	40				

Based on Table 4.4, a total of 57.5% (n=23/40) of rabbits were positive for ectoparasites regardless of sex. From that, there were 58.8% (n=10/17) male rabbits that were positive with ectoparasites and 56.6% (n=13/23) female rabbits that were positive with ectoparasites, indicating male rabbits had a higher percentage of ectoparasite positivity compared to female rabbits. However, the total number of positive cases was higher in females compared to males. A total of 42.5% (n=17/40) of rabbits were negative for ectoparasites regardless of sex. From that, there were 41.2% (n=7/17) male rabbits that were negative for ectoparasites and 43.5% (n=10/23) female rabbits that were negative for ectoparasites. The results from Pearson Chi-Square revealed there was no significant association between sex and presence of ectoparasites in rabbits (X^2=0.21, [df]= 1, P=0.884), despite having a weak positive association between the relationship ($\varphi = 0.07$). The odds ratio is 1.099. Since OR > 1, a positive association was observed between the exposure and the outcome. Male rabbits were 1.099 times more likely to be infested with ectoparasites compared to female rabbits. This result was not statistically significant, as the p-value was greater than 0.05, and the confidence interval does not include 1 (95% CI: 0.309-3.913).

Table 4.5: Association Between Ectoparasite Control Regime and Presence of Ectoparasites in Rabbits

Ectoparasite Control Regime	Positive	Negative	Total	X^2	P value	Odds Ratio	95% CI
Given	5 (100.0%)	0 (0%)	5 (100.0%)	4.224	0.061	1.944	1.409-2.683
Not Given	18 (51.4%)	17 (48.6%)	35 (100.0%)				
Total	23 (57.5%)	17 (42.5%)	40				

Based on Table 4.5, a total of 57.5% (n=23/40) of rabbits were positive for ectoparasites regardless if they were given ectoparasite control or not. From that, there were 100.0% (n=5/5) rabbits that were given ectoparasite control that were positive with ectoparasites and 51.4% (n=18/35) rabbits that were not given ectoparasite control that were positive with ectoparasites, indicating rabbits given with ectoparasite control had higher percentage of ectoparasite positivity compared to rabbits not given ectoparasite control. A total of 42.5% (n=17/40) of rabbits were negative for ectoparasites regardless if they were given ectoparasite control or not. From that, there were 0% (n=0/5) rabbits that were given ectoparasite control that were negative for

ectoparasites and 48.6% (n=17/35) rabbits that were not given ectoparasite control that were negative for ectoparasites. The results from Fisher's exact test revealed there was no significant association between ectoparasite control and presence of ectoparasites in rabbits (X^2=4.224, [df]= 1, P=0.061), albeit having a moderate positive association between the relationship (φ = 0.32). The odds ratio was 1.944. Since OR > 1, a positive association was observed. Rabbits that were given ectoparasite control were 1.944 times more likely to be infested with ectoparasites compared to rabbits that were not given ectoparasite control. This result was not statistically significant, as the p-value exceeds 0.05, and the confidence interval does not include 1 (95% CI: 1.409-2.683).

CHAPTER 5

DISCUSSION

According to Li *et al.,* in 2023, since *Sarcoptes* spp. are burrowing mites, it can be identified commonly in deep skin scrapings and sometimes tape strips on the alopecia, pruritus and erythema sites (Guan *et al.,* 2023). Therefore, if the skin scraping was not deep enough, we may not be able to observe these mites. In a prevalence study in a rabbit farm in Selangor, the detection percentage was (25.92% ± 0.44) (Mohamad-Radzi *et al.,* 2020). However, in this study, the detection percentage of *Sarcoptes* spp. among the three zoos was 12.5% (n = 5/40), which was considered low. However, all the *Sarcoptes* spp. identified sample was from one zoo, which was Zoo B. This makes the detection percentage for that particular zoo was 100% (5/5), indicating the Sarcoptic infestation in this study was more severe. This was also supported by a history of past infestations of *Sarcoptes* spp. In this study, the ectoparasites were identified with microscopic examination. However, we can only identify it until the genus level. Other than that, during sampling, the presence of crusts and scabs may interfere with visualisation during observation under the microscope, thus reducing the visibility of mites.

There have been reported cases of rabbits infested with *Notoedres* spp. in America, causing lesions similar to those caused by *Sarcoptes* spp. (Chouhan *et al.,* 2025). It can be challenging to differentiate between these two genera, as they have almost identical morphology, with the key difference being the location of the anus. The ectoparasites can only be identified at the genus level according to the taxonomic characteristics (Mullen & OConnor, 2019). However, to confirm the morphological identification, the ectoparasites must be sent for polymerase chain

reaction (PCR) and sequencing to determine the species with specific primers (Diarra *et al*., 2020).

The next genus was *Leporacarus* spp., also known as fur mites. This genus had the highest number of mites identified among the others in this study. However, in a study in South Korea, the prevalence of *Leporacarus* spp. was low, which was 4.3% (n=6/140) (Kim *et al.,* 2008). It was usually distinguished by the small, brown or black debris distributed over the dorsum, especially the caudal dorsum. Therefore, it can be mistaken for debris or dirt on the fur. The mites usually grasp and cling to the hair; therefore, it can be observed from the hair pluck sample (Zygner & Gójska-Zygner, 2018). However, it became challenging to obtain the fur sample together with the mites. This is because they move quickly, and during hair plucking, we cannot pluck the fur too deeply at the base to maintain its aesthetic appearance, as it is used for exhibition in the zoo enclosure. Many *Leporacarus* spp. infestations are asymptomatic, but some rabbits may present with alopecia, pruritus, unkempt coat and erythema (Hasler *et al.,* 2025). Since it is usually subclinical, infected rabbits may remain unidentified for a certain period. Moreover, rabbits in zoos mostly originated from commercial breeders rather than the wild, making subclinical ectoparasite infestations unnoticed. A case report by Vale *et al.* (2025) also noted the identification of ectoparasites among rabbits from breeders in Portugal. The mixture of infected and healthy rabbits resulted in silent transmission and spread more than we had expected. Thus explaining why it has the highest detection percentage in this study. Since the samples taken were based on rabbits with clinical signs, the difference in numbers among the zoos varies widely, leading to uneven sample distribution across the three zoos. This eventually weakened the comparison among the zoos. Other than that, Martins *et al*., (2024) mentioned that

since *Leporacarus* spp. Although it does not cause any clinical signs, it was considered a commensal; however, a high parasite burden may lead to clinical signs.

The total detection percentage for the three zoos was moderate, with 57.5% (n = 23/40) of the sampled rabbits being positive for ectoparasites. There was an association between the presence of ectoparasites in rabbits with age, but no association with sex and the ectoparasite control regime. From the age factor, there were 72.0% (n=18/25) young rabbits that were positive for ectoparasites, and 33.3% (n=5/15) old rabbits that were positive for ectoparasites, indicating that young rabbits had a higher percentage of ectoparasite positivity compared to old rabbits. This suggests that young rabbits are more susceptible to ectoparasite infections than older rabbits. Based on the chi-square test, age was identified as a significant risk factor (P value < 0.05). This result is consistent with findings of a study conducted by Chebet *et al.,* (2018) that identified age, which is a significant risk factor for ectoparasite infestation, where young rabbits are more susceptible to ectoparasites compared to older rabbits. This could be related to the mixing of young and adult rabbits, where infestation occurs via direct contact. Young rabbits typically exhibit lower resistance to infection compared to older rabbits, making them more susceptible (Pilarczyk *et al.,* 2020). However, in another study by Shilereyo *et al.* (2022), adults have a higher chance of being infested with a higher parasitic load because they provide better nutritional resources for ectoparasites compared to young individuals. Additionally, a study noted that there were no significant differences in age, which may be due to both age groups being exposed to the same environmental factors (Christe *et al*., 2007).

In terms of sex, there were 58.8% (n=10/17) male rabbits that were positive with ectoparasites and 56.6% (n=13/23) female rabbits that were positive with ectoparasites, indicating male rabbits had a higher percentage of ectoparasite positivity compared to female rabbits. The samples evaluated in this study showed females were identified more often with ectoparasites compared to males. However, based on the chi-square test, sex was not found to be a significant risk factor (P-value> 0.05). This result is aligned with the findings of several studies conducted by El-Ghany (2022) and Chebet *et al.,* (2018), where they found that both sexes are susceptible to ectoparasite infestation with no significant difference in prevalence between males and females. Since both males and females were located in the same environment, both sexes had equal risk of being exposed to the contaminated environment. Sex-biased parasitism is a complex phenomenon that is more influenced by the environmental factors, with limited evidence that the parasite actively selects or preferentially distributes itself among hosts based on sex (Lin *et al.,* 2014). However, it has been suggested that male rabbits may be more susceptible to ectoparasite infestation due to increased contact with other rabbits and territorial defence behaviours compared with females (El Shahawy *et al.,*2016). Therefore, this increased susceptibility is likely due to behaviours that increase the risk of infection. Another study also noted that males are more prone to ectoparasites due to their larger body sizes compared to females (Shilereyo *et al.,* 2022).

From that, there were 100.0% (n=5/5) rabbits that were given ectoparasite control that were positive with ectoparasites and 51.4% (n=18/35) rabbits that were not given ectoparasite control that were positive with ectoparasites, indicating rabbits given with ectoparasite control had higher percentage of ectoparasite positivity compared to rabbits not given ectoparasite

control. However, based on Fisher's exact test, ectoparasite control was not found to be a significant risk factor (P-value> 0.05). Since simple random sampling was used in this study, the distribution of rabbits across each risk factor was imbalanced, affecting the associations between the variables. The total sample size for this study might be too small and insufficient and it will be more difficult to determine the true differences and relationships, therefore increasing the risk of Type II error. The rabbits under ectoparasite control were given ivermectin subcutaneously every 3 months as prevention. This schedule aligned with the recommendation according to Mitra *et al.,* (2014) that suggested ivermectin should be given once in 6 months as prophylaxis and long-term treatment. However, they were still infested with the ectoparasites. Since there were historical infestations of *Sarcoptes scabiei* among the rabbit population that were positive, the environmental parasite load may already be high, making the ectoparasite control regime inefficient. This can be supported with a statement from Takano *et al*., (2023), control failures that lead to reinfestation are possible via direct or indirect contact with infected individuals or contaminated environments. Moreover, ivermectin is one of the most frequently used therapies and preventive measures against ectoparasites, especially *Sarcoptes scabiei* and *Psoroptes cuniculi;* however, treatment failure can be due to noncompliance, high treatment costs, or also resistance (Absil *et al*., 2022). El-Ghany *et al*. (2022) also noted that the resistance of *Sarcoptes scabiei* to ivermectin has developed, raising concerns.

Since *Sarcoptes* spp. was identified, the zoonotic potential in this study was considered present as it is a well known zoonotic mite. According to Mullen & OConnor in 2019, *Sarcoptes* consists as a single species which is *Sarcoptes scabiei* with different varieties or physiological types depending on the host and they can affect more than 150 mammals. Additionally, rabbits

have been identified as a common source of Sarcoptic transmission to humans (Moroni *et al*., 2022). As for *Leporacarus* spp. and *Notoedres* spp., eventhough they were only identified only until genus level, they still harbor zoonotic potential. According to Chouhan *et al.*, (2025), *Notoedres cati* is one of the common species from the *Notoedres* genus with zoonotic potential. A 2013 report in Italy by D'Ovidio and Santoro described two pet rabbits and their owner, who were infested with *Leporacarus gibbus.* Therefore, it is essential to be aware and cautious when handling infected animals. Wearing gloves when handling the animal can prevent direct contact transmission, together with thorough cleaning of any contaminated equipment or environment (Singh *et al.,* 2024). Infected rabbits should be quarantined and isolated for a period to monitor their prognosis before being reintroduced into the population (Barrows *et al.,* 2017).

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1. CONCLUSION

In summary, ectoparasites were identified from skin scrapings, hair plucks, and tape strips obtained from rabbits at three selected zoos in Malaysia. A total of 57.5% (23/40) of rabbits sampled were positive for ectoparasites, and 42.5% (17/40) were negative for ectoparasites. The most common ectoparasite identified was *Leporacarus* spp. or also known as fur mites. A statistically significant association was found between age and the presence of ectoparasites in rabbits. However, there was no statistically significant association between sex and ectoparasite control with the presence of ectoparasites in rabbits. The sample size in this study was small and might be insufficient. It will be difficult to determine the true differences and relationships. In this study, the ectoparasites can only be identified up to genus level. Hence, to achieve more accurate and precise identification of the ectoparasites to the species level, molecular identification and sequencing techniques should be used. As a conclusion, from the findings, there is importance of ectoparasite identification and surveillance among rabbits in the zoo where this will lead to a better management and control practice to prevent further infestation and transmission to other animals and humans.

6.2. RECOMMENDATION

Further studies are needed to gather more comprehensive information. Since this study only identifies species at the genus level, the implementation of molecular identification methods

for species identification should be considered for improved accuracy in the future. Simple random sampling was used in this study, resulting in unbalanced numbers in each risk factor group. Stratified sampling can be considered for future studies where the population can be divided into strata based on risk. Stratified sampling can prevent the problem and control the group sizes. The sample size in the current study was small; it is recommended to increase the sample size to achieve greater accuracy and reliability of the results, thereby enhancing the ability to identify real associations and reducing Type II errors in future studies.

APPENDIX

Table 7.1. List of equipments for sampling procedure

NO.	EQUIPMENT	QUANTITY	INDICATION
1.	Scalpel blade	100 unit	For skin scraping sampling
2.	Urine container (small)	100 unit	Put scalpel blade with the scrapped material
3.	Glycerol	1 bottle	For skin scraping
4.	70% Ethanol	(5ml X 200 vial)= 1L	Preserve sample
5.	Glove (M)	1 box	Biosafety purposes
6.	Polystyrene (big)	1 box	Put all the samples collected
7.	Ziplock bag (small)	100 pcs	Put fur sample
8.	Cotton	1 roll	Wound dressing
9.	Scotch tape	2 unit	For acetate tape sampling

10.	Glass slide	2 box	For acetate tape method
11.	Face mask	1 box	Biosafety purposes
12.	Disposable pipette	1 box	To drop the glycerol
13.	Povidone iodine	1 bottle	Antiseptic if there is any injury to the animal

Figure 7.1: Equipments and materials used for sampling

Figure 7.2: Physical examination of rabbit before sampling

Figure 7.3 : Sampling rabbits with skin scraping method

Figure 7.4: Rabbit with an unkempt appearance

REFERENCE

Absil, G., Lebas, E., Libon, F., Hayderi, L. E., Dezfoulian, B., & Nikkels, A. F. (2022). Scabies and therapeutic resistance: Current knowledge and future perspectives. JEADV Clinical Practice, 1(3), 157–164. https://doi.org/10.1002/jvc2.25

Barrows, M., Killick, R., Saunders, R., Tahas, S., Day, C., Wyatt, K., Horspool, T., Lackey, L. B., Bristol Zoological Society, Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty, University of Zurich, World Association of Zoos and Aquariums (WAZA), University of Bristol, School of Veterinary Sciences, Langford, Bristol, BS40 5DU, & Cook, J. (2017). Retrospective analysis of elective health examinations as preventative medicine interventions at a zoological collection. Journal of Zoo and Aquarium Research, 5(1), 25–26.

Braverman, I. (2014). The ethics of captivity. In Oxford University Press eBooks. https://doi.org/10.1093/acprof:oso/9780199977994.001.0001

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

Chebet, J., Waruiru, R. M., & Ogolla, K. O. (2018). Prevalence, control and risk factors associated with rabbit mange in Kiambu and Nyeri counties, Kenya. Livestock Research for Rural Development, 30(6), 108.

Choe, S., Kim, S., Na, K. J., Nath, T. C., Ndosi, B. A., Kang, Y., Bia, M. M., Lee, D., Park, H., Eamudomkarn, C., Jeon, H. K., & Eom, K. S. (2020). First Infestation Case of Sarcoptic

Mange from a Pet Rabbit Oryctolagus Cuniculus in Republic of Korea. The Korean journal of parasitology, 58(3), 315–319. https://doi.org/10.3347/kjp.2020.58.3.315

Chouhan, K., Dittmer, M., Barron, H., Francisco, R., Reyes, J. R., Broadhurst, J. R., Nemeth, N. M., Fisher, T., Weyna, A. A. W., Stilz, C. R., Teo, X. H., Andreasen, V. A., Cunningham, M. W., Clemons, B. C. F., & Yabsley, M. J. (2025). Identification and molecular characterization of Notoedres spp. from notoedric mange cases in four species of mammals from Florida, USA. International journal for parasitology. Parasites and wildlife, 28, 101118. https://doi.org/10.1016/j.ijppaw.2025.101118

Christe, P., Glaizot, O., Evanno, G., Bruyndonckx, N., Devevey, G., Yannic, G., Patthey, P., Maeder, A., Vogel, P., & Arlettaz, R. (2007). Host sex and ectoparasites choice: preference for, and higher survival on female hosts. Journal of Animal Ecology, 76(4), 703–710. https://doi.org/10.1111/j.1365-2656.2007.01255.x

D'Ovidio, D., & Santoro, D. (2013b). Leporacarus gibbus infestation in client‐owned rabbits and their owner. Veterinary Dermatology, 25(1), 46. https://doi.org/10.1111/vde.12089

Diarra, A. Z., Kone, A. K., Niare, S. D., Laroche, M., Diatta, G., Atteynine, S. A., Coulibaly, M., Sangare, A. K., Kouriba, B., Djimde, A., Dabo, A., Sagara, I., Davoust, B., Ranque, S., Thera, M. A., Raoult, D., Doumbo, O. K., & Parola, P. (2020). Molecular Detection of Microorganisms Associated with Small Mammals and Their Ectoparasites in Mali. American Journal of Tropical Medicine and Hygiene, 103(6), 2542–2551. https://doi.org/10.4269/ajtmh.19-0727

El-Ghany, W. a. A. (2022b). Mange in Rabbits: An Ectoparasitic Disease with a Zoonotic Potential. Veterinary Medicine International, 2022, 1–11. https://doi.org/10.1155/2022/5506272

Elshahawy, I., El-Goniemy, A., & Ali, E. (2016). Epidemiological survey on mange mite of rabbits in the Southern Region of Egypt. Sains Malaysiana. http://journalarticle.ukm.my/9878/

ESCCAP (European Scientific Counsel Companion Animal Parasites). (2015). Guideline 03: Control of Ectoparasites in Dogs and Cats (4th ed.). ESCCAP. https://www.esccap.org/uploads/file/file/ESCCAP_Guideline_03_Fourth_Edition_December_2015.pdf

Guan, K., Xu, J., Gu, X., He, R., Xie, Y., Jing, B., Peng, X., & Yang, G. (2023). Artificial Infestation of Sarcoptes scabiei (Acari: Sarcoptidae) in Rabbits Exhibits Progressive Pathological Changes, Apoptosis, and Keratinization in the Skin. International Journal of Molecular Sciences, 24(3), 2187. https://doi.org/10.3390/ijms24032187

Kim, S. H., Jun, H. K., Song, K. H., Gram, D., & Kim, D. H. (2008). Prevalence of fur mites in pet rabbits in South Korea. Veterinary dermatology, 19(3), 189–190. https://doi.org/10.1111/j.1365-3164.2008.00673.x

Hajipour, N., & Zavarshani, M. (2020). Ectoparasites and Endoparasites of New Zealand White Rabbits from North West of Iran. Iranian Journal of Parasitology. https://doi.org/10.18502/ijpa.v15i2.3310

Hasler, D. E., Long, J. E., Nickerson, K. P., Lester, P. A., Martin, T. L., & Freeman, Z. T. (2025). Pruritus and Unkempt Coat in a New Zealand White Rabbit (Oryctolagus cuniculus). Journal of the American Association for Laboratory Animal Science, 64(4), 584–587. https://doi.org/10.30802/AALAS-JAALAS-25-088

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.12798

Kim, S. H., Kim, S., Park, H. J., Seo, K. W., & Song, K. H. (2013). Ectoparasites infestation rates in the pet rabbits of Daejeon area, Korea. Journal of Veterinary Clinics, 30(3), 186–188. https://ucdavis.pure.elsevier.com/en/publications/ectoparasites-infestation-rates-in-the-pet-rabbits-of-daejeon-are

Kumar, V. V. V., Effendi, M. H., Lastuti, N. D. R., Triakoso, N., & Fiorenza, M. P. (2022b). Prevalence and Severity of Scabies (Sarcoptes scabiei) on Rabbits in Kuala Lumpur City. Journal of Parasite Science, 6(1), 23. https://doi.org/10.20473/jops.v6i1.34286

Li, W., Li, X., Song, L., Li, H., Wu, Y., & Li, J. (2023). Optical microscopic study on a novel morphological classification method of multiple diagnostic features of Sarcoptes scabiei var. hominis. Parasitology, 150(11), 1070–1075. doi:10.1017/S0031182023000938

Lin, J., Lo, H., Wang, H., & Shaner, P. L. (2014). The effects of mite parasitism on the reproduction and survival of the Taiwan field mice (Apodemus semotus). Zoological Studies, 53(1). https://doi.org/10.1186/s40555-014-0079-2

Martins, N. S., Lignon, J. S., Pinto, D. M., Ferreira, M. R. A., Gasparetto, R., & Pappen, F. G. (2024). First record of Leporacarus gibbus infestation in domestic rabbits (Oryctolagus cuniculus) in southern Rio Grande do Sul state, Brazil. Acta Veterinaria Brasilica, 18(1), 21–24. https://doi.org/10.21708/avb.2024.18.1.11929

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

Mir, A. Q., Allaie, I. M., Mufeeda, T., Bhat, R. A., Wani, Z. A., Tramboo, S. R., Abdullah, M., Bulbul, K. H., Insha, A. M., & Shah, S. M. (2025). Psoroptes cuniculi infestation in an Angora rabbit from Kashmir and its therapeutic management. Journal of Parasitic Diseases, 49(4), 1109–1114. https://doi.org/10.1007/s12639-025-01827-x

Mitra J, Shikari R N, Das A K, Roy B B, Mitra M (2014) Therapeutic management of sarcoptic mange In rabbit with Ivermectin. Explor Anim Med Res 4(1): 116-120.

Mohamad-Radzi, N. N., Che-Amat, A., Aziz, N. a. A., Babjee, S. M. A., Mazlan, M., Hamid, N. F. S., & Lekko, Y. M. (2020b). Preliminary detection of mites and coccidia with their zoonotic potential in meat-farmed rabbits in three districts in Selangor, Malaysia. Journal of Parasitic Diseases, 45(1), 169–175. https://doi.org/10.1007/s12639-020-01291-9

Moroni, B., Rossi, L., Bernigaud, C., & Guillot, J. (2022). Zoonotic Episodes of Scabies: A global overview. Pathogens, 11(2), 213. https://doi.org/10.3390/pathogens11020213

Muhammad, A., Bashir, R., Mahmood, M., Afzal, M. S., Simsek, S., Awan, U. A., Khan, M. R., Ahmed, H., & Cao, J. (2021). Epidemiology of ectoparasites (Ticks, lice, and mites) in the livestock of Pakistan: a review. Frontiers in Veterinary Science, 8, 780738. https://doi.org/10.3389/fvets.2021.780738

Mullen, G. R., & OConnor, B. M. (2019). Mites (Acari). In Medical and Veterinary Entomology (pp. 533–602). https://doi.org/10.1016/b978-0-12-814043-7.00026-1

Nelder, M. P., Reeves, W. K., Adler, P. H., Wozniak, A., & Wills, W. (2008). Ectoparasites and associated pathogens of Free-Roaming and captive animals in zoos of South Carolina. Vector-Borne and Zoonotic Diseases, 9(5), 469–477. https://doi.org/10.1089/vbz.2008.0008

Paichitrojjana, A., & Paichitrojjana, A. (2024). Die-off reaction of Demodex mites after treating demodicosis with oral ivermectin: A case report. JAAD Case Reports, 52, 1–3. https://doi.org/10.1016/j.jdcr.2024.07.006

Paterson, S. (2006). Skin diseases of exotic pets. In Wiley eBooks. https://doi.org/10.1002/9780470752432

Pereira, A., Pereira, S., Gremião, I., Campos, M., & Ferreira, A. (2012). Comparison of acetate tape impression with squeezing versus skin scraping for the diagnosis of canine

demodicosis. Australian Veterinary Journal, 90(11), 448–450. https://doi.org/10.1111/j.1751-0813.2012.00994.x

Pilarczyk, B., Tomza-Marciniak, A., Pilarczyk, R., Januś, E., Stanek, P., Seremak, B., & Sablik, P. (2020). The effect of the sex, age, and breed of farmed rabbits and the choice of management system on the extensity and intensity of Eimeria infection. Veterinary world, 13(8), 1654–1660. https://doi.org/10.14202/vetworld.2020.1654-1660

Rodrigues, F. T., Simões, J., & Lopes, A. P. A. (2024). Ectoparasitoses in Rabbits. In Veterinary Care of Farm Rabbits (pp. 659–690). https://doi.org/10.1007/978-3-031-44542-2_31

Rosumeck, S., Nast, A., & Dressler, C. (2018). Ivermectin and permethrin for treating scabies. Cochrane Library, 2018(4). https://doi.org/10.1002/14651858.cd012994

Shilereyo, M., Magige, F., Ranke, P. S., Ogutu, J. O., & Røskaft, E. (2022). Ectoparasite load of small mammals in the Serengeti Ecosystem: effects of land use, season, host species, age, sex and breeding status. Parasitology Research, 121(3), 823–838. https://doi.org/10.1007/s00436-022-07439-1

Singh, S. K., Srivastava, M. K., Yadav, R. S., Gandhar, J. S., Kumari, S., Dawar, P., & Verma, K. (2024). Sarcoptic mange in domestic rabbits: Pathogenesis, impact, and control strategies. Veterinary Parasitology, 333, 110357. https://doi.org/10.1016/j.vetpar.2024.110357

Takano, K., De Hayr, L., Carver, S., Harvey, R. J., & Mounsey, K. E. (2023). Pharmacokinetic and pharmacodynamic considerations for treating sarcoptic mange with cross-relevance

to Australian wildlife. International Journal for Parasitology Drugs and Drug Resistance, 21, 97–113. https://doi.org/10.1016/j.ijpddr.2023.02.004

Vale, C., Lozano, J., Reisinho, A., Louro, M., Oliveira, M., Cunha, E., Lopes, P., Gomes, L., & De Carvalho, L. M. (2025). Gastrointestinal Parasites, Ectoparasites, and Fungi in Rabbits Attending Clinical Consultations and from Private Owners and Breeders in Portugal. Microorganisms, 13(9), 2146. https://doi.org/10.3390/microorganisms13092146

Zygner, W., & Gójska-Zygner, O. (2018). The first case of Leporacarus gibbus infestation in a rabbit from Poland. Acta Parasitologica, 63(1), 210–213. https://doi.org/10.1515/ap-2018-0024