BJNRD (2022), 9(2): 27-35
Bhutan Journal of Natural Resources & Development

Article

www.bjnrd.org

Open Access

ISSN 2409–2797 (Print)
ISSN 2409–5273 (Online)

DOI: https://doi.org/10.17102/cnr.2022.77

Analysis of Physical and Chemical Properties of Natural Salt Licks and Determination of Animal Presence

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Abstract

Natural salt licks are deposits of salt that are found in the wild. They can have a variety of physical and chemical properties depending on their location and minerals that they contain. Some common physical properties of natural salt licks include their size, shape, color, and texture. This study was conducted to analyze physical and chemical properties of natural salt licks and determine presence of animals on and around the natural salt lick sites. Soil samples from 10 lick sites were collected and analyzed. A total of 10 Reconyx cameras were deployed across 10 lick sites for documentation of wild animals. Most lick areas were found to be sandy, clayey, and silty in texture with high pH (mean = 7.94, *SD* = 1.05) and electrical conductivity (mean = 7.24, *SD* = 0.98). Chemical analysis indicated that the natural salt licks had higher concentrations (mg/100g) of sodium, potassium, magnesium and calcium. The total sampling effort of 300 camera trap days yielded 289 independent events in 30 days covering elevation ranging from 1000 to 3000 metre above sea level. The most commonly photographed species were barking deer, Assamese macaque and Himalayan serow.

Keywords: Abundance, frequency, geophagy, keystone, nutrients

Introduction

It is typical for many wild animals, particularly herbivores, to consume soil and drink water from salt-rich sites (Dudley *et al.,* 2012). This behavior is most readily observed in herbivores such as ungulates and primates. The cause of this behavior is due to lack of essential nutrients in their daily diet of plant tissues (Panichev *et al.,* 2012). So, wild animals ingest soil to obtain necessary elements to compensate for nutritional deficiencies in their diet (Atwood and Weeks, 2002). This behaviour of soil ingestion by wild animals especially by herbivores is called geophagy (Ajay *et al.*, 2020).

Wild animals ingest soils from areas that are rich in sodium content. These sites are called natural salt licks (Fraser *et al.,* 1980).

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Received: August 22, 2022
Accepted: December 22, 2022
Published online: December 30, 2022
Editor: DB Gurung, College of Natural Resources, Lobesa

Natural salt licks are rich in essential minerals, and are frequently used by herbivores for licking minerals (Rea *et al.*, 2004). It is also defined as mineral reservoir visited by various wildlife species to regulate the concentration of salt and other essential elements such as zinc, magnesium, sodium, and calcium in their bodies (Razali *et al.,* 2020). This geophagic behaviour has numerous functions and benefits which include mineral supplementation, detoxification of plant secondary metabolites, and alleviation of digestive disorders (Tobler *et al.*, 2009). Health of animals exhibiting geophagic behaviors is dependent on minerals obtained from salt lick sites (Blake *et al.,* 2010). Studies regarding species usage of natural salt licks across diverse habitats are reported from many parts of the world (King *et al.*, 2016) and these studies stress geophagy as nutritional ecology.

Since salt is deficient in herbivorous diet, wild animals get salt (Sodium chloride) from natural salt licks (Ayotte *et al.,* 2006). Recent studies have shown that essential elements such as sodium, calcium, magnesium, and potassium are found in high concentrations in lick sites (Sitienei *et al.,* 2012). Dudley *et al.* (2012) emphasized that natural salt licks are an important source of sodium since this mineral is not naturally accumulated in terrestrial plants to meet the animal's demand especially in areas far from ocean. Natural salt licks are also important sources of other essential minerals such as magnesium, calcium and iodine (Elyau *et al.,* 2012).

Natural salt lick sites are considered as the keystone resources – resources that are critical and limited yet crucial for wildlife (Primack, 1993). Montenegro (2004) suggested that the natural salt licks have a significant influence on the density and structure of population, distribution of wildlife, and carrying capacity of habitats. Salt licks are widely recognized to attract a large number of wild animal species and can be considered as hotspots of their own (Blake *et al.,* 2011). The natural salt lick sites are important habitat features that are essential in retaining a healthy wildlife population (Montenegro, 2004). As carnivores can ambush prey species concentrated in a single hotspot, natural salt licks are also essential to the survival of carnivores.

Given the significance of natural salt licks to wild animals especially to herbivores, there is a need for extensive study and documentation of salt lick sites. The need to analyze physical and chemical composition of the soils from salt lick sites is equally important in defining conservation strategies. There is also a need to document wild animal species that utilize lick sites. Accordingly, this research focuses on the hypothesis that sodium chloride is the main nutrient that wild animals are attracted to in natural salt lick sites. Therefore, soil samples from identified lick sites were analyzed in terms of nutrient content to verify this hypothesis. Moreover, wild animals using natural lick sites were identified using camera traps and sign surveys.

Materials and Methods

Study area

This study was conducted primarily in Geling and Meadtakha *Gewogs* (sub-districts) of Chhukha *Dzongkhag* (district). Altitude of the study areas ranges from 700 to 3,000 metre above sea level (m asl). The area falls in the warm broadleaved forest experiencing hot and humid monsoon season and brief dry and warm winter months. Soil found here is mainly sandy loam and clayey types (Baillie *et al*., 2003). The average monthly temperature varies from 15-25 °C in winter to 27-45 °C during summer months. The annual average rainfall varies from 3,000 to 4,000 mm (National Center for climatology and hydrology, 2020).

A total of 10 salt licks sites (Table 1) were identified and documented with help of local people and forest officials. The study area covers elevation from about 1,000 m to 3,000 m asl. At each site, one Reconyx camera was set up to identify wild animals visiting the site.

Soil physiochemical analysis

Soil samples from the lick sites were collected

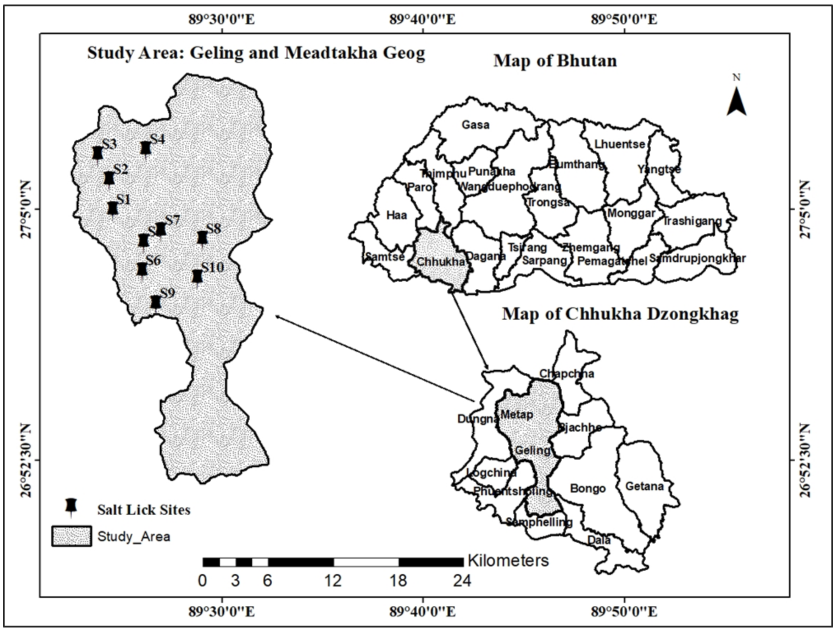

Figure 1: Map of the study area

in air-tight plastic bags after removing about 5 cm of surface soil. This was done to remove organic materials present on the surface of topsoil. Four mineral samples were collected from each site. These samples are mixed to form a composite sample per site. The samples were air-dried at room temperature for one week, crushed, and sieved to remove rock debris (Ajayi *et al.*, 2020). Physical properties such as soil texture, pH, and electrical conductivity were analyzed. Soil texture analysis was done using a soil hydrometre or by pipette method (Ayotte *et al.,* 2006).

Electrical conductivity was measured using an EC metre. Likewise, soil pH was determined with the help of a potentiometre in a volumetric 1:1 soil: water suspension. The soil samples were analyzed for the following nutrient contents: total nitrogen, available phosphorus, calcium, potassium, magnesium, and sodium. The available phosphorus was determined by the Bray II method (Norris, 2008). Total Nitrogen was determined by the Micro-Kjeldahl method. The exchangeable Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+} were extracted using ammonium acetate method (Klein *et al.*, 2008). The soil samples were analyzed either in the laboratory of the College of Natural Resources or in the National Soil Service Center at Simtokha.

Camera trapping

Reconyx PC85 Rapid Fire camera traps were used to capture the photographs of wild animals visiting the mineral lick sites. In each site, a camera was placed at the edge. These cameras are triggered by Integrated Passive InfraRed (PIR) motion detectors (with 'high' sensitivity) and were set up to record three pictures per trigger, with a 5-second pause between pictures. There was no delay between trigger events. Animals visiting sites were then identified from the photographs. Cameras were active from 1st February to 10th March 2021. The total survey effort was 300 camera trap days – CTDs (Jokinen *et al.*, 2017).

Camera trap data management and analysis

Time interval of one hour was used to treat image as an independent event. The total collection effort or CTDs, capture frequency (CF) and the Relative Abundance Index (RAI) were calculated by using formulae provided below; and the camera trap images were managed and analyzed using Renamer software.

$$\text{CTDs} = \text{No. of cameras used x No. of days those cameras were operational in field}$$

$$\text{CF} = \frac{\text{Total numbers of photos of individual species}}{\text{Total collection effort}} \text{x } 100\%$$

$$\text{RAI} = \frac{\text{Total Number of Independent Event}}{\text{Total Collection Efforts}} \times 100$$

Results and Discussion

Physical properties

Most of the natural salt licks in this area have clayey and sandy soil texture. From 10 lick sites studied, 5 sites have sandy soil texture, 4 sites clayey texture, and 1 site has silty texture. The texture of individual samples from salt licks studied by Montenegro (2004) in Yavari-Miri River valley in the northeastern Peruvian Amazon varied from loam to sandy loam, silt loam and clay loam texture. The soil samples from lick sites studied by Young *et al.* (2009) in Zanzibar archipelago, Tanzania were also found to be rich in clay. The soil texture of lick sites in the current study was similar to natural salt licks studied by Chandrajith *et al.* (2009) in Udawalawe National Park, Sri Lanka and Jokinen *et al.* (2017) in southwest Alberta Canada.

The pH of the soil varies from a minimum of 6.40 to a maximum of 9.87. The sites have neutral to slightly basic pH (mean = 7.94 ± 1.05 *SD*). The lowest value of conductivity was 5.29 µs/cm and the highest was 9.06 µs/cm with a mean of 7.24 ± 0.98 *SD* (Table 2). Such high electrical conductivity is recorded in study conducted by Sitienei *et al.* (2012) indicating high amounts of dissolved salts (Mohammed *et al.*, 2016).

Table 1: Physical properties of salt licks

Site ID	Soil Texture	pH	Electrical Conductivity(µs/cm)
S1	Clay	8.1	5.29
S2	Sandy loam	7.5	6.25
S3	Clay	6.4	7.47
S4	Sandy clay	8.71	8.18
S5	Sandy	7.21	7.04
S6	Clay	8.89	6.29
S7	Silty clay	7.39	7.7
S8	Sandy loam	6.9	7.13
S9	Sandy	9.87	6.09
S10	Clay loam	8.41	9.06
	Mean ± SD	7.94 ± 1.05	7.25 ± 0.98

Chemical properties

Chemical analysis indicated that the soil samples from natural salt licks had higher concentrations of sodium (mean = 4.66 mg/100g ± 1.95 *SD*), potassium (mean = 4.19 mg/100g ± 1.74 *SD*), magnesium (mean = 3.87 mg/100g ± 1.13 *SD*), and calcium (mean = 3.29 mg/100g ± 2.49 *SD*) compared to nitrogen (mean = 0.09 mg/100g ± 0.03 *SD*) and phosphorus (mean = 1.73 mg/100g ± 0.72 *SD*) (Table 3).

High presence of elements such as magnesi-

Table 2: Composition and concentration (mg/100g) of minerals in saltlicks

	Major Elements(mg/100g)			Cation Exchange Complex (mg/100g)		
Site ID	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium	Sodium
S1	0.08	1.02	4.6	1.19	4.45	4.56
S2	0.05	2.34	5.11	7.55	3.27	5.07
S3	0.05	3.36	7.26	4.77	4.21	1.55
S4	0.05	1.96	5.73	4.42	5.11	4.47
S5	0.09	1.04	2.97	0.43	3.15	2.76
S6	0.14	1.86	5.509	2.03	2.13	5.31
S7	0.13	1.1	3.206	6.8	4.68	2.68
S8	0.09	1.56	2.27	1.85	2.6	8.3
S9	0.14	1.28	3.45	2.85	3.45	5.96
S10	0.12	1.76	1.76	0.98	5.67	5.93
Mean ± SD	0.09 ± .03	1.73 ± .72	4.19 ± 1.74	3.29 ± 2.49	3.87 ± 1.13	4.66 ± 1.95

um or calcium suggests that there may be multiple reasons for the use of licks, not just for sodium supplementation (Mills and Milewski, 2007). The variation in the composition of lick soils across studies suggests that different licks serve different roles (Abbo *et al.*, 2012). High concentrations of magnesium were noted in the soil samples from natural salt licks in the Yavari region, and it is also common in salt licks across North America (Ayotte *et al.,* 2006).

The concentration of sodium, potassium and calcium were found in higher concentrations from salt licks in the current study compared to those documented by Thinley *et al*. (2020) from salt lick sites in Jomotsangkha Wildlife Sanctuary, Bhutan. The concentration of nitrogen, phosphorus, and magnesium were found in lesser quantities compared to those recorded by Abbo *et al.* (2012) from salt licks in Darfour and Northern Kurdufa. In this study, sodium, potassium, magnesium and calcium were in sufficiently high concentration compared to nitrogen and phosphorus. This can be interpreted as wild animals especially ungulates ingesting more concentrations of sodium, potassium, magnesium and calcium compared to phosphorus and nitrogen from lick areas (Figure 2). The difference in concentration may be due to different geographic locations and geological formations.

Analysis of elements found that calcium and potassium are higher in concentration in this study compared to those reported by Ayotte *et al.* (2006) from high-use lick sites in British Columbia. Calcium and sodium are found in almost equal quantities as reported by Elyau *et al.* (2012).

Wild animal species composition

The 10 Reconyx cameras gave a total sampling effort of 300 Camera trap days with 289 independent events in 30 days. Over 1,408 photos of wild animals consisting of 4 orders, 9 families, and 10 species were recorded at the salt lick sites (Table 4). Herbivores including a few omnivores were found frequently visiting the salt lick sites. Cervidae (47.3%, n = 666) was the most dominant family followed by Cercopithe-

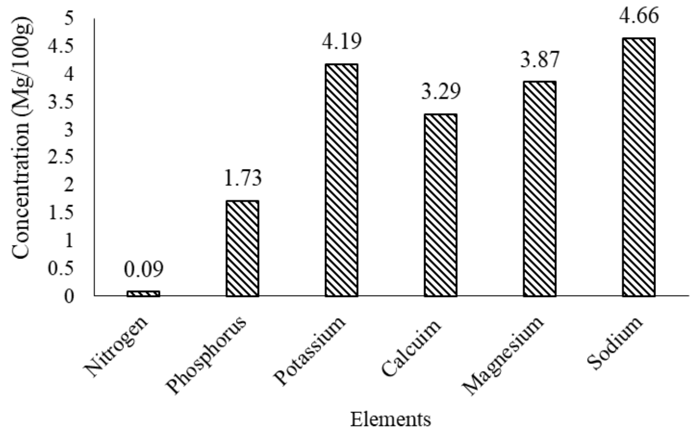

Figure 2: Bar graph representing concentration of different minerals in lick soil (all sites)

Table 4: Capture frequency of individual Species

Sl.	Common name	No of photos	CTDs	Capture frequency (%)
1	Himalayan Black Bear	87	300	29
2	Assamese Macaque	234	300	78
3	Hairy Footed Flying Squirrel	120	300	40
4	Himalayan Serow	226	300	75.3
5	Himalayan Goral	80	300	26.67
6	Barking Deer	250	300	83.3
7	Sambar Deer	190	300	63.3
8	Wild Boar	185	300	61.7
9	Yellow Throated Marten	17	300	5.67
10	Asiatic Golden Cat	19	300	6.3

cidae (16.62%, n = 234), and Suidae (13.4%, n = 185). Mustelidae (1.2%, n = 17) and Felidae (1.35%, n = 19) were the least encountered species at the lick sites. This indicates that the salt licks are used mostly by herbivore species. Figure 4 shows different wild animals licking soil at the lick sites.

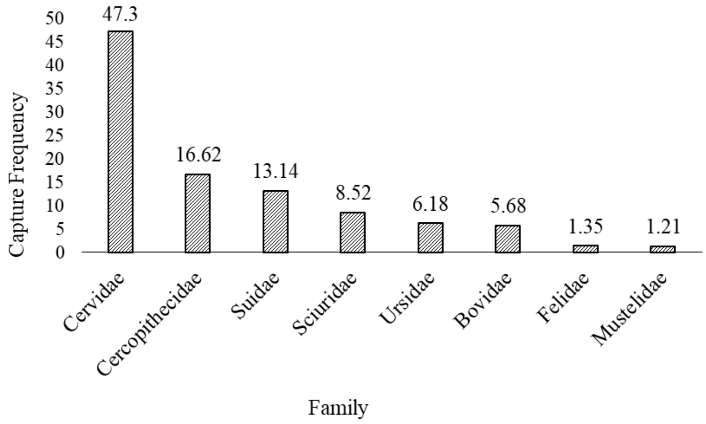

Figure 3: Capture frequency of different families

Capture frequency

Barking deer (21.45%, n = 62) followed by Assamese macaque (20.42%, n = 59), Himalayan serow (17.99%, n = 52) were the most frequently encountered wild animals at the lick sites. Asiatic golden cat (1.384%, n = 4) and Yellow throated marten (1.038%, n = 3) were the least encountered species (Table 5). Thinley *et al*. (2020) recorded 10 families consisting of 12 species with Bovidae, Cervidae, Cercopithecoidea, and Elephantidae at the saltlicks in Jomotsangkha Wildlife Sanctuary, Bhutan. They also reported that Sambar deer was the most common species captured at the lick sites.

In the current study, a total of 9 families and 10 species were recorded at the lick sites. A similar study by King *et al.* (2016) in northeastern Cambodia recorded nine species of mammals and three species of birds. Only six (Red-shanked douc, Annamese silvered langur, Malayan porcupine, Indian muntjac, Sambar, and Gaur) from the nine species of mammals visiting the sites were licking soils at the lick sites. The Indian muntjac and Sambar were also recorded in their study. Thinley *et al.* (2020) noted that there is a high preference of saltlicks by herbivores. This study also recorded a similar preference of salt licks by herbivores (Figure 3).

Relative abundance index

Among the species captured at the lick sites, Barking deer was the most abundant species (RAI = 20.67) followed by Assamese macaque (RAI = 19.67) and Himalayan serow (RAI = 17.33). Yellow-throated marten was captured less at the lick sites (RAI = 1). Likewise, Asiatic golden cat (RAI = 1.33) and Himalayan black bear (RAI = 3.33) were among the less spotted animals at the natural salt lick sites (Table 6).

Zangmo *et al.* (2018) stated that there is a high occurrence of Gaur near salt lick sites.

Table 5: Relative abundance index of individual species

Common name	Independent Event	Sampling Effort	RAI
Himalayan Black Bear	10	300	3.33
Assamese Macaque	59	300	19.67
Hairy Footed Flying Squirrel	13	300	4.33
Himalayan Serow	52	300	17.33
Himalayan Goral	16	300	5.33
Barking Deer	62	300	20.67
Sambar Deer	51	300	17
Wild Boar	19	300	6.33
Yellow Throated Marten	3	300	1
Asiatic Golden Cat	4	300	1.33

Similarly, there was high abundance of herbivores near the salt lick sites compared to carnivores and omnivores. King *et al.* (2016) also found that salt lick sites are most frequently visited by herbivores and frugivores. Presence of carnivores at the salt lick sites indicates that the sites are used by carnivores as hunting ground.

Conclusion

The natural salt lick sites are frequently visited by herbivores. There was high species capture rates at the lick sites. The salt licks are also visited by carnivores mainly to hunt preys. Therefore, salt licks are keystone resources for wild animals especially for ungulates.

Considering such importance of the natural salt licks, efforts must be made to document such salt lick sites throughout the forest ecosystems of the country. Rules and regulations concerning its protection and management could be framed. Management of salt lick sites should also be included in conservation and management plans of protected areas and biological corridors. However, there is a high probability that these lick sites could be used by poachers to hunt wild animals. Therefore, if possible, such areas should be monitored frequently using camera traps for detecting illegal activities at the sites.

Acknowledgements

We sincerely thank the officials of the Nature Conservation Division, Department of Forest and Park Services, and Jigme Dorji National Park for kindly lending us camera traps for the study. Without their support, this research would not have been materialized. We are grateful to the officials of the National Soil Service Centre for extending their support in-soil analysis and laboratory facilities. Finally, we extend our sincere thanks to UNESCO Madanjeet Singh Centre for South Asia Forestry Studies (UMCSAFS) for funding the project.

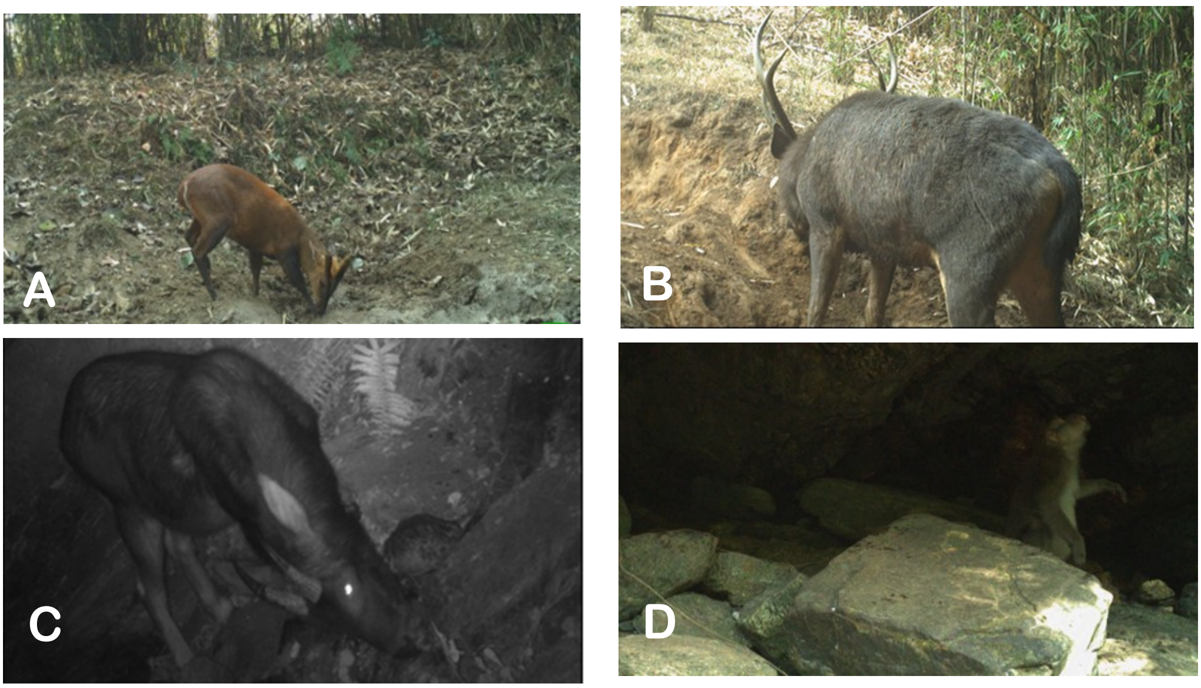

Figure 4: Various types of animals visiting the salt lick sites; Barking deer [A], Sambar deer [B], Himalayan Serow, and Assamese macaque [D]

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