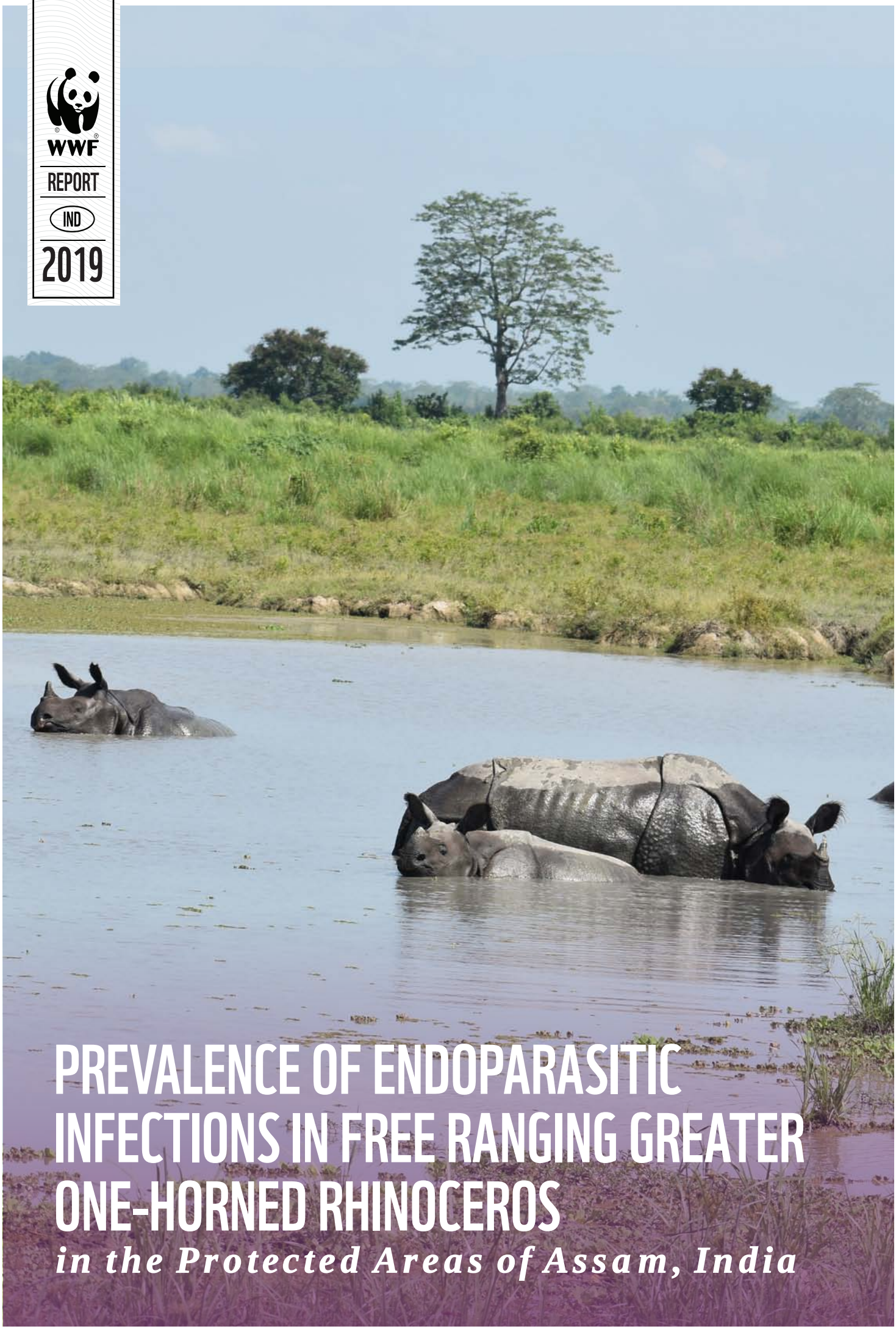
WWF

REPORT

IND

2019



PREVALENCE OF ENDOPARASITIC INFECTIONS IN FREE RANGING GREATER ONE-HORNED RHINOCEROS

in the Protected Areas of Assam, India

WWF-India, 172-B, Lodi Estate, New Delhi 110 003
Tel: +91 11 4150 4814, Website: www.wwfindia.org

Published by WWF-India

Citation:
Kakati, P.K., Islam, I., Sharma, A., and Phukan, D. (July, 2019). Prevalence of Endoparasitic Infections in Free Ranging Greater One-Horned Rhinoceros in the Protected Areas of Assam, India. A technical report. World Wide Fund for Nature-India. New Delhi.

Prevalence of Endoparasitic Infections in Free Ranging Greater One-Horned Rhinoceros in the Protected Areas of Assam, India

Technical report
June 2019

Prepared by:
Dr. Parikshit Kakati,
Dr. Saidul Islam,
Mr. Amit Sharma and
Dr. Debabrata Phukan

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The greater one-horned rhinoceros (GoH) (*Rhinoceros unicornis*) also known as the Indian rhino is a vulnerable wildlife species found in the Indian subcontinent. Of the Indian population of about 2979 individuals, around 2652 (89.35%) of the rhinos are found in Assam and around 91% of these are found in Kaziranga National Park alone with a population of 2413 individuals, 102 (3.84 %) in Pobitora Wildlife Sanctuary, 101(3.80 %) in Rajiv Gandhi Orang National Park as per the 2018 rhino estimation in Assam and 36 (1.35 %) in Manas National Park. The need to initiate studies on diseases and pathogens affecting the Indian rhino is urgent as considerable number of cases on rhino deaths go unaddressed and due to increasing livestock pressure on protected areas there is a possible threat of pathogens getting transferred from domestic animals to wild animals. Additionally, dearth of data in India makes it even more crucial to initiate such studies to plug the knowledge gaps in rhino diseases and help draw up measures to address a disease outbreak. As per the National Conservation Strategy for the greater one horned rhinoceros, dedicated research on rhinos in India is very scanty. The strategy advocates concerted efforts by the central and state governments, scientific Institutes and NGOs to address this gap and conduct research on the rhino ecology, disease, habitat and population dynamics. Hence, this study on parasite prevalence using non-invasive qualitative method was initiated in all the rhino bearing PAs of Assam, India.

The current study was conducted in Assam's four rhino bearing Protected Areas viz. - Rajiv Gandhi Orang National Park, Pobitora Wildlife Sanctuary, Manas National Park, and Kaziranga National Park. Dung samples (weighing 100 gm) were collected and kept in plastic zip bags without any preservative and immediately dispatched for analysis. All possible efforts were made to collect freshly voided dung samples not older than the previous night. The selection was purely based on physical and visual parameters of the dung. The samples were provided with unique IDs and dispatched to the laboratory located at the Department of Parasitology, College of Veterinary Science, Assam Agricultural University, Khanapara, Guwahati, Assam for analysis.

A total of 309 GoH rhino dung samples were collected from the four PAs in Assam for this study. The overall prevalence of endoparasites were found to be 58.57 % (n=181) comprising of four genera of endoparasites mainly *Amphistome spp.* with a

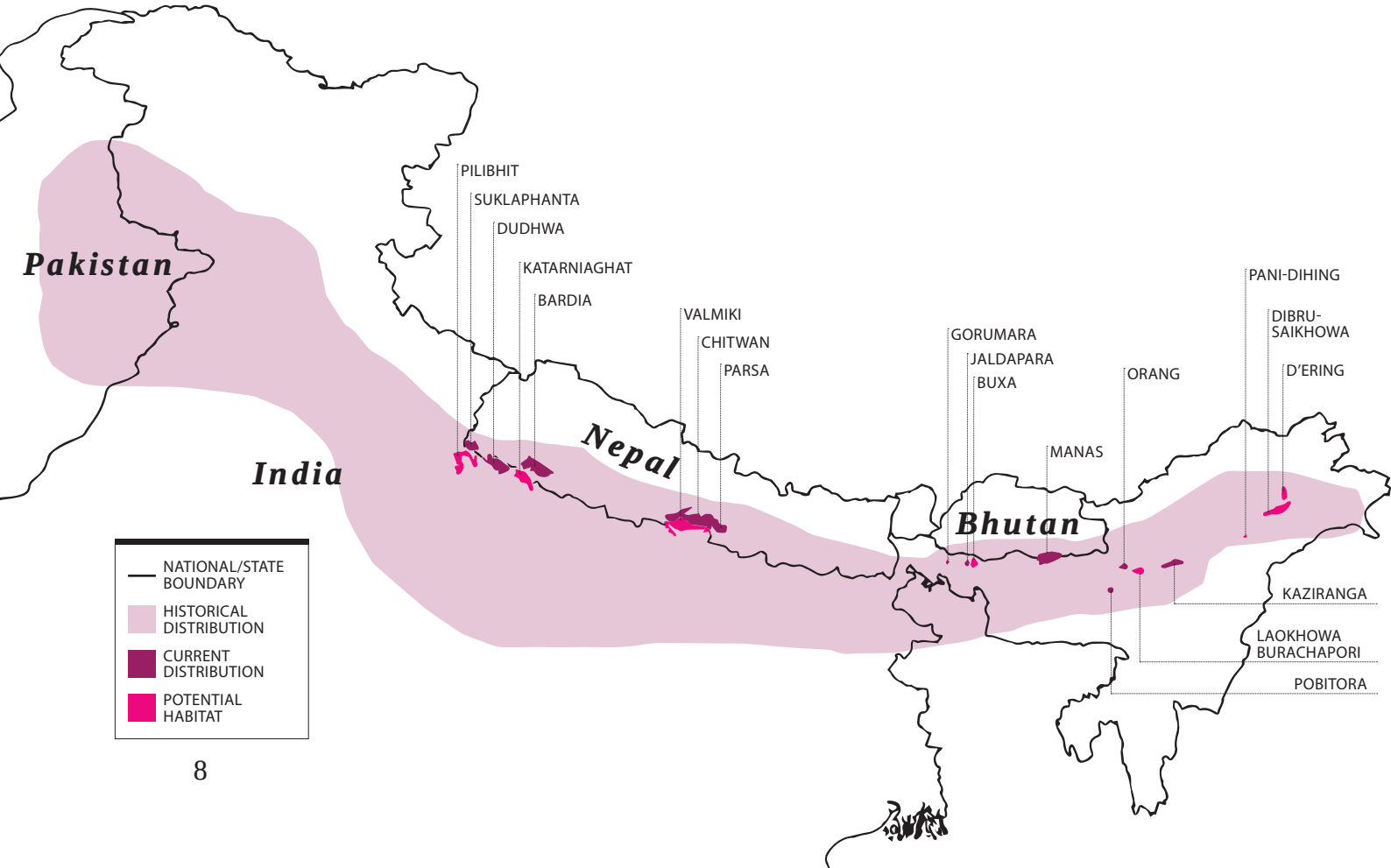
prevalence rate of 17.15 % (n=53), *Strongyle spp.* with a prevalence rate of 43.68 % (n=135) and two sporadic occurrence of *Bivitellobilharzia nairii* (n=1) and *Spirurid spp.* (n=2) only in Pobitora Wildlife Sanctuary. Mixed infection rate was found to be 6.47 % (n=20) amongst all the four areas. The present study will serve as a basis for future studies on the species involving pathogens and host interaction, emerging and unknown diseases and these should help us to manage our GoH Rhino population with even better understanding and knowledge about its diseases and pathogen diversity. The following recommendations were drawn up based on the current study:

1. Detailed post mortem of rhino carcass
2. Dung screening of other wild herbivores and domesticated elephants in the PAs.
3. Disease surveillance in captive animals in the adjoining village areas of PAs.
4. Seasonal examination of rhino dung samples in the PAs of Assam.

INTRODUCTION:

The greater one-horned rhinoceros (GoH) (*Rhinoceros unicornis*) also known as the Indian rhino is a vulnerable wildlife species found in the Indian subcontinent. Historically, rhinoceros was once distributed in the floodplains and forest tracts in the Brahmaputra, the Ganges and the Indus river valley (Fig 1). But its population gradually declined over the last 400 years as a result of habitat destruction and poaching. By the 19th century, rhino population survived only in the Terai grasslands of northern Uttar Pradesh, southern Nepal, northern Bihar, northern West Bengal and the Brahmaputra valley of Assam. Concerted conservation efforts have managed to bring back the species to around 3,582 individuals in the wild and these are distributed in a limited range within the Terai at the foothills and grasslands of Eastern Himalayas, and Brahmaputra Valley (WWF 2016). Conservation efforts have led to the IUCN red list status of the greater one-horned rhinoceros to be downgraded from Endangered to Vulnerable in the year 2009. Even though the species is doing well in the state of Assam, it is found only in isolated pockets of the state and the population is highly threatened due to both poaching and non-poaching threats like disease and in-breeding. Of the Indian population of about 2979 individuals, around 2652 (89.35%) of the rhinos are

Fig1: Map showing GoH rhino distribution, past and present



found in Assam and around 91% of these are found in Kaziranga National Park alone with a population of 2413 individuals (The Hindu, 30 March, 2018 report), 102 (3.84 %) in Pobitora Wildlife Sanctuary (Times of India, 19March, 2018), 101(3.80 %) in Rajiv Gandhi Orang National Park (Times of India, 17March, 2018) as per the 2018 rhino estimation in Assam and 36 (1.35 %) in Manas National Park (Unpublished report, MNP, 2018). Additionally, rhinos are distributed in three other protected areas in the country viz. Jaldapara National Park with a population of 237 and Gorumara National Park with a population of 52 rhinos as per the 2019 census (Directorate of Forests, Govt. of West Bengal) and Dudhwa National Park with 38 rhinos in Uttar Pradesh (WII RhoDIS report 2019, Unpublished). Rest of the world's rhino population of 645 individuals are distributed in Nepal's four Protected Areas namely Chitwan National Park (CNP) with 605 individuals, Bardia National Park (BNP) with 29, Shuklaphanta Wildlife Reserve (SWR) with 8 and Parsa Wildlife Reserve (PWR) with 3 rhinos respectively as per the National Rhino Census, 2015 carried out in Nepal (GoH Rhinoceros Conservation Action Plan for Nepal 2017-21).

RATIONALE:

Poaching and habitat destruction are the most pressing threats to the survival of the greater one-horned rhinoceros, however disease and presence of a large population in an isolated habitat, namely Kaziranga National Park also poses as a threat. Review of records from the rhino bearing Protected Areas (PAs) of Assam reveal that as compared to reported 217 deaths caused due to poaching, more than 600 natural deaths have been recorded during 2008-2018 (Unpublished data), meaning about 60 deaths every year. Post mortem records reviewed as part of this study showed that there is a lack of proper laboratory investigation in the assessment of those 600 deaths. Documented causes of rhino deaths from 2008-2019 categorised under natural deaths include old age, infighting, predation and other unknown causes. Systematic scientific investigations could reveal more information in these cases reported as natural deaths. Several causes related to viruses, bacteria, protozoa, parasites, congenital anomalies, difficult births or dystokia, deficiencies and many more unexplored territories could be related to these deaths.

Threatened species may be particularly vulnerable to parasites, as many of the causes of the current biodiversity decline also expose hosts to a greater parasite burden (Smith et al., Chapter 1: 16 2009a). Habitat loss and fragmentation can restrict species dispersal, which in turn increases contact rates and parasite transmission which will ultimately increase parasite abundance (Scott, 1988). Further, habitat fragmentation and isolation also often create more frequent and unwanted interaction between wildlife and livestock. Domestic livestock can act as high density reservoir-hosts for parasites of wildlife, leading to higher parasite abundance within wildlife (Lafferty and Gerber, 2002). It has been shown that wildlife living in close proximity to domestic animals is more likely to be affected

by parasitism (Pedersen et al., 2007). The above cited situation is true for Assam where all the rhino bearing areas are fragmented and prone to pressure from livestock grazing thereby increasing the risk of parasites to the GoH population. In Assam, there is a gap in knowledge and studies to compare parasitic infections in domestic and wild animals and possible risks of transmission of the parasites between the two populations.

Threatened species are also more likely to suffer from inbreeding. A key effect of inbreeding is increased vulnerability to parasitism, which can ultimately increase mortality rates (Coltman et al., 1999). Conservationists must also be aware of a variety of conservation actions that can increase the susceptibility of individuals and populations to parasitism. Animal translocations, in particular, are situations in which the host-parasite population dynamic may be changed, especially in the relocated (reintroduced) or receiving (restocked) population. For instance, conservation translocations may introduce new parasites to an area, and may also introduce naïve translocated hosts to new parasites. For example, eggs and juveniles of the swim bladder nematode *Anguillicola crassus*, a parasite of the Japanese eel *Anguilla japonica*, were introduced by aquaculture transport vehicles into the United Kingdom, where they have successfully parasitized native European eels, *Anguilla Anguilla* (Kirk, 2003). Alien parasites may also be introduced with native hosts, if those hosts have been translocated, acquired infection with a new parasite species and then been re-introduced into their original habitat. For example, the natural host of the parasitic brood mite *Varroa destructor* is the Asian bee *Apis cerana*. The European honeybee *Apis mellifera* acquired the mite when it was introduced to Asia early in the 20th century. Although the details are unclear, it appears likely that the mite was then introduced into Europe with infested European honeybees, rather than with the alien Asian bee (Oldroyd, 1999; Anderson and Trueman, 2000).

This may be exacerbated by the stress caused by translocation making individuals more susceptible to parasitism. Another potential influence of species reintroduction may be the introduction of a new reservoir host which would change the existing host-parasite population dynamics in the area (Cunningham, 1996; Jørgensen, 2014; Sainsbury and Vaughan-Higgins, 2012). As per the IUCN Reintroduction guidelines under biological feasibility (5.1) and disease and parasite consideration (5.1.6), surveillance of source populations can establish the potential pathogen community present and individuals can then be selected for purposes of reintroduction or translocation, based on a risk assessment. Pathogenicity may be promoted by the stress of unfamiliar or unnatural conditions of confinement, especially during the translocation process and that is why the management of disease and known pathogen transfer is important, both to maximise the health of translocated organisms and to minimise the risk of introducing a new pathogen to the destination area (IUCN Guidelines for Reintroductions and Other Conservation Translocations). The IRV 2020 programme in the state of Assam has been instrumental in the translocation of 20 rhinos till date but the deaths of two translocated rhinos in Burachapori Wildlife Sanctuary failed to reveal much information regarding the cause of death. It could have been stress related where a concurrent disease or pathogen might have flared up leading to their deaths. In order to confirm this hypothesis and prevent such episodes, screening of animals in the wild is very necessary.

The need to initiate studies on diseases and pathogens affecting the Indian rhino is urgent as considerable number of cases on rhino deaths go unaddressed and due to increasing livestock pressure on protected areas there is a possible threat of pathogens getting transferred from domestic animals to wild animals. Surveillance and monitoring of threats and probable pathogens which might affect the rhinos in the PAs of Assam is critical. Additionally, dearth of data in India makes it even more crucial to initiate such studies to plug the knowledge gaps in rhino diseases, and help draw up measures to address a disease outbreak.

REVIEW OF WORK DONE EARLIER:

There are no systematic studies on the prevalence of parasite and parasitic diseases in free ranging GoH rhino populations present in the PAs of Assam.

Phukan (2013) in his study in Manas National Park found 33.33 % prevalence with *Amphistome spp.* in 11 dung samples. Chakraborty and Islam (1993) reported 46.42 % infection with *Amphistome spp.* in GoH Rhinoceros based on examination of 84 dung samples collected from 11 different areas viz. Mihimukh, Kathpura, Tatibeel, Diphalu, Bagori, Amkathani, Rowmari, Bimoli, Borbeel and Baruntika in Kaziranga National Park. They also recorded the prevalence of *Strongyle spp.* (20.23%), *Anoplocephala spp.* (2.38 %) and *Coccidia spp.* (3.57 %) infection from the same samples. The parasite samples collected from post mortem examination of GoH rhinoceros from the Assam State Zoo also revealed infections with *Kiluluma spp., Amphistome spp., Chabertia spp., Bunostomum spp., Anoplocephala spp.* and *Balantidium coli* infection (Chakraborty and Gogoi, 1995).

OBJECTIVE:

To document the parasitic fauna present in the GoH rhinoceros population within rhino bearing PAs of Assam using non-invasive qualitative dung examination method and establish a baseline for future intervention.

STUDY AREA:

The current study was conducted in Assam's four rhino bearing Protected Areas viz. - Rajiv Gandhi Orang National Park, Pobitora Wildlife Sanctuary, Manas National Park, and Kaziranga National Park.

The Rajiv Gandhi Orang National Park (RGONP) is situated on the northern bank of the river Brahmaputra and encompasses 78.8 sq.km of riverine landscapes. In 1985, it was established as a wildlife sanctuary encompassing an area of 78.8 sq. km and

was thereby declared as a national park in 1999. This protected area is a part of the Brahmaputra riverine landscape and is also popularly known as 'Mini Kaziranga' with a rhino population of 101 individuals as per the 2018 estimation.

Pobitora Wildlife Sanctuary is located in the Morigaon district of Assam. It is situated in the south bank of the Brahmaputra River at a distance of about 50 km, east of the Guwahati city with an area of 38.31 sq. km. The rhino bearing area of the wildlife sanctuary is only about 16 sq. km and there are 102 rhinos as per the 2018 GoH Rhinoceros estimation.

Manas National Park is one among the most pristine wildlife habitats in the world. The area has the unique distinction of being a Natural World heritage site, a Tiger Reserve, an Elephant Reserve, Biosphere Reserve and Important Bird Area and has a total area of 850.00 sq.km after the 1st addition of 350 sq.km. The GoH rhinoceros (*Rhinoceros unicornis*) is one of the four mega herbivores of the park and currently has a population of 36 individuals (2018) with the birth 20 calves in the park in September 2012, post the translocation .

Kaziranga National Park is located between latitudes 26°30' N and 26°45' N, and longitudes 93°08' E to 93°36' E within four districts in the Indian state of Assam viz. – Golaghat, Nagaon, Sonitpur and Biswanath. The park has a total area of 858.98 sq.km which includes all the six additions of the park. Success of rhino population can be best studied in this park as from not more than two dozen rhinos in 1905 it has now the highest population of GoH rhinos in the world with a healthy population of 2413 individuals, as per the last estimation in 2018.

METHODOLOGY:

Rhino dung sampling was carried out in Manas National Park and Pobitora Wildlife Sanctuary in the month of February, 2018 while the sampling in Kaziranga and Orang National Park was done in the month of June, 2018 covering the dry period prior to the floods. The sampling was done by veterinarians and staff from WWF-India and Kaziranga NP, officials from Wildlife Institute of India, Dehradun and frontline staff from all the parks. The sampling methodology was based on the following procedures:

1. Forest staff conducted a recce before the sampling to determine the dung locations.

2. All possible rhino ranging areas in the parks were covered using vehicles, departmental elephants and on foot in the early hours of the day (0500 - 1200 hours).

3. In Kaziranga National Park, it was not possible to cover the entire rhino ranging area as done in other areas owing to difficult terrain, lack of accessible path and risks involving animal attacks. Samples were therefore collected on the basis of a systematic random sampling plan. Sampling was carried out in both the core area and areas along the park boundary where livestock movement is seen. Sampling was carried out in such a manner that both grassland and woodland were covered. The following methods were adopted for the collection:

    - A minimum of 2 dung samples were collected every 1 km starting from the southern boundary of all the four ranges towards the river Brahmaputra to the north.

    - A minimum of 2 dung samples were collected every 1 km along the southern boundary where livestock grazing is more prominent.

    - Apart from the designated north-south routes, opportunistic dung samples in the east-west direction of the road were also collected to cover additional areas.

4. Dung samples (weighing 100 gm) were collected and kept in plastic zip bags without any preservative and immediately dispatched for analysis. All possible efforts were made to collect freshly voided dung samples not older than the previous night. The selection was purely based on physical and visual parameters of the dung (moisture content, presence of maggots, dung beetles and external/surface fungal growth like mushrooms and toad stools). The dried samples with external fungal growth over the surface, dung heaps scratched and dispersed by wild fowls, birds and wild boars were not picked for the study. Local knowledge of the forest staff was utilized to ascertain the rhino home range and avoid replication.

5. The samples were provided with unique IDs and dispatched to the laboratory located at the Department of Parasitology, College of Veterinary Science, Assam Agriculture University, Khanapara, Guwahati, Assam for analysis.

6. Both salt floatation and sedimentation techniques were done as per standard protocols (Soulsby, 1982) to detect the presence of parasitic ova and larvae in the dung samples.

RESULTS:

Kaziranga National Park:

A total of 61 rhino dung samples were collected (Fig: 2) and screened for parasitic load. All the four ranges viz. Agaratoli, Burapahar, Kohora and Bagori were covered. The dung collection in Kaziranga NP was carried out during the month of June for a period of 7 days which started at 0500 hrs. until noon. Only 61 samples could be collected during that period, which can be attributed to the tall grasses hampering visibility and movement posing a challenge. Most of the rhinos were using the water bodies throughout the day and sparingly came out near the tracks and forest roads due to the hot conditions. Most of the dung samples were therefore collected from woodlands and few from the patrolling paths. Out of the 61 samples, 49 (80.32 %) were found to be positive for moderate to heavy parasitic infection. 30 samples (49.18 %) were positive for *Amphistome spp.*, 19 (31.14 %) for *Strongyle spp.* and 10 (16.39 %) were positive for mixed infection with both *Amphistome spp.* and *Strongyle spp.* respectively (Annexure-I). Prevalence of endoparasites in Kaziranga National Park in the present study correlates with that of Chakraborty and Islam (1993) who reported 46.42 % *Amphistome spp.* infection in GoH Rhinoceros from 11 different areas viz. Mihimukh, Kathpura, Tatibeel, Diphalu, Bagori, Amkathani, Rowmari, Bimoli, Borbeel and Baruntika area respectively of

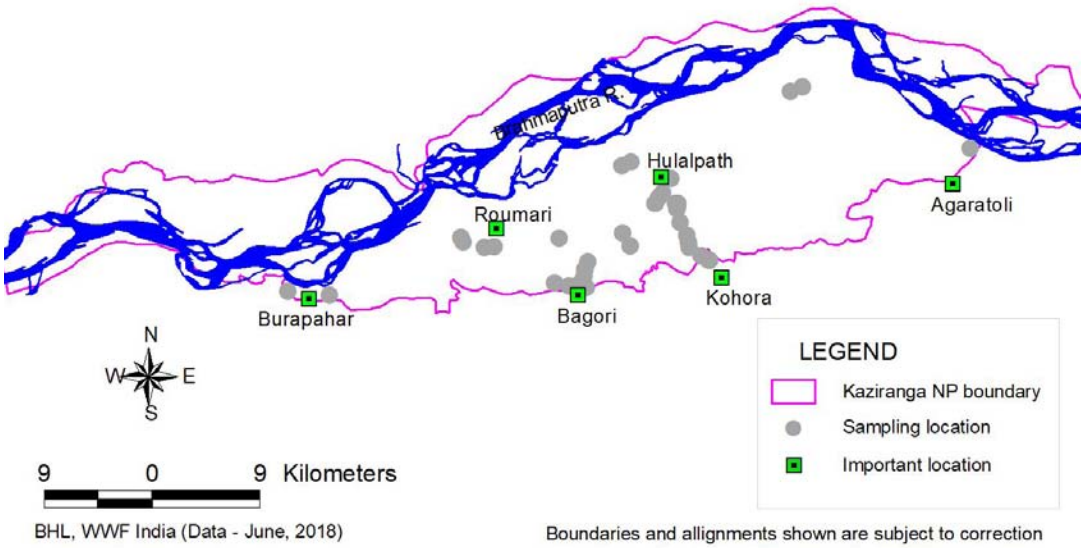


Fig: 2 Sampling location inside Kaziranga National Park.

Kaziranga National Park within 84 dung samples collected in 1984.They could also detect the prevalence *Strongyle spp. larvae* (20.23%), *Anoplocephala spp.* (2.38 %) and *Coccidia spp.* (3.57 %) infection from the same samples.

Manas National Park:

A total of 55 rhino dung samples were collected from the field which included both the ranges of the park namely Bansbari and Bhuyapara (Fig: 3) which were screened for parasitic load by qualitative methods. From the 55 dung samples that were analysed, it has been observed that 39 samples (70.90 %) had moderate to heavy parasitic infection. Out of the 55 samples, 3 (5.45 %) were positive for *Amphistome spp. spp* . and 36 (65.45 %) were positive for *Strongyle spp.* (Annexure: II). Phukan (2013) during his study in Manas National Park found 33.33 % prevalence with *Amphistome spp.* and no other parasite species were recorded during that study. In the present study in Manas National Park, we could detect a higher prevalence of *Strongyle spp.* in comparison to *Amphistome spp.* The difference in this particular aspect may be attributed to the lesser sample size (n=11) in the study carried out by Phukan, 2013 and also the limited range covered.

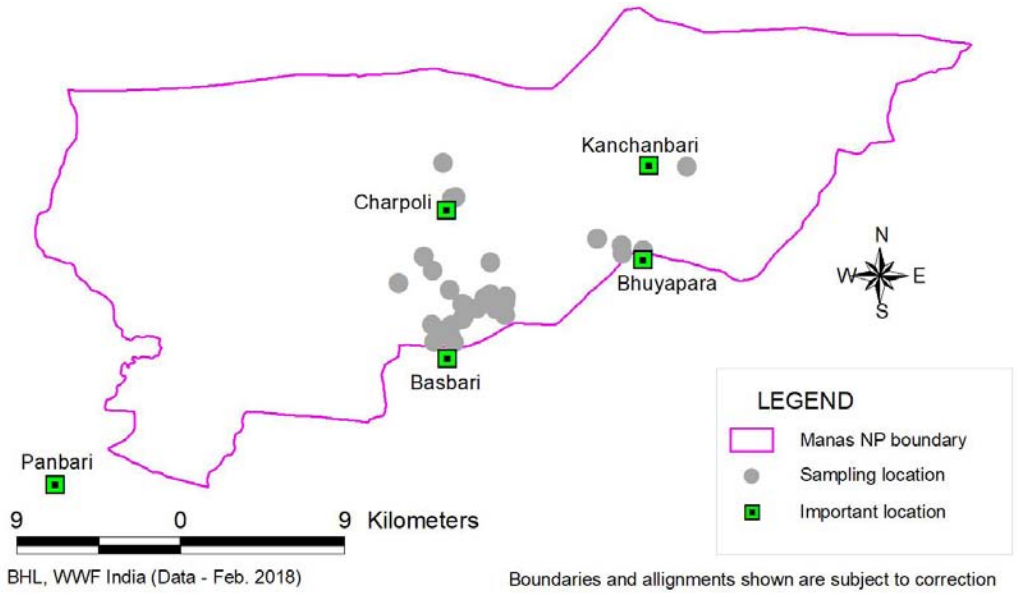


Fig: 3 Sampling location inside Manas National Park.

Pobitora Wildlife Sanctuary:

A total of 158 rhino dung samples were collected from different locations (Fig: 4) inside the Pobitora WLS and screened for parasitic load. Out of the 158 samples, 69 samples (43.67 %) were positive for moderate to heavy parasitic infection. 3 samples (1.89 %) were positive for mixed parasitic load. Parasitic ova of 4 genuses could be detected during the present study out of which *Strongyle spp.* was detected in 61 samples (38.60 %) followed by *Amphistome spp.* in 5 samples (3.16 %), *Spirurid* nematodes in 2 samples (1.26 %) and 1 sample revealed the presence of *Bivitellobilharzia nairii* infection (Annexure-III). The presence of *Schistosome spp.*, *Bivitellobilharzia nairii* in GoH Rhino is further substantiated by a similar report by Devkota et al. 2014 from Chitwan National Park in Nepal, wherein the workers could detect the parasite in 7 out of 14 rhino dung samples and also in elephant dung samples. This suggests that both the mega herbivores share the same parasite. However, the absence of wild elephants in the Pobitora WLS sanctuary indicates that the infection can either be contracted from the domesticated elephants or another host like the Asiatic Wild Buffalo may harbour the parasite.

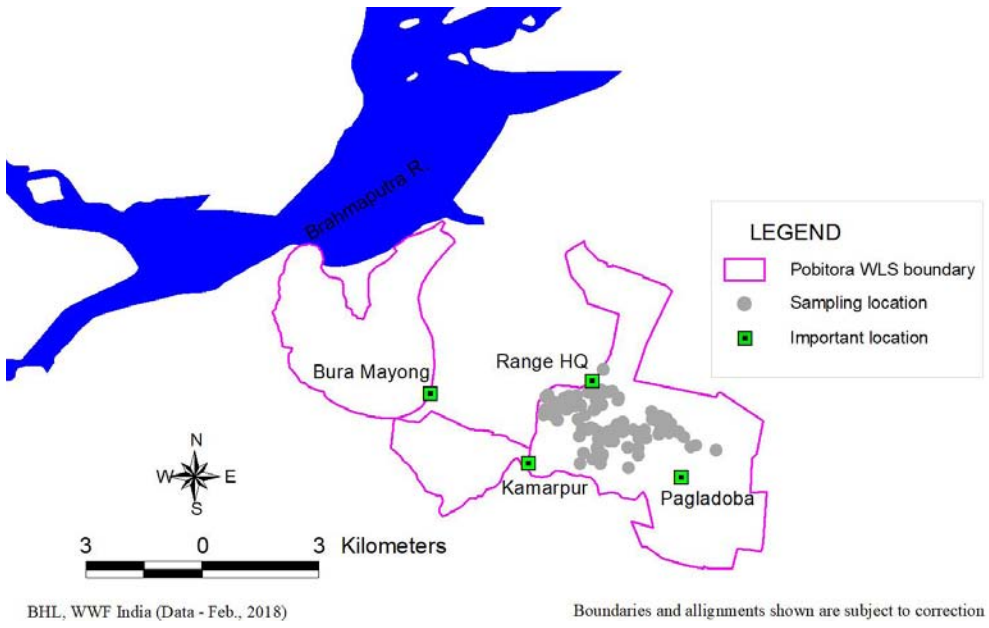


Fig:4 Sampling location inside Pobitora Wildlife Sanctuary.

R.G. Orang National Park:

A total of 35 rhino dung samples were collected from different locations (Fig. 5) inside the RGONP and screened for parasitic load. Out of the 35 samples, 28 (80.00 %) samples were found positive for moderate to heavy parasitic infection. Of the total samples that were examined, 15 samples (42.85%) were positive for *Amphistome spp.* 19 samples (54.28 %) for *Strongyle spp.* and seven samples (20.00 %) were positive for mixed infection with both *Amphistome spp.* and *Strongyle spp.* (Annexure-IV).

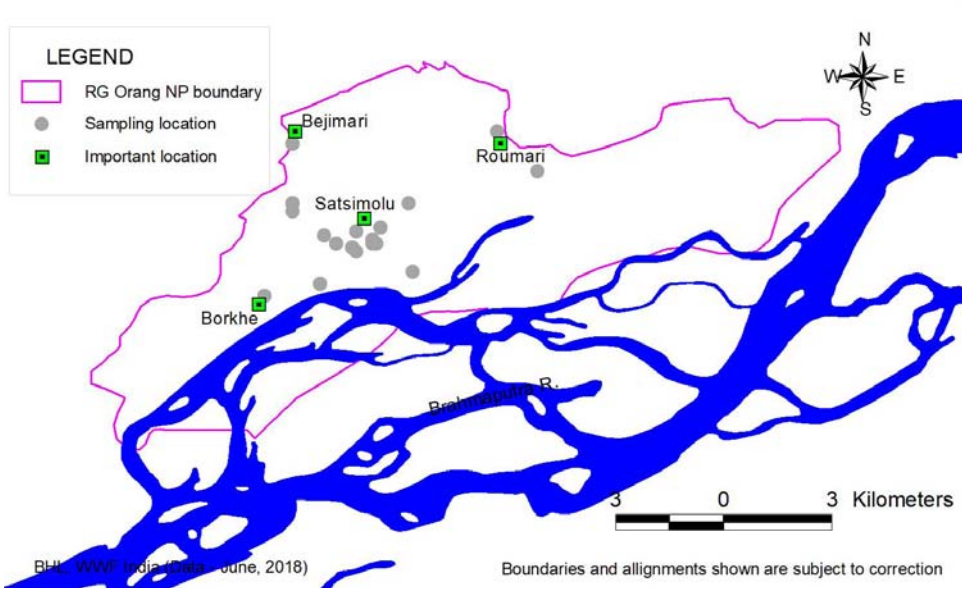


Fig: 5 Sampling location inside R.G. Orang National Park.

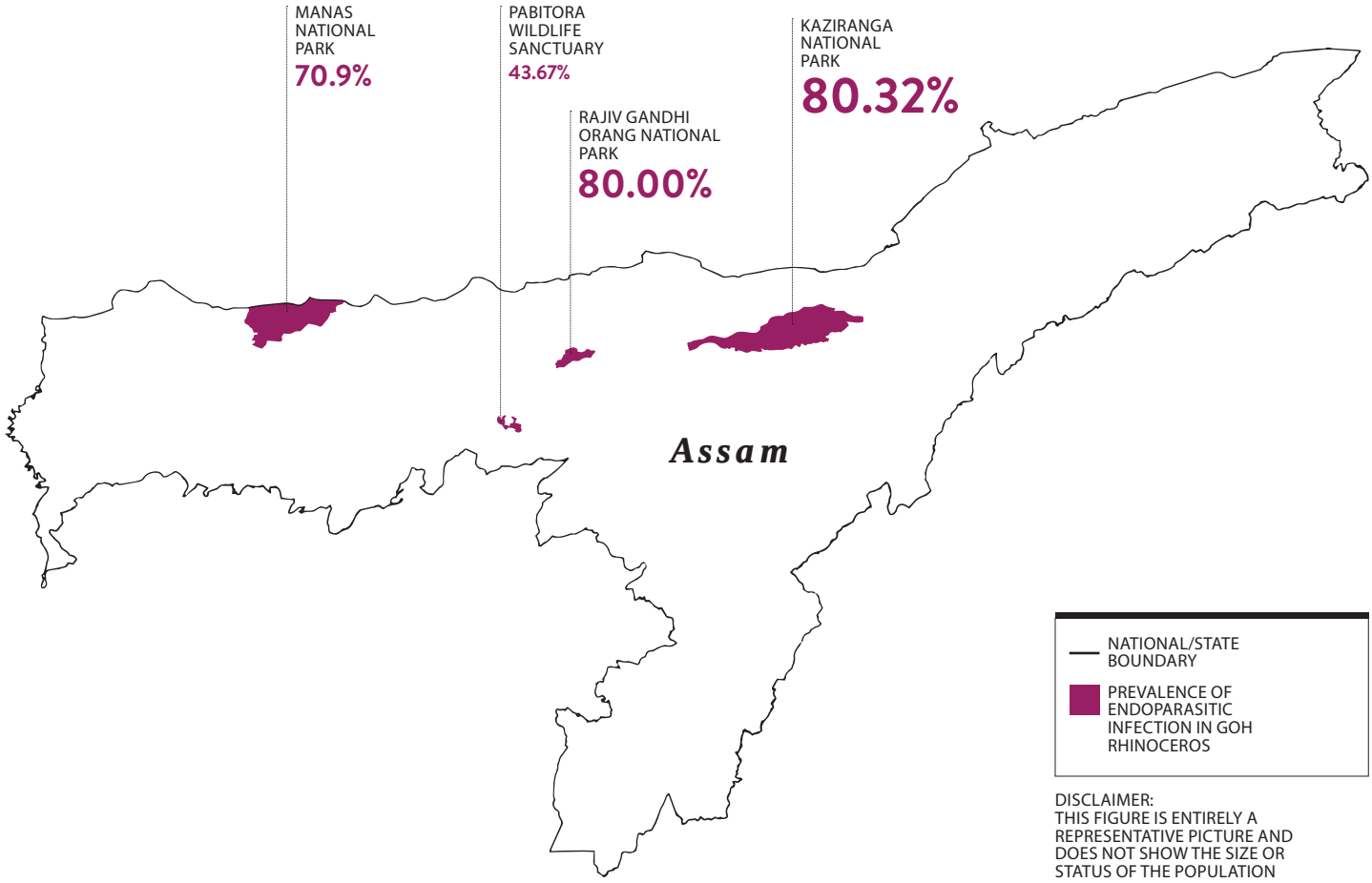


Table: 1: Overall prevalence of endoparasitic infection in GoH Rhinoceros in four protected areas of Assam.

Protected Area Name	Period of sample collection	Number of samples collected	Samples positive for parasites	Prevalence rate(%)	Species wise prevalence				
					Amphistome spp.	*Strongyle spp.*	*Bivitellobilharzia nairii*	*Spirurid spp.*	Mixed infection
Kaziranga National Park	June, 2018	61	49	80.32	30 (49.18 %)	19 (31.14 %)	xxx	xxx	10 (16.39 %)
Rajiv Gandhi Orang National Park	June, 2018	35	28	80.00	15(42.85 %)	19(54.28 %)	xxx	xxx	7(20.00 %)
Manas National Park	February, 2018	55	39	70.9	3 (5.45 %)	36 (65.45 %)	xxx	xxx	xxx
Pobitora Wildlife Sanctuary	February, 2018	158	69	43.67	5 (3.16 %)	61 (38.60 %)	1	2 (1.26 %)	3 (1.89 %)
Total samples		309	181	58.57%	53 (17.15%)	135 (43.68 %)	01 (0.30 %)	02 (0.64 %)	20 (6.47 %)

Dung sampling in Pobitora Wildlife Sanctuary

RECOMMENDATION FROM THE CURRENT STUDY:

A total of 309 GoH Rhino dung samples were collected from the four PAs in Assam. The overall prevalence of endoparasites were found to be 58.57 % (n=181) comprising of four genera of endoparasites mainly *Amphistome spp.* with a prevalence rate of 17.15 % (n=53), *Strongyle spp.* with a prevalence rate of 43.68 % (n=135) and two sporadic occurrence of *Bivitellobilharzia nairii* (n=1) and *Spirurid spp.* (n=2) only in Pobitora Wildlife Sanctuary. Mixed infection rate was found to be 6.47 % (n=20) amongst all the four areas. Post mortem reports of more than 600 rhinos from the PAs of Assam revealed very scanty information regarding prevalence endoparasites. Dung samples in Orang National Park and Pobitora Wildlife Sanctuary were collected for the first time. Due to the lack of earlier work from the two PA's we do not have any reference to compare the results.

The *Strongyles* are nematodes or round worms which occur primarily in Equines and other mammals like rhinoceros, elephants and rodents (Levine, 1968). These parasites have a direct life cycle and hosts are infected when they ingest vegetation contaminated with the larvae. Under optimum temperature of 35° c, the larvae hatch from the eggs in faeces in 10 hours or less and infective stage is reached within 48 hours. But at a temperature of above 40° c the development of eggs ceases.

Amphistome spp. are found in a wide variety of domestic and wild herbivores and a light to moderate infection seldom causes any harmful effect on the host. There are number of species which effects wild herbivores like Elephants, Rhinoceros, Wild Buffaloes, Deer, Antelopes etc. to name a few (Soulsby, 1968).Infections with *Amphistome spp.* may be due to ingestion of metacercariae while grazing in contaminated pastures. Infection can be transmitted either from wild herbivores or domestic herbivores. The prevalence of *Amphistome spp.* in wild herbivores depends upon the factors determining the availability, development and survival of intermediate host in the environment and influences the level and severity of the infections (Kusikula and Kambarage 1996).

Examinations of dung samples of domestic cattle (n=2339) and buffaloes (n=1258) in Assam by Das *et. al* (2017) revealed an overall prevalence of 58.35% and 29.80% infections in cattle and buffalo, respectively. In cattle, *Strongyle spp.* (18.76%) was predominant while in buffalo, *Amphistome spp.* (8.90%) was predominant. Mixed infections with more than one species were recorded in 8.76% and 3.89% cattle and buffalo, respectively. This makes it necessary to carry out extensive surveillance of parasitic diseases of domestic animals in the areas adjoining these Protected Areas and correlate the same with that of wild counterparts through a systematic study and during opportunistic post mortem examination.

Most of the infectious diseases of livestock like Foot and Mouth (FMD) (Chakraborty and Mazumdar, 1989; Rahman *et al.*, 1988), Black Quarter (BQ), Haemorrhagic Septicaemia (HS) and Anthrax are transmissible from domestic livestock to wildlife and there had been severe mortalities in Assam in domestic cattle and wild animals.

As per the National Conservation Strategy for the GoH, dedicated research on rhinos in India is very scanty. The strategy advocates concerted efforts by the Central and State Governments, Scientific Institutes and NGOs to address this gap and conduct research on the rhino ecology, disease, habitat and population

dynamics. Based on these strategies and to secure the existing rhino population in India, we have drawn up the following recommendations based on the current study.

Recommendation 1: Detailed post mortem of rhino carcass:

The identification of the parasites up to the species level is very crucial and is possible if gross parasites are collected during post mortem examination of the gastro-intestinal tract. The gastro-intestinal tract needs to be properly examined for presence of any helminths and collected in normal saline or 70 % alcohol and sent to the laboratory for identification. The proper identification of the parasites will help us to determine whether the same parasites are shared by domestic livestock and if there is any transmission from the domestic livestock to the wild animal population in the PAs. This will not only help us in understanding the prevalence and effects of parasites but also in detecting and documenting other concurrent diseases in GoH rhinoceros.

Recommendation 2: Dung screening of other wild herbivores and domesticated elephants in the PAs.

The presence of *Bivitellobilharzia nairii* in GoH Rhino in Pobitora WLS suggests that both elephants and rhino can share the same parasite. However, the absence of wild elephants in the Pobitora WLS sanctuary indicates that the infection can either spill over from the domesticated elephants or another host like the Asiatic Wild Buffalo may harbour the parasite. In order to confirm the source of this infection, screening of dung samples of the domesticated elephants in the park and also the wild buffalo needs to be initiated.

Recommendation 3: Disease surveillance in domestic animals in the adjoining village areas of PAs.

The interaction between domestic and wild animals always pose a risk to both the sides due to spill out and spill in phenomena of infectious diseases and parasites. That makes it even more necessary to carry out extensive disease surveillance of infectious diseases of domestic animals near the fringe areas and correlate the same with that of wild counterparts during opportunistic samplings and post mortem examination.

Recommendation 4: Seasonal examination of rhino dung samples in the PAs of Assam.

The findings from the current study indicate that the incidences of *Amphistome*

spp. and *Strongyle spp*. predominates the rhino population in Assam. The direct effect of these parasites on the health of the rhinos is difficult to assess within the scope of the current study as there is no baseline data to compare or post mortem reports to refer to. As discussed earlier, parasites have the ability to predispose their hosts to other concurrent diseases in case of heavy infection. Also, heavy infection with tapeworms can sometimes lead to intestinal obstruction and nutritional deficiencies. The wild animals are more vulnerable just after the floods when faecal matters and pathogenic organisms are spread across the forests after the water recedes. Since pathogenic effects of endoparasites in GoH Rhinos are yet to be assessed in the wild, this necessitates further screening of dung samples and detailed post mortem analysis to gather more data and knowledge regarding the host-parasite interactions. With more studies on the same aspect, we can determine baseline for parasitic load for the GoH Rhino and any deviation from that can be used to formulate preventive and remedial measures to safeguard our rhino population in Assam.

Multiple dung piles in a single location

ACKNOWLEDGEMENT

We would like to acknowledge the support of the Chief Wildlife Warden of Assam for initiating the study. We are thankful for the help and needful support provided by the Field Directors of Kaziranga National Park and Manas National Park, and the Divisional Forest officer of Eastern Assam Wildlife Division, Mangaldai Wildlife Division and Guwahati Wildlife Division to conduct the study. The study would not have been possible without the support and help of all the Range Forest officers and the forest staff of all the four rhino bearing Protected Areas. We are thankful to the Dean, College of Veterinary Science, Assam Agricultural University, Khanapara, Guwahati, Dr Apurba Chakraborty, former Director of Research (Veterinary) from CVSc, AAU, Khanapara and staff and faculty of the Department of Parasitology, College of Veterinary Science, Dr.Dilip Kumar Deka, HoD, Dept. of Parasitology, CVSc, AAU, Khanapara, Assam Agricultural University, Khanapara, Guwahati for their technical help in analysing the samples and allowing us to use their laboratory facilities for the study. We would like to thank Sri Ravi Singh, SG & CEO, WWF India for his constant motivation and support to undertake such challenging studies. We thank the team members from WWF- India- Dr Dipankar Ghose, Dr Anupam Sarmah, Dr Pranab J. Bora and Mr. Munin Gogoi for their help and support during the study. We would also like to offer our sincere gratitude to Dr.Sanjoy Barthakur, Professor, Department of Parasitolgy, College of Veterinary Science, Selesih, Mizoram and Dr. Friederike von Houwald, International Studbook Keeper for Greater one-horned rhinos, EAZA Rhino TAG Chair, IUCN AfRSG & AsRSG member for reviewing our work and for providing us their valuable suggestions. This study was possible because of the support of our donors, especially WWF-US. Last but not the least, we would like to thank Ms Indira Akoijam and Ms Nitisha Mohapatra for their support in giving a final shape to the report. We would like to offer our gratitude to Dr.Samrat Mandal and Miss. Tista Ghosh from WII, Dehradun for their help during collection and compilation of the field data in Pobitora and Manas.

REFERENCES

1. Anderson, D.L., Trueman, J.W.H., 2000. *Varroa jacobsoni* (Acari: Varroidae) is more than one species. Exp. Appl. Acarol. 24, 165–189.
2. Chakraborty, A and Gogoi, A. Parasites of Rhinoceros (*Rhinoceros unicornis*). Indian Journal of Animal Sciences. 65(4), 421-422. April, 1995.
3. Chakraborty, A and Islam, S. A survey of gastro-intestinal parasitic infection in free living rhinoceros of the Kaziranga National Park. Indian Journal of Animal Sciences. 63(2), 155-156. February, 1993.
4. Chakraborty, T. and Mazumdar, B.K. (1989). Foot and Mouth Disease in captive elephant. Proceedings of the Asian Elephant held at Thrissur, Kerala, pp178.
5. Coltman, D.W., Pilkington, J.G., Smith, J.A. & Pemberton, J.M. (1999) Parasite-mediated selection against inbred Soay sheep in a free-living, island population. Evolution, 53, 1259-1267.
6. Cunningham, A.A. (1996) Disease risks of wildlife translocations. Conservation Biology, 10, 349-353.
7. Das, M., Deka, D.K., A.K. Sarmah, P.C. Sarmah and S. Islam. Gastrointestinal parasitic infections in cattle and swamp buffalo of Guwahati, Assam, India. Indian J. Anim. Res. DOI: 10.18805/ijar.B-3427.
8. Devkota, R., Brant, SV, Thapa, A., Loker, ES. Sharing Schistosomes: the elephant Schistosome *Bivitellobilharzia nairi* also infects the greater one-horned rhinoceros (Rhinoceros unicornis) in Chitwan National Park, Nepal.J Helminthol. 2014 Mar;88(1):32-40. doi: 10.1017/S0022149X12000697. Epub 2012 Oct 31.
9. Directorate of Forest, Govt. of West Bengal, Estimation of Indian Rhinoceros (Rhinoceros unicornis), 2019, West Bengal.
10. http://wwf.panda.org/?246012/Nepal-achieves-21-increase-in-rhino-numbers
11. https://timesofindia.indiatimes.com/city/guwahati/Orang-National-Park-Rhino-population-pegged-at-100/articleshow/12308715.cms
12. https://timesofindia.indiatimes.com/city/guwahati/pobitora-census-finds-102-rhinos/articleshow/63362834.cms
13. https://www.thehindu.com/news/national/other-states/rhino-census-2018-kaziranga-now-has-2413-rhinos/article23393316.ece

14. Jørgensen, D. (2014) Conservation implications of parasite co-reintroduction. Conservation Biology.

15. Kirk, R.S., 2003. The impact of *Anguillicola crassus* on European eels. Fish. Manage.567Ecol. 10, 385–394.

16. Kusiluka, L. and Kambarage, D. 1996. Diseases of small ruminants: A handbook, Common diseases of sheep and goats in Sub-Saharan Africa. Capital Print Ltd., Scotland, 110 p.

17. Lafferty, K.D. & Gerber, L.R. (2002) Good medicine for conservation biology: The intersection of epidemiology and conservation theory. Conservation Biology, 16, 593-604.

18. Levine, Norman D. Nematode Parasite of domestic animals and of man. 1968, Burgees Publishing Company, Minneapolis.

19. Oldroyd, B.P., 1999. Coevolution while you wait: Varroa jacobsoni, a new parasite of 600 western honeybees. Trends Ecol. Evol. 14, 312–315.

20. Pedersen, A.B. & Fenton, A. (2007) Emphasizing the ecology in parasite community ecology. Trends in Ecology and Evolution, 22, 133-139.

21. Phukan, D. Assessment of livestock diseases as an indicator of risk to greater one horned Rhinoceros (*Rhinoceros unicornis*) in Manas National park, Assam, Master's thesis, 2013.

22. Rahman, H., Dutta, P.K. and Dewan, J.N. (1988) Foot and mouth disease in elephant (Elephas maximus). Zentralbl. Vet.Med (B) 35: 70-71.

23. Sainsbury, A.W. & Vaughan-Higgins, R.J. (2012) Analyzing Disease Risks Associated with Translocations. Conservation Biology, 26, 442-452.

24. Scott, M.E. (1988) The Impact of Infection and Disease on Animal Populations: Implications for Conservation Biology. Conservation Biology, 2, 40-56.

25. Smith, K.F., Acevedo-Whitehouse, K. & Pedersen, A.B. (2009) The role of infectious diseases in biological conservation. Animal Conservation, 12, 1-12.

26. Soulsby, EJL. Helminths, Arthropods and Protozoa of Domesticated Animals. 1982. London: Baillière Tindall.

27. WWF-Global: Asian Rhinos, Species Account.

The team after a successful collection in Pobitora Wildlife Sanctuary

The team after in Kaziranga National Park

The study team:

1. Dr. Parikshit Kakati, Senior Program Officer-Veterinary, WWF-India, Guwahati, Assam.
2. Mr. Amit Sharma, Sr.Coordinator, Rhino Conservation, WWF-India, Guwahati, Assam.
3. Dr. Saidul Islam, Professor, Parasitology, CVSc, AAU, Khanapara, Guwahati, Assam.
4. Dr. Debabrata Phukan, Forest Veterinary Officer, Kaziranga National Park.
5. Dr. Samrat Mondol, Scientist-D, WII, Dehradun, Uttarakhand.
6. Miss. Tista Ghosh, PhD Research Scholar, WII, Dehradun, Uttarakhand.
7. Mr. Munin Gogoi, Project Assistant, WWF-India, Assam.
8. Mr. Bipul Nath, Assistant Project Officer, WWF-India, Assam.
9. Mr. Sande Daimary, Field Assistant, WWF-India, Assam.

ANNEXURE-I

Detailed results of the dung study in Kaziranga National Park
+: Light infection; ++: moderate infection; +++ and above: Heavy infection.

SL.No	Sample ID	Range	Parasite
1.	Debeswari 01	Eastern (Agaratoli)	*Strongyle spp.* larvae++, *Ova of Amphistome spp.*+
2.	Debeswari 02	Eastern (Agaratoli)	*Strongyle* larvae++, *Ova of Amphistome spp.*+
3.	Debeswari 03	Eastern (Agaratoli)	Negative
4.	Dhanbari 04	Eastern (Agaratoli)	Negative
5.	Mihimukh 1	Central (Kohora)	Negative
6.	Mihimukh 2	Central (Kohora)	*Strongyle spp.* larvae++ *Ova of Amphistome spp.* +
7.	Mihimukh 3	Central (Kohora)	*Strongyle spp.* larvae++, *Ova of Amphistome spp.*+
8.	Mihimukh 4	Central (Kohora)	Negative
9.	Mihimukh 5	Central (Kohora)	*Strongyle spp.* larvae++
10.	Mihimukh 6	Central (Kohora)	*Strongyle spp.* larvae++
11.	Mihimukh 7	Central (Kohora)	*Strongyle spp.* larvae++++
12.	Mihimukh 8	Central (Kohora)	*Strongyle spp.* larvae+++++
13.	Mihimukh 9	Central (Kohora)	Strongyle spp. larvae+++++, Ova of *Amphistome spp.*++
14.	Mihimukh 10	Central (Kohora)	Strongylespp.larvae+, Ova of *Amphistome spp.*++
15.	Duflang 11	Central (Kohora)	Negative
16.	Baruntika 12	Central (Kohora)	Negative
17.	Baruntika 13	Central (Kohora)	Ova of *Amphistome spp.*++
18.	Baruntika 14	Central (Kohora)	Negative
19.	Baruntika 15	Central (Kohora)	Negative
20.	Hulalpat 17	Central (Kohora)	Negative
21.	Borbeel 18	Central (Kohora)	*Strongyle spp.* larvae++
22.	Borbeel 19	Central (Kohora)	*Strongyle spp.* larvae++
23.	Baishamari 16	Central (Kohora)	Strongyle spp. larvae++, Ova of *Amphistome spp.*+
24.	Monabeel 16	Central (Kohora)	Ova of *Amphistome spp.*++
25.	Karasing 17	Central (Kohora)	Ova of *Amphistome spp.*++
26.	Karasing 18	Central (Kohora)	Ova of *Amphistome spp.*++
27.	Karasing 19	Central (Kohora)	Ova of *Amphistome spp.*++
28.	Baruntika 5	Central (Kohora)	Negative
29.	Baruntika 6	Central (Kohora)	Ova of *Amphistome spp.*++
30.	Baruntika 7	Central (Kohora)	Negative
31.	Kawoimari 9	Central (Kohora)	Negative
32.	Kawoimari 10	Central (Kohora)	Ova of *Amphistome spp.*++
33.	Kawoimari 11	Central (Kohora)	Ova of *Amphistome spp.*++

SL.No	Sample ID	Range	Parasite
34.	Kawoimari 12	Central (Kohora)	Ova of *Amphistome spp.*+
35.	Kawoimari 13	Central (Kohora)	Ova of *Amphistome spp.*+
36.	Kawoimari 14	Central (Kohora)	Negative
37.	Kawoimari 15	Central (Kohora)	*Strongyle spp.* larvae++++
38.	Mihimukh 1	Central (Kohora)	Negative
39.	Mihimukh 2	Central (Kohora)	Negative
40.	Mihimukh 3	Central (Kohora)	*Strongyle spp.* larvae++
41.	Mihimukh 4	Central (Kohora)	Negative
42.	Singimari 1	Eastern (Bagori)	Negative
43.	Goroimari 2	Eastern (Bagori)	Ova of *Amphistome spp.*+++
44.	Rowmari 3	Eastern (Bagori)	Ova of *Amphistome spp.*++
45.	Rowmari 4	Western (Bagori)	Strongylespp. larvae+++, Ova of *Amphistome spp.*++
46.	Rowmari 5	Western (Bagori)	Negative
47.	Bimoli 6	Western (Bagori)	Ova of *Amphistome spp.*+
48.	Borbeel 7	Western (Bagori)	Negative
49.	Tatibeel 8	Western (Bagori)	Negative
50.	Amkathani 8	Western (Bagori)	Negative
51.	Amkathani 9	Western (Bagori)	Ova of *Amphistome spp.*++
52.	Amkathani 10	Western (Bagori)	Strongyle spp.larvae++++, Ova of *Amphistome spp.*++
53.	Bagori 12	Western (Bagori)	Ova of *Amphistome spp.*++
54.	Bagori 13	Western (Bagori)	Ova of *Amphistome spp.*++++
55.	Dunga 14	Western (Bagori)	Ova of *Amphistome spp.*++, Strongyle spp. larvae+
56.	Dunga 15	Western (Bagori)	Ova of *Amphistome spp.*+
57.	Vitortangi 16	Western (Bagori)	Negative
58.	Vitortangi 17	Western (Bagori)	Ova of *Amphistome spp.*++
59.	Bholukajan 18	Western (Bagori)	Ova of *Amphistome spp.*++
60.	Janata 1	Burapahar	*Strongyle spp.* larvae++++
61.	Xorali 2	Burapahar	Ova of *Amphistome spp.*++++

ANNEXURE-II

Detailed results of the dung study in Manas National Park

S.No.	Collection Date	Field ID	Location,Range	Result
1	06-02-2018	BB/01	Bansbari Range, MNP	Negative
2	06-02-2018	BB/02	Bansbari Range, MNP	*Strongyle spp.* larvae+++
3	06-02-2018	BB/03	Bansbari Range, MNP	*Strongyle spp.* larvae+++
4	06-02-2018	BB/04	Bansbari Range, MNP	*Strongyle spp.* larvae++
5	06-02-2018	BB/05	Bansbari Range, MNP	Negative
6	06-02-2018	BB/06	Bansbari Range, MNP	*Strongyle spp.* larvae++++
7	06-02-2018	BB/07	Bansbari Range, MNP	*Strongyle spp.* larvae+++
8	06-02-2018	BB/08	Bansbari Range, MNP	*Strongyle spp.* larvae+++
9	06-02-2018	BB/09	Bansbari Range, MNP	*Strongyle spp.* larvae+++
10	06-02-2018	BB/10	Bansbari Range, MNP	*Strongyle spp.* larvae+++
11	06-02-2018	BB/11	Bansbari Range, MNP	*Strongyle spp.* larvae+++
12	06-02-2018	BB/12	Bansbari Range, MNP	*Strongyle spp.* larvae+
13	06-02-2018	BB/13	Bansbari Range, MNP	*Strongyle spp.* larvae+
14	07-02-2018	BB/14	Bansbari Range, MNP	*Strongyle spp.* larvae++
15	07-02-2018	BB/15	Bansbari Range, MNP	Unsuitable
16	07-02-2018	BB/16	Bansbari Range, MNP	*Strongyle spp.* larvae++
17	07-02-2018	BB/17	Bansbari Range, MNP	Negative
18	07-02-2018	BB/18	Bansbari Range, MNP	*Strongyle spp.* larvae++
19	07-02-2018	BB/18 rptd. nmbr	Bansbari Range, MNP	Repeated sample
20	07-02-2018	BB/19	Bansbari Range, MNP	*Strongyle spp.* larvae+++
21	07-02-2018	BB/20	Bansbari Range, MNP	*Strongyle spp.* larvae++++
22	07-02-2018	BB/21	Bansbari Range, MNP	*Strongyle spp.* larvae+++
23	07-02-2018	BB/22	Bansbari Range, MNP	Negative
24	07-02-2018	BB/23	Bansbari Range, MNP	*Strongyle spp.* larvae++
25	07-02-2018	BB/24	Bansbari Range, MNP	*Strongyle spp.* larvae+++
26	07-02-2018	BB/25	Bansbari Range, MNP	*Strongyle spp.* larvae++
27	07-02-2018	BB/26	Bansbari Range, MNP	Unsuitable
28	07-02-2018	BB/27	Bansbari Range, MNP	*Strongyle spp.* larvae++
29	07-02-2018	BB/28	Bansbari Range, MNP	*Strongyle spp.* larvae++
30	07-02-2018	BB/29	Bansbari Range, MNP	*Strongyle spp.* larvae+
31	07-02-2018	BB/1	Bansbari Range, MNP	Negative
32	07-02-2018	BB/2	Bansbari Range, MNP	*Strongyle spp.* larvae+++
33	07-02-2018	BB/3	Bansbari Range, MNP	*Strongyle spp.* larvae++++

S.No.	Collection Date	Field ID	Location,Range	Result
34	07-02-2018	BB/4	Bansbari Range, MNP	Unsuitable
35	07-02-2018	BB/5	Bansbari Range, MNP	*Strongyle spp.* larvae+++
36	07-02-2018	BB/6	Bansbari Range, MNP	*Strongyle spp.* larvae++
37	07-02-2018	BB/7	Bansbari Range, MNP	Ova of *Amphistome spp.* sp++
38	07-02-2018	BB/8	Bansbari Range, MNP	*Strongyle spp.* larvae++
39	07-02-2018	BP/TOI/S1	Bhuyapara, MNP	*Strongyle spp.* larvae++
40	07-02-2018	BP/TOI/S4	Bhuyapara, MNP	Negative
41	07-02-2018	BP/TOI/S5	Bhuyapara, MNP	*Strongyle spp.* larvae+
42	07-02-2018	BP/TOI/S2	Bhuyapara, MNP	Ova of *Amphistome spp.*++
43	07-02-2018	BP/TOI/S3	Bhuyapara, MNP	Ova of *Amphistome spp.*++
44	07-02-2018	SL/2	Bhuyapara, MNP	Negative
45	07-02-2018	SL/1	Bhuyapara, MNP	Negative
46	07-02-2018	SL/3	Bhuyapara, MNP	*Strongyle spp.* larvae+
47	07-02-2018	SL/4	Bhuyapara, MNP	Negative
48	08-02-2018	BB/68	Bansbari Range, MNP	*Strongyle spp.* larvae++++
49	08-02-2018	BB/69	Bansbari Range, MNP	*Strongyle spp.* larvae+++
50	08-02-2018	BB/70	Bansbari Range, MNP	*Strongyle spp.* larvae+++
51	08-02-2018	BB/71	Bansbari Range, MNP	*Strongyle spp.* larvae+++
52	08-02-2018	BB/72	Bansbari Range, MNP	Unsuitable
53	08-02-2018	BB/73	Bansbari Range, MNP	Negative
54	08-02-2018	BB/74	Bansbari Range, MNP	*Strongyle spp.* larvae++
55	08-02-2018	BB/1	Bansbari Range, MNP	Unsuitable

ANNEXURE-III

Detailed results of the dung study in Pobitora Wildlife Sanctuary

Sl.No	Date of collection	Sample ID	Location	Result
1.	10-02-2018	PIP/50	Pipolati, PWLS	*Strongyle spp.* Larvae++
2.	10-02-2018	PIP/47	Pipolati, PWLS	*Strongyle spp.* Larvae +++
3.	10-02-2018	PIP/48	Pipolati, PWLS	*Strongyle spp.* Larvae++
4.	10-02-2018	PIP/49	Pipolati, PWLS	*Strongyle spp.* Larvae +++
5.	10-02-2018	HC/26	Hati Camp, PWLS	Negative
6.	10-02-2018	HC/35	Hati Camp, PWLS	*Strongyle spp.* Larvae++
7.	10-02-2018	HC/30	Hati Camp, PWLS	Negative
8.	10-02-2018	HC/31	Hati Camp, PWLS	Negative
9.	10-02-2018	PIP/45	Pipolati, PWLS	Negative
10.	10-02-2018	HC/37	Hati Camp, PWLS	*Strongyle spp.* Larvae +++
11.	10-02-2018	HC/39	Hati Camp, PWLS	Ova of *Amphistome spp.* ++
12.	10-02-2018	PIP/44	Pipolati, PWLS	*Strongyle spp.* Larvae++
13.	10-02-2018	PIP/41	Pipolati, PWLS	*Strongyle spp.* Larvae +++
14.	10-02-2018	PIP/46	Pipolati, PWLS	Ova of *Amphistome spp.* ++
15.	10-02-2018	PIP/40	Pipolati, PWLS	*Strongyle spp.* Larvae +++
16.	10-02-2018	PIP/43	Pipolati, PWLS	Negative
17.	10-02-2018	HC/22	Hati Camp, PWLS	Negative
18.	10-02-2018	HC/20	Hati Camp, PWLS	Negative
19.	10-02-2018	HC/36	Hati Camp, PWLS	*Strongyle spp.* Larvae++
20.	10-02-2018	HC/32	Hati Camp, PWLS	Negative
21.	10-02-2018	JOG/16	Jogdal, PWLS	*Strongyle spp.* Larvae +++
22.	10-02-2018	HC/19	Hati Camp, PWLS	Negative
23.	10-02-2018	HC/33	Hati Camp, PWLS	*Strongyle spp.* Larvae++
24.	10-02-2018	HC/24	Hati Camp, PWLS	*Strongyle spp.* Larvae++
25.	10-02-2018	HC/34	Hati Camp, PWLS	Negative
26.	10-02-2018	HC/18	Hati Camp, PWLS	Negative
27.	10-02-2018	PIP/42	Hati Camp, PWLS	*Strongyle spp.* Larvae++
28.	10-02-2018	JOG/17	Jogdal, PWLS	Negative
29.	10-02-2018	HC/21	Hati Camp, PWLS	Negative
30.	10-02-2018	HC/29	Hati Camp, PWLS	*Strongyle spp.* Larvae +++
31.	10-02-2018	HC/23	Hati Camp, PWLS	Negative
32.	10-02-2018	HC/27	Hati Camp, PWLS	Ova of Spirurid spp. +++
33.	10-02-2018	HC/28	Hati Camp, PWLS	Negative

Sl.No	Date of collection	Sample ID	Location	Result
34.	10-02-2018	TUP/06	Tuplung Camp, PWLS	Negative
35.	10-02-2018	TUP/05	Tuplung Camp, PWLS	Negative
36.	10-02-2018	TUP/01	Tuplung Camp, PWLS	Negative
37.	10-02-2018	TUP/02	Tuplung Camp, PWLS	Negative
38.	10-02-2018	TUP/14	Tuplung Camp, PWLS	Negative
39.	10-02-2018	TUP/04	Tuplung Camp, PWLS	Negative
40.	10-02-2018	TUP/08	Tuplung Camp, PWLS	*Strongyle spp.* Larvae++
41.	10-02-2018	TUP/07	Tuplung Camp,PWLS	Ova of *Amphistome spp.* ++
42.	10-02-2018	TUP/12	Tuplung Camp, PWLS	Negative
43.	10-02-2018	TUP/09	Tuplung Camp, PWLS	Negative
44.	10-02-2018	TUP/10	Tuplung Camp, PWLS	Negative
45.	10-02-2018	TUP/03	Tuplung Camp, PWLS	Negative
46.	10-02-2018	TUP/11	Tuplung Camp, PWLS	Negative
47.	10-02-2018	TUP/13	Tuplung Camp, PWLS	Negative
48.	11-02-2018	HC/56	Hati Camp, PWLS	*Strongyle spp.* Larvae +++
49.	11-02-2018	JOG/62	Jogdal, PWLS	Ova of *Amphistome spp.* ++, Strongyle spp. larvae +
50.	11-02-2018	AM/51	Amaramul, PWLS	Negative
51.	11-02-2018	JOG/64	Jogdal, PWLS	*Strongyle spp.* Larvae++
52.	11-02-2018	PIP/72	Pipalti, PWLS	*Strongyle spp.* Larvae +++
53.	11-02-2018	AM/52	Amaramul, PWLS	Negative
54.	11-02-2018	HC/53	Hati Camp, PWLS	Negative
55.	11-02-2018	PIP/74	Pipolati, PWLS	Negative
56.	11-02-2018	PIP/75	Pipolati, PWLS	Negative
57.	11-02-2018	JOG/61	Jogdal, PWLS	*Strongyle spp.* Larvae++
58.	11-02-2018	HC/55	Hati Camp, PWLS	*Strongyle spp.* Larvae +++
59.	11-02-2018	JOG/67	Jogdal, PWLS	*Strongyle spp.* Larvae++
60.	11-02-2018	JOG/71	Jogdal, PWLS	Negative
61.	11-02-2018	JOG/66	Jogdal, PWLS	Negative
62.	11-02-2018	JOG/63	Jogdal, PWLS	*Strongyle spp.* Larvae +
63.	11-02-2018	JOG/65	Jogdal, PWLS	Negative
64.	11-02-2018	JOG/68	Jogdal, PWLS	Negative
65.	11-02-2018	JOG/69	Jogdal, PWLS	Negative
66.	11-02-2018	JOG/59	Jogdal, PWLS	*Strongyle spp.* Larvae +++
67.	11-02-2018	JOG/60	Jogdal, PWLS	*Strongyle spp.* Larvae++
68.	11-02-2018	HC/57	Hati Camp, PWLS	*Strongyle spp.* Larvae +++
69.	11-02-2018	JOG/58	Jogdal, PWLS	Negative
70.	11-02-2018	JOG/86	Jogdal, PWLS	*Strongyle spp.* Larvae++

Sl.No	Date of collection	Sample ID	Location	Result
71.	11-02-2018	PIP/79	Pipolati, PWLS	*Strongyle spp.* Larvae +++
72.	11-02-2018	TUP/88	Tuplung Camp, PWLS	Negative
73.	11-02-2018	TUP/98	Tuplung Camp, PWLS	*Strongyle spp.* Larvae++
74.	11-02-2018	JOG/84	Jogdal, PWLS	Negative
75.	11-02-2018	PIP/80	Pipolati, PWLS	Negative
76.	11-02-2018	TUP/94	Tuplung Camp, PWLS	Negative
77.	11-02-2018	TUP/89	Tuplung Camp, PWLS	Negative
78.	11-02-2018	TUP/97	Tuplung Camp, PWLS	Negative
79.	11-02-2018	PIP/76	Pipolati, PWLS	Negative
80.	11-02-2018	JOG/81	Jogdal, PWLS	Negative
81.	11-02-2018	TUP/99	Tuplung Camp, PWLS	Ova of *Amphistome spp.* +, Strongyle spp. larvae++
82.	11-02-2018	JOG/87	Jogdal, PWLS	Negative
83.	11-02-2018	JOG/82	Jogdal, PWLS	*Strongyle spp.* Larvae++
84.	11-02-2018	HC2/52	Hati Camp, PWLS	*Strongyle spp.* Larvae +
85.	11-02-2018	HC2/46	Hati Camp, PWLS	Negative
86.	11-02-2018	PIP/36	Pipolati, PWLS	*Strongyle spp.* Larvae +++
87.	11-02-2018	HC2/48	Hati Camp, PWLS	Negative
88.	11-02-2018	HC2/47	Hati Camp, PWLS	Negative
89.	11-02-2018	HC2/44	Hati Camp, PWLS	Negative
90.	11-02-2018	HC2/51	Hati Camp, PWLS	Negative
91.	11-02-2018	HC2/42	Hati Camp, PWLS	Negative
92.	11-02-2018	PIP/37	Pipolati, PWLS	*Strongyle spp.* Larvae++
93.	11-02-2018	HC2/49	Hati Camp, PWLS	*Strongyle spp.* Larvae +++
94.	11-02-2018	HC2/53	Hati Camp, PWLS	*Strongyle spp.* Larvae +
95.	11-02-2018	HC2/41	Hati Camp, PWLS	Negative
96.	11-02-2018	HC2/50	Hati Camp, PWLS	*Strongyle spp.* Larvae +++
97.	11-02-2018	JOG/T4	Jogdal, PWLS	*Strongyle spp.* Larvae +
98.	11-02-2018	JOG/T6	Jogdal, PWLS	*Strongyle spp.* Larvae++
99.	11-02-2018	TUP/93	Tuplung Camp, PWLS	*Strongyle spp.* Larvae +
100.	11-02-2018	JOG/T3	Jogdal, PWLS	*Strongyle spp.* Larvae++
101.	11-02-2018	TUP/95	Tuplung Camp, PWLS	Negative
102.	11-02-2018	BKJ/15	Bakuljaan, PWLS	Negative
103.	11-02-2018	TUP/90	Tuplung Camp, PWLS	Negative
104.	11-02-2018	BKJ/17	Bakuljaan, PWLS	negative
105.	11-02-2018	BKJ/14	Bakuljaan, PWLS	negative
106.	11-02-2018	BKJ/16	Bakuljaan, PWLS	negative
107.	11-02-2018	TUP/96	Tuplung Camp, PWLS	*Strongyle spp.* Larvae++

Sl.No	Date of collection	Sample ID	Location	Result
108.	11-02-2018	TUP/92	Tuplung Camp, PWLS	Negative
109.	11-02-2018	TUP/91	Tuplung Camp, PWLS	*Strongyle spp.* Larvae +++
110.	11-02-2018	BKJ/13	Bakuljaan, PWLS	Negative
111.	11-02-2018	JOG/T2	Jogdal, PWLS	negative
112.	11-02-2018	JOG/T5	Jogdal, PWLS	*Strongyle spp.* Larvae +
113.	11-02-2018	HC2/55	Hati Camp, PWLS	Negative
114.	11-02-2018	SM/1	Sheetalmari, PWLS	*Strongyle spp.* Larvae +++
115.	11-02-2018	BKJ/11	Bakuljaan, PWLS	Negative
116.	11-02-2018	BKJ/18	Bakuljaan, PWLS	Negative
117.	11-02-2018	BKJ/21	Bakuljaan, PWLS	Negative
118.	11-02-2018	BKJ/26	Bakuljaan, PWLS	*Strongyle spp.* Larvae++
119.	11-02-2018	BKJ/22	Bakuljaan, PWLS	Negative
120.	11-02-2018	BKJ/23	Bakuljaan, PWLS	Negative
121.	11-02-2018	BKJ/20	Bakuljaan, PWLS	*Strongyle spp.* Larvae++
122.	11-02-2018	BKJ/27	Bakuljaan, PWLS	*Strongyle spp.* Larvae++
123.	11-02-2018	HC2/54	Hati Camp, PWLS	Negative
124.	11-02-2018	BKJ/25	Bakuljaan, PWLS	Negative
125.	12-02-2018	TD/26	Tamuli Doba, PWLS	Negative
126.	12-02-2018	TD/14	Tamuli Doba, PWLS	*Strongyle spp.* Larvae++
127.	12-02-2018	TD/17	Tamuli Doba, PWLS	*Strongyle spp.* Larvae++
128.	12-02-2018	TD/16	Tamuli Doba, PWLS	Negative
129.	12-02-2018	TD/21	Tamuli Doba, PWLS	Negative
130.	12-02-2018	TD/23	Tamuli Doba, PWLS	Negative
131.	12-02-2018	TD/22	Tamuli Doba, PWLS	Negative
132.	12-02-2018	TD/19	Tamuli Doba, PWLS	Ova of Bivetellobilharzia nairi +
133.	12-02-2018	TD/15	Tamuli Doba, PWLS	Negative
134.	12-02-2018	TD/28	Tamuli Doba, PWLS	*Strongyle spp.* Larvae +
135.	12-02-2018	TMDV/15	Tamuli Doba, PWLS	Negative
136.	12-02-2018	HC4/03	Hati Camp, PWLS	Negative
137.	12-02-2018	TD/25	Tamuli Doba, PWLS	Negative
138.	12-02-2018	TMDV/14	Tamuli Doba, PWLS	Negative
139.	12-02-2018	TMDV/10	Tamuli Doba, PWLS	Negative
140.	12-02-2018	HC3/11	Hati Camp, PWLS	Negative
141.	12-02-2018	TMDV/04	Tamuli Doba, PWLS	*Strongyle spp.* Larvae +++
142.	12-02-2018	TMDV/11	Tamuli Doba, PWLS	Negative
143.	12-02-2018	TMDV/09	Tamuli Doba, PWLS	*Strongyle spp.* Larvae +
144.	12-02-2018	TMDV/12	Tamuli Doba, PWLS	Negative
145.	12-02-2018	TMDV/08	Tamuli Doba, PWLS	*Strongyle spp.* Larvae++++

Sl.No	Date of collection	Sample ID	Location	Result
146.	12-02-2018	TMDV/13	Tamuli Doba, PWLS	Negative
147.	12-02-2018	HC3/3	Hati Camp, PWLS	*Strongyle spp.* Larvae +
148.	12-02-2018	TMDV/06	Tamuli Doba, PWLS	Negative
149.	12-02-2018	TMDV/01	Tamuli Doba, PWLS	*Strongyle spp.* Larvae +++, Spirurid spp. ++
150.	12-02-2018	HC3/05	Hati Camp, PWLS	Negative
151.	12-02-2018	HC3/8	Hati Camp, PWLS	*Strongyle spp.* Larvae++
152.	12-02-2018	HC3/2	Hati Camp, PWLS	*Strongyle spp.* Larvae++
153.	12-02-2018	HC4/1	Hati Camp, PWLS	Negative
154.	12-02-2018	TMDV/3	Tamuli Doba, PWLS	*Strongyle spp.* Larvae++
155.	12-02-2018	TMDV/7	Tamuli Doba, PWLS	Negative
156.	12-02-2018	TMDV/2	Tamuli Doba, PWLS	Negative
157.	12-02-2018	HC3/06	Hati Camp, PWLS	*Strongyle spp.* Larvae++
158.	12-02-2018	TMDV/05	Tamuli Doba, PWLS	Negative

ANNEXURE-IV

Detailed results of the dung study in Orang National Park.

S.No	Sample ID(Area)	Date	Camp	Results
1.	Satsim-1	27-06-2017	Satsimalu	Negative
2.	Satsim-2	27-06-2017	Satsimalu	Ova of *Amphistome spp.* ++++
3.	Satsim-3	27-06-2017	Satsimalu	Negative
4.	Roumari-4	28-06-2018	Roumari	Strongyle spp. larvae++, Ova of *Amphistome spp.* +
5.	Bontapu-5	28-06-2018	Bontapu	*Strongyle spp.* larvae+++
6.	Hatipota-6	28-06-2018	Hatipota	Ova of *Amphistome spp.* ++++
7.	Hatipota -7	28-06-2018	Hatipota	Negative
8.	Tincona-8	28-06-2018	Tincona	*Strongyle spp.* larvae++
9.	Tincona-9	28-06-2018	Tincona	*Strongyle spp.* larvae++
10.	Tincona-10	28-06-2018	Tincona	Ova of *Amphistome spp.* +
11.	Borkhe-11	28-06-2018	Borkhe	Negative
12.	Borkhe-12	28-06-2018	Borkhe	Ova of *Amphistome spp.* ++
13.	Borkhe-13	28-06-2018	Borkhe	Strongyle spp. larvae++, Ova of *Amphistome spp.* ++
14.	Borkhe-14	28-06-2018	Borkhe	*Strongyle spp.* larvae+++
15.	Satsimalu-15	28-06-2018	Satsimalu	Ova of *Amphistome spp.* ++
16.	Bejimari-16	28-06-2018	Bejimari	Negative
17.	Bejimari-17	28-06-2018	Bejimari	*Strongyle spp.* larvae++
18.	Bejimari-18	28-06-2018	Bejimari	Negative
19.	Bejimari-19	28-06-2018	Bejimari	*Strongyle spp.* larvae++
20.	Naurasisha-20	28-06-2018	Naurasisha	Ova of *Amphistome spp.* +, Strongyle spp. larvae+++
21.	Naurasisha-21	28-06-2018	Naurasisha	*Strongyle spp.* larvae+
22.	Naurasisha-22	28-06-2018	Naurasisha	*Strongyle spp.* larvae++
23.	Naurasisha-23	28-06-2018	Naurasisha	Strongyle spp. larvae+++, Ova of *Amphistome spp.* ++
24.	Satsimalu-24	29-06-2018	Satsimalu	Ova of *Amphistome spp.* +++
25.	Satsimalu-25	29-06-2018	Satsimalu	Strongyle spp. larvae++, Ova of *Amphistome spp.* ++
26.	Satsimalu-26	29-06-2018	Satsimalu	Ova of *Amphistome spp.* +++
27.	Satsimalu-27	29-06-2018	Satsimalu	Strongyle spp. larvae+++, Ovaof *Amphistome spp.* ++
28.	Satsimalu-28	29-06-2018	Satsimalu	Strongyle spp. larvae++, Ova of *Amphistome spp.* +
29.	Satsimalu-29	29-06-2018	Satsimalu	*Strongyle spp.* larvae+++

S.No	Sample ID(Area)	Date	Camp	Results
30.	Satsimalu-30	29-06-2018	Satsimalu	*Strongyle spp.* larvae++
31.	Satsimalu-31	29-06-2018	Satsimalu	*Strongyle spp.* larvae++
32.	Satsimalu-32	29-06-2018	Satsimalu	*Strongyle spp.* larvae++
33.	Satsimalu-33	29-06-2018	Satsimalu	*Strongyle spp.* larvae+++
34.	Satsimalu-34	29-06-2018	Satsimalu	Negative
35.	Satsimalu-35	29-06-2018	Satsimalu	Ova of *Amphistome spp.* +++

ANNEXURE-V

Reagents and equipments used in the study

1. Plastic zip bags 10 X 8 inches.
2. Disposable hand gloves.
3. Water resistant marker.
4. Compound microscope.
5. Glass slide.
6. Saturated salt solution.
7. Plastic sieve.
8. Glass petridish.
9. Pestle and mortar.
10. Stirring rod.

ANNEXURE-VI

List of Forest personals trained during the Rhino dung study

S.No	Name of person	PA	Designation
1.	Masud Barbhuya	Kaziranga National Park	Forest Guard
2.	Sekhawat Hussain	Kaziranga National Park	Forest Guard
3.	Tapan Das	Kaziranga National Park	Forest Guard
4.	Bhupen Hazarika	Kaziranga National Park	Forest Guard
5.	Manoj Gogoi	Kaziranga National Park	Forester -I
6.	Gopal Gogoi	Kaziranga National Park	Forest Guard
7.	Lamphai Saroh	Kaziranga National Park	Forest Guard
8.	Bir Bahadur Chetry	Kaziranga National Park	Boatman
9.	Rajen Kalita	Kaziranga National Park	Forest Guard
10.	Minaram Doley	Kaziranga National Park	Game Watcher
11.	Ramakanta Nath	Kaziranga National Park	Boatman
12.	Sombar Killing	Kaziranga National Park	Boatman
13.	Medini Gogoi	Kaziranga National Park	Forester -I
14.	Rajpallab Neog	Kaziranga National Park	Forester -I
15.	Bhaskar BorGoHain	Kaziranga National Park	Forester -I
16.	Jukti Bora	Kaziranga National Park	Forester -I
17.	Dipak Deka	Pobitora Wildlife Sanctuary	Forest Guard
18.	Babul Deka	Pobitora Wildlife Sanctuary	Forest Guard
19.	Amal Adhikary	Pobitora Wildlife Sanctuary	Forest Guard
20.	Mantu Nath	Pobitora Wildlife Sanctuary	Forest Guard
21.	Medaram Saikia	Pobitora Wildlife Sanctuary	Forest Guard
22.	Jogeswar Kalita	Pobitora Wildlife Sanctuary	Forest Guard
23.	Biren Kalita	Pobitora Wildlife Sanctuary	Forest Guard
24.	Dilwar Hussain	Rajiv Gandhi Orang National Park	Forest Guard
25.	Sailen Deka	Rajiv Gandhi Orang National Park	Forest Guard
26.	Manjit Deka	Rajiv Gandhi Orang National Park	Forest Guard
27.	Mwgthangkhwr Boro	Manas National Park	Forest Guard
28.	Mangal Khaklary	Manas National Park	Forest Guard
29.	Kiran Narzary	Manas National Park	Forest Guard
30.	Rajib Bargayang	Manas National Park	Forest Guard
31.	Rajen Chetry	Manas National Park	Forest Guard
32.	Samesh Daimary	Manas National Park	Forest Guard

Why we are here.
To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

www.wwf.panda.org

WWF-India Secretariat
172 B, Lodhi Estate
New Delhi- 110003
Tel: +91 11 4150 4815

WWF • IDENTIFYING THE PREVALENCE OF ENDOPARASITIC INFECTIONS IN FREE RANGING GREATER ONE-HORNED RHINOCEROS IND WWFINDIA.ORG