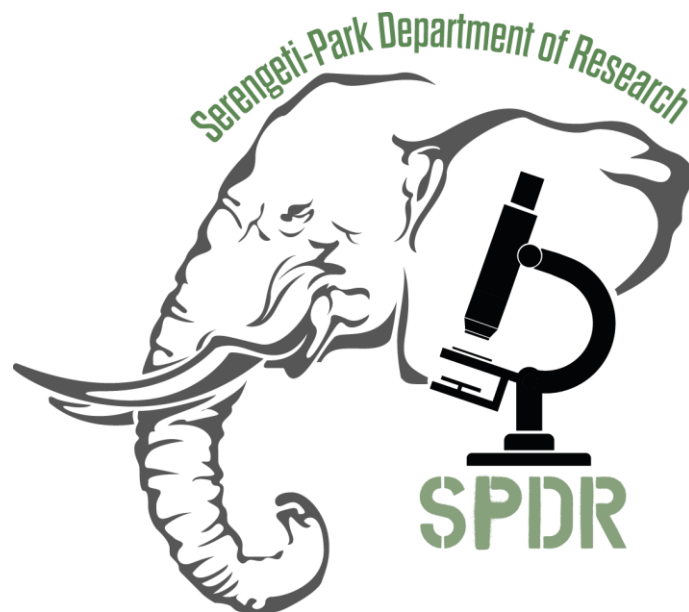


Social behavior of young African savannah elephant male
Jumanee during interactions with the herd at the
Serengeti-Park Hodenhagen

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Abstract

Female African savannah elephants live in matrilineal family units with strong social dominance hierarchies. Male elephants leave upon reaching sexual maturity and establish themselves in bull societies or roam around as loners. They primarily join females for reproduction purposes. The Serengeti-Park Hodenhagen houses one small adult bull Jumanee, the large adult cow Veri with her small adult daughter Nelly, the large adult cows Umtali and Bibi as well as the small adult cow Panya (daughter of Bibi) with her juvenile son Ayo. Due to a temporary construction site to enlarge housing of the elephants, Jumanee has no possibility to stay in a separate bull enclosure and therefore resides with the herd.

As Jumanee is not part of the natural social hierarchy of the female herd, this study aims at examining his dominance status when he resides with the herd. To achieve this, the influence of abiotic covariates such as temperature and weather conditions were analyzed as well as observations with a focal and continuous sampling method of the elephant Jumanee. The behavioral contexts were affiliative, aggressive (dominance) and avoidance. With that, his behaviors during different times of day and toward specific individuals were examined. Furthermore, it was analyzed whether he displayed any dominance changes over the observational course of around three weeks and if visitor interactions influenced natural social interactions of the animals. With an animal keeper survey, observations were compared with the keepers' perceptions of the elephants.

The results of this study indicate a primary dominance display during noon due to food competition, more affiliative behavior in the afternoon with less visitors present and reduced food competition. Sunnier weather increased dominance displays over natural resources while temperature had no significant influence on Jumanee's behavior. Visitor interactions increased negative social behaviors (avoidant and aggressive) and decreased affiliative behaviors. Furthermore, his behavior was highly dependent on female rank as higher ranked elephants competed with him over food and resulted in generally more interactions. Avoidance behaviors were primarily displayed during interactions with Umtali as she is the only elephant that could dominate him. Aggressive and affiliative behaviors were mostly directed at Bibi since they interacted often, and he showed strong dominance towards her. There was a tendency of increasing dominance within three weeks due to improved aggression towards Bibi.

This report presents many aspects that may influence the behavior of the young bull Jumanee. However, with the possibility for further development of Jumanee and supporting measures of the park, elephant management, husbandry and possible breeding can be improved.

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1 Introduction

1.1 Social structure of African savannah elephants

Wild African savannah elephants (*Loxodonta africana*, BLUMENBACH, 1797) live in fission-fusion societies in which males and females do not co-reside in permanent social groups [1].

Female elephants reside in matrilineal family units with a basic social unit, the “family group”, consisting of typically two or more adult females and their dependent offspring. They are therefore mostly closely related and maintain stable relationships over many years [2, 3]. Within a social bond lies a strong age- and size-ordered dominance hierarchy. This allows the herd to maximize survival and reproductive success and to reduce rates of conflict within the group, since the use of tusks as weaponry and the very close proximity of the elephants could lead to dangerous conditions if conflicts occur [3, 4].

In contrast, male elephants disperse from the natal herd between the age of 10 – 20 years upon reaching sexual maturity and are rather transitory in their community: they can choose to establish themselves in a separate bull society, spend some of their time alone or in short-term association with various family groups [2, 5]. During adolescence, young male elephants usually join bull societies in a period of learning and development and to establish themselves in the dominance hierarchy [6]. The leaders of bull societies are of high dominance which is dependent on larger size and age. They typically lead by travelling at the front of group movements and most likely lead passively by making choices based on enhanced experience and being tolerant to the active followers that target and trail them [1, 5]. Therefore, older male elephants act as repositories of ecological knowledge to younger males [5]. Additionally, male African elephants spend a portion of each year in a physiological and behavioral condition called musth, which is manifested by elevated testosterone and aggression and heightened sexual activity. Being in musth temporarily raises the male’s dominance status above other males larger, older and not in musth [1].

Naturally, mature males join females primarily to reproduce and typically dominate them by size, body mass, tusk weight, old age and musth [1].

1.2 Living conditions of the African savannah elephant herd at the Serengeti-Park

Similar to the social structure of African savannah elephants in the wild, a herd of elephants is kept under human care in the Serengeti-Park Hodenhagen. Since 2012, the animal group consisted of the cow Veri with her daughter Nelly and the cow Umtali, as well as the bull Tonga and a younger bull Jumanee. Although this was an already established group of elephants for around five years, the cow Bibi was transferred to the safari park in 2017 and was reunited with her daughter Panya and grandson Ayo in 2020 [7]. Half a month later, the older bull Tonga was transported from the safari park to Dresden Zoo in November 2020. Accordingly, the young bull Jumanee (13 years of age at the time) became the new breeding male and is establishing himself in the dominance hierarchy of the group.

The elephant bull at the safari park is normally housed overnight in a separate bull box, and in the morning, he joins a few females (e.g. females in oestrus) of the herd for a few hours and is then relocated to a separate enclosure for the rest of the day. Since the end of the year 2021, neither the bull box nor the bull enclosure is available due to ongoing construction to enlarge the housing for the elephants. Therefore, there is no possible separation of the herd and bull. As such, Jumanee has been in unusually close and continuous contact with the herd.

1.3 Aims

To further improve African savannah elephant management and husbandry, it is of importance to review the social status of the bull Jumanee within the herd in their currently shared environment and to achieve a better understanding of aspects influencing their natural behavior.

Therefore, the first aim of this study is to analyze the social behavior of Jumanee toward the herd at different times of day, while observing the presence of affiliative, aggressive (primarily dominant) as well as avoidant behaviors. On the one hand, Jeffrey (2017) reported a peak in social interactions as well as agonistic behaviors in the morning caused by higher tourist presence and competition over food and affiliative behaviors primarily in the morning and lesser during noon [8]. On the other hand, Horback *et al.* (2014) reported more affiliative behaviors at noon and agonistic behaviors generally at very low rates [9]. Based on these reports and the knowledge of visitor presence with the possibility to feed the elephants, it is hypothesized that social interactions will be increased at noon with rather avoidant or aggressive behaviors due to food competition and affiliative behaviors will primarily occur in the morning and afternoon hours with less visitors present. In addition, covariates such as temperature and weather conditions are to be examined. However, no greater influence is hypothesized since in European late spring, no extreme weather phenomenon is expected that might impact African elephants.

The second aim is to observe Jumanee's behaviors toward different age groups and specific individual elephants, as he may exhibit different dominance patterns toward e.g. younger or older individuals, a mother and calf pair or females he grew up with since his transfer to the Serengeti-Park Hodenhagen. As reported by Jeffrey (2017), adult elephants display higher rates of agonistic behavior toward other adults as a form of dominance display [8]. Since male elephants dominate females usually by size, age and strength [1], it is hypothesized that Jumanee will show higher amounts of dominance behavior toward older, higher ranked and therefore more dominant individuals due to greater possibilities of e.g. food competition. In contrast, he may display more affiliative behaviors toward younger individuals with less dominance displays coming from lower ranking elephants. In addition, any changes in Jumanee's dominance behavior over the course of the three weeks observation will be examined. However, no greater change is hypothesized due to the relatively short time of observation.

The third aim is to assess the influence of visitor feeding on the social behavior of Jumanee. Since visitor feeding is possible between 10:00 am and 4:00 pm with fruits and vegetables provided by the safari park, feeding situations may influence social interactions due to competition over food. As previously mentioned, food competition has been reported to result in more agonistic behaviors [8]. Therefore, it is hypothesized that visitor feeding may influence natural social behavior of the elephants.

The fourth aim is to report animal keeper ratings via survey on the perceived dominance hierarchy of the elephants which may be predictive of social behavior. Freeman *et al.* (2009) have shown that keeper surveys and short-term behavioral observations can provide similar behavioral profiles due to high levels of training, direct contact and intimate knowledge on individual animals although, they might also miss less common interactions in their limited time to observe the animals [10]. Accordingly, it is hypothesized that keepers' perceptions will be similar to the observations.

Findings regarding the behaviors of Jumanee may indicate his dominance patterns toward individuals of the herd and aid in improving animal management of the group.

2 Methods

2.1 Animals, location and materials

This research was conducted in the Serengeti-Park Hodenhagen between April and May 2022, and focuses on the group of African savannah elephants. The group consists of seven African elephants (Table 1):

Table 1: African savannah elephant group of the Serengeti-Park Hodenhagen. Name, sex, date of birth, age, age group [11] and relations of the observed elephants.

Name	Sex	Date of birth	Age	Age group	Relation
Veri	Female	07.1985	36	Large adult	Mother of Nelly
Nelly	Female	27.12.2009	12	Small adult	Daughter of Veri
Umtali	Female	12.1985	36	Large adult	
Bibi	Female	07.1985	36	Large adult	Mother of Panya, grandmother of Ayo
Panya	Female	22.08.2007	14	Small adult	Daughter of Bibi, mother of Ayo
Ayo	Male	03.08.2016	5	Juvenile	Son of Panya, grandson of Bibi
Jumanee	Male	04.09.2007	14	Small adult	

Figure 1 shows the enclosure of the elephants. Due to ongoing construction to enlarge the elephant housing, the bull house and enclosure is temporarily not in use. Therefore, all male and female elephants stay in their housing overnight (yellow box, Figure 1 A; Figure 1 B). During the day, the elephants are let out one by one through a smaller enclosure (red box) to get to the big enclosure (blue shape), where all elephants stay until the end of the day.

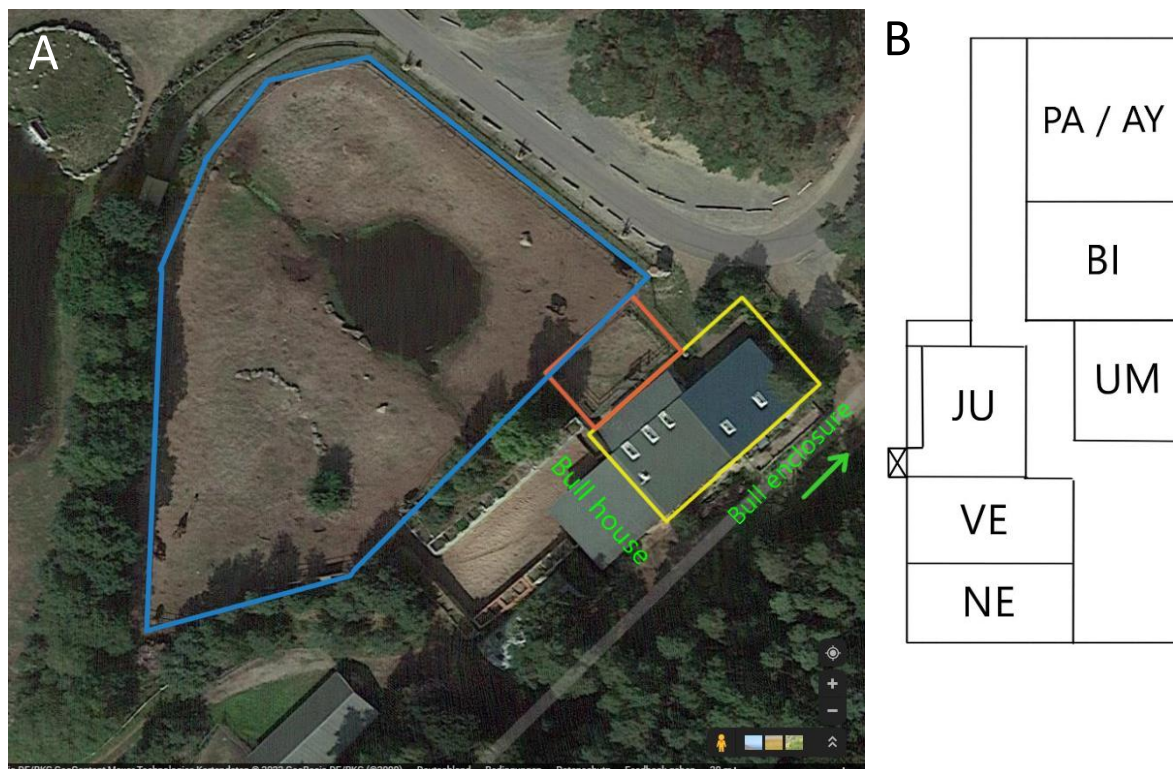


Fig. 1: African savannah elephant housing at the Serengeti-Park. A) The elephants' housing (yellow box) connects to the small enclosure (red box), which leads to the great enclosure (blue shape). The green term „bull house“ marks the separate house the bull usually resides in. The green term „bull enclosure“ with the arrow marks the direction where the separate bull enclosure is located. This snapshot is taken from Google Earth and shows a scale of 20 m. B) Housing boxes of the elephants. Jumanee (JU) resides at the entrance with Veri (VE) right next to him and Nelly (NE) next to Veri. Across Jumanee, Umtali (UM) stays in her box with Bibi (BI) and Panya (PA) and Ayo (AY) next to her. Please note that size proportions of the boxes are not drawn to scale.

The big enclosure contains a great water hole, a smaller mud wallow as well as several branches of wood and stones. The elephants are fed by the keepers primarily with hay or bread, vegetables and fruits for leading or training purposes. However, the animals also had access to naturally growing grass as well as vegetables, fruits and waffles fed by visitors (provided by the safari park) between 10:00 am and 4:00 pm.

2.2 Data collection

During data collection, all elephants were in the great enclosure. A focal and continuous sampling method was used to observe the behavior of the elephant Jumane. Therefore, observation positions were adjusted according to the movement of Jumane. The behavioral contexts of interest were affiliative, aggressive (this includes dominance) and avoidance behaviors with Jumane as the initiator or receiver. The appropriate ethogram is adapted from „ElephantVoices – Ethogram Table“ (see Appendix I). Apart from Jumane’s behaviors, the temperature in °C, weather conditions, tourist presence as well as the location of Jumane and his interaction partner were noted. The temperature and weather conditions were noted at the beginning of each observation and data was collected for Heidekreis, Germany (AccuWeather). A complete data collection table is attached in the appendix (Appendix II). To determine the location of Jumane and his interaction partner, the enclosure was divided into six sections as shown in Figure 2 and approximately divided further into left, middle, right, front, back or water for more specific locations.

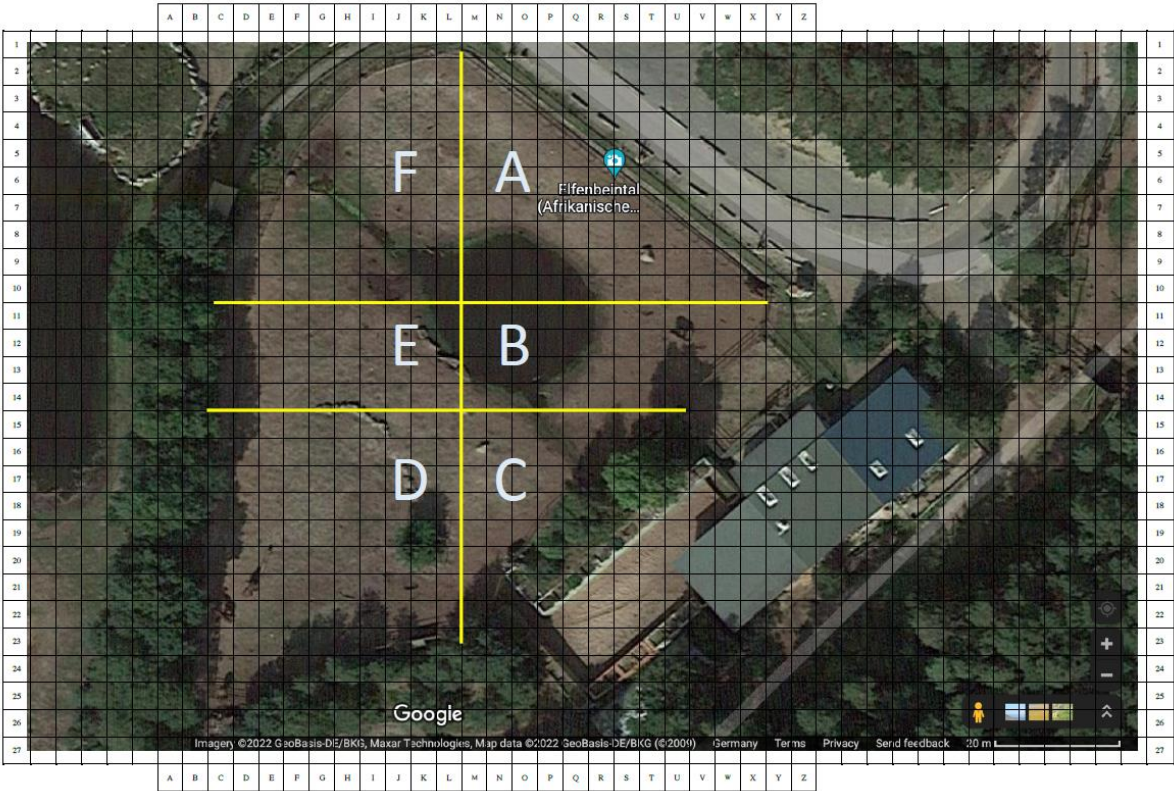


Fig. 2: Enclosure division into six sections. The enclosure is further divided into areas A, B, C, D, E and F. The small grid scale is 4 m. Snapshot is taken from Google Earth with a greater scale of 20 m.

The observation schedule was chosen in a time range when all elephants were out in the great enclosure between 10:30 am and 4:30 pm. Similar to Jeffrey (2017), time of observation was alternated between „Day A“ and „Day B“ observations [8]. „Day A“ observations occurred on Mondays and Wednesdays and started at 10:30 am with 30 *min* observation ranges and 30 *min* breaks in between. „Day B“ observations occurred on Tuesdays and Thursdays and started at 11:00 am with equal observation ranges and breaks in between (Table 2). Therefore, each „Day“ consisted of 6 *h* observation and the alternating pattern was implemented to allow for observations the whole time the elephants were out in the enclosure without having to observe the elephants for 6 consecutive hours.

Table 2: Observation schedule on „Day A“ and „Day B“. Between each observation is a 30 *min* break.

„Day A“	„Day B“
10:30 am – 11:00 am	11:00 am – 11:30 am
11:30 am – 12:00 pm	12:00 pm – 12:30 pm
12:30 pm – 1:00 pm	1:00 pm – 1:30 pm
1:30 pm – 2:00 pm	2:00 pm – 2:30 pm
2:30 pm – 3:00 pm	3:00 pm – 3:30 pm
3:30 pm – 4:00 pm	4:00 pm – 4:30 pm

The observations were made between April 25th and May 12th with a total of 35.5 *h*. On the first day, observations started at 11:30 am in contrast to the planned 10:30 am due to an emergency.

2.3 Animal keeper survey

The elephant keepers were surveyed about their perception on the social behaviors within all the elephants of the group and their perception of Jumanee’s behaviors toward the other elephants. The survey included questions about the social hierarchy within the elephants, their activity during the day, how likely the elephants are to interact with visitors as well as questions about the behavioral contexts of interest. For the latter, the keepers rated which elephant was most or least likely to be affiliative, aggressive (dominant) or avoidant, and especially to which elephant Jumanee was most or least likely to behave in an affiliative, aggressive (dominant) or avoidant manner. The complete survey is attached in the appendix (Appendix III).

The animal keepers’ experience with elephants ranged from 1.2 to 15 years and each keeper is currently employed at the Serengeti-Park Hodenhagen and is primarily responsible for the care of the African elephants.

2.4 Data analysis

Statistical analysis were performed via DATAtab (2022).

To examine the social interactions of Jumanee toward the herd during the day, the means and standard deviations of each observation time were calculated. To evaluate the contexts of interest, social interactions were further divided into affiliative, avoidant and aggressive while behaviors of “other” contexts were ignored. Additionally, only unambiguous behaviors were analyzed in the latter while behaviors that could fit in both the affiliative and aggressive context (such as displays of Orient-Toward, Ears-Stiff or Head-Raising without the presence of additional behaviors to aid in clearly defining whether it was part of affiliative or aggressive behaviors) were left out. Total social interactions, affiliative, avoidant and aggressive behaviors at were analyzed using a non-parametric Friedman test ($\alpha = 0.05$). To examine specific differences of the time groups, a post-hoc test was performed ($\alpha = 0.05$).

The influence of the covariates weather and temperature on affiliative, avoidant and aggressive behaviors of Jumanee toward the herd was analyzed by performing linear regressions.

The distribution of affiliative, avoidant and aggressive behaviors of Jumanee toward the individuals of the herd was analyzed by counting the behaviors toward each individual and performing a non-parametric Friedman test ($\alpha = 0.05$). Differences between groups were examined with a post-hoc test ($\alpha = 0.05$) as well.

To examine if any dominance changes occurred over the course of observations, affiliative, avoidant and aggressive behaviors were first compared at each observation week. Afterwards, the behaviors of interest were distributed to the individual elephants of the herd and compared at each observation week as well. Lastly, Jumanee's distance to Umtali each time he started to display avoidance behavior towards her was analyzed. In this regard, a non-parametric Friedman test ($\alpha = 0.05$) and, if necessary, a post-hoc test ($\alpha = 0.05$) was used for each analysis of dominance changes over the course of three weeks.

The analysis, whether visitor interactions influence natural elephant social behavior, was performed by marking each social interaction with visitors. Therefore, a distribution of affiliative, avoidant and aggressive behaviors during visitor interactions and without visitor interactions is possible. This was analyzed with a non-parametric, two-sided Wilcoxon-test ($\alpha = 0.05$).

3 Results

3.1 Analysis of social interactions of Jumaneer with the herd during the day

Figure 3 shows the total social interactions of Jumaneer with the herd during the observed times of day.

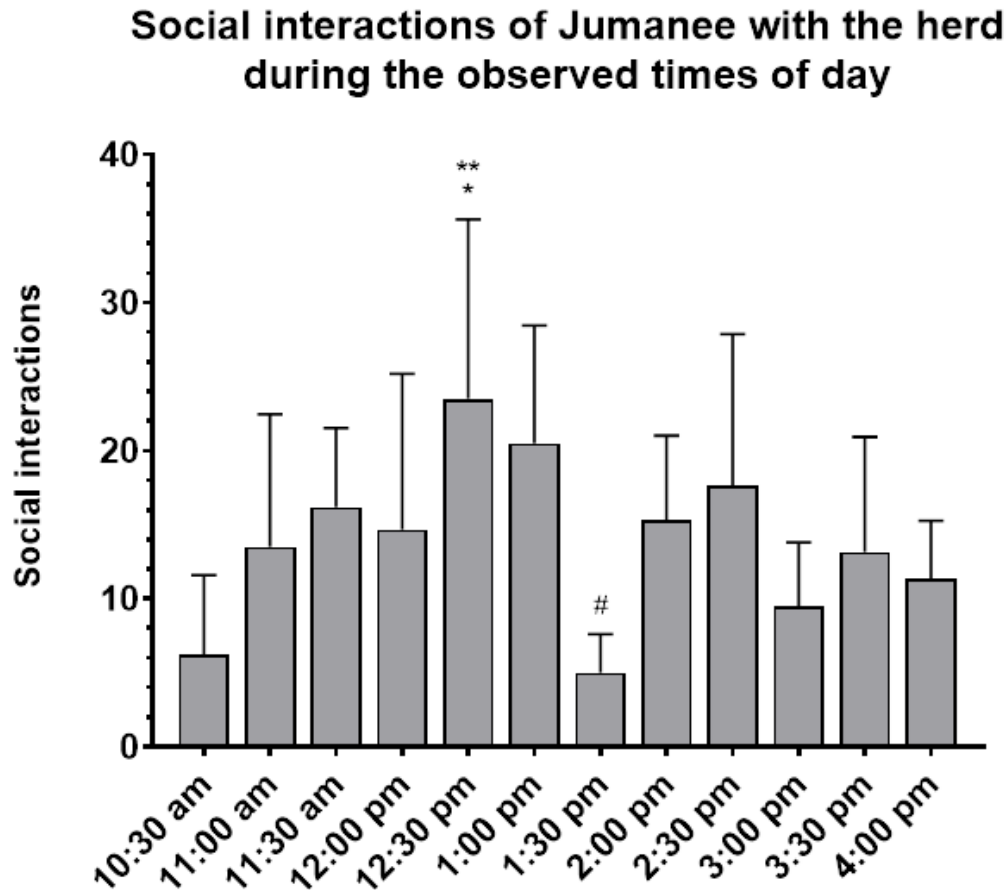


Fig. 3: Total social interactions of Jumaneer toward the herd during the observed times of day. Social interactions at 12:30 pm significantly differed from interactions at 10:30 am (* = $p < 0.05$) and 1:30 pm (** = $p < 0.01$) and social interactions at 1:30 pm significantly differed from interactions at 1:00 pm (# = $p < 0.05$). Error bars show the standard deviation of the mean. (n = 5 (10:30 am), n = 6)

The total social interactions (Figure 3) of Jumaneer with the herd increased until a peak at 12:30 pm (23.5 ± 12.11 interactions), but decreased strongly at 1:30 pm with only 5 ± 2.61 interactions. Half an hour later, the number of social interactions went up to 15.33 ± 5.68 again and then slightly decreased until the end of the observation times (11.33 ± 3.93 interactions at 4:00 pm). A Friedman test showed a significant difference between the interactions of different times of day ($p = 0.015$). A post-hoc test revealed significant differences between 10:30 am and 12:30 pm ($p = 0.03$), 12:30 pm and 1:30 pm ($p = 0.006$) as well as between 1:00 pm and 1:30 pm ($p = 0.019$). The distribution of social interactions in affiliative, avoidant and aggressive behaviors is shown in Figure 4.

Affiliative, avoidant and aggressive behaviors of Jumanee toward the herd during the observed times of day

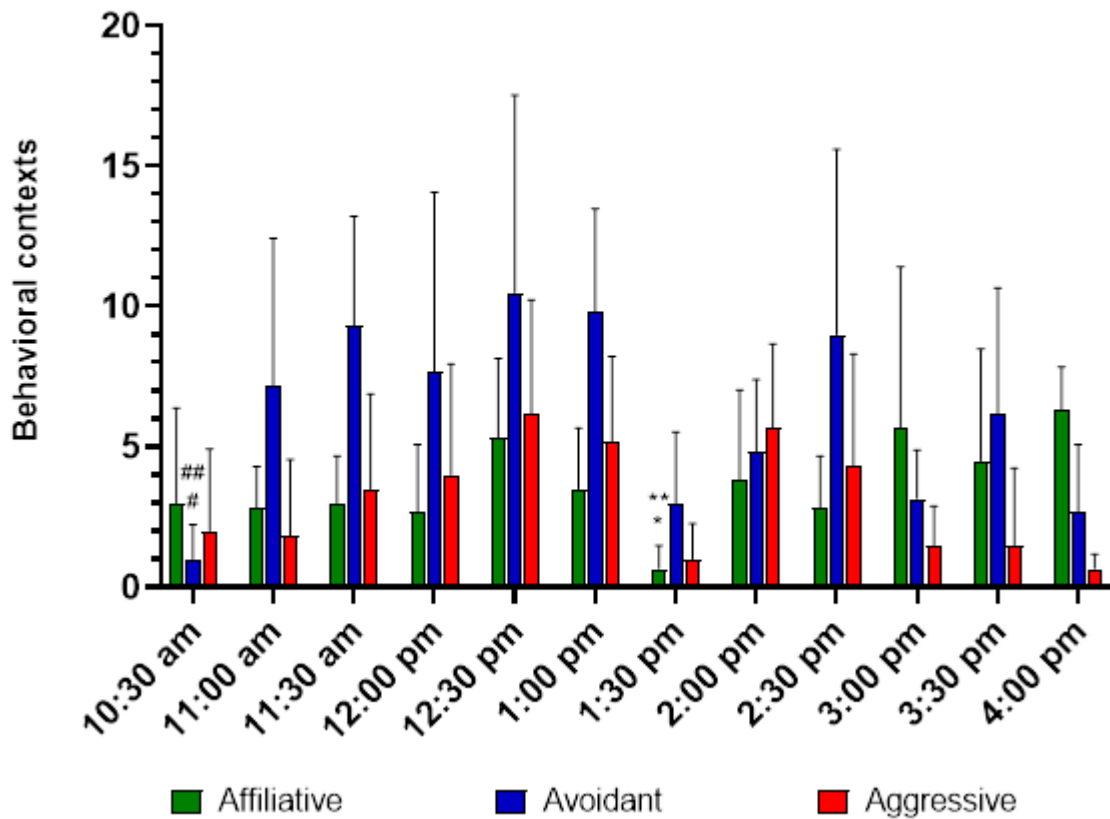


Fig. 4: Distribution of affiliative, avoidant and aggressive behaviors of Jumanee at different times of day. Affiliative behaviors expressed around 1:30 pm significantly differed from similar behaviors expressed at 12:30 pm, 3:30 pm (* = $p < 0.05$) and 4:00 pm (** = $p < 0.01$). Avoidant behaviors expressed around 10:30 am significantly differed from similar behaviors at 1:00 pm (# = $p < 0.05$) and 12:30 pm (## = $p < 0.01$). Affiliative behaviors are represented in green, avoidant in blue and aggressive in red bars. Error bars show the standard deviation of the mean. (n = 5 (10:30 am), n = 6)

A similar time dependent effect shows the distribution of social interactions into affiliative, avoidant and aggressive behaviors of Jumanee toward the herd (Figure 4). Affiliative behaviors stayed at around 3 during the morning (e.g. 3 ± 3.39 at 10:30 or 2.67 ± 2.42 at 12:00 pm), increased at 12:30 pm with 5.33 ± 2.8 affiliative behaviors, but decreased to 0.67 ± 0.82 affiliative behaviors at 1:30 pm. However, the number of affiliative behaviors increased again with a peak at 4:00 pm (6.33 ± 1.51). A Friedman test revealed a significant difference between the different observation times regarding affiliative behaviors ($p = 0.045$). A post-hoc test showed a significant difference between 12:30 pm and 1:30 pm ($p = 0.04$), 1:30 pm and 3:30 pm ($p = 0.03$) as well as between 1:30 pm and 4:00 pm ($p = 0.003$). Avoidant behaviors showed the greatest increase until 12:30 pm (1 ± 1.22 behaviors at 10:30 am, 10.5 ± 7.04 behaviors at 12:30 pm). The number of behaviors decreases at 1:30 pm to 3 ± 2.53 and is rather irregular in the afternoon hours (e.g. 9 ± 6.6 behaviors at 2:30 pm, 3.17 ± 1.72 behaviors at 3:00 pm, 6.17 ± 4.49 behaviors at 3:30 pm). A Friedman test revealed a significant difference in avoidant behaviors as well ($p = 0.007$). A post-hoc test showed a significant difference between 10:30 am and 12:30 pm ($p = 0.008$) as well as between 10:30 am and 1:00 pm ($p = 0.01$). The morning and early afternoon hours show a similar tendency in aggressive behaviors with a slight increase until 12:30 pm (6.17 ± 4.07 behaviors). The lowest number in behaviors is again at 1:30 pm with only 1 ± 1.26 behaviors. Half an hour later, Jumanee's aggressive behaviors increased up to 5.67 ± 3.01 again and then slowly decreased until 4:00 pm with only 0.67 ± 0.52 aggressive behaviors left. A Friedman test

showed a significant difference in aggressive behaviors as well ($p = 0.008$). However, the post-hoc test did not show any significances between specific observation times.

3.2 The influence of covariates on social behavior of Jumanee

The temperature ranged from 6 to 25 °C but did not show any significant influence ($p = 0.343$), ($p = 0.343$, $R^2 = 0.01$). Meanwhile, weather conditions were separated into following categories: cloudy, mostly cloudy, partially sunny, mostly sunny and sunny. In this case, a significant influence of sunnier weather (e.g. as the weather conditions shifted from cloudy to sunny) on total social interactions of Jumanee toward the herd was detected ($p = 0.004$), ($p = <0.001$, $R^2 = 0.96$). While weather conditions showed no significant effect on affiliative behaviors ($p = 0.114$), ($p = 0.078$, $R^2 = 0.62$), avoidant and aggressive behaviors increased linearly to sunnier weather conditions with ($p = 0.001$), ($p = 0.001$, $R^2 = 0.98$) for avoidant behaviors and ($p = 0.029$), ($p = 0.011$, $R^2 = 0.84$) for aggressive behaviors.

3.3 Distribution of affiliative, avoidant and aggressive behaviors of Jumanee toward individual elephants

The distribution of affiliative, avoidant and aggressive behaviors of Jumanee toward each individual is shown in Figure 5.

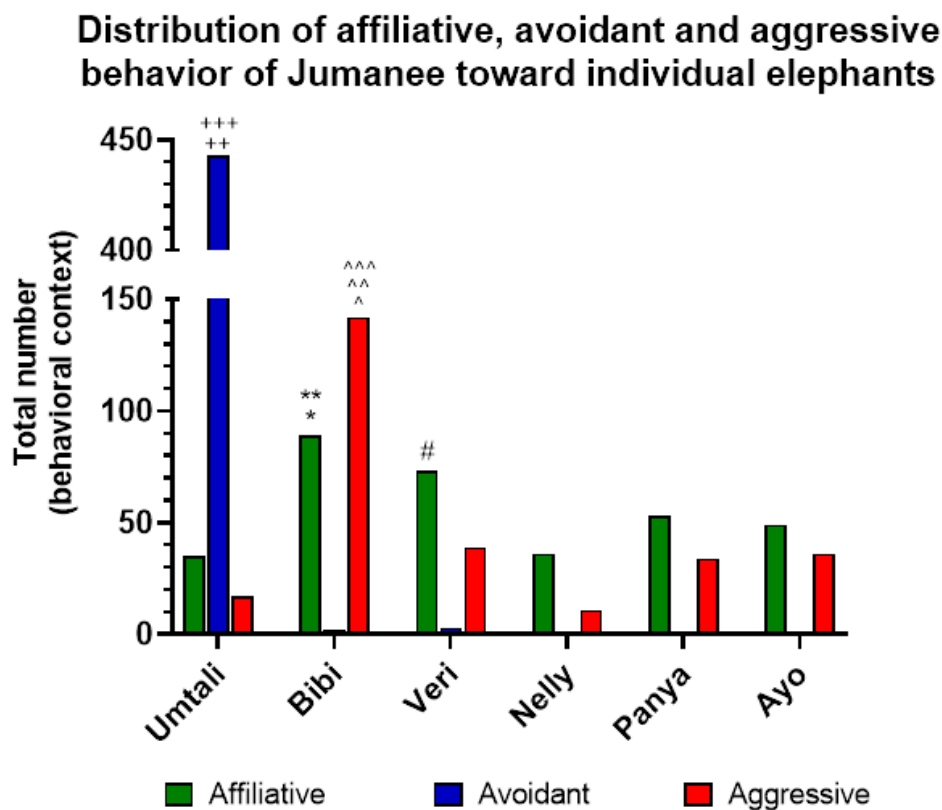


Fig. 5: Distribution of affiliative, avoidant and aggressive behaviors of Jumanee toward each individual of the herd. Affiliative behaviors expressed by Jumanee toward Bibi significantly differed from similar behaviors expressed toward Umtali ($* = p < 0.05$) and Nelly ($** = p < 0.01$) as well as behaviors expressed toward Veri significantly differed from similar behaviors expressed toward Umtali and Nelly ($\# = p < 0.05$). Avoidant behaviors expressed toward Umtali significantly differed from similar behaviors expressed toward Bibi, Veri ($++ = p < 0.01$), Nelly, Panya and Ayo ($+++ = p < 0.001$). Aggressive behaviors expressed toward Bibi significantly differed from similar behaviors expressed toward Panya, Ayo ($\wedge = p < 0.05$), Veri ($\wedge\wedge = p < 0.01$), Umtali and Nelly ($\wedge\wedge\wedge = p < 0.001$). Total numbers of expressed behaviors were counted. Affiliative behaviors are represented in green, avoidant in blue and aggressive in red bars.

Jumanee shows most affiliative behaviors toward Bibi (89 in total) and then Veri (73 behaviors) (Figure 5). Toward the mother and son pair Panya and Ayo, he shows a similar number of affiliative behaviors (53 toward Panya, 49 toward Ayo). Lastly, he shows 36 affiliative behaviors toward Nelly and with 35 behaviors, Umtali receives the least. A Friedman test revealed a significant difference in affiliative behaviors ($p = 0.004$). A post-hoc test showed a significant difference between the number of affiliative behaviors toward Umtali and Bibi ($p = 0.032$), Umtali and Veri ($p = 0.043$), Bibi and Nelly ($p = 0.004$) and Veri and Nelly ($p = 0.027$). Regarding avoidant behaviors of Jumanee, primarily Umtali is the receiver (443 avoidant behaviors in total). For Bibi, two interactions with avoidance behaviors coming from Jumanee could be counted and three behaviors toward Veri. Jumanee showed no avoidance toward Nelly, Panya and Ayo. The Friedman test showed a significant difference in avoidance behaviors ($p < 0.001$) and the following post-hoc test revealed significant higher avoidance toward Umtali in comparison to Bibi ($p = 0.001$), Veri ($p = 0.004$), Nelly ($p < 0.001$), Panya ($p < 0.001$) and Ayo ($p < 0.001$). The distribution of aggressive behaviors, however, were rather similar to affiliative. Jumanee displayed most aggression towards Bibi (142 in total), and aggressive behavior was comparable toward Veri (39 behaviors), Panya (34 behaviors) and Ayo (36 behaviors). Umtali (17 behaviors) and Nelly (11 behaviors) received less aggression from Jumanee. In this case, the Friedman test showed a significant difference as well ($p < 0.001$). The post-hoc test revealed significantly more aggressive behaviors towards Bibi in comparison to Umtali ($p < 0.001$), Veri ($p = 0.004$), Nelly ($p < 0.001$), Panya ($p = 0.016$) and Ayo ($p = 0.014$).

3.4 Examination of dominance changes over the observational course of three weeks

Figure 6 presents the comparison of affiliative, avoidant and aggressive behavior at each week.

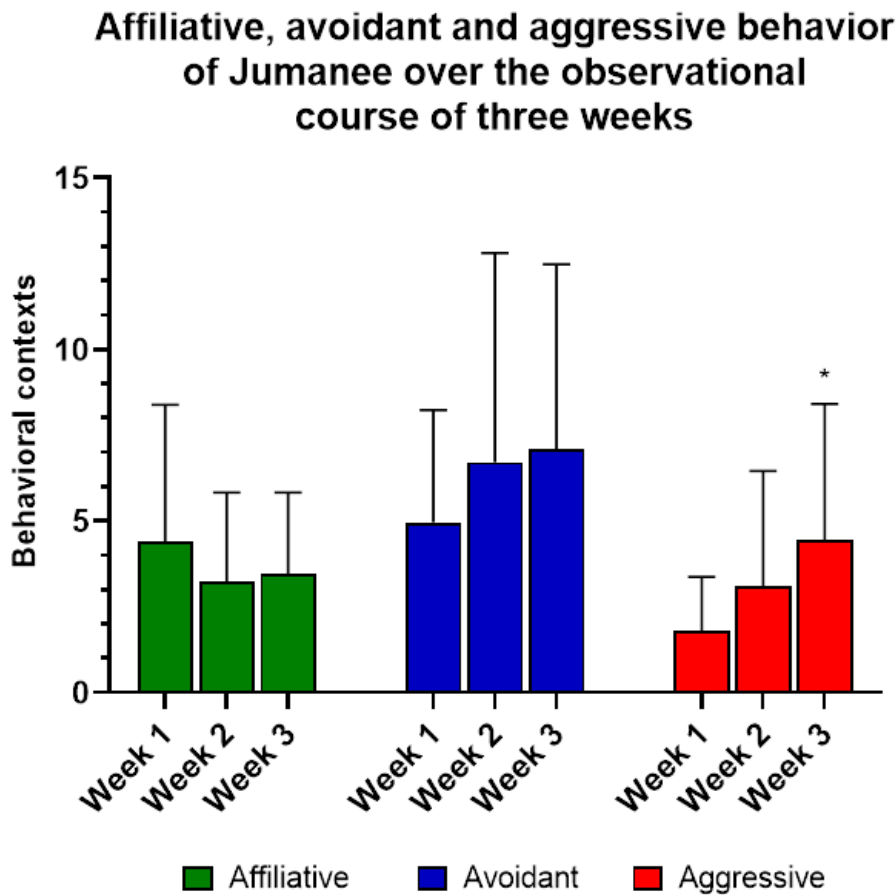


Fig. 6: Affiliative, avoidant and aggressive behaviors of Jumanee over the course of three weeks. Aggressive behaviors expressed in week three significantly differed from similar behaviors expressed in week one (* = $p < 0.05$). Affiliative behaviors are represented in green, avoidant in blue and aggressive in red bars. Error bars show standard deviation of the mean. ($n = 24$ (week 1), $n = 25$ (week 2, 3)).

Figure 6 shows an overview of affiliative, avoidant and aggressive behaviors of Jumanee over the course of three weeks. While in the first week, there are slightly more affiliative behaviors (4.39 ± 4) than in the second (3 ± 2.57) or third (3.52 ± 2.38), but the numbers are relatively similar. Regarding avoidant and aggressive behaviors, there was an increase in both cases over the course of three weeks. Avoidance behaviors increased from 4.96 ± 3.27 in the first week up to 7.26 ± 5.4 in the third week and aggressive behaviors increased from 1.78 ± 3.27 to 4.35 ± 3.96 . A Friedman test revealed a significant increase in aggressive behavior over the three weeks ($p = 0.02$).

The distribution toward individual elephants is shown in Figure 7.

Affiliative, avoidant and aggressive behaviors of Jumanee toward individuals over the course of three weeks

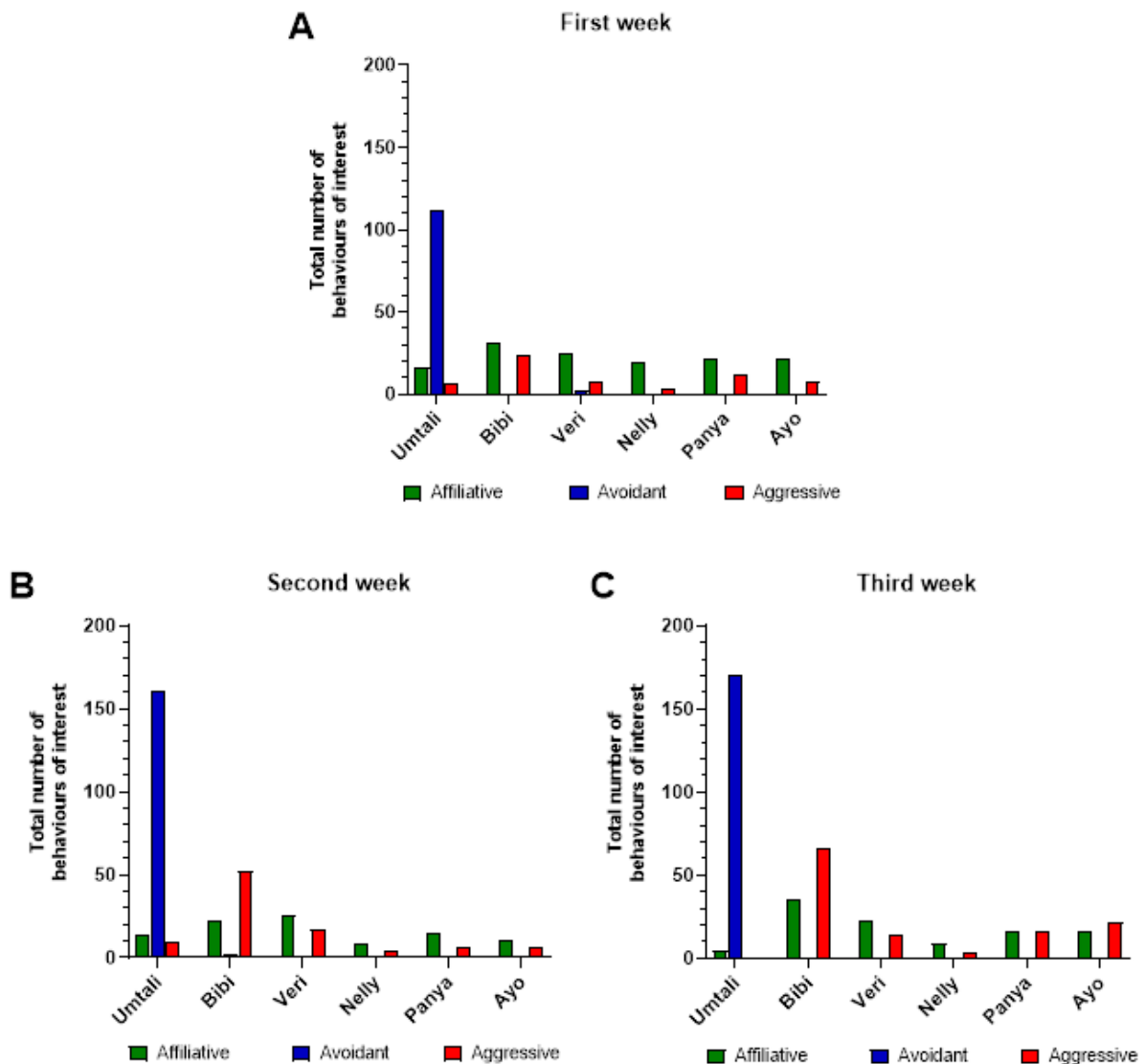


Fig. 7: Distribution of affiliative, avoidant and aggressive behaviors of Jumanee toward individual elephants over the course of three weeks. Distribution toward individuals during the first (A), second (B) and third (C) week. Affiliative behaviors are represented by the green, avoidant by the blue and aggressive by the red bar. Total numbers of the appropriate behaviors of interest are shown.

Figure 7 A-C show the distribution of affiliative, avoidant and aggressive behaviours of Jumanee toward each individual elephant of the herd during the first (A), second (B) and third (C) week of observation. The slight decrease in affiliative behavior most likely occurs due to a decrease in affiliative behavior towards Nelly (19 behaviors in the first week, 8 in the second, 9 in the third) and Umtali (16 in the first, 14 in the second and 5 in the third week). Bibi received, in the second week, less affiliative behaviors (22 behaviors) than in the first (31 behaviors) and third (36 behaviors) week, Veri received each week around 23 – 25 affiliative behaviors. Lastly, the affiliative behaviors toward Panya and Ayo both decreased from 22 behaviors in the first to 16 behaviors in the third week. However, a Friedman test showed no significant differences of each individual in the course of three weeks in regard to affiliative behavior. The increase in avoidance behaviors up to the third observation week primarily results from avoidance toward Umtali. While Jumanee displayed 112 avoidance behaviors in the first week, the

number increased to 161 in the second and 170 behaviors in the third week. In this case, a Friedman test showed no significant differences as well. The increase in aggressive behaviors most likely results from dominance toward Bibi and Ayo. Jumanee displayed 24 aggressive behaviors toward Bibi in the first week, 52 in the second and 66 in the third. Aggressive behaviors towards Ayo went from 8 in the first week up to 22 in the third week. Furthermore, Jumanee showed relatively irregular numbers of aggressive behaviors toward Umtali, Veri and Panya (e.g. 6 behaviors toward Umtali in the first week, 10 in the second and 1 in the third; 8 aggressive behaviors toward Veri in the first week, 17 in the second and 14 in the third), while his behavior towards Nelly stayed at around 3 or 4 at each week. Regarding aggression, a Friedman test revealed no significant differences over the course of three weeks.

Since Jumanee more or less only displayed avoidance during interactions with Umtali, the distance between those two individuals was noted after each interaction (e.g. the distance to Umtali when Jumanee first displayed avoidance behaviors such as Orient-Away or Retreat-From while Umtali Advanced-Towards him). The results are shown in Figure 8.

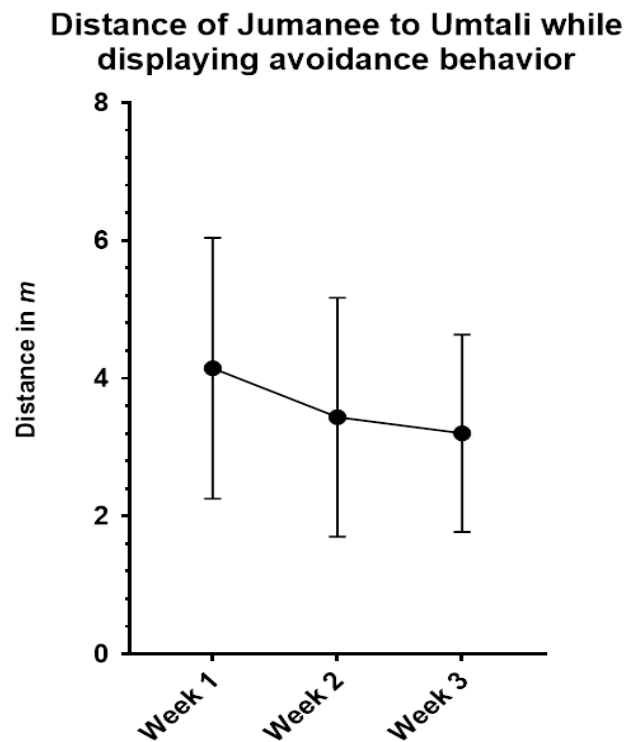


Fig. 8: Distance in m of Jumanee to Umtali while displaying avoidance behavior over the course of three weeks. Error bars show standard deviation of the mean. (n = 41 (week 1), n = 47 (week 2), n = 151 (week 3)).

The distance between Umtali and Jumanee as he initially displayed avoidance behaviors towards her decreased slightly over the course of three weeks (Figure 8). In the first week, Jumanee displayed avoidance behaviors at a distance of 4.15 ± 1.89 m, in the second week at a distance of 3.44 ± 1.73 m and in the third week at 3.2 ± 1.43 m. A Friedman test revealed no significant difference. However, it is important to note that this data was measured by eyes only and that 3.7 times more distances were noted in the third week in comparison to the first week.

3.5 Effects of visitor interactions on natural social behavior

Figure 9 shows the total amounts of the behaviors of interest during visitor interactions and without.

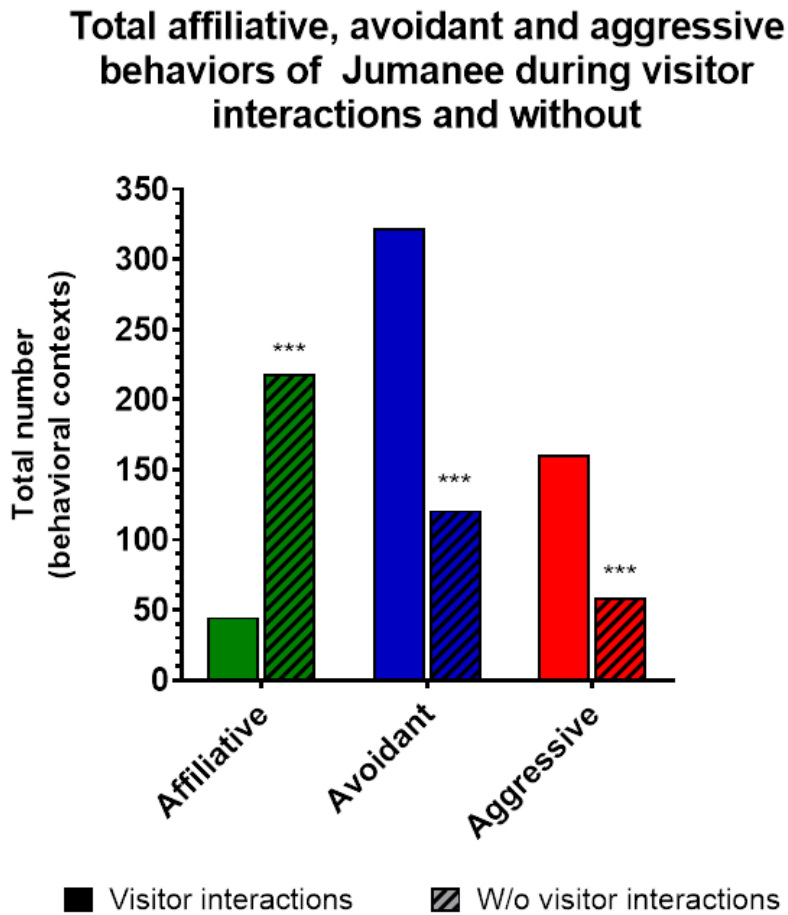


Fig. 9: Distribution of affiliative, avoidant and aggressive behaviors of Jumanee toward the herd during visitor interactions and without. Each behavioral context expressed by Jumanee towards the herd significantly differed during and without visitor interactions (***) ($p < 0.001$). The total numbers of affiliative (green), avoidant (blue) and aggressive (red) behaviors are shown. The filled bars represent behaviors during visitor interactions, the patterned bars represent behaviors without visitor interactions.

During visitor interactions, Jumanee displayed 45 affiliative, 322 avoidant and 161 aggressive behaviors towards the herd. In contrast, without visitor interactions, he displayed 218 affiliative, 121 avoidant and 59 aggressive behaviors. A two-sided Wilcoxon test revealed significant differences in affiliative ($z = -5.75$, $p < 0.001$), avoidant ($z = -4.13$, $p < 0.001$) and aggressive ($z = -3.58$, $p < 0.001$) behaviors during visitor interactions and without.

3.6 Animal keepers' perceptions on the elephants' behaviors

The animal keepers were surveyed to compare their perceptions on the elephant's behaviors to the findings of this study.

Table 3 shows the keepers' perception of questions regarding all elephants kept at the Serengeti-Park.

Table 3: Animal keepers' perception regarding all elephants. This includes hierarchy, activity level, affiliative, aggressive and avoidant behavior as well as visitor interaction. The table shows the elephants ranks from highest to lowest in each category.

Hierarchy rank	Highest activity level	Most likely affiliative	Most likely aggressive	Most likely avoidant	Most likely to interact with visitors
Veri	Umtali	Veri	Umtali	Nelly	Umtali
Umtali	Jumanee	Nelly	Bibi	Panya	Jumanee
Bibi	Bibi	Panya/Ayo	Ayo	Veri	Bibi
Panya	Veri	Jumanee	Jumanee	Bibi	Veri
Nelly	Panya	Bibi	Panya	Ayo	Nelly
Jumanee	Ayo	Umtali	Veri	Jumanee	Panya/Ayo
Ayo	Nelly		Nelly	Umtali	

Regarding the hierarchy ranks, the keepers noted that cows and bulls should be considered separately in this context since bulls usually are not part of the maternal hierarchy. Activity levels, aggressiveness and visitor interaction depends on the situation, as noted by the keepers.

Table 4 shows the keepers' perception regarding the questions with a Jumanee focus. Therefore, the herd is ranked in who is most to least likely to receive affiliative, aggressive or avoidant behaviors from Jumanee.

Table 4: Animal keepers perception on affiliative, aggressive and avoidant behaviors received from Jumanee. The table shows the remaining elephants in order of who is most to least likely to receive the behaviors of interest from Jumanee.

Most likely to receive affiliative behaviours from Jumanee	Most likely to receive aggressive behaviours from Jumanee	Most likely to receive avoidant behaviours from Jumanee
Veri/Nelly	Bibi	Umtali
Bibi	Panya	Veri
Panya	Ayo	Nelly
Ayo	Nelly	Ayo
Umtali	Veri	Panya
	Umtali	Bibi

4 Discussion

4.1 Social behavior of the elephants is dependent on their daily routine

The analysis of Jumanee's daily social interactions resulted in an increase in total social interactions (Figure 3) as well as in affiliative, avoidant and aggressive behaviours until 12:30 pm (Figure 4). Interestingly, there was a decrease in all social interactions at 1:30 pm in comparison to the overall higher amounts of interactions and behaviors in the noon and early afternoon hours. Until 4:30 pm, total social interactions as well as aggressive behaviors decreased again, while avoidance behaviors were displayed rather irregularly. However, affiliative behaviors increased and reached a peak at 4:00 pm.

In contrast, Jeffrey (2017) observed African savannah elephants at a similar time frame (9:00 am – 4 pm) and revealed a peak in total social behaviors in the morning at 11:00 am and low numbers of social interactions in the afternoon at around 2:00 pm. In this current study, the elephants were out in the enclosure since around 10:15 am until 4:30 pm and observations took place from 10:30 am until 4:30 pm. Therefore, similar to Jeffrey (2017), no observations in the early morning, evening or night hours could be performed. During the observed hours, total interactions were generally higher at noon with the exception of 1:30 pm (Figure 4). At around 10:00 am until 4:00 pm, park visitors had the possibility to feed the elephants with fruits and vegetables provided from the park. However, visitors primarily were present since 11:00 am with larger crowds during noon. In the afternoon hours, mostly smaller visitor crowds or only a few individuals were present. In addition to that, there were two different feeding tours taking place during midday hours. At 12:30 pm or 1:00 pm, the „Elite Safari“ took place and at 2:30 pm (once at 2:00 pm), a feeding tour called „Big Five Express“ took place. These feeding tours could explain the elevated numbers in social interactions at these hours of the day, particularly regarding the amounts of avoidance and aggressive behaviors presumably due to food competition. To strengthen this finding, Jumanee and his interaction partners were primarily located in areas A and B, where feeding through visitors is possible during feeding tours. In this regard, the extremely low number of social interactions at 1:30 pm could indicate some sort of self-soothing of the individual elephants immediately after the highly stressful situation influenced by the Elite Safari.

Horback *et al.* (2014) reported that positive social interactions such as affiliative most likely occurred in the early morning (6:00 am), at noon (1:00 or 3:00 pm) and in the early evening hours (7:00 pm). In contrast, Jeffrey (2017) reported most affiliative interactions at 10:00 am and lower amounts at 12:00 pm. In the study presented here, most affiliative interactions occurred at noon and in the afternoon (Figure 4). Since no observation took place in the early morning hours, no results can be presented in this regard. The increased affiliative interactions at noon could be explained due to the generally higher amounts of total social interactions. The increasing affiliative behaviors in the afternoon could be a result of low visitor numbers and food competition – whether from visitors or hay provided by the keepers. Between 3:30 and 4:00 pm, the elephants primarily waited to go back into their boxes and typically remained in area B or walked around in area B or A. Therefore, more affiliative interactions were possible. However, Jumanee generally showed less affiliative interactions in comparison to avoidant and aggressive behaviours. This could also be explained by the fact that affiliative interactions typically or most likely involve a calf or juvenile with its mother [9], but Jumanee already is a small adult without any relatives in the herd.

According to Horback *et al.* (2014), negative interactions occur in the early morning (6:00 am) and late evening (7:00 and 10:00 pm) but only at very low rates and due to dominance. In the study of Jeffrey (2017), agonistic behaviors correlated to total social interactions and therefore peaked during morning and were lower in the afternoon. Visitor presence has been reported to influence the elephants toward more agonistic behaviors [8]. In the current study, negative interactions such as aggressive and

avoidant behaviors were highest during noon and the early afternoon hours with a low at 1:30 pm (Figure 4). Here, negative interactions also occurred primarily due to dominance status within the herd and not because of true aggression. As previously mentioned, avoidance as well as aggressive behaviors peaked during times of the feeding tours suggesting that food competition might lead to stressful situations and therefore result in a higher peak of behaviors related to dominance status. As such, elevated levels of aggression may indicate or result in poor welfare or stress (Horback *et al.*, 2014).

To summarize, avoidant and aggressive behaviors of Jumanee toward the herd peaked during noon resulting in higher total social interactions during these hours. These elevated behavior numbers might have been negatively influenced due to food competition caused by visitor feedings. In between regularly occurring feeding tours, Jumanee barely interacted with the herd. However, this might also be a result of stress caused by competition over food and displays of dominance within the herd. Affiliative behaviors occurred generally lesser and primarily in the afternoon hours when avoidant and aggressive behaviors slowly decreased. However, the elephants are only able to freely roam around the enclosure between around 10:15 am and 4:30 pm. The remaining time, the animals are kept in separate boxes in which physical contact is not always possible. For example, Jumanee is only in direct contact to Veri and otherwise nearest to Umtali (see Figure 1 B). It has been shown that unrestricted enclosure access, and thus direct contact, facilitates affiliative behaviors [12]. Particularly at night, since elephants sleep for only 4 – 6.5 h [12]. Therefore, the elephants have limited time during the day to perform natural behavior and are always confronted by food competition resulting in higher amounts of negative behaviors such as aggressive or avoidant and less affiliative interactions. Observations should be repeated in 24 h frames with cameras installed in the boxes, for instance, or perhaps the elephants could be kept outside in the enclosure at nights during the summer to get a better look at the elephants' natural behavior and ideas for enhanced management and husbandry.

4.2 Sunnier weather increased dominance displays

The analysis of the covariates temperature and weather conditions showed a significant increase in avoidant and aggressive behaviors of Jumanee as weather became sunnier. Temperature, on the other hand, did not influence social behavior.

Sunnier weather might arouse the impression of being in the dry season, where resources are limited [13] while during the wet season, there has been a reported lack of competition since resources are more widely available [13]. In this case, dominance relations are driven by competition and individuals of higher rank are predominant [13]. Jumanee is solitary in nature and not part of the social structure of the herd, but he does associate with family units to which he is not related. Therefore, he usually does not have a specific rank in the herd and dominates the females by size and strength. [1]. This could lead to stronger dominance displays when Jumanee is with the herd and the weather gets sunnier, instinctively indicating less resources. The elephants display higher amounts of dominance behaviors such as aggression and, in return, avoidance behaviors, over scarce resources such as food or water and mud wallows.

4.3 Jumanee's social behavior is highly dependent on the individual he interacts with

Jumanee displayed most affiliative behaviors towards Bibi, second most towards Veri and least towards Umtali and Nelly (Figure 5). Avoidant behaviors were more or less only directed towards Umtali. Highest aggressive or dominant behaviors were displayed towards Bibi and least aggressive towards Nelly.

The female elephants Umtali, Bibi and Veri are categorized as large adults, Nelly and Panya as small female adults and Ayo as a male juvenile. Therefore, Jumanee generally displayed most social

interactions toward large adults relative to similar social interactions towards small adults and a juvenile male. According to Jeffrey (2017), adults perform higher rates of agonistic and affiliative behaviors than juveniles as displays of dominance, discipline or mothering. In this case, the female large adults are higher in the social hierarchy and therefore particularly show displays of dominance in order to compete over resources in comparison to younger smaller adults or juveniles.

Out of the large adult elephants, Jumanee interacted most with Umtali and Bibi (Figure 5). Those three often were together in areas A and B where feedings from visitors were possible (whether it was due to general visitor presence or specific feeding tours such as the Elite Safari or Big Five Express). These aspects also fit the perceptions of the animal keepers as they ranked Umtali as the elephant most likely to be active and to interact with visitors, Jumanee second and Bibi third (see Table 3). Interestingly and particularly during food competition, there is a dominance triangle between those three individuals. Umtali typically dominates Jumanee, Jumanee dominates Bibi and Bibi dominates Umtali in return. Thus, Jumanee primarily displays avoidant behaviors during social interactions with Umtali. With Veri and Bibi, he displayed avoidant behaviors two or three times, but never with the remaining individuals. Umtali is the only elephant dominating Jumanee and did so whenever possible. In this case, weather conditions as mentioned in 6.2 could have an influence, since Umtali primarily dominated Jumanee during feeding situations (whether it was food from visitors or provided by the keepers) but also in terms of mud and water mallow.

The high amounts of observed avoidance behaviors of Jumanee during interactions with Umtali are comparable with the keepers' predictions of Umtali as the individual most likely to receive avoidance behaviors from Jumanee. During interactions with Bibi, Jumanee primarily displayed aggressive behaviors. However, as previously mentioned, aggression was almost exclusively displays of dominance and never with intent to harm. Particularly in the case of Bibi, as Jumanee also directs most affiliative behaviors toward her, dominance display presumably contributes to courtship behavior. This last aspect is similar to the predictions of the keepers who ranked Bibi as the elephant most likely to receive aggressive behaviors but in a dominance and courtship way.

Interestingly, Veri, the matriarch of the herd, is less active than Umtali, Jumanee or Bibi and mostly stayed in the background of the enclosure near her daughter Nelly. In situations with many visitors present or during feeding tours, she often interacted with the elephants of the dominance triangle as well. However, Jumanee was usually preoccupied with Umtali and Bibi, so interactions with her did not occur as often (Figure 5). When they did occur, he dominated her in food competition or displayed affiliative behaviors towards her, second to Bibi. Also in this case, affiliative interactions contributed to courtship behavior.

Jumanee interacted least with Nelly (Figure 5). If he did, it was either in a dominant or affiliative situation. However, he displayed least aggressive behaviors towards her. This could result from the facts that Nelly is the daughter of Veri and they both grew up together. Affiliative behaviors toward her contributed to a courtship context most of the time. However, since Nelly was usually located in areas D and E (see Figure 2) and barely approached visitors, Jumanee did not interact with her as often as with the other elephants.

In comparison to the keepers' perception, first Veri and Nelly and then Bibi were to receive most affiliative behaviors of Jumanee. After observing the elephants, Bibi received most affiliative behaviors, but Jumanee generally interacted more with her than with Veri and Nelly due to similar space usage of the enclosure.

The amounts of behaviors Panya and her 5-year-old son Ayo received from Jumanee are almost identical, because they almost exclusively roamed together in the enclosure. In comparison to Nelly,

Panya and Ayo are more likely to approach visitors or at least reside in areas near Jumanee (for example, they often stay in area F). Therefore, Jumanee generally interacted more with Panya and Ayo in contrast to Nelly (Figure 5). However, affiliative behaviors toward Panya barely led to courtship situations. In this case, Ayo may act as a disruptive factor as he is a rather bold juvenile that likes to test his boundaries during interactions with the older individuals. For example, if Jumanee displays dominance toward Panya and Ayo, Panya immediately retreats from Jumanee while Ayo often stayed in his place.

To conclude, Jumanee's behaviors are strongly dependent on the rank of the herds' elephants. Large adults rank higher in the social hierarchy than small adults or juveniles and therefore compete for food. Therefore, he generally interacted more with the large adults. However, this aspect is also strongly dependent on the individual. As he can dominate all other elephants except for Umtali, he predominantly displays avoidance behaviors during interactions with her. Since Bibi most often is present during interactions with Umtali (for example in dominance displays during feeding situations), she received the second most interactions. However, Bibi primarily received aggressive and affiliative behaviors. This could either be a result of Jumanee dominating her in a courtship background but also presumably due to the generally stressful situation when he gets dominated by Umtali repeatedly. So, he might also use Bibi as an outlet for his own stress as she is mostly the elephant nearest him other than Umtali. Further assessments are required to better understand this relationship. With Veri, Nelly, Panya and Ayo, Jumanee interacted less since they primarily resided in the background of the enclosure. However, affiliative behaviors toward Nelly and Veri most often contributed to courtship situations.

4.4 Jumanee increases his dominance displays via greater aggression

Over the observational course of three weeks, Jumanee showed increasing dominance toward the herd. Affiliative behaviors slightly decreased but remained the same (Figure 6). His aggressive behaviors significantly increased within the three weeks (Figure 6) and he primarily directed them toward Bibi and Ayo (Figure 7). Furthermore, although he displayed more avoidance behaviors toward Umtali, his distance to her in the third week of observation was slightly decreased relative to the first week of observation (Figure 8).

Regarding the slight increase in avoidance behaviors across the three weeks (Figure 6), it is important to point out that the Elite Safari tours began in the second half of the first week. With the Elite Safari being a very stressful situation due to strong food competition, most social interactions were observed in the hours when this feeding tour took place. Therefore, the lower number of avoidance behaviors in the first week is also a result of the lack of the Elite Safari. The avoidance behavior showed no significant increase over the course of three weeks but was similar during the second and third weeks relative to the first week. This provides support that avoidance behavior may be influenced by food competition. This finding should be regarded with caution since much less data was noted in the first week in comparison to the third week and distances were only measured visually by the observer. For future studies, the impact of visitor feeding tours, such as the Elite Safari on avoidance behavior should be addressed.

Notably, Jumanee significantly increased his aggressive behaviors over the course of three weeks. Therefore, a change in dominance is visible. Not only due to a significant increase in aggressive behaviors but also due to lower distances between him and Umtali before displaying avoidance behaviors. To further analyze possible changes in his dominance status within the herd, the analysis should be repeated in regular gaps (e.g. every four months) and compared with this current study.

4.5 Visitor interactions significantly influence natural social behavior

Jumanee displayed significantly less affiliative and significantly more avoidant and aggressive behaviors toward the herd during visitor interactions.

This is strengthened by Jeffrey (2017), where tourist presence with the opportunity to feed the elephants resulted in more agonistic social interactions caused by food competition. As already indicated several times in 6.1 – 6.4, Jumanee most likely displayed avoidance behaviors towards Umtali and aggressive behaviors towards Bibi in situations where visitors had the opportunity to feed the animals. In this regard, the analysis of behaviors during visitor interactions revealed a significant negative influence of visitor feeding opportunities in the natural social behavior of the elephants. As Horback *et al.* (2014) reported, negative social interactions indicate or result in stress. In comparison to the current study, Jumanee displayed significantly more negative social behaviors during visitor interactions than during natural social interactions with the herd. Therefore, the opportunity of visitors to feed the elephants led to avoidance behaviors and dominance displays due to competition over food, and significantly decreased positive social interactions such as affiliative behaviors. This situation can be improved if visitor feeding opportunities are limited and the natural feeding behavior of elephants are nurtured.

5 Conclusion

This report examined the dominance or hierarchy status of a small adult African savannah elephant bull Jumanee within the herd at the Serengeti-Park Hodenhagen.

Findings revealed a time-dependent behavior of Jumanee. His dominance behavior (aggressive and avoidant) was highest during noon, with a self-soothing time at 1:30 pm which occurred between more stressful situations due to food competition (Figure 4). Affiliative behaviors were highest in the afternoon with less visitors present and reduced food competition (Figure 4). The covariate weather condition influenced the behavior of the elephants as sunnier weather increased dominance displays over resources such as food or use of mud wallows. Additionally, visitor interactions negatively influenced natural social behaviors as increased avoidance and aggressive behaviors were displayed. In contrast, without visitor interactions, Jumanee showed more affiliative behaviors toward the herd (Figure 9). The distribution of Jumanee's behavior toward the herd is dependent on the individual's rank. Higher ranked elephants compete with him over food. In this context, he primarily displayed avoidance behaviors during interactions with Umtali and aggressive behaviors towards Bibi, whether in a courtship context or as a form of a stress outlet (Figure 5). Toward Bibi, Veri and Nelly, he was most affiliative, which led to a courtship context as well (Figure 5). The overall analysis of his dominance displays revealed an increase in dominance over the course of the three weeks observation. He displayed further aggressive behaviors towards Bibi (Figure 7) and reduced the distance towards Umtali before showing avoidance behaviors (Figure 8).

To conclude, Jumanee shows dominance behavior towards every individual elephant except for Umtali. Though, his dominance behavior is primarily directed at Bibi, he also shows interest in the females with signs of affiliative behaviors, which may contribute to courtship situations. However, bulls usually dominate females by their enormous size, weight and strength [1]. In this regard, Jumanee is still a small adult bull. Future studies could aim towards understanding factors that may influence Jumanee's dominance, ranked status and possible breeding.

6 Future Outlook

There are many aspects that might negatively influence the dominance status of Jumanee, in particular since he is generally a rather calm and less dominant bull (See Supplementary Materials). However, if he gets the possibility to further develop and experience a more stable musth with cows in estrus, he will most likely be able to dominate all cows. But in a long-living species such as the African savannah elephant, it may take more time. To support the development of Jumanee and therefore his dominance status within the herd, there needs to be the possibility of separating the herd or at least Umtali. Also, limiting the time frames in which visitors can feed the animals, or investing in different forms of enrichment, might reduce stress and support natural behavior while the elephants are out in the enclosure. To improve housing and management of the animals, a 24 h observation should be considered to examine the behavior of the elephants in their boxes overnight. This might give insight into the elephants' natural behavior and further improve the welfare of animals kept under human care.

7 Supplementary Materials

Several aspects that may influence Jumanee and his dominance display:

- The continuous opportunity of visitors to feed the animals when they are out in the enclosure results in stress.
- Sunnier weather might give the impression of a dry season with sparse resources and therefore further increases competition over resources.
- The ongoing construction site results in stress due to unknown sounds and people.
- The elephants are housed in separate boxes most of the time with barely physical interactions possible. This might suppress natural behavior during the night [12].
- There is currently no possible separation of the bull and the herd. Therefore, Jumanee continuously resides with the herd, whether at night in separate but close boxes or together out in the enclosure. So, he is in permanent contact with all the cows and no focused contact to specific cows or cows in estrus is possible. This might restrict his development as bulls usually are loners or establish themselves in bull societies [2, 5] and he cannot focus on specific cows for e.g. breeding purposes.
- Umtali is a disruptive factor as she continuously dominates Jumanee whenever possible further resulting in stress. A separation of those two should be considered as soon as the construction site allows. As mentioned by the animal keepers, after the older bull Tonga left the Serengeti-Park, Jumanee stayed at the bull house together with Umtali (see Figure 1 A). During this time, she dominated him. Afterwards, there was a time where Jumanee was alone in the bull house and he was able to dominate her. Now, that they are in relatively close contact in boxes and together in the enclosure, she dominates him again.
- Jumanee was greatly dominated by Tonga. In 2012, with four years of age, Jumanee arrived at the Serengeti-Park. At this time, Tonga was the breeding male with 24 years of age. First, Tonga was the leader and Jumanee had the possibility to learn from the older bull. However, as Jumanee aged, Tonga further focused on Jumanee, and started to dominate him (his dominance displays got more aggressive by the time) while ignoring the cows, unless the cows were in estrus. In 2020, Tonga left the Serengeti-Park. The then 13-year-old Jumanee was supposed to establish himself in his new role as the breeding male. As explained by the animal keepers, Jumanee first had problems accepting the bull house and enclosure since the smell of Tonga still lingered and kept suppressing him.
- Older, higher ranked bulls can suppress premature musth in young males to decrease inappropriate behavior (e.g. aggressiveness toward non-elephant targets such as vehicles and other animals) [6, 14, 15]. As Jumanee is still very young with 14 years of age, no stable musth can be expected from him. In young males, musth is experienced at irregular intervals with durations of only a few days or weeks. Older males experience more stabilized musth with approximately annual occurrence and durations of several months [1]. However, males experience their first stable musth between 25 and 30 years of age [5]. As soon as Jumanee gets into musth, his dominance status temporarily raises [1] and he will be able to dominate all female elephants, even Umtali.
- Except for Bibi, no other female elephant was in estrus during the time of observation. Although the estrus cycle takes 14-16 weeks, the receptive period lasts for only 2-10 days in which the female signals her receptive period by chemical, auditory and behavioral signals [16]. And though male elephants are physiologically able to reproduce by 14-17 years of age [17], it has been reported that musth males have higher mate guarding and mating success [1]. Jumanee did show affiliative and dominance behavior, particularly directed at Bibi, that also contributed to courtship behavior. The cows also showed interest in him, as they stood

and waited as he displayed affiliative or courtship behavior. However, at the time of observation, food seemed more interesting. This might change when he is in musth and cows in estrus.

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Appendix I - Ethogram

Table 5: Ethogram. The behaviors are distributed in behavioral contexts such as affiliative, avoidant, aggressive and others and further divided into body parts. Each behavior has a specific abbreviation and description.

Affiliative			
Body part	Behavior	Abbreviation	Description
Whole body	Social-Rubbing	So-R	Approaching a stationary individual from behind and rubbing the head, ear, shoulder and/or flank against the standing individual.
	Walk-Wait	W-Wa	Alternatively walking a few steps and then standing idly while waiting for other elephants to either catch up or to initiate movement.
	Purposeful-Walk	P-W	An elephant walking with long strides in a directed, intentional manner as if he or she has a goal in mind.
	Orient-Toward	O-Tw	Reorientation of the body to face or look at another elephant, animal or object of interest.
	Walk-Toward	W-Tw	Walking toward another elephant.
	Lean	Le	One elephant presses all or part of its body against another.
	Back-Toward	B-Tw	Walking backward toward another or other elephant(s).
Ears	Ear-Brush	E-Bru	Purposefully brushing a flared ear against the face, head or body of another.
	Ears-Stiff	E-Sf	An elephant holding his or her ears tensed, cocked or stiffened.
	Ear-Flap-Slide	E-Fl-Sl	Flapping the ears moderately loudly and then swishing them against the neck and shoulders causing a rasping sound.
	Ear-Slap	E-Sla	Slapping the ears loudly and sharply against the neck and shoulders.
	Rapid-Ear-Flapping	R-E-Fl	Flapping the ears vigorously and rapidly in a raised position.
	Ear-Lifting	E-Li	Spreading and lifting the ears.
Head	Head-Raising	H-Rs	Raising the head.
	Look-Back	L-B	Standing or walking away while looking back over the shoulder.
	Pushing	Push	Pushing the head or base of trunk into the back, side, head or trunk of another to move it away or along or to assist it.
	Open-Mouth	O-M	Opening the mouth.
	Open-Mouth-to-Open-Mouth	OM-OM	Opening the mouth while touching it to another elephant's mouth who is also displaying Open-Mouth.
	Tusk-Clank	Tu-C	Clicking (affiliative) or clanking of tusks together.
	Temporin	Tem	Streaming of secretion from the temporal glands of non-musth elephants.
Trunk	Trunk-to-Mouth	T-to-M	Reaching of the trunk to touch or near touch or place into the mouth of another.
	Trunk-to-Genitals	T-to-G	Reaching of the trunk to touch or near touch the genitals of another.
	Periscope-Trunk	Per-T	Lifting and holding the trunk up in an S-shape.
	Trunk-to-Body	T-to-B	Reaching of the trunk toward or touching the body of another.
	Trunk-to-Face	T-to-F	Reaching of the trunk to touch, or near touch the face of another.
	Trunk-Toward	T-Tw	Using the trunk to point toward or sniff toward an individual, object or scent of interest. The trunk is held relatively straight and pointed in the direction of the object of interest.
	Allo-Check-Tusk	A-Tu	Using the tip of the trunk, or its fingers, to feel the tusks of another elephant.
	Allo-Trunk-Sucking	A-T-Su	An elephant grasping the trunk of another elephant, placing it in his or her mouth and sucking on it.
	Grasp-Leg	G-Leg	Using the trunk to briefly grasp the leg of another.

	Grasp-Tail	G-Ta	Using the trunk to briefly grasp the tail of another.
	Grasp-Trunk	G-T	Using the trunk to grasp the trunk of another.
	Grasp-Tusk	G-Tu	Using the trunk to grasp the tusk of another.
	Trunk-Push-Down	T-Pu/Do	Placing the trunk over the head of an opponent and pushing down.
	Trunk-Twining	T-Twi	Using the trunk to point toward or sniff toward an individual, object or scent of interest. The trunk is held relatively straight and pointed in the direction of the object of interest.
Tail	Tail-Raising	Ta-Rs	Raising the tail.
Vocalization	Rumble	R	Call with very low fundamental frequencies.
	Trumpet	Tru	A forceful expulsion of air through the trunk, creating a trumpeting sound.
Aggressive			
Whole body	Advance-Toward	Adv	Purposeful, directed walking with hostile intent toward another elephant, or toward a perceived non-elephant threat. Includes a single step to a persistent, prolonged and highly aggressive pursuit as a fast walk.
	Kick-Dust	Ki-Du	An individual Advancing-Toward or Charging in the direction of an offending object and at the end of the movement appears to ,stub its toe’ and kicks up a cloud of dust in the direction of its antagonist.
	Sashay	Sash	An elephant taking exaggerated sideways steps, to maneuver rapidly into a new position that is immediately to the elephant’s left or right.
	Look-Back	L-B	Standing or walking away while looking back over the shoulder.
	Orient-Toward	O-Tw	Reorientation of the body to face or look at another elephant, animal or object of interest.
	Run-Toward	R-Tw	Running towards another elephant.
	Run-After	R-Af	Moving at a fast amble, or ‘run’ after another elephant.
	Ramming	Ram	Rushing at another with head lowered and trunk curved under (to expose tusks) and goring or poking it with the tusks.
Ears	Ear-Folding	E-Fo	Forcing the lower half of ear under and back so that a prominent horizontal ridge or fold appears across the ear.
	Ear-Spreading	E-Sp	Standing or moving with the ears fully extended at around 90 degrees from the body.
	Ear-Slap	E-Sla	Slapping the ears loudly and sharply against the neck and shoulders.
	Ears-Stiff	E-Sf	An elephant holding his or her ears tensed, cocked or stiffened.
Head	Pushing	Push	Pushing the head or base of trunk into the back, side, head or trunk of another to move it away or along or to assist it.
	Tusking	Tu	Poking another elephant with the tip of the tusks.
	Bow-Neck	B-Ne	An aggressor lowering the head and bowing the neck downward and simultaneously tilting the head upward so that the tusks are approximately horizontal to the ground.
	Open-Mouth	O-M	Opening the mouth. During excited vocal interactions elephants open their mouths wide, often holding their trunks curved upward, exposing the mouth.
	Tusk-Clank	Tu-C	Clicking or clanking the tusks together.
	Head-Raising	H-Rs	Raising the head.
	Head-Swinging	H-Sw	A slow swinging of the head from one side to the other.
	Chin-Up	C-Up	Standing or Walking with the “chin” or jawline lifted up so that it is almost parallel to the ground.
	Head-Swipe	H-Swp	Sharp and sudden swinging or tossing of the head and tusks down, up and sideways, to threaten or hit an elephant who is either too close or doing something that displeases the elephant.
Trunk	Forward-Trunk-Swing	Fw-T-Sw	A swinging or tossing of the trunk in the direction of an adversary typically while simultaneously blowing forcefully out through the trunk.

	Throw-Debris	Th-Deb	Grasping and lifting or uprooting vegetation, a rock or other object with the distal portion of the trunk and using movement of the entire trunk to throw or fling the object in the direction of an opponent or predator.
	Reaching-High	Re-Hi	At the end of a Run-After or a Charge when the attacker slows his or her pursuit, he or she may extend the trunk upward and outward toward the opponent or a threat.
	Trunk-Twining	T-Twi	A mutual entwining of trunks.
	Trunk-to-Mouth	T-to-M	Reaching of the trunk to touch or near touch or place into the mouth of another.
Vocalization	Rumble	R	Call with very low fundamental frequencies.
	Trumpet	Tru	A forceful expulsion of air through the trunk, creating a trumpeting sound.
Avoidance			
Whole body	Back-Away	B-Aw	In a form of Retreat-From, and elephant may walk away in reverse, or Back-Away, from a threatening elephant or situation.
	Look-Back	L-B	Standing or walking away while looking back over the shoulder.
	Orient-Away	O-Aw	Reorientation of the body to face or look away from another elephant, animal or object of interest.
	Retreat-From	Re	Walking or running away from a threatening elephant. The individual may adopt a Head-Low posture and Look-Back warily.
Head	Chin-Up	C-Up	Standing or Walking with the "chin" or jawline lifted up so that it is almost parallel to the ground.
Ears	Ears-Back	E-Ba	Holding or flattening the ears against the neck or body.
Tail	Tail-Raising	Ta-Rs	Raising the tail.
Vocalization	Rumble	R	Call with very low fundamental frequencies.
Others			
Whole body	Visitor Feeding	Fe V	Standing at the visitor feeding area, head between bars, tail down and relaxed, ears back and relaxed, trunk reaching toward visitors. May grasp food from the visitors directly and eat it or from the ground after they visitors threw it there.
	Feeding	Fe	Feeding. Tail down and relaxed, ears back and relaxed, trunk searching or grabbing food from the ground and eating.
	Walking	W	Walking around in the enclosure with head relaxed, ears back, trunk relaxed and tail down.
	Foot-Feeding	F-Fe	Standing, kicking the ground with foot to loosen up vegetation, grasping vegetation with trunk and eating it.
	Standing	St	Standing with head relaxed, ears back and relaxed, tail and trunk down and relaxed.
	Walk-Away	W-Aw	Walking away from another elephant.
	Scrub	Scr	Scrubbing legs, body, head, ears, etc. either with another body part or with an object.
	Urinating	Ur	Urinating.
	Defecating	Def	Defecating
	Approach	App	Walk toward human, approaching within 2 meters (subsequent approaches that occur within 2 min of an initial approach are recorded as "follows")
	Foot-Mud	F-M	Using a forefoot in a swinging motion to splash water and mud onto the underside of the body.
Ears	Ear-Flap	E-Fl	Single flapping of the ears, spreading less than 90° and no slapping sound.
Head	Head-Shake	H-Sh	An abrupt shaking of the head, which causes the ears to flap sharply and dust to fly.
Trunk	Trunk-Swing	T-Sw	Swinging of the trunk forward and then backwards between the front legs and slapping it against belly.
	Throw-Mud	Th-M	Throwing mud or water onto self.
	Throw-Dust	Th-D	Throwing dust onto self.
	Touch-Self	To-S	Self-directed touching of the face (mouth, ear, trunk, tusk or temporal gland) or chest, with the fingers or tip of the trunk.
	Grasp-Food	G-Fe	Grasping food with trunk and placing it between trunk, mouth and tusks for transport.

	J-Trunk	J-T	Holding the trunk in a relaxed position, but with the tip of the trunk curled under and around such that the trunk fingers point in the direction of an object of interest.
	Reach-Over	Re-Ov	An elephant, typically male, and usually with an erection, reaching his trunk over or along the back of another elephant.
	Drinking	Dr	Using the trunk to suck in water and bring it to mouth while raising the chin to drink.
	Trunk-Wipe	T-W	Using the trunk to swing or slap it against self. Perhaps to fight off insects?
	Trunk-Out	T-Out	Trunk extended outwards and held for at least 2 s toward human
	Snort	Sn	A short (typically less than a second in duration), sharp, noisy, broadband sound produced by purposefully blowing air through the trunk.
	Trunk-Up	T-Up	Lifting the trunk up in the air presumably to sniff.
Tail	Tail-Movement	Ta-Mo	Moving the tail from left to right, without swatting or raising it.
Vocalization	Roar	Ro	A highly variable roaring, bellowing, screaming, shrieking, or squealing call typically lasting 1-2 seconds in duration. Mostly emitted by protesting individuals or those in some form of distress.

Appendix III – Animal keeper survey

Animal keeper survey – Social behaviour of African elephants

Serengeti-Park Hodenhagen

Name:

Date:

- 1) List the elephants in order of their status in the hierarchy. 7 means this elephant has the highest rank in the hierarchy, 1 means this elephant has the lowest rank in the hierarchy.

7. _____ 4. _____ 1. _____
6. _____ 3. _____
5. _____ 2. _____

- 2) List the elephants in order of how active they are. 7 means this elephant is most active, 1 means this elephant is least active.

7. _____ 4. _____ 1. _____
6. _____ 3. _____
5. _____ 2. _____

- 3) List the elephants in order of how friendly they are with other elephants or how much they like to socialize with other elephants. 7 means this elephant is more friendly, 1 means this elephant is least friendly.

7. _____ 4. _____ 1. _____
6. _____ 3. _____
5. _____ 2. _____

- 4) List the elephants in order of how likely they are to be aggressive towards other elephants. This includes dominance. 7 means this elephant is most aggressive, 1 means this elephant is least aggressive.

7. _____ 4. _____ 1. _____
6. _____ 3. _____
5. _____ 2. _____

- 5) List the elephants in order of how likely they are to be avoidant or try to evade another elephant. 7 means this elephant is most avoidant, 1 means this elephant is least avoidant.

7. _____ 4. _____ 1. _____
6. _____ 3. _____
5. _____ 2. _____

- 6) Jumanee focus: List the remaining elephants in order of how friendly Jumanee is with each individual or how much he likes to socialize with them. 6 means Jumanee behaves most friendly towards this individual, 1 means Jumanee behaves least friendly towards this individual.

6. _____ 3. _____
5. _____ 2. _____
4. _____ 1. _____

- 7) Jumanee focus: List the remaining elephants in order of how likely Jumanee is to be aggressive towards each individual. This includes dominance. 6 means Jumanee behaves most aggressive towards this individual, 1 means Jumanee behaves least aggressive towards this individual.

6. _____ 3. _____
5. _____ 2. _____
4. _____ 1. _____

- 8) Jumanee focus: List the remaining elephants of how likely Jumanee is to be avoidant or tries to evade each individual. 6 means Jumanee is most avoidant towards this individual, 1 means Jumanee is least avoidant towards this individual.

6. _____ 3. _____
5. _____ 2. _____
4. _____ 1. _____

- 9) List the elephants in order of how likely they are to interact with visitors. 7 means this elephant is more interactive with visitors, 1 means this elephant is least interactive with visitors.

6. _____ 3. _____
5. _____ 2. _____
4. _____ 1. _____

- 10) How many years of experience do you have working with elephants?

- 11) Have you worked with elephants anywhere else? If so, where?

