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A SURVEY OF VERTEBRATES' ROADKILL WITHIN A 10 KM RADIUS FROM THE CENTRE OF KUALA PILAH TOWN, NEGERI SEMBILAN

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Abstract:

Assessing animal roadkill provides valuable insights into the diversity and abundance of different species within a particular area. This study has the potential to uncover factors influencing the occurrence of animal roadkill. However, there is a scarcity of studies focusing on animal roadkill in small, secluded areas such as the Kuala Pilah district, Negeri Sembilan. Thus, this study evaluates the composition and distribution of vertebrate roadkill within a 10 km radius from the centre of Kuala Pilah Town, with a focus on temporal (time of discovery), spatial (types of roads and types of surrounding areas), and environmental factors (the presence of streetlights). The road segments located within a 10 km radius from Kuala Pilah Town have been examined in ten weeks and the found carcasses were identified by their taxonomic groups and photographed. Further, their discovery location has been observed and marked with coordinates. A chi square test was then performed to evaluate the occurrence of animal roadkill with all recorded data. This study revealed 48 animal carcasses, with a taxonomic composition of 27.08% birds (13 individuals), 50% mammals (24 individuals), 18.75% reptiles (9 individuals), and 4.17% amphibians (2 individuals). The roadkill patterns showed that squirrels and cats as the most prevalent species found, with higher carcass rates found in plantation/forest areas and on state roads. Roadkill occurrences increased between 7 a.m. and 1 p.m., while streetlights had no noticeable impact on the numbers. Overall, mammals turned out to be the most frequent vertebrate class involved in roadkill with time being the only significant factor influencing the numbers. With a better understanding of the factors influencing vertebrate roadkill, mitigation strategies such as fencing, roadside vegetation

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clearance, and vehicle speed restrictions might be devised to minimize the adverse impacts of road infrastructure on local animal populations.

Keywords:

Road Development, Vertebrate Roadkill, Taxonomic Composition

Introduction

The world's surface is covered in roads, from arid deserts to verdant tropical forests. Road construction strives to hasten social integration and growth in the economy, simplify the movement of people and commodities, and reduce manufacturing costs (Ivanová & Masárová, 2013). However, roads and human activities that take place on roadways have harmful effects on animals, particularly wild animals. Among the most prevalent and prominent consequences of road construction include animal roadkill, which can be blamed on a variety of factors, such as habitat fragmentation and poor roadway positioning and design (Jamhuri et al., 2020). The construction of roads has disrupted the forest-covered region and indirectly forced animals to leave their designated zones and cross the roads while oblivious to the danger that awaits them. In fact, roads and traffic can be regarded as brand-new predators in which the animals have not yet evolved any defences or behavioural strategies that would boost their chances of surviving.

There are currently 21.6 million kilometres of roads in the world, and by 2050, that number is predicted to grow by 23% (Meijer et al., 2018). Malaysia also is one of the countries that have fast-growing road constructions. The development of roads in Malaysia has been happening since before the country's independence in 1957. Following its declaration of independence, Malaysia established the "Five-Year Malaysian Plan," which includes an effort to further develop its road network, placing a greater emphasis on the construction of rural and regional roadways. However, as the number of automobiles owned by individuals expanding, the focus of the following development plans shifted to the construction of urban and inter-urban highways (Olszewski & Tay, 1996). As forests become more divided into plantation roads and highways, the rate of animal-vehicle collisions is expected to grow (Wadey et al., 2018).

The impact of the rapidly expanding road development, this nation is also unable to prevent the occurrence of animal roadkill, which contributes to the decline in animal biodiversity in Malaysia. The Malayan Tapir, one of the International Union for Conservation of Nature (IUCN)-listed endangered species, is one of the animals that frequently become victims of road accidents in Malaysia (Traeholt et al., 2016). From 2006 to 2017, a total of 92 Malayan Tapir fatalities due to traffic collisions were recorded, with Pahang and Terengganu having the highest frequency of incidents (Department of Wildlife and National Parks Peninsular Malaysia, 2017). Negeri Sembilan was also not far behind with 14 Malayan Tapir deaths recorded, of which seven occurred on the same road connecting Seremban to Gemas (Magintan et al., 2021). This statistic is extremely alarming because, according to experts, there are only 1,500 to 2,000 Malayan Tapirs left in the entire globe (Traeholt et al., 2016), which, if it is not swiftly addressed, would result in the extinction of this species. Apart from Tapir, a press release from the Department of Wildlife and National Parks (DWNP) of Malaysia reported that 103 leopard cats and Asian golden cats were involved in road collision cases in Malaysia from 2015 to 2019 (Md Denin, 2020). The IUCN Red List classifies leopard cats in the "Least Concern (LC)" category (Ghimirey et al., 2022). However, since 2008, the Asian golden cat has been identified as "Near Threatened" (McCarthy et al., 2016). It might soon be vulnerable

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to endangerment if it is not properly addressed. By researching the causes of this issue, it is, therefore, possible to stop future incidents of these species being killed in roadkill incident.

Indeed, animal roadkill is the most evident and obvious undesirable consequence of road construction. Negeri Sembilan itself is consider as one of Malaysia's states with a high rate of animal roadkill cases with 164 counts of animal roadkill from 2019 to 2021 (PERHILITAN, 2019, 2020, 2021). Kasmuri et al. (2020) analyzed the PERHILITAN roadkill data from 2012 to 2017 to develop mitigating solutions. Magintan et al. (2021) also used the roadkill data from the PERHILITAN to measure and evaluate the regional and temporal patterns of Malayan tapir roadkill. There is also a study conducted by Jamhuri et al. (2020) that compared fatalities of large and medium-sized mammals on plantation roads to highways. However, most research papers on animal roadkill in Malaysia select a broad study region without addressing a more localized region. For this reason, this study focusses on investigating animal roadkill cases in small, secluded areas like Kuala Pilah Town. In addition, Kuala Pilah is regarded as an agricultural district, with a significant route from Malacca and Negeri Sembilan to the east coast states of Pahang, Terengganu, and Kelantan that bypasses the Klang Valley. Particularly, this study aims to determine the difference in the number of animal roadkill cases between the types of roads and the environment in which they occur. As well as to investigate the correlation between the factors that may contribute to the occurrence of animal roadkill. The outcomes of this research project might therefore reveal a representative background roadkill frequency for roads located around Kuala Pilah Town, Negeri Sembilan. The data collected will be useful to experts as they work to develop strategies that would reduce the amount of animal roadkill

Literature Review Roadkill

Three points have been covered in the literature review part. First, the prevalence of animal roadkill was reviewed, emphasizing its scale and consequences. Next, we looked into environmental and human-related elements that contribute to animal roadkill. Finally, we emphasized the unique features of Malaysian roads, differentiating between residential, non-plantation, and plantation roads to fully explore their respective contributions to animal roadkill events. The purpose of this review is to provide insights that could be used to develop targeted mitigation strategies for dealing with animal roadkill in Malaysia.

Prevalence of Animal Roadkill

Roadkill is regarded as one of the primary culprits of animal mortality across the globe. One study discovered that roadkill was the leading cause of death in over one-third of the populations investigated, outpacing diseases and hunting (Moore et al., 2023). Moore et al. (2023) also stated that collisions with automobiles accounted for up to 80% of death rates in some species of animals. Animals are compelled to cross busy roads to access water, food, or shelter. A collision between an animal and a moving vehicle is also inclined to occur when there is heavy traffic on the roads and highways.

Many of the large animals that inhabit Malaysia, such as elephants and tigers face the risk of getting killed or harmed on the nation's road networks. The Department of Wildlife and National Parks (DWNP) in Peninsular Malaysia recorded a total of 1790 wildlife mortality as a result of roadkill over the previous five years (Department of Wildlife and National Parks Peninsular Malaysia, 2021). The Malayan Tapir, an endangered species recognized by the International Union for Conservation of Nature (IUCN), is also listed as the most common victim of roadkill in Malaysia (Traeholt et al., 2016).

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Table 1 shows that from 2006 to 2017, a total of 92 Malayan Tapir fatalities due to traffic collisions were recorded, with 2017 being the most occurrences. (Department of Wildlife and National Parks Peninsular Malaysia, 2017). This statistic is extremely alarming because, according to experts, there are only 1,500 to 2,000 Malayan Tapirs left in the entire globe (Traeholt et al., 2016), which, if it is not swiftly addressed, would result in the extinction of this species. Apart from Tapir, a press release from the Department of Wildlife and National Parks (DWNP) of Malaysia reported that 103 leopard cats and Asian golden cats were involved in road collision cases in Malaysia from 2015 to 2019 (Md Denin, 2020). The IUCN Red List classifies leopard cats in the "Least Concern (LC)" category (Ghimirey et al., 2022). However, since 2008, the Asian golden cat has been identified as "Near Threatened" (McCarthy et al., 2016), and it might soon be vulnerable to endangerment if it is not properly addressed.

Table 1: Roadkill Cases Involving Malayan Tapirs from Year 2006 To 2017 Obtained from Department of Wildlife and National Parks Peninsular Malaysia.

State	2006-2009	2010-2013	2014	2015	2016	2017	Total number
Pahang	5	8	4	0	1	6	24
Terengganu	1	4	4	9	6	3	27
N. Sembilan	1	0	3	1	1	2	8
Johor	5	1	1	1	2	7	17
Selangor	6	2	1	0	0	1	10
Kelantan	1	1	1	0	0	3	6
Total number	19	16	14	11	10	22	92

Source: Department of Wildlife and National Parks Peninsular Malaysia, (2017).

Factors Contributing to Animal Roadkill

Animal roadkill is caused by many kinds of elements, which involve both natural and anthropogenic sources. One of these factors is habitat fragmentation. The homes of animals are frequently disturbed as humans continue to build on and intrude upon wilderness areas. This may push animals to travel across roadways to fulfill their physiological needs. The risk of vertebrates getting run over by vehicles may be attributed to the presence of food along the roadside, which encourages more animals to cross the road and travel along it more frequently. The sheer amount of fruit trees cultivated by the village residents along the roadside may have contributed to the roadkill that occurred in the village road stretch. Birds and mammals are drawn to these food sources, especially during the fruiting season, leaving them defenceless as they wander back and forth across the road from one tree to another (Hui et al., 2021). The rate of animal roadkill might also be increased or decreased by weather conditions (Carvalho et al., 2017). Fog might appear after a particularly hard downpour and makes it difficult for drivers and some animal species to navigate through, which increases the chance of a collision. However, certain animals might prefer not to venture out during heavy rain, which will lessen the amount of roadkill. A noteworthy point is that various species will react to climate and weather differently. Hui et al. (2021) claim that snakes may abandon their natural habitats in hot and cold weather to move to regions with higher temperatures, such as roadways, to regulate their body temperatures. The reason for this is that because snakes are exothermic,

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they get most of their body heat from the sun and higher ambient temperatures. Naturally, this will increase the possibility of this reptile species being killed on the road.

Roads in Malaysia: Plantation Road, Non-plantation Road and Residential Road

Roads in Malaysia can be classified into two primary classifications, i.e. Federal Roads and State Roads. Federal roads have been designated by the Federal Road Ordinance (1959) and are exclusively identified by numbers, such as Federal Route 3. Most federal roads in Malaysia are typically two-lane. Federal roads may become four-lane thoroughfares in urban areas, and some may even feature motorcycle lanes. While state roads are the secondary routes that link the administrative centres in each state, denoted by the state code alphabet and allocated numbers; for instance, Route (N)20 for Negeri Sembilan state road (Mat Jusoh et al., 2021). Subsequently, the road system can be further categorized into several different parts, including plantation roads, village roads, state roads, low-cost residential area roads, back lanes, and tourism island routes.

A plantation road is a road designed with the purpose of providing access to a plantation for labour, supplies, and agricultural equipment (Sukami, 2016). Plantation roads can be beneficial to more than just accessing the plantations; they can also make it easier to reach rural areas and encourage economic growth in the areas. there. study conducted by Jamhuri et al. (2020) discovered that roadkill was higher on plantation roads than on highways. Each year, the quantity and size of palm oil and rubber plantations in Peninsular Malaysia grow, resulting in the construction of new roads. As their natural environment becomes depleted and fragmented, forest-dependent mammals will find themselves encountering roadways more frequently. Some animal species might use the forest of palm oil plantations for hunting food sources; hence they might cross roadways to make their way to these regions.

In contrast to a plantation road, a non-plantation road is constructed for the general public's needs like transit, traveling, or recreational endeavours (Sukami, 2016). Highways are examples of non-plantation roads as they serve as routes for many kinds of human activities. Plantation roads are supposed to have a higher rate of animal roadkill than highways because they are closer to the forest and hence are likely to have more animal crossings there. Furthermore, roadkill mitigation measures such as eco-viaducts and wildlife warning signs were being placed more frequently on non-plantation roads. However, this claim can be refuted by other variables such as the ratio of vehicles on non-plantation roads to those on plantation roads. Data from a study by Kasmuri et al. (2020) suggest that more Malayan Tapirs were involved in roadkill on highways between 2012 and 2017. Despite having three eco-viaducts, Terengganu and Pahang still had the highest number of Malayan Tapirs killed on the roads when compared to the other states.

A residential road is an access road to residential areas, such as neighbourhoods or real estate developments (Háznagy & Fi, 2016). Although it is not impossible to happen, the frequency of animal roadkill on this type of road is thought to be far lower than on other types of roads. In this case, a lot of wildlife choose to stay away from humans (Hui et al., 2021), which may be the reason why there were fewer roadside animal deaths detected closer to residences. Furthermore, the chance of an animal collision is lower on these roads because they frequently have less traffic. Compared to highways and other types of roads, the speed limit in residential areas is lower (Goonting et al., 2019). Nevertheless, it is still conceivable that roadkill will occur on this road. Domestic animals and pets that reside close to a human residence are

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vulnerable to being subjected to roadkill, particularly if they have the freedom to wander freely outdoors. Pets, such as dogs and cats, may come into contact with roadways while exploring and scavenging. Some of them do not perceive vehicles as being hazardous, which increases their risk of being struck by one. According to research in South Texas by Blackburn et al. (2021), 46% of 54 ocelots are involved in roadkill in residential areas with less traffic.

As a result of the rapidly expanding road development and the occurrence of animal roadkill reported in this nation which are alarming, thus, this study aims to determine the difference in the number of animal roadkill cases between the types of roads and the environment in which they occur. In addition, the correlation between the factors that may contribute to the occurrence of animal roadkill will also be investigated. The outcomes of this research project might therefore reveal a representative background roadkill frequency for roads located around Kuala Pilah Town, Negeri Sembilan. The data collected will be useful to experts as they work to develop strategies that would reduce the amount of animal roadkill.

Methodology

This study was conducted within a 10 km radius from the centre of Kuala Pilah Town, Negeri Sembilan. The study sites covered road segments in 6 mukims in the Kuala Pilah district, which are as follows: Ampang Tinggi, Juasseh, Kepis, Parit Tinggi, Pilah, and Ulu Muar (Pejabat Daerah dan Tanah Kuala Pilah, 2023). The survey focused on two types of roads in the Kuala Pilah district: Federal Road and State Road (Mat Jusoh et al., 2021), and three types of surrounding areas: plantation/forest area, non-plantation/non-forest area, and residential area. The length of the road and the location of the road segment surveyed have been randomly chosen in order to increase the chances of finding carcasses and acquiring data. The map in Figure 1 illustrates the search area for carcasses, which is a radius of 10 kilometres from the centre of Kuala Pilah Town.

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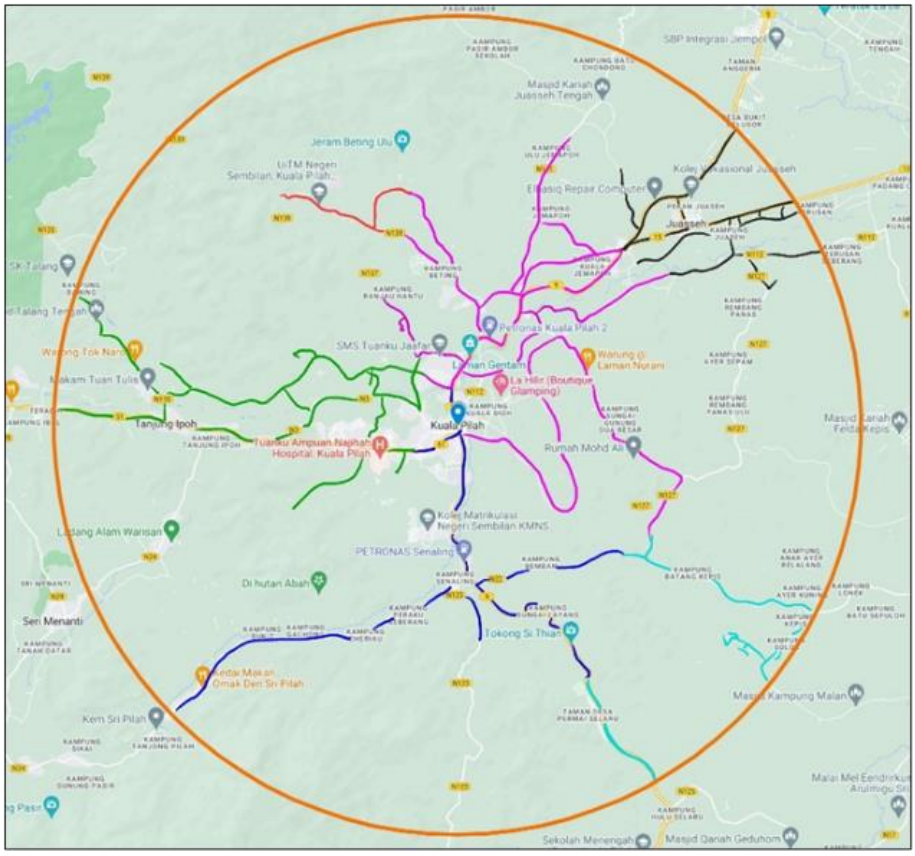

Figure 1: Map Image of 10 Km Radius from The Centre of Kuala Pilah Town (1. Red Line : Parit Tinggi, 2. Purple Line : Ulu Muar, 3. Black Line : Juasseh, 4. Green Line : Ampang Tinggi, 5. Blue Line : Pilah, 6. Turquoise Line : Kepis).

Source: Google Maps (2023).

Data Collection

The observation of vertebrate carcasses on the road has been done while driving at a speed between of 50-80 km/h. The roads were inspected for ten weeks, starting from the final week of September 2023 until the middle of November 2023. The inspections took place from early in the morning at 7.00 a.m. to as late as 7.00 p.m. at the most. Once the carcasses were discovered, the carcasses were photographed, and the taxonomic group of the samples were specified. The coordinates of the location were marked using Google Maps. Additionally, the genomic source of the samples, such as tissue, hair, or scale, has been collected and preserved for future study. The type of road was determined whether the carcass was found on a Federal Road or State Road. The landscape surrounding the road was then observed, whether it was situated next to a plantation/forest area, a non-plantation/non-forest area, or a residential area. This allowed us to analyse the relationship between the quantity of carcasses and the location where they were discovered. Additionally, since it might be a factor influencing the amount of animal roadkill, the presence of street lights near the inspected road and the time of discovery have also been considered. In order to avoid count repetition, the counted carcasses were taken off from the road.

Data Analysis

The chi-square test was conducted in Microsoft Excel to evaluate if there is an association between the frequency of roadkill carcasses among taxa and; 1) the presence of street lights (present or absent), 2) the type of roads (Federal Road and State Road), 3) the surrounding

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areas (plantation/forest area, non-plantation/non-forest area, and residential area), and 4) the time of discovery (7.00 a.m. to 1.00 p.m. or 1.01 p.m. to 7.00 p.m.).

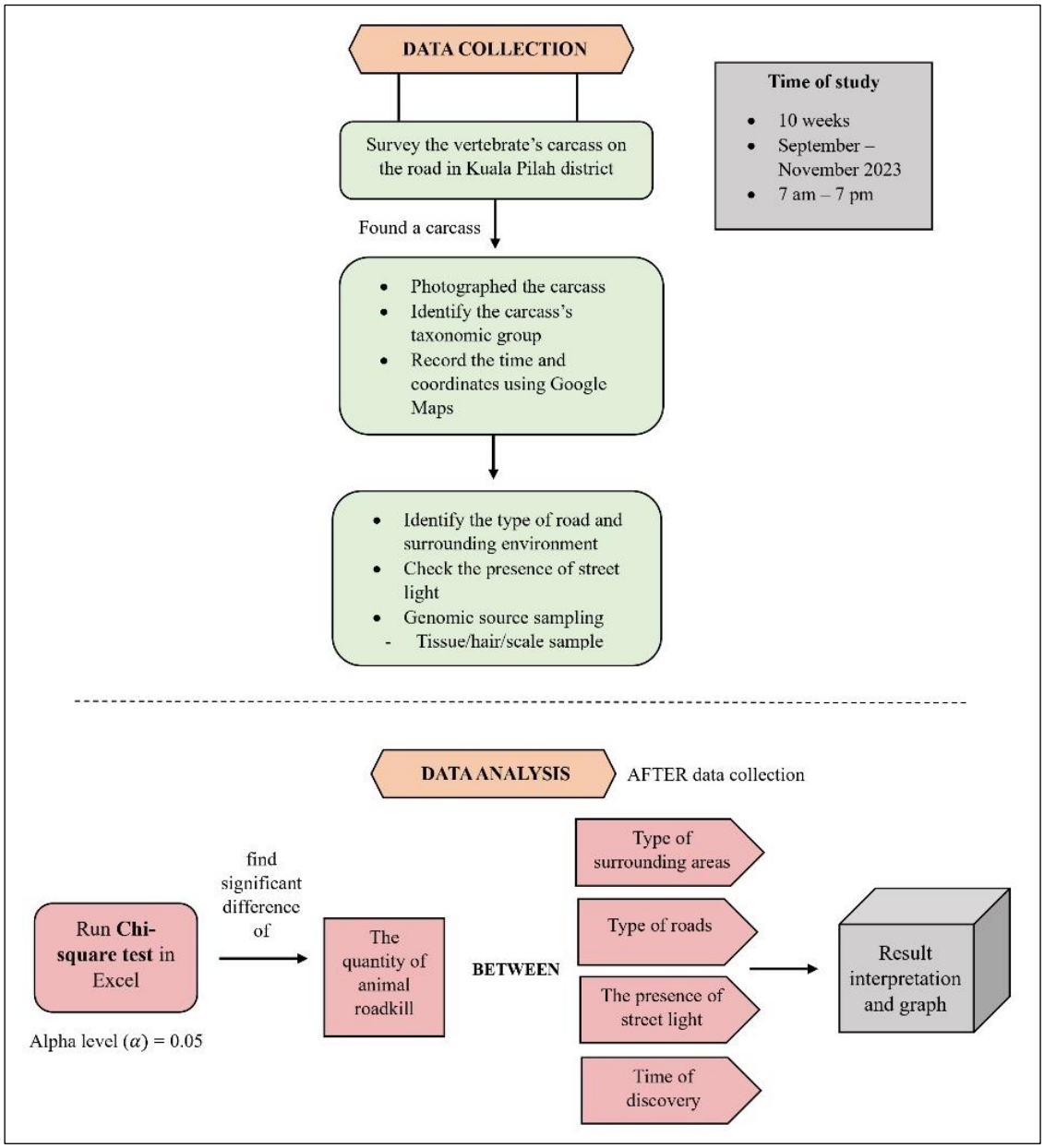

Figure 2: A flowchart illustrating the methodology's processes for gathering and analysing data.

Results and Discussion

Roadkill trends varied depending on the taxonomic group. Figure 2 displays a pie chart that reveals the percentage of each vertebrate's carcasses that were discovered dead on the road throughout the 10-week search period. The vertebrate class of 48 carcasses were identified, comprising 13 birds (27.08%), 24 mammals (50%), 9 reptiles (18.75%), and 2 amphibians (4.17%).

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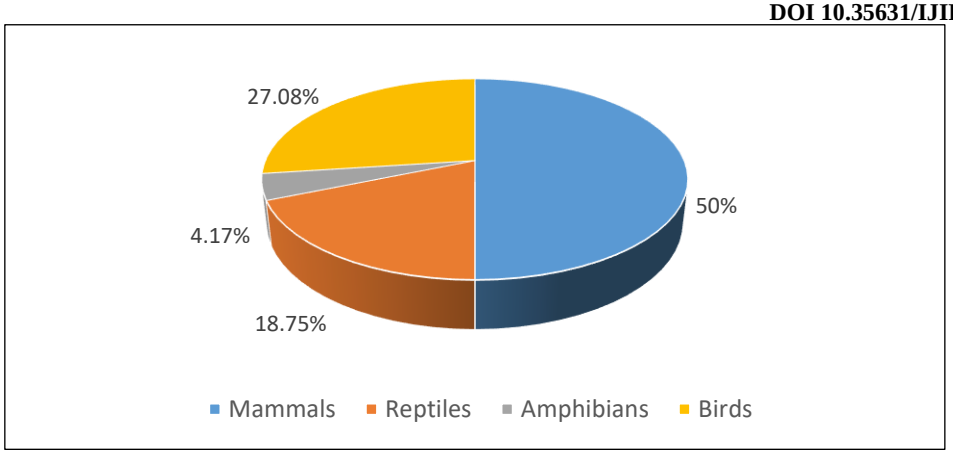

Figure 3: Composition of Animal Roadkill from September 2023 Until November 2023 (10 Weeks).

Table 2 lists the count of vertebrate carcasses detected in each of the following six mukims: Ampang Tinggi, Juasseh, Kepis, Parit Tinggi, Pilah, and Ulu Muar. The locations of the vertebrates' carcasses are marked on a map in Figure 3.

Table 2: A Record of Vertebrates' Carcasses Discovered Across Six Mukims in Kuala Pilah. Bold Values Denote "Total Values".

Vertebrate group *Family	Ampang Tinggi	Juasseh	Kepis	Parit Tinggi	Pilah	Ulu Muar	Total
AMPHIBIANS	**0**	**0**	**0**	**1**	**0**	**1**	**2**
**Ranidae*	0	0	0	1	0	0	1
**Bufonidae*	0	0	0	0	0	1	1
MAMMALS	**7**	**1**	**0**	**7**	**4**	**5**	**24**
**Sciuridae*	1	0	0	5	1	3	10
**Felidae*	3	1	0	0	3	1	8
**Cercopithecidae*	2	0	0	1	0	1	4
**Canidae*	0	0	0	1	0	0	1
**Muridae*	1	0	0	0	0	0	1
REPTILES	**2**	**1**	**1**	**3**	**0**	**2**	**9**
**Pythonidae*	0	0	0	0	0	1	1
**Colubridae*	0	0	0	3	0	0	3
**Varanidae*	2	1	1	0	0	1	5
BIRDS	**3**	**1**	**0**	**4**	**3**	**2**	**13**
**Rallidae*	0	0	0	1	0	1	2
**Sturnidae*	1	0	0	1	0	0	2
**Phasianidae*	1	0	0	0	0	0	1
Unknown	1	1	0	2	3	1	8
TOTAL	**12**	**3**	**1**	**15**	**7**	**10**	**48**

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Figure 4: Distribution of Animal Roadkill Occurrences on Six Different Mukims in Kuala Pilah District. Black Mark Denoted One Animal Carcass.

Source: Google Maps (2023).

All the animals found in this survey have been assigned to their appropriate family. Overall, mammal fatality in the study areas was higher in comparison to other vertebrates. The mukims of Parit Tinggi and Ampang Tinggi were the hotspots of these casualties. According to Table 2, squirrels (*Sciuridae*) and cats (*Felidae*) are the two mammal families that suffer from roadkill the most, with 10 and 8 respectively. Birds had the second-highest mortality rate among vertebrates. Their carcasses were mostly discovered in Parit Tinggi, however, the number of casualties in Pilah and Ampang Tinggi was equally sampled. Out of the 13 bird carcasses found, only one domesticated bird—a chicken (*Phasianidae*)—was a roadkill victim. Only two families of birds can be identified, two from the *Rallidae* family (White-breasted Waterhen) and another two from the *Sturnidae* family (Myna bird). The rest, however, could not be recognized because the carcass had already dried and decomposed. Two samples of reptiles—the snake (*Pythonidae* and *Colubridae*) and the monitor lizard (*Varanidae*)—were killed on the road during the search period. Amphibians, on the other hand, are the least abundant, with only one frog (*Ranidae*) and one toad (*Bufonidae*) recorded in Parit Tinggi and Ulu Muar.

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According to other study, the most frequent vertebrate discovered as roadkill was amphibians. The study by Hui et al. (2021) reported roadkill of 305 carcasses on road segments in Terengganu and Pahang, with 33.44% of them were amphibians. However, the majority of the roadkill in this study have turned out to be mammals. The disparities in the results are probably due to how differently we conducted our carcass surveys. Hui et al. (2021) conducted the survey on foot rather than by a car, which increased the detectability of the carcasses. However, in this study, the survey was executed while driving a car. Even at speeds ranging from 50 to 80 km/h, it is still ineffective for detecting small creatures, most of which are amphibians. This explains why the number of amphibians found in this study is so low in comparison to other vertebrate groups. On top of that, it is assumed that the animals that are most frequently killed on roads—in this case, squirrels, cats, and birds—are generally the most abundant and widely distributed (Rosa & Bager, 2012). This explains why larger species, including tapirs, did not appear in this study's list of roadkill since they are already relatively rare in Malaysia and are primarily roam in pristine rainforests. Moreover, larger mammals are easier for drivers to see from a distance, giving them more time to avoid a collision.

This study revealed a very low quantity of amphibians compared to other vertebrate classes; however, this pattern has been observed in several previous studies as well (Arca-Rubio et al., 2023; Ayob et al., 2020; Jemali et al., 2021). Some researchers are convinced that one of the influencing factors is the size and visibility of these creatures, as smaller animals are less likely to be spotted on the road and may be overlooked during roadkill surveys (Arca-Rubio et al., 2023; Cook & Blumstein, 2013). Small animals may not be given as much attention as observers tend to focus on larger species and they may be less inclined to report unidentified or "low profile" species, presuming the information to be of little scientific value (Périquet et al., 2018). Additionally, when small animals like amphibians get run over by vehicles, their bodies break down and flatten more easily, making it difficult for observers to see the carcasses (Arca-Rubio et al., 2023). Furthermore, the remains of these small vertebrates are more easily removed from the road, particularly by nearby predators (Teixeira et al., 2013). These elements may present methodological challenges that lead to inaccurate documentation of roadkill incidents involving amphibians, and may also explain why these animals have a low representation in roadkill datasets (see Figure 4 for 14 different animals' carcasses found in this study during the 10-week search).

Figure 5: Pictures of 14 Different Animals Found Dead on The Road During The 10-Week Search (1. Squirrel, 2. Cat, 3. Monkey, 4. Dog, 5. Frog, 6. Rat, 7. Python, 8. Monitor Lizard, 9. Toad, 10. Colubrid Snake, 11. Myna Bird, 12. White-Breasted Waterhen, 13. Chicken, And 14. Bird (Unknown Species)).

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Relationship Between the Type of Surrounding Area and Animal Roadkill Occurrences

The data was analysed using the chi-square test, with 0.05 set as the alpha level (α). The findings indicate that there were no significantly different patterns in the frequency of vertebrates' carcasses in different areas ($\chi 2$ (6, N=12) = 4.45, P = .616). This suggests that the locations of animal roadkill have no major influence on their occurrence.

Table 3 presents the number of animal carcasses classified by vertebrate class that are found in three different areas: plantation/forest areas, non-plantation/non-forest areas, and residential areas.

Table 3: Animal Roadkill Found Along the Kuala Pilah Road Listed According to The Number of Individuals Per Vertebrate Group, Family, And Type of Discovery Area. Bold Values Denote "Total Values."

Vertebrate group *Family	Plantation/ Forest area	Non-plantation/ non-forest area	Residential area	Total
AMPHIBIANS	**1**	**0**	**1**	**2**
**Ranidae*	1	0	0	1
**Bufonidae*	0	0	1	1
MAMMALS	**11**	**7**	**6**	**24**
**Sciuridae*	8	2	0	10
**Felidae*	0	4	4	8
**Cercopithecidae*	2	1	1	4
**Canidae*	1	0	0	1
**Muridae*	0	0	1	1
REPTILES	**5**	**1**	**3**	**9**
**Pythonidae*	1	0	0	1
**Colubridae*	3	0	0	3
**Varanidae*	1	1	3	5
BIRDS	**5**	**6**	**2**	**13**
**Rallidae*	1	1	0	2
**Sturnidae*	0	2	0	2
**Phasianidae*	0	0	1	1
Unknown	4	3	1	8
TOTAL	**22**	**14**	**12**	**48**

On average, residential areas reported the fewest roadkill (N=12), while plantation and forest areas accounted for the most carcasses (N=22). Vehicle collisions with mammals were observed to be more common near plantation and forest areas, which are natural habitats for most species (Corlett & Hughes, 2015). Herbivorous and omnivorous mammals like squirrels and monkeys are drawn to the road in search of food sources due to the availability of roadside vegetation and other animal carcasses. This has led to more animals moving across and down the road, which raises the risk of animal-vehicle collisions. For reptiles, many snake carcasses were discovered in plantation and forest areas. While snakes do naturally inhabit this area, they occasionally venture outside of it in search of food. They may be drawn to the road by the presence of roadkill carcasses or prey foraging on the roadside (Hui et al., 2021). Furthermore, snakes can be drawn to open locations with higher temperatures, such as roadways, in order to regulate their body temperature (Shine et al., 2004). The lack of snakes in urban residential and

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commercial areas may be attributed to several factors, including limited availability of prey, and the potential threat associated with human presence (Lettoof et al., 2023). Since many people believe that snakes are dangerous to humans, chemical pesticides are frequently used in residential and commercial locations to keep snakes away, which contributes to the lowered snake populations in these places (Punetha & Vuppu, 2023). This helps to explain why roadkill rates for snakes are lower in these locations compared to in plantation and forest areas.

Another reptile species, the monitor lizards, were more frequently discovered killed in residential areas. It is not uncommon to encounter monitor lizards strolling near households because they have a habit to consume human scraps and are not often intimidated by human presence (Uyeda, 2009). Ayob et al. (2020) state that monitor lizards are also energetic foragers who frequently travel great distances in search of food. They will therefore frequently cross the road, increasing their risk of dying there. For this study, the limited occurrence of monitor lizards as roadkill in both plantation/forest areas and commercial areas could be explained by particular factors. Dense vegetation in plantations and forest areas offers suitable homes for monitor lizards, enabling them to move around with minimal contact with roadways. There is no immediate need for them to go out onto the road and encounter vehicles because these environments provide them with plenty of opportunities to obtain food, shelter, and ideal breeding grounds (Guerrero-Sánchez et al., 2022). On the other hand, roadkill of monitor lizards is less common in commercial areas, which may be attributed to the species' adaptability to a diverse range of habitats (Rahman, 2019). This characteristic helps them navigate these areas more skilfully since they become more aware of their surroundings and steer clear of crowded areas like roads.

Bird mortality was higher in plantation/forest areas as well as non-plantation/non-forest areas. Birds may be driven to plantation area because it provides common food sources for birds such as insects, grains, and small animals (Santos et al., 2022). Moreover, a lot of birds become vulnerable to roadkill risk during the fruiting season as they fly across the road from one fruit to the next (Orłowski, 2008). Birds can also find food in non-forest and non-plantation areas. Birds in such areas frequently scavenge trash or food crumbs dropped on the road (Tryjanowski et al., 2015). This increases their vulnerability to the dangers of road traffic. Aside from that, these places are frequently bustling with human activity, and birds might not be as wary of humans and vehicles as they would be in less disturbed locations (Ramli & Norazlimi, 2017). This carelessness can contribute to increased roadkill cases in birds. Since only two types of amphibians were discovered during search period, a more thorough discussion of them is not possible. However, they were expected to be found more near aquatic or freshwater ecosystems, considering it was the natural habitat for their species (Mauro et al., 2005).

Relationship Between the Road Types and Animal Roadkill Occurrences

Compared to State Road, Federal Road are frequently built to accommodate heavier traffic volumes and at faster speeds. Serving as the primary routes for long-distance travel and cargo transport, they are vital to the nation's transportation system (Mat Jusoh et al., 2021). State Road, on the other hand, connects locations inside a specific state and are typically more localized. They might be slower and carry less traffic than Federal Road (Mat Jusoh et al., 2021). As a result, it makes sense that there would be more animal roadkill incidences on Federal Road than on State Road. However, the study's outcomes disprove the previous theory. Table 4 shows that there were 36 animals' roadkill on State Road as opposed to just 12 roadkills on Federal Road.

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Table 4: Animal Roadkill Found Listed by The Number of Carcasses Per Vertebrate Group and The Type of Road Where It Was Discovered. Bold Values Denote "Total Values."

Vertebrate group	Federal Road	State Road	Total
Amphibians	0	2	2
Mammals	7	17	24
Reptiles	2	7	9
Birds	3	10	13
Total	**12**	**36**	**48**

One possible explanation is the fragmentation of habitats. State Road may pass through regions where animal habitats are more diverse and interconnected. Habitat fragmentation might raise the possibility that animals will attempt to cross the road in order to find food or migration, which can increase episodes of roadkill (Cassimiro et al., 2023). In contrast, Federal Road might be given more consideration when it comes to animal mitigation strategies, like having wildlife crossings, fences, and signage (Magintan, 2012). Therefore, this might aid in lowering the frequency of animal roadkill on this type of road. Additionally, it can be challenging to slow down a car on the Federal Road because it is frequently crowded with traffic. Thus, it is possible that observers overlooked the carcass.

However, it is crucial to note that most studies on animal roadkill, including the one conducted by Magintan et al. (2021), have been done over a long period of time, requiring months or even years to complete. Given that this study lasted only ten weeks, it is clear that the findings may not be sufficient to conclusively verify whether State Roads have more roadkill than Federal Roads. A long-term survey is considered to be more effective than a short-term one since significant trends and accurate hypothesis testing can only be achieved by observing population changes over an extended period of time (Canova & Balestrieri, 2018).

A chi-square test was performed to statistically explain the association between the type of road and the frequency of the carcass. The results reveal that there is no statistically significant pattern difference between the two variables ($\chi 2$ (3, N=8) = 0.95, P = .813). Therefore, it was determined that the type of road had little to no effect on the total quantity of carcasses in this study.

Relationship Between the Presence of Street Lights and Animal Roadkill Occurrences

While street lights are crucial for maintaining human safety and visibility at night, there are several concerns about the unexpected effects they may have on wildlife, particularly vertebrates. One benefit of street lights is that they improve driver visibility, which lowers the risk of vehicle and animal collisions on the road (Beyer & Ker, 2009). This is especially essential in places with abundant biodiversity and nocturnal animal activity. Nonetheless, some research offers different points of view on this issue, suggesting that one of the variables that put animals at risk of dying on the streets is the existence of street lights. Dean et al. (2019) and Straka et al. (2019) states that insects are drawn to street lights, which in turn attract insect-eating animals such as birds and bats. There is a chance that more animals will become roadkill because of their proximity close to roadways. In addition, because nocturnal animals are frequently sensitive to artificial light, streetlights may interfere with their usual behaviours (Schirmer et al., 2019). For instance, artificial light may cause certain species to change their

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feeding and migrating behaviours and therefore, putting them in the way of approaching vehicles.

According to Norevik et al. (2019), certain animals, especially birds, depend on celestial cues like the moon and stars for nighttime navigation. Bright street lights have the potential to interfere with these natural cues, causing confusion and even navigational errors (La Sorte et al., 2017). Birds may run into buildings, become lost, or have their migratory patterns changed. Moreover, in response to the presence of artificial light, certain animals may modify their foraging routines (Rotics et al., 2011). Street lights may enhance visibility for some species, causing them to become more active during the night and alter their hunting methods. They might eventually approach the street lights and expose themselves to passing vehicles.

In this study, the presence of street lighting at the location of the carcass discovery was analysed to determine whether it affected the occurrence of roadkill. The number of carcasses for each vertebrate group discovered in two different areas—one with street lights and the other without—is displayed in Table 5.

Table 5: Animal Roadkill Found Listed by The Number of Carcasses Per Vertebrate Group and The Existence of a Street Light at The Area Where the Carcasses Were Discovered. Bold Values Denote "Total Values."

Vertebrate group	Present	Absent	Total
Amphibians	0	2	2
Mammals	13	11	24
Reptiles	7	2	9
Birds	7	6	13
Total	**27**	**21**	**48**

The chi-square test result indicates there is no significant difference in the frequency of carcasses in locations with and without street lighting ($\chi 2$ (3, N=8) = 4.55, P = .208). Simply stated, the occurrence of roadkill is not much impacted by the presence of street lighting. However, because street lights are only functional at night, this outcome could have been influenced by external factors such as the timing of the collision and the animal behaviours at night.

Relationship Between Time and Animal Roadkill Occurrences

According to chi-square test result, there is a significant difference between the frequency of carcasses and the time intervals at which they were found ($\chi 2$ (3, N=8) = 10.99, P = .012). This suggests that the occurrences of animal roadkill are dependent on time. The time frame for doing the carcass survey was 7 a.m. to 7 p.m. This time frame is separated into two intervals (7 a.m. to 1 p.m. and 1.01 p.m. to 7 p.m.) to observe the trend of encountering carcasses. We discovered that more animal road deaths were reported between 7 a.m. and 1 p.m., as Table 6 demonstrates.

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Table 6: The List of Animals That Were Found Dead on The Roads Between the Hours of 7 A.M. to 1 P.M. and 1.01 P.M. to 7 P.M., Sorted by Their Corresponding Vertebrate Species. Bold Values Denote "Total Values."

Vertebrate group *Family	7.00 a.m. - 1.00 p.m.	1.01 p.m. - 7.00 p.m.
AMPHIBIANS	**1**	**1**
**Ranidae*	1	0
**Bufonidae*	0	1
MAMMALS	**20**	**4**
**Sciuridae*	10	0
**Felidae*	6	2
**Cercopithecidae*	2	2
**Canidae*	1	0
**Muridae*	1	0
REPTILES	**2**	**7**
**Pythonidae*	0	1
**Colubridae*	1	2
**Varanidae*	1	4
BIRDS	**8**	**5**
**Rallidae*	1	1
**Sturnidae*	1	1
**Phasianidae*	0	1
Unknown	6	2
TOTAL	**31**	**17**

Among mammal species, squirrels and cats have a significant proportion of carcasses discovered on the road during the first interval. Squirrels are known to be diurnal creatures, which means they are more active during the day (Wei, 2020). Squirrels could be occupied in the morning gathering food, interacting with one another, or exploring their environment. This increased activity may cause them to come into contact with roads on the morning hours. Cats, unlike squirrels, are crepuscular, meaning they are most active at sunrise and dusk hours (Parker et al., 2019). They might be more likely to roam around and explore their environment in the early morning and at night. Being innate hunters, cats tend to exhibit stronger hunting instincts in low light (Crowley et al., 2019). They might be hunting for prey, which could cause them to cross roadways carelessly and become roadkill.

Birds' carcasses were also abundant between 7 a.m. and 1 p.m. Birds are frequently foraging and feeding in the morning (Yousaf et al., 2020). They may search for insects, seeds, or other food sources by flying low over land and roadways. Aside from that, some bird species are more active in the morning around their nesting areas. The bird may be flying to and from its nest to collect materials for building their nest or to feed their young (Amichai & Kronfeld-Schor, 2019). These activities may bring them into proximity to roadways and ended up as roadkill. For reptile species, the opposite has occurred. More snakes and monitor lizards were discovered dead on the road in the second interval (1.01 p.m. - 7 p.m.). This could be due to the fact that monitor lizards and snakes are ectothermic, which means that they depend on external sources of heat to maintain their body temperature (Shine, 2013). The sun is at its hottest in the afternoon, warming everything around it, even the surfaces of the roads. Reptiles

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are especially vulnerable to collides with vehicles during this period because they may venture onto roads to bask in the sun and absorb heat for thermoregulation.

Conclusion

In conclusions, the occurrence of animal roadkill within the 10 km radius from the centre of Kuala Pilah town is considered moderate with 48 cases recorded in ten weeks of inspections. The highest number of animals roadkill occurred at Ampang Tinggi and Parit Tinggi, where the lowest occurred at Kepis, in which the plantation and forest areas recorded a higher frequency of roadkill, surpassing both non-plantation/non-forest areas and residential areas. State Road was found to be riskier for animals compared to Federal Road. Roads illuminated with street lights encountered more animal fatalities than roads without this feature. Furthermore, the period from 7 a.m. to 1 p.m. showed a higher frequency of animal roadkill compared to the period from 1.01 p.m. to 7 p.m. Intriguingly, the chi-square analysis revealed that the study results were time-dependent, but no significant differences were observed in the frequency of animal roadkill between the areas where carcasses were discovered, the presence of street lights, and the types of roads. Finally, yet importantly, the vertebrates' carcasses found were from the families *Ranidae*, *Bufonidae*, *Sciuridae*, *Felidae*, *Cercopithecidae*, *Canidae*, *Muridae*, *Pythonidae*, *Colubridae*, *Varanidae*, *Rallidae*, *Sturnidae*, *Phasianidae*, and from class Aves (which were unable to be identified due to decayed carcasses). All taxonomic groups are vulnerable to road and vehicle crashes, yet certain animals, such as squirrels and cats, dominate the counts. This study provides a basal information relating to animal roadkill's at a secluded yet busy area as such Kuala Pilah Town which may be a starter for planning a better way in road development.

This study may still be improved by extending the survey duration and narrowing the search area. Due to time constraints, not all roads could be examined in the 10-week study period, so the results may still be argued and not fully considered. Furthermore, it is advised to conduct the survey on foot or by motorcycle instead of driving a car to avoid overlooking any small or decomposed animal carcasses on the road. This will result in better and more accurate data for analysis.

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