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The Response of Orangutans to a Total Solar Eclipse Event

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Abstract

A complete solar eclipse is a rare event, and we know very little about how other species, including our closest living relatives the primates, react to these events. We observed orangutans on the island of Borneo, Indonesia during a rare astronomical event of a total solar eclipse. Captive orangutans in Nyarumenteng rehabilitation center, Central Kalimantan were observed to document their reaction to this unexpected environmental event. Based on this study that was conducted in 2016, the dramatical behavior demonstrated in the time of the total solar eclipse, and the general response differed between before and after the event. During the total solar eclipse, flanged males tended to increase their social behavior compared to the unflanged males. These findings indicate that the total solar eclipse resulted in an environmental stressor for these captive orangutans.

Keywords*: behavior, orangutans, solar eclipse*

Introduction

A solar eclipse occurs when the moon blocks the sun light that reaches the earth. There are three types of solar eclipses that relate to the coverage of moon's shadows on the earth (Littmann et al., 2009). The first type is a total solar eclipse, in which the earth, the moon, and the sun are in a direct line. The second is a partial solar eclipse, which occurs when the earth is not in the exact same line as the moon and the sun. The third type is an annular solar eclipse, which occurs when the moon's center covers the center of the sun because it is positioned at its farthest point from earth, causing a ring around the moon. A partial solar eclipse is more typical compared to an annular solar eclipse, whereas the total solar eclipse is the rarest event. For example, the record of solar eclipses in Palangkaraya, Central Kalimantan, Indonesia shows that a partial solar eclipse has occurred 38 times since 1900th, whereas an annular solar eclipse and a total solar eclipse only has occurred once (Thorsen, 2016). Moreover, according to a NASA report, March 9th, 2016 was one of the most important days for an astronomical event in Central Kalimantan, Indonesia. The total solar eclipse occurred in this area for the first time in its history (Espenak, 2016).

When a total solar eclipse takes place, it causes darkness for short period of time during the daylight hours. When this occurs, it is similar to the night periods without moon light and the lights levels are close to zero, potentially inhibiting visual abilities in diurnal animals. Understanding how animals' reaction to a novel solar eclipse is something that has received little attention, but is important to see how intelligent animals like great apes react to novel environmental events. Since 1971, there has been a large amount of research on wild and captive orangutan. Several worldwide-recognized research stations (e.g., Tanjung Puting National Park (Galdikas, 1975), OuTROP-Sebangau National Park (Morrogh-Bernard et al., 2003), and Tuanan Orangutan Research Station-Kapuas (van Schaik et al., 2005) have documented long-term variation in orangutan behavior. In addition, the BOSF orangutan rehabilitation center in Nyarumenteng also plays an important role in orangutan research development, particularly of animals that will be reintroduced into the wild again.

Total solar eclipses have been known to temporarily change the behavior in some animals; for example, the freshwater Cercaria varied their emergence patterns (Madhavi, 1983) and zooplankton have been observed to migrate to the water surface (Bright et al., 1970; Economou et al., 2008). Furthermore, several farm animals have been less active during an eclipse (Bozic, 2003), and captive males baboons wree observed to reduce locomotion and increase grooming (Gil-Burmann & Beltrami, 2003). Because total solar eclipse events are rare and only occur for a few minutes, research focusing on animal behavior during these events is limited. Prior to this study, there were no documented studies focusing on orangutan behavior during an eclipse, although total solar eclipses have been reported twice in West Kalimantan and East Kalimantan, Indonesia since 1900th (Thorsen, 2016).

Orangutans are diurnal primates that are more active during daytime and increase their inactivity as night approached, when the typically make a night nest. The daily activities begin when the sun is rises; orangutans will leave their night nest and start traveling to find food and do other activities (Morrogh-Bernard, 2009). When the sun sets, visibility decreases and individual typically make a new nest by the time it is dark. This behavior is repeated daily and occurs in both wild populations as captive orangutans. However, young orangutans are often reported to go out from its nest and return to the closest fruit tree to eat and then return to the nest (Utami-Atmoko & Mitrasetia, *personal communication*). This behavior occurs during the full moon when there are more lights in the forest such that orangutans can travel and still locate food.

Because this was the first documented total solar eclipse in Central Kalimantan-Indonesia, we recorded the orangutan's behavior to these light changes at the Nyarumenteng Rehabilitation Center in Central Kalimantan. The study group consisted of orangutans that were monitored simultaneously before-during-and after the solar eclipse. We predicted that during the total solar eclipse, orangutans would decrease their activity compared to their prior-post behaviors.

Method

This study was carried out at an orangutan rehabilitation center, Nyarumenteng, in Palangkaraya, Central Kalimantan, Indonesia (2°02'23.4"S and 113°45'06.4"E). The Borneo

Orangutan Survival Foundation (BOSF) has managed this center since 1999 and more than 500 rescued and confiscated orangutans were placed into two different facilities: 1) quarantine that focuses on the process to improve the health of orangutans, and 2) rehabilitation, which is the next step before the orangutans can be released into the wild. The rehabilitation facility is divided into two different sites. The first one is the socialization facility (NM2) which has 10 group cages, and each group contains 12 individual cages. In this group, every cage (and hence individual) is separated by a solid border made from concrete or a metal-plate to avoid physical contact between orangutans. Only the front and back side of the cages were built with a grid border that allows orangutans to see each other, although all individuals can hear each other. At this facility, orangutans were housed for long time periods, until they are ready to be released at which time they are moved into NM3. The second site is the monitoring facility (NM3) or sometimes called "transit cage" that has 5 different group cages which contain 54 individual cages. There are 3 connected cages with grid borders in NM3 that allow orangutans to interact, whereas two other groups are separated by solid borders. Depending on the logistics of the release process, orangutans that live in this facility could be stay for short (1 month) or long time periods (2 years).

Five adult male orangutans were selected, which were divided into two different classes (e.g., three flanged males and two unflanged males). The sample was selected based on their location within the center so that observations could be conducted at the same time and with all five orangutans within view of the observer. Focal animal data sampling was used to observe the orangutans' behavior with instantaneous data intervals recorded every two minutes for each individual (Altmann, 1974). Also, ad libitum sampling was also carried out during eclipse period, which lasted 2 minutes and 29 seconds (Altmann, 1974; Espenak, 2016).

Behavioral data were collected seven days prior to the solar eclipse, the day of the solar eclipse, and seven days after the solar eclipse. Based on the observations that were conducted from dawn until dusk, we collected 121 hours of focal data comprised of 3,300 data points. Also, the solar radiation was measured a day before and a day after the solar eclipse, and during solar eclipse using the free ©Pyranometer app by Hukseflux for iOS mobile phone. This app is used to record solar radiation levels in every square meter area (http://www.hukseflux.com/product/pyranometer-app). Observations on solar radiation were carried out every hour from the dawn (05:00 AM) until it was dark (18:00 PM).

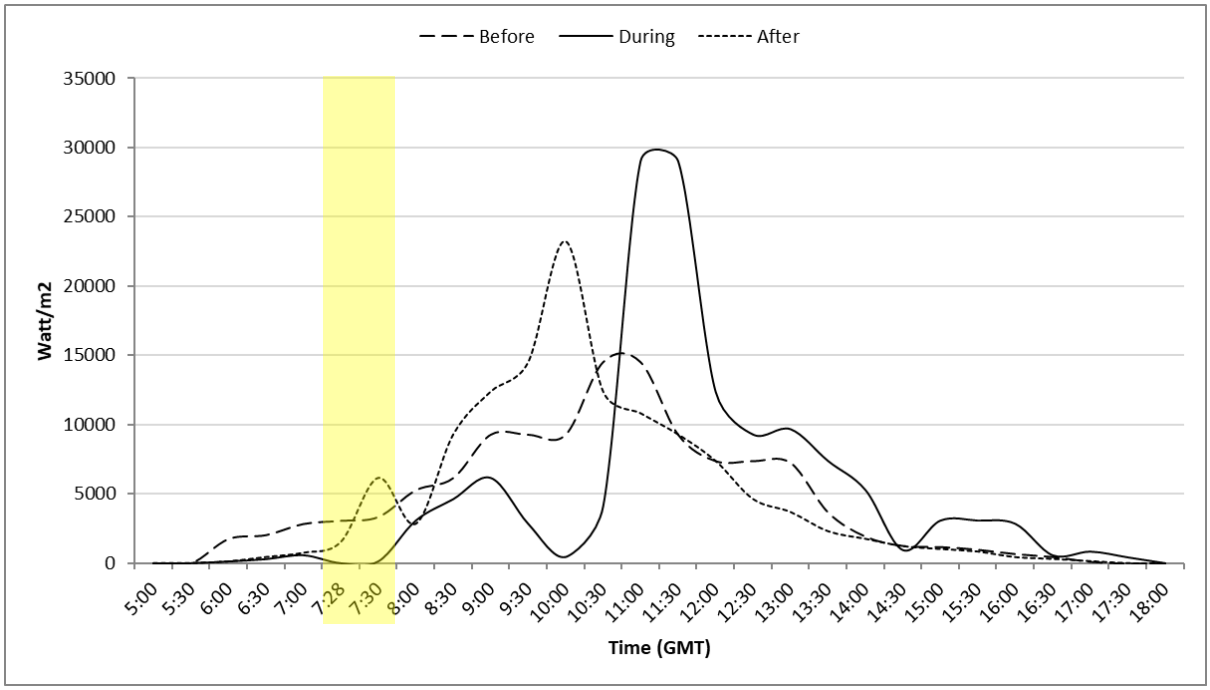
Results

1. Solar Radiation

As the sun rises, solar radiation will increase to the highest level when the position of the sun is directly above the observer, called the zenith point. As the sun starts to set, the radiation will decrease. The measurement of solar radiation from this study on the day of the solar eclipse is shown in the Fig. 1. The sun was rising at 5:30 AM, and the radiation level varied between 3-15 Watt/m^2. Then the radiation level increased to the highest level, which varied from previous days without an eclipse. The day before the solar eclipse, the highest radiation level occurred from 10:30 to 11:00 AM, with the radiation level measuring 14.516 Watt/m^2. During the eclipse, the sun rose to the zenith point a half-hour earlier than the previous day, but with

two times the radiation level (29.032 Watt/m^2). After the eclipse, the highest level of solar radiation was about 15.000 Watt/m^2, which indicated the level of radiation returned to similar levels prior to the eclipse.

Figure 1. The solar radiation levels before, during, and after total solar eclipse. A yellow color box indicated the total solar eclipse time.



During the solar eclipse, as the sun rose the radiation levels increased slightly. However, when the solar eclipse began at 07:00 AM, the solar radiation level declined to zero (07:28 AM) for about two minutes, followed by a sudden return to the radiation level prior to the eclipse. According to NASA, the total length of the solar eclipse in Palangkaraya, Central Kalimantan, Indonesia was 2 minutes and 29 seconds long (Espenak, 2016).

2. Orangutan Behavior

Orangutan behavior footage during the solar eclipse event can be described below:

Time (GMT)	Solar Eclipse (Thorsen, 2016)	Orangutans' behavior
06:23	 Partial solar eclipse begins	All orangutans were resting. Some individuals were still in their sleeping sites, whereas others just sat towards the front side of the cages. There was little activity among individuals during this time.

07:28	 Total solar eclipse begins	Solar lights level drastically declined, indicating that the solar eclipse was occurring. A flanging male (i.e., not fully flanged) from other cage group emitted a long call, but there was no feedback from the other orangutans. Ten seconds after sky became dark, another flanged male emitted long calls and other males orangutans began to pound the cage simultaneously, making an undocumented sound. Then almost all flanged males emitted long calls, and the other orangutans continued to bang on their cages. Unfortunately, we could not count how many orangutans were expressed in this time due to visual limitation during observation.
07:30	 Maximum total solar eclipse	The sky was completely dark with zero readings. All orangutans became very quiet, and just insect sounds could be recorded. The orangutans were sitting and watching the situation.
07:31	 Total solar eclipse ends	The sky became slightly became brighter, indicating the end of the total solar eclipse. One focal (flanged male) moved from his previous position in the cage and tried to get some food on the rack. At this time, the birds began to vocalize, and insect

			sounds could no longer be heard.
08:46		Partial solar eclipse ends	As the solar eclipse ended, the behavior of the orangutan went back to normal and they were observed sitting and resting as usual.

In general, orangutans in the rehabilitation center spend most of their time resting (81%), foraging (16%), and small proportion of their time in social interactions with other individuals (2%). In addition, because all orangutans lived in the smaller cage space, moving was also rarely observed (<1%). This differs from wild orangutans in which they spend the majority of their day active period foraging, feeding, and moving. Based on our observations of all orangutans "before", "during", and "after" the total solar eclipse event, resting behavior was higher during the solar eclipse compared to before and after the event. A similar pattern was observed in moving and social activity, but different result were found for feeding time, with all orangutans feeding less during the solar eclipse (Table 1).

Table 1. The average of orangutans' activity budget before-during-after the solar eclipse event.

Observation period	**Activity Budget**			
	Resting	**Feeding**	**Moving**	**Social**
Before	238 ± 11	56 ± 3	0	6 ± 1
During	275 ± 10	48 ± 9	0	6 ± 3
After	232 ± 9	44 ± 7	0	7 ± 4

When the analysis was focused on flanged and unflanged male, during the solar eclipse flanged male orangutans tended to decrease their feeding time and social behavior and increase their moving and resting behavior. Meanwhile unflanged male tended to decrease all activities examined except for resting behavior (Table 2).

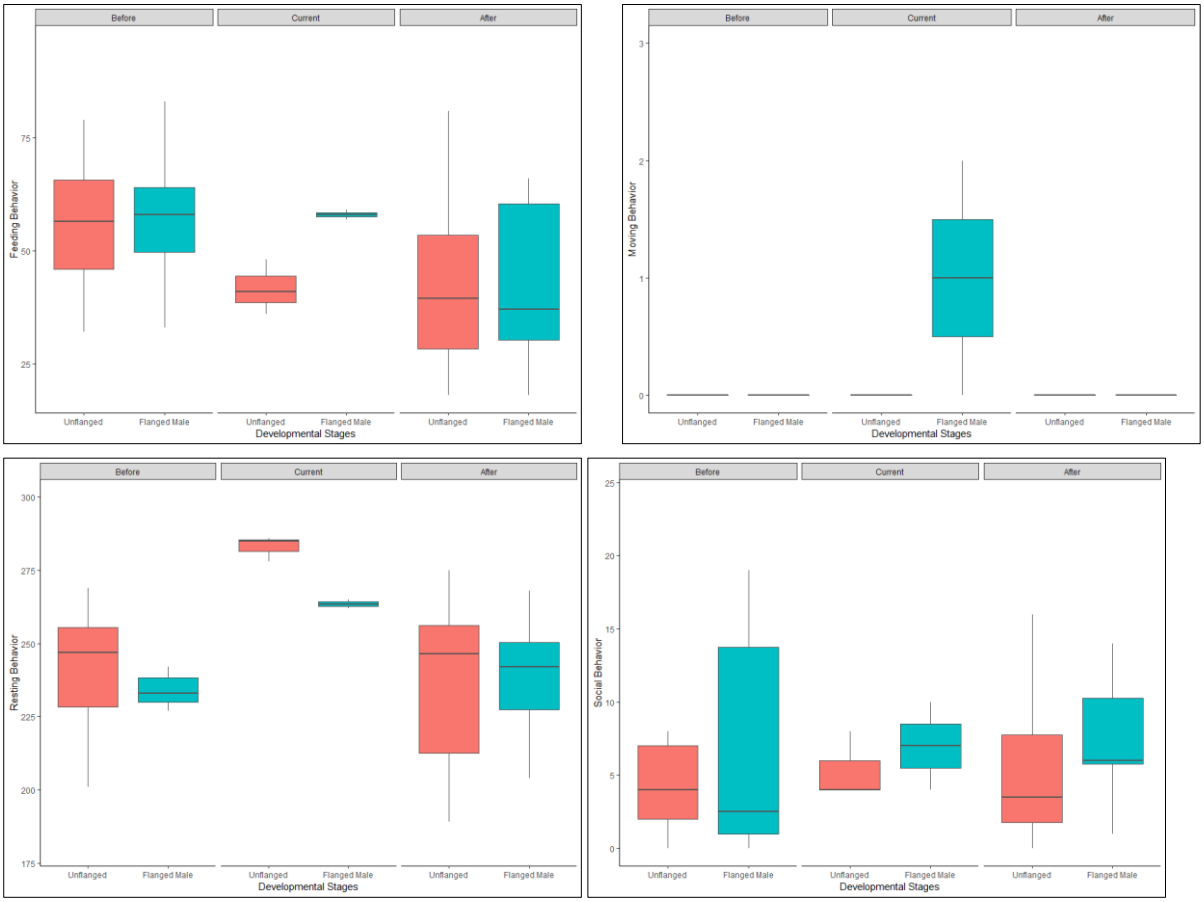
Table 2. The average of orangutan's activity budget before-during-after the solar eclipse event between flanged and unflanged males.

Observation Period	**Flanged male**				**Unflanged male**			
	Resting	Feeding	Moving	Social	Resting	Feeding	Moving	Social
Before	232 ± 2	58 ± 3	0	7 ± 1	234 ± 12	57 ± 3	0	6 ± 1
During	264 ± 2	58 ± 1	1 ± 1	7 ± 4	282 ± 4	42 ± 5	0	6 ± 2

After	229 ± 10	±	42 ± 13	±	0	9 ± 3	229 ± 9	44 ± 3	0	8 ± 4

Although the sample size was too small to compare the behavior of flanged and unflanged males for the periods before, during, and after the eclipse, we can describe some basic observed patterns. For example, for feeding behavior, flanges males and unflanged males did not differ in the amount of time feeding before and after the solar eclipse (before: 58 ± 3 and 57 ± 3; after: 42 ± 13 and 44 ± 3 respectively). However, during the solar eclipse event, unflanged males slightly decreased their feeding time (42 ± 5) compared to the flanged males (58 ± 1). In terms of moving, the only change during the eclipse was that flanged males moved more during the eclipse (Figure 2). For resting, both flanged and unflanged males seemed to rest more during the solar eclipse overall. The average of time in social behavior did not seem to vary between the three defined periods.

Figure 2. The different pattern of activity budget between unflanged and flanged males before-during-after the total solar eclipse.



Discussion

A total solar eclipse is a rare astronomical event, and here we describe an event that occurred and was recorded for the first time in Central Kalimantan, Borneo-Indonesia. Because a total solar eclipse has a very short duration, it was difficult for us to obtain enough data on

enough individuals to analyze the data with statistical analyses. However, the general descriptive observations can be used to discuss how orangutans respond to the different light levels that occur during a total solar eclipse. The reaction of animals to a solar eclipse has been conducted in several animal taxa, ranging from lower taxa class like plankton to the higher animal taxa such as mammals and primates. In a zooplanktons' study, the solar eclipse influenced the migratory movement of some zooplankton species (Bright et al., 1970; Economou et al., 2008; Sherman & Honey, 1970). In a study of insects, the solar eclipses were shown to have a similar effect: (Ugolini et al., 2004) found that the sand-hopper orient properly during a solar eclipse; whereas (Cadwallader & Eden, 1977) found an increase in the occurrence of nocturnal helodid, leptocerid, and conoesucus larvae. In contrast, some studies on mammals such as horses, dogs, and cows found that animals demonstrated inactivity during the eclipse. They also expressed a nervous response of pawing the ground before the total solar eclipse began (Bozic, 2003; ÖZbey et al., 2004; Rutter et al., 2002).

In general, our study of captive orangutans support findings from chimpanzees (*Pan troglodytes*) and Hamadryas baboons (*Papio hamadryas*) in a similar environment (Branch & Gust, 1986; Gil-Burmann & Beltrami, 2003). During the total solar eclipse, orangutans in captivity seemed to become more inactive; as a result, orangutans decreased time spent feeding, moving, and in social behavior. Orangutans, like other captive primate species, may have been less active because they are in an environment that does not let them escape or move away. Another problem with the data is that it is possible that the timing of when the food supply was given to the orangutans in their cages may also have influenced the feeding time. They are given their food at approximately 08:00 AM, and thus it is possible that they were not foraging during the eclipse. In contrast, Shanida et al. (2016) found that during a total solar eclipse, *Nasalis larvatus* in East Kalimantan increased the amount of time feeding, resting, and moving. Similar to this finding, an observation of one individual orangutan in the wild (Tuanan Orangutan Research Station) found that this individual's behavior did not change during the same total solar eclipse (Brittain, R. and Misdi, pers.com.).

Flanged males responded to changes in the light during the solar eclipse event by giving long calls, whereas the unflanged males that are unable to emit long calls displayed instead by banging and hitting the cage they were in. Long call vocalizations that are emitted by flanged male orangutans have been documented to be used in response to unexpected conditions such as thunder, chainsaws, or falling trees (Mackinnon, 1974). In many cases, long calls are used by flanged males to advertise their location to other males who may be within their ranger or to females (Delgado, 2007; Lameira & Wich, 2008; Mitra Setia & van Schaik, 2007). In captivity, we have found that flanged males also emit long-calls as a response to other male's long-calls, during veterinarian and technician visit, or when unfamiliar humans come near the cages. We have also heard flanged males at Nyarumenteng emit long calls several times at night for no apparent, and this behavior was also reported by (Samson et al., 2014).

Conclusion

Similar to the finding in flanged male's orangutan, unflanged male that could not react by giving long-calls instead banged on the cages, made rumble noises and kiss-squeak vocalization. In general, the observed orangutans seemed stressed and confused when it start to get dark during the eclipse and they emitted vocalizations and banged on the cages, and when it was completely dark, they got very quiet. Then, when it started to get light again after the eclipse, the animals seemed to resume their normal activity.

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