

BULLetin

Journal of the IUCN SSC Asian Wild Cattle Specialist Group



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Editorial Information

Journal editor: Corinne Bailey
Assistant editor: Caitlin Cross
Editorial advisor: Dr James Burton

Please address all correspondences to:

Corinne Bailey
Chester Zoo
Upton-by-Chester
Chester
CH2 1LH
c.bailey@chesterzoo.org

IUCN SSC Asian Wild Cattle Specialist Group

Chair: Dr James Burton

Website: www.asianwildcattle.org

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Cover Photo

Asian Wild Water Buffalo

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EDITOR'S NOTE

By Corinne Bailey, AWCSG Programme Officer

Welcome to the sixth issue of BULLETIN, the newsletter of the IUCN SSC Asian Wild Cattle Specialist Group (AWCSG). In BULLETIN, we present novel research on the ecology and conservation of Asian wild cattle species, and share stories about their conservation.

This issue highlights field research conducted and Asian wild cattle conservation. We present a range of news and research that has been conducted to preserve and manage these species.

This issue profiles some of the amazing and diverse research that has been published so far this year, including news of wild yaks making a comeback in Nepal, a study on the gut microbiome of wild gaur, and sobering news regarding the decline of banteng in the Eastern Plains Landscape of Cambodia. Multiple articles explore the threats, habitat preference and considerations for reintroductions of Wild water buffalo in their native range; including a study of habitat use by a small population of wild ranging male buffalo on a landscape and home range level in Chhattisgarh, Central India.

This issue also contains news of ongoing genetic and camera trapping research with conservation implications for anoa, wild water buffalo, Tamaraw and babirusa.

The seventh issue of BULLETIN will be published at the end of the year and we look forward to receiving your interesting articles and updates. Get in touch via social media, our [website](https://www.asianwildcattle.org) or contact Corinne at c.bailey@chesterzoo.org. We particularly encourage novel research article submissions so please share this call with your network.

In the coming months, we will be reaching out to you to update membership of AWCSG, you will need to respond to continue your membership.

Keep up to date with our activities and other Asian wild cattle news on our website (www.asianwildcattle.org) and social media (Facebook: [IUCN Asian Wild Cattle Specialist Group](https://www.facebook.com/IUCNAsianWildCattleSpecialistGroup), Twitter: [@IUCN_WildCattle](https://twitter.com/IUCN_WildCattle) and Instagram: [@iucn_wildcattle](https://www.instagram.com/iucn_wildcattle)). We hope you enjoy this issue, and look forward to hearing from you. Finally, we would like to extend our wishes to all of our readers during these challenging times of the Covid-19 pandemic.

We hope you enjoy this issue, and thank you for your continued efforts in conserving Asian wild cattle.



Photo credit: Udayan Borthakur

NEWS AND UPDATES

Wild yaks make a comeback in Nepal

By Naresh Kusi, Country Program Director for Himalayan Wolves Project

The wild yak (*Bos mutus*) is a globally 'Vulnerable' ungulate inhabiting the alpine tundra, grasslands, and cold desert regions of the north-western Qinghai-Tibetan Plateau (QTP) and adjacent high-altitude regions. The species was considered regionally extinct in Nepal for decades until two live individuals were documented from the remote Transhimalayan valleys of Upper Humla in north-western Nepal, in 2014. [The finding was published in the journal Mammalia in 2015](#) to indicate a rediscovery (that was based on morphology and behaviour of the sighted animals). However due to the

lack of a genetic analysis, the International Union for Conservation of Nature (IUCN) considered the sighting as uncertain and demanded additional evidence.

[In a study published in the journal Ecology and Evolution](#) (seven years after the sighting), the team presents phylogenetic and haplotype network analyses of wild and domestic yak samples to reveal that the wild yaks in Upper Humla, Nepal, share the haplotype with wild yaks from the north-western region of the QTP in China. By providing the missing genetic proof (to the presence of wild yaks in Nepal), the authors posit that the IUCN should update the wild yak distribution range to include the Transhimalayan regions of northern Nepal.

Wild yaks face multitude of threats throughout



Wild Yak in Nepal Credit: Naresh Kusi

their range. These include hybridization with domestic yaks, retaliatory deaths (usually bulls) due to conflicts with domestic yak herders, habitat encroachment and displacement by the herders and their domestic livestock, possibilities of disease transmission between wild-domestic yak interfaces and illegal hunting for meat and trophy.

Following a [National reassessment in 2018](#), wild yaks are 'Critically Endangered' in Nepal.

Read the full report: Kusi, N, Manandhar, P, Senn, H, et al. (2021) Phylogeographical analysis shows the need to protect the wild yaks' last refuge in Nepal. *Ecol Evol.*; 11: 8310 – 8318. <https://doi.org/10.1002/ece3.7660>

Note from AWCSG Chair James Burton:

The AWCSG will conduct Red List Assessment updates for certain species in this IUCN quadrennium 2021-2024. We hope this will include wild yak. Our Red List Coordinator Tom Gray will be discussing timelines for these updates with the relevant Species Coordinators in the coming months.

Dramatic decline in the most significant global population of banteng

By Milou Groenenberg^a, Rachel Crouthers^a, and Yoganand Kandasamy^b

^aWorld Wide Fund for Nature-Cambodia

^b World Wide Fund for Nature-Greater Mekong,

A previous issue of BULLETIN ([February 2020, #3](#)) featured a report with an optimistic title: “A hopeful future for Banteng in Cambodia”, portraying an extraordinary local community effort to protect a banteng (*Bos javanicus*) population in Kampong Speu, Cambodia. Unfortunately, this promising situation does not extend to the Eastern Plains Landscape (EPL) in the Monduliri and Kratié provinces of Cambodia. The banteng populations in the protected areas of the EPL, one of the last remaining strongholds of banteng, are now steeply declining (Griffin & Nuttall, 2020; Groenenberg et al., 2020)

The EPL in eastern Cambodia and central Vietnam comprises one of the largest remaining expanses of lowland Deciduous Dipterocarp

Forest, a type of forest that is severely threatened, and harbours globally significant populations of endangered wildlife, including the Critically Endangered species of ibises and vultures, Cambodia's largest population of Asian elephants (*Elephas maximus*), and the only remaining Indochinese leopard (*Panthera pardus delacouri*) population in Vietnam, Laos and Cambodia.

In the Phnom Prich and Srepok Wildlife Sanctuaries (PPWS and SWS, respectively), located in the heart of the EPL, a long-term ungulate monitoring programme is being implemented by WWF using a standardized distance-sampling statistical framework. The results of the first ten-year period (2010-2020) of this programme were compiled in a [report](#) recently launched by the Ministry of Environment and WWF-Cambodia. The 2010-11 [baseline survey](#) revealed that the EPL contained the largest global population of the endangered banteng in its native range. Only 10 years later, in 2020, the estimated remaining population size of banteng has declined by nearly 72%. Population densities in neighbouring protected areas within the EPL, such as [Keo Seima Wildlife](#)



Herd of banteng © Fletcher & Baylis/ WWF Cambodia

Sanctuary and Yok Don National Park are even lower, indicating a depleted wild cattle population that is far below the landscape's inherent carrying capacity.

Remaining banteng populations in Indonesia, Thailand, Malaysia (Sabah), Laos, Myanmar, and Viet Nam are small (rarely exceeding 50 individuals), fragmented, and declining (Gardner et al., 2016). A significant population, consisting of approximately 6,000 pure-bred banteng (i.e. no introgression with other domesticated *Bos* species) currently occurs in Garig Gunak Barlu National Park, Australia.

However, this population is considered originating in a subspecies (*Bos j. javanicus*) different from the mainland Southeast Asian subspecies (*Bos j. birmanicus*). In addition, there is a high likelihood that this population is genetically homogenous, as the initial source

population consisted of only 20 domesticated individuals introduced from Bali in 1849.

Historically, the EPL contained large congregations of ungulate species that then formed a prey base for a variety and abundance of large carnivores. Decades of armed civil war, paired with excessive hunting led to significant reductions of most large mammal populations and resulted in the likely extinction of species such as the kouprey (*Bos sauveli*) and the likely local extirpation of the wild water buffalo (*Bubalus arnee*). More recently, an unprecedented poaching and snaring crisis was sweeping through Indochina (Belecky & Gray, 2020). In the EPL of Cambodia, a rapid acceleration and intensification of poaching has been observed over the past decade. During the monitoring period, the rate at which ranger patrol teams encountered and removed snares and other such lethal wildlife traps increased over a hundredfold from 0.04 traps

per 100 km patrolled in 2010 to 6.46 in 2020. Increasingly devastating poaching methods such as blanket snaring, jaw traps, and live electrified wires to kill animals have been observed regularly in recent years along with an increase in hunting with dogs and firearms including high-powered rifles.

With the current estimated population size of a little over 850 individuals, the EPL's banteng population is still the largest remaining population in its native range and is therefore of irreplaceable global conservation value. The Banteng has important ecosystem functions as a key prey species for large carnivores and scavengers, and as ecosystem engineers. To prevent this critical banteng population from following the same extinction path as the kouprey, it is crucial that effective and comprehensive conservation management interventions are implemented immediately. WWF-Cambodia in close coordination with partners is developing a "Wildlife Recovery Zone" concept that combines intensive protection and species recovery measures in carefully selected zones within the protected areas. We also aim to tackle the root causes of wildlife decline, including the local, national, and regional wildlife trade. Just like in Kampong Speu, community engagement and stewardship by local conservation champions will continue to play a crucial role in these conservation efforts.

The unique EPL and the wildlife it harbors is facing severe threats to its integrity, and is at a tipping point. Comprehensive measures for protection of forest habitats and restoration of extirpated wildlife - a 'rewilding of the landscape,' is an urgent priority.

For more information on WWF-Cambodia's work visit: <https://www.wwf.org.kh/>

Read the full report: https://wwfasia.awsassets.panda.org/downloads/the_ungulate_report_final_file.pdf

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Camera trapping reveals a small population of tamaraw

By *Fernando Garcia Gil and Emmanuel Schutz, D'ABOVILLE Foundation and Demo Farm, Inc*

The Aruyan Malati area, located in the Municipality of Sablayan in Occidental Mindoro, is home to one of the few remaining sub-populations of the critically endangered tamaraw (*Bubalus mindorensis*) (Boyles et al., 2016). In 1987, the tamaraw subpopulation in the area was estimated as 45 individuals, but by 2017 this estimate had decreased to only between ten and twelve animals (Long et al., 2018). The number of animals remaining in the Aruyan Malati area is unknown due to the limited amount of monitoring in recent years.

Following the Population and Habitat Viability Assessment (PHVA) workshop of 2018, a Tamaraw Conservation and Management Action Plan 2019-2028 (TCMAP) was formulated, proposing a new set of actions and a global strategy towards the conservation of the species. Among them, the TCMAP states a

clear ambition to improve the protection of the sub-population of the Aruyan-Malati area and restore it to a viable level. The first step is to foster and proclaim the area as “Critical Habitat”, one of the protected area categories of the Department of Environment and Natural Resources of the Philippines. This requires a better understanding of the habitat range and habitat use of the tamaraw in this area.

To fulfil that aim, the Tamaraw Conservation Program (DENR TCP), in collaboration with the local NGO D'ABOVILLE Foundation and Demo Farm, Inc. (DAF), have carried out an exhaustive occupancy survey study using camera trap technology. Fifteen camera traps were placed in 60 stations in 4 rounds of deployment. The stations were semi-randomly selected, representing the different habitats in the study area following the classification from the 2015 Land Cover Mapping from the National Mapping and Resource Information Authority (NAMRIA) from the Philippines (i.e. grassland, bushes /shrubs, secondary forest). The survey has revealed evidence of the presence of tamaraw in the area. In the initial overview of the data, the cameras



Adult male and juvenile in a wallowing area. Both images were taken in the same location. Credit: DAF

have captured photos of tamaraw at least in nine locations. The next step will be to conduct statistical analysis that will hopefully help to assess the exact status of the species, and to help to design and to implement future camera trap studies in the area to continue the monitoring of the tamaraw population. The last pictures of tamaraw were captured in 2017 after a rapid survey combining camera traps from DAF and WWF Philippines (DAF, 2017).

In addition to collecting images of the tamaraw, this survey is helping to build our knowledge of the presence of other large-bodied Mindoro wildlife, such as the Mindoro warty pig (*Sus oliveri*) (EN) and the Philippine brown deer (*Rusa marianna*) (VU) (Schütz, 2016; MacKinnon et al., 2015).

The study area is located within the ancestral domain of the Tau-buid, an indigenous tribe who cohabitate with tamaraw in this region. Any current or future wildlife conservation effort will require their acceptance and collaboration (find out more [here](#)). The regular presence of the field team is hoped to improve communication and build connections with the indigenous people.



Adult tamaraw. Credit: DAF

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Banteng and Gaur distribution in Thailand's Western Forest Complex:

A summary of a report by the Wildlife Conservation Society (WCS) report by Caitlin Cross, Field Programmes Intern, Chester Zoo

Wildlife Conservation Society (WCS) led a [study in Thailand's Western Forest Complex](#) (WEFCOM) – an 18,000 km² network of protected forest - to better understand factors impacting large ungulate distribution in the area. This comes as global population numbers of tigers are in decline, largely as a result of the depletion of ungulate prey.

Researchers conducted sign surveys for banteng (*Bos javanicus*), gaur (*Bos gaurus*), and sambar (*Rusa unicolor*) along 3,517 1 km transects. These species are the preferred prey of tigers in WEFCOM, but they are severely threatened by anthropogenic pressures such as poaching and changes to land use that have

resulted in habitat degradation.

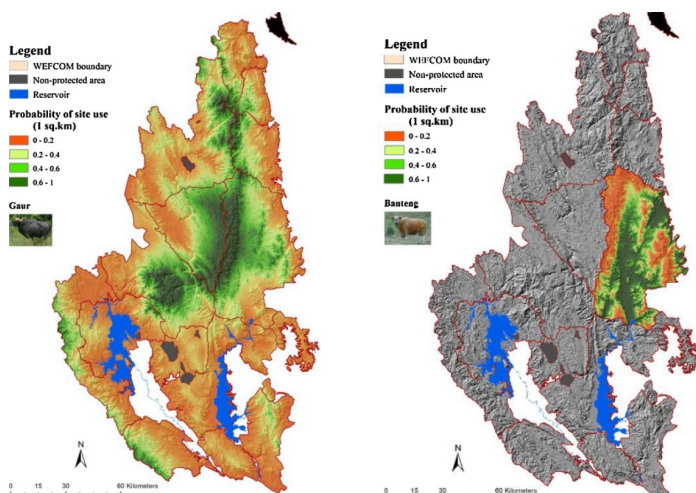
Occupancy models were used to determine covariates in habitat use by each species. It was found that gaur and sambar occupied 28 and 50 percent of suitable habitat respectively in WEFCOM, and that banteng no longer occupied most of the area. Banteng were only found in one of 17 protected areas, Huai Kha Khaeng (HKK) Wildlife Sanctuary, where they occupied 57 percent of suitable habitat.

This was then compared to a model in which human activities were decreased around nine central villages in WEFCOM; the percentage of suitable habitat increased to 68 percent for gaur and 75 percent for sambar. For banteng, the extent of suitable habitat that still remains in the other 16 protected areas was modelled, and it was found that rewilding could result in a four-fold increase.

The recovery of these species has the potential to support conservation management, and increase the distribution of tigers across WEFCOM and beyond.

Read the full article:

Jornburom et al., (2020) Habitat use by tiger prey in Thailand's Western Forest Complex: What will it take to fill a half-full tiger landscape? J. Nat. Conserv; 58 <https://doi.org/10.1016/j.jnc.2020.125896>



Spatially-explicit prediction maps of gaur and banteng occupancy probability. Credit: Jornburom et al, 2020.

The gut microbiome of wild gaur and its conservation implications

By Vandana R. Prabhu and Muniyandi Nagarajan, Department of Genomic Science, Central University of Kerala

The Indian gaur (*Bos gaurus*) is the largest species among Bovidae. Though the largest gaur population is present in India, a gradual decline in number of gaur has been recorded in the last few decades due to various anthropogenic factors such as habitat destruction, poaching, and disease. Hence, the gaur has been categorized as vulnerable species by IUCN and protected under schedule I of Indian wildlife (protection) Act 1972. Recent studies have clearly demonstrated the role of gut microbes in animal health and fitness. Although gut microbes benefit the host in several ways, how anthropogenic factors impact the gut microbiome of wild animals is not yet completely understood.

Our research group at Central University of Kerala, recently characterized the gut microbiome of wild and captive gaur and the large domestic mithun (*Bos frontalis*) to understand effect of captivity and domestication on gut microbiome.

Wild gaur dung samples for microbial DNA isolation were collected from the western Ghats region of Tamil Nadu and Kerala. Dung samples of captive gaur were collected from the Zoos of Tamil Nadu, Kerala Karnataka and Goa whereas dung samples of the domestic mithun were collected from Arunachal Pradesh and Mizoram.

We sequenced the V3-V4 hypervariable region of bacterial 16S rRNA gene to profile the microbiome of gaur and mithun. The gut microbiome of gaur and mithun was majorly constituted by the following 10 bacterial phyla, Actinobacteria, Bacteroidetes, Chloroflexi, Cyanobacteria, Firmicutes, Lentisphaerae, Proteobacteria, TM7, Tenericutes, and Verrucomicrobia. However, the phylum, Firmicutes (91.5%) was



Image credit: M. Nagarajan

dominant in the gut of gaur and mithun. Further, the microbial diversity and abundance were reduced in captive gaur and domestic mithun as compared to wild gaur. Particularly, two commensal bacterial families *Ruminococcaceae* and *Lachnospiraceae*, which plays a significant role in the herbivore's digestion, were low in abundance in captive gaur and domestic mithun. As a consequence, pathways predicted to be related to metabolism and immune system exhibited lower abundance in captive gaur and domestic mithun compared to wild gaur.

Overall, our study suggested that captivity and domestication can alter the gut microbiome which might adversely affect the health and fitness of the host animal. However, further studies are necessary across a wide range of species to understand the general trend of microbi-

ome shifts in captive and domestic animals. A key purpose of keeping endangered animals in captivity is for protection, increasing their population size and successfully reintroducing them into the wild. If the microbiome is altered during captivity, animals are more likely to face health complications which in turn may reduce the success rate of their reintroduction into the wild. Therefore, microbiome studies between wild and captive populations are of greater importance as they can provide important suggestions to restore the lost microbiome diversity of captive species which might have implications in the conservation and management of wild animals.

Read the full report: Prabhu, V. et al., (2020) Consequences of Domestication on Gut Microbiome: A Comparative Study Between Wild Gaur and Domestic Mithun. *Front. Microbiol.*;11 <https://doi.org/10.3389/fmicb.2020.00133>

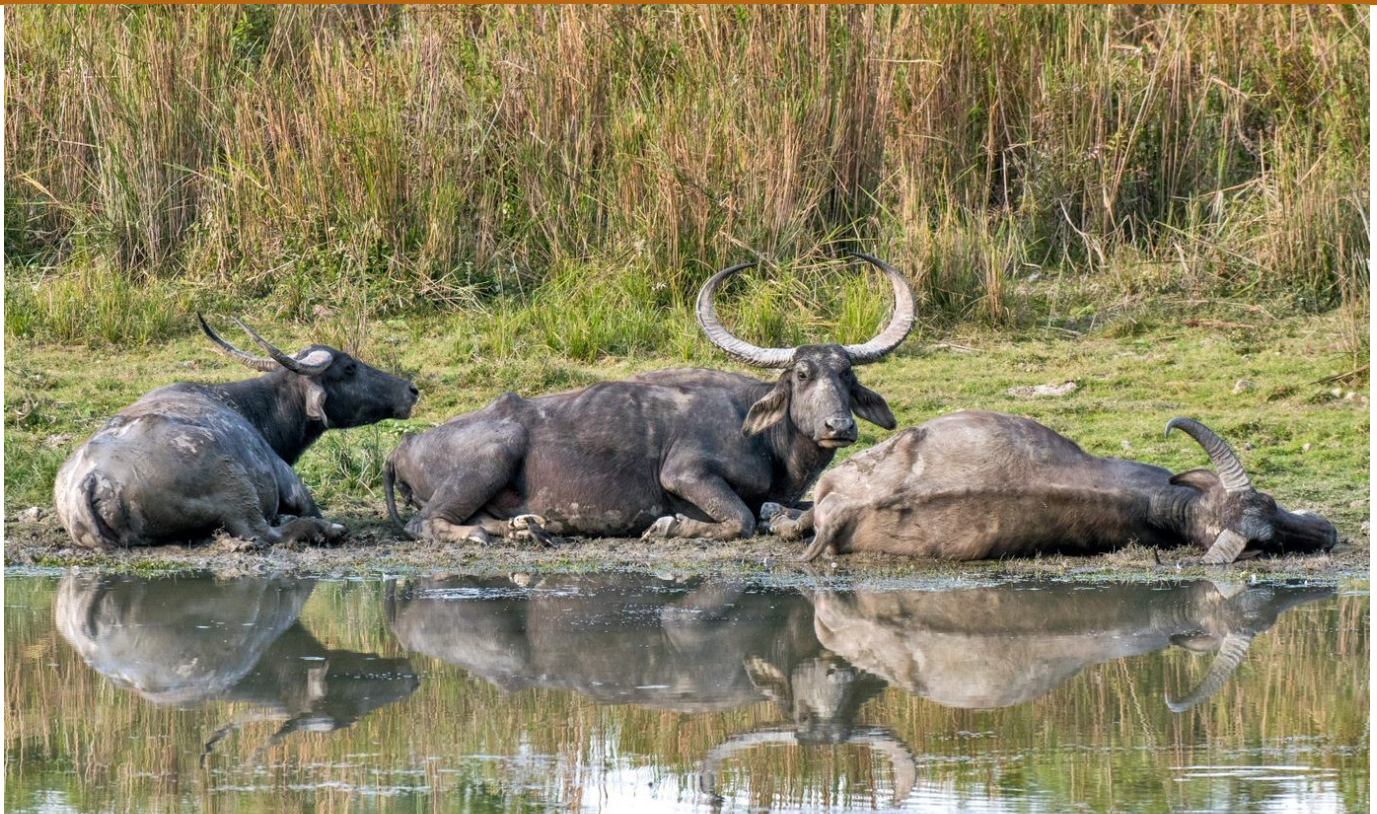
Assessing the threats facing wild water buffalo in India

By Arnab Chatterjee, Friedrich-Schiller University Jena

Wetland ecosystems are threatened by continuous environmental change and the anthropogenic pressure that results in native biodiversity loss. Our recent study, "Assessing the threats facing wetland mammals in India using an evidence-based conservation approach" explores the ecological and anthropogenic threats faced by 11 wetland mammals, including the wild water buffalo (*Bubalus arnee*).

Furthermore, we tried to gauge the current state of knowledge and the knowledge gap

about these wetland mammals using a systematic review and evidence-based conservation approach. We formulated a cumulative threat score using the ecological and anthropogenic threat score, knowledge gap score, and IUCN conservation status score for each of the mammal species to identify the priority species for immediate conservation efforts. Our study revealed that ecological threat scores are comparatively higher in herbivores than in carnivores. Life history traits such as long gestation period and large body weight contributed to a higher extinction risk in large-bodied herbivores. Additionally, a diminishing and fragmented population of wetland mammals elevated the extinction risk. Habitat destruction and hunting / poaching were the primary 'twin extinction threats' of wetland mam-



Wild Asian Buffalo, Kaziranga National Park, Assam, India . Credit: Udayan Borthakur

mals of India. All the wetland mammal species were also threatened by diverse anthropogenic pressure such as human-wildlife conflict, invasive alien plant species, infectious diseases and pollution. Sangai deer had the highest cumulative threat score followed by the wild water buffalo and the Bengal marsh mongoose. Our study recommends to initiate immediate conservation on these species to ensure their long-term survival.

Ecological & anthropogenic threats:

Heavy body weight (800 kgs ♀ and 1200 kgs ♂; Macdonald, 2010) and long gestation period (10 years; Kaul et al., 2019) are the major ecological threats to the wild water buffalo. A decreasing population trend and relatively moderate population number (approximately more than 2500 individuals) increased the threat to this species (Kaul et al., 2019).

All tested anthropogenic threats for wetland mammals of India, e.g., human-animal conflict,

habitat loss due to anthropogenic activity, impact of invasive species, poaching / hunting, hybridization with domestic animal, habitat loss due to natural processes (e.g., flood), diseases and pollution, were reported for the species which heightened the threat level to wild water buffalo (Heinen & Kandel, 2006; Kaul et al., 2019; Singh et al., 2015).

Knowledge gap:

A total of 15 papers on wild water buffalo, published between 1978 and 2015, were accessible in the online repository (e.g., Google Scholar and Web of Science) for our study. Only four studies were conducted in India, and the majority of studies on wild water buffalo were either done for a short duration (less than 3 years), or duration was not indicated.

Conservation Effort:

Our systematic search found a five-year conservation action plan which been initiated by a collaboration between the [Wildlife Trust of In-](#)

[dia](#) and the Chhattisgarh state forest department. This cooperation, the central India wild buffalo recovery project in the Udanti-Sitanadi Tiger Reserve, successfully increased the wild buffalo population in 2015 using ex-situ (e.g., conservation breeding) and in-situ techniques (e.g., habitat improvement).

Future opportunities for research:

Our study highlights the less-explored research areas in relation to wetland mammals. Further research is required for a better understanding of wild water buffalo population abundance and life history traits, anthropogenic threats such as human-wildlife conflict, impacts of land use, land cover changes, climate change, molecular ecology, and disease ecology.

Read the full report: Chatterjee, A. & Bhattacharyya, S. (2021) Assessing the threats facing wetland mammals in India using an evidence based conservation approach. *Mamm Rev*; 51(3). <https://doi.org/10.1111/mam.12242>.

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Wild Asian Buffalo, Bura chapori Wildlife Sanctuary, Assam, India . Credit: Udayan Borthakur

Considerations for buffalo reintroductions

Summarised by Caitlin Cross, Field Programmes Intern, Chester Zoo

A study has been published on the feasibility of reintroducing the greater one-horned rhinoceros (*Rhinoceros unicornis*) and wild water buffalo (*Bubalus arnee*), within their historic global range. Wild water buffalo were once abundant across the northern and central plains of the Indian subcontinent, but are now restricted to small, isolated pockets in north-eastern and central India, Nepal, Bhutan, Myanmar, Cambodia and Thailand. The total population is estimated as 3000-4000 individuals.

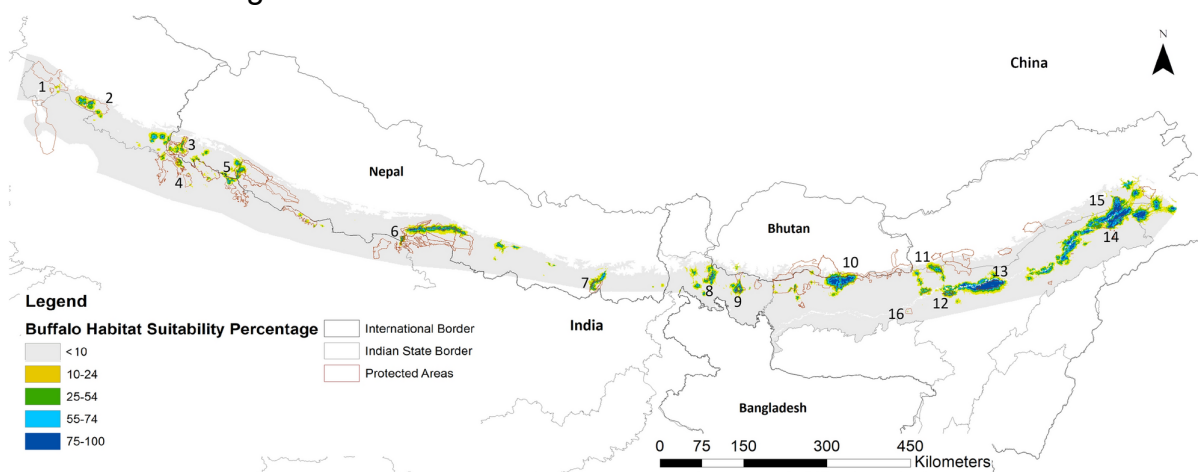
Jhala et al. (2021) used a variety of methods including species distribution modelling, population habitat viability analysis, field surveys, literature review and talks with protected area managers to prioritize sites for reintroduction and supplementation of the species. The study also provided the data required for conservation management recommendations in areas with extant populations.

For buffalo, the model showed high habitat suitability at forest edges, with the probability of occurrence decreasing as the distance from

forest increased. They also preferred areas close to water, and with annual rainfall above 1500mm. Large populations of 100-200 individuals with a founding population of more than 30 were the only modelled size to remain viable in settings that experience natural catastrophes and moderate poaching. Introduced populations are sensitive to the size of the founding population and depend upon continual supplementation to be successful. If supplementation were to continue for longer than 5-10 years, the genetic variability and resilience of populations would increase dramatically.

When applied to suitable habitats for buffalo, the PA complex of Chitwan NP-Valmiki TR-Parsa Wildlife Sanctuary and Bardia NP-Shuklaphanta NP-Katerniagath WLS-Pilibhit TR were top priority. In keeping with the IUCN Red List, the results show that buffalo are more prone to extinction than the greater one-horned rhinoceros.

Read the full paper: Jhala, H.Y., Qureshi, Q., Jhala, Y.V. et al. (2021) Feasibility of reintroducing grassland megaherbivores, the greater one-horned rhinoceros, and swamp buffalo within their historic global range. *Sci Rep* 11, 4469 <https://doi.org/10.1038/s41598-021-83174-4>



Distribution probability of wild water buffalo across the Terai-Brahmaputra floodplain, from Harishini et al., 2021

A new classification of domestic water buffalo and its implication for wild water buffalo and anoa

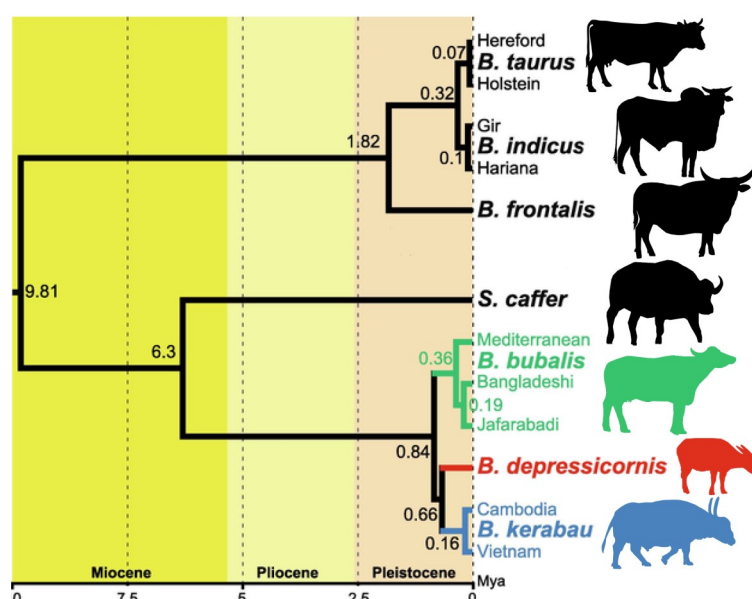
By Roberto Rozzi, German Centre for Integrative Biodiversity Research & Museum für Naturkunde,

In a recent study (Curaudeau et al., 2021), we investigated phylogenetic relationships within the genus *Bubalus* by analysing 15 genomes, including three newly sequenced genomes from two domestic swamp buffaloes and from a lowland anoa (*Bubalus depressicornis*). We assembled and analysed three genomic datasets: the mitochondrial genome (15,468 bp; maternal transmission), two concatenated Y chromosomal genes, AMELY and DDX3Y (20,036 bp; paternal transmission), and a selection of 30 nuclear genes extracted from all cattle chromosomes (364,887 bp; biparental transmission). Results of our phylogenetic and molecular dating analyses suggest that the

lowland anoa, the river buffalo, and the swamp buffalo should be considered as three distinct, but closely related species, which separated rapidly from each other at around 0.84 Mya (95% CI: 1.28–0.49 Mya; Figure 1). In particular, two species of domestic water buffalo should be recognised: the swamp buffalo, *Bubalus kerabau*, which occurs in China and Southeast Asia, and the river buffalo, *Bubalus bubalis*, found in the Indian subcontinent and Mediterranean countries. This taxonomic view is also supported by cytogenetic evidence and morphological data. Available genetic data on wild water buffalo (*Bubalus arnee*), albeit scarce, seem to reflect this West-East dichotomy detected in domestic lineages. Accordingly, sequencing the genomes of wild forms of water buffalo could prove crucial in further investigating the evolution of the genus and for conservation purposes.

Read the full paper: Curaudeau, M., Rozzi, R. & Hassanin, A. (2021) The genome of the lowland anoa (*Bubalus depressicornis*) illuminates the origin of river and swamp buffalo. *Mol Phyl Evol*;161

doi.org/10.1016/j.ympev.2021.107170.



BEAST chronogram inferred from the concatenation of the three genomic data sets. The mean divergence times are reported on the nodes. All nodes were supported by posterior probability [PP] = 1. Modified from Curaudeau et al., 2021.



Anoa and babirusa Credit: Chester Zoo

Using ancient DNA from museum collections to assist the conservation of anoa and babirusa

By Sabhrina Gita Aninta, Queen Mary University of London and Natural History Museum.

The endangered anoa (*Bubalus* spp.) is the largest native mammal inhabiting Sulawesi, the largest island of the Wallacea region in Indonesia, is currently threatened by high rate of deforestation (Supriatna *et al.*, 2020) and hunting rate (Latinne *et al.*, 2020). As the national development plan pursues economic growth in the Wallacea, the threat level to anoa may not decrease anytime soon. More evidence to assist any future policy related to land-use change thus needs to consider how current developmental activities affect the bio-

diversity in the region, including anoa.

To answer this challenge, the genetics part of a joint UK and Indonesian Natural Environment Research Council (NERC)-Ristekdikti 'Wallacea Region' project (NERC, 2018) has been upgrading the genetic information of anoa and babirusa samples from previous studies (Burton, 2005; Frantz *et al.*, 2018) and the collection of early 19th century natural historians preserved in natural history museums all over the world. More specifically, the remaining DNA extracts of these samples are processed for whole genome sequencing along with newly extracted DNA from museum collections. The resulting genomic data are thus analysed to detect any changes in genetic diversity across time and date any changes in population size. Was the change related to a large deforestation event that happened in the 1990s or were the populations already in decline before then?

Knowing when and how the population has

changed will help us to evaluate and understand the species potential for adaptation to their changing environment (Díez del Molino *et al.*, 2017). By matching this to maps of deforestation, we can further understand how these taxa respond to habitat degradation. Armed with this knowledge, we can help local practitioners to support populations which are more resistant to change, and which may need extra care. This can improve regulation and designation of protected areas and captive breeding programs.

Since the meetings between collaborators (Frantz, 2019), we have been generating and analysing whole genome sequences, discussing preliminary results, and still working on generating more genomic information from museum specimens. We are currently processing museum collections from Gothenburg National History Museum, Sweden, National Museum of Scotland, UK, and in the middle of getting permits to process samples from the Natural History Museum of UK in London. Please [get in touch](#) if you want to support or learn more.

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Raising funds for wild cattle

Thank you to everyone who continues to support Asian Wild Cattle conservation. If you are inspired to start your own fundraiser, we'd love to hear from you! Get in touch with [Corinne](#) to share your ideas.

Cycle for Sulawesi!

In April, Flamingo Land zookeeper Matt Thompsett cycled the equivalent of from Bitung (North Sulawesi) to Makassar (South Sulawesi) on his exercise bike in just 10 days to raise money for conservation in Sulawesi! He cycled 1092 miles and raised over £1,000, which will be used to support anoa conservation and population monitoring research in Sulawesi.



Matt's story:

"I've always had a love of all things cattle since starting my career working with domestic livestock. During my time working at a safari park,

I was fortunate to be able to spend 3 years working with Lowland Anoa, Banteng and Asian Water Buffalo. At this point I knew that this is where my passion lies, and where I wanted to tailor my career towards, to be able to help and support these species.

That is where the idea of this fundraiser came from. I had never tackled anything like this before and I knew it would be tough. I spent a solid 4 months training and altering my diet. The actual cycle was harder than I imagined it to be, both mentally and physically. There were highs and lows as expected, but finishing each day knowing I was just that little further was enough to keep me going.

I look forward to seeing all the incredibly generous donations being put towards the species I truly love and hope that for many more years, these species can survive and start to thrive."

Art for Asian Wild Cattle

Thank you to Marcus Burkhardt for his continued support through amazing art! Check out and buy more of his work at <http://natural-and-history-art.de/en/asianwildcattle/>.



RESEARCH AND REPORTS

Habitat utilization by solitary males of Asian wild buffalo (*Bubalus arnee*) in Central India

By Rajendra Prasad Mishra*, Poonam Chandel and Adrish Poddar, Wildlife Trust of India

*Correspondence: rajendra@wti.org.in / rpmishra1@rediffmail.com

Abstract

Asian wild buffalo are generally found in wet environments and show a distinct preference for low-lying waterbodies and grasslands. However, a small population of the species also exists in central Indian landscape, dominated by tropical dry deciduous forests. We investigated the habitat use by five solitary wild ranging male buffalos in the Udanti-Sitanadi Tiger Reserve of the Chhattisgarh state of Central India. We used compositional analysis of location data of five male buffaloes collected for two years to understand their habitat use at two levels – landscape level and individual home range level. Land-cover was categorized into six categories; dense forest, moderate forest, grassland, water body and agriculture. At the landscape level, buffaloes showed fidelity towards agriculture and moderate dense forests, which could be linked with nutritious food availability in agricultural areas. At the home range level, the buffalo showed preference for water bodies and grasslands. The study underlines the importance of maintenance of forest cover with sufficient grassy glades in the landscape, and employing protection measures to avert poaching near human use areas and enhance tolerance among villagers to reduce retaliation on account of crop raiding.

Key words

Habitat selection, compositional analysis, Udanti-Sitanadi Tiger Reserve, home range.

Introduction

Habitat preference in the Asian wild buffalo (*Bubalus arnee*; Kerr, 1792) also known as wild water buffalo includes low-lying waterbodies with alluvial grasslands, seasonally flooded grasslands and mixed forests, oxbow lakes and other depressed derelict water bodies along rivers, sandy islets situated between branches of a river in a braided river system, and grasslands, mixed deciduous forests and dry evergreen forests along the rivers in Indochina, Nepal, Thailand, and India (Lydekker, 1924; Wharton, 1957; Spillet, 1966; Prater, 1971; Dahmer, 1978; Nakhasathien and Cox, 1990; Choudhury, 1994 & 2010, Kaul *et al.* 2019). In contrast, the buffalo also inhabits tropical dry deciduous forests with grass dominated under-storey of Teak (*Tectona grandis*) and the Sal (*Shorea robusta*) forests in Central India (Daniel and Grubh, 1966; Mishra, 2001, 2003 & 2004).

The buffalo population in Central India has witnessed a sharp decline in the recent years. Less than 50 individuals are distributed in Udanti Wildlife Sanctuary and Indravati National Park in Chhattisgarh, and Kopela- Ko-

lamarka conservation reserve in Maharashtra, which adjoins the Indravati National Park (WTI, 2009). The recent decline in wild buffalo population in Central India has highlighted the importance of understanding the habitat preference of the species. Knowledge about the relationships between wildlife and the ecosystem is fundamental to understanding and effectively managing it (Hizrel *et al.*, 2006; Pearce and Boyce, 2006). Wild animals rarely use the entire habitat homogeneously and habitat selection is determined by the availability of food resources, mate distribution as well as safety from predators (Fjellstad and Steinheim, 1996). Wild herbivores are adaptive in habitat preference to increase fitness (Martin, 1998) and accordingly, their habitat selection traits exhibit increasing preference for areas with desirable microclimate that fulfil dietary requirements. An understanding of these habitat-species relationship helps in developing conservation strategies for threatened species (Lecis and Norris,

2003). This underpinned the importance of conducting a study on habitat use by wild buffalo in the Udanti-Sitanadi landscape in Central India.

Materials and methods

The study was conducted in Udanti-Sitanadi Tiger Reserve (USTR), which is comprised of Udanti Wildlife Sanctuary (Udanti WLS; 237.27 km²) and Sitanadi Wildlife Sanctuary (Sitanadi WLS; 553.36 km²) (Figure 1). The peripheral landscape of Udanti Wildlife Sanctuary is mostly hilly while the central portion is generally plain or gently sloped. Terrain in Sitanadi Wildlife Sanctuary is hilly. The forests are primarily dry deciduous dominated by teak (*Tectona grandis*) and sal (*Shorea robusta*). Areas of mixed species dry deciduous forest are also found in the sanctuaries.

The ungulate community is comprised of cervids (*Axis axis*, *Rusa unicolor*, *Muntiacus muntjak*); bovids (*Tetracerus quadricornis*, *Bosela-*

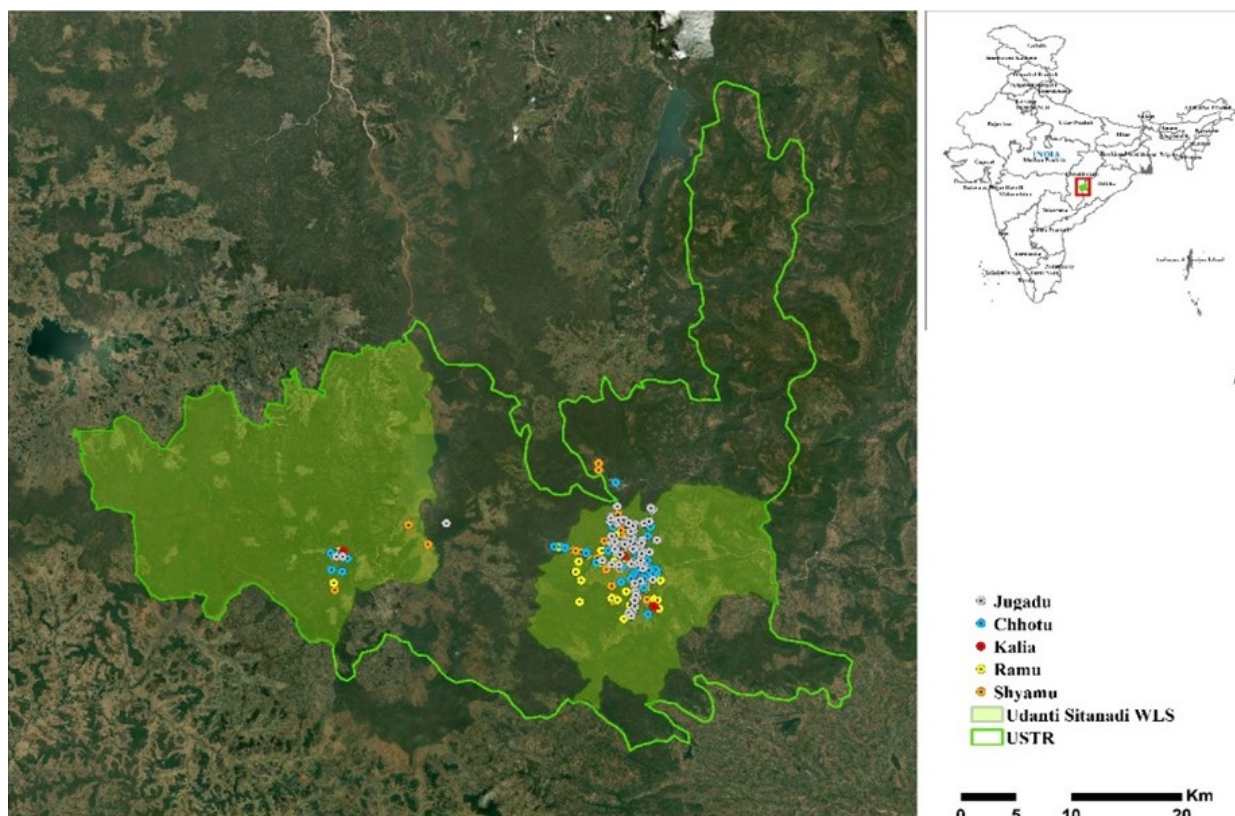


Figure 1. Map showing location of USTR and representation of five free ranging wild buffaloes in USTR between 2006-08

phus tragosamelus, *Bos gaurus*); and Suidae (*Sus scrofa*). Tiger (*Panthera tigris*), leopard (*Panthera pardus*) and wild dog (*Cuon alpinus*), wolf (*Canis lupus pallipes*) are the key predators. There are 30 small revenue villages inside the sanctuaries.

The study area currently holds a small population of 10 individuals of wild buffalo (WTI 2018). The free-ranging buffaloes were monitored on day-to-day basis by trained trackers during 2006-07 to 2019-20. A maximum of five males ranged free during 2006-08. Location data points of these individuals were used to perform compositional analysis (Aebischer *et al.*, 1993) in determining the habitat types that govern the preferences of buffaloes at the USTR level and at the range level. The analysis was done using Adehabitat HS package (Calenge, 2006) in R version 3.5.3.

The technique used individuals as the sample unit (N) and the variance amongst the use of habitats between buffaloes was analysed as

opposed to pooling data across buffaloes and avoiding the problem of unit-sum constraint as observed in other conventional techniques of assessing preferences of habitat (Byers *et al.*, 1984, Aebischer *et al.*, 1993). The free-ranging wild buffalo population in the study area is comprised of males only and it was possible to identify them all individually. 330 location points were obtained over the two years (2006-08) and were ascribed to all individually identified buffaloes; namely Chhotu (74), Jugadu (82), Kalia (80), Ramu (45) and Shyamu (49). The buffaloes mainly used Udanti Wildlife Sanctuary part of USTR (Figure 1). The data were analyzed at two scales:

i) Larger landscape level analysis to evaluate second-order habitat selection (i.e., factors responsible for determining the individuals' home range). The available habitat was the proportion of different habitat types available within the delineated project area, and habitat used was the habitat composition of the same con-

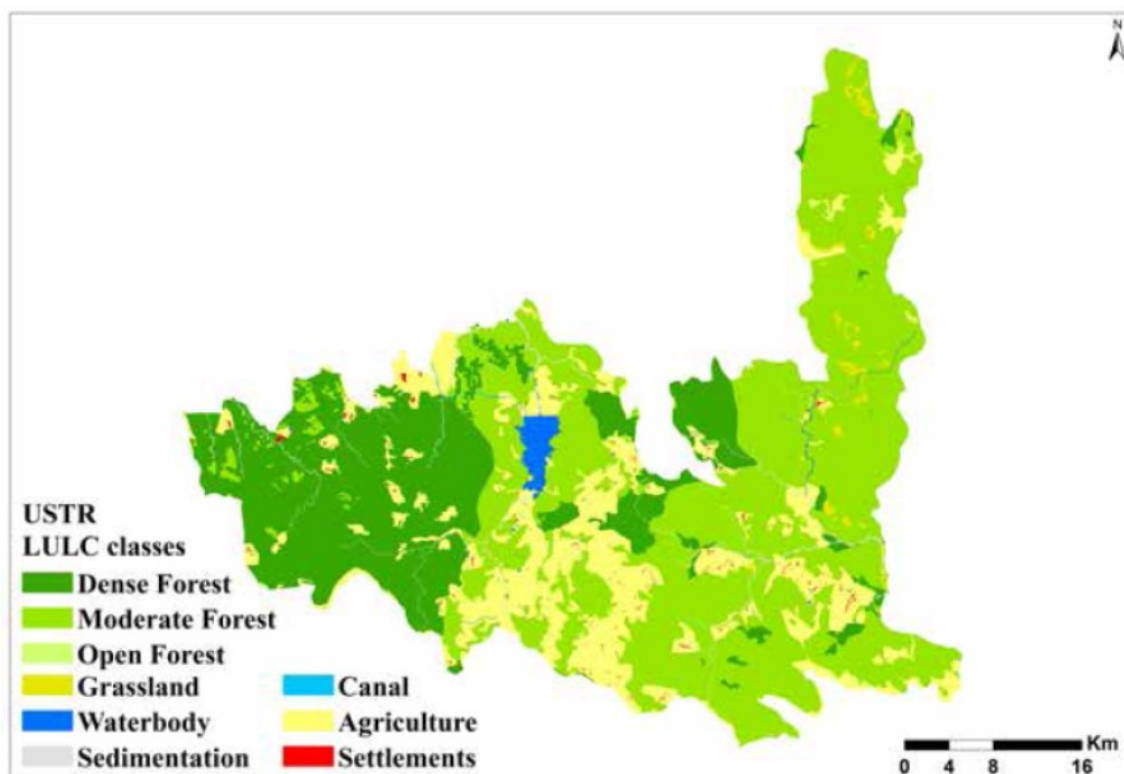


Figure 2: Map showing USTR Land Use Land Cover (LULC)

stituents of habitat within each individuals' home range.

ii) Smaller scale analysis to evaluate third-order habitat selection (i.e., habitats used within a home range). Availability was measured as the proportion of each habitat type within a Minimum Convex Polygon (MCP) home range of an individual and use as the percentage of tracker locations within each habitat type.

The land-cover layer was created by using satellite imagery of Sentinel 2 Multi Spectral Instrument (MSI) scene, with 10m ground resolution, taken over the area on 15 February 2020. Object oriented classification was performed to classify the imagery (Burnett and Blaschke, 2003) into nine land-use classes: Dense Forest (DF), Moderate Forest (MDF), Open Forest (OF), Grassland (G), Water body (W), Sedimentation (SED), Canal (C), Agriculture (AGRI) and Settlements (SET). For the compositional analysis, the following land-use classes were joined: OF with MDF; C and SED with W; and SET with AGRI, resulting in five broad habitat categories. The utilization of these habitats was determined by the proportions of the five habitats present in the ranges of the five buffaloes as determined by creating a home range for each buffalo using the MCP method.

Results

Table 1: Area constituting each land use class in USTR

Land use classes	Area (in hectares)	Proportion
Dense Forest (DF)	48059.03	0.267
Moderate Forest (MDF)	93972.091	0.523
Grassland (G)	1386.61	0.007
Water body (W)	3106.19	0.017
Agriculture (AGRI)	32883.28	0.183
Total	179,407.2	

Habitat availability and utilization

In USTR, 'Forest' is the most dominant habitat category accounting for over 79% of the study area. Of this, the Moderate Forest (MDF category) comprised of about 52% and 27% was Dense Forest (DF) (Table 1 and Figure 2). The other significant categories of habitat were Agriculture (including settlements) which comprised of 18% of total land cover. Waterbodies and grasslands, habitat types that wild buffaloes are generally associated with constituted a relatively negligible 0.017% and 0.007% of total land cover respectively.

Proportion of utilised habitat by the five wild buffalo individuals within their home range (MCP) during 2006-2008 is shown in Table 2. The home ranges of the five wild buffalo tended to overlap with each other and ranged from 233 km² to 174 km² (Figure 3).

The juxtaposition of the individual ranges seemed to follow a pattern of largely occupying the lowland portions of Udanti WLS, seemingly avoiding the hilly eastern and southern parts (Figure 3). All five buffaloes made occasional forays into the south eastern part of Sitanadi WLS across the gap which is dominated by human settlements. Habitat availability within the home range of all the buffaloes showed that MDF category constituted the main habitat type followed by AGRI, DF, W and G, in that order (Table 2).

Habitat selection at USTR level

Prior to running the compositional analysis, a *Chi-square* test was done using the available as 'expected' and used as 'observed'. The results showed that there was overall habitat se-

Table 2. Proportion of used habitat by all the tracked wild buffalo within their home range (MCP)

Individual Wild Buffalo	DF	MDF	G	W	AGRI
Chhotu	16.26	51.91	0.25	1.24	30.34
Jugadu	14.48	53.47	0.26	1.19	30.60
Kalia	16.38	51.83	0.25	1.23	30.31
Ramu	10.17	54.08	0.24	1.34	34.18
Shyamu	12.81	34.89	0.17	26.51	25.61

lection, i.e. buffaloes were not using the habitats as expected by the proportions available and therefore selected certain types ($p < 0.001$). Therefore, preference and avoidance were established.

Residual relationship matrix was generated to derive a ranking of habitat selection by wild buffalo. A (+) sign was given when the habitat shown in the row was used more than the habitat in column, and a (-) sign in case of underuse. When the difference was significant, the sign was tripled.

The results indicated that MDF, W and AGRI was used more when compared to DF type in

determining the habitat selection (Table 2). The order of ranks in decreasing order of selection of habitats at landscape level thus was Agriculture (AGRI) > Moderate Forest (MDF) > Water Body (W) > Dense Forest (DF) > Grassland (G). Therefore, at the landscape level, a combination of agricultural fields and forest seemed to determine factors driving habitat use.

Habitat use at the home range level

The factors driving the use at the micro-habitat level were examined by comparing the proportion of habitats available within each buffalo home range and the buffalo locations recorded

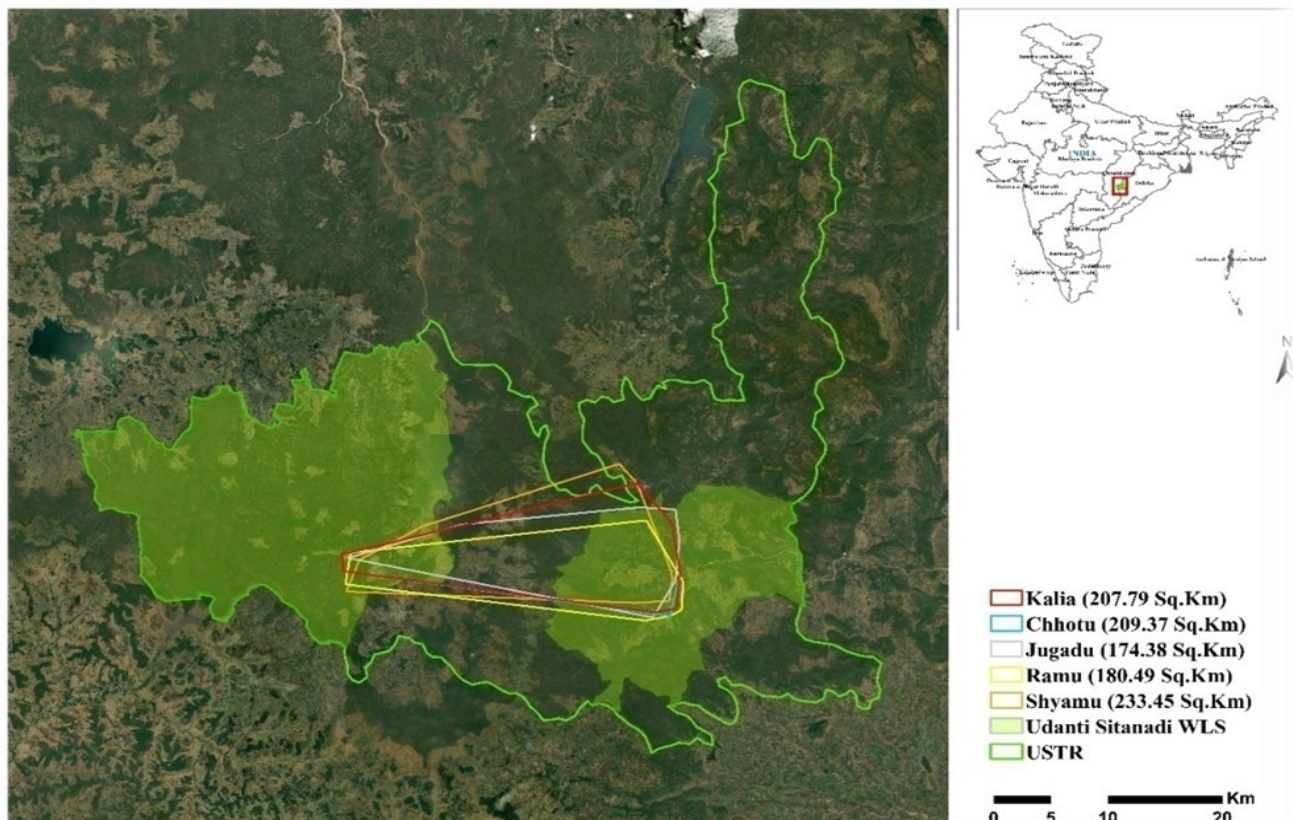


Figure 3: Home ranges of individual buffalo

Table 3: Relationship matrix showing rankings of habitat selection at the home range level

	Dense Forest	Moderate Forest	Grassland	Waterbody	Agriculture
Dense Forest	0	---	-	-- -	+
Moderate Forest	+++	0	-	---	+++
Grassland	+	+	0	-	+
Waterbody	+++	+++	+	0	+++
Agriculture	-	---	-	---	0

in each of these habitat types within each home range. For the habitat use assessment at the home range level, *Chi-square* tests were run on the observed use against the expected use. The test indicated that the habitat was not being used by the wild buffalo as expected from proportion of habitat types available and therefore the buffalo used certain habitat types more than expected (showing preference for that habitat). Probability values at which the null hypothesis was rejected were Chhotu ($p = 3.866263e-05$), Jugadu ($p=2.446313e-04$), Kalia ($p = 5.193947e-05$), Ramu ($p= 4.350231e-09$), Shyamu ($p= 2.737358e-04$). The habitat use determinants changed at the home range level when compared to the landscape level selection. At the home range level, W and G seemed to be used more than expected from the proportions available. Surprisingly, AGRI were avoided. The decreasing order of selection was Water Body (W) >Grassland (G) > Moderate Forest (MDF) >Dense Forest (DF) >Agriculture (AGRI) (Table 3).

Discussion

This investigation on habitat selection by wild buffalo in central India clearly indicates the high-priority habitats for conservation efforts for

the species, though it also demonstrates a conflicting theory evidencing shift in ranging patterns, at particular times of the year and somewhat contradicting the hypotheses that buffaloes prefer greener and wetter portions of the area available (Daniel and Grubh, 1966).

At the landscape level, the study demonstrated buffalo's fidelity towards agriculture and moderately dense forests, which could be linked with nutritious food availability in agriculture areas as both agricultural crops and moderately dense forests (with grassy glades) provide optimum habitat for nutrition and cover. However, at the home range level, water bodies were preferred. This difference may be due to water bodies escaping remote detection at the landscape level, either due to their small size or by being concealed under a layer of forest. It was, however surprising that buffaloes avoided agricultural habitats at the home range level. This may be due to the limitation of data collection being undertaken largely as a diurnal activity, as buffaloes tended to stay concealed inside the forests in the day and largely utilising the farm at night.

Grasslands too were underused against all other habitat types at the landscape level. A reason for this could be that buffaloes prefer grazing on small clearings within forested areas rather than open degraded grasslands, and that the clearings were not classified as 'grassland'. Kingdon (1982), described similar habitat use by African Forest Buffalo (*Syncerus caffer nanus*), as small open areas within forests supplied sufficient foods resources throughout the year.

Korte (2008) found that female buffaloes selected proportionally more open habitat and used continuous forest less than would be expected based on available habitat at the landscape level. In general, the species forms maternal groups, with young ones led by a dominant matriarch and often by a single adult bull (Nowak, 1999; Aryal et al., 2011). They exhibit a polygynous mating system, and males mix with females at mating time. The studied population comprised of only males, because there were no free ranging females in the study area. Thus, implications of this social structure on the habitat utilization and ranging patterns of solitary males could not be studied, which must be taken into consideration when interpreting these results. Solitary males often visit the agricultural and human settlement areas seeking domestic buffaloes for mating (Mishra and Gaur, 2019); such behaviour is likely to affect habitat selection by the studied males.

Tropical ecosystems are governed by fluctuations in water availability and seasonal rainfall in tropical regions influences the spatial distribution of herbivores by causing temporal variation in the availability of water and the productivity of particular habitats. These variations

introduce fluctuations on a larger temporal scale, affecting seasonal resource availability for herbivores (Hughes *et al.*, 2011). Such seasonal effects on the wild buffalo habitat utilization should be an important aspect of future studies on the species.

The present study is an important step towards the conservation of a small population of wild buffalo in Central Indian region by providing first-hand information on habitat preference of the species. The wild buffalo population in the Central Indian landscape is not associated with a typical wetter habitat, unlike its North-eastern Indian and South-east Asian populations, despite its availability at larger landscape. However, smaller waterbodies in their home-ranges are essential. Maintenance of forest cover with sufficient grassy glades are important for the buffalo in Central India. Preference for agricultural areas at the larger landscape underpins the need of measures to ensure protection against poaching and enhance tolerance among villagers to reduce retaliation on account of crop raiding.

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Asian wild water buffalo 'Prince'. Credit: Wildlife Trust India

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AUTHOR GUIDELINES

Aim & Scope

BULLETIN is the official, peer-reviewed publication of the IUCN/SSC Asian Wild Cattle Specialist Group. It aims to provide information on all aspects of natural history for the relevant species (Anoa, banteng, gaur, kouprey, saola, tamaraw, water buffalo and yak), with a particular focus on their conservation and management, both *in* and *ex situ*.

BULLETIN accepts manuscripts of original research findings that have not been published or submitted simultaneously to other journals, and with a minimal overlap of contents with other published papers. As well as these, *BULLETIN* also accepts and encourages submission of other relevant news, thesis abstracts, book reviews, summaries from workshops and meetings as well as a “notice-board” to publicise relevant upcoming conferences, funding opportunities etc.

Subscription and processing of manuscripts

We prefer manuscripts in English. If English is not your first language, then please have your text thoroughly reviewed by a native speaker before submitting. Abstracts must also be in English, but we encourage an additional abstract in the language of the country where the project has been conducted. We will consider manuscripts in other languages; speed of publication in that case depends on availability of reviewers. If the article is not in English, then an English abstract must be provided.

Manuscripts should be submitted in MS Word and sent to James Burton (jamesaburton@yahoo.co.uk). Submitted manuscripts will initially be evaluated by the editors. Manuscripts which fail to meet the editorial requirements will be returned to the author without review. Research articles and reviews will be sent to one or two independent reviewers. We aim for less than two months between initial submissions until final acceptance for publication.

Types of contributions and requirements

News and field notes

Relevant news and notes from the field that may contain figures and tables (up to 2,500 words)

Book reviews

Short evaluations of recently published books and monographs of interest to the AWCSG (up to 1,500 words)

Review papers

Unbiased reviews of the existing knowledge on a specific topic, providing novel insight and synthesis are welcomed (up to 6,000 words)

Research papers

Original research articles (up to 8,000 words including all text, references and legends). Manuscripts should adhere to the following structure:

- Title
- Author details (names, affiliations and contact details for corresponding author)
- Abstract (not more than 250 words)
- 4-8 key-words (additional key-words not appearing in the title – if any)
- Introduction
- Materials and methods
- Results
- Discussion
- Acknowledgements (optional)
- References (Harvard style)
- Figures and tables, presented alongside individual captions (please also send photos and figures in separate files in the highest available resolution)

Numbers and units

The metric system should be used for all measurements and weights with a space between the number and the unit of measurement. Temperature should be expressed as degrees Celsius (°C). Numbers from one to nine should be spelled out except when used with units; e.g. one anoa but ten banteng and 3 km.

Nomenclature

Please use common English names of plants and animals, and adhere to the taxonomy used in the IUCN Red List. At first mention in the main text, give both the common and scientific names (in italics). If possible, also add the local name of the species in the area where you work.

Figures and tables

Figures and tables should be cited in the text in the order that they should appear. Figures and images should be in one of the following file formats:

- Encapsulated PostScript (EPS)
- Tagged Image File Format (TIFF)
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- Portable Document Format (PDF)

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References

We use the Harvard style and the name-year method of citing and listing references. Citation to work by one or two authors should give the author names in full, e.g. (Smith 2017) or (Smith & Miller 2017). Citation to work with three or more authors should be abbreviated with the use of et al. (e.g. Smith et al. 2017). Citations in the text should be separated by a semicolon and listed in chronological order. Works with the same first author and date should be coded by letters (e.g. Smith 2017a). The reference list should be organised alphabetically by first author, punctuation should be minimised and journal names should be unabbreviated. The minimum reference information required is as follows:

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