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ORIGINAL ARTICLE

The influence of season and sex on rumen fluid and hematobiochemical constituents of Alpacas (*Vicugna pacos*) in Egypt

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Abstract

Alpaca (*Vicugna pacos*) is a South American camelid that was introduced recently to Egypt and considered a zoo animal in different country zoos. There are no available data regarding the normal values of rumen fluid and hematobiochemical constituents of alpacas bred in Egypt. The aim of this study was to estimate normal values for rumen fluid and blood constituents of alpaca and determine the influence of season and sex on these parameters under Egyptian circumstances. The study was conducted on seventeen (8 female and 9 male); 2–6 years apparently healthy alpacas. Rumen fluid and blood samples were taken from each animal (from August 2022 to February 2023) and divided into summer and winter samples. Rumen fluid constituents were influenced by seasonal changes and showed a significant ($p < 0.05$) increase in the total protozoal count in summer, while in winter, rumen fluid pH and ammonia values were significantly ($p < 0.05$) increased. For hematology, the effect of season was evident in the red blood cells count and packed cell volume, which increased significantly ($p < 0.05$) in winter. Regarding serum biochemistry, winter showed significant ($p < 0.05$) elevation in glucose, urea and magnesium levels, while summer had significantly ($p < 0.05$) increased chloride levels. The effect of sex was minimal, and only glucose and creatinine values showed significant ($p < 0.05$) increases in males compared to females. The effect of season was evident in rumen fluid, hematology and serum biochemical parameters of alpaca, while sex has minimal effect on these parameters. Rumen fluid and hematobiochemical constituent values of apparently healthy alpacas bred under Egyptian conditions were consistent with those in other countries, while slight differences were observed in total protozoal count and serum minerals. The data obtained in this study can be used as preliminary data for the rumen fluid and hematobiochemical constituents of alpacas kept under Egyptian circumstances.

Keywords Alpaca (*Vicugna pacos*) · Rumen fluid · Hematobiochemical constituents · Season · Sex

Introduction

Alpaca (*Vicugna pacos*) belongs to the family Camelidae, genus *Vicugna* and species *Vicugna pacos*. It is a South American camelid (SAC) that consists of four species: alpaca (*Vicugna pacos*), llama (*Lama glama*), vicuña (*Vicugna vicugna*) and guanaco (*Lama guanicoe*). Alpacas represent a very important part of the economy in South American countries, and they are used by native people who live in altiplano regions as food animals and in the wool fiber industry (Burton et al. 2003). They are kept in herds that graze at an altitude of 3500 to 5000 m above sea level; however, in recent decades, SACs were introduced to new countries at sea level in North America, Europe, Asia and Africa (Azwai et al. 2007; Liu et al. 2009). Although Egypt is not the natural habitat for alpacas, in recent years, the species gained wide popularity and their number increased significantly in different country zoos. There are many differences in geographical, nutritional, and climatic conditions in Egypt in comparison with those in South America, North America and Europe.

Evaluation of rumen fluid and blood constituents of animals is one of the most important methods for assessing health status and understanding the impact of disease

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on animals, taking into consideration the influence of many factors, such as nutrition, sex, climate, season, and environment to correctly interpret the results (Abd Al-Galeel et al. 2023). The results will help in the early diagnosis and management of clinical and subclinical affections and metabolic health problems (Husáková et al. 2014, 2015; Zapata et al. 2003). There were many studies conducted on the effect of season and sex on hematobiochemical parameters and they showed significant effect of season and sex in alpacas (Husáková et al. 2014, 2015) and other different species (Abd Al-Galeel et al. 2023; Zapata et al. 2003).

Rumen fluid and hematobiochemical parameters of alpaca have been studied in South America (Burton et al. 2003; Del Valle et al. 2008; Fowler 2010), Europe (Husáková et al. 2014, 2015; Foster et al. 2009), and North America (Davies et al. 2007; Dawson et al. 2011a, b); however, to our knowledge, similar studies were not conducted under Egyptian conditions. As there are differences in conditions in Egypt in comparison with those in South America, North America and Europe, the aim of our study was to estimate the normal values for rumen fluid, hematology, and serum biochemistry parameters of clinically healthy alpacas kept under Egyptian conditions with special consideration of the effect of season and sex.

Materials and methods

Animals

The study was conducted on seventeen apparently healthy alpaca (8 females and 9 males), whose body weight and age ranged between 60–75 kg and 2–6 years, respectively. The animals were kept in a private zoo in the Ismailia governorate and the Giza Zoo for more than 1 year before sampling. Samples were collected in summer and winter during the period from August 2022 to February 2023. The ambient temperature (T) in Egypt during the course of the study ranged from 18 to 25 °C with an average of 21.5 °C in winter, while in summer, it ranged from 34 to 40 °C with an average of 37 °C. The feed was dried alfalfa in summer and green alfalfa in winter with a small intake of grassland. Clean water was freely available ad libitum all day. Prior to sampling, an individual complete physical examination was performed on each animal. The body temperature of the animals ranged between 37.6 and 38.2 °C. All animals included in this study were on a regular deworming program, and all fecal samples taken to test for internal parasites were negative.

Sample collection

Samples were taken in the early morning before feeding without sedation. Blood samples were obtained from jugular vein puncture, and each sample was divided into two tubes: the first tube was an EDTA tube for hematological estimation, and the second tube was a plain tube for separation of serum for biochemical analysis. Rumen fluid (20 ml) was collected in sterile cups by using a rubber stomach tube as described by Ceron Cucchi et al. (2016). Samples were placed in an ice box and transported to the laboratory for examination.

Rumen fluid analysis

Rumen fluid samples examined physically (odor, color, consistency), microscopically (total protozoal count (TPC) and protozoal activity) and biochemically (pH, ammonia, total and fractionation of volatile fatty acids, phosphorus, calcium, and magnesium), as described by Al-Azazi et al. (2018) and Zaki et al. (2021a, b). Volatile fatty acids fractionation was performed by HPLC YL 9100, Korea. Estimation of fermentation efficiency, Co_2 and methane production was determined using formulas described by Wang et al. (2022) and de Oliveira et al. (2022), respectively.

Hematobiochemical analysis

Complete blood count analysis which includes packed cell volume (PCV), hemoglobin concentration (Hb), erythrocytes count, total and differential leukocytes count was performed by the methods described by Abd Al-Galeel et al. (2023), Schalm et al. (1975) and Wagener et al. (2021) and, red cell indices include mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) were calculated by the formulas described by Wintrobe (2008).

Serum biochemistry estimation was performed by centrifugation of blood samples taken on plain tubes at 3000 rpm for 10 min for separation of non-hemolytic serum. Serum samples were stored at −20 °C until analysis. The analysis included aspartate aminotransferase (AST), alkaline phosphatase (ALP), alanine transaminase (ALT), gamma-glutamyl tansferase (GGT), Lactate dehydrogenase (LDH), total proteins, albumin, glucose, triglyceride, cholesterol, urea, creatinine, bilirubin, calcium, phosphorus, magnesium, chloride, potassium and sodium. Globulins and the albumin/globulins (A/G) ratio were measured mathematically. All biochemical analyses were conducted by ROBONIC biochemistry analyzer, India, and by using specific kits supplied by Spectrum Company, Egypt.

Statistics

Statistical analysis was performed using SPSS version 25. Normality checking and descriptive statistics (range and mean) determination were performed using the Shapiro–Wilk test. Independent sample *t* test and Mann–Whitney test were used for comparisons of normally distributed and non-normally distributed data of season and sex, respectively. The results are expressed as the Mean ± SE, and $p < 0.05$ was considered statistically significant.

Results

Regarding rumen fluid constituents (Table 1), the physical analysis showed a change in the rumen fluid color from brown in summer to olive green in winter. By microscopic analysis, TPC was significantly ($p < 0.05$) increased in summer while, the biochemical analysis showed significant ($p < 0.05$) increase in rumen fluid pH and ammonia in winter. There was no obvious effect of sex on rumen fluid constituents.

The seasonal effect on hematology was evident in the red blood cell count (RBCs) and PCV which increased significantly ($p < 0.05$) in winter, while sex had no effect on hematological parameters (Table 2).

Serum biochemical parameters showed significant ($p < 0.05$) increases in glucose, urea and magnesium levels in winter, while in summer, chloride values were significantly ($p < 0.05$) increased. Under the effect of sex, glucose and creatinine values showed significant ($p < 0.05$) increases in males compared to females (Table 3).

Discussion

Alpaca (*Vicugna pacos*) is a South American camelid that was introduced recently to Egypt. In recent years, the species gained wide popularity and their number increased significantly in zoos. The climatic, geographical and environmental differences between native countries of alpaca and our country necessitate re-estimation of normal values of rumen fluid and hematobiochemical parameters of this animal species under Egyptian circumstances with special consideration of the effect of season and sex.

For rumen fluid constituents, the rumen fluid color differed according to feeding type; in winter, it was olive green, while in summer, it was brown. The consistency, odor and protozoal activity were similar to those reported by Al-Azazi et al. (2018) and Zaki et al. (2021a, b) in sheep and Baraka et al. (2000) and Eissa et al. (2022) in dromedary camel, and they were not affected by season or sex. There are scanty papers available about physical properties of the rumen fluid constituents of alpaca as most of the papers dealt with protozoal populations and biochemical constituents (Liu et al. 2009; Del Valle et al. 2008; Chao et al. 2021; Oldham et al. 2014; Robinson et al. 2013; Nilsen et al. 2015). The rumen fluid pH of alpaca in our study was similar to that recorded in alpaca fed on grass and alfalfa hay (6.6–8.0) (Oldham et al. 2014; Robinson et al. 2013; Nilsen et al. 2015); however, it appears to be higher than that of llama (Dulphy et al. 1997; Ortiz-Chura et al. 2018) and dromedary camel (Eissa et al. 2022; Baraka 2012). Rumen pH as higher in winter, could be attributed to the elevated ammonia level in this season. Ammonia values were similar to those reported by Nilsen et al. (2015). Feeding on green alfalfa which is high in protein could be implicated in ammonia elevation and increasing urea concentration in blood (Faye and Bengoumi 2018). In ruminants and camelids, urea in blood partly returns to the rumen by transportation via the rumen wall and saliva and breaks down to ammonia by rumen microflora (Faye and Bengoumi 2018). TPC count was similar to that reported by Pinares-Patiño et al. (2003) in alpacas in New Zealand; however, it was higher than that reported by Chao et al. (2021) in China and lower than that reported by Del Valle et al. (2008) in Bolivia. Changes in environment, feeding type and rumen ecosystem might cause difference in TPC (Ceron Cucchi et al. 2016). TPC was significantly increased in summer compared with winter which could be explained by increased rumen fluid pH in winter. Rumen ciliates are sensitive to changes in pH, this finding agreed with other reports in sheep by Zaki et al. (2021b). The total and fractionated volatile fatty acids (acetic, propionic, and butyric) concentrations were similar to those of Liu et al. (2009), and they did not differ statistically under the effect of season or sex. Fermentation efficiency, methane and Co_2 values were similar to Baraka and Abdl-Rahman (2012), and they were not affected by sex or seasonal change. The data available about minerals concentration in alpaca rumen fluid are scarce. Rumen fluid mineral values were recorded in dromedary camel by Baraka et al. (2000) and Shoeib et al. (2019), though these values appear to be higher than that recorded of alpaca in our study. Though both are camelids but, they are not from the same species. It appears that some species variations exist between different camelids. Nutrition and rumen fluid pH may also play a role in this difference.

Regarding hematobiochemical parameters, the general mean and range of erythrogram in our study were similar to those in previous studies on clinically healthy alpacas bred in South America, North America and Europe (Husáková et al. 2015; Fowler 2010; Foster et al. 2009; Dawson et al. 2011a; Teare 2013). Erythrogram of alpaca is similar to other SACs; however, there are relative differences between SACs in general and alpaca in particular with other ruminants. The RBCs count of SACs is relatively high compared

Table 1 General mean and range and effect of season and sex on rumen fluid constituents of alpacas in Egypt

Parameter	Season		Sex		General mean	Range
	Summer	Winter	Female	Male		
Color	Brown	Olive green	Brown to olive green			
Consistency		Slimy				
Odor		Aromatic odor				
Protozoal activity		++ to +++				
pH	6.95 ± 0.10	7.6 ± 0.05*	7.18 ± 0.17	7.12 ± 0.16	7.15 ± 0.11	6.4–7.70
TPC(10^4/ml)	32.21 ± 8.68*	9 ± 0.64	25.58 ± 8.86	21.6 ± 10.35	23.77 ± 6.42	7.5–66
Ammonia(mmol/l)	3.94 ± 0.80	6.92 ± 0.25*	5.26 ± 0.85	4.52 ± 1.07	4.86 ± 0.68	1.58–8.50
TVFAs (mmol/l)	48.44 ± 3.76	53.12 ± 2.13	52.08 ± 5.41	48 ± 2.20	49.88 ± 2.70	37.50–75
Acetic (mmol/l)	29.20 ± 9.17	34 ± 2.63	32.59 ± 6.75	29.95 ± 5.98	31.60 ± 4.51	14.25–54.97
Propionic (mmol/l)	14.38 ± 3.57	16.41 ± 3.44	13.09 ± 2.95	19.24 ± 3.10	15.40 ± 2.32	8.54–24.67
Buyteric (mmol/l)	8.93 ± 3.82	11.25 ± 3.26	10.77 ± 4.05	9.57 ± 2.07	10.25 ± 2.31	1.91–19.74
Calcium (mmol/l)	0.58 ± 0.23	0.33 ± 008	0.59 ± 0.29	0.37 ± 0.04	0.48 ± 0.14	0.21–1.76
Phosphorus(mmol/l)	0.78 ± 0.18	1.06 ± 0.12	0.88 ± 0.16	0.92 ± 0.18	0.90 ± 0.11	0.27–1.36
Magnesium (mmol/l)	0.33 ± 0.06	0.13 ± 0.009	0.23 ± 0.06	0.27 ± 0.08	0.25 ± 0.05	0.12–0.60
Methane(mmol/l)	14.94 ± 7.11	18.52 ± 2.81	18.51 ± 5.41	14.95 ± 2.83	16.98 ± 3.16	5.37–28.85
Co_2 (mmol/l)	32.04 ± 12.81	37.98 ± 5.87	36.41 ± 10.45	34.14 ± 4.80	35.43 ± 5.89	12.7–56.26
Fermentation efficiency (%)	79.87 ± 1.43	77.58 ± 1.34	77.47 ± 1.52	80.02 ± 0.82	78.57 ± 1.01	75.35–81.9

Asterisks in the row mean significant difference ($p < 0.05$) in sex and season

TPC total protozoal count, *TVFAs* total volatile fatty acids

++ Decrease in motility and/or crowdness of protozoa

+++ Overcrowded and high motile protozoa

Table 2 General mean and range and effect of season and sex on hematology of alpacas in Egypt

Parameter	Season		Sex		General mean	Range
	Summer	Winter	Female	Male		
Hb(g/dl)	13.29 ± 0.54	14.80 ± 0.90	12.84 ± 0.41	14.81 ± 0.76	13.95 ± 0.51	10.62–17.64
PCV (%)	26.11 ± 1.12	30.14 ± 1.43*	27 ± 1.06	28.55 ± 1.59	27.87 ± 1.00	20–37
RBCs ($\times 10^6$)	12.74 ± 0.38	15.01 ± 0.85*	13.41 ± 0.77	13.99 ± 0.69	13.73 ± 0.50	11.30–18
MCV (fL)	20.91 ± 0.50	21.53 ± 0.54	20.75 ± 0.45	21.59 ± 0.54	21.20 ± 0.36	19.37–23.61
MCH (pg)	10.42 ± 0.28	9.93 ± 0.58	9.71 ± 0.52	10.60 ± 0.29	10.21 ± 0.29	7.59–11.74
MCHC (g/dl)	51.03 ± 0.94	49.45 ± 3.05	48.08 ± 2.58	52.10 ± 1.29	50.34 ± 1.39	35.4–56.96
WBCs ($\times 10^3$)	10.58 ± 1.31	13.42 ± 0.94	12.93 ± 1.46	10.95 ± 1.09	11.82 ± 0.89	6.4–17.80
Absolute neutrophil ($\times 10^3$)	7.49 ± 1.00	9.2 ± 0.93	9.14 ± 1.24	7.53 ± 0.80	8.23 ± 0.71	4.14–13.52
Relative neutrophil (%)	70 ± 2.44	68 ± 3.11	70 ± 3.59	68.44 ± 2.04	69.12 ± 1.88	52–80
Absolute lymphocytes ($\times 10^3$)	2.99 ± 0.42	3.32 ± 0.26	3.23 ± 0.32	3.07 ± 0.40	3.14 ± 0.25	1.77–5.50
Relative lymphocytes (%)	28.66 ± 2.05	25.14 ± 1.89	25.71 ± 1.82	28.22 ± 2.17	27.12 ± 1.44	18–38
Absolute eosinophils ($\times 10^3$)	0.05 ± 0.03	0.50 ± 0.20	0.33 ± 0.19	0.19 ± 0.11	0.25 ± 0.10	0–1.34
Relative eosinophils (%)	0.88 ± 0.58	4 ± 1.69	2.57 ± 1.42	2 ± 1.15	2.25 ± 0.87	0–10
Absolute basophils ($\times 10^3$)	0	0	0	0	0	0
Relative basophils (%)	0	0	0	0	0	0
Absolute monocytes ($\times 10^3$)	0.02 ± 0.01	0.37 ± 0.18	0.22 ± 0.14	0.15 ± 0.11	0.18 ± 0.08	0–1.07
Relative monocytes (%)	0.44 ± 0.29	2.85 ± 1.37	1.71 ± 1.10	1.33 ± 0.88	1.50 ± 0.67	0–8

Asterisks in the row mean significant difference ($p < 0.05$) in sex and season

Table 3 General mean and range and effect of season and sex on serum biochemistry of alpacas in Egypt

Parameter	Season		Sex		General mean	Range
	Summer	Winter	Female	Male		
AST(IU/L)	134.76 ± 14.71	136.90 ± 8.42	132.71 ± 11.60	138.48 ± 12.85	135.76 ± 8.48	83.14–208.41
ALP(IU/L)	108.20 ± 14.44	89.92 ± 14.99	114.78 ± 19.49	86.10 ± 7.69	99.60 ± 10.33	49.98–182.79
ALT(IU/L)	11.34 ± 2.06	12.42 ± 1.87	12.85 ± 2.46	10.96 ± 1.45	11.85 ± 1.36	5.11–23.93
GGT(IU/L)	30.56 ± 1.94	30.91 ± 2.56	32.79 ± 2.11	28.90 ± 2.13	30.73 ± 1.53	21.95–40.83
LDH(IU/L)	154.89 ± 18.12	177.45 ± 8.81	182.34 ± 9.51	153.60 ± 15.69	166.17 ± 10.16	74.76–245.89
Total proteins(g/dl)	5.63 ± 0.18	5.99 ± 0.19	5.93 ± 0.26	5.68 ± 0.12	5.80 ± 0.13	4.61–6.74
Albumin(g/dl)	3.52 ± 0.17	3.51 ± 0.07	3.38 ± 0.14	3.64 ± 0.11	3.52 ± 0.09	2.47–4.21
Globulins(g/dl)	2.10 ± 0.15	2.47 ± 0.20	2.54 ± 0.18	2.04 ± 0.15	2.28 ± 0.13	1.34–3.33
A/G ratio	1.78 ± 0.22	1.49 ± 0.12	1.37 ± 0.10	1.89 ± 0.20	1.65 ± 0.13	1.02–3.09
Glucose(mg/dl)	100.49 ± 6.26	127.11 ± 9.14*	97.47 ± 5.78	126.83 ± 8.32*	113.01 ± 6.21	75.07–178.65
Triglyceride(mg/dl)	27.83 ± 2.92	30.80 ± 4.21	28.21 ± 2.89	30.42 ± 4.26	29.31 ± 2.50	14.75–56.5
Cholesterol(mg/dl)	19.27 ± 4.46	25.06 ± 2.70	17.74 ± 1.97	26.58 ± 4.49	22.16 ± 2.63	9.9–48.66
Urea(mg/dl)	29.28 ± 4.90	50.73 ± 6.45*	42.63 ± 6.06	36.48 ± 7.26	39.37 ± 4.70	12.93–78.46
Creatinine(mg/dl)	1.78 ± 0.09	1.79 ± 0.09	1.60 ± 0.08	1.95 ± 0.06*	1.78 ± 0.06	1.40–2.22
Bilirubin((mg/dl)	0.43 ± 0.06	0.58 ± 0.10	0.50 ± 0.07	0.49 ± 0.11	0.49 ± 0.06	0.2–0.92
Calcium(mg/dl)	10.25 ± 0.47	10.17 ± 0.40	9.88 ± 0.51	10.49 ± 0.32	10.21 ± 0.29	8.59–12.44
Phosphorus(mg/dl)	4.64 ± 0.56	5.99 ± 0.68	5.12 ± 0.63	5.32 ± 0.67	5.23 ± 0.45	2.31–7.83
Magnesium(mg/dl)	1.00 ± 0.09	1.26 ± 0.09*	1.22 ± 0.10	1.05 ± 0.10	1.13 ± 0.07	0.73–1.61
Chloride(mmol/l)	117.62 ± 3.00*	108.61 ± 2.21	113.08 ± 3.54	113.15 ± 2.68	113.11 ± 2.14	100–126.35
Potassium(mmol/l)	6.78 ± 0.50	6.76 ± 0.39	6.87 ± 0.41	6.66 ± 0.45	6.77 ± 0.29	5.05–8.13
Sodium(mmol/l)	155.98 ± 5.92	164.17 ± 10.04	159.28 ± 5.23	159.55 ± 11.26	159.39 ± 5.28	135.36–198.11

Asterisks in the row mean significant difference ($p < 0.05$) in sex and season with that of other ruminants, and they have a unique small, elliptical, and flat shape that facilitates movement during dehydration in blood capillaries (Vap and Bohn 2015). The MCV values of SAC are lower than those of other species, which gives a large surface area:volume ratio for more efficient gas exchange, while those of MCHC are more than 40 g/dl, which is higher than those of other true ruminants (Foster et al. 2009). SACs also have lower PCV values compared to other animals and they can appear healthy and able to tolerate severe anemia with a PCV less than 10% (Foster et al. 2009). The general mean and range values of total and differential leucocytes count in this study were similar to those previously reported by Husakova et al. (2015), Fowler (2010), Foster et al. (2009), Dawson et al. (2011a), and Teare (2013). The leucogram of alpaca is characterized by an elevated total leucocytes count accompanied by high neutrophils in contrast to other ruminants where lymphocytes are the predominant cells (Husáková et al. 2015). The hematological values of alpacas bred in Egypt were consistent with those raised in South America, North America and Europe, which means that alpaca has adapted to live in Egypt with minimal change in hematological parameters. Season appears to have an influence on PCV and RBCs, as they both elevated in winter compare to summer, this finding agreed with previous reports in alpacas (Husáková et al. 2015) and in guanacos (Zapata et al. 2003). This increase in RBCs and PCV values was attributed to slight dehydration that can occur in winter season due to decrease water consumption which leads to hemoconcentration (Husáková et al. 2015; Zapata et al. 2003). The effect of sex on hematology was minimal, and there were no sex-related differences for any of the hematological results in agreement with Husakova et al. (2015) and Dawson et al. (2011a).

In our study, the general mean and range of the estimated biochemical parameters were similar to previous reports in alpaca (Husáková et al. 2014; Fowler 2010; Foster et al. 2009; Teare 2013) while exception for minerals, though they were still within normal range. This difference could be due to changes in the environment, nutrition, and soil. Regarding season, summer season was associated with elevated chloride level; a similar finding was reported in dromedary camel by Faye and Bengoumi (2018); however, it contrasts with Husakova et al. (2014) who reported an elevation in chloride level during winter in alpaca reared in Europe. This difference may be attributed to climatic change between Egypt and Europe. In winter, there was a significant increase in magnesium and urea levels which could be related to increased magnesium and protein levels in green alfalfa in winter compared with dry alfalfa in summer (Faye and Bengoumi 2018; Aichouni et al. 2013; Amin et al. 2007). Glucose values also showed a significant increase in winter compared with summer, which was linked to the seasonal change in feed intake (Aichouni et al. 2013; Badawy et al. 2008). The effect of sex was evident in glucose and creatinine levels. Glucose values showed a significant increase in males compared with females in accordance with Al-Harbi (Al-Harbi 2012). The creatinine level was higher in males than females; similar finding was reported in dromedary camel by Barakat and Abdel Fattah (1971). Increasing muscle mass in males compared with females could be implicated, as daily creatinine production is linked to body muscular mass (Faye and Bengoumi 2018).

Conclusion

There was a significant effect of season on rumen fluid, hematology, and serum biochemistry constituents of alpaca, while the effect of sex on these parameters was minimal. Rumen fluid and hematobiochemical parameters values of apparently healthy alpacas bred under Egyptian conditions were consistent with those in other countries, while slight differences were observed in mean and range values of total protozoal count and serum minerals. The obtained data can serve as preliminary data for rumen fluid and blood constituents of alpacas bred in Egypt, and can be used by veterinarians to interpret the health status and early diagnosis of clinical and subclinical diseases of this animal species.

Author contribution All authors contributed to the study conception and design. Sample collection and analysis and writing of the first draft of the manuscript were performed by Mariam Gamal Zaki. Taher Ahmad Baraka, Mohammed Awny Elkhiat and Fatma Abd EL- Fattah Tayeb contributed to the work design and follow up stages of application, statistical analysis and revision of the manuscript. Mohamed Ragaii Younis helped with sample collection and material supplementation at Giza Zoo. All the authors have read and approved the final manuscript.

Compliance with ethical standards

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Informed consent For this type of study informed consent is not required.

Consent for publication For this type of study consent for publication is not required.

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