Evaluation of Three Deworming Methods and their Long-Term Effect on the Weight of Buffaloes Raised in Silvopastoral Systems

Efraín Chacón-Condori[1], Wimar Díaz[1], Carlos Sonabi[1], Jorge Hinojosa[1], Luis Alberto de la Cruz-Cruz[2,3] and Jesús Alfredo Berdugo-Gutiérrez[4,*]

[1]*Career in Tropical Agriculture and Management of Renewable Resources "CATREN" of the Faculty of Agricultural, Livestock and Forestry Sciences "Martín Cádenas" (FCAPyP) of the Universidad Mayor de San Simón (UMSS), Cochabamba, Bolivia*

[2]*Preservation of Animal Welfare/Wildlife Management, Department of Agricultural and Animal Production, Universidad Autónoma Metropolitana, Xochimilco, Calzada del Hueso 1100, Col, Villa Quietud, Mexico City, 04960, Mexico*

[3]*School of Health Sciences, Veterinary Medicine and Zootechnics, University of the Valley of Mexico-Coyoacán, Calzada de Tlalpan 04910, Mexico City, Mexico*

[4]*Universidad Nacional de Colombia, Sede Orinoquia. Km 9. Via Tame-Arauca- Grupo de Investigación en Ciencias de la Orinoquia*

Abstract: *Purpose of the Study*: The present work aimed to evaluate the effect of three deworming methods on body weight gains in buffaloes raised in silvopastoral systems (SPS).

Methods: Thirty buffaloes were divided into three groups (ten per group) as follows: 1) Albendazole 10 g + 1.3 g of cobalt sulfate at one week of age and 14 days later; 2) Albendazole 10 g + 1.3 g of cobalt sulfate at one week of age and 14 days later, then at 6 months and 14 days later; 3) Ivermectin 1 g at 30 days of age and then at six months of age. Birth, weaning (9 months), and final (18 months) weight were registered, and daily weight gains were calculated. The McMaster technique was used to evaluate the presence of parasites.

Results: The overall prevalence of parasites in the animals evaluated was 93.33%. The most common parasites were: Strongylus sp., Neoascaris sp., Moniezia sp., and Eimeria sp. Before the application of the dewormers, initial values in G1, G2, and G3 were 360, 350, and 210 hpg/opg; after the application of the treatments, 60, 25, and 20 hpg/opg were obtained, respectively. Buffaloes in G2 showed significantly (P=0.046) high final weights (415.10±23.76 kg) compared to G1 (354.80±46.71 kg) but showed no difference with G3 (374.80±43.60k).

Conclusion: It is concluded that albendazole at 10 g and a repeat at six months of age can be used in buffalo breeding in SPS, which could help to implement regenerative livestock programs, decreasing the use of Ivermectin.

Keywords: Palabras clave, Buffalo calves, Daily Gain, Albendazole, Ivermectin.

INTRODUCTION

The water buffalo was introduced to Bolivia in 1964 from Brazil, and it is estimated that there are currently around 50,000 animals distributed in the country. Initially, the objective of buffalo breeding was the conservation and preservation of the species; however, since 2013, buffalo production has been used for the production of meat and milk in alternative grazing systems such as Voisin rotational grazing (PRV) and Silvopastoral Systems (SPS) [1].

SPS is a particular type of agroforestry system that combines animals, forages, plants, and trees in the same area that could be adopted to provide thermal comfort to animals through the shade provided by trees [2]. Water buffalo rearing in SPS has become a promising alternative to improve rearing conditions in the tropics compared to traditional systems [3, 4], as they improve animal welfare [5, 6] and increase productivity [7, 8]. In addition, it has been reported that animals raised in SPS show low amounts of parasites [5, 6], possibly because in these systems exist a varied fauna in the soil that contributes to the rapid decomposition of excreta. The rotation of pastures reduces cattle access to the infective stages of parasites [9].

Gastrointestinal parasitism in water buffalo causes significant economic losses, especially when parasite loads are high, resulting in reduced weight gain or even death of animals, particularly young animals [10, 11]. Gastrointestinal nematodes are the most frequent parasites of ruminants worldwide and represent a problem in production units [12]. The most frequent nematodes identified in young buffaloes are: *Trichostrongylus* sp., *Strongyloides* sp., *Trichuris* sp.,

*Address correspondence to this author at the Latin American Buffalo Center, Carrera 68 No. 42-25 Medellín, Colombia; Tel: +57 310 5059801;
E-mail: investigacionbufalina@gmail.com

and the protozoan *Eimeria* sp. and the tapeworm (*Cestoda) Moniezia* sp., among others genus [10, 13, 14].

The control of gastrointestinal nematodes in ruminants has been mainly based on the administration of dewormers, and it has been reported that it causes the appearance of resistant parasites [15], so SPS and paddock rotation could be an alternative for the management of ruminants in tropical systems. Therefore, the objective of the present work was to evaluate the effect of three deworming methods on body weight gains in buffaloes raised in SPS.

MATERIALS AND METHODS

This work was performed between 2019-2020 in Belonging to Saint Simon Major University, located 232 Km from Cochabamba City, 17°10'58" de latitude south 64°78'76" de longitude west, 219 ovsl, average annual temperature 26°C, humidity 75-80% and average annual rainfall 3850 mm [16]. For sample collection, the animals were handled according to the ethical guidelines of the Faculty of Agricultural, Livestock, and Forestry Sciences "Martín Cádenas" (FCAPyP) of the Saint Simon Major University (UMSS) and based on Bolivian laws for the protection of experimental animals (Law No. 4489 and Law No. 700).

Animals

Thirty young buffaloes were allocated into three groups (five males and five females). The calves were born between January and April 2019. Each group was assigned to one of the following treatments: 1) Albendazole 10 g + 1.3 g of cobalt sulfate (Vetalben®, Laboratorios Quimtia, Peru) at one week of age with reinforcement at 14 days later; 2) Albendazole 10 g + 1.3 g of cobalt sulfate (Vetalben®, Laboratorios Quimtia, Peru) at one week of age with reinforcement at 14 days and a third dose at 6 months of age and a reinforcement at 14 days later; 3) Ivermectin 1 g (Ivermic 1%®, Laboratorios Microsules Uruguay S.A.) at 30 days and reinforcement at six months of age. The quantity of each protocol was adjusted to the weight according to the manufacturer's instructions. In addition, the animals were subjected to a sanitary program for the control of foot and mouth disease (Biaftogen®, Biogénesis Bagó) and Clostridia (Providean Clostridial 8®, Tecnovax).

The mothers of the buffaloes were milked once a day between 5:00 and 6:00 hours (mainly three-quarters of the udder). The calf was used as a stimulus to promote milk ejection. After milking, the calves were kept with the mother, so they were fed with one of the quarters of the udder and residual milk. The calves were separated from dams each day at noon and stayed separated in some barns with grass and water until the next day at a milking time until weaning. Animals were grazed in an SPS system distributed in 15 paddocks of 38 hectares with 85% of native grasses: *Panicoideae: Andropogon, Axonopus, Cenchrus, Coix, Digitaria, Echinochloa, Eriochloa, Hyparrehenia, Melinis, Panicum, Paspalum, Pennisetum, Setaria, Stenotaphrum, Tripsacum*. *Panicoideae, Chloridoideae y Ehrhartoideae (leersia)* and 15 % of improved pastures *Brachiaria MG*5, *Brachiaria mulato II*, *Brachiaria Brizanta, Brachiaria decumbens* y *Megathyrsus maximus* (mombasa). Each paddock has a water source and trees for shade (*Gmelina arborea, Tabebuia sp*., *Alnus sp*., *Ficus sp.*, *Guarea guidonia*, *Terminalia sp., Psidium guajava*). Additionally, animals were supplemented with minerals once a week.

Sampling and Parasitological Analysis

Before starting the administration of the dewormers, a sample of 10 gr of feces was obtained directly from the rectus and transferred to polyethylene bags (20 x 30 cm), refrigerated at 4 ^{o}C, and transported to the laboratory CATREN-Valle Sacta. The McMaster Technique was used; coccidial oocysts (opg) and nematode eggs (hgp) were determined using a saturated sugar-salt solution (1 L of saturated NaCl solution with 500 g of sugar). The intensity of infection was determined by multiplying by 50 the number of eggs and oocysts counted in the two-chamber reticles, according to the methodology used by Pinilla [17]. The oocysts and eggs were characterized with the methodology of Rodríguez *et al*. [18] and Alcalá-Canto and Figueroa [19].

All animals were weighed at birth, weaning, and 18 months old using an electronic scale (ALLFLEX, Model F600, Brazil). Likewise, the monthly weight gains (kg) and the daily weight gains (kg) will be calculated.

Statistical Analysis

Weight gains were calculated and compared using a mixed linear model for repeated observations (JMP®, 1989-2019), using as variables the treatment (G1, G2, and G3) and weight (birth, weaning, 18 months), the interaction between group and weight as fixed effects, and the animal within the group as an aleatory effect.

Data were evaluated for normality before ANOVA. The least significant difference (LSD) criterion was used for mean comparisons. The effect of sex was not considered as part of the model due to a lack of statistical differences. Tukey tests were used for comparisons, and p<0.05 were considered statistically significant. The prevalence of parasitosis was determined by dividing the number of positive animals by the total number of animals in the population sampled by a group. The results obtained were analyzed using descriptive statistics.

RESULTS

The overall prevalence of parasites in the animals evaluated was 93.33 % (n=28). Before the application of the dewormers, the initial egg count in G1, G2, and G3 were 360, 350, and 210 hpg/opg; after the treatments, the results were 60, 25, and 20 hpg/opg. A reduction of 83.33, 92.85 y 90.47%, respectively, have been observed. No clinical signs related to parasitosis were observed in the present study. Table **1** shows the different parasitic genera found in the study, of which the most prevalent ones were: *Strongyloides* sp., *Neoascaris* sp., *Moniezia* sp., y Eimeria sp. (Figure **1**). After six months of age, no parasites were recorded in the three groups of animals evaluated.

Table **2** shows the weight gains of the calves at different times. No significant differences were observed at birth (P=0.25) and nine months (P=0.70). However, the final weight was higher in G2 (P=0.046), 60 kg more compared to G1, but with no differences compared to group 3.

Table 1: Genus, Number, and Prevalence of Parasite Infections in Buffaloes Raised in the SPS System

Genus	Positive (n)			Prevalence (%)			Intensity of infection (opg/hpg)		
	G1	G2	G3	G1	G2	G3	G1	G2	G3
Strongylus sp.	6	3	6	60	30	60	60	30	60
Neoascaris sp.	5	7	5	50	70	50	130	120	130
Moniezia sp.	9	9	9	90	90	90	250	170	250
Eimeria sp.	3	5	3	30	50	30	50	100	50

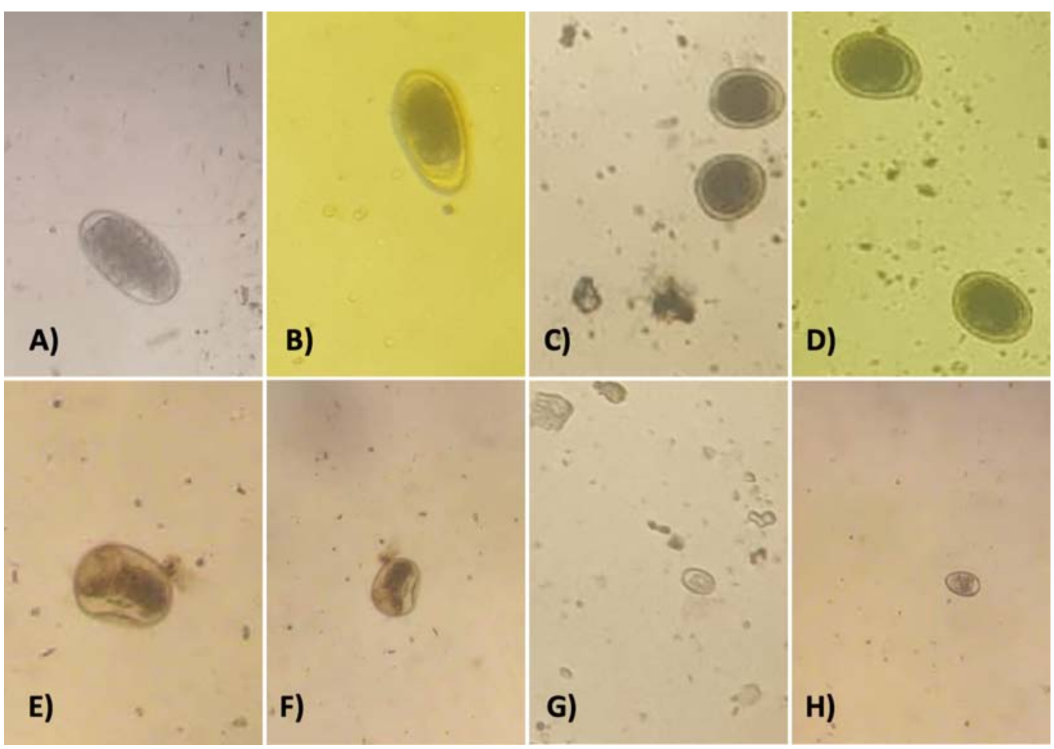

Figure 1: Gastrointestinal parasite eggs found in calf feces, using the McMaster technique, at CATREN-Valle Sacta: **A**, **B**) *Strongylus* sp.; **C**, **D**) *Neoascaris* sp.; **E**, **F**) *Moniezia* sp.; **G**, **H**) *Eimera* sp.

Table 2: Weight Gains in Buffaloes at Birth, at Nine Months of Age, and at 18 Months

Group	Birth Weight (P-value=0.2564)	Weaning Weigh (9m) (P-value=0.703)	Final weight (18 m) (P-value=0.046)
G1	37.40±0.22	213.60±57.74	354.80±46.71^{B}
G2	37.80±0.29	253.50±35.28	415.10±23.76^{A}
G3	37.20±0.24	211.60±33.63	374.80±43.60^{AB}

^{A,B}Different letters in each column indicate significant statistical differences by group effect.

Table 3: Calculated Monthly and Daily Weight Gains in Buffaloes from Birth to 18 Months

Group	Monthly weight gain (P-value=0.0153)	Daily weight gain (P-value=0.0153)
G1	16.71±0.82B	0.55±0.2^{B}
G2	19.83±0.74A	0.66±0.02^{A}
G3	17.72±0.73AB	0.59±0.02^{AB}

^{A,B}Different letters in each column indicate significant statistical differences by group effect.

Table **3** shows the monthly and daily weight gains of the buffaloes. Higher monthly (P=0.01) and daily (P=0.01) weight gains were recorded in group 2 animals concerning group 1 animals, but no differences were observed concerning group 3 animals (P>0.05).

DISCUSION

Buffaloes are easily adapted to wet and swampy soils, which is an advantage for producers who own land under this condition. However, these environments are suitable for spreading bacteria and parasites in adult animals, especially young ones [20]. The overall prevalence of parasites in the animals evaluated was 93.33 %. However, no animal showed signs of disease during the present work due to gastrointestinal parasites. Generally, buffaloes are considered resistant to clinical diseases related to gastrointestinal parasites [21]. Buffalo calves from the present study remained in contact with their mothers after delivery, which ensured the transfer of passive immunity [22]. Therefore, parasitic infections may have been subclinical in all animals due to pre-immunity against parasites. Likewise, according to Rodríguez *et al*. [18], the intensity of the infection was less than 300 opg/epg per gram, which is considered a mild infection.

The prevalence of parasites in the present study was high compared to studies in calves reported in Romania (86.80 %) [23], Mexico (60.00 %) [10], and India (32.50 %) [14]. It is important to mention that the mothers of the buffalo calves evaluated were not dewormed. Therefore, in previous studies, it is mentioned that some parasites have the ability to cross the placenta and infect the whelks before birth, in addition to trans-mammary transmission [18, 24]. In addition, agro-climatic conditions (temperature and humidity) of the regions where the buffalo are reared represent a favorable environment for the lifecycle of parasites [10, 17].

After deworming, a reduction in parasites was lower than 100% (range 83-92%), showing some degree of dewormer resistance. This was observed in a study with buffalo calves in the Mexican tropics, where the efficiency of different dewormers was found to be ≥ 94% for gastrointestinal nematodes of the *Strongylidae* family [15]; the authors conclude that indiscriminate use, under or overdosing, as well as genetic mechanisms could be associated with this problem.

Prada-Sanmiguel and Plazas-Caro [24], regarding the elimination of eggs per gram of fecal matter of the order *Strongylida* and the genera *Strongyloides*, *Neoascaris*, and *Eimeria* in buffaloes from different ages found in animals under 12 months of age the most constant parasite eggs throughout the year were *Strongyloides* sp. and oocysts of *Eimeria* sp; in the group from 13 to 36 months of age and older than 37 months, the most constant parasites were of the order *Strongylida* and the genus *Eimeria* sp, being the eggs of *Trichuris* sp.

From the results of this research, at birth, Strongyloides, *Neoascaris vitulorum*, *Moniezia benedeni* y *Eimeria* were identified. León [25] reported that albendazole at 15% presented a greater effect on gastrointestinal parasites in buffalo calves compared to

Ivermectin at 1.5%. In the present work, a similar result was evidenced at albendazole at 10%, compared to Ivermectin at 1%. In addition, final weights in G2 were higher (P=0.046) than those obtained in G1 but no differences with G3. It is known that one of the problems with the use of ivermectins is that their excretion in the feces affects some insects associated with manure, especially their larval forms, which has been observed to delay the degradation of fecal matter and the incorporation of nutrients in the soil, in addition to adverse effects on water reserves [26, 27].

After six months of age, no parasites were recorded in the three groups of animals evaluated, similar to what has been found in other studies [28]. It is important to mention that the buffaloes in the present study were raised in SPS, which are systems that combine shrubs/trees and forages with livestock activities, which is related to good land use policies, productivity, and socioeconomic benefits [29]. It has also been observed that they can decrease parasite loads in animals. Soca *et al.* [30] found significant differences in favor of the SPS, which showed lower parasite infestation values in both seasons (dry and rainy) with respect to the traditional system. Additionally, previous studies in cattle have shown that rotational grazing is a potential strategy to reduce livestock losses caused by high ecto- and endoparasite loads in cattle, especially in the hot and wet seasons [31]. This could be explained by the fact that these systems favor the rapid decomposition of excreta and pasture rotation, which reduces the exposure of cattle to the different infective stages of parasites [9]. Additionally, the inclusion of trees in pastures has been related to a decrease in parasitic diseases by *Haemonchus* and *Ostertagia* in buffaloes due to the presence of condensed tannins and polyphenols with antiparasitic effect [5].

CONCLUSIONS

The findings of the present study represent an important step for future studies to develop sustainable control programs in alternative production systems such as SPS. Rearing buffaloes in SPS can use albendazole at 10% and a repeat at six months of age, which could help the implementation of regenerative livestock programs by decreasing the use of Ivermectin.

APPROVAL FOR PUBLICATION

The authors declare that the producers and the CATREN livestock unit agree to publish the information derived from the research work, recorded photographic material, and field data.

AVAILABILITY OF DATA AND MATERIAL

All the data and material of this research are available from the authors on request.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest with respect to the publication of this manuscript.

ACKNOWLEDGEMENT

The authors express their gratitude to the Tropical Agriculture and Renewable Resources Management Career Unit (CATREN-Valle Sacta, Bolivia) for their contributions to successfully completing this bubalinoculture research. Luis Alberto de la Cruz-Cruz is a member of the National System of Researchers (SNI-CONACyT).

REFERENCES

[1] Quiles-Skorc L. Buffalo in Bolivia. Buff News 2021; 37: 24-26.

[2] Alves dos Santos NF, Rodrigues da Silva JA, Alencar de Araújo A, Batista VR, Rosseto-García A, Santana BA, de Souza B, Brito Lourenco JJ. Silvopastoral Systems Contribute to Water Buffalo Welfare and Normal Behavior Pattern Under Eastern Amazon Conditions. J Agric Stud 2021; 9: 260-271. https://doi.org/10.5296/jas.v9i2.18022

[3] Garcia AR, Matos LB, Lourenco JD, Nahum BD, de Araujo CV, Santos AX. Physiological features of dairy buffaloes raised under shade in silvipastural systems. Pesqui Agropecu Bras 2011; 46: 1409-1414. https://doi.org/10.1590/S0100-204X2011001000039

[4] Castro AC, Lourenco JD, dos Santos NDA, Monteiro EMM, de Aviz MAB, Garcia AR. Silvopastoral system in the Amazon region: tool to increase the productive performance of buffaloes. Cienc Rural 2008; 38: 2395-2402. https://doi.org/10.1590/S0103-84782008000800050

[5] Galloso-Hernandez MA, Rodriguez-Estevez V, Alvarez-Diaz CA, Soca-Perez M, Dublin D, Iglesias-Gomez J, Simon GL. Effect of Silvopastoral Systems in the Thermoregulatory and Feeding Behaviors of Water Buffaloes Under Different Conditions of Heat Stress. Front Vet Sci 2020; 7: 1-8. https://doi.org/10.3389/fvets.2020.00393

[6] Galloso-Hernandez MA, Rodriguez-Estevez V, Alvarez-Diaz CA, Soca-Perez M, Dublin DR, Iglesias-Gomez J, Simon GL. Selectivity of Leguminous Trees by Water Buffaloes in Semi-intensive Systems. Front Vet Sci 2020; 7: 1-9. https://doi.org/10.3389/fvets.2020.542338

[7] Peixoto MRS, Lourenco JB, Faturi C, Garcia AR, Nahum BS, Lourenco LFH, Meller LH, Oliveira KCC. Carcass quality of buffalo (Bubalus bubalis) finished in silvopastoral system in the Eastern Amazon, Brazil. Arq Bras Med Vet Zootec 2012; 64: 1045-1052. https://doi.org/10.1590/S0102-09352012000400034

[8] Gomez JMI, Galloso-Hernandez MA, Toral-Perez OC, Aguilar-Hernandez A. Productive performance and behavior

of grazing river buffaloes and Zebu bulls in a silvopastoral system. Pastos y Forrajes 2019; 42: 223-229.

[9] Soca-Perez M, Simón L, Francisco AG. Comportamiento de las nematodosis gastrointestinales de bovinos jovenes en un sistema silvopastoril. Pastos y Forrajes 2000; 23: 1-7.

[10] Ojeda-Robertos N, Torres-Chable OM, Peralta-Torres J, Luna-Palomera C, Aguilar-Cabrales A, Chay-Canul A, González GR, Machain WC, Camara SR. Study of gastrointestinal parasites in water buffalo (Bubalus bubalis) reared under Mexican humid tropical conditions. Trop Anim Health Prod 2017; 49: 613-618. https://doi.org/10.1007/s11250-017-1237-4

[11] Amer S, Zidan S, Feng YY, Adamu H, Li N, Xiao LH. Identity and public health potential of Cryptosporidium spp. in water buffalo calves in Egypt. Vet Parasitol 2013; 191: 123-127. https://doi.org/10.1016/j.vetpar.2012.08.015

[12] AbouLaila M, Igarashi M, ElKhatam A, Menshawy S. Gastrointestinal nematodes from buffalo in Minoufiya Governorate, Egypt with special reference to Bunostomum phlebotomum. Vet Parasitol: Reg Stud Rep 2022; 27: 100673. https://doi.org/10.1016/j.vprsr.2021.100673

[13] Rinaldi L, Musella V, Veneziano V, Condoleo RU, Cringoli G. Helmintic infections in water buffaloes on Italian farms: a spatial analysis. Geospatial Health 2009; 3: 233-239. https://doi.org/10.4081/gh.2009.223

[14] Dappawar MK, Khillare BS, Narladkar BW, Bhangale GN. Gastrointestinal parasites of buffaloes from Udgir area of Marathwada: a coprological appraisal. Buffalo Bull 2020; 39: 285-291.

[15] Ojeda-Robertos NF, Aguirre-Serrano AM, Cardenas de la Cruz R, Hernández-Martínez LN, Peralta-Torres JA, Chay-Canul AJ, *et al*. Strongyloides sp. resistant to albendazole and levamisole in buffaloes from Mexico. Rev MVZ Cordoba 2022; 27: 1-6. https://doi.org/10.21897/rmvz.2227

[16] SENAMHI. Servicio nacional de Meteorología e Hidrología del Estado Plurinacional de Bolivia. Boletin Climatológico Ministerio de Medio Ambiente y agua, Bolivia; 2022. Available online at: https://www.senamhi.gob.bo/ (accessed November 19, 2022).

[17] Pinilla JC, Flórez P, Sierra M, Morales E, Sierra R, Vásquez MC, Tobon CJ, Sánchez A, Ortiz D. Prevalencia del parasitismo gastrointestinal en bovinos del departamento Cesar, Colombia. Rev Investig Vet Perú 2018; 29: 278-287. https://doi.org/10.15381/rivep.v29i1.14202

[18] Rodríguez-Vivas RI, Ojeda-Chi MM, Quintero-Martínez MT, Vergara-Pineda S. Examen coproparasitológico. In: Rodríguez-Vivas RI, editor. Técnicas para el diagnóstico de parásitos con importancia en salud pública y veterinaria. AMPAVE-CONASA 2015; pp. 78-128.

[19] Alcalá-Canto Y, Figueroa CJA. Diagnóstico de parásitos de interés en Medicina Veterinaria. 1st ed. CDMX-México: FMVZ-UNAM 2019. https://doi.org/10.22201/fmvz.9786073011556e.2019

[20] Grazzioto NM, Maidana SS, Romera SA. Susceptibilidad de los búfalos de agua frente a diferentes enfermedades infecciosas. Rev Vet 2020; 31: 215-223. https://doi.org/10.30972/vet.3124750

[21] de Barros LD, Garcia JL, Bresciani KDS, Cardim ST, Storte VS, Headley SA. A Review of Toxoplasmosis and Neosporosis in Water Buffalo (Bubalus bubalis). Front Vet Sci 2020; 7: 455. https://doi.org/10.3389/fvets.2020.00455

[22] de Souza DC, da Silva DG, Fonseca LCC, de Castro FL, Moura M B, Bernardes O, Batista V R, Jurandir FJ. Passive Immunity Transfer in Water Buffaloes (Bubalus bubalis). Front Vet Sci 2020; 7: 247. https://doi.org/10.3389/fvets.2020.00247

[23] Barburas DA, Cozma V, Ionica AM, Abbas I, Barburas R, Mircean V, Dámico G, Dubey JP, Gyorke A. Intestinal parasites of buffalo calves from Romania: molecular characterisation of Cryptosporidium spp. and Giardia duodenalis, and the first report of Eimeria bareillyi. Folia Parasitol 2022; 69: 015. https://doi.org/10.14411/fp.2022.015

[24] Prada-Sanmiguel GA, Plazas-Caro E. Curvas de eliminación de huevos por gramo de materia fecal de parásitos gastrointestinales en Búfalos de agua (Bubalus bubalis) del Magdalena Medio Colombiano. Rev Med Vet 2010; 19: 47-59. https://doi.org/10.19052/mv.779

[25] León DF, Gelvez JF, Ortega LE. Evaluación del efecto del ricobendazol e ivermectina sobre la carga de parásitos gastrointestinales en bucerros. Rev Fac Cien Agropec-FAGROPEC 2016; 8: 56-61.

[26] Halley BA, VandenHeuvel WJA, Wislocki PG. Environmental effects of the usage of avermectins in livestock. Vet Parasitol 1993; 48: 109-125. https://doi.org/10.1016/0304-4017(93)90149-H

[27] Mesa L, Gutiérrez MF, Montalto L, Perez V, Lifschitz A. Concentration and environmental fate of ivermectin in floodplain wetlands: An ecosystem approach. Sci Total Environ 2020; 706: 135692. https://doi.org/10.1016/j.scitotenv.2019.135692

[28] Bier D, Teruya S, Gonçalves D, Borges L, Paniago J, Neves L, dos Santos LB, de Almeida B F. Epidemiologia de helmintos gastrintestinais em búfalos epidemiology of gastrointestinal helminths in buffaloes. Ciênc Anim Bras 2018; 19: 1-9. https://doi.org/10.1590/1809-6891v19e-40882

[29] da Silva JAR, Garcia AR, de Almeida AM, Bezerra AS, de Brito Lourenco Junior J. Water buffalo production in the Brazilian Amazon Basin: a review. Trop Anim Health Prod 2021; 53: 343. https://doi.org/10.1007/s11250-021-02744-w

[30] Soca M, Francisco AG, Simón L, Roche R. Producción animal y biodiversidad en un sistema silvopastoril de formación natural. Pastos y Forrajes 2003; 26.

[31] Tavassoli M, Dalir-Naghadeh B, Valipour S, Maghsoudlo M. Prevalence of Gastrointestinal Parasites in Water Buffalo (Bubalus bubalis) Calves Raised with Cattle in Smallholder Farming System in the Northwest of Iran. Acta Vet Eurasia 2018; 44: 6-11. https://doi.org/10.5152/actavet.2018.003

Received on 20-12-2022 Accepted on 13-03-2023 Published on 16-05-2023

https://doi.org/10.6000/1927-520X.2023.12.09