



Original Research Article

doi: <https://doi.org/10.20546/ijcrbp.2018.512.005>

## A Study on the Potential of Mammalian Feces as Seed Dispersal Agent in a Disturbed Forest Landscape

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### Article Info

Date of Acceptance:  
29 October 2018

Date of Publication:  
06 December 2018

### Keywords

Disperser  
Mammalian feces  
Regeneration  
Seed viability

### ABSTRACT

Mammalian feces are digestive residuals that come out through the anal in the form of materials that is partially or completely digested. Mammals have the potential to disperse seeds and regenerate forests through feces. However, quantitative studies on the potential of various species of mammals need to be done to clarify such a role. We collected mammalian feces through field surveys in forest habitat, forest edges and along the riverbank at Solok Selatan, West Sumatra. Seed viability test was carried out at the Laboratory of Plant Physiology and Greenhouse of the Department of Biology, Andalas University. We successfully collected 31 piles from eight species of mammals belonging to three orders and six families. Seeds of four plant species were found in 63% of mammalian feces, all of which are from the Viverridae family (*Paradoxurus hermaphroditus*, *Arctogalidia trivirgata*, *Arctictis binturong*). The piles were more often (80.6%) found at the forest edge than at riverside and forests. Seed viability tests showed that all seeds failed to germinate. The results of this study indicate that Viverridae has the potential for seed dispersal but viability test does not support the role of mammals for forest regeneration through germination.

### Introduction

Mammal is an important element in maintaining the balance of tropical forest ecosystem (Fimbel et al., 2001; Meijaard et al., 2006). Mammals can spread the plant seeds through their feces that have potential as seeds for forest regeneration. Based on the class of food, mammals can be classified into herbivores (plant eaters), carnivores (meat eaters),

and omnivores (meat and plant eaters). Furthermore, Herbivores are divided into grazer, browser, and graminivore (Alikodra, 2002).

Mammal feces is one of the signs of mammal presence that can be recognized (Liebenberg, 2000). Feces can also support in observing the food type and food composition of mammals. Feces consist of material which is digested in whole, in

part, or undigested. One of the components that can be found in feces is the plant seeds (Bang, 1975; Bujne, 2000).

Several research related to the mammal role as the plant seeds carrier have been conducted by Pratiwi (2014) on the role of large mammals as *Acacia nilotica* seed carrier. The research results showed that water buffalos and bulls play a role in spreading *A. nilotica* seeds. Water buffalos are specifically proven to be able to spread the seeds to the outside of *A. nilotica* woody stands.

In the research of Setia (2008) on the spread of seeds by wild animals in the Bodogol natural conservation education forest area, it concluded that there are three types of wild animals that have the potential to spread seeds through the feces, namely: Asian palm civet (*Paradoxurus hermaphroditus*), Silvery Gibbon or *Owa Jawa (Hylobates moloch)*, and Sooty Headed Bulbul or *Burung Kutilang (Pycnonotus sp.)*. Red stinkwood is a food source that is often found in every feces. Seeds that come from the feces can grow and germinate faster than seeds that fall directly from the tree. In this research, however, it has not been able to show the quantitative data on the seeds percentage that are able to germinate.

At the same research site, in South Solok, Fikri (2015) had inventoried 26 types of mammals. The diversity of these mammals is thought related to the high potential as seed carrier. This research aims to determine the types of mammal spreading the plants seeds as well as the types of plant spread in the forest area. This research analyzed the role of mammals in forest regeneration quantitatively through seed viability test.

## Materials and methods

Mammal feces collection was conducted from May to August of 2017 in the Conservation Forest Area of Prof. Dr. Sumitro Djohadikusumo PT. Tidar Kerinci Agung (TKA) and Conservation Forest of PT. Kencana Sawit Indonesia, South Solok Regency, West Sumatera Province. The method in

mammal feces collection was to search and collect directly at the site. Mammal feces collection was performed along the path that was thought to have been crossed by mammals.

The collected feces were photographed first. Then, they were observed for the shape and color. Next, it was followed by measuring the length and diameter of the feces (Chame, 2003). The collected feces were classified into two, namely new feces and old feces. New feces are feces that are less than one day and still slightly wet, while old feces are feces that have been more than one day and dry. After that, the collected feces were labelled.

Furthermore, identification of mammal types based on the feces collected was performed by referring to the research of Tillah (2014) on the study of mammal feces morphology. Then, it was confirmed to mammal expert, Dr. Junaidi (John) Payne (Personal communication, 2017). In addition, the identification was also strengthened by other supporting data in form of food scraps, traces left, camera trap data in the research of Solina (2016), Fikri (2015), and field guide book of mammal identification by Payne et al. (2000).

The seed viability treatment was conducted until December 2017 at Plant Physiology Laboratory and Home Wire of Biology Department, Andalas University, Padang. The collected feces were put on 1 mm sieve. Then, they were washed by using flowing water until clean, so that there were only large size undigested materials left. The materials were separated according to the type (Anoop and Hussain, 2005). Materials in the form of seeds were identified by applying Vogel (1980) identification guide book at Herbarium of Andalas University, Padang.

The seeds that had been separated based on the type were classified into poor and good quality seeds. Good quality seeds were whole seeds that have potential to grow. To determine which seeds having good quality, the seeds were soaked in water. Seeds that sank were good quality seeds. On the other hand, the poor-quality seeds were the whole seeds

but empty or having no potential to grow. The poor-quality seeds would float if soaked in water. Then, the allseeds were calculated. However, the *Callicarpa arborea* seeds were not included due to its large number and very small seed size. For this reason, it would be difficult to estimate the number of whole seeds and damaged seeds, therefore the estimation was performed to determine it.

The good quality seeds were directly planted and some were provided initial treatment before planting. Seeds without pretreatment were immediately planted on sand and cotton media. The seeds with pretreatment were soaked in GA3 solution for two hours. Then, they were planted in humus soil media and left until the seeds germinate for 40 days.

## Results

### Mammal feces

In this research, 31 piles of mammal feces were obtained. The number of feces found consisted of 27 piles from conservation forest area of Prof. Dr. Sumitro Djojohadikusumo PT. Tidar Kerinci Agung (TKA) and 4 piles from Conservation forest of PT. Kencana Sawit Indonesia (KSI). The mammal feces found were in form of new and old feces. The 27 feces found are from 8 types of mammals that are classified into three orders (Table 1) and 4 piles of unidentified feces as they had been dry and the shape were not intact. The most common feces are from carnivore by 25 feces and 61.3% of all feces were found plant seeds inside.

**Table 1.** Feces found in the conservation forest area of PT. TKA and PT. KSI.

No.	Taxa	Local name	No. of feces	Seed content in the feces
<b>Carnivore</b>				
<b>Viverridae</b>				
1	<i>Paradoxurus hermaphroditus</i>	Asian Palm Civet	9 piles	Yes
2	<i>Arctogalidia trivirgata</i>	Weasel Root	8 piles	Yes
3	<i>Arctictis binturong</i>	Binturong	1 pile	Yes
<b>Felidae</b>				
4	<i>Prionailurus bengalensis</i>	Wild Cat	4 piles	No
<b>Ursidae</b>				
5	<i>Helarctos malayanus</i>	Sun Bear	1 pile	No
<b>Cetartiodactyla</b>				
<b>Cervidae</b>				
6	<i>Rusa unicolor</i>	Sambar Deer	1 pile	No
<b>Suidae</b>				
7	<i>Sus scrofa</i>	Wild Boar	2 piles	No
<b>Perissodactyla</b>				
<b>Tapiridae</b>				
8	<i>Tapirus indicus</i>	Tapir	1 pile	No

### Type of location where mammal feces were found

There are 3 types of locations where mammal feces were found, the first is in the forest with fairly dense vegetation. The second is in the river side, and the third is in the forest edge, which is an open location in the form of dividing road between the

forest and oil palm plantations (the fragmented area). From the three locations, feces were found mostly in the third location, which is the forest edge. The most mammal feces found were from carnivore of Viverridae family, in which from the types of *Paradoxurus hemaphroditus*, *Arctogalidia trivirgata*, and *Arctictis binturong* (Table 2).

## Mammal feces content based on the class of food

The analysis result from 31 of mammal feces shows that the food source composition consumed by the mammals are varied (Table 3). In general, the mammal feces compositions are fine fibers, coarse fibers, plant seeds, bones, and

hair of the prey.

## Description of seeds found in mammal feces

From all mammal feces that have been analyzed on 19 piles of feces, there are 4 types of plants seeds. The types of seed obtained can be seen in detail in Table 4.

**Table 2.** Distribution of mammal feces based on the types of location where feces were found in the conservation forest area of PT. TKA and PT. KSI

Type of Location	Number of feces	Information
Forest	4 piles	Feces of <i>Rusa unicolor</i> and <i>Sus scrofa</i> ,
Forest Edge	25 piles	Feces of <i>Paradoxurus hemaphroditus</i> , <i>Arctogalidia trivirgata</i> , <i>Arctictis binturong</i> , <i>Prionailurus bengalensis</i> , and <i>Helarctos malayanus</i>
Riverside	2 piles	Feces of <i>Tapirus indicus</i>

**Table 3.** Mammal class of food found in the conservation forest of PT. TKA and PT. KSI based on the content in the feces.

No.	Types	Class of food	Feces content
1	<i>Paradoxurus hermaphroditus</i>	Omnivore	Fiber (coarse and fine from plants), plant seeds.
2	<i>Arctogalidia trivirgata</i>	Omnivore	Fiber (coarse and fine from plants), plant seeds.
3	<i>Arctictis binturong</i>	Omnivore	Fiber (coarse and fine from plants), plant seeds.
4	<i>Prionailurus bengalensis</i>	Carnivore	Fine fiber, fur, hair, bone.
5	<i>Helarctos malayanus</i>	Omnivore	Fiber (coarse and fine from plants), bones.
6	<i>Rusa unicolor</i>	Herbivore	Fiber (coarse and fine from plants).
7	<i>Sus scrofa</i>	Omnivore	Fiber (coarse and fine from plants).
8	<i>Tapirus indicus</i>	Herbivore	Fiber (coarse and fine from plants).

**Table 4.** The types of mammal feces found in the Conservation Forest area of Prof. Dr. Sumitro Djojohadikusumo PT. Tidar Kerinci Agung (TKA) and Conservation Forest of PT. Kencana Sawit Indonesia (KSI).

No.	Types of seed	Types of mammal	No. of seeds	No. of whole seeds	No. of damaged seeds
1	<i>Maesopsis eminii</i> Engl.	<i>Paradoxurus hermaphroditus</i>	82 seeds	78 seeds	4 seeds
2*	<i>Callicarpa arborea</i> Roxb.	<i>Arctogalidia trivirgata</i>	± 1950 seeds	-	-
3	Sapotaceae Family	<i>Arctictis binturong</i>	28 seeds	28 seeds	-
4	Unidentified	Unidentified	116 seeds	94 seeds	22 seeds

(\*). The seed calculation was performed by estimation.

## Discussion

Feces of *Paradoxurus hemaphroditus* or Asian Palm Civet are the most frequently found. It has high tolerance to changes in natural habitat. In line with the research of Solina (2016), the result of camera trap data showed *Paradoxurus hemaphroditus* photos were the most with a total of

20 photos with percentage of 57.14 of the total photos obtained. Factor that enables the number of mammals found in Viverridae family in the fragmented forest was the narrow forest area and the abundant of food source (Mudappa, 2007). The feces of Asian Palm Civet were mostly found in the forest edge, which is in an open location namely dividing road between oil palm plantations with the

fragmented forest. This is also in line with the research results of Fikri (2016) on inventory of mammals in Conservation Forest of Prof. Dr. Sumitro Djojohadikusumo, South Solok, West Sumatera. From the photograph, video camera trap, and field observation, they show that mammals are predominantly found in forest areas with medium vegetation or logging track. Pardini (2004) stated that fragmented forest areas have increased heterogeneity (variability and composition) of mammals, especially forest edge habitats. Edge habitats at the research site have shelter and relatively closer (5 - 10 meters) with opposite forest side. The presence of shelter area that still supports the daily activity of mammals is the cause why mammal feces are frequently found in the boundary edge area between one fragmented area and the others.

Differences in digestive systems, how to process feed, and types of mammal feed will have an effect on the composition of mammal feces. Deer, boar, and tapir are groups of mammals that the main food is plants. In this research, however, no plant seeds were found in the feces. According to Clauss et al. (2011), the digestive system of deer is Moose-type. Deer is a mammal that cannot distinguish food particles entering the digestion so that the processing is same and the results become more homogeneous. In deer digestive system, the digested food particles will be finer, so that the plant seeds eaten will also become fine. Therefore, deer is called as seed predation since deer destroy the plant seeds they eat (Bodmer, 1991).

In addition, other plant-eating mammals like boar and tapir also do not have any plant seeds in the feces. Referring to Bodmer (1991) on the strategy of seed dispersal and seed predation, it is found that boar has strong teeth structure to masticate the food until the seeds are damaged and destroyed. The seeds are not found in tapir feces because during the mastication of food, the plant seeds eaten usually come out with the saliva, so that the seeds are not digested.

After the seed germination on the planting medium,

both the pretreatment or not, it was obtained that there was no seed that could germinate within 40 days. This failure was probably due to the seed character that had passed the digestive process. The seeds experiencing dormancy are assumed as the cause why they cannot germinate. Therefore, the preliminary treatment was given for the four types of seed by providing hormones GA<sub>3</sub>. The four types of seed were previously soaked with GA<sub>3</sub> solution of and then grown on the planting medium. However, the seeds were unable to germinate. The seeds soaking and hard seed coat thinning were also performed but none of these seeds could germinate. The second possibility is the lack of food reserve contents as the source of energy for the seeds to germinate (Sutopo, 2004). This was observed during the process of seeds soaking where more seeds floated on the water surface.

According to Sutopo (2004), the floating seed indicates the lack of food reserve content in the seeds, while the sinking seeds indicate that the amount of fat, carbohydrate, and protein in the seeds will support the germination process.

## Conclusion

From the research conducted, it can be concluded that 31 feces found are from eight types of mammals classified into three orders. The three types of mammals have potential to carry plant seeds in their feces, namely the types of *Paradoxurus hermaphroditus*, *Arctogalidia trivirgata*, and *Arctictis binturong*. In the feces, it was found four types of plant seeds, which are *Maesopsis eminii*, *Callicarpa arborea*, seeds from Sapotaceae family, and one unidentified type. The research results indicate that mammals from the Viverridae family have the potential to spread the seeds, however the viability test does not support the role of these mammals in plant regeneration.

## Conflict of interest statement

Authors declare that they have no conflict of interest.

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### How to cite this article:

Tillah, M., Novarino, W., Rizaldi, 2018. A study on the potential of mammalian feces as seed dispersal agent in a disturbed forest landscape. *Int. J. Curr. Res. Biosci. Plant Biol.* 5(12), 39-44. doi: <https://doi.org/10.20546/ijcrbp.2018.512.005>