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Changes in the Home Range of Bornean Orangutans (*Pongo pygmaeus wurmbii*) Before and After Forest Fires at Tuanan Research Station, Central Kalimantan

Silvia Hasan[1,2*], Sri Suci Utami Atmoko[1,2]

[1]Department of Biology, Faculty of Biology and Agriculture, Universitas Nasional
[2]Primate Research Centre, Universitas Nasional
*Correspondence Author: silviahasan156@gmail.com

Abstract

The Bornean orangutan (*Pongo pygmaeus wurmbii*), an endangered species native to the tropical forests of Borneo, plays a crucial role in the ecosystem as a keystone species and seed disperser. However, habitat degradation, particularly from forest fires, poses a significant threat to their survival. This study investigates the impact of forest fires on the home ranges of Bornean orangutans at the Tuanan Orangutan Research Station (TORS), Central Kalimantan, Indonesia. Data were collected before and after the 2019 forest fire, focusing on changes in orangutan movement patterns and their responses to altered fruit availability. The results showed that, following the fire, most observed individuals decreased their home range size, except for the flanged male (Dado) and the adult female (Juni), who expanded their home ranges. The forest fire led to a significant reduction in fruit tree productivity, which was reflected in the fluctuating fruit availability index (FAI). Additionally, smoke from the fire disrupted pollination, further impacting fruit production and orangutan foraging behavior. Kernel Density Estimator (KDE) analysis revealed changes in the movement paths and home-range sizes of the orangutans before and after the fire. These findings highlight the adaptability of orangutans to habitat changes induced by fire, and the importance of understanding how fire-related environmental changes affect orangutan survival and behavior. The study underscores the need for practical conservation efforts to mitigate the effects of habitat degradation and maintain food resources for orangutans in post-fire landscapes.

Keywords: Bornean orangutan, forest fire, fruit availability index, home range

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INTRODUCTION

The Bornean Orangutan (*Pongo pygmaeus wurmbii*), one of the great ape species found in the tropical forests of Borneo, shares 89–96% genetic similarity with humans (Hernando-Herraez et al., 2015). As umbrella species, orangutans play a crucial ecological role in tropical forest ecosystems, serving as keystone species and effective seed dispersers (Santosa & Rahman, 2012). Their presence has a significant impact on the structure and function of the ecosystem, and they are also an important indicator of forest health. Currently, they are listed as *Critically Endangered* by the International Union for Conservation of Nature (IUCN) (Ancrenaz et al.,

2024) and are nationally protected under Law No. 5 of 1990 on the Conservation of Natural Resources and Ecosystems, as well as the Ministry of Environment and Forestry Regulation No. P.106 of 2018 (Ministry of Environment and Forestry, 2018).

The home range of wild orangutans results from the accumulation of their daily movements over a specific period, encompassing areas used for foraging, social interactions, and other daily activities (Lady, 2025). The home range is not fixed but varies based on resource availability, seasonal changes, and environmental pressures. It also refers to the area an orangutan uses to meet various life needs, such as foraging, mating, and caring for offspring, within a specific timeframe. In this context, male orangutan home ranges tend to be larger than those of females, with male ranges 3–5 times broader than those of females within the same population (Saputra et al., 2017). Meanwhile, female orangutans exhibit a philopatric lifestyle, residing in areas that overlap with those of their mother or group, which makes their home range more stable and consistent (van Noordwijk et al., 2012; Wartmann et al., 2010). One of the orangutan habitats in Borneo, located outside national park areas, is the Tuanan Orangutan Research Station (TORS) in Central Kalimantan. TORS is situated in a peat swamp forest with relatively homogeneous vegetation and low fruit productivity (Vogel et al., 2009).

The area has undergone large-scale deforestation and is part of the former One Million Hectare Peatland Project, which has significantly degraded the ecosystem and increased its vulnerability to forest fires that occur almost every year (Saputra et al., 2017). The major fires of 2015 and 2019 further exacerbated the condition of orangutan habitats, forcing orangutans to adapt to limited food availability. This phenomenon directly affects orangutan home ranges, which are influenced by changes in the availability of fruiting trees. Therefore, understanding changes in orangutan movement patterns and the strategies they use to respond to fruit availability dynamics is crucial.

The forest fires in peatland areas have had a significant impact on wildlife health. Orangutans, as an indicator species, can provide crucial signals regarding environmental quality and ecosystem health. Habitat degradation caused by fires affects not only food availability but also the physical health and behavior of orangutans. Therefore, monitoring fruit availability is crucial for understanding the impact of habitat changes on orangutan populations. Given this background, this study aims to compare the home range sizes of orangutans at TORS, with a focus on the differences before and after the forest fires. This study aims to provide new insights into orangutan adaptation to environmental changes resulting from forest fires and how these changes impact their survival and home ranges.

METHOD

Study Area

This study was conducted at the Tuanan Orangutan Research Station (TORS), located approximately 1.5 km from the Kapuas River, between the Daha and Bengkirai Rivers, two

tributaries of the Kapuas. Administratively, it is situated in Tuanan, Tumbang Mangkutub Village, Mentangai District, Kapuas Regency, Central Kalimantan (Figure 1).

The study was conducted across two distinct time periods: before and after the forest fire. Post-fire data were collected from September 2019 to February 2020, while pre-fire data were obtained from the TORS database covering March to August 2019. The focal individuals observed consisted of two flanged adult males, one unflanged male, two adult females, and one adolescent. Each individual was followed for a varying number of observation days.

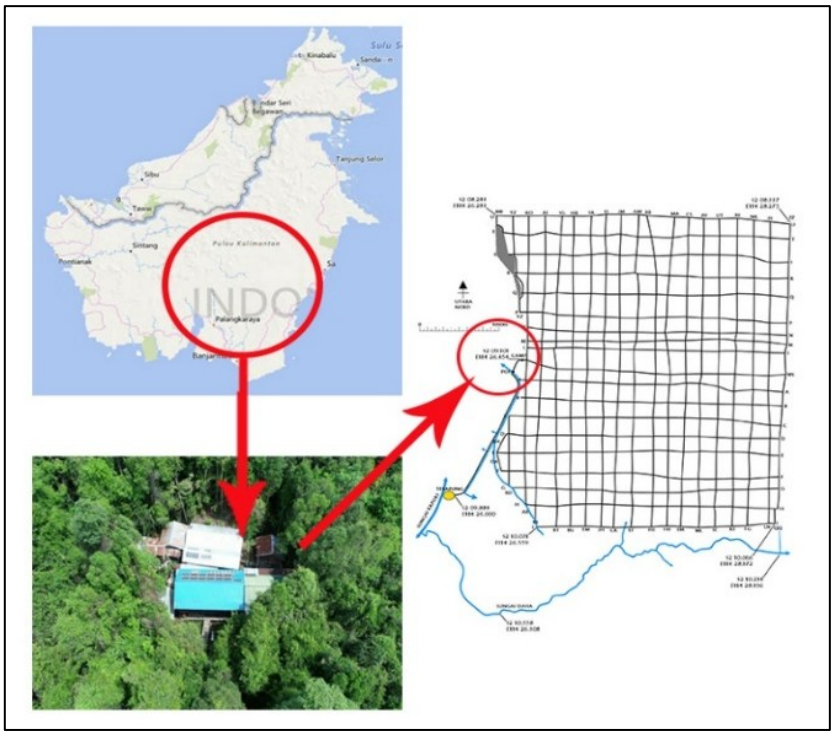

Figure 1. Tuanan Orangutan Research Station (Makur, 2019)

Table 1. Orangutan object

Stage	ID	Nest to Nest	
		Pre-forest fire	Post-forest fire
Adolescent	Mawas	5	8
Adult female	Mindy	17	14
	Juni	17	9
Unflanged male	Ted	5	5
Flanged male	Dado	25	16
	Gismo	7	3

Data Collection

Phenology

Phenology data were collected monthly by monitoring phenology plots comprising 1,868 trees with a diameter at breast height (DBH) greater than 10 cm, distributed across the TORS area (Vogel et al., 2017). A total of six phenology transects were established, each exceeding 1 km

in length with a 10 m radius on both sides (Vogel et al., 2008). Only trees were included in the measurements, as no lianas with DBH ⩾ 10 cm were recorded within the phenology plots (Tuanan Project, unpublished data). To estimate fruit availability, we calculated the Fruit Availability Index (FAI), defined as the percentage of trees bearing fruit within the phenology plots each month (Vogel et al., 2009).

Day Journey Length (DJL)

DJL observations were conducted to measure the orangutans' daily journey length and home range. Each focal individual was followed from the nest in the morning until the nest in the evening, with observations limited to a maximum of 10 days per month to prevent habituation. Geographic locations of the orangutans were recorded every 30 minutes using GPS, including at morning and evening nest sites. All GPS data were processed using Garmin MapSource (version 6) and ESRI ArcGIS (version 10.3).

Data Analysis

Home-range analysis was conducted using the Kernel Density Estimator (KDE) method in ArcGIS to map the distribution of coordinate points and estimate home-range size.

RESULT

Phenology

The graph below shows the dynamics of rainfall (mm) and the Fruit Availability Index (FAI, %) in the TORS area of Central Kalimantan from March 2019 to February 2020. The graph also highlights three key periods related to forest fires and smoke events: the smoke season, the fire season, and the smoke season 2.

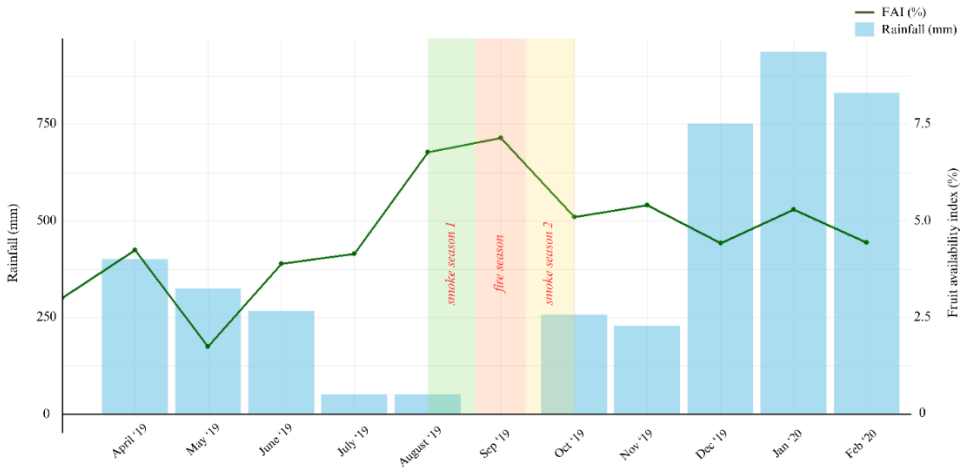

Figure 2. Rainfall Patterns and Fruit Availability Index During Smoke and Fire Seasons in the TORS area

Description:

Smoke season 1: Period affected by smoke originating from external locations
Smoke season 2: Period affected by smoke originating locally from TORS
Forest fire: Period of active forest fire events within the TORS area

During smoke season 1, rainfall decreased compared to the previous months. This period was influenced by smoke from large forest fires occurring outside the research area, across a wider region of Kalimantan. The smoke, carried by the wind, reached the TORS area, resulting in poor air quality and negatively impacting the local ecosystem. The decrease in rainfall during this period indicated drier conditions, which allowed the smoke to spread more extensively and intensively. During the 2019 fire season (around September), no rainfall occurred, yet the Fruit Availability Index (FAI) remained relatively high. However, as the TORS area entered smoke season 2 (around October 2019), a combination of smoke season 1 effects and ongoing fires led to a decline in FAI despite rainfall. This decrease in FAI is likely due to the continued impact of the fires, which affected habitat quality and food availability for wildlife, including orangutans.

Day Journey Length (DJL)

Orangutans undertake exploration primarily to forage for food, such as fruits and other dietary resources, to sustain their survival. An extended DJL over a defined period contributes to the formation of their home range. The home range area was calculated by measuring the collective use of space by all six individuals, excluding overlapping areas (Table 2).

Table 2. Calculation of DJL Area (hectare) and Average DJL per Day

Stage	ID	Pre-forest fire			Post-forest fire		
		DJL area (hectare)	n	Average (hectare/day)	DJL area (hectare)	n	Average (hectare/day)
Adolescent	Mawas	27.5	5	5.50	19.92	8	2.49
Adult female	Mindy	72.38	17	4.25	49.98	14	3.57
	Juni	111.83	17	6.57	80.17	9	8.90
Unflanged male	Ted	166.78	5	33.35	50.43	5	10.08
Flanged male	Dado	54.82	25	2.19	58.15	16	3.63
	Gismo	87.61	7	12.51	0.86	3	0.28

Based on the calculation of the Day Journey Length (DJL) in hectares and the average DJL per day (hectares/day), differences were observed between the periods before and after the forest fire for each individual. In general, after the fire, most observed individuals showed a decrease in home range size. However, exceptions were noted for the adult female (Juni) and the flanged male (Dado), both of whom exhibited an increase in their home range size. Additionally, Kernel Density Estimator (KDE) analysis was performed to map the movement paths and DJL of each individual before and after the forest fire.

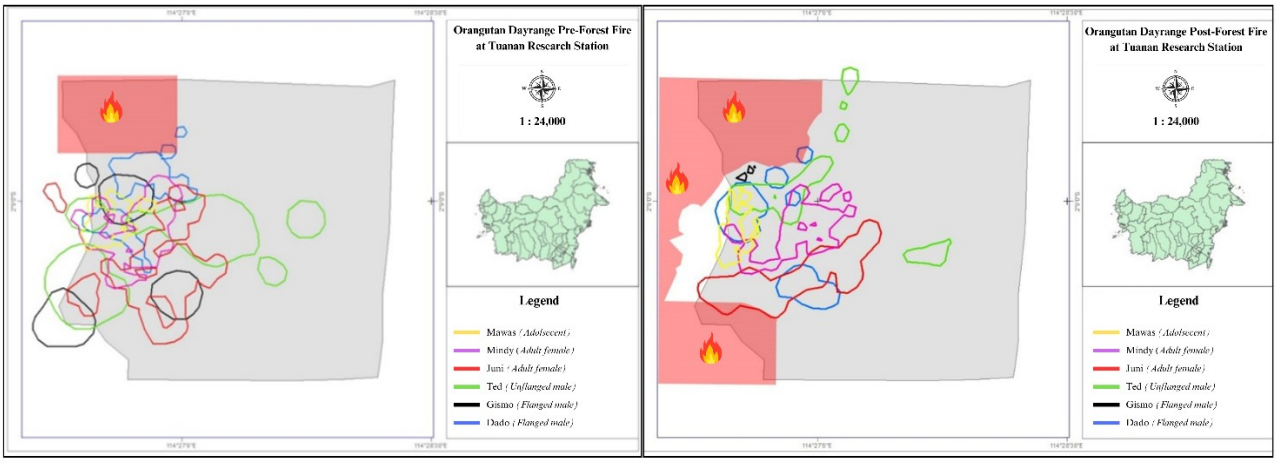

Figure 3. Day Journey Length (DJL) of Orangutans pre-fire (left) and post-fire (right) at Tuanan Research Station

Based on Figure 3, which shows the DJL in the TORS area, changes in the orangutans' movement patterns are observed. However, their home range remains more concentrated in the eastern part of the research area. These results suggest that the forest fire likely affected food availability, which, in turn, influenced the orangutans' home range.

DISCUSSION

Weather factors and ecological conditions, such as rainfall, significantly influence the productivity of fruit-bearing trees. Figure 2 shows that the 2019 forest fire led to a decrease in rainfall, which, in turn, affected fruit productivity. The highest fruit tree availability was recorded from December to February, while the lowest occurred from July to August, coinciding with the smoke period and the early stages of the forest fire. The presence of the smoke season indicates a phase of dense smoke prior to the forest fire, resulting from fires occurring in other areas (e.g., TORS). This is believed to have inhibited fruit tree productivity at the TORS area, as no significant correlation was found between rainfall and the Fruit Availability Index (FAI) (Spearman's $\rho < 0.05$). Conversely, smoke from the fires is suspected to have led to a decline in fruit productivity in the TORS area. The smoke disrupted pollination, affecting pollinating insects and preventing the successful reproduction of flowering plants. Several gases in the smoke can react to produce toxic pollutants, and short-term exposure to these pollutants acts as a narcotic for insects, affecting their respiration and making them less active, posing a danger to them (Marlier et al., 2013). This condition caused temporary changes in phenological patterns, the first response of species to environmental changes, leading to erratic, unpredictable fluctuations in fruit productivity (Diez et al., 2012).

This also reflects the process of vegetation recovery and habitat regeneration post-fire, which is crucial for supporting the survival of fauna, particularly orangutans, who rely on fruits as their primary source of nutrition. Fluctuating phenological conditions influence the foraging behavior of orangutans, including increased travel activity over a period, which subsequently shapes their daily home range. After the forest fire, only the flanged male (Dado) and adult female (Juni) expanded their home ranges. The larger home range of the flanged male (Dado)

was due to the high encounter frequency during the study, as he was the dominant male in the research area. The study shows that during his travels, the flanged male (Dado) tended to avoid interactions with other males and often emitted long calls, which served to drive other orangutans away from his territory. This behavior allowed the flanged male (Dado) to search for food in a broader area, particularly in non-burnt regions, to meet his nutritional needs. Furthermore, with a larger body size compared to other individuals, the flanged male (Dado) had an advantage in accessing more extensive resources. Overlapping home ranges with other individuals provided flanged male (Dado) opportunities to interact with both subadult and adult females during his foraging activities. In comparison, the unflanged male (Ted) had the most extensive home range, averaging 10 hectares per day after the fire and 33 hectares per day before the fire. This relates to the wandering nature of unflanged males, who tend to have a more random foraging pattern and rarely return to the exact location for at least 3 years.
In addition, unflanged males also avoid encounters with dominant flanged males to minimize conflict, resulting in a broader home range to prevent overlap with their territory. This behavior is linked to their social status, as unflanged males often try to avoid interactions with flanged males to maintain social stability. Adult unflanged male orangutans, particularly those undergoing a sexual phase after reaching independence, tend to expand their daily home ranges during their mating period. They actively explore over longer distances compared to other individuals. This is influenced by the fact that unflanged males spend more time searching for females, exhibit more social behaviors, and interact more with other individuals, whereas flanged males do not (Morrogh-Bernard et al., 2009). In contrast, adult female orangutans, such as Juni, who expand their home range, do so due to increased nutritional needs associated with having two offspring. This requires them to search a larger area for food, thus increasing their movement. Meanwhile, adult female Mindy, who has only one offspring, tends to restrict her home range. This is believed to be due to pressure from forest fires, which reduces their movement and prevents them from entering fire-affected areas.

Orangutan home ranges also overlap among individuals. The overlapping areas of orangutans are regions formed by the overlapping movements of two or more orangutans (Singleton & van Schaik, 2001). Before and after the fire, the home ranges of adult female Mindy and adolescent female Mawas overlapped. This is due to their kinship: an adolescent female Mawas is the offspring of an adult female Mindy, who has reached adolescence. The home ranges of adult female Mindy and adult female Juni also overlapped before the 2019 fire, indicating that these two individuals shared the same foraging area. Similarly, the adult females Juni and Mindy are closely related, as they are from the same mother. Generally, female orangutan foraging behavior is influenced by kinship (van Noordwijk et al., 2012). Female orangutans tend to form home ranges close to their mothers, a behavior referred to as philopatry (Singleton et al., 2009). The impact of the forest fire on philopatric females increases competition for food resources, leading them to maintain their home ranges by minimizing their individual territories. This philopatric behavior fosters high tolerance toward closely related individuals. Furthermore, philopatry offers social benefits by maintaining strong bonds in maternal care and ecological advantages by reducing risks associated with unfamiliar ecological conditions (Ariyanto, 2015).

Orangutans with overlapping home ranges are influenced by fruit availability, habitat, and reproduction (Singleton et al., 2009).

Based on the day journey length locations, the home ranges of the six individuals were primarily concentrated in the western and southern parts of the research area, extending to the central and eastern regions before the 2019 fire. After the 2019 fire, the home ranges remained in the western part of the research area, although with varying sizes. It is suspected that, prior to the 2019 fire, these areas had abundant fruit availability. This is supported by Saputra's (2018) study, which found that throughout the year, high fruit tree productivity was consistently located in the western and southern areas. Following the 2015 fire, the southern region showed a low abundance of food patches, while the western region had a moderate abundance due to the presence of large-diameter trees and many canopy gaps (Saputra, 2018). These gaps in the forest canopy promote the growth of lianas, which are pioneer species that easily regenerate. Additionally, lianas play a significant role in forest dynamics, including succession and tree regeneration (Barry et al., 2015). The uneven distribution and high productivity of liana species at TORS can provide an alternative foraging area for orangutans. The western area had a moderate to high abundance of lianas, but the most extensive home-range utilization occurred in areas with moderate fruit abundance on trees (Saputra, 2018).

The varying home ranges of individual orangutans reflect an adaptation to post-fire forest conditions. According to Singleton (2009), female orangutans at TORS that lose their home ranges due to habitat destruction tend to maintain them firmly regardless of the circumstances. Meanwhile, unflanged males travel greater distances daily than flanged males (Mitra-Setia et al., 2009). The differences in orangutan home ranges are influenced by factors such as age, sex, and habitat (Singleton et al., 2009). Consequently, orangutans adjust their travel patterns in response to fruit availability to meet their nutritional needs. As stated by Morrogh-Bernard et al. (2011), orangutans adapt their feeding and daily movement strategies according to fruit availability. This study confirms that forest fires and smoke events, both from external sources and from local fires, affect microclimate conditions and food resource availability in the TORS area. These impacts could exert ecological pressure on the local biotic community, making it a critical conservation concern.

CONCLUSION

The 2019 forest fire affected the home ranges of orangutans at TORS. Reduced rainfall and wildfire smoke decreased fruit tree productivity, affecting food availability. The smoke also disrupted pollination, further hindering fruit production and altering phenological patterns. Only flanged males and adult females with offspring expanded their home ranges after the fire. This study emphasizes the significance of conservation efforts in supporting habitat recovery and enhancing food resource availability following fires.

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