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Haematology, serum biochemistry and mineral profiles of Trinket cattle, an endangered feral cattle associated with the colonial history of Nicobar

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ABSTRACT

Trinket cattle is a highly endangered feral cattle of Trinket Island, linked with the colonial history of Andaman and Nicobar Islands. Danish people during their colonial time introduced these cattle in Trinket Island. Great Sumatra earthquake and Indian Ocean Tsunami in 2004 has forced these cattle to become feral in nature. Due to negligence, the cattle is at the brink of extinction and only around 150 of descendants of the cattle are reported. In the present study, the haematology, serum biochemistry and mineral profiles of Trinket cattle were evaluated. Study indicated that all the values were under the normal physiological range. These findings of this study may serve as reference values in which alterations due to metabolic, nutrient deficiency, physiological and health status can be compared for diagnostic and therapeutic purpose.

Keywords: Haematology, Mineral profiles, Nicobar, Serum biochemistry, Trinket cattle

Trinket cattle (Fig. 1), a group of feral cattle, are found in Trinket Island, a small island under Nicobar group of islands. This cattle is associated with the colonial history of Andaman and Nicobar islands. Historical documents suggest that Nicobar islands were under the control of Danish from 1756 to 1768 and during their colonization period, they introduced these cattle to Trinket island for milk purpose (Kloss 1903). At the end of Danish colonization, the aboriginal tribes used to look after the cattle. On 26th December 2004, Andaman and Nicobar Islands were hit by devastating Great Sumatra earthquake and Indian Ocean Tsunami, and Trinket Island was one of the worst affected islands. After that, the tribes deserted Trinket Island and Trinket cattle became feral in nature. These cattle population is highly endangered in nature and currently existence of only 150 cattle has been reported (De *et al.* 2019). In the present study, we have evaluated the haematological, serum biochemical and mineral profiles of Trinket cattle.

Importance of determining the biochemical and haematological indices of domestic livestock species have been well acknowledged and documented (Opara *et al.* 2006). Hematological as well as biochemical values can provide the strong valuable baseline information which inturn helps to assess the realistic evaluation of managemental practices, physiological and nutritional status of the animals, and also help to diagnose and asses the health condition or status (Radostits *et al.* 2006, Jezek *et al.* 2006, Mir *et al.* 2008). Metabolic disorders, nutritional deficiencies and prevalence of the diseases can be easily detected by proper analysis as well as monitoring of blood and other body fluids (Otto *et al.* 1992). However, this requires for the establishment of normal reference values for the particular species. Pathological values are defined as those values deviating from the normal standard reference values (Radostits *et al.* 2006). Evaluation, analysis and interpretation of the obtained results mainly depend on the standard reference values for different species of the animals in different regions as well as under existing environmental or climatic conditions. Since the Trinket bovine species used in the present study did not show any significant clinical signs and/or pathological symptoms, therefore they were believed as healthy animals and the result or data observed can serve as standard reference values for these animals in future in veterinary science and animal husbandry (Kaneko *et al.* 1997). There is paucity of literature or information for Trinket cattle on hematological and serum biochemical values in Andaman and Nicobar Islands of India. To the best of our knowledge and based on the availability of the literature, this study is to be the first report on normal hematological and serum biochemical indices in Trinket cattle in India. The present investigation describes about the composition of blood, biochemical profiles and serum mineral attributes of the relatively genetically pure germplasm of Trinket cattle of Andaman and Nicobar

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Fig. 1. Trinket cattle of Trinket Island.

Islands. The data was given in the present communication can serve as the standard reference values for Trinket cattle grown in the Trinket Island and other islands having similar climatic and nutritional conditions.

MATERIALS AND METHODS

Study area: Trinket island (8.08°N 93.58°E), situated in Indian Ocean, is one member of Nicobar archipelago (Fig. 2). It is a very small island with area of 12.25 km^2. Currently, the island is left abandoned and no human population has been reported. With the permission from Tribal Council, Nicobar, Scientists from ICAR-CIARI, Port Blair along with aboriginal tribes visited the island in 2018.

Collection of samples: Three clinically healthy cattle were captured by the aboriginal Nicobari tribes. Blood samples were collected into heparinised vacutainer following standard aseptic measures.

Measurement of haematological, biochemical parameters and mineral profiles: Haematological parameters of Trinket cattle such as total white blood cell (TWBC), neutrophil, eosinophil, monocyte, lymphocyte, total red blood cells (TRBC), haemoglobin (HGB), haematocrit, mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC) and platelet were measured in a automatic Haematology Analyser, (Prokan, India).

Serum profile of total protein, albumin, globulin, glucose, urea, aspartate aminotransferase /serum glutamic oxaloacetic transaminase (AST/SGOT), alanine aminotransferase/serum glutamic pyruvic transaminase (ALT/SGPT) and alkaline phosphatase (ALP) was done using commercially available kits (TBL, Solan, India) in a automated clinical chemistry analyser (Transasia Biomedical Limited, India).

Serum concentration of sodium, potassium, calcium, phosphorus, magnesium, iron and cobalt was estimated in an atomic absorption flame emission spectrophotometer (Shimadzu Analytical Pvt. Ltd., India) using standard methodologies.

Statistical analysis: Data were analysed for mean values and standard errors using standard statistical methods (Snedecor and Cochran 1989).

RESULTS AND DISCUSSION

Trinket cattle are highly endangered cattle breed of Nicobar. These animals after Tsunami have survived against environmental challenge which brings the greater possibility that; specific adaptive traits have evolved to survive in this island ecosystem. Metabolic, nutritional, health as well as physiological status of animal can be determined by analysis, evaluation and monitoring the blood and other bio-fluids by the use of the different clinical pathological and also with chemistry procedures (Bogin 1994, Kaneko *et al.* 1997). Pathologic values are defined as the values that are deviated from the standard normal references values (Kaneko *et al.* 1997), for that, it is required to establish the normal reference values for different heamatological and biochemical indices. In the present study, the animals used were almost healthy by observation, palpation and percussion, and did not reveal any abnormal clinical signs and/or pathological conditions. Therefore, these can be considered as healthy animals and the hematological as well as the biochemical profiles of these animals can work as the standard reference values for the Trinket cattle for future use in Andaman and Nicobar Islands or having similar nutritional, climatic or environmental conditions in other countries. These established standard values will serve as reference values which will be helpful to estimate the health status of these precious germplasm of Trinket cattle in any future studies related to this bovine species. However, the final interpretation of obtained results by laboratory analysis will depend on the standard reference values of each and every species of animal in different geographical as well as the environmental conditions.

Biochemical reports to the different physiological stages are very complex as these values are influenced by many different factors like species, breed, age, sex, nutrition, physiological status such as pregnancy and lactation, illness and also the seasonal variations (Kaneko *et al.* 1997, Whitaker 1997). The reports of the biochemical investigations has shown the highest deviations in total serum protein, urea, sodium and potassium concentrations which inturn can be influenced by various factors like nutrition, health status, lactation stage and season (Jezek *et al.* 2013).

Haematological values in terms of leukocytic parameters, erythrocytic parameters and thrombocytic parameters are given in Table 1. All the haematological parameters were within the normal physiological range of cattle as depicted in Merck's Veterinary Manual. Study on the blood composition can address the valuable information about the general health of the animal and so that, this can be utilized to evaluate the health status of the animal. Deviation of values in certain blood parameters from their normal ranges could be a very good guide to make diagnosis or for differential diagnosis of a particular disease or pathological condition (Radostits *et al.* 2006). Haematological profile or complete blood count (CBC) is being very essential in evaluation of the animal health status as well as the

Table 1. Haematological parameters of Trinket cattle

Blood parameter (unit)	Value (Mean±SE)	Merck's Veterinary Manual (Range)	Similar to the present study	Higher than the present study	Lower than the present study
TWBC (10^3/μL)	10.44±0.40	4–12	–	Sripad *et al.* 2014	Mahima *et al.* 2013 Bedenicki *et al.* 2014 Manjappa *et al.* 2018 Suharti *et al.* 2017
Neutrophil (%)	27.56±0.45	15–45	Bedenicki *et al.* 2014 Manjappa *et al.* 2018 Sripad *et al.* 2014	Mahima *et al.* 2013	
Eosinophil (%)	5.88±0.05	2–20	Manjappa *et al.* 2018 Sripad *et al.* 2014	Mahima *et al.* 2013	Bedenicki *et al.* 2014
Monocyte (%)	1.64±0.04	2–7	Sripad *et al.* 2014	Mahima *et al.* 2013 Manjappa *et al.* 2018	Bedenicki *et al.* 2014
Lymphocyte (%)	63.27±0.37	45–75	Bedenicki *et al.* 2014 Sripad *et al.* 2014	–	Mahima *et al.* 2013 Manjappa *et al.* 2018
TRBC (10^6/ μL)	7.71±0.09	5–10	Sripad *et al.* 2014	–	Mahima *et al.* 2013 Bedenicki *et al.* 2014 Manjappa *et al.* 2018 Suharti *et al.* 2017
HGB (g/dL)	12.51±0.26	8–15	Bedenicki *et al.* 2014 Manjappa *et al.* 2018	–	Mahima *et al.* 2013 Bedenicki *et al.* 2014 Suharti *et al.* 2017 Sripad *et al.* 2014
Haematocrit (%)	34.19±0.35	24–46	Otto *et al.* 2000 Mahima *et al.* 2013 Manjappa *et al.* 2018 Sripad *et al.* 2014	–	Suharti *et al.* 2017
MCV (fl)	45.97±0.52	40–60	Mahima *et al.* 2013 Manjappa *et al.* 2018 Sripad *et al.* 2014	Suharti *et al.* 2017	Bedenicki *et al.* 2014
MCH (pg)	16.55±0.22	11–17	Mahima *et al.* 2013 Manjappa *et al.* 2018	Sripad *et al.* 2014	Suharti *et al.* 2017
MCHC (g/dl)	36.19±0.13	30–36	Manjappa *et al.* 2018 Suharti *et al.* 2017	–	–
Platelet (10^3/μL)	268.00±1.52	100–800	–	–	–

laboratory data clinical interpretation which is a prerequisite for proper diagnosis for different patho-physiological as well as infectious disorders in the Trinket cattle (Opera *et al.* 2006). Moreover, the CBC is an important as well as the powerful diagnostic tool in the component of a minimum database for disease diagnosis. It can also be used to monitor or watch the response to treatment or therapy, to follow up the severity of a disease or illness or used as a starting point to formulate a list of differential diagnosis. Interpretation of the CBC can be grouped into three divisions as erythrocyte, leukocyte and platelets evaluation. Each of these divisions can be interpreted separately and individually, and integration of these divisions is very much important to get highest diagnostic yield or result (Barger 2003). Heamatological examination is also done as a routine screening procedure for assessment of general health (Gutienez De Lar *et al.* 1971). Blood values are also clear indicators to assess the stress and welfare of animals (Anderson *et al.* 1999).

Knowledge on the hematological values is very much useful to diagnose the different pathological as well as the metabolic disorders, which adversely or deleteriously affect the reproductive and productive performance of the cows (Ahmad *et al.* 2003). Therefore, these hematological data can help to a large extent to determine the disease course and their outcome of several viral, bacterial and parasitic diseases (Swenson 1977). Factors such as breed, sex, age, seasonal variation, pregnancy, lactation, nutritional and health status of the animal alter hematological attributes (Mirzadeh *et al.* 2010).

The serum biochemical parameters of Trinket cattle are given in Table 2. Total serum protein concentration was 7.490±0.1442 g/dL (7.21 g/dL–7.69 g/dL). Concentration of serum albumin and globulin was 3.48±0.13 g/dL and 4.23±0.07 g/dL respectively. Serum concentration of glucose, urea, SGOT, SGPT and ALP was 63.59±2.58 mg/dL, 31.75±1.43 mg/dL, 88.85±2.22 IU/L, 28.70±1.11 IU/L and 101.60±2.25 IU/L respectively.

Concentration of minerals in serum of Trinket cattle is given in Table 3. Sodium and potassium concentration were 142.20±1.89 mmol/L and 5.68±0.34 mmol/L, respectively. Calcium and phosphorus concentration were 10.78±0.32 mg/dL and 6.29±0.14 mg/dL, respectively. Magnesium, iron and cobalt concentrations were 2.71±0.10 mg/dL, 1.77±0.33 mg/L and 50.10±2.30 µg/L, respectively. ALP is an enzyme synthesized and secreted in the liver, bone and also in placenta. It is available normally in bile fluid and growing bone in higher concentrations. It is secreted into the main blood stream at the time of injury or during the activities such as bone growth as well as pregnancy. Abnormally high concentration of ALP is observed in blood which may clearly indicate the diseased status of the liver or bone or bile duct obstruction or may be certain malignancies. And also a significant decrease of ALP activity with increased rectal temperature is in calves which have been exposed to heat (O'kelly 1973).

Basically AST transfers the amino group to α-ketoglutaric acid from aspartate to form glutamate and oxaloacetate. In bovine, ovine and caprine, the AST enzymes are present in several different tissues, mainly in liver, striated and cardiac muscle, thus it is a good bio-marker or indicator of the soft tissue damage (Otto *et al.* 2000). Jenkins *et al.* (1982) revealed the normal concentrations of this enzyme in young calves as well as the adult mature bovines. Similarly, the ALT catalyzes the two parts of the alanine cycle. It is also found in liver, plasma as well as in the various body tissues with higher level in the liver. Serum ALT concentration or serum AST level and/or their ratio (AST/ALT ratio) are normally estimated clinically as biomarkers to assess the liver health. Similarly, Piccioni *et al.* (2010) observed a

Table 2. Serum biochemistry of Trinket cattle

Biochemical parameter (unit)	Value (Mean±SE)	Merck's veterinary manual (Range)	Similar to the present study	Higher than the present study	Lower than the present study
Total protein (g/dL)	7.49±0.24	6.5–7.5	Otto *et al.* 2000 Surya Prakash *et al.* 2018	Xuan *et al.* 2018 Mamun *et al.* 2013 Suharti *et al.* 2017	Mahima *et al.* 2013
Albumin (g/dL)	3.48±0.22	2.5–3.8	Otto *et al.* 2000 Mahima *et al.* 2013 Mamun *et al.* 2013	Xuan *et al.* 2018	Surya Prakash *et al.* 2018 Suharti *et al.* 2017
Globulin (g/dL)	4.23±0.11	3.0–3.5	Otto *et al.* 2000 Xuan *et al.* 2018	–	Mahima *et al.* 2013
Glucose (mg/dL)	63.69±4.47	40–100	Otto *et al.* 2000 Mamun *et al.* 2013	–	Surya Prakash *et al.* 2018 Suharti *et al.* 2017
Urea (mg/dL)	31.75±1.43	10–25	Otto *et al.* 2000 Mahima *et al.* 2013	Xuan *et al.* 2018 Bedenicki *et al.* 2014	Suharti *et al.* 2017
AST/SGOT (IU/L)	88.85±2.22	60–125	Otto *et al.* 2000	Mamun *et al.* 2013	Mahima *et al.* 2013 Xuan *et al.* 2018 Bedenicki *et al.* 2014
ALT/SGPT (IU/L)	28.70±1.11	6.9–35	Mahima *et al.* 2013	Otto *et al.* 2000 Mamun *et al.* 2013	Xuan *et al.* 2018 Bedenicki *et al.* 2014
ALP (IU/L)	101.60±2.25	18–153	–	Otto *et al.* 2000 Mamun *et al.* 2013	Bedenicki *et al.* 2014

Table 3. Serum mineral profile of Trinket cattle

Biochemical parameter (unit)	Value (Mean±SE)	Merck's veterinary manual (Range)	Similar to the present study	Higher than the present study	Lower than the present study
Sodium (mmol/L)	142.20±3.28	136–144	Otto *et al.* 2000	–	–
Potassium (mmol/L)	5.67±0.58	3.6–4.9	Otto *et al.* 2000	–	–
Calcium (mg/dL)	10.78±0.55	8.0–11.4	Otto *et al.* 2000 Bedenicki *et al.* 2014	–	Mahima *et al.* 2013 Mamun *et al.* 2013
Phosphorous (mg/dL)	6.29±0.24	5.6–8.0	Mahima *et al.* 2013 Bedenicki *et al.* 2014	–	Mamun *et al.* 2013
Mg (mg/dL)	2.70±0.16	1.50–2.90	Mahima *et al.* 2013 Mamun *et al.* 2013	–	–
Iron (mg/L)	1.76±0.05	–	–	–	–
Cobalt (µg/L)	50.10±3.98	–	–	–	–

significant effect of days of life on SGOT levels but not on SGPT during the first week or first month of life.

Liver enzymes such as ALP, AST/SGOT and ALT/SGPT are measured in serum and commonly routinely used as biomarkers of reliable or suitable hepatic diagnostic purpose (Quintela *et al.* 2011, Jeong *et al.* 2013) in all different animal species includes sheep and goats (Tibbo *et al.* 2008) and cattle (Quintela *et al.* 2011, Noro *et al.* 2013). It is also observed that normal range of these liver specific enzymes is influenced by various internal as well as the external factors like age of the animals and lactation stage (Otto *et al.* 2000), nutrition, season and managemental practices (Quintela *et al.* 2011) and sex of the animals (Tibbo *et al.* 2008). The reference values of Trinket cattle showed higher blood levels of the enzymes ALT, AST and ALP than with other cattle, which clearly indicate that the more active muscle mass in Trinket cattle resulting from a greater as well as more active grazing and search for feed (Bogin *et al.* 1988).

The increased activities of AST and ALT in serum/plasma is mainly due to the leakage of these enzymes in heat stressed animals from liver cytosol into blood stream, which clearly indicates the liver damage and normal liver functions disruption (Shakoori *et al.* 1994). The enzyme levels of AST and ALT are dependent on the amino acid groups of alanine and glutamine which are taken up by the liver and indicate the changes in the liver metabolism which is associated with glucose synthesis (El-Maghawry *et al.* 2000).

Blood glucose concentration is one of the biochemical profiles from which one may get body energy supply. Serum protein concentration suggests the balance between catabolism and anabolism of protein in the body and its concentration at any given time which in-turn is a function of nutritional status, hormonal balance, water balance and other parameters affecting health status (Samanta and Das 2007). Albumin is a transport protein which remains functioned in calcium, phosphorus, fat soluble vitamins, free fatty acids transport etc. Albumin indicates a long-term protein status and plasma albumin concentrations could be changed by effect of liver function, protein and energy intake, age and protein losses during some disease condition like parasitism. Plasma albumin concentrations are a indication of plasma protein levels. Physiological status or pathological status or lactation stage of the cows significantly can alter the serum levels of albumin (Otto *et al.* 2000). Moreover, the concentration of total protein, globulin, albumin and urea-N in blood serum are the biomarkers of the adequacy or inadequacy of nitrogen in the animal diet (Hammond 1983). In addition, serum proteins constitute a portion of the amino acid pool in the body and it is believed to be indicative of the nutritional status of the animal.

Most of the analyzed heamatological, biochemical and serum mineral profiles were within normal range, which clearly indicates that, the studied Trinket bovine populations were in healthy condition. Thus, during diagnostic procedure or measurement, it is very useful to compare the values obtained from ill or sick animals with normal reference values of healthy animal (Jezek *et al.* 2006). The values or findings of the present study may serve as the standard reference values in which deviations due to metabolic, nutrient deficiency, physiological and health status can be compared for diagnostic, prognostic and therapeutic purpose for Trinket cattle.

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REFERENCES

Ahmad I, Gohar A, Ahmad N and Ahmed M. 2003. Haematological profile in cyclic, non cyclic and endometritic cross-bred cattle. *International Journal of Agriculture and Biology* **5**: 332–34.

Anderson B H, Watson D L and Colditz I G. 1999. The effect of Dexamethasone on some immunological parameters in cattle. *Veterinary Research Communication* **23**: 399–413.

Barger A M. 2003. The complete blood cell count: a powerful diagnostic tool. *Veterinary Clinics of North America*: *Small Animal Practice* **33**: 1207–12.

Bedenicki M, Potocnjak D, Harapin I, Radisic B, Samardzija M, Kreszinger M, Zubcic D, Djuricic D and Bedrica L. 2014. Haematological and biochemical parameters in the blood of an indigenous Croatian breed – Istrian cattle. *Archiv Tierzucht* **57**(18): 1–7.

Bogin E. 1994. *Handbook for Veterinary Clinical Chemistry*. Kodak Publications, USA.

Bogin E, Seligman N G, Holtzer Z, Avidar Y and Baram M. 1988. Blood profile of healthy beef herd grazing seasonal Mediterranean range. *Zentralblatt für Veterinärmedizin Reihe A* 35: 270–276.

De A K, Muthiyan R, George Z, Ponraj P, Malakar D, Kundu A, Sunder J and Bhattacharya D. 2019. Complete mitochondrial genome of Trinket cattle, a Danish colonial leftover. *Mitochondrial DNA Part B* **4**: 2053–54.

El-Maghawry A M, Soliman M M, El-Sayiad G H A and Mahrose K H M. 2000. Effects of breed, season of kindling and pregnancy status on some blood measurements of doe rabbits raised in Egypt. *Egyptian Journal of Rabbit Science* **10**: 295–306.

Gutienez De Lar J H, Warnick A C, Cowley J J and Hentages J F. 1971. Environmental physiology in the subtropics. I. Effect of continuous environmental stress on some hematological values of beef cattle. *Journal of Animal Science* **32**: 968–73.

Hammond A C. 1983. The use of blood urea nitrogen concentration as an indicator of protein status in cattle. *Bovine Practice* **18**: 114–18.

Jenkins S J, Green S A and Clark P A. 1982. Clinical chemistry reference values of normal domestic animals in various age groups as determined on the ABA-100. *Cornell Veterinarian* **72**: 403–415.

Jeong S Ch, Kim S M, Jeong Y T and Song Ch H. 2013. Hepatoprotective effect of water extract from *Chrysanthemum indicum* L. flower. *Journal of Chinese Medicine* **8**: 7.

Jezek J, Klopcic M and Klinkon M. 2006. Influence of age on biochemical parameters in calves. *Bulletin of Veterinary Research Institute in Pulawy* **50**: 211–14.

Je•ek J, Stariè J, Nemec M and Klinkon M. 2013. Deviation of biochemical variables in dairy cows with reproductive disorders - Data Analysis. *Agriculturae Conspectus Scientificus* **78**: 267–69.

Kaneko J J, Harvey J W and Bruss M L (Eds). 1997. Clinical Biochemistry of Domestic Animals. Acad. Press, New York.

Kloss B C. 1903. In the Andamans and Nicobars. London, John Murray, Albemarle Street, London.

Mahima, Singh K V, Verma A K, Kumar V, Singh S K and Roy D. 2013. Hematological and serum biochemical profile of apparently healthy Hariana cattle heifers in Northern India. *Pakistan Journal of Biological Science* **16**(21): 1423–25.

Mamun M A, Hassan M M, Shaikat A H, Islam S K M A, Hoque M A, Uddin M and Hossain M B. 2013. Biochemical analysis of blood of native cattle in the hilly area of Bangladesh. *Bangladesh Journal of Veterinary Medicine* **11**(1): 51–56.

Manjappa K, Tejaswi V, Venkataramireddy B, Balachandar B, Lahari L and Prasad G. 2018. Assessment of hematological profile in Amrith Mahal breed of cattle. *International Journal of Livestock Research* **8**(8): 320–24.

Mir M R, Pampori Z A, Iqbal S, Bhat Z I A, Pal M A and Kirmani M A. 2008. Hemato-biochemical indices of crossbred cows during different stages of pregnancy. *International Journal of Dairy Science* **3**: 154–59.

Mirzadeh K H, Tabatabaei S, Bojarpour M and Mamoei M. 2010. Comparative study of hematological parameters according to strain, age, sex, physiological status and season in Iranian cattle. *Journal of Animal and Veterinary Advances* **9**(16): 2123–27.

Noro M, Cid P, Wagemann C, Arné V and Wittwer F. 2013. Valoración diagnóstica de enzimas hepaticas en perfiles bioquímicos sanguíneos de vacas de leche. *Revista MVZ Córdova* **18**(2): 3474–79.

Okelly J C. 1973. Plasma lipid changes in genetically different types of cattle during hyperthermia. *Comparative Biochemistry and Physiology-Part A Physiology* **44**: 313–20.

Opara M N, Ike K A and Okoli I C. 2006. Haematology and plasma biochemistry of the wild adult African grass cutter (*Thryonomys swinderianus*, Temminck). *Journal of American Science* **2**: 17–22.

Otto F, Ibanez A, Caballero B and Bogin E. 1992. Blood profile of Paraguayan cattle in relation to nutrition, metabolic state, management and race. *Israel Journal of Veterinary Medicine* **47**: 91–99.

Otto F, Vilela F, Harun M, Taylor G, Baggasse P and Bogin E. 2000. Biochemical blood profile of Angoni cattle in Mozambique. *Israel Journal of Veterinary Medicine* **55**(3): 1–9.

Piccioni G, Casella S, Pennisi P, Giannetto C, Costa A and Caola G. 2010. Monitoring of physiological and blood parameters during perinatal and neonatal period in calves. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia* **62**: 1–12.

Quintela L, Becerra J, Rey C, Díaz C, Cainzos J, Rivas F, Huanca W, Prieto A and Herradon P G. 2011. Perfiles metabolicos en preparto, parto y postparto en vacas de raza Rubia Gallega: estudio preliminar. *Recursos Rurais. Revista do IBADER* 7: 5–14.

Radostits O M, Gay C C, Hinchciliff K W and Constable P D. 2006. Veterinary Medicine. 10th Edn, Elsevier Science Ltd., USA.

Rowlands G J, Manston R, Pockock R M and Dews S M. 1975. Relationship between stage of lactation and pregnancy and blood composition in herds of dairy cows and the influence of seasonal changes in management on these relationships. *Journal of Dairy Research* **42**: 349–62.

Samanta A K and Dass R S. 2007. Effect of Vitamin E supplementation on growth, nutrient utilization, blood biochemical and enzymatic profile in male crossbred (*Bos indicus* × *Bos taurus*) calves. *International Journal of Cow Science* **3**(1&2): 34–43.

Shakoori A, Butt G, Riffat R and Aziz F. 1994. Hematological and biochemical effects of danitol administrated for two months on the blood and liver rabbits. *Zeitchrift Fuer Angewandte Zool* **80**: 156–80.

Sripad K, Kowalli S and Metri R. 2014. Hematological profile of Khillar breed of cattle in Karnataka. *Veterinary World* **7**(5): 311–14.

Suharti S, Khotijah L, Nasution A R, Warmadewi D A, Cakra G L O, Arman C and Wiryawan K G. 2017. Productive and reproductive performances and blood profile of Bali cows supplemented with calcium soap-soybean oil. *Pakistan Journal of Nutrition* **16**: 882–87.

Surya Prakash M, Pathan M M, Arya J S and Lunagariya P M. 2018. Assessment of glucose, total protein, albumin and cholesterol level and its correlation with milk production during different stages of lactation in indigenous and crossbred cows. *International Journal of Current Microbiology and Applied Science* **7**(04): 1248–56.

Tibbo M, Woldemeskel M, Aragaw K and Rege J E. 2008. Serum enzyme levels and influencing factors in three indigenous Ethiopian sheep breeds. *Journal of Comparative Clinical Pathology* **17**: 149–55.

Whitaker D A. 1997. Interpretation of metabolic profiles in dairy cows. *Cattle Practice* **5**: 57–60.

Xuan N H, Loc H T and Ngu N T. 2018. Blood biochemical profiles of Brahman crossbred cattle supplemented with different protein and energy sources. *Veterinary World* **11**(7): 1021–24.