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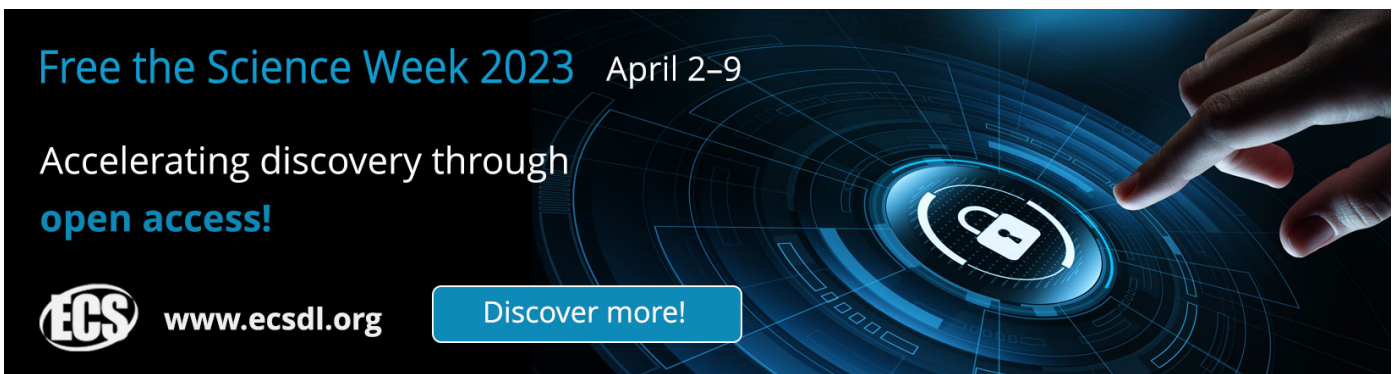
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9 Use of faecal pellet count method in estimating population density of mammals in Gunung Ciremai National Park

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Abstract. Population data is very necessary in the conservation of a species and area management. However, population estimation often faces obstacles, such as difficulty meeting individual animals directly. The purpose of this study were to identify the types of mammals based on the presence of feces and to analyze the types of mammals whose population estimation can use the pellet count method. Research in the form of experiments was carried out in two blocks by clearing the forest floor measuring 9 m² with 35 sample plots and the distance between the plots was 100 meters. Observations have also been made on patrol routes and access roads. Data analysis was carried out descriptively. Research has found feces of *Felis bengalensis* and *Paradoxurus hermaphroditus* species specifically from sample plots. Apart from these two species, research has recorded the excrement of *Sus scrofa*, *Muntiacus muntjac*, and *Panthera pardus* species on the patrol and access roads. This study shows that it is possible to estimate wildcat and civet populations by using the method of counting the feces in the sample unit in the form of plots. Based on this method, the density of the wildcat was around 0.026 ind/ha and the civet were around 2.8 ind/ha. The combination of sample unit forms (sample plots, paths, patrol lines, and access roads) can accommodate other animal species in population estimation using this method

1. Introduction

The existence of herbivorous mammal populations has an important role for the conservation of carnivorous mammal populations which are generally protected species. Carnivorous will use herbivorous that occupy their home ranges as a source of food for their survival. Herbivorous scattered in Java include the banteng *Bos javanicus*, timor deer *Cervus timorensis*, deer *Muntiacus muntjac*, kancil *Tragulus javanicus* [1], and wild boar *Sus scrofa* [2]. Meanwhile, the predatory mammals that are also scattered on the island of Java are leopards and panthers. These two predators have the same scientific name (*Panthera pardus melas*) and are protected by the Government of the Republic of Indonesia through Regulation of the Minister of Environment and Forestry Number P.106/Menlhk/Setjen/Kum.1/12/2018.

The most studied parameter related to the role of herbivores in predators were population size. Information about the population size of herbivorous mammals is very important for the management of predatory animals so that their existence is sustainable. However, some herbivorous mammals are nocturnal, making it difficult to estimate the population at the location of their distribution.



13 Gunung Ciremai National Park (TNGC) is one of the distribution sites for herbivorous mammals. The herbivores that occupy this area are the wild boar *Sus scrofa* and kijang muncak *Muntiacus muntjac* [3]. Gunawan et al. also encountered the civet *Paradoxurus hermaphroditus* in the same area. The distribution of mammals in TNGC ranges from lowland forest ecosystem types to mountainous forests [3]. From the predatory group, the species that occupy TNGC is leopards [3]. This leopard has become part of the TNGC logo which indicates that this species is one of the species prioritized for conservation.

Previous researchers in estimating population in many places generally used the direct encounter method. For example, in TNGC; Gunawan et al. [3] used the strip transect method. Santosa et al. [4] used the strip transect method to estimate the deer population of timor *Cervus timorensis* in Alas Purwo National Park, East Java; where the observer travels at a constant speed on a predetermined path. Meanwhile, Kangiras [5] used the Concentration Count method to estimate the Timor deer population in the Pananjung Nature Reserve and Nature Park, Pangandaran, West Java.

Estimation by direct encounter is sometimes difficult because some species are generally active at night while surveys are generally carried out during the day. However, encounters with feces for certain species are often easier than encounters with direct individuals [6]. The presence of feces can be an indirect alternative in estimating the population. Estimation of absolute population abundance through the presence of feces is still rare in Indonesia, even in TNGC it has never been done. In the tropics, it is difficult to estimate the population by means of faeces [6]. Given this hypothesis, is it possible to estimate the absolute density through the presence of feces for herbivorous mammals that inhabit Mount Ciremai National Park? Therefore, this study has analyzed the effectiveness of using the fecal count method in estimating the population of herbivorous mammals.

The results of this study explain: 1) the types of mammals that have been identified based on the presence of feces; 2) the feasibility of using the dung count method in estimating the population density of mammals; and 3) species of mammals whose population estimation can use the dung count method. Data collection has been carried out by observing the artificial sample plots and patrol routes and access points. The research results are expected to assist in estimating mammals in conservation areas and other areas.

10 2. Methodology

2.1 Location and Time of Research

The research was conducted at Bintangot Research Station, Seda and Pasir Batang Research Station, Karangsari. The research station at Bintangot belongs to the Faculty of Forestry, Bogor Agricultural University; while the research station in Pasir Batang belongs to the Faculty of Forestry, Kuningan University. The land cover types in the two research stations have the same conditions, consisting of pine and shrub stands [7][8]. The existing pine stands are classified as old pine stands and the lower part is planted with coffee by the community. Research has been conducted on both types of cover. 14 Data collection was carried out from August to October 2020.

2.2 Research Variables

The research variables consisted of the type of animal, the amount of droppings, and the length or interval of observation (days). Another variable that is needed is the intensity of defecating animals in one day. However, this latter variable was obtained based on the results of interviews and based on assumptions because research information for these variables was difficult to obtain. Interviews were conducted with researchers who have long concentrated in the field of wildlife.

2.3 Research Design

3 This research design was in the form of sample plots. Sample plots were made by cleaning litter, undergrowth and other species of shrubs with a certain area [9] except for tree saplings. Clearing land cover aims to make it easier for researchers to identify and count the amount of wildlife waste. The size of each sample plot was 3 m x 3 m; following Smith's [10] recommendation. Sample plots were

made on a path or about five meters from the trail depending on the conditions in the field. The number of sample plots were 10 for the Bintangot Research Station and 25 for the Karang Sari Block Research Station. Apart from creating sample plots, the research also utilized the Bintangot - Karangdinding patrol route, the Karang Sari - Palutungan patrol route, and the access road that connects the Bintangot research station - the JICA Restoration Area.

2.4 Data Collection

Data collection was carried out several days after plotting the samples and was repeated. The observation time interval after plotting varies for each sample plot. Observations were made during the day. The data recorded includes animal species based on identified feces and the number of piles of manure for each species. The feces contained in the sample plots was not collected or disposed of when calculating, but was not recorded or recalculated when doing the repetition if it was still there or not yet rotten. The understory growing covering the sample plots was not cleaned. This is because the main objective was to identify the effectiveness of the methods used in estimating the density of mammals.

2.5 Data Analysis

The data analysis included qualitative descriptive and quantitative descriptive. Qualitative descriptive analysis was used for the diversity of mammals and the feasibility of using the dung count method. The analysis for the mammalian diversity data only describes the species of mammals that occupy the study site and those whose traces can be found in the sample plots. Analysis for the feasibility of using method data only describes whether the method can be used or not. This method can be used if wildlife feces can be found in the sample plots and can be analyzed according to the formula that has been made. On the other hand, the method cannot be used if the data obtained from the sample plots is insufficient for analysis. Analysis of the types of mammals whose population estimation can use this method will also be carried out descriptively by only mentioning the types.

Quantitative descriptive was used to estimate the population density of each type of mammal when the data obtained meets the requirements for further processing. The formula used to estimate population density is (modified from Plhal et al. [11]):

$$\delta = \frac{(\mu)(10.000)}{(\rho)(T)(A)}$$

Information:

δ	=	Density of animals (ind/ha)
μ	=	The amount of dirt in the second survey (dung/ plot)
ρ	=	Intensity of defecation (defecation rate) in a day (feces / individual / day)
T	=	Time between the first and second survey (days)
A	=	Area of each sample plot (m ²)

3. Result and Discussion

3.1 Identified Footprints and Species

The observation time for the sample plots has been carried out for 72 days for Line 1, for 53 days for Line 2, and for 28 days for Line 3. Observations have recorded signs of the presence of wildlife species in the sample plots. The marks are in the form of footprints, ramming marks, and feces. Wildlife species identified based on these signs are wild boar, deer, wildcat, civet and tiger (Table 1; Table 2; Table 3). Of the 5 types of animals, the types identified based on their feces were wildcats and civets.

Table 1. Signs of Attendance, Animal Types, and Number of Wildlife Observations on Line 1 (Karang Sari) During the 72 Days Observation Period

No	Presence Signs (Species)	Plots										Total
		1	2	3	4	5	6	7	8	9	10	
1	Footprints (wild boar)						2	1		2		5
2	Footprints (deer)				1		1		2			4
3	Footprints (wildcat)					1						1
4	Footprints (civet)						1					1
6	Feces (wildcat)	1										1
7	Feces (civet)				1			1				2
	Total	1	0	0	2	2	1	3	3	0	2	14

Table 2. Signs of Attendance, Animal Types, and Number of Wildlife Observations on Line 2 (Karang Sari) for 53 Days of Observation Period

No	Presence Signs (Species)	Plots														Total	
		11	12	13	14	15	16	17	18	19	20	21	22	23	24		25
1	Footprints (wild boar)	2	1		1	2					1					1	8
2	Footprints (deer)		1	1			1										3
3	Footprints (wildcat)			1													1
4	Footprints (tiger)		1														1
6	Feces (civet)				1												1
	Total	2	3	2	2	2	1	0	0	0	1	0	0	0	0	1	14

Research has also recorded wild boar and deer dung, but it was outside the predetermined observation plots that cannot be used as a basis for population calculations. Wild boar manure was identified between plots 3 and 4 as many as three piles when observed on Line 3. Deer manure was identified on the road connecting Bintangot research station and JICA's planting work station. The presence of deer can also be identified from the bite marks on the white calliandra stems when the observation is made in line 1 and line 2. White calliandra bark is one type of feed for deer.

Table 3. Signs of Attendance, Animal Types, and Number of Wildlife Observations on Track 3 (Seda) During the 28 Day Observation Period

No	Presence Signs (Species)	Plot										Total		
		1	2	3	4	5	6	7	8	9	10			
1	Footprints (wild boar)		1	1	3				1				1	7
2	Footprints (deer)						1	2	1	1				5
3	Footprints (civet)			1										1
4	Feces (civet)											1		1
	Total		1	1	1	3	1	2	2	1	1	1	1	14

Observations have also been made on the patrol route, both in the Karang Sari block and the Bintangot block. The length of the observation path in the Karang Sari block was 2000 meters towards Palutungan, while in the Bintangot block, it was 3,200 meters long to Karangdinding and about 1500 km to the JICA restoration area. The feces found on the patrol paths in the Karang Sari block were wild cat and civet; while in the Seda block are civets, wild cat, deer and tiger (Table 4). The population estimation on the Karang Sari patrol route could not be carried out because of the high intensity of the

motorbikes passing through the route and the presence of a large enough groundwater flow when it rains which allows the presence of dirt to be washed away by the water.

Table 4. Observation Results of Types of Dirt on the Seda-Karangdinding Patrol Path of Mount Ciremai National Park

No	Type of Feces	Observation	Observation Time (days)	Line Length (m)
Karangsari - Palutungan				
1	Unidentified	1	-	2000
2	Wildcat	1	-	2000
Bintangot - Karangdinding				
1	Civet	5	28	3.200
2	Wildcat	2	28	3.200
3	Tiger	1	28	3.200
Bintangot - JICA area				
1	Deer	1	-	1.500
2	Wild cat	2	-	1.500
3	Civet	1	-	1.500

3.2 Amount of Animal Dung

The main hope of this experiment was that it will collect a large amount of feces from various species of wildlife in the sample plots. Data collection has recorded feces from two types of wildlife, namely feces from civets and wild cats. Wild cat feces can only be found on line 1, which is 1 pile. Civet feces were found in all lanes, totaling 4 piles (Table 1; Table 2; Table 3). The number of feces on the Karangsari - Palutungan patrol path were two, consisting of 1 forest cat and 1 more unidentified. The number of animal droppings on the Bintangot - Karangdinding patrol route during the observation period were 8 piles of three species of animals and most of them were civet dung, while on the Bintangot access road - JICA restoration area were 4 piles (Table 4).

3.3 Animal Population Densities

Considering that the feces found in the observation plot are only wild cats and civet from the five identified animal species, then the density estimation can only be done for these two species. Information on the intensity of excreting each individual in one day for both types was needed in estimating population density using the dung count method. Given the difficulty of obtaining information on the intensity of defecating, this estimation used the assumption that the intensity for the bobcat were 2 times / day / individual and the ferret was 1 time / day / individual (Sopyan pers.comm).

Based on the results of calculations and assumptions used, the civet density was 3.09 ind / ha for lane 1, 1.4 ind / ha for lane 2, and 3.9 ind / ha for lane 3, so that the average the average was 2.8 ind / ha. The density of forest cats was around 0.08 ind / ha for lane 1, while for lane 2 and lane 3 is 0; so that the average is around 0.026 ind / ha. Population density estimation through data from patrol lines and access roads was not carried out because some feces was thought to have washed away before being counted when it rained, so the recorded data might not be accurate.

3.4 Discussion

Estimation of wildlife populations was generally carried out through the direct encounter method through field surveys: tracing paths that have been provided or determined by researchers. However, population estimation using this method was often constrained by the difficulty of finding individual wildlife for certain species. On the other hand, the presence of feces for several types of animals is often easy to find, including for species whose individuals are difficult to find directly. Therefore, population estimation by counting the pile of manure can be an alternative. In connection with the foregoing, research has been carried out by making a number of sample plots on several paths with the

distance between sample plots being uniform. The research expects the results that the droppings of several species of animals can be found in the sample plots, especially those that are difficult to find directly. Therefore, animal species whose feces are found in the sample plots are considered as species whose population estimation can use the calculation of the presence of feces using the plot method.

The discovery of wildcat and civet feces in the sample plots shown that these two species are wildlife species whose population can be estimated using the fecal count method. Estimation of civet and cat populations using the fecal count method is still rarely carried out (for civets only found in the research of Parikesit et al. [12]); this is different from the estimated population of elephants [13] [14][15][16][17] and kangaroos that occupy rainforests [18]. Based on the literature review, several studies that have been carried out on the civet population include research related to the role of civets as seed dispersers [19] [20] and stress index [21]. Wildcat feces was identified by the presence of fine hairs on the feces which are thought to be its own fur which was eaten when cleaning its body by licking. In this study, civet feces are easily recognized and distinguished from other types of dirt: civet feces were mixed with seeds such as *Ficus* sp. Seeds, coffee, and papaya (according to the results of Subrata and Syahbudin [22] research). In a study in Kerala India, researchers found that papaya is a type commonly found in civet droppings and along [20].

The amount of feces of civet and wild cats recorded in the sample plots were quite low (Table 1; Table 2; Table 3). This is predicted by several possibilities such as the small number of sample plots and observation techniques. As already mentioned in the research method section, the total sample plots made in this study were 35 plots which were placed in two blocks, namely Karangasari block with 15 sample plots and Bintangot block with 10 sample plots. One of the considerations in determining the number of sample plots in this study was the presence of invasive species. Sample plots were made by clearing the forest floor. The presence of animal feces, on the one hand, was difficult to see without clearing the forest floor because the soil surface was covered by thickets. However, land clearing, on the other hand, will lead to the growth of invasive species such as calliandra [7]. Therefore, the small number of sample plots created in this study in order to avoid the growth of invasive species. In theory, the more sample plots that are created the greater the chance of dirt in the plot, and vice versa. Another form of sample unit observation should also be considered.

The observation time interval from plotting the sample to the first observation was quite long in this study. This is done because the research was conducted in the dry season, so it was assumed that time does not have much effect on the level of sewage decomposition. According to Krebs [6], the counting interval must adjust to the level of decomposition of the waste. Still according to Krebs, in tropical regions with the presence of dung-eating insects, feces can last for several hours so this method was difficult to use. Therefore, this research needs to be refined by paying attention to the observation time interval.

As a comparison, research has also been carried out by tracing the patrol paths and access roads connecting the Bintangot research station and the JICA work station to record the presence of wildlife droppings along the route / access. Research that has found the presence of deer dung on access roads and tigers on patrol routes shown that access roads and patrol routes also have the opportunity to serve as model units in estimating wildlife population density through dung counts. Deer (*kijang*) are mammals that are closely related to deer (*rusa*). Based on previous studies, deer are a type of mammal whose population estimation can use the dung count method [23]. Of the two patrol routes, the path that is more likely to use this method is the Bintangot - Karangdinding patrol route because the presence of vehicles or humans on this route is quite rare. On the other hand, the Karangasari - Palutungan patrol route is not suitable for use because of the high intensity of human presence and trail motorbikes.

This condition also indicates that the patrol route can be used as an observation unit if the route is quiet enough from human presence; although some previous researchers have used sample plots of certain sizes, such as 3 x 20 meters [24], line transects [25], and circles [9]. The importance of using pathways that are quiet enough for human presence is supported by the study of Barnes et al. [26]: the

density of dirt adjacent to roads is relatively lower than the density of dirt located further from the road. This is presumably because it relates to the level of human presence.

The finding of wild boar dung on line 3 but outside the sample plots shown that the estimation of wild boar population by counting manure can actually be done by making a path as a unit of observation, as research by Plhal et al [11]. The observation path can be made with a width of 2 meters to make it easier to identify the presence of dirt with a path length of 100 m [11] or adjust to conditions in the field. Other researchers in population estimation by counting manure used circular sample units: a radius of 1 m and a distance between sample units of 5 meters [9]. The presence of wild boars was also identified in the Karangsari block through footprints supported by the research of Andriansyah et al. [27].

Based on the results of recording in the field, the types of animals whose density can be predicted through the presence of feces are civets and wild cats. The civet population in the study location has a higher density compared to the civet population in Sukaresmi Landscape, West Bandung which is 0.144 ind / ha [12]. These results indicate that Gunung Ciremai National Park is still suitable for civet populations compared to other places outside the conservation area. The density of wild cats in the study location was higher than the density of wild cats as a result of Mohamed et al. [28] in a protected area in Sabah.

3.5 Implications of Research Results

In the results of the study, the presence of animal waste was not entirely covered by the sample plot method. There are feces for other types only found in patrol lines. The sample plot method only records civet and wildcat feces. Wild boar manure was identified in the path that connects between the plots. Other types, tiger and deer droppings were recorded on patrol routes and access roads; besides civet and wildcat feces too. This shown that the estimation of wild animal populations, especially terrestrial animals, should combine various forms of sample units. The form of a sample unit that allows the use of sample plots, patrol routes, access roads, artificial paths, and paths. This is in accordance with what Krebs [29] suggests: population estimation using the fecal count method requires a different sample size and shape in order to obtain optimal results. The line transect method is one of the possible methods of estimating the deer population by counting manure [23].

In the bush area, the use of access roads, paths and patrol paths is more feasible in calculating the use of this method because dirt is easier to detect. Vegetation and grass height affect the detection rate of manure [24]. Research that has recorded several feces from various types of animals shown that the method of counting feces can also be used to estimate the diversity of mammals, especially large mammals. This study is in accordance with the results of research by Cromsigt et al. [30] who stated that counting the amount of manure resulted in a higher estimate of the richness and diversity of herbivore species compared to direct observations.

3.6 Research Limitations

Although this research was repeated, the interval count did not consider the rate of decomposition of the feces of wildlife species. In fact, the decomposition of manure must be a consideration in determining the counting interval must adjust to this level [6]. The factors that influence the accuracy of using this method are knowledge of the rate of defecation, time of decomposition and the ability to detect feces [24]. The time it takes for manure to decompose is influenced by several factors, including varying species of wildlife. In tropical regions with the presence of dung-eating insects, manure can last for several hours, making this method difficult or even unusable. Meanwhile, in arctic regions, manure will last up to 10 years [6]. Therefore, this research needs to be refined by considering the rate of decomposition of manure. In other words, studies with shorter repetition intervals need to be conducted.

Although the focus of this study was the effectiveness of using the waste count method in population estimation, this study has also tried to analyze data for population estimation based on recorded feces data. As is well known, one of the information needed in estimating the population by

this method is the number of poop. However, this information is difficult to obtain for wildcat and civet cat species, even though various research results have been carried out. The number of poop in a day of both types is based on personal communication and assumptions. This also indicates that there is a need for research on the intensity of defecating in nature for several types of wildlife that have never been studied.

4. Conclusion

The species of mammals that can be identified by the presence of their feces are wild cats, civets, deer, wild boar and tigers. The dung count method can be used to estimate the population of wildlife both inside the Gunung Ciremai National Park and it is possible outside the conservation area. By combining various forms of sample units (plots, artificial paths, trails, patrol routes, and access roads), other species of terrestrial animals can estimate their population density using the litter counting method, not just wild cats and civets.

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