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DEVELOPMENT OF ANIMAL HAZARDS IN AN ACCIDENT PROFILE CHART AND ITS APPLICATION

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ABSTRACT

An animal hazard by accident profile is a profile chart that classifies the risk of collision between animals and vehicles. It is described through a color-coded profile along the road. Through animal hazards by accident map, road users can accurately identify hotspots along roads that are at risk of collision with animals and take precautionary measures. Besides, local authorities can plan mitigation measures, so that collisions with animals can be avoided or at least minimized. The main thrust of profile charts is mass and velocity (speed) of animals as main indicators, while endangered animal as supporting indicator. The article discusses in detail the creation of the profile chart, in addition to its implication as an additional mitigation measure to deal with collision with animals on the road. Overall, road users and local authorities agree that profile charts and profile maps are mitigation measures capable of reducing accident rate involving animals, as well as easy to understand and being used. The only challenge regarding of utilizing the profile chart is to ensure that the collection of comprehensive, valid and prompt of animal accident information.

Keywords: Animal hazard, accident information, map, mitigation measure, profile chart.

INTRODUCTION

One of the common accidents in Malaysia is due to the collision between animals and vehicles. This accident causes damages to vehicles, injuries and deaths to both animals and humans. The accident occurs when the vehicle tries to avoid animals or animal carcasses on the roads, but unfortunately hits them [15,26]. The risk of the accident increases when the roads or highways are developed and constructed along animal habitat patches, thus, disrupting their vital ecological processes.

Width of the road zones, traffic volumes and road avoidances have obstructed the movement of animals within their habitat [11,13,17,22]. As agreed by [4] that animals crossing the road because they need an access to critical resources such as food, shelter and mates from their habitat. Meanwhile, carcasses could pose a threat to drivers if they are not picked up promptly by the assigning worker. This problem arises when there are no responsible agencies who are assigned to overcome these problems [7].

Table-1 shows a sample of typical accidents involving animals and their impacts in Malaysia which were collected from local newspapers. The collision between vehicles with animals also has been reported as one of the highest cause of fatal accidents at East Coast Highway 2 from 2011 to 2015 where there were 107 accident cases and 7 of the cases were fatal accidents [18]. As a result, this problem should be given an attention and effective mitigation measures need to be developed.

Several mitigation measures have been developed to overcome the collisions between animals and vehicles such as warning sign at the roadside and build underpass road to allow animals to cross the road so that it could reduce fatal accidents and maintain habitat connectivity. However, some of them are impractical because they are expensive to be implemented throughout a road alignment [3,6,9,10,12]. As suggested by [16] that before any mitigation measure is implemented, priority should be given to accurately identify hotspots or critical sites.

A hotspot is defined as a site where animals are most likely to cross roads, fatal accidents at high risk and structural barriers or behavior avoidance prevent animals from crossing the road for habitat connectivity. Moreover, the hotspot identification is essential due to resources limitation for installation and maintenance the mitigation measures.

An accident profile due to animal hazards was created as an alternative mitigation action for the animal-vehicle collisions. The profile enables to avoid this type of accident or at least to minimize the accident effects. Furthermore, the profile chart can also be used as a supporting tool to identify the hotspots for monitoring and mitigation according to its risk categories and ranks. The profile chart is created similar to the approach used to develop a Rainfall-Soil Chart (RS Chart) [25]. The RS Chart categorizes slopes along a path according to their risk assessment. This article discusses the development of accident profile due to animal hazards and the implementation of this profile to avoid or unless minimize the animal-vehicle collision impacts.

Table-1. Accidents involving animals and vehicles and their impact in Malaysia.

Animal	Date	Location	Impact
Bear	May 5th, 2015	KM 358.0 East Coast Highway 2	Vehicle severely damaged
Buffalo	May 7th, 2015	KM 357.9 East Coast Highway 2	Human severely injured
Cat	May 9th, 2014	KM 4, Kuala Pilah-Tampin Road	Vehicle damaged
Cow	March 12th, 2012	Labok	Animal died, human injured and vehicle severely damaged
Deer	October 16th, 2014	KM 213.3 North-South Highway	Vehicle damaged
Dog	February 6th, 2011	KM 154.2 North-South Highway	Animal died and vehicle damaged
Elephant	February 15th, 2014	Kampung Wakaf Zing	Human died
Monitor lizard	June 27th, 2015	KM 105.0 North-South Highway	Vehicle broke out
Monkey	October 21st, 2014	Kampung Parit Abas	Vehicle broke out
Pig	July 6th, 2015	KM 20 Kampung Sri Nawar	Human injured
Tapir	November 18th, 2012	KM 15 Dungun-Bukit Besi Road	Vehicle severely damaged
Tiger	February 7th, 2016	KM 321.2 East Coast Highway 2	Animal died
Wild boar	August 17th, 2016	Hulu Yam Bharu-Sungai Tua Road	Human severely injured and died

METHODOLOGY

The risk levels in the profile chart were established based on contributing risk factors. It begins with identification of the contributing factors for each risk level which were through literature survey and questionnaire or interviews. Then, contributing factors were ranked according to the impacts of the collisions. The rank was based on the interview results and questionnaires. Finally, the threshold values of each contributing factors were determined to facilitate the risk categorization.

RESULTS AND DISCUSSIONS

The contributing factors identified for the profile chart are mass and speed of animal as main indicators and endangered animals as a supporting indicator. The mass and speed (velocity) were selected when a collision is fulfilled according to the law of conservation of linear momentum:

$$p = mv$$

where
p = momentum
m = mass
v = velocity

According to this equation, it shows that the mass and velocity are two proportional factors that could give direct impact if two objects collide. Besides, based on collision definition, collision is an event where momentum or kinetic energy is transferred from one object to another. On the other hand, momentum (impact) of animal which depend on mass and velocity will be transferred to the vehicle when animal collided with the vehicle. Meanwhile, the selection of endangered animal factor because endangered animal is the highest attribute of animals that being selected by the respondents, as they considered the most adverse effects when vehicle-animal collisions occur (Figure-1). Furthermore, it liaised with Non-Governmental Organisation (NGO) in Malaysia such as World Wildlife Fund (WWF) and Malaysian Nature Society (MNS), conservation of our wildlife not only because more than 1914 animals died on roads and highway since year 2011 to 2016 but also Malaysia is tops the list under International Union for Conservation of Nature (IUCN) Red List of Threatened Species [5]. Description of each animal attribute as shown in Table-2.

Majority respondents ranked mass, followed by velocity (speed) and then endangered as the risk factors that possibly cause the collision impacts more severe (Table-3). According to the questionnaire, respondents also gave a reason why a certain factor is more risk than the other factors. However, out of 100 respondents, only 54 respondents gave a reason.

The mass is considered as the most risk factor because heavy animals that are generally large in size can lead to severe damage to the vehicle and potentially lead to injuries and died to drivers and passengers. Nevertheless, the driver also will try to avoid these animals if they are crossing the road. As the result, the probability of an accident to be happened is high. The second risk factor is velocity since the faster the animal, the greater impacts may possible to the vehicle and animal especially when the fast-paced animals suddenly appeared on the road and the driver could not avoid them, thus cause an accident. However, the fast-paced animals are usually small in size and the impacts are more likely on the animals rather than on the vehicles and human. Moreover, fast animals can act quickly to avoid from being hit if they are vulnerable to violation. The

endangered factor is considered because if endangered animals are often killed in accidents, the existing small population of animals will soon become extinct [2,19,24].

Table-4 shows the threshold values for mass and velocity factors. The mass is divided into two categories namely heavy (>120 kg) and light (<119 kg) animals. While, the velocity factor as categorized into fast-paced and slow-paced animals with their speed of >45 km/h and <44 km/h respectively. The threshold values for both factors were chosen by considering their impacts due to mass and velocity on vehicles and human after collisions. Study cases used in the study were subjected to the accident reports that involved vehicles and animals in Malaysia. These animals are identified through mass media reports from 2010 to 2016. Whereas, endangered animals are as stated in the list of Department of Wildlife and National Parks Peninsular Malaysia (PERHILITAN).

The classification of contributing factors was developed according to animal masses and velocities as the main indicators and endangered animals as the supporting indicator. These classification as shown Table-5 and further details are shown in Table-6. The animals were classified with specific colors (color-coded) as presented in Table-7. The mitigation measures were developed according to the expert advices such as civil, mechanical and electrical engineers and zoologist. Engineers are expert group in design and construct a road safety system in preventing road users from being killed or seriously injured. Meanwhile, zoologist is a person that expert in animal behavior, migration, interactions with other species, and reproduction, as well as the habitat changes that affect them.

Table-8 shows road users and local authorities (respondents) agreed that animal hazards in the accident profile map not only can assist the users to minimize the accidents involving animals but also easy to be used. Furthermore, they are willing and confidence to use this profile in the future. However, the respondents were skeptical of the ability to collect comprehensive and prompt of animal accident information which will depends on the volunteer spotters. The respondents were more confident if the data collection was done by paid spotter. The questionnaire was adapted with modification from the surveys in the study by [1,14,20] in which the studies mainly to identify the quality of products and mobile applications from the user's perspective.

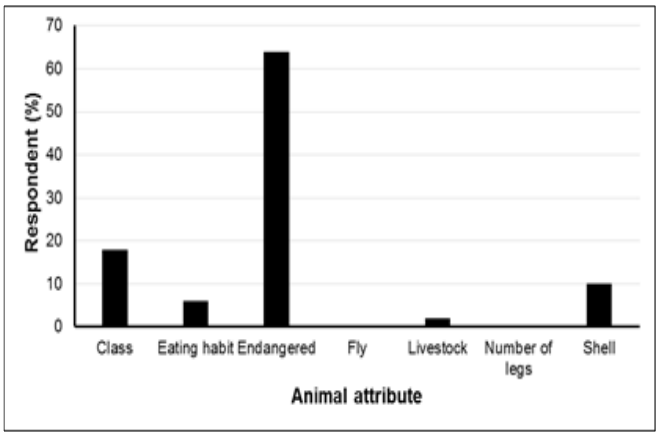

Figure-1. Contributing risk factors (animal attributes) to the impacts of collisions.

Table-2. Animal attributes and description.

Attribute	Description	Example
Class	Animals that classified based on their food requirements, habitats, size, reproduction, body anatomy etc.	Amphibians (salamander), birds, fishes, invertebrates (scorpion), mammals (camel) and reptiles (crocodile)
Eating habit	Animal habit on eat specific diets that connect them together in a food chain.	Carnivore (tiger), herbivore (horse) and omnivore (bear)
Endangered	Animal species which has been categorized as very likely to become extinct. Faces a high risk of extinction in the near future.	Elephant
Fly	Animals that have wings and can move through the air and can continue flying for an extended time.	Bat
Livestock	Domesticated animals raised in an agricultural setting to produce labor and commodities such as meat, eggs, milk, fur, leather, and wool	Cattle, sheep, pigs, goats, horses
Number of legs	Animals that classified based on their number of legs such as two or four or even none.	Cow, chicken
Shell	A shell is a hard outer layer, which has evolved in a very wide variety of different animals	Turtles and tortoises

Table-3. Opinion on contributing risk factors.

Risk	Respondent (%)
Mass > velocity > endangered	52
Mass > endangered > velocity	18
Velocity > mass > endangered	10
Velocity > endangered > mass	8
Endangered > mass > velocity	11
Endangered > velocity > mass	1

Table-4. Animal hazards by accident profile.

Animal		Speed and endangered			
		Fast and endangered	Fast	Endangered	None
Mass	Heavy	Risk 1	Risk 2	Risk 3	Risk 4
	Light	Risk 5	Risk 1	Risk 7	Risk 8

* Animal mass : Heavy > 120 kg and light < 119kg
Animal speed : Fast > 45 km/h and slow <44km/h
Endangered animal : Listed by PERHILITAN
.* > = more risk

Table-5. Animal weight and speed and its collisions impacts with vehicles or when the animal is on the road.

Animal	Average weight (kg)	Top speed (km/h)	Consequences caused by collisions or animal on road
Bear	650	30	Animal severely injured, vehicle severely damaged,
Buffalo	785	40	Animal died, human severely injured and died, vehicle broke out
Cat	5	46	Animal died, vehicle broke out
Cow	650	40	Animal died, human injured, severely injured and died, vehicle broke out
Deer	80	48	Animal severely injured and died, vehicle damaged and broke out
Dog	35	70	Animal severely injured and died, vehicle damaged and broke out
Elephant	4500	40	Animal severely injured and died, vehicle severely damaged
Monitor lizard	25	40	Animal died, vehicle broke out
Monkey	1	35	Animal died, vehicle broke out
Pig	70	20	Animal died, vehicle damaged and broke out
Tapir	250	40	Animal severely injured and died, human injured, vehicle severely damaged and broke out
Tiger	275	96	Animal severely injured and died, human severely injured and died, vehicle severely damaged and broke out
Wild boar	120	48	Animal severely injured and died, human injured, vehicle severely damaged and broke out

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Table-6. Details of animal hazards by accidents profile chart.

Scale		Animal	Hazards	Risk	Precaution	Mitigation measures
Critical	**C1**	Heavy, fast, endangered animal	Animal severely injured, died and species extinction, human severely injured and died, vehicle severely damaged and high possibility broke out	RISK	PRECAUTION / DRIVING SPEED	Warning signage, underpasses, overpasses, remote monitoring camera, animal GPS detector collar, fencing, jump-out motion sensor monitoring, legal protection, speed breakers signage, transverse bar
	C2	Heavy, fast animal	Animal severely injured and died, human severely injured and died, vehicle severely damaged and high possibility broke out			Warning signage, speed breakers signage, transverse bar, jump-out motion sensor monitoring, remote monitoring camera, underpasses, overpasses
	C3	Heavy, endangered animal	Animal severely injured, died and species extinction, human severely injured and died, vehicle severely damaged and broke out			Warning signage, speed breakers signage, transverse bar, jump-out motion sensor monitoring, remote monitoring camera, legal protection,
Very high	VH	Heavy animal	Animal severely injured, died and species extinction, human severely injured and died, vehicle severely damaged and broke out			Warning signage, speed breakers signage, transverse bar, jump-out motion sensor monitoring
High	H1	Light, fast, endangered animal	Animal severely injured, died and species extinction, vehicle damaged and high possibility broke out			Warning signage, speed breakers signage, aerial rope bridge, transverse bar
	H2	Light, fast, animal	Animal severely injured and died, vehicle damaged and high possibility broke out			Warning signage, speed breakers signage, aerial rope bridge
	H3	Light, endangered animal	Animal severely injured, died and species extinction, vehicle damaged			Warning signage, aerial rope bridge
Moderate	M	Light animal	Animal severely injured and died, vehicle damaged			Warning signage
Low	L	None	None			None

Table-7. Classification of animals according to animal hazards to profile chart by accidents profile chart.

Animal	Mass	Speed	Endangered	Scale
Bear	Heavy	Slow	Endangered	C3
Buffalo	Heavy	Slow	No	VH
Cat	Light	Fast	No	H2
Cow	Heavy	Slow	No	VH
Deer	Light	Fast	Endangered	H1
Dog	Light	Fast	No	H2
Elephant	Heavy	Slow	Endangered	C3
Monitor lizard	Light	Slow	No	M
Monkey	Light	Slow	No	M
Pig	Light	Slow	No	M
Tapir	Heavy	Slow	No	C3
Tiger	Heavy	Fast	Endangered	C1
Wild boar	Heavy	Fast	Endangered	C2

Table-8. Survey of animal hazards by accident profile chart and map.

Item	Mean score	Remarks
I think that I understand the idea of this profile chart	4.63	Agree
I felt this hazard map is helpful and useful to me as road users	4.60	Agree
I felt this profile chart and hazard map is helpful and useful to local authorities for early planning	4.31	Agree
I think that I would need assistance to be able to use this hazard map	1.33	Strongly disagree
I found this hazard map very awkward to use	1.17	Strongly disagree
I felt very confident using this hazard map	4.90	Agree
I think that I would like to use this hazard map frequently	4.54	Agree
I found this hazard map unnecessarily complex	4.23	Agree
I believe the idea utilizing volunteer spotter to get information of hazard map is effective	2.88	Disagree
I believe the idea utilizing paid spotter to get information of hazard map is effective	4.06	Agree

PROFILE CHART APPLICATION

The end product of this profile chart is the color-coded profiling along the road which was displayed in Google Map (Figure-2). The colored stretches the potential accident areas that were based on the color-coded of the animal shown in Table-7. The coordinates show the location of the potential accidents. Distance profile shows the distance of the accident potential stretch, which is based on the speed limit of the road. For example, if the road speed limit at a potential accident stretch is 120 km/h, thus the distance range of the colored stretch is 0.07 km (Figure-3). This measurement is by considering 2 seconds as the response time [8,21], where the response time is defined as the length of time taken for a person or system to react to a given stimulus or event. The calculation of the profile distance is as follows:

Profile distance = Speed limit x reflection time

The process of the profiling along a road begins with the volunteer spotters identified the location of the animal carcass being trespassed. All the infringement information will be sent to the spotter network administrator. Then, the information will be checked by the district administrator to ensure the information is complete and valid. Later, the information will be sent to the profile chart administrator. The profile administrator digitized the accident stretch profile of animal hazards in a draft map of Google Map (Figure-4). If it was the first case encountered, it is considered a coincidence or isolated case, but if more than once, the location is considered a location which often passed by animals and may cause accidents.

Profile chart will only be marked in animal hazards by accident map in Google Map if the collision occurs in the same location more than two times. Risk categories will represent by color-coded profiles. These maps will always be updated especially when there is a new animal collision case. In summary, the process of producing and distributing animal hazards by accident map is shown in Figure-5.

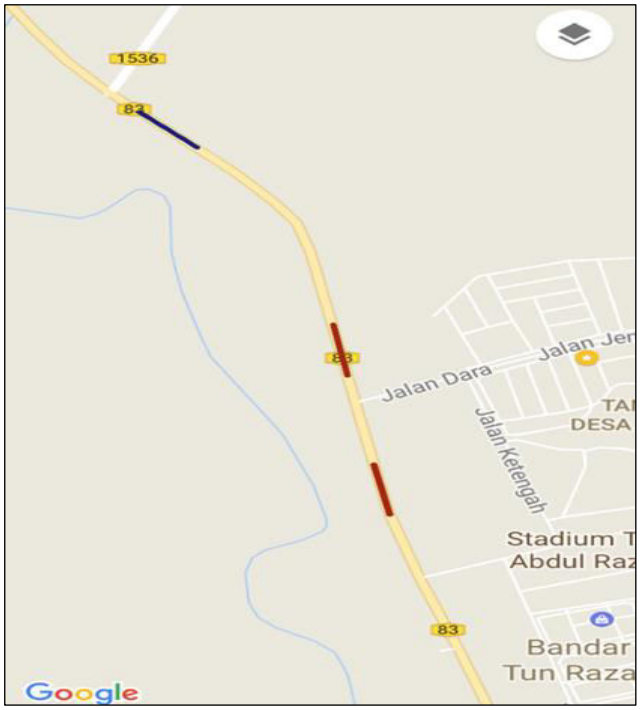

Figure-2. Animal hazards map.

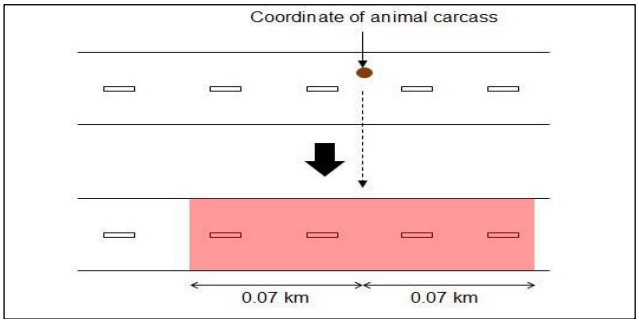

Figure-3. Profile of animal hazards chart remarked at the road.

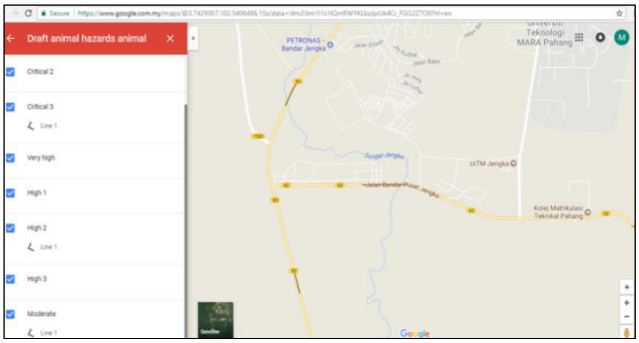

Figure-4. Profile of animal hazards chart remarked at the road.

CONCLUSIONS

The collision between vehicle and animal on the road can create various adverse effects on either humans or animals itself. For that reason, animal hazards by accident profile charts are developed so that animal collisions can be avoided or at least minimized the impacts. This profile chart is a guideline to indicate the hotspots for animal collisions along any roads. Animal hazards by accident map displayed through Google maps can be used by road users to navigate spot at risk so that when road users go through these spots, they need to take extra precautions to avoid collision with animals.

Even though there are warning signs on the roadside, road users still cannot utilize this sign in the best possible way. This due to the distance between the warning sign and the vehicle is quite distant, making it difficult for the user to track and read the warning sign. Meanwhile, for the local authorities, they can design and take mitigation measures at the hotspots. This profile chart is essentially an alternative mitigation measures to avoid collision of vehicle-animal on the road due to its practicality, user friendly and low cost. Thus, the creation of the profile is not only will benefit to the road users but also animals since expected to reduce the rate of vehicle-animal collisions.

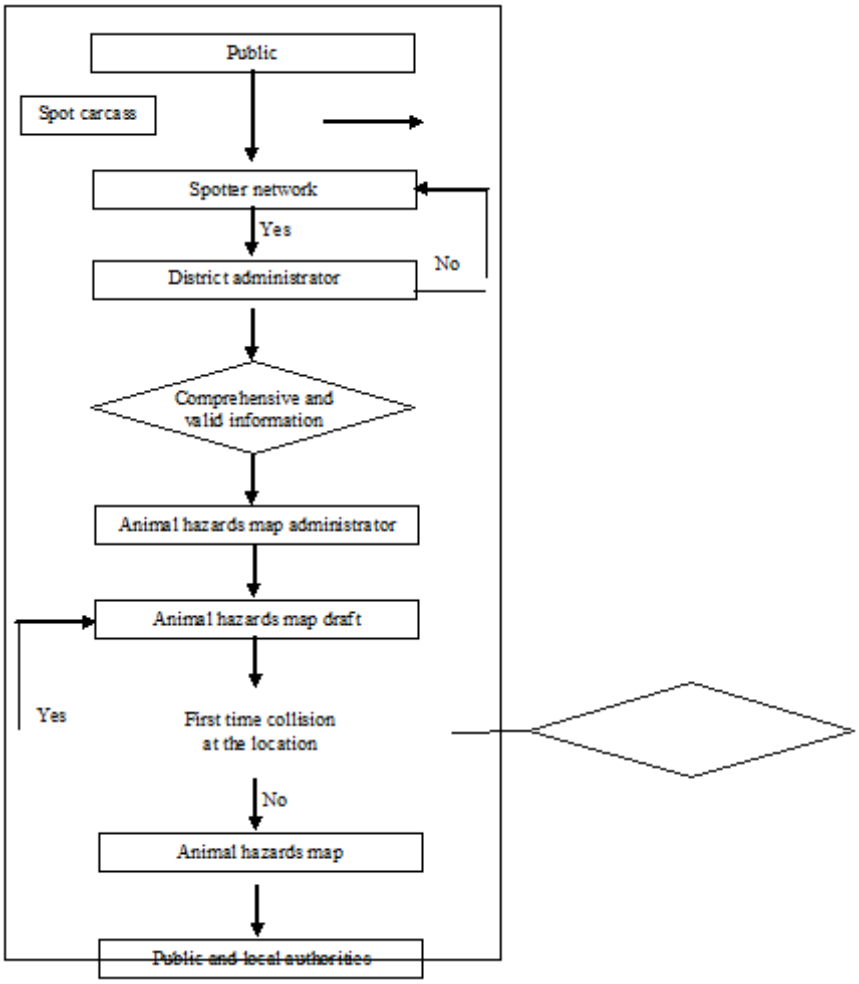

Figure-5. Profile of animal hazards chart remarked at the road.

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