

Docility Behavioral Development in *Nilgai* (*Boselaphus tragocamelus*), a Signs of Taming towards Domestication

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Authors' contributions

This work was carried out in collaboration between both authors. Author SP designed the study, performed the statistical analysis, wrote the protocol and wrote the manuscript. Author CSP managed the literature searches and analyses of the study. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2020/v39i4131117

Editor(s):

(1) Dr. Belisario Dominguez-Mancera, University of Veracruz, Mexico.

Reviewers:

(1) Julio César González-Gómez, Colombia.

(2) Thakur Krishna Shankar Rao, Navsari Agricultural University, India.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/63394>

Original Research Article

Received 28 September 2020

Accepted 03 December 2020

Published 21 December 2020

ABSTRACT

Nilgai has some unique ecological function and they may be beneficial in many ways. Killing of *Nilgai* is not a long - term solution to overcome human- animal conflict. A study was conducted to know the docility pattern and behavior of *Nilgai* (*Boselaphus tragocamelus*) in Bihar state, India. Present docility pattern shows that adult females graze with juveniles and dwelling near the human habitation in proximity of in a close distance in anthropogenic environments. It also grazes and share food & fodders with domestic animals like cow, goat, and buffalo in periphery of village areas. Only males possess horns though a few females may be horned as well. Females were less aggressive than males and are of different size and color. Adult males are in blue grey color which reveals sign of territoriality, whereas females color is light in shade which showed evidence of the existence of social hierarchy and increased docility behavior. Females were sitting in group with juveniles in gregarious forms, however, male were found to be scattered. *Nilgai* migrates in search of food towards cultivated grass, agricultural crops and periphery of the villages areas during dusk and return when less human activity during dawn. Shahabad area Bhojpur, Buxar & Sasaram are characterized by extreme hot and heavy rains. During the unfavorable condition (Rainy and

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summer season) they: showed seasonal migratory behavior. These behaviors marked in *Nilgai* may be developing closer social bonds with human being on a way towards domestic relationship. It can be integrated into human society in favour of co-existence as well as a step towards domestication useful for human in coming future.

Keywords: Antelope; behavior; docility pattern; domestication; ethology; Nilgai.

1. INTRODUCTION

Uncontrollable human population growth leading to the industrialization and urbanization is rapidly replacing natural habitat, local vegetation and decreasing free space for wild animal's day by day [1]. The *Nilgai* or blue bull (*Boselaphas tragocamelus*) is one of the largest antelope in Indian sub-continent [2]. In recent time *Nilgai* has posed a serious challenge to agricultural production and considered as a pest in several north Indian states due to grave impact on cultivated crops [3,4]. The Government of Bihar declared this animal as vermin and ordered to kill them in favour of farmers moreover, a total 2,228 numbers of nilgai were killed during 2017-2018 in different district of Bihar [5]. *Nilgai* may be beneficial in many ways we need to explore their ecological functions, importance and uniqueness of products viz-milk and flesh. Black marketing of *Nilgai* body parts such as skin, teeth, nail and meat has been reported in Uttar Pradesh and their adjoining areas [6]. Kalyankar et al. [7] suggested domestication of *Nilgai* for generation of bio-energy and its application in the field. Sclater and Thomas [8] reported regarding the tastiness the flesh of (*B. tragocamelus*) were less than flattering, however, flesh of adult females (*Nilgai*) is of comparable texture and tenderness to beef with less flavorful and lower in fat (by-2 times) and cholesterol [9]. The meat of *Nilgai* is said to be lighter and mild flavored than blackbuck meat [10]. Behavioral development in animals undergoing domestication is characterized by changes in the quantitative rather than qualitative nature of responses and also having peculiar type of relationship between man and some species of animals Price, [11] defined animal domestication is an on-going process, as human have brought a wide range of animals into domestic partnerships over the past 11,000 years-as livestock, working animals, household pets, had more than one ancestor according to Darwin and had related the same parents [12,13]. Time spent by *Nilgai* on various activities is influenced by environmental factors, particularly weather conditions and food [14]. The study area is characterized by extreme hot and heavy rain. Recent few years it has been seen dramatic improvement altering behavior in

Nilgai to changing climatic and demographical scenario in Bihar. Killing of *Nilgai* is not a long-term solution to human animal conflict.

In this background, the study has been planned to understand the docility behavioral ecology and uses of *nilgai* in changing demographical situation, which may act as stressor and its successfully adaptation in such type of extreme climate.

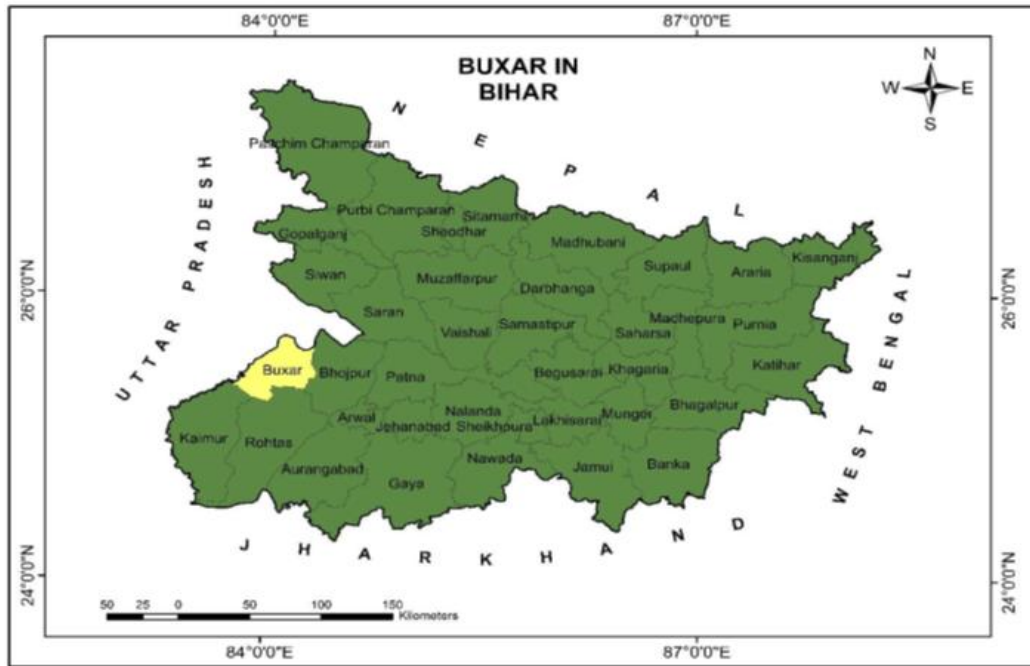
2. MATERIALS AND METHODS

2.1 Study Area

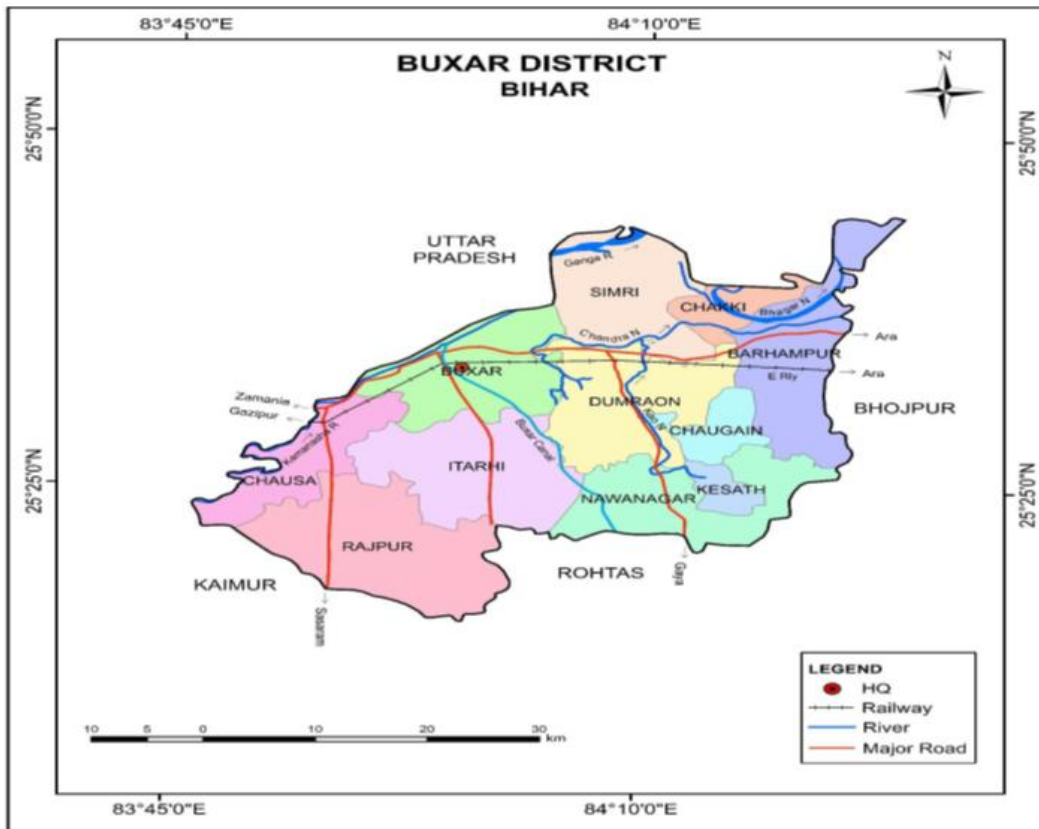
Study area of present research work is Dumraon city of Buxar district of Bihar state, which is harbor of wild mammalian species including Nilgai [15]. Dumraon is one of the oldest municipalities of Bihar and one of India's oldest princely states, lies between 25.55°N Latitude and 84.15°E Longitude at the average elevation of 61 meters (200 feet). Fig. 1. It is located 1.5 km South of National High way (NH-44; Ara-Buxar Highway) with human population of 53,618 as per census- 2011.

2.2 Animal Detail

The *Nilgai* word was first recorded in use in year 1882 (Merriam Webster Dictionary). The gross feature of Nilgai include longer forelegs often marked with white 'socks' thus called white footed antelope, also called blue bull or blue buck. The *Nilgai* was known by the name *nilghor* ('nil' for 'blue' and 'ghor' for 'horse') during the period of Mughal Emperor Aurangzeb (1658-1707) of India, [17]. Adult males are in blue grey in color but females including adolescents are light in shade. The Indian name 'nilgai' comes from the fusion of the Hindi word's *nil* ('Blue') and *gai* ('Cow'), *gai* is female gender, but is used for either sex of the species and as one of a variety of cattle. The generic name *Boselaphas* comes from the combination of the Latin word *bos* means ('Cow' or 'Ox') and the Greek word *elaphos* means ('Deer'). The specific name of *tragocamelus* comes from the two Greek words *tragos* means ('he-Goat') and *Kamelos* means ('Camel'). The binomial combination of Nilgai was first used by English Zoologist Philip Sclater in 1883, [18].



i) Map of Bihar indicated District Buxar



ii) Map of District Buxar

Fig. 1. Map of study area in District Buxar, Bihar, India (I &ii), source: [16]

2.3 Animal Monitoring

The present study was carried out to understand behavioral strategy of *Nilgai* in Dumraon, Buxar Bihar, India from January 2018 to December 2019. Animals were monitored using a combination of direct sighting by scan sampling methods [19]. Monitoring were performed during the morning to evening on the specific days by motorcycle and walking. Waking were practiced in case of unavailability of footpath due difficult undulated study area. The direct methods utilized sighting of animals from a close distance. Behaviors of the animal was also observed. Photographs were taken with digital camera and necessary information's were also collected through the past history and attitudes of the people towards the *Nilgai* behavior from the villagers those living near in the fringe areas of Dumraon city. The collected data presented in simple tabular form.

3. RESULTS AND DISCUSSION

In India, Nilgai placed under scheduled III of the wildlife protection Act, 1972, and this animal is red listed under endangered species of International Union for the Conservation of Nature (IUCN), and its categorized as an animal of 'Least concern' [20]. During the year 2017 the maximum crop damage has been reported in different districts and farmers demanded immediate action. It forced officials of Vaishali and Nalanda districts of Bihar to permit the killing of *Nilgai* [5]. Total 2653 and 175 *Nilgai* were killed during year 2017 and 2018 respectively in the

Bihar state due to human animal conflict, Table 1.

Male *Nilgai* is look like horse and shows clear sexual dimorphism. It has a strong thin white foot that often marked with white socks. *Nilgai* characterized by inclined back, a profound neck with a white patch on throat-having short tresses of hair behind and along the back end. Male possess a pair of horns on head which is circular, smooth and triangular at the base and pointed towards the tip. *Nilgai* has sharp ears and eyes, being a fast and swift-moving animal. Behind the shoulder having around two white spots each and also found on its face, ears, cheeks lips and chin. Female usually lacks horns or may be rarely bear it as well. *Nilgai* gives birth to singlet or twins, rarely triplets.

Adult male was blue-grey in colour but females were smaller with all adolescents are light in shade and look like a cow details presented in (Table 2, Fig. 2, a, b, d & f). Oguya and Eltringham [21] reported only males possess horns 15-24 cm in length. Leslie, [18] reported a clear cut sexual dimorphism in animals. The males are larger than females and differ in coloration. In the present study it is observed that the *Nilgai* has reshaped the pattern of grazing, distribution and behavior due to demographic pressure, climate change and decline in food and water resources, increase human population and with development work, the populations of *Nilgai* were forced to move out of the "ideal zones" into the "small areas" in due course of time this may led to the domestication of this animals.

Table 1. Killing of *Nilgai* in different districts of Bihar [5], due to human animal conflict

Districts	2017-18
Saran	1163
Nalanda	0676
Vaishali	0609
Patna	0380
Total	2828



Table 2. Characteristics features of male vs. female Nilgai (Fig. 2 a& b)

SL. No.	Male	Female
1	Adult male looks in blue grey with white markings and larger than female and are of different color.	Female is brownish with light shade and are smaller in size as compared to male.
2	Male possess a pair of horns, circular, smooth and pointed towards tip.	Generally, females lack horn and rarely had horns and produces singlet or twins, rarely triplets.
3	Males are more aggressive in nature.	Females are docile in temperament
4	Male are having tuft of hair like beard (at the midpoint on ventral side of the neck) that are more pronounced below the white guler patch.	Female are having tuft of hair less (at the midpoint on ventral side of the neck) and is not as much pronounced below the white guler patch.
5	Male is a horse like creature and looks like wild animals.	Female looks like a cow and some behavior are similar to cow
6.	Males are generally found in scattered form; they may be in single or in group.	Females are comparatively social in nature; they are generally found with juveniles in group as gregarious forms.

Price, [11] noticed that the degree to which a wild population of animals is pre-adapted for domestication largely depends on the degree of plasticity of the development and expression of species- typical behavioral pattern compatible with husbandry techniques. Bagchi et al. [22] reported that *B. tragocamelus* was tolerant of livestock grazing and associated degradation of grass. During the course of study, it was observed that with development activities led to the shrinkage of natural habitats which forced the *Nilgai* to move to the areas near the human habitats under stress situation. They also observed Nilgai dwelling near the human habitation and often share food and fodder with domestic animals like cow, goat and buffaloes. These signs of docility are primitive phase of domestication, the details of which are presented in (Table 3 and Fig. 2 c, d & e).

Our recent study documented residential population structure and reported that higher population densities of *Nilgai* in area of Haryana Cattle Breeding Farm (HCBF) Dumraon [23].

HCBF area of Dumraon, the open place was covered with short bushes, scattered trees, sandy soil, which makes the topography a short forest island. Nilgai calves stay hidden in areas for the first few weeks of their lives. It also provides protection from rigorous climatic condition, privacy for mating and rearing of offspring, and a means of escape from predators

and aggressive social partners. The social structure of animal populations may change when space becomes limited [11,24]. The stress situation caused by demographic pressure may have been a stimulus for the process of domestication of wild animals [25,26]. Bagchi et al. [22] reported that *B. tragocamelus* was tolerant of livestock grazing and associated degradation of grass cover. In the present study *nilgai* prefers and shares fodder of domestic animals, mainly cultivated grasses and field crops like, paddy, wheat, maize, pulses and this occurs by dwelling near human habitation. It has also been observed a positive associative conditioning in which fear of *Nilgai* for human is reduced by the latter's role as a secondary reinforcement. Feeding behavioral preferences observed as minimum competition among domestic ungulates; however, when forage supplies are low. The tameness pattern of *Nilgai* was correlated with the availability of food/ crop field with rich vegetation. In summer, the availability of food is low so docility pattern of *Nilgai* is high for search of food and water, during this period they basically get near water body nearby villages due to the scarcity of water and food, (Tables 3, 4 and Fig. 2 c & d). Thomas, [27] suggested several stages for the domestication of wild animals. In it contrast to this, author put forward the first and the foremost steps are establishment of the loose contacts of man with free breeding animal. In fact, the *Nilgai* did not belong to cow family.

Table 3. Feeding pattern and availability of food during different season in Dumraon

Food Crop availability	Field condition			Nearby village area		
	Summer	Winter	Monsoon	Summer	Winter	Monsoon
High	-	-	+	-	-	+
moderate	-	+	-	+	+	+
Low	+	-	-	-	-	-

+ = Present

Table 4. Docility and grazing pattern of Nilgai as indicated by taming domestication

Sl.No.	Tameness	Behavioral changes
1	Dwelling and grazing near the human habitation	<i>Nilgai</i> dwelling and grazing the cultivated grass & field crops without any fear in human habitation with loose contact as indicated in domestic syndrome. (Fig. 2., c & d)
2	Grazing with cow	<i>Nilgai</i> shares the food and fodder with cow, they together grazed cultivated grasses. Female looks slightly similar to cow and there was increase in docility due to simultaneous grazing (Fig. 2., e)
3	Grazing with goat	<i>Nilgai</i> shares the food and fodder with goat and graze together near the human habitation.
4	Grazing with buffaloes	<i>Nilgai</i> also shares the food and fodder with buffaloes. (Fig. 2., e)
5	Females grazing with juveniles	<i>Nilgai</i> especially female sitting and grazing with calf and juveniles all together near human habitation. (Fig. 2., f)
6	Taming	Due to positive associative pattern, <i>Nilgai</i> shares habitat with the domestic ungulates and fear of human was reduced slowly.

In the present study it has been observed that some behavior and physical features of females *Nilgai* were found similar to cows. Generally, only male animals possess horns, though a few females may be horned as well. *Nilgai* (females) also found to be grazing together with domestic animals in the field; this behavior indicates its first phase of domestication. According to Diamond [28], animal species must meet some criteria in order to be considered for domestication such as, flexible diet, reasonable fast growth rate, ability to be breed in captivity, pleasant disposition, temperament which makes it unlikely to panic modifiable social hierarchy for domestication. Our recent study documented that change in social behavior is a usual event in mammals, it can be grouped and it is a natural process of maintaining a species-specific characters' like group size and structure in relation to their environment [29].

In the present study females and juveniles do not interact appreciably with males. Females *Nilgai* was comparatively social and grazing with juveniles' groups in gregarious form but males were observed in scattered form, (Fig. 2 c & f). These changes are commonly referred to as the domestication syndrome and include behavioral change, such as increased docility as well as

alteration in size, colour and facial characteristics. The early human population noticed certain advantages in conserving certain animals near to his dwelling place and thus animals entered into the first phase of domestication [30]. [13] reported regarding commensal pathway is the first phase of general domestication scenarios, which are travelled by animals that feed on refuse around human habitats or by animals that prey on other animals drawn to anthropogenic environments. *Nilgai* show extraordinary kind of social organization and behavior; although the individual wondering male can be seen rarely live in isolation. *Nilgai* basically described as diurnal animal, [31]. In this study, some degree of nocturnal activities has been observed as *Nilgai* migrate for food and water towards agricultural lands and periphery of the villages areas during dusk and returned to places with less human activities during dawn. Climate has played a major role in shaping the human culture and domestication of plants and animals is also affected by that. The months of May- June are extremely hot and the ambient temperature rises up to 45°C, winter starts towards the middle of October and January is the coldest month when the, temperature drop down to 4°C. The average annual rainfall is 1021 mm and nearly 85% of annual rain fall is due to

Southwest monsoon (active between June to September) [16]. Buxar is a part of the Southern gangetic plain. Physiographic of the district is alluvial plain having gentle slope towards south to north. The elevation of the land surface in the district varies between 55 m amsl and 85 m amsl. *Nilgai*, spend the entire period of rainy and winter months (HCBF) in the area southwards of the Dumraon railway line which passes through the district in East-West direction, area of Keshat, Nawanagar, Itarhi, Dumraon block, and its surrounding details are presented in (Table 5). Wild species with sufficient levels mobility may respond quickly to climate (environmental) change such as temperature, flood and grassland with species capable of undertaking migratory movements [12]. During the survey of this experiment, we encountered many times *Nilgai* near the Bhagar oxbow lake area in Chakki block of Dumraon [32].

Nilgai is both a grazer and browser, but during summer, most of the water resources and green bushes dried up then they migrated from the plain region (high) of the South to the low-lying Northern plain area like Simri, Chakki and Brahampur block, near Bhagar oxbow lake and near village area in search of food and water. The seasonal variation also causes a change in their diet, so *Nilgai* exposed them to two different adverse conditions road & rail accidents and human wildlife conflict. [33] reported that seasonal variation also causes adverse condition like road or rail accidents and human wildlife

conflict leading to more mortality of animals. [21,34], reported, *Nilgai* is non migratory although individuals and groups are capable of considerable movement if ambient conditions (e.g. drought) dictate.

Taming is the conditioned behavioral modification of wild born animal when its natural avoidance of humans is reduced and accepts the presence of human. However, the universal features held in common by all adapted animals, there is significant mark in the ways in which animals respond to domestication. No doubt, domestication of wild animal species will never be termed as natural but a positive behavioral characteristic makes certain animal taxa and convinced individuals within taxa better candidates for domestication than others [10,13]. As per report *B. tragocamelus* shares a common lineage with water buffaloes (*B. bubalis*) and Kudu (*Tragelaphus*) more than with domestic cattle [35]. Kalyankar et al., [7] advised that *Nilgai* has to be cared just like the other calves of buffalo and cow with slight modification. The animals were more powerful as compared to domesticated cattle and hence is beneficial used in farm thus improving the economics of farmers. Prajapati and Singh, [36] studied ecological values and beneficial aspects of *Nilgai*, they documented regarding dung's of the *nilgai* contained nearly 1.6 percent nitrogen, that could enhance the quality of the soil up to a depth of 30 cm. Seeds in the droppings could easily germinate and assist in afforestations.

Table 5. Migratory behavior of Nilgai in present scenario

S. N.	Plain Southern region of Dumraon	Low lying Northern region of Dumraon
1	Area covered from South-Eastward of Dumraon railway line like Keshat, Nawanagar, Itarhi, Dumraon block etc	Area covered North-Eastward of Dumraon railway line like Simri, Chakki and Brahampur bank of the river Ganga etc.
2	<i>Nilgai</i> migrate in groups during summer from South-Eastward to North-Eastward Dumraon railway line like Simri, Chakki and Brahampur and aggregate near the Bhagar oxbow lake in search of food and water.	<i>Nilgai</i> migrate in small groups during rainy season from (Low lying to upwards) North-Eastward Dumraon railway line like Keshat, Nawanagar, and Brahampur etc. for searching food, shelter and protection.
3	Plain areas important for the cultivated main crop like wheat, maize gram etc.	Low lying areas important for cultivated main crop like wheat, maize gram etc.
4	These areas were densely populated	These areas were less densely populated.
5	During the summer season most of these areas are dried up.	In rainy season most of the areas submerged and used for cultivation of paddy crops.
6	<i>Nilgai</i> being a fast with swift-moving and migrated daily from HCBF, Dumraon for food towards cultivated agricultural lands during dusk and returned to same places during less human activities of dawn.	



Fig. 2. *Boselephus tragocamelus* shows docility behavioral activity (a,b,c,d,e,f), in Dumraon

4. CONCLUSION

This study indicates some sign by *Nilgai* in first phase of domestication might be due to shrinkage of its natural habitats and behavioral changes was also noticed in animals which help to adapt in the present-day stress condition. So *Nilgai* may be useful for us in many ways, human

only needs to explore and exploit this situation in his favour and may assist the domestication in captivity. Therefore, it is primary need to study the qualitative and quantitative properties of their products, so that the value of nilgai and their domestication can be made and their products could be made valuable for human consumption including its therapeutic uses. Domestication will

further reduce the crop loss to Nilgai raid which may additionally reduce the incidence of farmers' suicide. More detailed study is required to understand ranging pattern, feeding, roaming, reproduction, milking and parental care in captive and wild state in order to make *Nilgai* a domestic animal rather a crop pest.

ETHICAL APPROVAL

Animal Ethic committee approval has been collected and preserved by the author(s).

ACKNOWLEDGEMENTS

Author wish to express his gratitude to Associate Dean-cum-Principal, Veer Kunwar Singh College of Agriculture (BAU, Sabour), Dumraon, Buxar (Bihar) for encouragements and Co-operation in implementing the serving work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:

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