

Chapter

An Assessment of the Population Density of Greater One-Horned Rhinoceros in Uttar Pradesh and Their Distribution in India

Richa Kumar and Moharangan Ashokkumar

Abstract

India's alluvial plains once supported the abundance of greater one-horned rhino (*Rhinoceros unicornis*; hereafter rhino). Due to uncontrolled poaching and land degradation due to human intervention, they lost almost 80% of their natural habitat. Around 90% of rhinos are confined to Assam, along the Gangetic plains in northeastern India. Having formerly been a habitat for Indian rhinos, Uttar Pradesh reintroduced them at Dudhwa National Park in 1984. Based on secondary data collected from the study area (1984–2021), we analyzed the rhino population's life-history traits. Seven rhinos were brought from Assam and Nepal to start the seed population, including two males and five females. The rhino population increased steadily in the Dudhwa NP and reached asymptote. Birth rate and mortality rate were 0.17/year and 0.05/year, respectively. Observation of 10 adult females over 47 birth records revealed a higher fertility rate between 8 and 20 years, with a mean inter-birth interval of 4.3 years. According to their large body size, rhinos exhibit similar life-history traits to other large mammals, such as a slow onset of sexual maturity, few young, high inter-birth intervals, and fertility into old age. The current estimated population of Indian rhinoceros is about 35–40 in Uttar Pradesh.

Keywords: *Rhinoceros unicornis*, reintroduction, population estimation, current habitat, threats

1. Introduction

In the Indian megafauna, the greater one-horned rhinoceros (*Rhinoceros unicornis*) [1] is one of the five remaining species of rhinoceros of approximately thirty genera [2]. Rhinos belong to the order Perissodactyla (odd-toed ungulates), which includes horses and tapirs. They are also called the Indian rhino, greater one-horned rhinoceros, or great Indian rhinoceros (hereafter rhino), native to the Indian subcontinent (India and Nepal). Rhino has become extinct from Bhutan and Bangladesh with a decline in the population in their distributional range [3, 4]. The estimated population in India is around 3262 [5] and is 752 in Nepal [6]. It is listed as Vulnerable on the

IUCN Red List, as populations are fragmented and restricted to distributional areas of less than 20,000 km [2]. This species is listed in CITES Appendix-I and is protected under Schedule I of the Wildlife Protection Act.

Previously, the greater one-horned rhinoceros (*R. unicornis*) was widely distributed from the Hindukush Mountain Range in Pakistan to Myanmar, and it also inhabited the Ganges floodplains [7]. For over 200 years, the Indian rhinoceros has been eradicated from the majority of their former range of distribution due to overhunting, fragmentation of habitat caused by clearing of forests for cultivation, desperate agricultural use, and expansion of tea gardens [5]. It has also been eliminated from most of its former range due to uncontrolled fires and grasslands and swamps being reclaimed by expanding livestock and humans. The Indian rhino once ranged throughout the northern part of the Indian subcontinent, along the Indus and Ganges river basins, and as far south as Bangladesh and the southern parts of Nepal and Bhutan. The Terai and Brahmaputra basins are home to a large number of them due to their alluvial grasslands. The Terai grasslands of southern Nepal, northern Uttar Pradesh, northern Bihar, northern West Bengal, and the Brahmaputra Valley of Assam are the only places where it survives as a result of habitat destruction and climatic changes. By the nineteenth century, it was only found in these areas.

We have limited information on the rhino population demographics and life-history traits in India. It is necessary to understand the changes in the population size, mortality, natality pattern, survival rate, and fecundity essential for strategizing conservation measures. We hypothesized that rhino survival, mortality, and natality varied by year, age, and gender during 1984–2021. We attempted to answer the following questions: 1. changes in the population size of rhinos in the Dudhwa National Park, 2. age-specific natality and mortality of rhinos, and 3. reproductive rate, fecundity, and inter-birth interval in the rhinos.

1.1 Current habitat of the greater one-horned rhinoceros in India

There are only three states in India that have rhino populations in different national parks: In Assam [5], there are Kaziranga National Park (2401), Manas Tiger Reserve (32), Pobitora Wildlife Sanctuary (92), and Orang National Park (100). In West Bengal, there are Jaldapara Wildlife Sanctuary (200) and Gorumara National Park (50), and in Uttar Pradesh, where rhinos are found after reintroduction in 1984, there is Dudhwa National Park (35–40). Apart from the population of rhinos in India, Nepal also consists of a good number of rhinos (752); the estimated population in the different protected areas [6] are Shuklaphanta wildlife reserve (17), Bardia wildlife reserve (38), Royal Chitwan National Park (694), and Parsa (3) (**Figure 1**).

1.2 Study area

Dudhwa National Park is located in the Terai region of Uttar Pradesh. The total area of the national park is 490.29 km [2], located along the Indo-Nepal border in Kheri District. Dudhwa was established in 1958 as a wildlife sanctuary for swamp deer and became a tiger reserve in 1979. The Terai ecosystem is one of the most threatened ecosystems in India. Located between the Himalayan foothills and the Gangetic plains, the region extends through Uttarakhand, northern Uttar Pradesh, Bihar, northwestern Bengal, Assam, and southern Nepal. The park falls within the upper Gangetic plain, a vast alluvial plain with an altitude ranging from 150 m in the southeast to 182 m in the north. Sal forests are very dense, and they can be divided into four types: the tropical

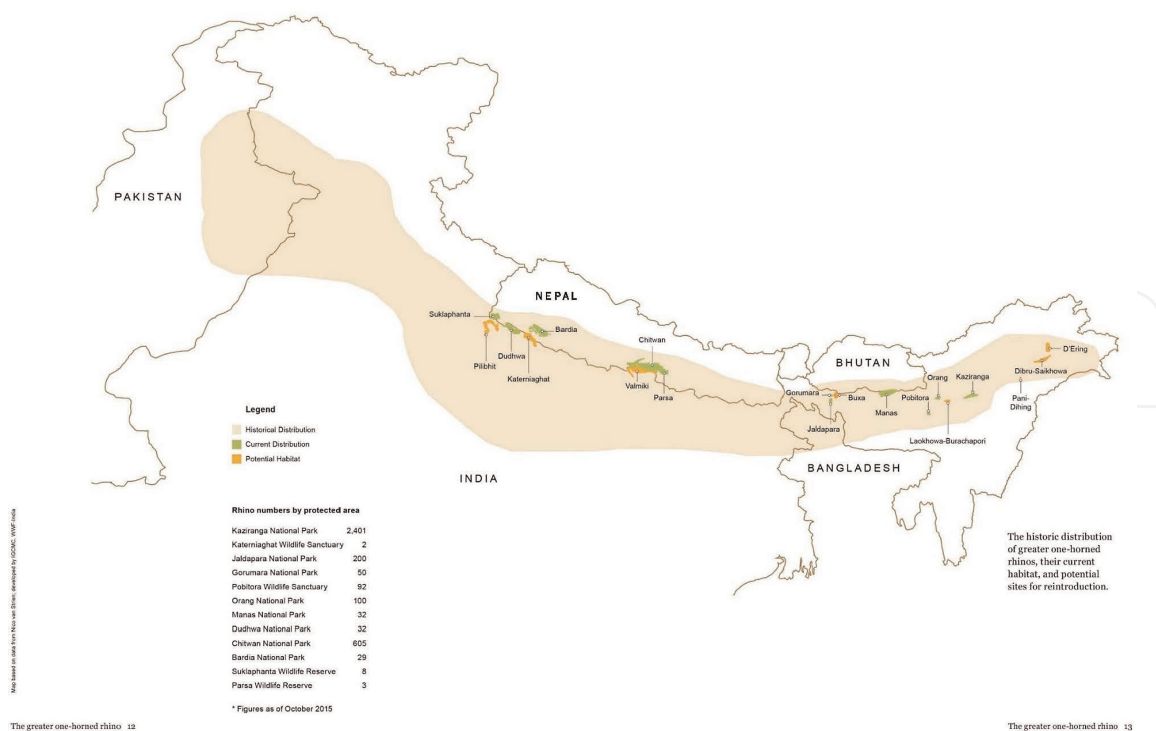


Figure 1. Existing population of the great one-horned rhinoceros only in India and Nepal (courtesy WWF-India).

semi-evergreen forest, the moist deciduous forest of northern India, the tropical swamp forest, and the tropical dry deciduous forest of northern Guatemala [8]. In total, the park comprises about 19% grassland. In addition to rivers, streams, lakes, and marshes, wetlands are a third major habitat type.

Dudhwa has a subtropical climate that is extremely humid, with a dry winter and three distinct seasons. The summer season begins in mid-March and lasts until mid-June. The weather gets hot with temperatures reaching 40°C. The winter season extends from mid-October to mid-March. The temperature ranges between 20 and 30°C during the day and is cold and foggy at night. Monsoons typically start in mid-July and last until September, resulting in 90% of the 150 cm of rainfall. The temperature during the rainy season ranges from 24 to 30°C.

1.3 Methods

Based on the annual reports and other public sources, we obtained secondary data about the rhino reintroduction program of 1984 and rhino birth records and mortality cases between 1984 and 2021. The annual reports provide detailed information on each case, including the estimated age, gender, cause of death, location, and mortality date. Life-history traits such as natality, age-specific survival, fecundity, mortality, and inter-birth interval were calculated [9, 10]. The rhino population growth model is predicted using a generalized linear model equation (1), specifically logistic non-linear least squares regression [10].

$$y = \beta_1 / (1 + \exp(-\beta_0 + \beta_2 * x)) \quad (1)$$

Where β_1 is the asymptote value (maximum population size). β_0 is the constant; β_2 is the growth parameter; and x is the year.

2. Result and discussion

2.1 Re-introduction program of the greater one-horned rhinoceros in Dudhwa National Park, that is, the rhino reintroduction program

The great horned rhinos roamed freely in the Terai belt of Uttar Pradesh, including Dudhwa forests, about 160 years ago. The last rhino in U.P. was shot in 1878 in the Pilibhit district near Dudhwa. The rhino population in much of this range was wiped out by hunting and habitat destruction in the last couple of centuries. During the 1979 IUCN Species Survival Commission meeting, the Asian Rhino Specialist Group called for continuous efforts in protecting and monitoring the species and took a step to establish rhinos in the former rhino distribution range. It was concluded that Dudhwa was the most suitable alternate habitat among the various areas considered by the subcommittee. As a result of a visit to Dudhwa NP in 1980–1981, Prof Schenkel, chairman of the SSC Asian Rhino Specialist Group, confirmed the suitability of the park for rhino conservation [11]. Later, it was recommended for translocation of the great one-horned rhinoceros in Dudhwa National Park [12]. Consequently, it was determined to be the best alternate habitat because of its similarities to Kaziranga NP, Assam, the fact that rhinos have been previously recorded there, as well as the adequacy of protection. It was determined by the committee that the Dudhwa NP could provide adequate food for rhinos, so the Botanical Survey of India [13] was commissioned to conduct a study of rhino food plants in the proposed reintroduction area. There were 14 plant species found in Dudhwa NP, including grasses that rhinos consume at Kaziranga in Assam. Furthermore, the area provided a variety of habitats, including grasslands flooded with water, ample shade, water for drinking and wallowing, as well as protection from human activity. Rhinos were relocated from Assam and Nepal to Dudhwa in 1984–1985 as part of efforts to reintroduce rhinos to this area, which has grasslands, swamps, and wooded forests, which are ideal habitats for rhinos.

With the original group of seven growing to approximately forty, the project has been successful. Although the planned soft release did not happen, the population is not released and is kept in fenced enclosures. Two areas in the Dudhwa are well suited for rhinos, namely, Bhadi Tal and Churela Tal, since they provide a combination of grasslands for food, wooded forests for shade, and shallow wetlands where rhinos can forage and wallow.

2.2 Translocation of the greater one-horned rhinoceros from Assam and Nepal to Uttar Pradesh

The first rhino reintroduction program was implemented from 1984 to 1995, and the area where rhinos were to be released is called the Rhino Reintroduction Area. In 1984, five rhinos, that is, two males and three females, from Pabitora Wildlife Sanctuary were translocated to Dudhwa National Park. Before being released into the main area of the Rhino Reintroduction Area (RRA), these animals were kept in specially constructed stockades so that they could receive healthcare and experience electric fencing. A female, out of these five, died of stress abortion before she could be released. On 20.05.1985, animals were released in an area of 27 sq. km in the south Sonaripur range of Dudhwa [14]. The large male was held back until the rest were settled and was released a few days later after being radio-collared. A second female

S. No.	Origin	Name	Sex	Age on arrival
1.	Pobitora WLS, Assam	Bankey	M	7–8 yr
2.	Pobitora WLS, Assam	Raju	M	25 yr
3.	Pobitora WLS, Assam	Pabitri	F	3–4 yr
4.	Royal Chitwan NP, Nepal	Swayambara	F	4–5 yr
5.	Royal Chitwan NP, Nepal	Narayani	F	5 yr
6.	Royal Chitwan NP, Nepal	Himrani	F	4 yr
7.	Royal Chitwan NP, Nepal	Rapti	F	5–6 yr

Table 1.
Released population of rhinos in Dudhwa National Park who started the population in 1984–1995.

died on July 31, 1984, after being tranquilized to treat a wound. Having only one female rhino and two males left, it was necessary to translocate more rhinos, so the government of Nepal agreed to exchange four young adult female rhinos for sixteen domestic elephants. In April 1985, four rhinos were captured near Royal Chitwan National Park and brought to Dudhwa. In this way, these seven rhinoceros, two males and five females, made up the rhinoceros seed population (**Table 1**).

2.3 Establishing a second rhino population within Dudhwa National Park, that is, Phase II

The Rhino Reintroduction Program has been executed by the National Park in two phases, RRA-I, that is, Phase I, and RRA-II, that is, Phase II. A second phase has been established to prevent rhino populations from inbreeding. Over the years, the rhino population in Dudhwa NP has grown steadily and is probably at risk of inbreeding, so to provide better conservation opportunities, it is necessary to move the rhinos to a potential protected area and also to bring in new individuals to make the population genetically healthier. As suggested by the Wildlife Institute of India (WII) [15] and following the management plan of Dudhwa Tiger Reserve, the second RRA of Dudhwa NP has a total area of about 14 sq. km. To create a genetically healthy rhino population, at least one male must be unrelated to Dudhwa's existing population. It was through the collaboration of the Uttar Pradesh Forest Department and WWF-India, with support from the Assam Forest Department and Wildlife Trust of India (WTI), that four rhinos were translocated, a significant milestone in the history of rhino conservation (**Figure 2**).

3. Population ecology of great one-horned rhinoceros in Dudhwa National Park after translocation

When the remains of a newborn calf were found in tall grass after the reintroduction in August 1987, the sign of breeding was detected. The first successful calving occurred in 1989. Three more calves followed this in the same year. According to estimates, 58 rhino calves have been born and 35 rhinos (adults and calves) have died in the past 37 years.



Figure 2.
Rhino mother and calf feeding in the grassland of Dudhwa National Park.

Birth rate: A total of 58 rhino calves were born between 1984 and 2021. The mean number of calves born per year is two calves per year. The population-specific crude birth rate is 0.17 per year for a number of adult females in the reproductive age class. The birth rate varied across the years with a higher birth rate at certain years followed by intermittent lower birth rates. This could be attributed to the number of females giving birth and the inter-calving interval duration (3–4 years) by adult females due to parental care.

Mortality: The mean mortality rate is 0.05/year for the rhino population in Dudhwa National Park. The mortality rate was higher during the initial period of the re-introduction of rhinos (0.4/year), and it was lower (0.2/year) in the subsequent years (**Figure 3**). The major causes of mortality were mal–male aggression, predation by tigers, and natural causes. Similarly, the major causes of mortality (80%) in rhinos were reported to be self-fight, tiger predation, and poaching in Nepal [16]. Male aggression and fighting among males were more during the breeding time, associated with the territorial behavior of males [17]. Further, male mortalities are significantly higher than females [18]. Retaliatory killing of rhinos due to the human-rhino conflict in Nepal was also reported. An increase in the population and dispersal of rhinos outside the protected area could be the factors attributed to the human-rhino conflict in their distributional range.

Population growth: The rhino population growth data were modeled using the logistic growth model by non-linear least squares. The parameter values (β_1) initial asymptote is 39.68, and the growth parameter value (β_2 is 0.12). The predicted curve is fitted with the actual population data (**Figure 4**), and the model was highly significant. The curve reached asymptote in the year 2010, and the population has been fluctuating near 35–40 individuals for the last 12 years. Further extension of the area or dispersal of individuals could enable the population size to increase.

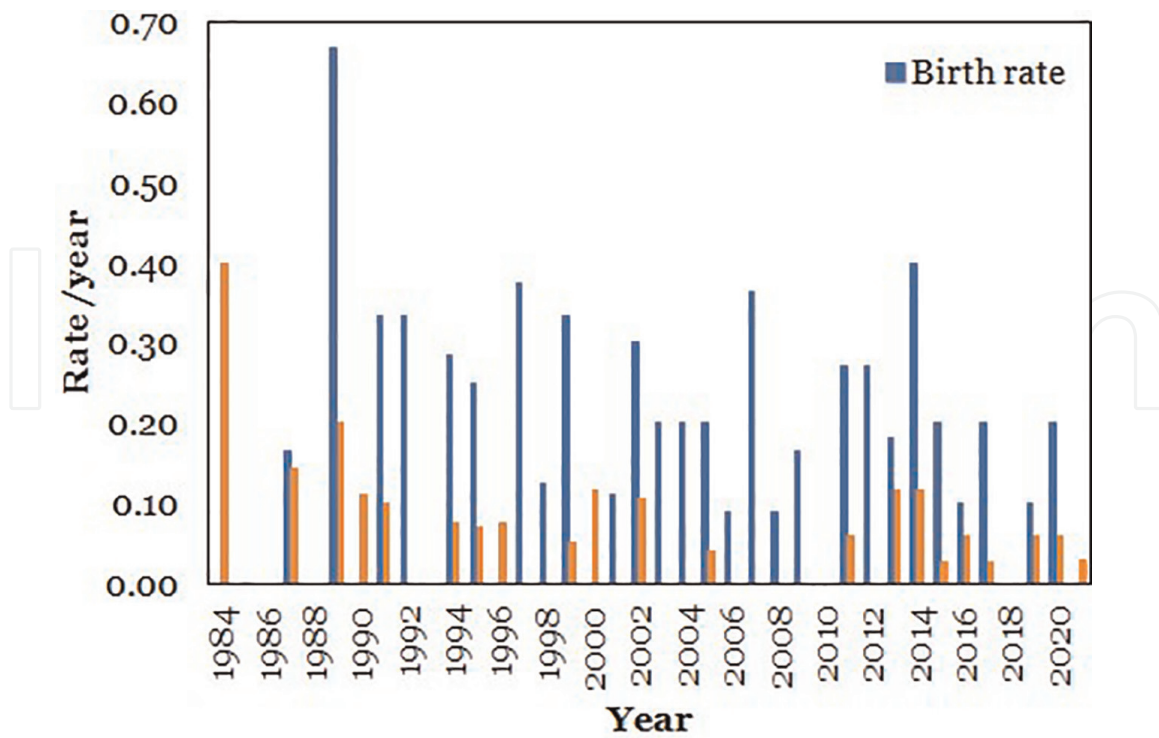


Figure 3. Birth rate/year/adult female and mortality rate of Indian rhinoceros across the years in Dudhwa National Park from 1984 to 2021.

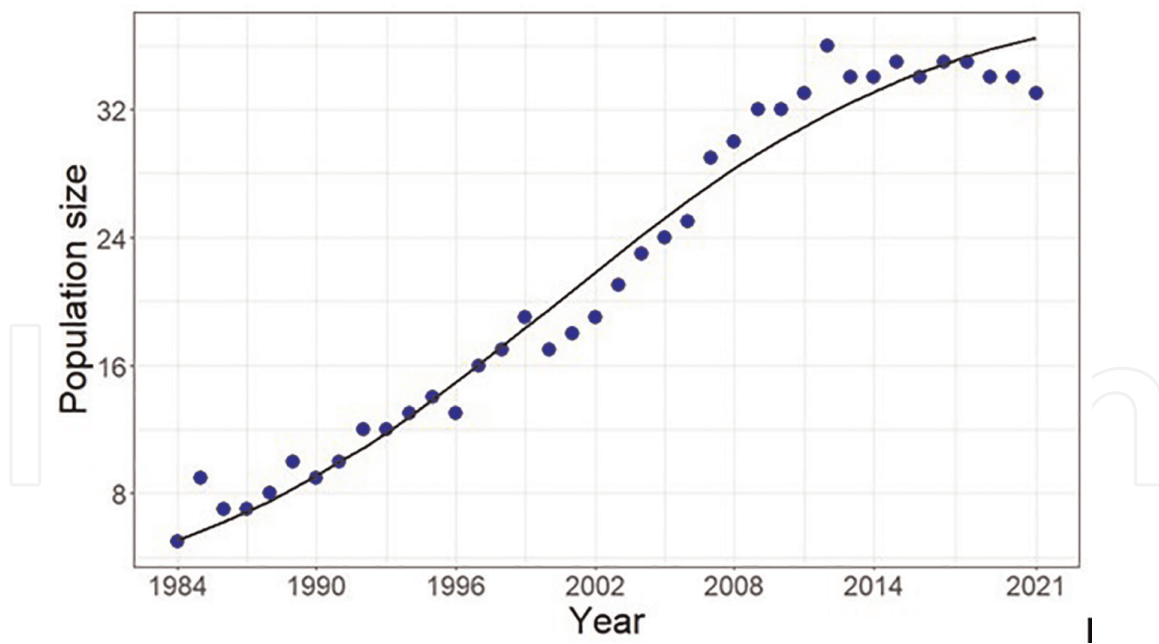


Figure 4. Actual Indian rhinoceros population and predicted logistic model of population growth in Dudhwa National Park (1984–2021).

3.1 Age-specific survival rate

The proportion of individual rhinos surviving at a particular age class was calculated based on the number of rhinos dying at the specific age class. The survivorship

curve is similar to other mammal species with higher mortality at the very young age class followed by moderate mortality in the middle ages and higher mortality at the older age class. Male rhinoceros mortality tends to be higher in the younger age class and female mortality is higher in older individuals. The mortality rate for a very young individual is higher due to predation by tiger (1%). Earlier studies on rhinos reported gender-specific differences in mortality with higher mortality among male rhinos [19, 20]. Male mortality is higher in the dispersal age class. In most of the ungulate species, males die disproportionately due to enhanced growth rates, dispersal behavior, and intra-male aggression [21]. Injuries sustained during the male-male fight may cause mortality directly or indirectly [22]. Male Indian rhinoceros fight each other for territory or mates to establish dominance (Figure 5).

Age-specific fecundity rate: The average age at primiparity observed in Indian rhinoceros is five years. The gestation period is 15–16 months. It appears that the female rhinos remain fertile in old age; an adult female gave birth to her sixth calf at the age of 34 years. The fertility rate varied across ages, with a higher fertility rate at the age class between 8 and 20 years, with a mean fecundity rate of 0.24 and a maximum of 0.40. The fertility rate reduces as the female rhinos reach more than 25 years old. The Indian rhinoceros female produces 4–6 calves in their lifetime (Figure 6).

Inter-birth interval: The reported inter-calving interval is 3–4 years. The present observation on 10 adult females over 47 birth records indicated a minimum of 1.6–10 years of an inter-birth interval with an average of 4.3 years. Thus, in Indian rhinos, about 61% of births occurred during 3–5 years of interval. The inter-birth interval rate is higher than that of the African buffalo, which is reported to have 1–2 years [23]. Earlier studies in the study area on rhinos indicated that inter-birth interval was associated with the age of the mother [24]. It can be inferred from the earlier graph that the fecundity rate decreases with the age of the female rhinoceros (Figure 7).

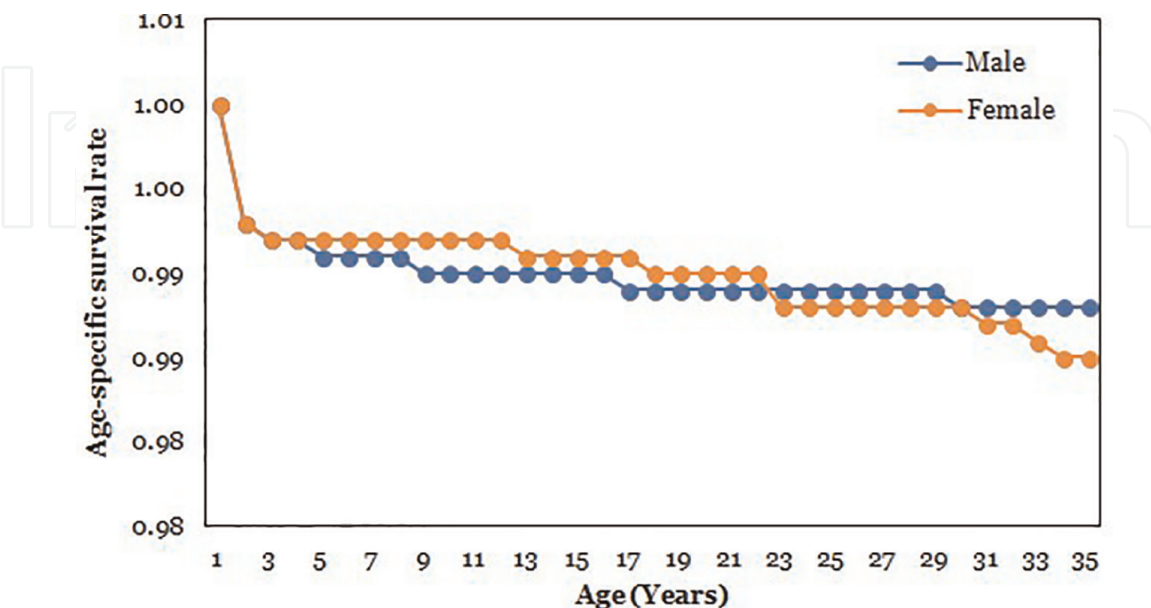


Figure 5. Age-specific survival rate of Indian rhinoceros in Dudhwa National Park (1984–2021; based on mortality record of male = 12; female = 15).

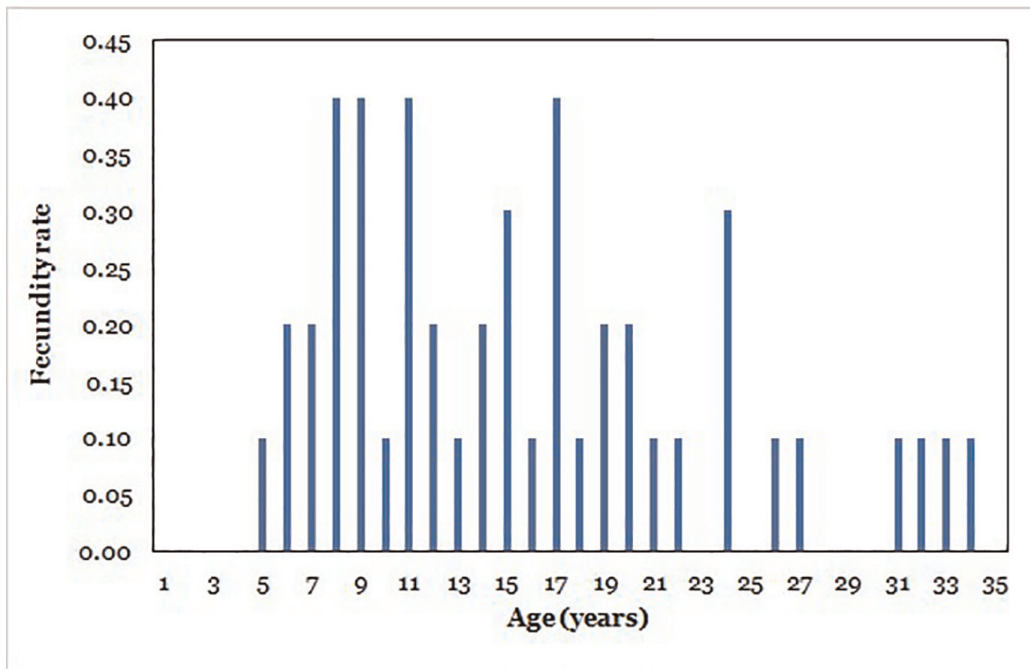


Figure 6. Age-specific fecundity rate of Indian rhinoceros in Dudhwa National Park (1984–2021; $n = 10$ adult females; over 47 birth records).

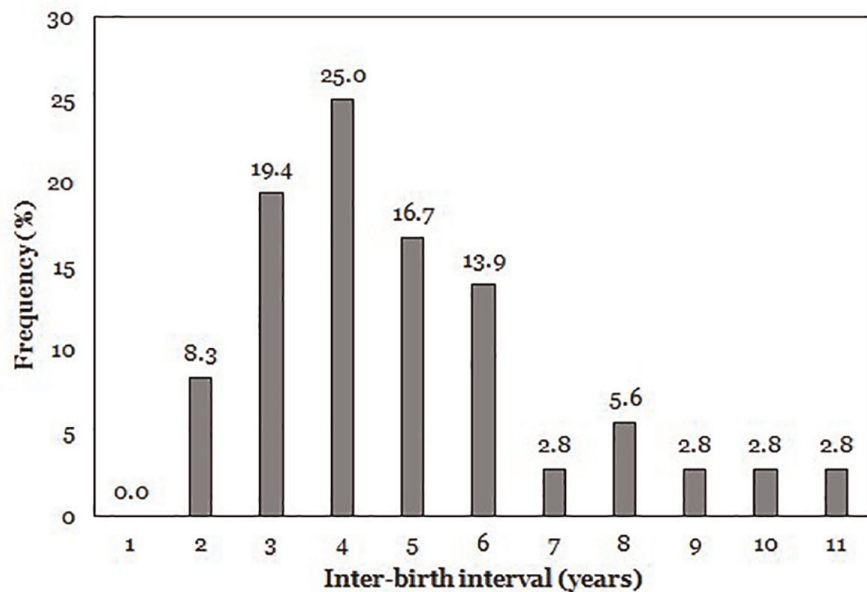


Figure 7. Inter-birth interval duration of Indian rhinoceros in Dudhwa National Park ($n = 10$ adult females; over 47 birth records).

4. Conclusions

The Indian rhinoceros population has increased and reached asymptote in the year 2010, and the population has been fluctuating near 35–40 individuals for the past 12 years. Further extension of the area or dispersal of individuals could enable the population size to increase. The mean birth rate and mortality rate of rhinos in

Dudhwa National Park are 0.17/year/adult female and 0.05/year, respectively. Rhinos, in accordance with their large body size, exhibit life-history traits similar to other large mammal species with a slow onset of sexual maturity, fewer number of young ones produced, and higher inter-birth interval and remain fertile in old age. The survival rate of a female is higher than that of a male. The environmental and ecological factors such as carrying capacity, food availability, predation, and environmental stochasticity may influence the life-history traits of rhinos. The natural forest areas adjacent to the protected areas need to be maintained to enable the dispersal of the increasing population in Dudhwa National Park.

Acknowledgments

We would express our sincere thanks to the Principal Chief Conservator of Forest (Wildlife, U.P.) for granting permission for the study. We express our gratitude to Shri. Sanjay Pathak (Field Director) and Shri. Manoj Kumar Sonkar (Deputy Director) of Dudhwa Tiger Reserve for their kind support. We are also thankful to park staff, including range officers, forest guards, and 'Mahouts,' for their help and co-operations from time to time during the study.

Abbreviations

CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DTR	Dudhwa Tiger Reserve
IUCN	International Union for Conservation of Nature
km	kilometer
km ²	kilometer square
n	number
NP	national park
PCCF	Principal Chief Conservator of Forests
RRA	Rhino Reintroduction Area
S. No.	serial number
sq.	square
UP	Uttar Pradesh
WTI	Wildlife Trust of India
WII	Wildlife Institute of India

IntechOpen

Author details


Richa Kumar^{1*} and Moharangan Ashokkumar²

1 Wildlife SOS, Chhattisgarh, India

2 Wildlife SOS, Karnataka, India

*Address all correspondence to: krricha05@gmail.com

IntechOpen

© 2023 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/3.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] Laurie WA. The Ecology and Behaviour of Greater One-Horned rhinoceros. Cambridge, United Kingdom: University of Cambridge; 1978. p. 450
- [2] Nowak RM, Paradiso JL. Walker's Mammals of the World. Baltimore, MD: Johns Hopkins University Press; 1983
- [3] Ellis S, Talukdar B. *Rhinoceros unicornis*. The IUCN Red List of Threatened Species 2019: e.T19496A18494149. DOI: 10.2305/IUCN.UK.2019-3.RLTS.T19496A18494149.en
- [4] Jhala HY, Qureshi Q, Jhala YV, Black SA. Feasibility of reintroducing grassland megaherbivores, the greater one-horned rhinoceros, and swamp buffalo within their historic global range. *Scientific Reports*. 2021;**11**(1):1-15
- [5] Asian Rhino Specialist Group (AsRSG) biannual survey report, 2022
- [6] National Rhino count 2021, Nepal
- [7] Dinerstein E. The Return of the Unicorns: The Natural History and Conservation of the Greater One-Horned Rhinoceros. New York: Columbia University Press; 2003. p. 316
- [8] Champion HG, Seth SK. Revised Survey of Forest Types in India. New Delhi: Manager of Publication; 1968. p. 404
- [9] Stiling P. Ecology Theories and Applications. 4th ed. New Delhi: Prentice-Hall of India; 2006. p. 403
- [10] Rockwood LL. Introduction to Population Ecology. Oxford: Blackwell Publishing; 2006. p. 339
- [11] Schenkel R. Report on the Suitability of Dudhwa National Park, UP, as Potential Site for Re-Introduction of the Indian Rhinoceros. Gland, Switzerland: IUCN Species Survival Commission; 1983
- [12] Sale JB. Final Recommendations of the Rhino Sub-Committee of the Wild Life Status Evaluation Committee of the IBWL, on the Translocation of Great Indian Rhinoceros. Government of India: New Delhi; 1981
- [13] Hajra PK, Shukla V. Dudhwa National Park: Some Botanical Aspects of the Proposed New Habitat for Rhino. Botanical Survey of India: Howrah; 1982
- [14] Tripathi AK. Status of Indian One-horned Rhino, *Rhinoceros unicornis* Linn. 1758 in Dudhwa National Park, Uttar Pradesh, India. *Journal of Biological Sciences*. 2018;2455-7676
- [15] Sinha SP, Sawarkar VB. Management of the Re-introduced Great One horned Rhinoceros (*Rhinoceros unicornis*) in Dudhwa National Park, U. P., India. WII, Dehradun. In: Ryder OA, editor. *Rhinoceros Biology and Conservation: Proceedings of an International Conference*. San Diego, USA; 1993. pp. 218-227
- [16] Bhandari S, Adhikari B, Baral K, Subedi S. Greater one-horned rhino (*Rhinoceros unicornis*) mortality patterns in Nepal. *Global Ecological Conservation*. 2022;**38**:e02189
- [17] Rachlow JL, Berkeley EV, Berger J. Correlates of male mating strategies in white rhinos (*Ceratotherium simum*). *Journal of Mammalogy*. 1998;**79**(4): 1317-1324

[18] Subedi N, Jnawali SR, Dhakal M, Pradhan NM, Lamichhane BR, Malla S, et al. Population status, structure and distribution of the greater one-horned rhinoceros *Rhinoceros unicornis* in Nepal. *Oryx*. 2013;**47**(3):352-360

[19] Dinerstein E, Price L. Demography and habitat use by greater one-horned rhinoceros in Nepal. *Journal of Wildlife Management*. 1991:401-411

[20] Subedi N, Lamichhane BR, Amin R, Jnawali SR, Jhala YV. Demography and viability of the largest population of greater one-horned rhinoceros in Nepal. *Global Ecological Conservation*. 2017;**12**: 241-252

[21] Berger J, Gompper ME. Sex ratios in extant ungulates: Products of contemporary predation or past life histories? *Journal of Mammalogy*. 1999; **80**:1084-1113

[22] Geist V. New evidence of high frequency of antler wounding in cervids. *Canadian Journal of Zoology*. 1986;**64**: 380-384

[23] Prins HHT. *Ecology and Behaviour of the African Buffalo: Social Inequality and Decision- Making*. London, UK: Chapman and Hall; 1996

[24] Pluhacek J, Steck BL, Sinha SP, Houwald FV. Inter birth intervals are associated with age of the mother, but not with infant mortality in Indian rhinoceroses. *Current Zoology*. 2017; **63**(3):229-235