MALAYAN TAPIR ROADKILL IN PENINSULAR MALAYSIA FROM 2006 TO 2019

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ABSTRACT

A total of 115 Malayan tapirs were recorded as roadkill in Peninsular Malaysia from 2006 to 2019 with the mean number 8.21 ± 1.69 individuals per year. The highest number of roadkill occurred in 2017, followed by 2014, 2019, 2015 and 2016. There were more recorded roadkill in the dry season (10.67 ± 0.71) compared to the wet season (8.50 ± 0.88), though not statistically significant. According to state, Terengganu (33) experienced the highest number of roadkill, followed by Pahang (26), Johor (20), Negeri Sembilan (14) and Selangor (13), while, Kelantan (6), Melaka (2) and Perak (1) with fewer than ten recorded incidents.

Keywords: roadkill, Malayan tapir, distribution, forest fragmentation, density

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INTRODUCTION

Malaysia is known for its mega-biodiversity (NRE, 2006; Struebig *et al*., 2010; NRE, 2016; Magintan *et al*., 2017), with Peninsular Malaysia being the most diverse and home to approximately 300 mammal species (Abdullah, 2016). For the past decades, research on fauna diversity has been conducted throughout

Peninsular Malaysia (Mohd-Azlan & Sharma, 2006; Hedges *et al*., 2013; Rajpar *et al*., 2014; Gumal *et al*., 2014; Ruppert *et al*., 2015; Sasidhran *et al*., 2016; Magintan *et al*., 2017; Ghazali *et al*., 2019). Meanwhile, Malaysia has invested in extensive industrial, agricultural development that has seen hundreds of thousands of hectares of tropical rainforest being replaced by mono-crop plantations. Concurrently, the human population has doubled in the past 40 years alone (DOSM, 2020), resulting in rapid urbanisation. Urbanisation in Malaysia increased from 25% in 1960 to 65% in 2005 (Siong, 2008), with 77% of the current population living in urban areas (Worldbank, 2021). Urbanisation is the result of Malaysia's economic development policy of aspiring to become an industrialised country (Lee & Jitaree, 2019). The development of infrastructures such as road networks, airports, dams and other facilities have contributed substantially to economic growth (Ng *et al*., 2018).

Peninsular Malaysia's forested area makes up 5.80 mill ha or 43.9% of the total land area, with 85% of this gazetted as permanent forest reserves (MTC, 2017). The main driver of deforestation in Peninsular Malaysia is industrial logging and the conversion of forested lands to agriculture and infrastructure (Yong *et al*., 2014), which indicates a rapid loss of biodiversity (Koh *et al*., 2013). Road construction in Peninsular Malaysia began before its formation. The road linking Johor Bahru in the south of Peninsular Malaysia to Kangar in the north as well as to Kota Bharu in the northeast were built before 1957. From Malaysia's first elected government in 1957 to the current government, road expansion has been a significant component in the development plans. From a modest budget in Malaysia's first 5-year plan in 1966 of an overall development allocation of RM4.55 billion at that time, infrastructure expenditure reached RM 21.8 billion in the 8th Malaysia plan in 2001-2005 (Lee & Chew-Ging, 2017). The total length of roads grew from less than 20,000km in 1965 to more than 160,000km of paved roads in 2016 (JKR, 2016) to support the nation's development and as a backbone of Malaysia's growth (MOT, 2019).

One of the impacts of road construction is forest fragmentation which is the process of breaking up continuous habitats thereby causing habitat loss, patch isolation and edge effects, affecting the quality and quantity of available wildlife habitats (Glista *et al*., 2008). Forest fragmentation disrupts the expansive roaming areas of large mammals such as elephants, Malayan gaurs and the Malayan tapir. This wildlife may enter crossroads that dissect their habitat, possibly leading to vehicle collision, especially when the dissected forest was in the 'home' area of the wildlife. Forest fragmentation displaces and disorients wildlife (Magintan *et al*., 2012) because mammals need to move freely across forests searching for food and mates (Clement *et al*., 2012). In the case of elephants, fragmentation increases the movement rate or speed (Alfred *et al*., 2012). The Baird tapir in central America faces the increased threat of vehicle

collision apart from deforestation, forest fragmentation, and poaching (Naranjo, 2018; Poot & Clevenger, 2018). Forests isolated due to road construction have decreased terrestrial mammal species due to the lower vegetation complexity (Bernard *et al*., 2014). Population decline and isolation are also consequences of habitat fragmentation (Bennett & Saunders, 2011). Gibson *et al*. (2013) estimated that in 13.9 years, half of the resident species of small mammals disappeared from the study area, i.e. islands emerging following land inundation from the construction of dams. Apart from losing corridors for connectivity, forest fragmentations facilitate hunters to encroach on wildlife habitats for hunting (Clement *et al*., 2014; Broadbent *et al*., 2012). The threats to wildlife are greater in forests nearer to roads than forest in the interiors (Clement *et al*., 2018).

The Malayan tapir is one of the four recognised tapir species found in Asia (Francis, 2019) and listed under Schedule 2 (totally protected) in the Wildlife Conservation Act 2010. It is listed as "Endangered" by the International Union for Conservation of Nature Red List of Threatened Species (Traeholt *et al*., 2016). This species' existence is threatened by habitat loss and forest fragmentation (Kinnaird *et al*., 2003; Rayan *et al*., 2012; Clements *et al*., 2012, Magintan *et al*., 2012). This species is important to the forest ecosystem as dispersal agents for plants with small seeds (Campos-Arceiz *et al*., 2012).

This study presents the temporal and spatial patterns of roadkill occurrence in Peninsular Malaysia for Malayan tapir. There is limited study of wildlife roadkill occurrences in Malaysia. Monge-Najera (2018), in his review paper on roadkill, found only one article about wildlife roadkill in Malaysia. Roadkill articles on wildlife of Peninsular Malaysia are hardly found in a scientific journal. Such information is usually in the form of monthly or annual reports. In the last five years, two articles were published on wildlife roadkill occurrences in Peninsular Malaysia, namely Mohd-Zahid *et al*. (2017) and Kasmuri *et al*. (2020). The former article detailed leopard cat roadkill incidents in the exterior wildlife reserve in Pahang, while the latter analysed the roadkill data recorded by PERHILITAN from 2012 to 2017 to identify mitigation measures based on the outcome of the analysis. This present study endeavours to quantify and assess spatial and temporal patterns of Malayan tapir roadkill using records from the Department of Wildlife and National Parks, Peninsular Malaysia.

METHODOLOGY

All roadkill data used in this study were recorded by the PERHILITAN from 2006 to 2019 throughout Peninsular Malaysia. We sorted records according to month, year and state. We split annual records into two seasonal categories,

namely "wet season" (October-March) and "dry season" (April-September). T-test analysis was used to compare the means of dry and wet seasons. We used simple linear regression to examine the relationship between the cumulative forest loss in hectare and the roadkill number using PAST (v. 2.17c). The Spatial Analyst and Spatial Statistics tools (ArcMAP 10.6.1) were used to calculate the density and distribution of roadkill in Peninsular Malaysia.

RESULTS

A total 115 Malayan tapir roadkill were recorded from 2006 to 2019 in Peninsular Malaysia. The highest number of roadkill occurred in the year 2017, followed by 2014, 2019, 2015 and 2016 (Figure 1). The period from 2006-2013 and 2018 had less than ten roadkill per year, respectively. The volume of roadkill that occurred throughout the year was not consistent with the highest rate in April, June and September (Table 1). The mean number of annual roadkill was 8.21 ± 1.69, with the highest number recorded in 2017 (26) and the lowest numbers in 2006, 2007, 2010 and 2013 (3).

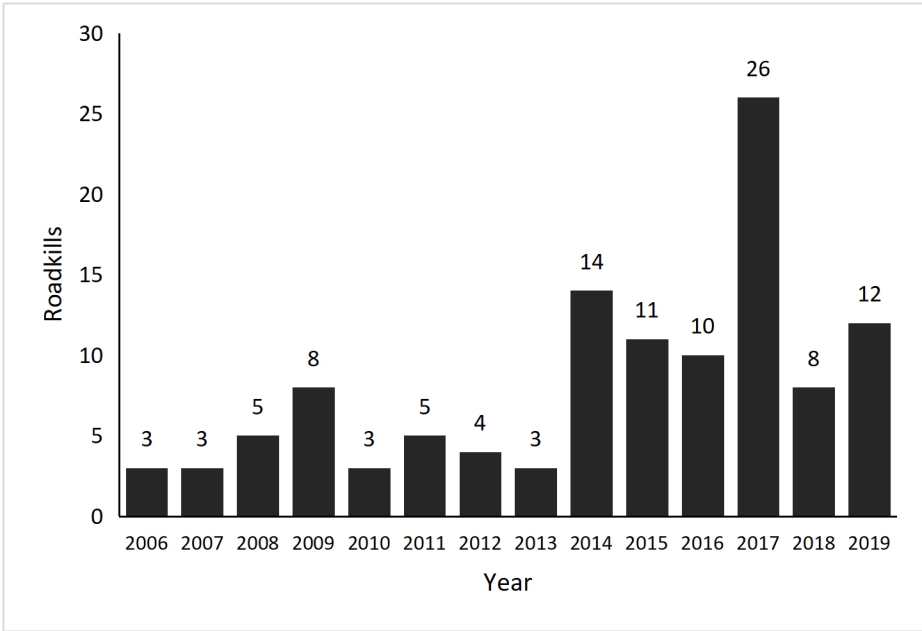

Figure 1 The annual number of roadkill of Malayan tapir in Peninsular Malaysia from 2006 to 2019.

Month/ year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
TOTAL:	*3*	*3*	*5*	*8*	*3*	*5*	*4*	*3*	*14*	*11*	*10*	*26*	*8*	*12*	**115**
January	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*2*	*1*	*2*	*0*	**6**
February	*0*	*0*	*0*	*1*	*1*	*0*	*0*	*1*	*1*	*3*	*0*	*1*	*1*	*2*	**11**
March	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*1*	*0*	*3*	*1*	*1*	**7**
April	*0*	*0*	*2*	*3*	*1*	*0*	*0*	*1*	*0*	*1*	*2*	*1*	*1*	*0*	**12**
May	*1*	*0*	*0*	*0*	*0*	*1*	*1*	*0*	*1*	*1*	*0*	*2*	*0*	*1*	**8**
June	*0*	*1*	*0*	*2*	*0*	*2*	*1*	*0*	*0*	*0*	*3*	*2*	*1*	*0*	**12**
July	*0*	*0*	*0*	*1*	*1*	*0*	*0*	*0*	*3*	*3*	*1*	*1*	*1*	*0*	**11**
August	*1*	*0*	*0*	*0*	*0*	*1*	*0*	*1*	*2*	*0*	*1*	*3*	*0*	*0*	**9**
September	*0*	*1*	*3*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*3*	*1*	*3*	**12**
October	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*2*	*1*	*0*	*2*	*0*	*1*	**7**
November	*0*	*1*	*0*	*0*	*0*	*0*	*1*	*0*	*3*	*0*	*0*	*4*	*0*	*2*	**11**
December	*1*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*1*	*1*	*3*	*0*	*2*	**9**

Table 1 Monthly roadkill from 2006-2019.

The number of Malayan tapir roadkill occurrences for each month was accumulated to get the total number of roadkill by month for 14 years (Figure 2). The monthly mean number of Malayan tapir roadkill for 14 years was 9.58 ± 0.63 individuals. The highest number of roadkill was 12 individuals in April, June and September, while the lowest number was six individuals in the month of January (Figure 2). Frequencies of Malayan tapir roadkill in wet and dry seasons were calculated and analysed across the 14 years. The average roadkill occurrences in the wet season was 8.50 ± 0.88 occurrences, while in the dry season, it was 10.67 ± 0.71 occurrences (Figure 3). However, based on T-test analysis, there is no significant difference between dry and wet seasons (t=-1.9044, p=0.086).

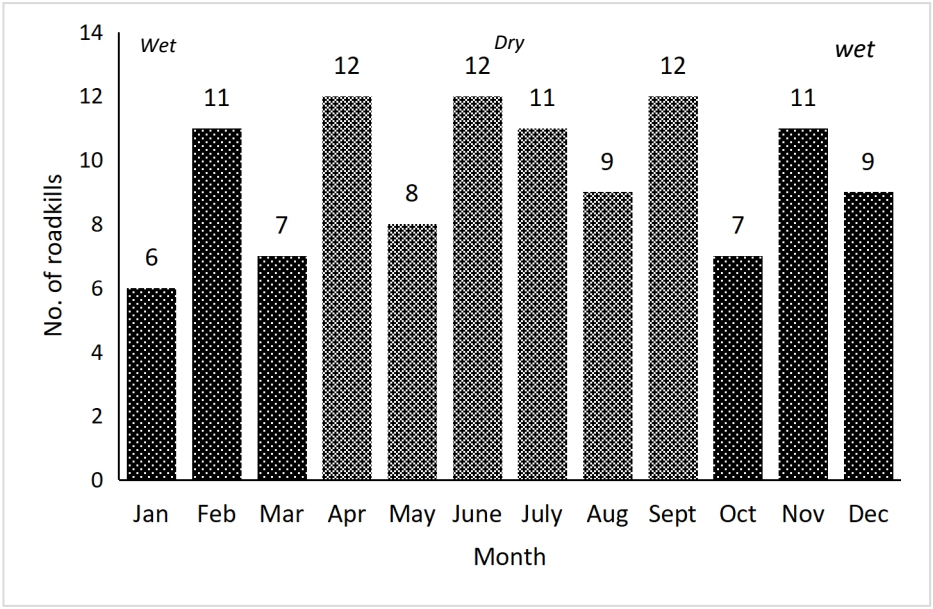

Figure 2 Roadkill in Peninsular Malaysia according to month from 2006 to 2019.

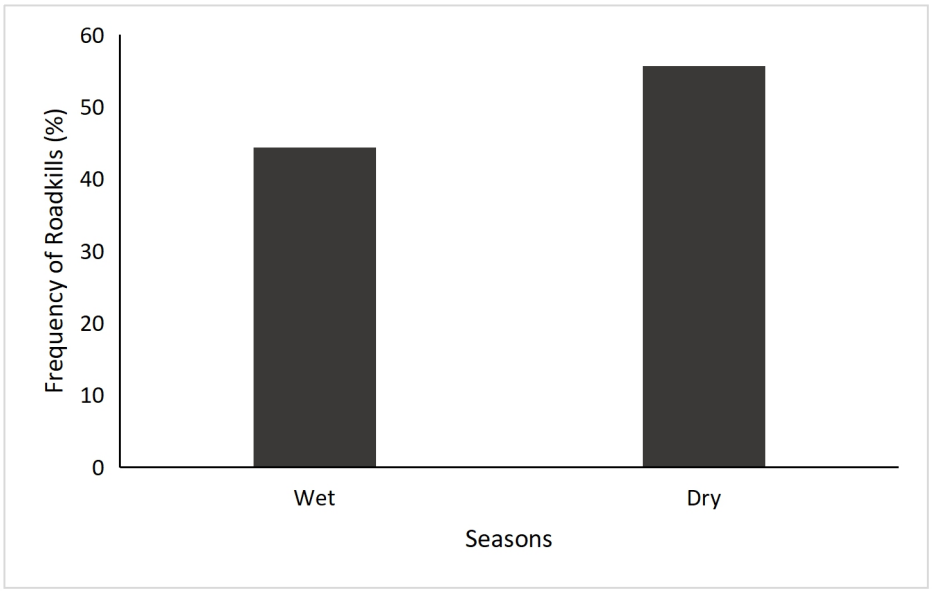

Figure 3 Frequency of roadkill occurrences according to wet and dry seasons.

The roadkill occurrences in Peninsular Malaysia for the past 14 years occurred in eight states (Figure 4). There were five states with more than ten roadkill where Terengganu (33) had the highest number of roadkill, followed by Pahang (26), Johor (20), Negeri Sembilan (14) and Selangor (13). Three states recorded less than ten occurrences of roadkill, namely Kelantan (6), Melaka (2) and Perak (1). There was no occurrence of roadkill in Perlis, Pulau Pinang and the Federal Territory of Kuala Lumpur.

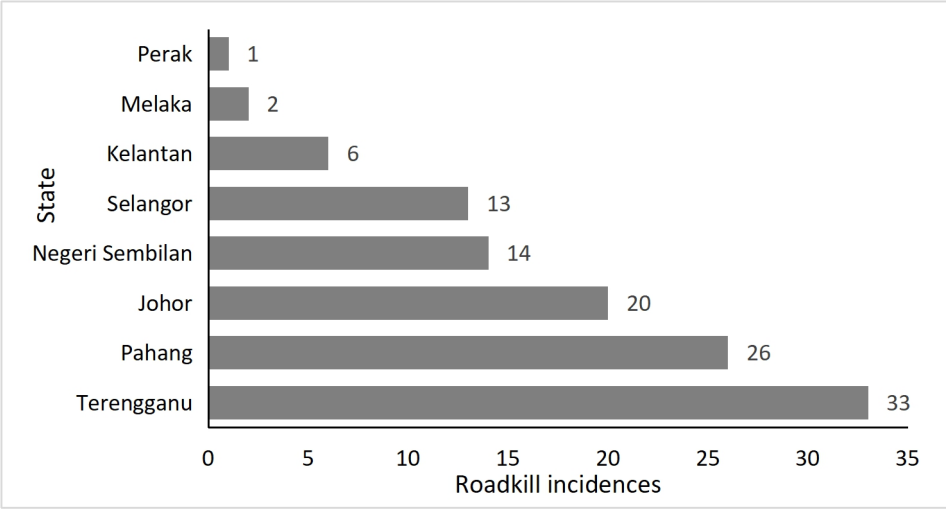

Figure 4 Number of roadkill occurrences according to state in Peninsular Malaysia from 2006 to 2019.

The distribution and density of Malayan tapir roadkill occurrences in Peninsular Malaysia is shown in Figure 5 and Figure 6, respectively. Based on the map, roadkill occurred mainly in the eastern of Peninsular Malaysia. Based on the data gathered by PERHILITAN, the roads with a high frequency of roadkill were the highways connecting Pekan, Kuantan in Pahang and Kuala Terengganu in Terengganu. In the past 14 years, 41 Malayan tapirs were killed along the mentioned highway. A simple linear regression test was performed to examine the relationship between the cumulative decreased size of forested area in Peninsular Malaysia from 2006 and a yearly number of roadkill occurrences of Malayan tapir in Peninsular Malaysia. We assumed that the more the forests were opened, the occurrences of roadkill increases. The coefficient of determination shows that (R^2 = 0.38%) (Figure 7) there is a fragile relationship between the yearly roadkill and cumulative decreased size of forested area. However, the test was not statistically significant.

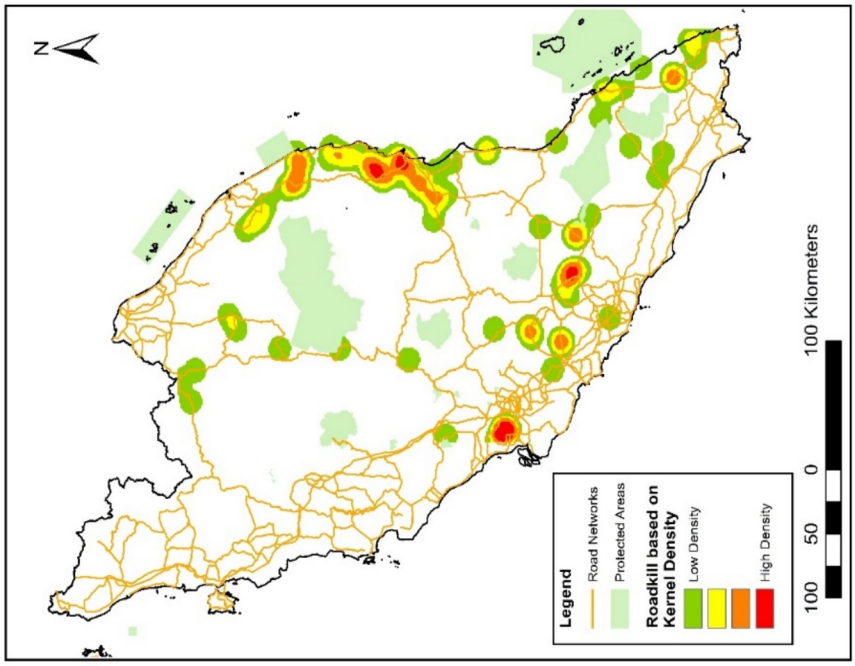

Figure 6 The density of Malayan tapir roadkill throughout Peninsular Malaysia from 2006 to 2019.

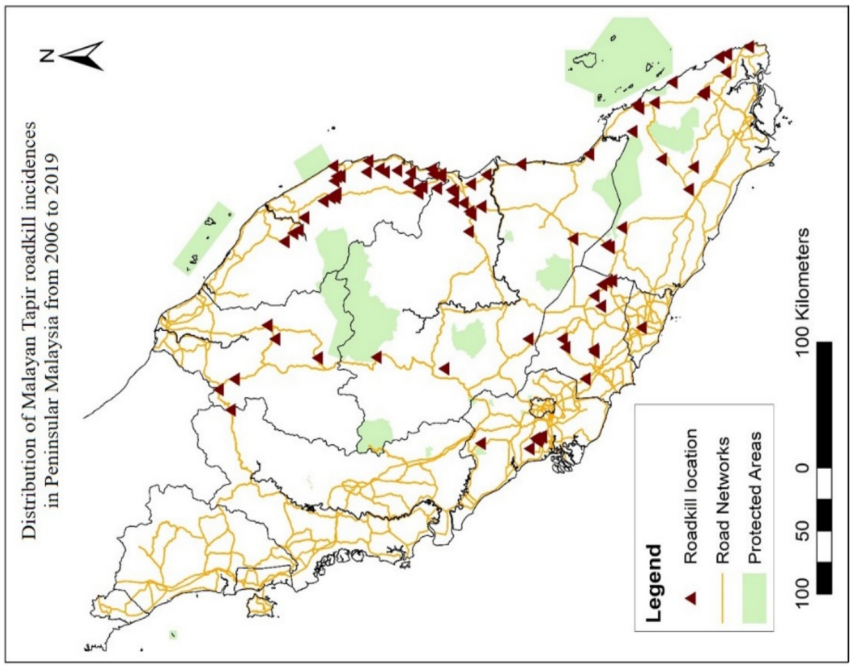

Figure 5 The distribution of Malayan tapir roadkill in Peninsular Malaysia from 2006 to 2019.

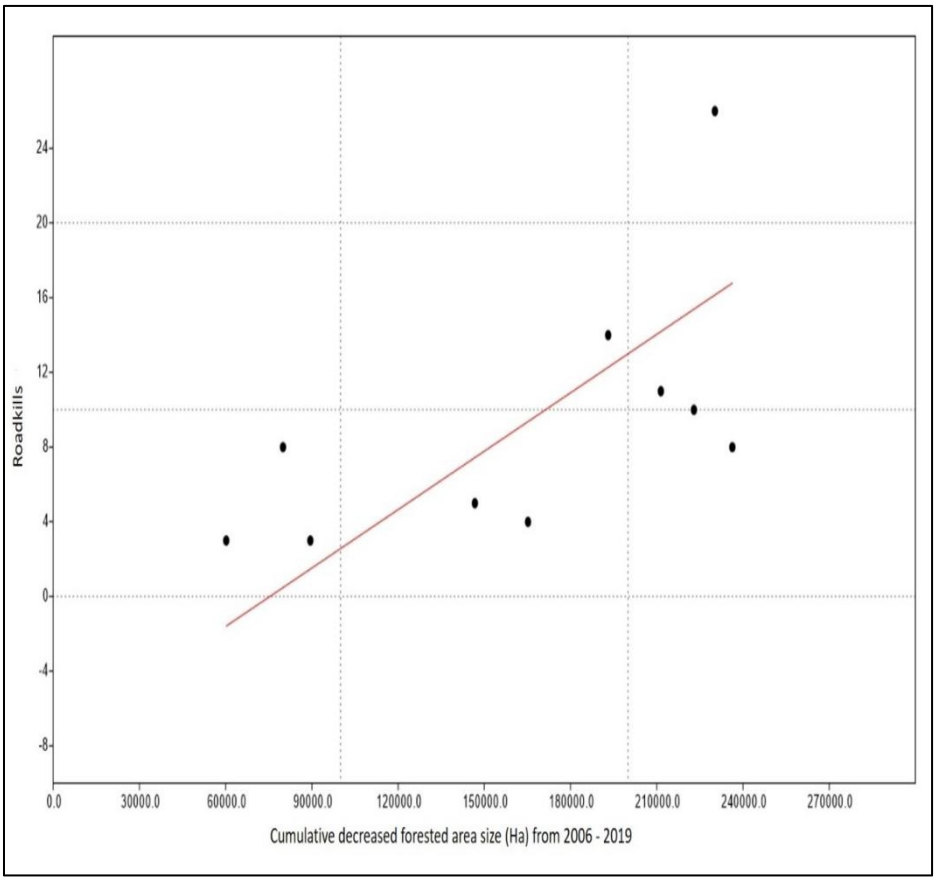

Figure 7 Relationship between the size of forested area decreased and roadkill occurrences from 2006 to 2019.

DISCUSSION

Vehicle collisions with wildlife on roads threaten the wildlife in many countries around the globe. In Malaysia, rapid urbanisation and the accompanying increase in road networks have placed pressure on Malaysia's biodiversity (CBD, 2019) and risks to wildlife. Clement *et al*. (2014) revealed that roads construction is one of the drivers of declines in mammal populations and extinctions in tropical forests (due to roadkill) apart from providing access of poachers into adjacent forest areas, road accidents and creating noise pollution.

Malayan tapir roadkill in Peninsular Malaysia has reduced its population significantly. In the past 14 years, PERHILITAN has recorded a total of 115 Malayan tapir roadkill occurrences. The data shows that (Figure 1) from 2006 to 2013, deaths did not surpass ten roadkill occurrences. However, the reasons for the number of roadkill occurrences jumped to more than ten individuals a year, except for 2018, mainly due to the opening of the East Coast Expressway Phase 2 with vehicles speeding on the highways. The total number of roadkill incidences along the expressway was 18 for three consecutive years, namely 2015, 2016 and 2017. These roadkill hotspots were mainly in Terengganu and located far from the existing underpasses.

In 14 years of records, the number of roadkill occurrences in Peninsular Malaysia according to month was not homogenous, with the highest number of roadkill occurring in April, June and September, while the lowest number of roadkill occurred in the month of January. Each month with a lower number of roadkill occurrences will be followed by a month with a higher number of roadkill. These variations were from January to June and from August to November. On the other hand, the number of roadkill occurrences according to wet season and dry season throughout the year showed greater during dry season as compared to wet season, though it was not statistically significant. A higher rate of Malayan tapir roadkill in Peninsular Malaysia during the dry season is possibly associated with the Malayan tapir movement in the dry season in search of water. In the case of elephants, their movements were a response to changes in rainfall events (Bohrer *et al*., 2014) which saw them disperse widely in the dry season (Chase & Griffin, 2008). Hasting *et al*. (2019) found that the season significantly influenced the number of reptiles roadkilled, where more was in the wet season.

Most roadkill for Malayan tapir occurred at night. Although the Malayan tapir is a nocturnal species (Magintan *et al.*, 2010; Francis, 2019), it was difficult to ascertain the exact time of the collision at night because of the report or the roadkill evidence mostly discovered the next day. Though the number of vehicles using the road at night dropped, drivers tend to drive faster (Munzilah & Rosnawati, 2013; Amiruddin *et al*., 2015), and driving is more dangerous at night due to darkness (Malek *et al*., 2019). Amiruddin *et al*. (2015) showed that speeding drivers increased the number of road accident collisions.

The kernel density analysis of Malayan tapir roadkill occurrences was noticeably higher in the eastern of Peninsular Malaysia (Figure 6). Based on the roadkill data, the East Coast Expressway Phase 2 had recorded 19 cases from 2012 to 2017, where nine of these cases occurred in 2015. The construction of the East Coast Expressway Phase 2 started in 2006 to provide a road network to Peninsular Malaysia's east coast. It was then opened to the public in stages,

which the earliest stage opened in 2011 and was fully opened to traffic in early 2015 (Nor-Azira, 2017). Subsequently, roadkill occurrences of Malayan tapir had increased along the expressway. Another area with high density of Malayan tapir roadkill occurrences was in Negeri Sembilan. Roadkill occurred along roads that connect Seremban – Kuala Pilah – Bahau – Rompin and Gemas (Figure 6). A total of seven out of 14 events occurred on these roads in the past 14 years. Based on Geographic Information System (GIS) analysis for land-use changes in Negeri Sembilan from 1969 to 2014, there was a significant change in land area for agriculture (Nur-Syabeera & Firuza, 2019).

Selangor experienced a high number of Malayan tapir roadkill in the past 14 years. Most roadkill occurrences in Selangor were confined to road networks around Bukit Cerakah areas. Nine out of the 13 roadkill occurrences in Selangor were from this area. This area is surrounded by residential areas, industrial factories, parks, highways and roads (Zakaria *et al*., 2017), and its forest size is slowly reducing due to the development pressure. It was estimated that between three and five Malayan tapirs are present in this area (PERHILITAN, 2010). Johor had experienced a moderate number of roadkill occurrences in the past 14 years, where roadkill occurred mainly in the districts of Kota Tinggi, Mersing, Segamat and Kluang. These districts are the main agricultural area in Johor (DoA, 2016). Declining habitats is one of the factors for displacing Malayan tapirs (Magintan *et al*., 2012), which may lead to roadkill. The majority of the forest in Perak and Kelantan found in large continuous blocks of forest known as the Banjaran Titiwangsa – Banjaran Bintang – Banjaran Nakawan range. The number of roadkill occurrences was smaller in these areas. Only two roadkill occurred in Melaka for the past 14 years but the individuals were believed to be from the nearest forest reserve in Tampin, Negeri Sembilan. Kedah does not have roadkill occurrences, as forest reserve areas in northern Kedah are connecting to a forest area in Perak and provide a large roaming area for Malayan tapirs.

In the past 15 years, the department has taken the initiative to formulate approaches to mitigate wildlife roadkill problems and reduce vehicle collisions with wildlife on Peninsular Malaysia roads. The government has allocated money for wildlife to cross roads safely by building viaducts in strategic areas. The viaducts are part of the larger Central Forest Spine (CFS) project (DTCP, 2005) to connect fragmented forests in Peninsular Malaysia. A total of three wildlife viaducts project were established in 2006 to act as safe highway crossing points for wildlife within forest complexes in Hulu Terengganu (Magintan *et al*., 2012), three viaducts have been constructed and completed in 2014 along Kuala Lipis – Gua Musang highway to provide corridors for animals between Sungai Yu Forest Reserve and Tanum Forest Reserve which is connecting to Taman Negara (Suhaida *et al*., 2017), and viaducts built along the

Gerik-Jeli Highway (Wong *et al*., 2018) to help elephants or other wildlife to crossroads. However, the initiatives mentioned have not been assessed thoroughly for their effectiveness. A study of underpasses at the highway connecting the Kuala Berang (Terengganu) and Gua Musang (Kelantan) revealed that wildlife such as the Asian elephant, Malayan tapir, panther, civets and barking deer were seen to use the underpasses occasionally, if not frequent (Clements *et al*., 2012; Wan-Nordin *et al*. 2020). In other reports, assessing the underpasses at Sungai Yu, Lipis, Pahang showed that there were records of wildlife using the underpass to move to the connecting Tanum Forest Reserve (Meisery *et al*., 2020). The underpasses or viaducts initiative needs a more thorough study to see its effectiveness in reducing roadkill.

The installation of wildlife-crossing area signage or "wildlife crossing" signboards has been used to deliver information to road users on the presence of wildlife to reduce roadkill, especially for the Malayan tapir (Magintan *et al*., 2012). The department also set up electric fences for forests bordering settlements or plantations to prevent elephants from encroaching on their orchards or plantations (Salman *et al*., 2011). At the same time, the electric fence can prevent other large mammals such as the Malayan tapir from displacing from their natural habitat. Translocation to a larger forest area such as the Taman Negara National Parks and wildlife reserves is the last resort to help prevent isolated Malayan tapirs from becoming the victim of roadkill. The mitigation is only for individuals with limited space and are likely to crossroads to move to other areas. The government has been using electric fences to prevent elephants from invading agriculture and settlement areas. The use of electrified fences as mitigation measures (Ahmad-Zafir & Magintan, 2016) has prevented the movement of other animals such as the Malayan tapir to pass into roadkill prone areas (PERHILITAN-MPOC-FELDA, 2018). This article suggests other possible methods to alert road users to reduce speeds at the roadkill hotspot areas. Firstly, to execute a regular integrated patrolling by the authorities (Police/ PERHILITAN/ Road Transport Department). Secondly, build a large statue of elephant or Malayan tapir painted with good reflecting colours at the side of the roads. Thirdly, build speed bumps to force the drivers to slow down.

Outreach programmes through awareness activities have been the main platforms carried out by PERHILITAN every year to spread public awareness on the importance of biodiversity and increase awareness of roadkill and human-wildlife conflict. In 2018, a total of 51 schools and 1,785 participants were involved in public awareness programmes through various activities, including the Biodiversity Education Programmes, local community outreach programmes, site visits, exhibitions and talks by PERHILITAN (PERHILITAN-MPOC-FELDA, 2018). However, it is yet to conclude that awareness

programmes are an effective tool to reduce roadkill. Thus, there is a need to evaluate the effectiveness of the awareness programmes to improve future methods and approaches. Data of roadkill needs to be detailed and include habitat type, the status of roads (e.g. federal or state road) and distance from main habitat or forest. Our analysis is also unable to specify the time range of the roadkill event due to a deferred report, as delayed roadkill incident reports typically reach the authority prior to further action taken.

CONCLUSION

Wildlife roadkill analysis can help the authorities and stakeholders manage the issue more effectively, find solutions, or minimise the incidents in the future. Interestingly, we observed that more roadkill occurred in the dry compared to wet seasons. Though it was not statistically significant, it has opened the opportunity for further research. Several components are essential for future research, such as the relationship between mating behaviours and seasons. We believe that the government's mitigation measures to reduce roadkill occurrences are beneficial to the wildlife and the survival of Malayan tapirs in their natural habitat.

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