Greater one-horned rhino (*Rhinoceros unicornis*) behaviour during high floods at Kaziranga National Park and the Burhachapori Wildlife Sanctuary, Assam, India

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Abstract

The behaviour of the greater one-horned rhinoceros (*Rhinoceros unicornis*) (GOH) in response to exposure to natural hazards like floods is poorly understood. This study recorded the behaviour of GOH in highland refuges during periods of seasonal and extreme flooding in two protected areas in the Brahmaputra River valley (Assam, India): Kaziranga National Park (KNP) and Burhachapori Wildlife Sanctuary (BWS). Following the death after monsoon floods in 2016 of a lone sub-adult female translocated to BWS from KNP, the study compared the behaviour of this individual during high flood periods to that of other adults, sub-adults and calves in KNP in 2017. Adult rhinos of KNP spent most of the time resting during high flood periods, which may be a behavioural response to overcome stress. By contrast, both calves and sub-adult rhinos in KNP and especially the lone BWS sub-adult female rhino were observed swimming from one highland to another, despite the heavy floodwater current. Sub-adults in KNP dedicated considerable time to feeding; however, the sub-adult in BWS spent less time feeding than any of the age groups in KNP, and her weakened state from starvation may have contributed to her death after the floods receded. The study concludes by offering recommendations to help rhinos survive and recover from seasonal flooding. Adult animals may be the better choice for future rhino translocations from KNP to other flood plain habitats than sub-adult rhinos or a mother with calf.

Keywords: Translocation, Indian Rhino Vision 2020, climate change, protected area management, adaptive behaviour.

Résumé

Le comportement du rhinocéros indien (*Rhinoceros unicornis*), suite à l'exposition aux risques naturels tels que les inondations, est mal compris. Cette étude a enregistré le comportement du rhinocéros indien dans les refuges des hauts-plateaux pendant les périodes d'inondations saisonnières et extrêmes, dans deux aires

protégées de la vallée du Brahmapoutre (Assam, Inde): le Parc national de Kaziranga (PNK) et le Sanctuaire de faune de Burhachapori (SFB). Suite à de graves inondations de mousson en 2016, qui ont causé la mort d'une femelle sub-adulte transférée seule au SFB depuis le PNK, l'étude a comparé le comportement de cet individu pendant les périodes d'inondations à celui d'autres adultes, sub-adultes et jeunes dans le PNK en 2017. Les rhinocéros adultes du PNK, pendant les périodes de fortes crues, passaient la plupart du temps au repos, ce qui peut être une réponse comportementale pour surmonter le stress. Par contre, autant les rhinocéros jeunes que les sub-adultes du PNK, et en particulier la femelle sub-adulte du SFB, ont été observés en train de nager d'un haut-plateau à l'autre, malgré le fort courant dû aux inondations. Les sub-adultes du PNK consacrent un temps considérable à l'alimentation; cependant, la sub-adulte du SFB a passé moins de temps à se nourrir que n'importe quel groupe d'âge du PNK, et son état d'affaiblissement dû à la famine a peut-être contribué à sa mort après le retrait des inondations. L'étude conclut en proposant des recommandations pour aider les rhinocéros à survivre et à se remettre des inondations saisonnières. Les animaux adultes sont probablement les individus les plus indiqués pour les futurs transferts de rhinocéros du KNP vers d'autres habitats de plaine inondable, plutôt que les rhinocéros sub-adultes ou qu'une mère avec un jeune.

Mots clés: Translocation, Indian Rhino Vision 2020, changement climatique, gestion des aires protégées, comportement adaptatif.

Introduction

The understanding of animal behaviour is crucial to wildlife conservation practices and management. However, knowledge of behavioural traits is seldom incorporated into the design and implementation of conservation programmes at the regional or the global scale (Tobias and Pigot 2019). This may be because the relevant behavioural traits are poorly understood, as is the case of the behaviour of the greater one-horned rhinoceros (*Rhinoceros unicornis*) (GOH) in response to exposure to natural hazards like floods (Gaucherel et al. 2016). This paper addresses this knowledge gap by presenting the results of a study of the behaviour of GOH during seasonal flooding of the Brahmaputra River basin in Assam, India. The study provides crucial information for better management of the species.

The study was carried out in two protected areas in the Brahmaputra River Valley: Kaziranga National Park (KNP) and Burhachapori Wildlife Sanctuary (BWS). The history of the KNP dates back to 1905. It was officially recognized as a national park in 1974 and was declared a UNESCO World Heritage Site in 1985. KNP currently holds the largest population of GOH in the world, comprising 2,413 individuals in 2018.

BWS was designated as a Proposed Forest Reserve in 1974 and was recategorized as a Sanctuary in 1995. BWS is contiguous with the Laokhowa Wildlife Sanctuary (LWS) to the south, and the two areas are known collectively as the Laokhowa and Burhachapori Wildlife Sanctuaries (LBWS). The LBWS area first attracted the attention of wildlife conservation more than a hundred years ago due to the presence of rhinos (Ellis et al. 2015). However, the entire resident rhino population of LBWS was wiped out by poaching in the mid-1980s and rhinos were declared locally extinct (Menon 1996; Sivakumar et al. 2013).

To revive the rhino population in the LBWS area, a rhino reintroduction plan was developed under the Indian Rhino Vision 2020 (IRV2020) programme of the Government of Assam (Bonal et al. 2009; Ellis et al. 2015). The rhino reintroduction plan incorporates a post-translocation holding phase (Bonal et al. 2009; Sivakumar et al. 2013), during which rhinos are kept in a 1.5 km^2 fenced enclosure in the BWS prior to releasing them in the wild (Emslie et al. 2009; Sivakumar et al. 2013).

As a part of the rhino reintroduction programme, two rhinos (mother and sub-adult female) were translocated from the Western Range (Bagori) of KNP to BWS on 29 March 2016. Unfortunately, the adult female died of natural causes on 22 May 2016 after 54 days of translocation, leaving her calf alone inside the enclosure. This sub-adult female had to withstand three waves of high floods in June, July, and September 2016. She died shortly afterwards on 26 October 2016, 211 days post-translocation to BWS.

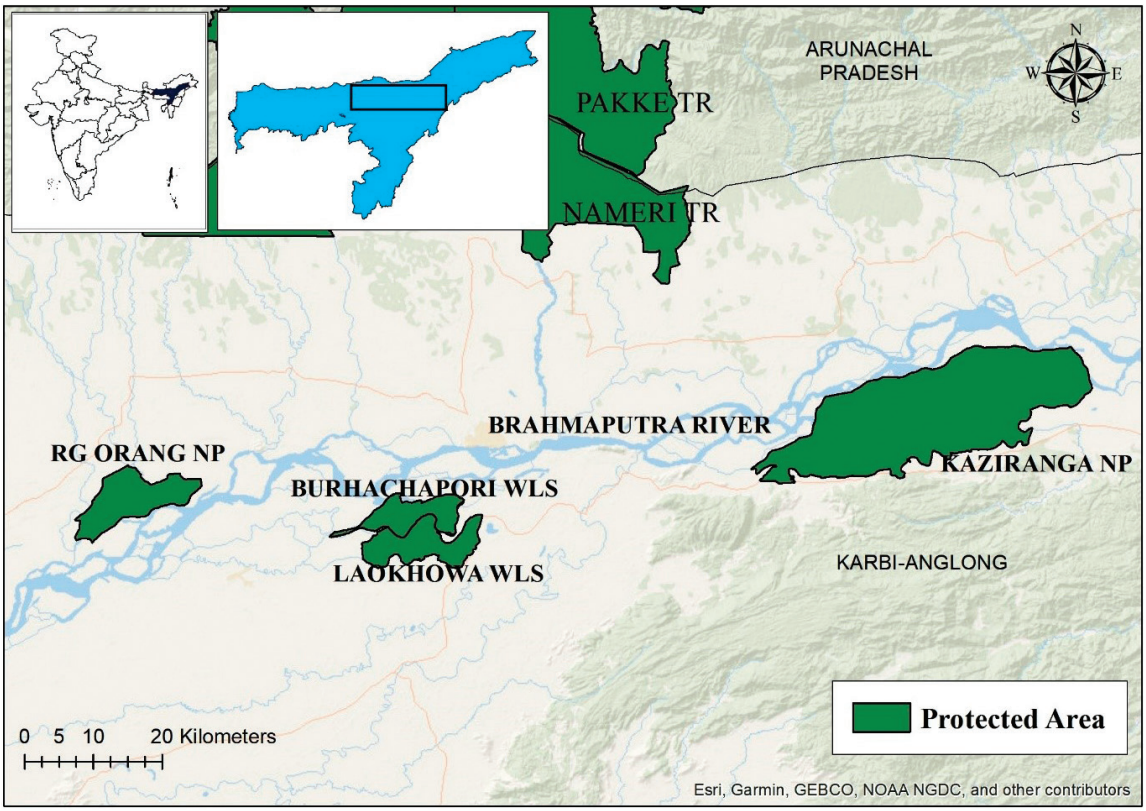

Figure 1. Location of protected areas in the Brahmaputra Valley, Assam.
Note the text in the map for Rajiv Ghandi Orang National Park. is RG Orang NP, NP: National Park; WLS: Wildlife Sanctuary.

During June–September 2016, floodwater submerged the entire rhino enclosure for periods of five to six days, causing acute stress to the lone female sub-adult rhino. The floods were observed to influence the behaviour of the rhino and it was conjectured that an inappropriate behavioural response to the floods may have contributed to her death. Therefore, following a suggestion by the Translocation Core Committee (TCC) of Assam, a research programme was initiated under IRV2020 to study the behaviour of rhinos in KNP during high floods in 2017 and to compare this to the behaviour of the lone sub-adult in BWS in 2016.

Study area

KNP is situated in the Biswanath, Golaghat, Nagaon, and Sonitpur districts of Assam. Its highly fertile habitats include extensive grassland areas, numerous water bodies, and mixed woodlands. In addition to rhinos, the diverse habitats of KNP are home to 34 other species of mammals, including other endangered species, namely tiger (*Panthera tigris tigris*) river dolphin (*Platansita gangetica*) and slow loris (*Nycticebus bengalensis*); as well as 480 species of birds, 60 species of reptiles, 24 species of amphibians, 42 species of fishes, and 491 species of butterflies (Sivakumar et al. 2013).

LBWS is situated on the south bank of the river Brahmaputra, between KNP to the east and Rajiv Gandhi Orang National Park (RGONP) to the west. It is considered a key habitat in the riverine corridor connecting RGONP and KNP (Sivakumar et al. 2013; Areendran et al. 2020) (Fig. 1). The alluvial wetland and grassland habitats of LBWS are similar to those of KNP.

The riverine landscape comprises—in addition to the main water course—flood-formed lakes known as beels, and sandbars known as *chapories* which provide retreats and shelter for animals during floods. In addition, artificial elevated areas, known as 'highlands', have been built with the help of the

different government agencies. These highlands provide refuges for animals, particularly rhinos (Patar 2005; Barman et al. 2014) within the KNP, so that they do not have to leave the protected area to find safety during high flood periods. Usually, groups of rhinos stay on the same highland for the duration of the high flood period, typically two to three days.

Both KNP and LBWS have a subtropical monsoon climate with annual temperatures of 5–25°C and three seasons: summer, monsoon, and winter. November–February is the winter or dry season, while monsoon rains occur mainly in July–September. Around 95% of both areas are submerged by floodwater every year at the peak of the monsoon (Areendran et al. 2020). If the floods are sustained for a longer period than normal, they can cause heavy losses of Park infrastructure, habitats, and wildlife (Vasu and Singh 2015). With a changing climate, weather patterns could become more extreme and the situation could escalate (Save The Rhino 2019).

Methodology

This study was carried out during the high flood periods (June, July, and September) of 2016 in BWS and 2017 at KNP. Rhino behaviour was recorded using focal sampling in BWS and scan sampling in KNP (Altman 1974). Scan sampling focused on a particular behaviour rather than a particular animal, while in focal sampling the behaviour of one individual was recorded throughout the predetermined period (Dutta 2018).

The behaviour of the lone female sub-adult at BWS was observed as part of ongoing monitoring of the individual. Efforts were made to observe the rhino from a small wooden boat as there were no other means of transportation available. Due to the fast-flowing flood water current, it was impossible to observe the rhino from stationary locations. The rhino was observed during the daytime between 06:00 and 17:00 hours, usually for periods of 20–30 minutes. Altogether 191 behaviour samples were recorded over 12 days of observation.

Single rhinos and groups of rhinos were observed in KNP during three high flood waves (each lasting two to three days) in 2017, when they took refuge on elevated land, i.e. roads, embankments, or on the highland refuges inside the Park. The rhinos were observed from a boat, or from observatory towers between 06:00 and 14:00 hours for periods of 20–45 minutes. It was not possible to make observations after 14:00 hours due to the unavailability of transportation and support staff. Altogether 207 behaviour samples of the KNP rhinos were recorded during 10 days of observation.

Following descriptions and procedures used in previous studies (Kandel and Jhala 2008; Dutta et al. 2017; Dutta 2018), types of behaviour were broadly categorized as grazing, wallowing, walking, browsing, and resting. We also observed an additional behavioural category, swimming, not recorded in previous studies (Table 1). Behavioural states were recorded if they lasted more than one minute. All observations were done by using binoculars (Nikon 10×40) and data were recorded and analysed using MS Excel.

Table 1. Ethogram of rhino behaviour

	Type of behaviour	Description	References
1.	Grazing	Approaches grasses and takes into the mouth	Laurie 1982; Dutta 2018
2.	Browsing	Approaches bush, tree twigs, takes into the mouth	Laurie 1982; Owen-Smith 1988; Dutta 2018
3.	Wallowing	Almost all parts of the body dip into mud and water	Laurie 1982; Dinerstein 2003; Dutta 2018
4.	Resting	The animal is in a resting position (lying and sitting, standing) inactive and relaxed	Dutta 2018
5.	Walking	The animal moves forward attentively	Laurie 1982; Dinerstein 2003; Dutta 2018
6.	Swimming	The animal uses its limbs for propulsion in the water	(Defined by the authors of this study)

Results

We compared the behaviour of rhinos in KNP in 2017 to that of the translocated rhino in BWS in 2016.

The lone sub-adult female rhino took shelter on two elevated areas within the 1.5 km^2 enclosure that remained just above the water line during high flood days. During the floods, the enclosure gates were opened and the animal had the opportunity to swim approximately 2 km distance to LWS to find a better refuge. But she remained on the elevated areas within the enclosure until the floodwater receded.

From the 191 behaviour samples collected, it can be inferred that, during daylight hours, the rhino spent almost half the time resting (45% of samples). It was notable that, during periods of activity, the rhino spent most time swimming (31%), although the proportion of time spent swimming declined in September. The rhino also spent a small but significant amount of time walking (6%). No wallowing was observed during the entire period of observation. This was probably caused by the ambient temperature decrease due to rain and wind. The water current may also have deterred wallowing.

Feeding accounted for only 18% of observed samples, and was almost exclusively by browsing, with very little time spent grazing, although it was observed that there were still areas with grass cover on some of the highlands (Table 2, Fig. 2).

In KNP in 2017, we observed the behaviour of 30 individuals in June, 29 individuals in July and 23 individuals in September, recording a total of 207 behaviour samples (Table 3). Of these observations, 37, 20 and 25 were of rhinos in Bagori (Western Range), Kohora (Central Range) and Agoratoli (Eastern Range), respectively.

Adult rhinos taking refuge from floods spent almost all of the time resting (73% of samples) and feeding (23%). Feeding was mainly by browsing. Animals were observed wallowing on two occasions and swimming on one occasion, while there were no observations of walking behaviour (Table 4, Fig. 3).

Sub-adults in KNP displayed patterns of activity very different from those of adults. Sub-adults spent much less time resting (18% of samples) and more than half of the time feeding (51%), again preferring to browse rather than graze. Sub-adults also spent much more time than adults moving around without feeding, either wallowing (11%) , walking (11%) or swimming (10%) (Table 5, Fig. 4).

Calves in KNP divided their time evenly between resting (33% of samples), feeding (37%, again mostly browsing) and moving around by swimming or walking (36% in total). Calves were observed wallowing on just two occasions, both in June (Table 6, Fig. 5).

Figure 6 compares the patterns of behaviour of adults, sub-adults and calves in KNP in 2017 alongside the behaviour pattern of the sub-adult in BWS in 2016. Notable features include the very large amount of time that adults spent resting, the time that sub-adults in KNP dedicated to feeding, and the fact that the sub-adult in BWS spent more time swimming, and less time feeding, than any of the age groups in KNP.

Discussion

Even though the annual floods are welcome, since they rejuvenate the rhino habitats in protected areas along the river Brahmaputra, they can cause huge challenges under certain circumstances. Factors such as the level and velocity of the floodwaters, duration of waterlogging, quality of deposit material, and erosion all have impacts on wildlife, including rhinos, and require appropriate management responses.

The behaviour of rhinos has been observed to be affected by the fluctuating water levels during the floods. In the past, as the water level rose in KNP, the rhinos attempted to move to nearby Karbi Anglong hills to find shelter and food (Patar 2005). However, with the increase of traffic on the highway and expansion of development activities in the surrounding areas of KNP it is becoming increasingly difficult for animals to move to nearby hilly areas and some rhinos prefer to remain in the artificially constructed highlands inside the Park.

In normal conditions, rhinos' daytime activities consist mainly of feeding, followed by wallowing, walking, and resting in that order (Laurie 1982; Owen-Smith 1988; Dinerstein 2003; Patar 2005; Dutta 2018). However, patterns of behaviour are altered during peak flooding, as shown by the results of this study (Figs. 3–5).

Table 2. Behaviour of lone sub-adult individual in Burhachapori Wildlife Sanctuary in 2016

Behaviour category	June	July	September	Total	Percentage
Grazing	1	1	0	2	1
Browsing	9	13	10	32	17
Wallowing	0	0	0	0	0
Resting	25	34	26	85	45
Walking	2	6	4	12	6
Swimming	20	30	10	60	31
Total observations	57	84	50	191	100

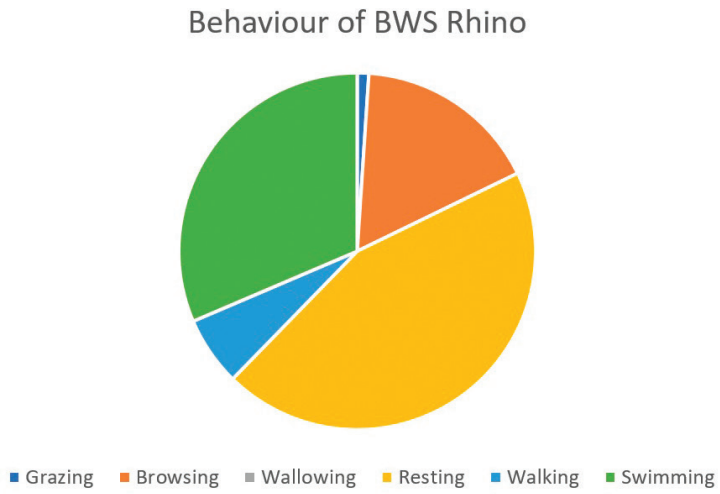

Figure 2. Behaviour of lone sub-adult individual in Burhachapori Wildlife Sanctuary in 2016.

Table 3. Age group and month of observation of rhinos observed in Kaziranga National Park in 2017

Age group	June	July	September
Adult	13	15	10
Sub-adult	14	9	7
Calves	3	5	6

Table 4. Behaviour of adults in Kaziranga National Park in 2017

Behaviour category	June	July	September	Total	Percentage
Grazing	1	2	0	3	4
Browsing	4	6	4	14	19
Wallowing	0	2	0	2	3
Resting	14	22	18	54	73
Walking	0	0	0	0	0
Swimming	1	0	0	1	1
Total observations	20	32	22	74	100

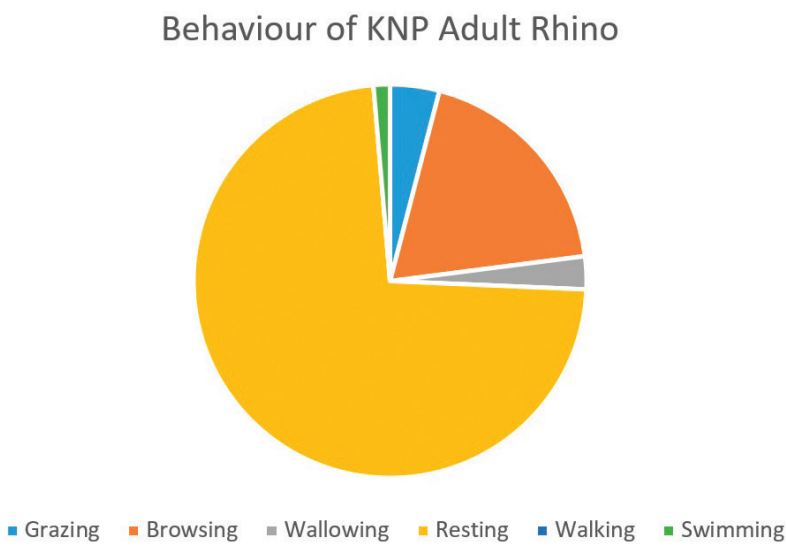

Figure 3. Behaviour of adults in Kaziranga National Park in 2017.

Table 5. Behaviour of sub-adults in Kaziranga National Park in 2017

Behaviour category	June	July	September	Total	Percentage
Grazing	3	4	2	9	11
Browsing	12	8	14	34	40
Wallowing	2	4	3	9	11
Resting	4	8	3	15	18
Walking	2	2	5	9	11
Swimming	2	3	3	8	10
Total observations	25	29	30	84	100

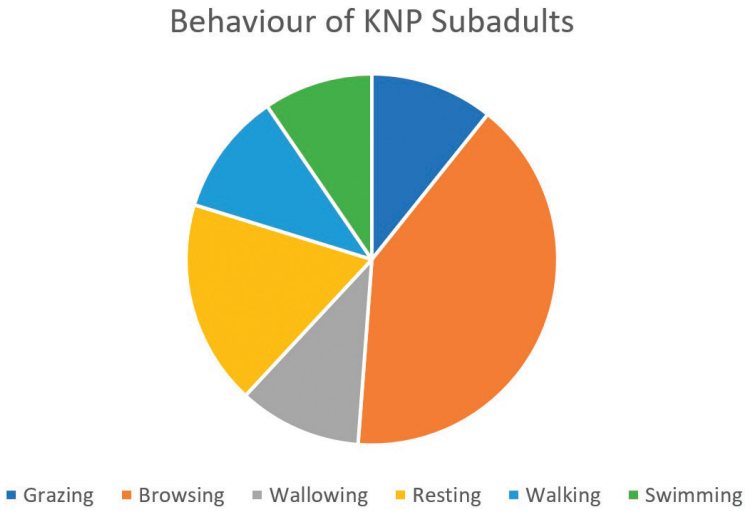

Figure 4. Behaviour of sub-adults in Kaziranga National Park in 2017.

Table 6. Behaviour of calves in Kaziranga National Park in 2017

Behaviour category	June	July	September	Total	Percentage
Grazing	1	1	1	3	6
Browsing	4	1	5	10	21
Wallowing	2	0	0	2	4
Resting	7	4	5	16	33
Walking	6	2	2	10	21
Swimming	2	3	2	7	15
Total observations	22	11	15	48	100

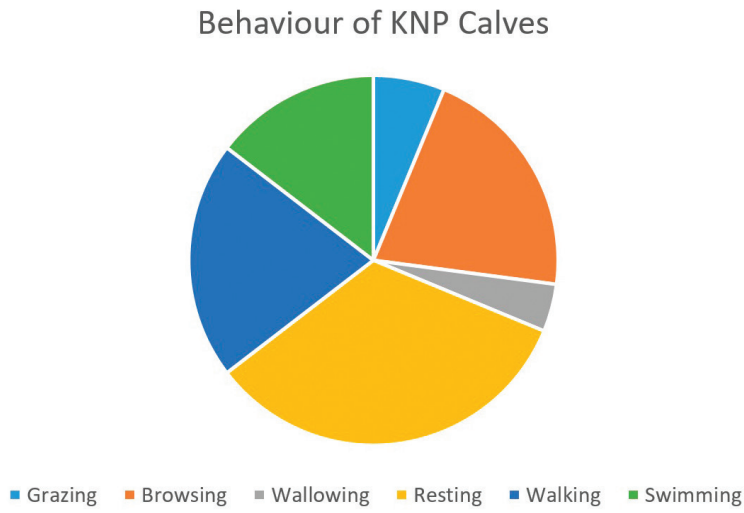

Figure 5. Behaviour of calves in Kaziranga National Park in 2017.

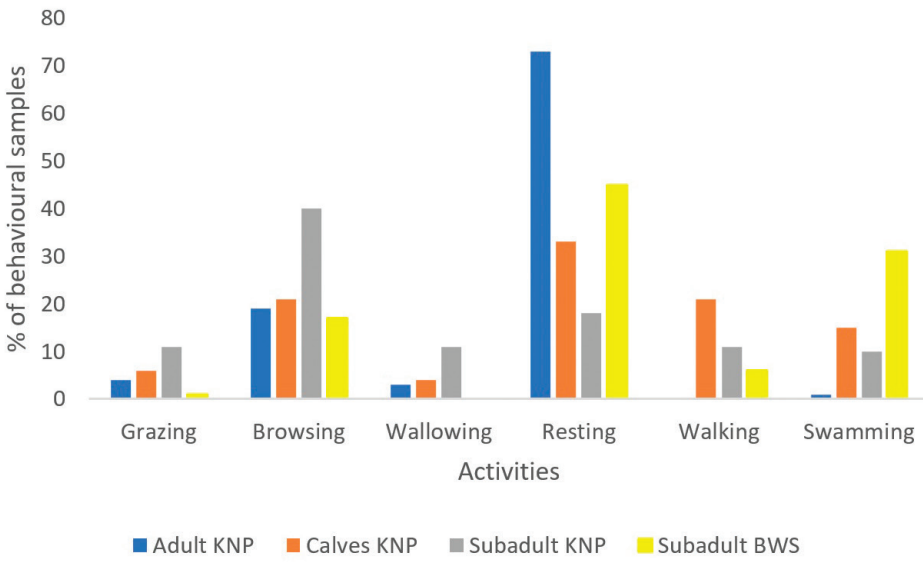

Figure 6. Comparison of behaviour of lone BWS sub-adult female rhino in 2016 with those of adults, sub-adults and juveniles in Kaziranga National Park in 2017.

In our study, during the high flood period, adult rhinos of KNP spent most time resting. This may be a behavioural response to overcome stress during high flood periods. Zheng and Zheng (2014) report that animals alter their behaviour under stressful situations as a means of coping. Specifically, animals in vulnerable situations may change their behaviour from positive states (struggle to escape/flee) to negative states (stay rested and limit movement). Zheng and Zheng (2014) suggest that this response to stress is an adaptive behaviour that may benefit survival. Thus, the behaviour inhibition exhibited by rhinos during periods of flood stress may be adaptive behaviour to survive in such a situation.

In this study we observed a new behavioural category, not reported in previous studies, i.e. swimming. Both calves and sub-adult rhinos in KNP and especially the lone BWS sub-adult female rhino were observed to swim frequently from one highland to another, despite the heavy floodwater current. The motive for these movements may have been to eat the aquatic plants or (in the case of KNP individuals) to avoid other animals (Fig. 6). In contrast, adult rhinos were almost never observed swimming. They remained on the highland refuges, appeared sluggish and hardly moved. We surmise that the minimal movement of adult rhinos was not only a tactic to overcome stress, but also behaviour learned from previous experience of high floods that it is safer to remain on the raised areas and not to attempt to escape by swimming against the strong current.

With less experience of floods, the sub-adults and calves might have been tempted to explore the situation. We observed that calves sometimes fell accidently into the rapid floodwater currents while wandering about and became separated from their mothers, and a number of deaths by drowning among these age groups (calf and sub-adult) during high floods were reported by Barman et al. (2014). All these observations concur with the conclusions of Nishimura et al. (1988), that an experienced animal can cope with adverse circumstances and stress more adequately than a novice one.

We observed some other differences in behaviour patterns among the groups of rhinos studied during the high flood days. All animals were observed browsing tree twigs, and shrubs, as observed in previous flood events in KNP (Patar 2005), but this activity was observed much more frequently among sub-adult rhinos in KNP, compared to all other groups. By contrast, the lone BWS sub-adult spent less time feeding than all animals in KNP, and notably less than sub-adults in KNP. The lone sub-adult in BWS also spent more time resting than sub-adults in KNP.

This suggests that the stress experienced by the lone and inexperienced sub-adult rhino may have led to starvation. If the food intake was less than the nutritional requirement of the calf, this could have contributed to her death after the flood receded.

Recommendations

Climate extremes, such as increased temperatures, heavier than average rainfall, flood, and drought, may directly impact on behaviour and welfare of wild animals and their habitats. Our observations highlight the need for further research on how food availability, food intake and rhinos' nutritional requirements are affected by periods of flooding, and the implications for the health conditions of rhinos. The rhinos' anomalous behaviour during flooding also suggests that it would be useful to study how other species are affected by flooding and, more generally, the effects on species' behaviour caused by other evolving natural phenomena affecting the area.

The present study highlights the importance of improving fodder diversity and availability for rhinos during all weather conditions, including periodic floods. Specifically, measures should be taken to diversify vegetation on the highlands by establishing trees and shrubs to meet the nutrient requirements of rhinos (and other herbivores) during the high flood days. Since the flood plain grassland areas are changing rapidly due to seasonal flood and silt deposition, there is also a need for periodic surveys of the flora, particularly of enclosures where it is planned to hold translocated rhinos.

Additional measures recommended to better protect rhinos in the Brahmaputra valley from seasonal flooding include identification and delineation of the corridor complexes within KNP, preparation of a flood susceptibility map and identification of flood prone areas (Areendran et al. 2020), construction of more *highlands* or raised platforms as refuges during high floods in LBWS, and contructions of underpasses at strategic locations across the highways beside KNP to facilitate

free movement of animals (Areendran et al. 2020).

The results of this study also suggest that the ideal time for rhino translocation would be early December. This would allow areas to recover from the effects of floods in June–September, while allowing newly released rhinos sufficient time to settle in their new habitat before the next monsoon starts.

Finally, our results suggest that adult animals may be the better choice for future rhino translocations from KNP to LBWS or other flood plain habitats than sub-adult rhinos or a mother with calf. As flood events in the LBWS area and other flood plain rhino habitats are similar to those in KNP, survival capabilities of adult animals are expected to be greater than those of immature individuals (sub-adult and calf) when released into a new environment. Lastly, we recommend further studies on how soon behaviour patterns revert to normal after the flood waters recede.

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