Comparison of artificial rearing systems using clinical and hematological parameters: A preliminary study

Comparación de sistemas de crianza artificial utilizando parámetros clínicos y hematológicos: Estudio preliminar

María Laura Galotta, Carlos Hernán Moscuzza, Luis Ambros, Alicia Fernández Cirelli*

Instituto de Investigaciones en Producción Animal / INPA (UBA-CONICET); Facultad de Ciencias Veterinarias, Universidad de Buenos Aires, Av. Chorroarín 280, C1427CWO Buenos Aires, Argentina.

*Corresponding author: afcirelli@fvet.uba.ar

ABSTRACT

Comparison of clinical and hematological profile of Anglo Nubian kids was performed under three different rearing systems. Animals were separated from their dams and rearing from birth until pre-weaning at 24 days of age. Kids were fed with goat milk, reconstituted cow powder milk and reconstituted cow powder milk with enrofloxacin in sub-therapeutic doses. Clinical exam and blood analysis were performed at 3, 10 and 21 days of treatment. As a result, body weight did not show significant differences between treatments. However, values of cardiac frequency, cholesterol, urea, serum alkaline phosphatase and segmented neutrophils (%) were higher than the reference values. These results could be explained considering the physiological state and age of the animals. During this experiment, the use of diet supplemented with enrofloxacin did not generate substantial benefits in the animals that received it. In addition, the use of antibiotics in farms needs to be reconsidered in order to avoid negative environmental effects.

Keywords: clinical-hematological parameters, kid goat, sucking period, antibiotic supplementation, artificial rearing.

RESUMEN

El uso de diferentes sustitutos lácteos es una práctica común en la crianza artificial de cabritos, sin embargo, no hay información suficiente sobre el impacto que

puedan tener tanto en el animal como en el ambiente. El objetivo de este estudio fue comparar los perfiles clínicos y hematológicos de cabritos de la raza Anglo Nubian bajo tres sistemas de alimentación diferentes. Al nacer, los animales fueron separados de sus madres y evaluados hasta el periodo de pre- destete (24 días). Los cabritos fueron alimentados con leche de cabra, leche de vaca (en polvo reconstituida) y leche de vaca (en polvo de reconstituida) con el agregado de enrofloxacina en dosis sub-terapéuticas. Sobre los animales ensayados se llevó a cabo un análisis clínico y hematológico a los 3, 10 y 21 días de iniciado el tratamiento. Como resultado se observó que la variable peso no presentó diferencias significativas entre los tratamientos. Sin embargo, los valores de frecuencia cardíaca, colesterol, urea, fosfatasa alcalina sérica, y neutrófilos segmentados (%) se encontraron por encima de los valores de referencia. Estos resultados pudieron ser explicados considerando el estado fisiológico y la edad de los animales. En conclusión, la suplementación de la dieta con enrofloxacina no generó un beneficio en los animales que la recibieron. Por otro lado, la utilización de antibióticos en los establecimientos productivos debe ser reconsiderada en orden de atenuar el efecto negativo en el ambiente.
Palabras clave: parámetros clínicos- hematológicos, cabritos, periodo de lactante, suplementación con antibióticos, crianza artificial.

INTRODUCTION

The most common system of goat production, in Argentina, is a subsistence economy under continuous grazing and meat production as the principal income of the stockmen (Guevara *et al.,* 2009). However, over the last years, the government showed a special interest in dairy production. In this way, different types of policies and credits were implemented with a positive effect in the sector (SENASA, 2017). In goat dairy system, milk is used for the production of artisan cheeses and other by-products (Damian *et al.,* 2008) being milk a critical factor to be utilized for feeding kids. Goat artificial rearing is a common practice in several countries, but in Argentina, it is used only in a few livestock farms. In general, methodologies of artificial rearing are based on local recommendations without any professional basis. For that reason, it is necessary to know if the artificial rearing methodology has a real impact on the health and growth of animals, especially, when antibiotics are incorporated as a productive tool such as prevention actions and growing promoters (Ghosh and LaPara, 2007; Allen *et al*., 2010; Hu *et al*., 2010; Chiesa *et al*., 2015; Van Boeckel *et al.,* 2015). Most farmers choose broad-spectrum antibiotics to reduce morbidity such as oxytetracycline, penicillin, cephalosporin, sulfonamide, and fluoroquinolone. One of the most used is enrofloxacin for its antimicrobial activity against gram-negative bacteria, Mycoplasma spp., some gram-positive bacteria and organisms which have resistance to other antibacterial agents

(Elmas *et al.,* 2001; Ebert *et al.,* 2011; Bearson and Brunelle, 2015). Sarkozy (2001) reported that the use of fluoroquinolones had no adverse effects if it is compared with its beneficial aspects. Fish (2001) described an association between the enrofloxacin use and some hematological abnormalities such as anemia, leukopenia and an increase or decrease of platelets with very low incidence (0.3 - 1 %). On the other hand, biochemical and hematological variables are often used to monitor and evaluate the health, nutritional and physiological ruminant state (Al-Eissa *et al.,* 2012; Scarpino *et al.,* 2014; Mohammed *et al*., 2016). In this context, these evaluations could be performed in order to determine nutritional efficiency of additives and foods supplied to animals (Akingbade *et al.,* 2002, Belewu and Ogunsola, 2010) and their immunological state (Al-Seaf and Al-Harbi, 2012). The aim of the present study is to compare three alternatives of artificial rearing in goat through the evaluation of clinical-hematological parameters.

MATERIAL AND METHODS

Animal, management and treatments: All experiment procedures and animal care practices were in agreement with the Institutional Committee for Care and Use of Laboratory Animals (Comisión Institucional para el Cuidado y Uso de Animales de Laboratorio - CICUAL). Eight Anglo Nubian kids were selected from the campus of Veterinary Faculty of the Buenos Aires University. Goat kids were separated from their dams after birth and were fed with colostrum during first-day of life. All of them were classified as healthy without abnormalities and identified with a plastic-tag in their ears (Rotatag®). Goat kids were placed in indoor pens of 12 m^2 bedded with wood shavings.
Kids were divided into three treatments according to treatment applied. The first group, defined as the control group (T1; n=2) was artificially fed with goat milk obtained from their dams, for comparison. In the second group (T2; n=3), kids received reconstituted cow powder milk in a relation of 150 g of powder per litter of suspension. Finally, kids of the third group (T3; n=3) were fed with reconstituted cow powder milk (in the same proportion than before) supplemented with enrofloxacin (Enromax®- Richmond). Enrofloxacin was added to powder milk in a relation of 17 to 35 mg/ 1500 mL (depending on animal weight during the experiment). In all cases, milk was previously tempered at 40 °C and administrated by a sucking bucket (milk composition is provided in Table 1). Tap drinking water was always available *ad libitum.* This study was performed for twenty-four days in the pre-weaning stage of ruminant where the basic feed is milk.

Sampling and analyses: Goat kids were weighed at birth and body weight was registered weekly. A clinical examination that included determination of cardiac (hear rate, HR; beats per minute) and breathing frequencies (BR; breaths per minute), mucous membrane color, capillary filling time, lymph nodes, sensory and rectal temperature was performed regularly.

Table 1

Composition of feedstuffs offered to goat kids

Composition (%)	Cow powder milk	Goat Milk
Crude protein	3.12	3.28
Fat	3.25	6.40
Lactose	4.37	4.92
ME MJ/Kg [a]	2.78	4.04

[a] Metabolizable energy (ME) of milk estimated according to the equation: MJ/ Kg= 1.4694 + (0.4025 X milk fat %) (Lama *et al.* 2014).

Blood samples were collected before the morning feeding by jugular venipuncture at 3 and 21 days of life. Non-anticoagulant and anticoagulant (ethylenediaminetetraacetic acid) tubes were used to collect blood samples. These were placed on ice immediately after collection and transported to the laboratory for further analyses.

Blood assays were performed according to the methodology from Handin *et al.* (2003). Hematocrit values were determined using microhematocrit capillary tubes, hemoglobin concentration was estimated by a spectrophotometer (Metrolab 1600), white blood cell, neutrophils, and lymphocytes were determined by manual methods. In serum samples, total protein was determined by refractometer, while albumin, urea, creatinine, cholesterol, glutamine-pyruvate transaminase (GPT), glutamic-oxaloacetic transaminase (GOT), and serum alkaline phosphatase (ALP) were determined by spectroscopic measurements (Auto-Analyzer Metrolab 2010).

Statistical analysis: Statistical analysis was performed using statistical software InfoStat 2016 (Di Rienzo *et al.,* 2016). Particularly, a multivariate analysis of principal components was employed for biochemical and hematological variables to identify those that are able to explain the major variability between individuals. Analysis of goat´s weight for the several diets was performed applying Wilcoxon tests.

RESULTS

Figure 1 shows the average body weight of goat kids taking at initial and final time of each treatment. During this trial, it was observed an increment in the body weight regarding the birth weight, as is expected. Average calculated values were 45%, 45% and 49% for groups feeding with goat milk, cow powder milk and cow powder milk supplemented with enrofloxacin, respectively. The Wilcoxon test analysis did not show any significant differences regarding the different kind of feeding (p> 0. 05). Additionally, clinical exam of animals at 3, 10 and 21 days of life was performed to monitor the health status and response to the different diets. In the three groups of animals was observed that cardiac frequency values were ranging from to 150 to 190 beats per minute that were higher than the previously reported in the literature (see Table 2). On the other hand, the cardiac frequency values decrease with the goat growth in the observed period of time. Also, some differences were noticed between the applied treatments, particularly, the addition of enrofloxacin to the diet has caused the lower heart rate values.

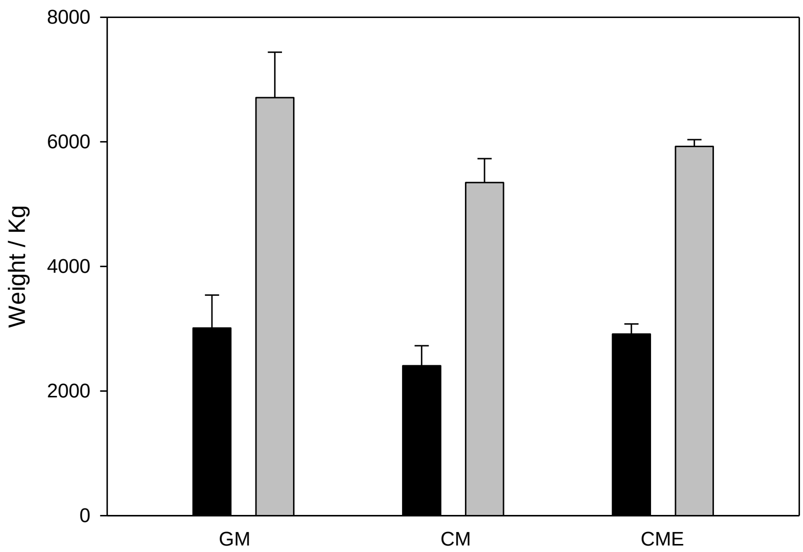

Fig.1. Average weight of goat kids and initial (▬) and final (▬) time breading with goat milk (GM), cow powder milk (CM) and cow powder milk added with enrofloxacin (CME). Error bars are SE.

In a similar way, most of breathing frequency values, registered in this experiment, were ranging below the references values reported by Terra and Reynolds (2014). Therefore, the analyses of breathing frequency data will be regarding the control group. As a principal result there is a difference in the tendency of the values for the control group regarding the T2 and T3. Particularly, the breathing rate, in T1, showed a slight decrease with the goat growth while for T2 and T3 a strong increase was observed.

In the case of temperature, the values remained relatively constant during the experiment and were in the range reported by Nagy and Pugh (2012). From these measurements a little diminution was observed with the time of life of kids during this experiment in all treatment.

Table 2

Average of clinical parameters (±SE) of kids feeding by artificial rearing evaluated at 3, 10 and 21 days.

		Period evaluated / days			
Clinical parameter	Treatment	3	10	21	Reference values
Heart rate	T1	192 ± 8	190 ± 10	172 ± 8	120 -160 beats per minute (Terra and Reynolds 2014)
	T2	192 ± 8	184 ± 18	161 ± 20	
	T3	179 ± 5	175 ± 8	151 ± 5	
Breathing frequency	T1	38 ± 2	34 ± 6	32 ± 8	40 - 65 breaths per minute (Terra and Reynolds 2014)
	T2	29 ± 4	46 ± 13	41 ± 12	
	T3	25 ± 1	48 ± 4	33 ± 5	
Temperature	T1	40.0 ± 0.1	39.0 ± 0.3	39.0 ± 0.2	38.0-40.0 ºC (Nagy and Pugh 2012)
	T2	40.0 ± 0.1	40.0 ± 0.1	39.0 ± 0.4	
	T3	40.0 ± 0.1	40.0 ± 0.2	39.0 ± 0.1	

T1: goat milk, T2: cow powder milk, T3: cow powder milk added with enrofloxacin.

In Tables 3-4 the principal hematological parameters from kids are presented. Hematocrit values have shown a slow decrease in the studied time, and the registered values for both T2 and T3 treatment have shown to be lower compared with the control ones. However the entire data set are according with the previously reported reference values. Hemoglobin, albumin and total proteins values were already constant during the trial time and for the different applied treatments. Also, hemoglobin and albumin data were according to reference values (8-12 g/dL; 2.7- 3.9 g/dL; respectively) while protein data were lower compared with the reference ones. A different situation was observed for the cholesterol results were the obtained values for the control group resulted higher than the reference data (80-130 mg/dL). In T2 and T3 an increase of cholesterol concentration was observed with the time. Although the values are included in the reference range, they are located near to the superior limit.

White blood cell values have shown an increase in the studied time for all the treatments; although only kids from T1 showed higher values than reference values at the end of the experiment.

Segmented neutrophils (%) and lymphocytes (%) have shown an inverse relationship with the trial time. In the case of segmented neutrophils (%) values were higher and overcoming the reference values (30 - 48%), at the beginning of experiment. Nevertheless, at the end of studied time values were closely to lower limit. The opposite situation was observed for the lymphocytes (%) values. In that case, values were lower than the reference data at the beginning. However, in subsequent sampling, lymphocytes

(%) values were higher and within the range (50 – 70%). Absolut account for lymphocytes and neutrophils have shown the same relation explained before. A greater difference with lymphocytes values were observed in sample time, whereas a smaller difference was obtained with neutrophils values.

Urea and creatinine values have shown a slow diminution in the studied time in control group. Most of urea values were included in the reference range (12-26 mg/dL) but they are located near to the superior limit while creatinine values were according to reference (0.6- 1.60 mg/dL). In T2 treatment, urea values were higher at the beginning and then were within the reference values in the subsequent sample (contrary to the others treatments). For creatinine values, T2 and T3 treatment, showed a low diminution at 21 days of life when they are compared with initial sample time, though the entire data set are according to the previously reported reference values. Values of GPT were already constant during the trial time with a little increased at the end of the sample time. Instead of values of GOT, were increased at the the end of the experiment, except for T2, where a diminution were observed. Nonetheless, data set were according to reference values in all different applied treatments. A different situation was observed for serum alkaline phosphatase results where the obtained values were higher than the reference data during this trial.

Table 3

Hematological parameters of kids feeding by artificial rearing evaluated at 3 and 21 days

Parameter	Hematocrit %		Hemoglobin g/dL		Total Protein g/dL		Albumin g/dL		Cholesterol mg/dL	
Days	3	21	3	21	3	21	3	21	3	21
Treatment 1	30 ± 6	29 ± 3	10 ± 2	10 ± 1	5.0 ± 0.1	5.0 ± 0.1	3.2 ± 0.2	3.1 ± 0.1	159 ± 14	145 ± 12
Treatment 2	27 ± 2	25 ± 1	8.0 ± 0.6	8.0 ± 0.2	6.0 ± 0.5	5.0 ± 0.1	2.8 ± 0.1	2.6 ± 0.4	105 ± 8	122 ± 9
Treatment 3	28 ± 2	25 ± 1	9.0 ± 0.6	8.0 ± 0.2	5.0 ± 0.1	5.0 ± 0.2	3.1 ± 0.1	3.1 ± 0.1	121 ± 9	146 ± 10
Reference values*	22 - 38		8.0-12.0		6.4-7.0		2.7 - 3.9		80 -130	

Treatment 1: goat milk, Treatment 2: cow powder milk, Treatment 3: cow powder milk added with enrofloxacin. Errors are SE.* Nagy and Pugh 2012.

The analysis of principal components was performed in order to explain the total variability of the 18 variables studied. The first four principal components (PC) explained approximately 73% of the total variance, with 32% explained by the first component (Figure 2).The variables that contributed most to the formation of the spatial gradient of the PC 1 scores were lymphocytes (%) (Eigenvector= 0.39), neutrophils (%) (Eigenvector= -0.38), lymphocytes (lymphocytes, cells / mm^3) (Eigenvector= 0.37) and weight (Eigenvector= 0.35). The second component (PC 2) explained 18% of the total variability with the most important variables being hematocrit (Eigenvector= 0.50), hemoglobin (Eigenvector= 0.48) and albumins (Eigenvector= 0.34) (Figure 3). In the plot, an association between neutrophils and animals in the initial state (N2T2$_i$, N2T3$_i$, N1T1$_i$, N1T2$_i$, and N3T3$_i$) were observed. Lymphocytes (%) and weight associated with animal N4T3$_f$ and lymphocytes (lymphocytes, cells / mm^3) associated with N3T2$_f$, N1T1$_f$, N3T3$_f$. Additionally, an association between animal N4T1$_i$ with hematocrit and the same animal with hemoglobin in the final state was observed.

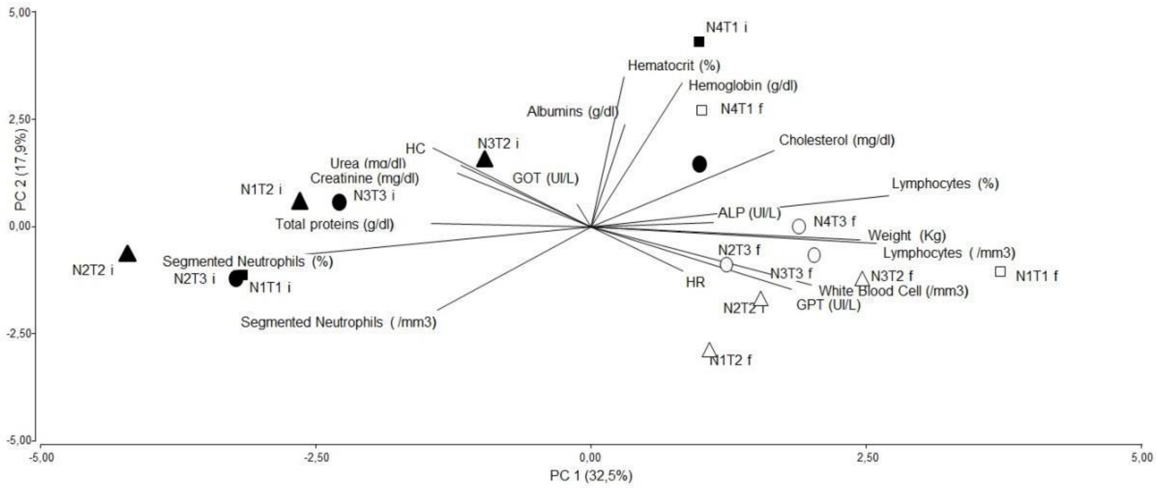

Fig. 2. Biplot of the first two main components (PC) based on the 18 variables studied, PC 1 vs PC 2. The squares represent the treatment one, the triangles the treatment two and the circles the treatment three. In all cases, the full figure (black) is the initial period and the empty figure (white) is the final period.

Table 4

Hematological parameters of kids feeding by artificial rearing evaluated at 3 and 21 days

Parameters	WBC (/mm^3)		Segmented neutrophils (%)		Segmented neutrophils (/mm^3)		Lymphocytes (%)		Lymphocytes (/mm^3)	
Days	3	21	3	21	3	21	3	21	3	21
Treatment 1	7550 ± 1300	15900 ± 1500	61 ± 20	34 ± 5	4920 ± 2300	5331 ± 403	37 ± 20	65 ± 5	2541 ± 1100	10410 ± 1700
Treatment 2	7450 ± 310	11966 ± 1075	63 ± 7	42 ± 3	4805 ± 780	5058 ± 680	34 ± 6	56 ± 2	2507 ± 385	6694 ± 690
Treatment 3	9800 ± 700	12033 ± 720	65 ± 12	39 ± 5	6189 ± 870	4711 ± 887	32 ± 14	58 ± 4	3334 ± 1600	6941 ± 317
Reference values*	4000-13000		30-48		1200-7200		50-70		2000-9000	

Treatment 1: goat milk, Treatment 2: cow powder milk, Treatment 3: cow powder milk added with enrofloxacin, WBC: White blood cell; * Nagy and Pugh 2012. Errors are SE.

Table 5

Average of biochemical parameters (±SE) of kids feeding by artificial rearing evaluated at 3 and 21 days

Parameters	Urea (mg/dL)		Creatinine (mg/dL)		GPT (UI/L)		GOT (UI/L)		ALP (UI/L)	
Days	3	21	3	21	3	21	3	21	3	21
Treatment 1	27 ± 2	34 ± 18	0.74 ± 0.08	0.83 ± 0.12	21 ± 6	24 ± 9	58 ± 6	70 ± 20	752 ± 82	856 ± 300
Treatment 2	38 ± 6	24 ± 2	0.87 ± 0.02	0.62 ± 0.15	21 ± 4	35 ± 2	87 ± 13	70 ± 7	1010 ± 273	1280 ± 345
Treatment 3	27 ± 5	30 ± 5	0.76 ± 0.13	0.68 ± 0.06	19 ± 6	31 ± 5	61 ± 5	88 ± 17	1150 ± 240	1119 ± 443
Reference values	12- 26 (Jackson and Cockcroft 2002)		0.60-1.60 (Jackson and Cockcroft 2002)		15 - 52		66 - 230		93 - 387 (Christian and Pugh 2012)	

Treatment 1: goat milk, Treatment 2: cow powder milk, Treatment 3: cow powder milk added with enrofloxacin.

The third axis (PC 3) explained 14% of the variability with the most important parameters being GOT (Eigenvector= 0.59), total protein (Eigenvector= 0.48) and urea (Eigenvector= 0.38). Finally, the fourth component explained 9% of the variability with the most significant variables being breathing rate (Eigenvector= 0.54), heart rate (Eigenvector= 0.50) and creatinine (Eigenvector= 0.40). According to the third and fourth component, an association between total protein and the animal $N2T2_i$, and also urea with animals $N2T3_f$ and $N4T3_f$ were observed, In addition, heart rate and creatinine are associated with animal $N2T2_f$ (Figure 3). The cophenetic correlation coefficient was 0.915 for this study.

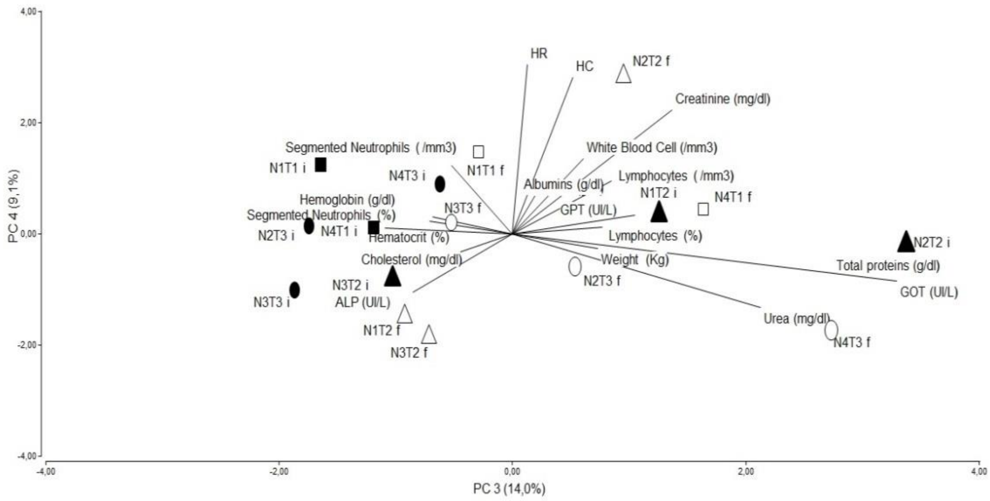

Fig.3. Biplot based on the 18 variables studied, PC 3 vs PC 4. The squares represent treatment one, the triangles treatment two and the circles treatment three. In all cases, the full figure (black) is the initial period and the empty figure (white) is the final period.

DISCUSSION

In this study, three diets were compared in order to estimate which one is the most appropriate to be used for artificial rearing in goats. Body weight could be an important tool to evaluate the growth rate and viability of diets. In this trial, there were no significant differences in weight between groups of animals, although the T3 group weight range were slightly more than the others groups. However, data suggest an extension of the experiment. The physiological state of animals can be determined by their clinical and hematological parameters (Khan and Zafar, 2005, Etim *et al.,* 2014), providing information on diagnosis and prognosis of different diseases (Olafadehan, 2011). Most of the neonate's parameters differ from the adult because of changes related to age and colostrum intake (Ježek *et al.,* 2006), as is the case of heart rate. That could explain why reference values differ from the taking ones. Despite values of heart rate, tachycardia should be considered normal in young animals, in rumination, lactation or the last gestation period (Nagy and Pugh, 2012). Data shown higher heart rate values at few days of life with a diminution afterwards. Furthermore, according to Terra and Reynolds (2014), in the absence of pathologies heart rate returned to normal with the animal at rest. Total serum proteins could be influenced by changes in protein intake, whereas albumin values are an indicator of long-term dietary deficiencies (Atasoglu *et al.,* 2008, Piccione *et al.,* 2011). At birth, serum protein concentration is usually low due to lower levels of immunoglobulin and albumin present in the blood of neonates (Allison 2012a), these agree with the results of the present trial. In the case of albumin values, these remained relatively constant from birth to the end of the experimental period within reference values. Plasmatic cholesterol values were higher than reference ones, though according to Öztabak and Özpinar (2006), high values are normal in this category of animals due to the consumption of colostrum.

In relation to ruminant hematological profile, there are physiological changes regarding the age of the animals and also the species. In sheep and cattle, neutrophils (N) outgrow lymphocytes (L) at birth until the first week of life when a reverse relationship is observed (Morris, 2014). In goats this relationship is observed until adulthood where since then N: L ratio remains at 1:1 (Jones *et al.,* 2012). Data obtained were in concordance with the reference before for the three feeding treatments. The neutrophil counts tended to be higher than the reference values at the first sampling point, but at the subsequent sampling, they modified and acquired values within the range. That could show that animals have had an active immune system during this study (Belewu and Ojo-Alokomaro, 2007); besides animals fed with enrofloxacin had no direct effects on lymphocyte proliferation or proliferation of bone marrow progenitor cells, in agreement with other studies (Manzella and Clark, 1988; Brown, 1996).

Urea may come from a dietary intake or from a rumen reentry through the ruminal epithelium (Lérias *et al.,* 2015), being the main source of nitrogen for ruminants. Otherwise, creatinine plays an important role in energy metabolism because it is a rapid source of high-energy phosphate via the enzymatic creatinine kinase pathway, which may be related to renal function and body mass (Brosnan and Brosnan, 2010). In this study, creatinine values were within reference range (0.60- 1.60 mg/dL). This is important because creatinine increases are related to a negative energy balance in malnourished animals where weight loss and mobilization of adipose tissue and muscle protein is characteristic (Lérias *et al.,* 2015).

The enzymatic values were within the reference range except for ALP enzyme. ALP was increased in all three treatments. At few days of life, values of enzyme were due to the absorption of colostrum (Blum and Hammon, 2000); but subsequent increase was related with endogenous sources such as the bone tissue of growing animals (Zanker *et al.,* 2001). The increase associated with an increase in osteoblastic activity occurs in all species. Results were accord with Allison (2012b) where values of growth animals were higher than obtained from adult reference intervals (93-387 UI/L).

The use of enrofloxacin in young animals has been questioned for its toxic effects on chondrocytes of canine, horse, and birds (Khazaeil *et al.,* 2012). However, there is little information related to ruminants. The toxicity of fluoroquinolones is largely dose and dependent species (Bertino and Fish, 2000). Most of the reactions are considered to be of low severity and reversible upon discontinuation of treatment. In goats, pre-stomachs are poorly developed and relatively nonfunctional in neonates (Waxman *et al.,* 2004). The development of the digestive tract could contribute to the increase in the volume of distribution of the different drugs with the age. This is the case of non-ionized compounds, with good lipid solubility, which passes through a passive diffusion mechanism through the ruminal epithelium. Therefore, considering the great capacity of digestive structures in adult goats, fluoroquinolones could diffuse and accumulate passively into the rumen when they are administered parenterally (Gonzalez *et al.,* 2001, Waxman *et al.,* 2004). The use of oral repeated doses in sheep and cattle had minimal effect on the ruminal flora, due to low activity against protozoa, streptococcus or anaerobic bacteria presented by enrofloxacin and its metabolite (Flammer *et al.,* 1991; Gandolf *et al.,* 2005).

The use of this antibiotic is associated with hematological abnormalities such as increases in hepatocellular enzymes (GPT and GOT) and decreases in hematocrit (Brown, 1996). In dogs administration of enrofloxacin for 14 days did not cause significant changes in hemoglobin concentration (Traş *et al.,* 2001), but there is a frequency of 2-3% in the elevation of liver enzymes such as GPT and GOT in those animals. This increase cannot be observed in the present study despite the fact that one of the animals in the enrofloxacin group has higher GOT values in relation to the rest, but this value is within the reference values.

In summary, hematological and biochemical parameters serve as indicators of the physiological and dietary status of animals. In this experiment, there were no differences in the weight gain of the three diets studied, so that, milk powder could be used as a replacement for goat's milk in animals under artificial rearing. In relation to the diet added with enrofloxacin, although it did not generate substantial changes in the animals that received it, its incorporation should be avoided for not having an additional advantage compared with animals that did not consume it. Moreover, the use of antibiotics in farms needs to be revisited in order to avoid negative environmental effects due its use and deposition.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial support from Consejo Nacional de Investigaciones Científicas y Técnicas and Universidad de Buenos Aires. Also, the authors offer special thanks to Avigliano Esteban and Iriel Analia for the help provided in the confection of the present paper.

REFERENCES

Akingbade, A. A., Nsahlai, I. V., Morris, C. D., & Iji, P. A. 2002. Field activities and blood profile of pregnant South African indigenous goats after receiving dihydroxy pyridone-degrading rumen bacteria and grazing Leucaena leucocephala-grass or natural pastures. The Journal of Agricultural Science 138: 103-113.

Al-Eissa, M. S., Alkahtani, S., Al-Farraj, S. A., Alarifi, S. A., Al-Dahmash, B., & Al-Yahya, H. 2012. Seasonal variation effects on the composition of blood in *Nubian ibex* (Capra nubiana) in Saudi Arabia. African Journal of Biotechnology 11: 1283-1286.

Allen, H. K., Donato, J., Wang, H. H., Cloud-Hansen, K. A., Davies, J., & Handelsman, J. 2010. Call of the wild: antibiotic resistance genes in natural environments. Nature Reviews Microbiology 8: 251-259.

Allison, R.W. 2012a. Laboratory evaluation of plasma and serum proteins. In: Thrall, M.A., Weiser, G., Allison, R.W., & Campbell, T.W. (eds) Veterinary Hematology and Clinical Chemistry, 2nd edn. Wiley-Blackwell, USA, p. 460- 475.

Allison, R.W. 2012b. Laboratory evaluation of the liver. In: Thrall, M.A., Weiser, G., Allison, R.W., & Campbell, T.W. (eds) Veterinary Hematology and Clinical Chemistry, 2nd edn. Wiley-Blackwell, USA, p. 401- 424.

Al-Seaf, A. M., & Al-Harbi, K. B. 2012. Variability of disease resistance, hematological parameters and lymphocyte proliferation in two goat breeds and their F1 and F2 crosses. International Journal of Food Agriculture & Veterinary Sciences 2: 47-53.

Atasoglu, C., Yurtman, I. Y., Savas, T., Gültepe, M., & Özcan, Ö. 2008. Effect of weaning on behavior and serum parameters in dairy goat kids. Animal Science Journal 79: 435-442.

Bearson, B. L., & Brunelle, B. W. 2015. Fluoroquinolone induction of phage-mediated gene transfer in multidrug-resistant *Salmonella*. International Journal of Antimicrobial Agents 46: 201-204.

Belewu, M. A., & Ogunsola, F. O. 2010. Haematological and serum indices of goat fed fungi treated Jatropha curcas kernel cake in a mixed ration. Journal of Agricultural Biotechnology and Sustainable Development 2: 35-38.

Belewu, M., & Ojo-Alokomaro, K. O. 2007. Haematological indices of West African dwarf goat fed leaf meal based diets. Bulgarian Journal of Agricultural Science 13: 601-606.

Bertino Jr, J., & Fish, D. 2000. The safety profile of the fluoroquinolones. Clinical Therapeutics 22: 798-817.

Blum, J. W., & Hammon, H. 2000. Colostrum effects on the gastrointestinal tract, and on nutritional, endocrine and metabolic parameters in neonatal calves. Livestock Production Science 66: 151-159.

Brosnan, J. T., & Brosnan, M. E. 2010. Creatine metabolism and the urea cycle. Molecular Genetics and Metabolism 100: S49-S52.

Brown, S.A. 1996. Fluoroquinolones in animal health. Journal of Veterinary Pharmacology and Therapeutics 19: 1-14.

Chiesa, L., Nobile, M., Arioli, F., Britti, D., Trutic, N., Pavlovic, R., & Panseri, S. 2015. Determination of veterinary antibiotics in bovine urine by liquid chromatography–tandem mass spectrometry. Food Chemistry 185: 7-15.

Christian, J. A., & Pugh, D. G. 2012. Reference Intervals and Conversions In: Pugh, D. G., & Baird, N. N. (eds) Sheep & goat medicine, 2nd edn. Elsevier, Missouri, p. 596- 600.

Damián, J. P., Sacchi, I., Reginensi, S., De Lima, D., & Bermúdez, J. 2008. Cheese yield, casein fractions and major components of milk of Saanen and Anglo-Nubian dairy goats. Arquivo Brasileiro de Medicina Veterinária e Zootecnia 60: 1564-1569.

Di Rienzo, J.A., Casanoves, F., Balzarini, M.G., Gonzalez, L., Tablada, M., Robledo, C.W. 2016. Grupo InfoStat, FCA, Universidad Nacional de Córdoba, Argentina. URL: http://www.infostat.com.ar.

Ebert, I., Bachmann, J., Kühnen, U., Küster, A., Kussatz, C., Maletzki, D., & Schlüter, C. 2011. Toxicity of the fluoroquinolone antibiotics enrofloxacin and ciprofloxacin to photoautotrophic aquatic organisms. Environmental Toxicology and Chemistry 30: 2786-2792.

Elmas, M., Tras, B., Kaya, S., Bas, A. L., Yazar, E., & Yarsan, E. 2001. Pharmacokinetics of enrofloxacin after intravenous and intramuscular administration in Angora goats. Canadian Journal of Veterinary Research 65: 64-67.

Etim, N. N., Williams, M. E., Akpabio, U., & Offiong, E. E. 2014. Haematological parameters and factors affecting their values. Agricultural Science 2: 37-47.

Fish, D. N. 2001. Fluoroquinolone adverse effects and drug interactions. Pharmacotherapy 21: 253S-272S.

Flammer, K., Aucoin, D. P., & Whitt, D. A. 1991. Intramuscular and oral disposition of enrofloxacin in African grey parrots following single and multiple doses. Journal of Veterinary Pharmacology and Therapeutics 14: 359-366.

Gandolf, A. R., Papich, M. G., Bringardner, A. B., & Atkinson, M. W. 2005. Pharmacokinetics after intravenous, subcutaneous, and oral administration of enrofloxacin to alpacas. American Journal of Veterinary Research 66: 767-771.

Ghosh, S., & LaPara, T. M. 2007. The effects of subtherapeutic antibiotic use in farm animals on the proliferation and persistence of antibiotic resistance among soil bacteria. The ISME Journal 1: 191-203.

Gonzalez, F., San Andrés, M. I., Nieto, J., San Andrés, M. D., Waxman, S., Vicente, M. L., & Rodríguez, C. 2001. Influence of ruminal distribution on norfloxacin pharmacokinetics in adult sheep. Journal of Veterinary Pharmacology and Therapeutics 24: 241-245.

Guevara, J. C., Grünwaldt, E. G., Estevez, O. R., Bisigato, A. J., Blanco, L. J., Biurrun, F. N., & Allegretti, L. I. 2009. Range and livestock production in the Monte Desert, Argentina. Journal of Arid Environments 73: 228-237.

Handin, R.I., Lux, S.E., & Stossel, T.P. 2003 Blood: principles and practice of hematology, 2nd edn. Lippincott Williams & Wilkins, Philadelphia.

Hu, X., Zhou, Q., & Luo, Y. 2010. Occurrence and source analysis of typical veterinary antibiotics in manure, soil, vegetables and groundwater from organic vegetable bases, northern China. Environmental Pollution 158: 2992-2998.

Jackson, P. G. G, & Cockcroft, P. D. 2002. Appendix 3: Laboratory reference values: Biochemistry. In: Jackson, P. G. G., & Cockcroft, P. D. (eds) Clinical examination of farm animals. Blackwell Science Ltd, Malden, USA, p. 303–305.

Ježek, J., Klopčič, M., & Klinkon, M. 2006. Influence of age on biochemical parameters in calves. Bulletin of the Veterinary Institute in Pulawy 50: 211-214.

Jones, M., Meisner, M. D., Baird, A. N., & Pugh, D. G. 2012. Diseases of the Urinary System. In: Pugh, D. G., & Baird, N. N. (eds) Sheep & goat medicine, 2nd edn. Elsevier, Missouri, p. 325-333.

Khan, T. A., & Zafar, F. 2005. Haematological study in response to varying doses of estrogen in broiler chicken. International Journal of Poultry Science 4: 748-751.

Khazaeil, K., Mazaheri, Y., Hashemitabar, M., Najafzadeh, H., Morovvati, H., & Ghadrdan, A. R. 2012. Enrofloxacin effect on histomorphologic and histomorphometric structure of limb articular cartilage. Global Veterinaria 9: 447-453.

Lama, S. P., Grilli, D., Egea, V., Fucili, M., Allegretti, L., & Guevara, J. C. 2014. Rumen development and blood metabolites of Criollo kids under two different rearing systems. Livestock Science 167: 171-177.

Lérias, J. R., Peña, R., Hernández-Castellano, L. E., Capote, J., Castro, N., Argüello, A., & Almeida, A. M. 2015. Establishment of the biochemical and endocrine blood profiles in the Majorera and Palmera dairy goat breeds: the effect of feed restriction. Journal of Dairy Research 82: 416-425.

Manzella, J. P., & Clark, J. K. 1988. Effects of quinolones on mitogen-stimulated human mononnclear leucocytes. Journal of Antimicrobial Chemotherapy 21: 183-186.

Mohammed, S. A., Razzaque, M. A., Omar, A. E., Albert, S., & Al-Gallaf, W. M. 2016. Biochemical and hematological profile of different breeds of goat maintained under intensive production system. African Journal of Biotechnology 15: 1253-1257.

Morris, D.D. 2014. Collection and submission of samples for cytologic hematologic studies. In: Smith, B. P. (eds) Large animal internal medicine, 4th edn. Mosby Elsevier, New York, USA, p. 410.

Naggy, D. W., Pugh, D. G. 2012. Handling and Examining Sheep and Goats, In: Pugh, D.G., & Baird, N. N. (eds) Sheep & goat medicine, 2nd edn. Elsevier, Missouri, p. 2-17.

Olafadehan, O. A. 2011. Changes in haematological and biochemical diagnostic parameters of Red Sokoto goats fed tannin-rich Pterocarpus erinaceus forage diets. Veterinarski arhiv 81: 471-483.

Öztabak, K., & Özpinar, A. 2006. Growth performance and metabolic profile of Chios lambs prevented from colostrum intake and artificially reared on a calf milk replacer. Turkish Journal of Veterinary and Animal Sciences 30: 319-324.

Piccione, G., Sciano, S., Messina, V., Casella, S., & Zumbo, A. 2011. Changes in serum total proteins, protein fractions and albumin-globulin ratio during neonatal period in goat kids and their mothers after parturition. Annals of Animal Science 11: 251-260.

Sarkozy, G. 2001. Quinolones: a class of antimicrobial agents. Veterinarni Medicina-Praha 46: 257-274.

Scarpino, F. B. O., Ezequiel, J. M. B., Silva, D. A. V., & Van Cleef, E. H. C. B. 2014. Óleo de soja e óleo de soja residual em dietas para ovinos confinados: parâmetros sanguíneos. Archivos de Zootecnia 63: 207-210.

Servicio Nacional de Sanidad y Calidad Agroalimentaria (SENASA). 2017. http://www.senasa.gob.ar/cadena-animal/caprinos. Accessed 26 November 2017.

Terra, R. L., Reinolds, J. P. 2014. Ruminant history, physical examination, welfare assessment, and records. In: Smith, B. P. (eds) Large Animal Internal Medicine, 5th edn. Mosby Elsevier, Missouri, p. 2-12.

Traş, B., Maden, M., Baş, A. L., Elmas, M., & Civelek, T. 2001. Investigation of Biochemical and Haematological Side effects of Enrofloxacin in Dogs. Transboundary and Emerging Diseases 48: 59-63.

Van Boeckel, T. P., Brower, C., Gilbert, M., Grenfell, B. T., Levin, S. A., Robinson, T. P., & Laxminarayan, R. 2015. Global trends in antimicrobial use in food animals. Proceedings of the National Academy of Sciences 112: 5649-5654.

Waxman, S., San Andres, M. D., Gonzalez, F., San Andres, M. I., De Lucas, J. J., & Rodriguez, C. 2004. Age related changes in the pharmacokinetics of marbofloxacin after intravenous administration in goats. Journal of Veterinary Pharmacology and Therapeutics 27: 31-35.

Zanker, I. A., Hammon, H. M., & Blum, J. W. 2001. Activities of γ Glutamyltransferase, Alkaline Phosphatase and Aspartate Aminotransferase in Colostrum, Milk and Blood Plasma of Calves Fed First Colostrum at 0–2, 6–7, 12–13 and 24–25 h after Birth. Transboundary and Emerging Diseases 48: 179-185.

Received: 12th March 2018.
Accepted: 13th April 2018.