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RESEARCH ARTICLE

Camera Trap-Based Assessment of Wild Boar (*Sus scrofa*) Abundance in a Tropical Protected Forest Landscape of Sumatra

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ABSTRACT

Wild boar (*Sus scrofa*) plays a crucial role in tropical forest ecosystems but also poses ecological and socio-economic challenges, including crop damage and susceptibility to African swine fever (ASF). This study assessed temporal changes in the relative abundance of wild boars in the core block of the Batutegi Protected Forest Management Unit (KPHL Batutegi), Lampung Province, Indonesia, using camera trap data collected in 2018, 2022, and 2024. A total of 18 camera traps were installed at fixed monitoring points, and all photographs of wild boars were processed to determine independent events (IE) following a ≥ 30-minute interval rule; these IE data were then used to calculate the Relative Abundance Index (RAI). The results revealed substantial temporal fluctuations: RAI was 3.18 in 2018, declined drastically to 0.55 in 2022, likely due to ASF outbreaks, and increased significantly to 7.29 in 2024, indicating potential recovery or adaptation to post-outbreak conditions. Seasonal patterns showed higher activity during drier months, suggesting that rainfall influences foraging behavior and the detectability of animals. Beyond wild boars, camera traps also recorded diverse non-target wildlife, including several threatened species listed in the International Union for Conservation of Nature (IUCN) Red List, emphasizing the ecological significance of the Batutegi Protected Forest. These findings highlight the importance of long-term wildlife monitoring using camera traps to detect population fluctuations, evaluate disease impacts, and inform adaptive management strategies. Continuous observation is essential for balancing wildlife conservation and mitigating human–wildlife conflict in tropical protected forests.

1. Introduction

The wild boar (*Sus scrofa*) is one of the mammal species with a wide geographical distribution, including in Indonesia (Linnell et al., 2020; Massei et al., 2015). Wild boars are also one of the land mammals with the widest geographical range (Apollonio et al., 2010; Keuling et al., 2018). According to Bosch et al. (2012), this species has an important ecological role in ecosystems, including helping seed dispersal, decomposing organic matter, influencing vegetation structure through foraging activities, and becoming potential prey for large predators such as the Sumatran tiger (*Panthera tigris sumatrae*) (Khalil et al., 2019; Pubianty et al., 2023). Additionally, wild boars are known to have high reproductive rates and adaptability (Rahmawati et al., 2024; Zulkarnain et al., 2018). This characteristic can lead these species to dominate a habitat, disrupt the balance of ecosystems, and alter interactions among species. Socially, uncontrolled wild boar populations often cause conflicts with the community, particularly through damage to crops and agricultural land, which affects both economic aspects and the welfare of the population surrounding the forest area (Bulu, 2022).

In addition to these ecological and social challenges, wild boars also face threats from infectious diseases, including African swine fever (ASF). The ASF is a highly contagious and deadly virus that affects both domestic and wild pigs. The ASF virus can cause high fever, internal bleeding, and death in a short period of time (Suartana and Arzam, 2024). This virus was first reported in Indonesia in 2019 and caused an outbreak in the domestic pig population in North Sumatra (Primatika et al., 2021). This disease is not transmitted directly to other mammals and is not harmful to humans or other animals except pigs. According to Sukoco et al. (2024), ASF disease has a limited host range and is not zoonotic. The ASF virus specifically affects domestic pigs and wild boars; therefore, from a virological perspective, it is not zoonotic and does not infect predators, such as tigers (*Panthera tigris sumatrae*). The potential transmission of ASF to wild boar populations is a significant concern, particularly in conservation areas that impact population survival and overall ecosystem balance (Bulu, 2022), including protected areas such as Batutegi FMUs, which serve as natural habitats for wildlife, including wild boars.

The Batutegi Protected Forest Management Unit (KPHL Batutegi) is one of the strategic protected forest areas in Lampung Province, Indonesia. This area has core blocks that serve as natural habitats for various wildlife species, including wild boars (Saputri, 2021). However, scientific data on the status of wild boar populations in the region are still very limited. Previous studies have focused more on the Artiodactyla group as a whole, without paying particular attention to wild boar abundance (Khalil et al., 2019; Pubianty et al., 2023).

Information about the relative abundance of wildlife in nature can be obtained from camera traps, with estimates calculated from recorded data. The use of camera traps has become an effective and widely used method. Camera trap is an automatic recording device that can detect wildlife based on movement or body temperature (Mitterwallner et al., 2023). This tool is very useful for monitoring elusive, nocturnal, and human-avoiding mammal species (Mason et al., 2022; Suárez-Tangil and Rodríguez, 2021). To overcome these challenges, camera trap data processing uses the relative abundance index (RAI) (Ariyanto et al., 2024).

Based on this, research on the relative abundance of wild boars in the core block of the Batutegi Protected Forest is highly relevant for determining the population dynamics of this species and the potential impact of ASF on its survival. Therefore, this study aims to analyze the relative abundance of wild boar (*Sus scrofa*) using camera trap data from the core blocks of the Batutegi Protected Forest in 2018, 2022, and 2024. The results of this study are expected to enrich the scientific literature on mammal conservation in Indonesia, especially for species that receive less attention, such as wild boar (*Sus scrofa*).

2. Materials and Methods

2.1. Time and Place

This research was conducted from March to May 2025 in the Batutegi Protected Forest Management Unit (KPHL Batutegi) area, Tanggamus Regency, Lampung Province, Indonesia (**Fig. 1**). The research location is a protected forest area with core blocks that function as natural habitats for various types of wildlife, including wild boar (*Sus scrofa*). The data used in the study were obtained from recordings of camera traps installed in the core block area in 2018, 2022, and 2024.

2.2. Tools and Materials

This study utilized 18 units of Browning and Bushnell type camera traps, installed at 18 monitoring points in 2018, 2022, and 2024. The differences in data collection duration in 2018, 2022, and 2024 were due to technical factors and field conditions. In 2018, camera traps installations were not carried out simultaneously due to the limited number of field teams, which numbered only 2 per month. Consequently, installation and checking were carried out in stages, resulting in shorter effective observation periods. In 2022, data collection lasted 10 months because some cameras experienced errors, were lost, or were only activated sometime after installation, resulting in not all locations recording data from the start.

Meanwhile, in 2024, data collection activities could be carried out for a full 12 months because the team size was adequate, the equipment was functioning correctly, and all cameras were active from the start. The camera is mounted on a tree trunk at a height of 40–60 cm above ground level, using a 2 × 2 km² grid system. In addition, the camera is automatically set to record for a full 24 hours, capturing every movement of animals that pass in front of it. The results of the recording will be in the form of photos, which will be analyzed and identified by species. After that, the number of individuals recorded for each species will be calculated. In addition, this study uses secondary data in the form of rainfall data for 2018, 2022, from the Lampung Province Central Statistics Agency, and 2024 from YIARI. Furthermore, the data were processed using Microsoft Excel software and Karen's Directory Printer.

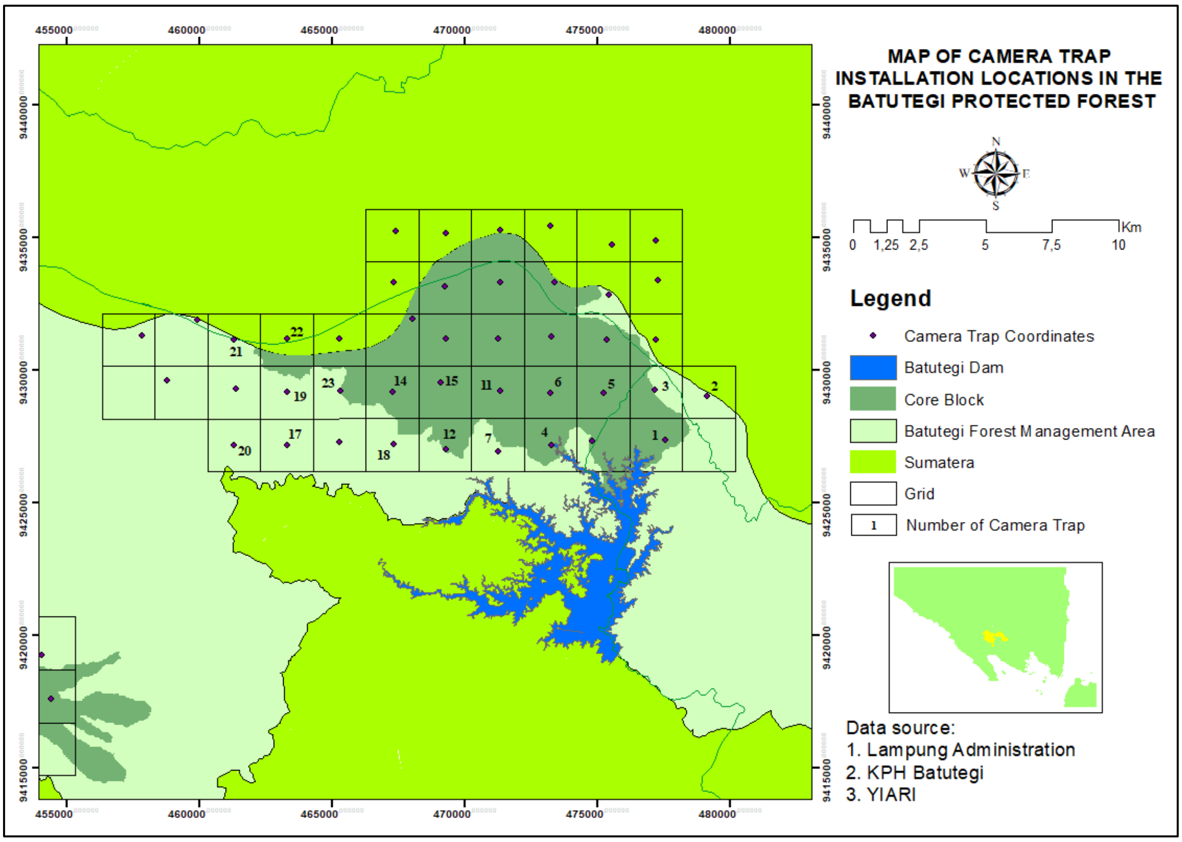

Fig 1. Map of the research location.

2.3. Data Analysis

According to O'Brien et al. (2003), photos or videos categorized as independent are documentation of wildlife presence, including individuals and species, with a time gap of at least 30 minutes between shots. A photograph is considered independent (value 1) if it meets the following criteria: (1) depicts different individuals of the same species or different species in order; (2) show the same individual with a time lag of more than 30 minutes; or (3) originated from the same individual but not recorded sequentially (O'Brien et al., 2003). The formula for determining independent photos is as follows (Haidir et al., 2017).

$$IE = IF(D2 <> D1; "1"; IF(E2 <> E1; "1"; IF(SQRT((C2 - C1)^2) > 0.0208; "1"; "0"))) \quad (1)$$

The formula description is presented in **Table 1**.

Table 1. Description of the independent event (IE) formula

Formula	Information
D_2<>D_1;"1"	If the location ("stat code" column) of the animals' photos 1 and 2 is different, then each photo is independent ("1").
E_2<>E_1;"1"	If the location is the same but the types ("object" columns) of the photo animals 1 and 2 differ, then they are independent.
SQRT((C_2-C_1)^2)>0.0208	If the location and type of animal are the same, but the time lag (the "date-hour" column between the photos is more than 30 minutes, then the two are independent.

The trap night concept is used to measure the level of camera monitoring efforts. Trap night refers to the number of days a camera is in operation; one camera active for one night counts as one trap night. This value is important for calculating the relative abundance index (RAI), which estimates the relative number of wild boar individuals in the study area. The calculation of RAI follows the formula from O'Brien *et al*. (2003).

$$RAI = \frac{Independent\ Event}{Trap\ night} \times 100 \quad (2)$$

Although the RAI does not reflect absolute population density, it does indicate a species' relative abundance in nature. The higher the RAI value, the more frequently the species occurs at the monitoring site. This analysis is used to evaluate the dynamics of wild boar populations in conservation areas and to examine possible changes over time.

3. Results and Discussion

3.1. Relative Abundance of Wild Boars

The data represent variations in the number of trap nights, total photographs, independent events (IE), and relative abundance index (RAI) recorded in 2018, 2022, and 2024. These values reflect changes in wild boar activity and population dynamics across different observation periods (**Table 2**). Independent photos or IE are photos of individual or group animals recorded in one photo frame, captured by camera traps. The number of active camera days minus the number of days the camera is down or out of battery is referred to as trap night. The observations showed significant changes in the number of camera captures, independent photos, and the relative abundance index (RAI). In 2018, the number of trap nights reached 2,611, resulting in 254 photos of wild boars, with 83 IEs identified. Based on this data, the RAI value was 3.179 with a standard deviation of 5.463, indicating that although wild boar activity is recorded quite frequently, there is substantial variation between locations or camera points.

Table 2. Camera traps installation results in 2018, 2022, and 2024

Year	Total trap night	Total wild boar photos	IE	RAI	Standard deviation (RAI)
2018	2611	254	83	3,179	5,463
2022	4150	96	23	0,554	0,657
2024	4623	5078	337	7,290	7,109

Notes: IE = independent event, RAI = relative abundance index.

In 2022, there was a very significant decrease in the number of photos and incidents of wild boars. Although the number of trap nights increased to 4,150, only 96 photos yielded 23 IEs. This had a direct impact on the decrease in the RAI value to 0.554, with a standard deviation of 0.657. A small standard deviation value indicates that the presence of wild boars is recorded at an equally low level at all observation points. The small number of catches suggests that wild boars are rarely detected, likely due to their low population and altered behavior. This condition coincides with the outbreak of African Swine Fever (ASF) that occurred in several regions of Indonesia. ASF is a highly lethal infectious disease for pigs, including wild boars, and can spread rapidly through direct or indirect contact (Kipanyula and Nong'ona, 2017; Sendow et al., 2020). ASF disease causes high fever, loss of appetite, ataxia and depression, and results in high mortality (Yao et al., 2023; Ma et al., 2020). This outbreak has led to a drastic decline in wild boar populations in various places. Based on research by Primatika et al. (2021), in North Sumatra, the mortality rate due to ASF reached 100% in both domestic and wild boars. Therefore, the small IE value in 2022 is very likely related to the decline in wild boar populations caused by ASF.

The situation changed drastically in 2024, with the number of trap nights continuing to increase to 4,623. The number of wild boar photos jumped sharply to reach 5,078 photos, with a total of 337 IEs identified. As a result, the RAI value increased to 7,290, with a standard deviation of 7,109. This illustrates the increase in wild boar activity in the area. The number of wild boar IEs this year increased quite significantly when compared to previous years. Wild boars themselves are omnivorous animals that can adapt well and occupy a variety of habitats, ranging from boreal forests and shrublands to temperate forests, tropical rainforests, and semi-desert areas (Keuling et al., 2018), and often use farmland for foraging and as shelter (Ferens et al., 2025). This could be a sign that wild boar populations are recovering after an ASF outbreak in 2022. Recorded wild boar as shown in **Fig. 2**.

Fig. 2. Wild boar (*Sus scrofa*) on camera traps: 2018 (a), 2022 (b), and 2024 (c).

3.2. Wild Boar Encounter on Camera Trap

The results of camera trap and rainfall measurements in 2018, 2022, and 2024 show differences (**Fig. 3**). Camera traps monitoring in 2018 was conducted from January to July, totaling 2,611 active days and 254 images of wild boars. The number of wild boars in 2018 recorded amounted to 83 IE. In January, 6 wild boar IEs were identified; this number increased to 14 in February, then decreased slightly in March and April, to 11 and 12, respectively. The highest IE score was recorded in May at 22 IE, followed by June at 16 IE. Meanwhile, rainfall decreased from March (399.5 mm) to July (9.3 mm). This pattern suggests that wild boar activity tends to increase as rainfall declines, likely because a drier environment facilitates their movement and foraging. However, in July, when rainfall is very low, the IE value drops sharply to 2, suggesting that overly dry conditions can also limit the animal's activity.

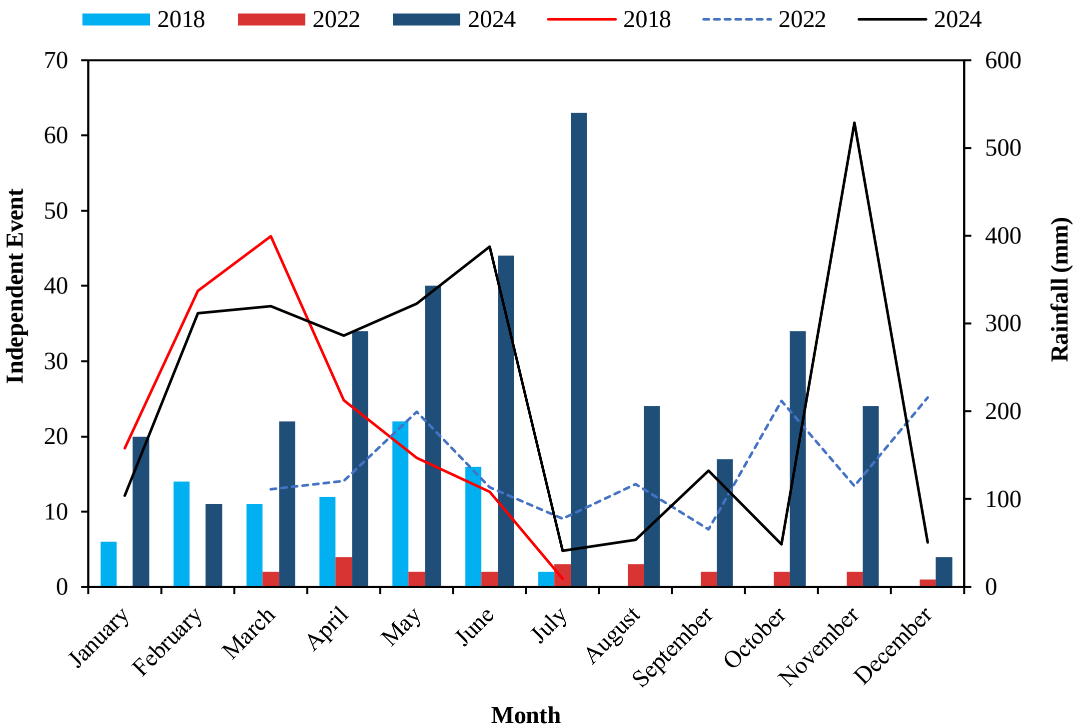

Fig. 3. Number of independent events (IE) of wild boars in 2018, 2022 and 2024 (The bar chart represents the independent events (IE) of wild boars, while the line graph indicates the corresponding rainfall data.).

In 2022, camera traps were installed between March and December, with a total of 4150 active days, and 96 images of wild boars were obtained (**Fig. 3**). The results show that the total number of wild boar IEs recorded in 2022 was 23. The IE of wild boar is very low and relatively stable throughout the year. The highest value was only recorded at 4 in April, while the other months ranged from 1 to 3. This IE value is derived from the number of independent photos captured by the camera traps, which depicts the activity or presence of wild boars in the monitoring area. This condition coincides with the outbreak of ASF in several regions of Indonesia (Primatika et al., 2021). In addition to disease factors, rainfall data also shows considerable variation throughout the year. The highest rainfall was recorded in October (211.9 mm) and in December (215.8 mm). Meanwhile, the other months showed lower but not extreme values. Despite fluctuations in rainfall, there is no discernible pattern of increasing IE values that correlates with rainfall. This indicates that rainfall is not the primary factor influencing wild boar activity this year. Given the overall low IE value, the limited number of independent photos, and the ASF pandemic, 2022 was a period of very low wild boar activity.

The number of wild boars recorded in 2024 is 337 IE. This shows a significant increase in wild boar activity, as indicated by high and varied IE values. The highest value was recorded in July at 63 IE, followed by June at 44 IE and October at 34 IE. These values are based on a significantly larger number of independent photographs than in previous years, suggesting that wild boars are detected by camera traps more frequently. Meanwhile, the highest rainfall occurred in November (528.8 mm), and it was also quite high in June (387.9 mm). Compared to rainfall, wild boar tend to increase when rainfall decreases. As shown in July, which had the lowest rainfall (41.2 mm), the highest IE value occurred. Similarly, in October, when rainfall was low (48.7 mm), the IE value was still quite high (34). On the other hand, when rainfall is very high, such as in November (528.8 mm), the IE decreases to 24. This pattern suggests that wild boars are more often seen during the dry season, likely because they move more frequently in search of food or to seek shelter.

A sharp decline in 2022 indicates the possibility of strong, sudden ecological stressors, such as disease outbreaks, while a significant increase in 2024 could indicate a population recovery process due to suspected reduced ASF contamination or adaptation to changing environmental conditions. Although the value of RAI has increased sharply, the high standard deviation in 2024 indicates that the increase has not occurred evenly across all observation points. Rainfall plays a crucial role in determining ecosystem productivity, as it stimulates vegetation growth, seed production, and the emergence of insects that serve as a source of food (Dueñas et al., 2021). This increase in food availability directly supports the foraging activity and reproductive success of omnivorous species such as wild boars. Higher rainfall leads to more abundant and diverse food resources, which can improve body condition, increase survival rates, and encourage population growth. Consequently, periods of high rainfall may coincide with increased detections of wild boar, as the species becomes more active and widely distributed while utilizing available food sources.

3.3. Wildlife Captured by Camera Traps

Camera traps installed during 2018, 2022, and 2024 not only recorded wild boar activity but also captured numerous other wildlife species living in the Batutegi core block (**Table 3**). According to the IUCN Red List, these species are listed as Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), and Critically Endangered (CR). Indicates that the Batutegi core block has a vital ecosystem supporting a variety of wildlife. These findings highlight the ecological significance of the area and underscore the need for continuous monitoring to conserve species diversity within the Batutegi ecosystem.

Based on camera trap capture data, one species was found to be in CR status, namely *Manis javanica*, which requires conservation efforts to reduce hunting and trade, because every year its population continues to decline (Rianti et al., 2024), which is indicated by an increase in the IUCN RedList threat status. Batutegi protected forest has animals that are very important in maintaining the ecosystem by preying on other animals or what are commonly called predators such as *Panthera tigris sumatrae*, and *Neofelis diardii* which are included in the EN status, *Catopuma temminckii* which is included in VU, *Pardofelis marmorata* which is included in LC, and *Neofelis diardii* which is included in NT, with this bringing a good message with controlled populations of prey animals such as babirusa, napu, and so on, so that concerns about damage to ecological functions due to deforestation and overpopulation have been refuted by the presence of interior species that need dense forest conditions as their habitat area (Malik and Hernowo, 2023), so that animals tend not to leave settlements which cause conflict in the community.

Table 3. Other wildlife caught by camera traps in 2018, 2022, and 2024

No	Common name	Scientific name	Famili	IUCN	2018	2022	2024
1	Moonrat	*Echinosorex gymnurus*	Erinaceidae	LC	-	✓	✓
2	Sunda Stink-badger	*Mydaus javanensis*	Mephitidae	LC	✓	✓	✓
3	Yellow-throated Marten	*Martes flavigula*	Mustelidae	LC	✓	✓	✓
4	Asian Golden Cat	*Catopuma temminckii*	Felidae	VU	✓	✓	✓
5	Mainland Leopard Cat	*Prionailurus bengalensis*	Felidae	LC	-	✓	✓
6	Marbled Cat	*Pardofelis marmorata*	Felidae	NT	✓	✓	✓
7	Sumatran Clouded Leopard	*Neofelis diardii*	Felidae	EN	-	✓	✓
8	Sumatran Tiger	*Panthera tigris sumatrae*	Felidae	EN	✓	✓	✓
9	Banded Civet	*Hemigalus derbyanus*	Viverridae	NT	-	✓	✓
10	Common Palm Civet	*Paradoxurus hermaphorditus*	Viverridae	LC	-	-	✓
11	Binturong	*Arctictis binturong*	Viverridae	VU	✓	✓	✓
12	Banded Linsang	*Prionodon linsang*	Prionodontidae	LC	✓	✓	✓
13	Sunda Pangolin	*Manis javanica*	Manidae	CR	✓	✓	✓
14	Southern Pig-tailed Macaque	*Macaca nemestrina*	Cercopithecidae	EN	✓	✓	✓
15	Long-tailed Macaque	*Macaca fascicularis*	Cercopithecidae	EN	✓	✓	✓
16	Southern Mitered Langur	*Presbytis mitrata*	Cercopithecidae	VU	✓	✓	✓
17	Silvery Lutung	*Trachypithecus cristatus*	Cercopithecidae	VU	-	-	✓
18	Siamang	*Symphalangus syndactylus*	Hylobatidae	EN	✓	✓	✓
19	Sambar	*Rusa unicolor*	Cervidae	VU	✓	✓	✓
20	Southern Red Muntjac	*Muntiacus muntjak*	Cervidae	LC	✓	✓	✓
21	Lesser Oriental Chevrotain	*Tragulus kanchil*	Tragulidae	LC	-	✓	✓
22	Greater Oriental Chevrotain	*Tragulus napu*	Tragulidae	LC	✓	-	✓
23	Great Argus	*Argusianus argus*	Phasianidae	VU	✓	✓	✓
24	Crested Partridge	*Rollulus rouloul*	Phasianidae	VU	-	✓	-
25	Red Junglefowl	*Gallus gallus*	Phasianidae	LC	-	✓	-
26	Ferruginous Partridge	*Calopedrix oculeus*	Phasianidae	NT	-	✓	✓
27	Sun Bear	*Helarctos malayanus*	Ursidae	VU	✓	✓	✓
28	Sumatran Porcupine	*Hystrix sumatrae*	Hystricidae	LC	✓	✓	✓
29	Common Water Monitor	*Varanus salvator*	Varanidae	LC	✓	-	✓
30	Roughneck Monitor	*Varanus rudicollis*	Varanidae	DD	-	✓	-

Note: IUCN accessed on 25 August 2025.

Eighteen species were recorded in 2018, 2022, and 2024, including *Catopuma temmincki*, *Panthera tigris sumatrae*, *Argusianus argus*, and *Macaca fascicularis*. These species were likely not exposed to ASF or were able to survive it. *Tragulus napu* and *Varanus salvator* were not recorded in 2022 but were recorded in 2018 and 2024, suggesting exposure to the ASF. The animals recorded only in 2024 were *Paradoxurus hermaphroditus* and *Trachypithecus cristatus*, which were also implicated in experiencing an ASF attack, resulting in data gaps in 2018 and 2022. Over the last 6 years, animals that survived the exposure to the ASF and deforestation were more numerous than those that did not; animals that were unable to survive were recorded only in 2018. However, these animals did not exist, so it can be inferred that the animals recorded by camera traps were able to survive the problems in the Batutegi Protected Forest.

4. Conclusion

The study revealed significant temporary variations in the Relative Abundance Index (RAI) of wild boars in the Core Block of the Batutegi Protected Forest Management Unit. In 2018, wild boar activity was relatively high (RAI = 3.179; IE = 83), but it declined in 2022 (RAI = 0.554; IE = 23), likely due to the African swine fever (ASF) outbreak that caused severe population losses. A substantive increase in 2024 (RAI = 7,290; IE = 337) suggests a potential recovery driven by reduced ASF impacts, natural regeneration, and favorable environmental conditions. Camera traps also recorded various non-target wildlife species, including several species listed as threatened under the IUCN Red List, highlighting the conservation importance of the the Core Block of the Batutegi Protected Forest. Continuous camera traps monitoring is crucial for assessing population dynamics and informing adaptive wildlife management in protected forest ecosystems.

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Data Availability Statement: The datasets generated and analyzed during the current study are not publicly available but are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

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