Trakia Journal of Sciences, No 1, pp 18-24, 2023

Available online at:
http://www.uni-sz.bg

ISSN 1313-3551 (online) doi:10.15547/tjs.2023.01.003

Original Contribution

CLINICAL AND HEMATO-BIOCHEMICAL STUDIES ON GOATS NATURALLY INFESTED WITH SUCKING AND BITING LICE

N. Nizamov*, P. Iliev

Department of Veterinary Microbiology, Infectious and Parasitic Diseases, Faculty of Veterinary Medicine, Trakia University, Stara Zagora, Bulgaria

ABSTRACT

The current study was performed to assess the most common clinical symptoms and hemato-biochemical alterations in goats naturally infested with sucking and biting lice. A total of 4599 goats were included in the clinical investigation. The changes in concentrations of some hematological and biochemical parameters were evaluated using 20 naturally infested animals divided into 2 equal groups – group 1 (infested with *Bovicola caprae*) and group 2 (infested with *Linognathus stenopsis*). Blood samples were collected before the treatment with Eprinomectin and on the 30th and 60th-day post-treatment (DPT). After sampling, the blood was examined for changes in the complete blood cell count including RBC, HGB, HCT, RBC indices (MCV, MCH, MCHC, RDW), WBC, leukocyte differential count as well as some biochemical parameters (Ca, P, Fe, total protein, albumin, bilirubin, ASAT, ALAT, AP). Clinical demonstrations in infested goats were not specific, represented with rubbing, scratching, broken hairs, alopecia, skin secretion, inflamed lesions (papules), crusts, and keratinization. The changes found in the hematological and biochemical parameters were normocytic hypochromic anemia ($p<0.001$) and hypoferremia ($p<0.01$) in the goats infested with sucking lice (*L. stenopsis*) and leukocytosis ($p<0.001$), hyperproteinemia ($p<0.001$) and hyperalbumineamia ($p<0.05$) in the animals infested with biting lice (*B. caprae*). All changed parameters have returned to the reference ranges on the 30th and 60th DPT.

Key words: goat phthirapterosis, hematology, biochemical parameters, lice, *Linognathus stenopsis*, *Bovicola caprae*

INTRODUCTION

Phthirapterosis is among the most common ectoparasite infestation in goats, mainly caused by the lice *Linognathus stenopsis* and *Bovicola caprae* (1). Generally, the lice are obligate stationary ectoparasites that inhabit the surface of the host body through all the stages of their development. Sucking and biting lice have different types of feeding, depending on the food substrate and the structure of their mouth apparatus. Blood-sucking lice feed on blood and cause mild to moderate anemia (2). Biting lice use desquamated epithelial cells, secretions from mast and sweat glands, and skin bacteria as food (3).

The economic losses from phthirapterosis in affected hosts (e.g. weight loss, reduced milk production) very often exceed those of some acute infectious and parasitic diseases (4).

Phthirapterosis in goats manifests with scratching against nearby objects and sometimes biting to self-harm. The skin is usually without crusts but in cases of heavy infestation there can be wounding, inflamed skin lesions (papules, crusts), pruritus, excoriations, and secondary alopecia (4-6). Or said otherwise the clinical signs of phthirapterosis in goats are non-specific

***Correspondence to**: *Nikola S. Nizamov, Department of Veterinary Microbiology, Infectious and Parasitic diseases, Faculty of Veterinary Medicine, Trakia University, 6014 Stara Zagora, e-mail: nikola_nizamov@abv.bg, GSM: +359898332326*

and similar to those in other skin conditions, and usually correspond to the intensity of infestation. Results of several studies concerning the changes in hematological and biochemical parameters in goats infested with blood-sucking lice revealed the presence of hypoglycemia, erythropenia, leucopenia, olygochromemia, hypoproteinemia with hypoalbuminemia, eosinopenia, reduced MCV and decreased blood levels of cholesterol and triglycerides (1, 7).

In cases of infestation with the biting louse *B. caprae*, the goats present oligochromemia, erythropenia, leucocytosis, hypoglycemia, hypoproteinaemia with hypoalbuminemia and hyperglobulinemia and increased concentrations of serum cholesterol and triglycerides (1, 8).

In this connection, the severity of changes in levels of RBC, WBC, and biochemical profile in animals infested with lice depends on both louse and host species involved, as well as the intensity of the infestation (8). The authors reported changes in RBC in goats infested with blood-sucking lice, while in cases of biting lice infestation there have been changes in WBC.

Given the widespread prevalence of lice in goats, the economic losses from reduced productivity, and the lack of recent research we aimed to study the changes in clinical signs and hemato-biochemical parameters in goats naturally infested with lice.

MATERIALS AND METHODS

Clinical study

Clinical observations were performed on 4599 goats, and the results were interpreted using a grading scale according to Christodoulopoulos et al. (9). The animals were observed for a period of 15 minutes for signs of disturbance, rubbing against nearby objects and scratching. After that all animals were individually examined using a magnifying glass for presence of skin lesions, such as alopecia, crusts, nodules, as well as eggs and adult ectoparasites.

Lice collection and identification

The lice were collected with tweezers and kept in containers filled with 70^{o} ethanol. The specimens were gathered from 7 body parts (shoulder, chest, neck, flank, thigh, groin and abdomen) by using a paper square (**Figure 1**) with a square shape and size of 10 cm^2 (10). Species identification was done according to the descriptions of Furman & Catts (11) and Blagoveshensky (12).

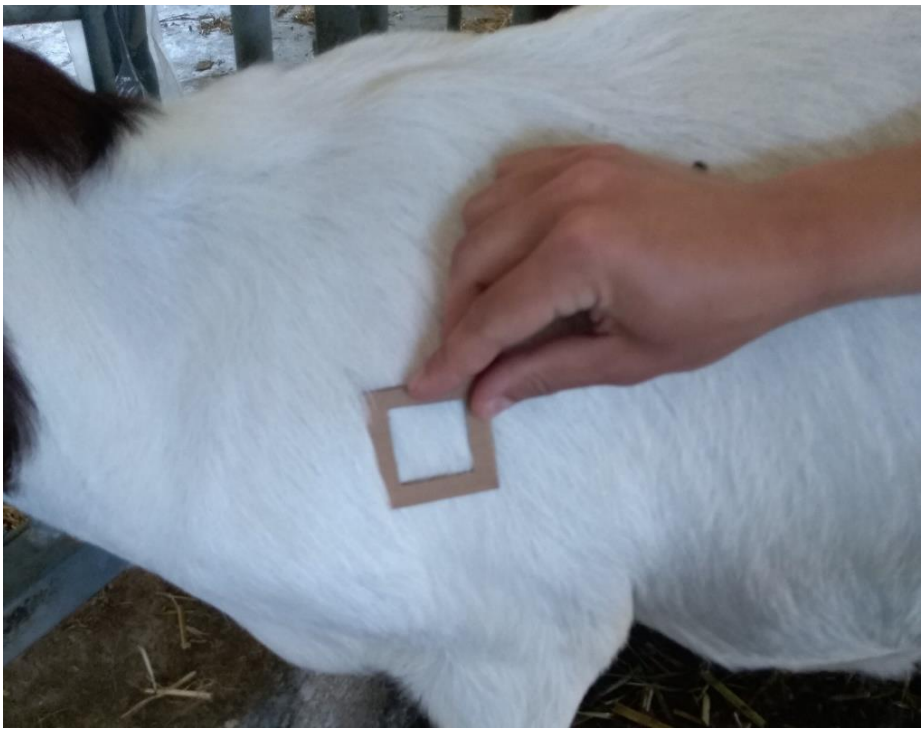

Figure 1. Square paper pattern for observation of the body of infested goats

Hemato-biochemical study

The influence of sucking and biting lice on the hematological and biochemical parameters was observed in 20 naturally infested goats aged between 1 and 2 years, reared on the premises, and fed on lucerne hay and grain. Experimental animals were divided into 2 equal groups – group 1 (infested with *B. caprae*) and group 2 (infested with *L. stenopsis*). The mean intensity of infestation was 5400 and 4100 *Lice Per Animal* (LPA) in group 1 and group 2 respectively. Prior to the study, the animals were examined for other ectoparasites by inspection, as well as for endoparasites through salt flotation technique, sedimentation method, and larvascopy by Baermann (13).

Infested goats were treated topically with eprinomectin (Eprinex multi® 5 mg/ml pour on, Boehringer Ingelheim Animal Health France SCS) at a dose of 1 mg/kg bodyweight. Blood samples were collected by venipuncture of *v. jugularis externa* into heparin vacutainers on day zero (before treatment) and on the 30th and 60th DPT. After sampling, the blood was used for determination of WBC, leukocyte differential count (Neu, Lym, Mon, Eos, Bas), RBC, RBC indices (MCV, MCH, MCHC, RDW), HGB, HCT (on Automatic hematologic analyzer BS-5000Vet, Mindray China), Ca, P, Fe, total protein, albumin, bilirubin, ASAT, ALAT, AP (on Automatic biochemistry analyzer BS-120, Mindray China).

Statistical analysis

The data were analyzed using one-way ANOVA (14). Obtained values were expressed as mean ($\bar{x}$) ± standard deviation (SD), and the differences were considered significant at $p<0.05$.

RESULTS AND DISCUSSION

The overall prevalence of the lice was 56.71% (2608 goats infested out of 4599 goats examined). Species identification revealed the presence of *B. caprae* and *L. stenopsis* as a single (n=644, 24.69%) or mixed (n=1964, 75.31%) infestation. Clinical signs corresponding to level 1 (disturbance, rubbing against objects, scratching) were observed in 41.22% of infested goats, followed by 25.08% to level 2 (secretion, broken hairs, alopecia) and 8.89% to level 3 (papules, crusts, keratinization). In addition, 24.81% of infested goats demonstrated no clinical signs and skin lesions. The lack of clinical appearance in infested animals is probably due to the low intensity of infestation. Our results are in general agreement to the data published by Nedelchev (4) concerning the clinical demonstration of lice infestation in goats. The symptomatology of phthirapterosis observed in the current study was non-specific and almost similar to other ectoparasitoses such as sarcoptosis, chorioptosis and melophagosis (15). Therefore, for determining a definitive diagnosis there should be more additional parasitological examinations including species isolation and identification.

The results of hematological parameters in *B. caprae* group (5400 LPA) showed that the WBC count is increased before treatment but without changes in leukocyte differential count (**Tables1 and 2**). On the 30th DPT WBC decreased and remained within reference ranges until the 60th DPT. That leukocytosis may be due to the active participation of WBC in the innate defense mechanisms against parasite infestations in the animals. A similar statement regarding the changes in WBC in goats infested with *B. caprae* was also reported (1). In contrast, Mehrotra and Singh (16) determined leukopenia and lack of significant difference in the number of eosinophils in sheep infested with *Damalinia ovis*. Prelezov (17) also determined leukocytosis in chickens infested with biting lice.

Table 1. *Changes in WBC (mean±SD) in goats naturally infested with B. caprae goats (n=10)*

Day post treatment	WBC x ± SD	Neu x ± SD	Lym x ± SD	Mon x ± SD	Eos x ± SD	Bas x ± SD
Before treatment	15.27 ± 2.32	6.07 ± 3.80	6.44 ± 3.12	0.50 ± 0.11	0.14 ± 0.03	0.10 ± 0.03
Day 30	10.44[3]±1.68	3.91 ± 1.68	5.69 ± 0.78	0.36 ± 0.19	0.42 ± 0.22	0.05 ± 0.02
Day 60	9.22[3]± 2.97	3.77 ±1.13	4.73 ± 2.10	0.18[3]± 0.10	0.36 ± 0.37	0.14 ± 0.10
Reference ranges	4.00 – 13.00	2.12 - 10.10	3.12 – 22.10	0.00 – 1.42	0.00 – 1.32	0.00 – 0.35

[a] - $p < 0.05$; [b] - $p < 0.01$; [c] - $p < 0.001$ – between groups in every interval;
[1] - $p< 0.05$; [2] - $p < 0.01$; [3] - $p < 0.001$ – compared to initial level.

Table 2. *Changes in leukocyte differential count (mean±SD) in goats naturally infested with B. caprae (n=10)*

Day post treatment	Neu (%)	Lym (%)	Mon (%)	Eos (%)	Bas (%)
Before treatment	45.88	47.80	4.13	1.38	0.10
Day 30	36.02	56.02	3.32	3.90	0.56
Day 60	42.73	49.19	2.02^{2a}	4.43	1.63^{b}
Reference ranges	13.0 – 58.0	35.0 – 83.0	0.0 – 11.0	0.0 – 8.0	0.0 – 2.5

[a] - $p < 0.05$; [b] - $p < 0.01$; [c] - $p < 0.001$ – between the groups in every interval;
[1] - $p < 0.05$; [2] - $p < 0.01$; [3] - $p < 0,001$ - compared to initial level.

Data of the red blood profile in *B. caprae* infested goats are presented in **Table 3**. Although there were some differences in RBC, HGB and HCT, all values showed no deviations from the reference range either before or after treatment with eprinomectin. This result may be explained with the specific morphology and type of feeding of the biting lice. These insects use desquamated epithelial cells, secretions from mast and sweat glands, epidermal cells and skin bacteria as food (3) but never blood (13). However, some authors revealed erythropenia in infested animals (1). This condition probably occurs secondarily as a result of the irritation, caused by lice, which disturbs the feeding and rest of the animal host.

Table 3. *Changes in RBC (mean±SD) in goats naturally infested with B. caprae (n=10)*

Parameter	$X_{Mean} \pm SD$			Reference ranges
	Before treatment	30 DPT	60 DPT	
RBC	12.81 ± 2.17	13.76^{a2} ± 1.10	13.92^{a2} ± 2.31	8.00 – 18.00
HGB	86.00 ± 18.74	92.40^{b3} ± 7.70	93.40^{b3} ± 22.25	80 – 120
HCT	24.11 ± 5.06	24.96^{b1} ± 2.12	26.66^{b3} ± 5.99	22.0 – 38.0
MCV	18.67± 1.65	18.16 ± 1.29	18.97 ± 10.35	16.0 – 25.0
MCH	6.66 ± 0.655	6.72 ± 0.41	6.61 ± 0.73	5.2 – 8.0
MCHC	356.70 ± 12.57	371.00^{b} ±11.45	348.40^{b} ± 10.35	300 – 360
RDW - CV	0.21 ± 0.00	0.21 ± 0.00	0.21 ± 0.00	0.180 – 0.300
RDW- SD	16.82 ± 1.52	16.58 ± 1.13	17.41 ± 1.71	12.1 – 23.1

[a] - $p < 0.05$; [b] - $p < 0.01$; [c] - $p < 0.001$ – between groups in every interval;
[1] - $p < 0.05$; [2] - $p < 0.01$; [3] - $p < 0.001$ – compared to initial level.

The average values of total protein and albumin in *B. caprae* infested goats were moderately elevated before treatment but became normal as early as the 30th DPT (**Table 4**). The high level of total protein during an infestation is probably due to the activation of the immune system, which leads to increased synthesis of immunoglobulins. This activation may be reviewed as a consequence of primary and secondary skin inflammation caused by the parasites themselves, or by scratching and biting as a result of pruritus. The blood concentration of Fe was within reference values, although there was a significant elevation on the 30th and 60th DPT when compared to the initial level. No changes were detected in concentrations of Ca, P, bilirubin, ASAT, ALAT, and AP (**Table 4**).

The results of hematological parameters in *L. stenopsis* group (4100 LPA) showed that the WBC count was in reference ranges except for the percentage of eosinophils, which were slightly increased before treatment, but normalized on the 30th DPT (**Table 5 and 6**). The elevation in circulating eosinophils is often associated with the presence of parasitic infections (18). It can be due to allergic reactions caused by the lice as well as inflammation as a part of the defense response of the host immune system (19). In contrast, Sharma et al. (7) and Ajitha et al. (1) revealed leucopenia in goats heavily infested with blood-sucking lice. In addition, the initial infestation usually leads to leukocytosis, while the prolonged progress of disease results in leukopenia.

Table 4. *Changes in biochemical parameters (mean±SD) in goats naturally infested with B. caprae (n=10)*

Parameters	$X_{Mean} \pm SD$			Reference ranges
	Before treatment	30 DPT	60 DPT	
Ca	2.56 ± 0.26	2.69 ± 0.21	2.91 ± 1.10	2.3 – 2.9
P	1.52 ± 0.40	1.48 ± 0.43	1.58 ± 7.70	1.4 – 2.9
Total protein	77.87 ± 7.46	74.26^{2c} ± 2.12	70.30^{3c} ± 5.89	61-75
Bilirubin	4.15 ± 1.15	5.73 ± 0.61	5.18 ± 1.29	1.7 – 7.0
ASAT	142.50 ± 1.99	153.88 ± 1.77	198.40 ± 0.41	66 – 230
ALAT	12.40 ± 2.79	14.80 ± 4.98	11.40 ±11.45	6 -19
AP	188.90 ± 3.84	217.50 ± 8.74	195.80 ± 6.87	61- 283
Albumin	37.54 ± 3.79	35.49^{a1} ± 3.11	34.64^{a2} ± 2.95	23 – 36
Fe	22.31 ± 4.84	23.53^{a1} ± 2.00	24.64^{a1} ±3.32	22 - 25

[a] - p < 0.05; [b] - p < 0.01; [c] - p < 0.001 – between groups in every interval;
[1] - p< 0.05; [2] - p < 0.01; [3] - p < 0.001 – compared to initial level.

Table 5. *Changes in WBC (mean±SD) in goats naturally infested with L. stenopsis (n=10)*

Day post treatment	WBC x ± SD	Neu x ± SD	Lym x ± SD	Mon x ± SD	Eos x ± SD	Bas x ± SD
Before treatment	9.97 ± 2.09	3.28 ± 2.20	5.50 ± 0.95	0.32 ± 0.27	0.75 ± 0.07	0.06 ± 0.04
Day 30	8.58 ± 1.50	3.01 ± 1.09	4.43 ± 1.10	0.32 ± 0.29	0.73^{a}± 0.19	0.08 ± 0.04
Day 60	11.37 ±2.65	4.12 ± 2.39	6.11 ± 2.17	0.71 ± 0.28	0.39^{a1}± 0.30	0.07 ± 0.03
Reference ranges	4.00 – 13.00	2.12 - 10.10	3.12 -22.10	0.00 – 1.42	0.00 – 1.32	0.00 – 0.35

[a] - p < 0.05; [b] - p < 0.01; [c] - p < 0.001 – between groups in every interval;
[1] - p< 0.05; [2] - p < 0.01; [3] - p < 0.001 – compared to the initial level.

Table 6. *Changes in leukocyte differential count (mean±SD) in goats naturally infested with L. stenopsis (n=10)*

Day post treatment	Neu (%)	Lym (%)	Mon (%)	Eos (%)	Bas (%)
Before treatment	34.60	51.96	3.66	8.79	0.99
Day 30	34.39	52.54	6.12	6.28	0.67
Day 60	31.68	60.15	3.06	4.43	0.68
Reference ranges	13.0 – 58.0	35.0 – 83.0	0.0 – 11.0	0.0 – 8.0	0.0 – 2.5

[a] - p < 0.05; [b] - p < 0.01; [c] - p < 0.001 – between groups in every interval;
[1] - p< 0.05; [2] - p < 0.01; [3] - p < 0.001 – compared to initial level.

Obtained values of red blood profile apparently indicate that no disturbances occur in the number RBC and corresponding RBC indices in *L. stenopsis* group (**Table 7**). Changes were observed in the levels of HGB and HCT which were decreased at the beginning of the trial. However, MCV and MCH values bordered the lower reference limit. These results indicate the presence of normocytic normochromic anemia, which is not surprising considering that the lice use blood as food. Similar data have been also reported by Ajiha et al. (1), Nedelchev (4), Sharma et al. (7) and Lasisi et al. (20).

Table 7. *Changes in RBC (mean±SD) in goats naturally infested with L. stenopsis (n=10)*

Parameter	$X_{Mean} \pm SD$			Reference range
	Before treatment	30 DPT	60 DPT	
RBC	11.44 ± 2.57	12.30 ± 2.29	13.42 ± 3.39	8.00 – 18.00
HGB	69.60 ± 11.71	78.60 ^{c3} ± 9.60	95.90 ^{c3} ± 16.70	80 – 120
HCT	19.68 ± 3.30	22.13 ^{b2} ± 2.36	24.57 ^{b2} ± 4.60	22.0 – 38.0
MCV	17.70 ± 2.13	18.32 ± 2,24	18.54 ± 2.12	16.0 – 25.0
MCH	6.27 ± 0.76	6.48 ± 0.74	6.83 ± 0.482	5.2 – 8.0
MCHC	353.60 ± 12.85	354.60 ± 5.44	359.80 ± 14.74	300 – 360
RDW - CV	0.25 ± 0.02	0.22 ± 0.00	0.24 ± 0.04	0.180 – 0.300
RDW- SD	18.96 ± 2.45	17.02 ± 1.80	18.23 ± 4.83	12.1 – 23.1

[a] - $p < 0.05$; [b] - $p < 0.01$; [c] - $p < 0.001$ – between groups in every interval;
[1] - $p < 0.05$; [2] - $p < 0.01$; [3] - $p < 0.001$ – compared to the initial levels

The changes in values of biochemical parameters in cases of *L. stenopsis* infestation are presented in **Table 8**. No changes were found in blood levels of Ca, P, total protein and albumin that generally corresponds to the results of Ajitha et al. (1) and Nedelchev (4). In contrast, the level of Fe was significantly decreased before treatment but became elevated on the 30th and 60th DPT. Observed hypoferremia may be due to blood loss as well as chronic inflammation of the skin as a consequence of itching and wounding that usually accompany lice infestations. Skin integrity damage is the primary stimulus activating different classes of white blood cells to synthesize acute phase reactants such as TNF-α, IL-6 and hepsidine, which change the iron metabolism (21). TNF-α stimulates the entrance of iron in the macrophages, and TNF-α and IL-6 secure its retention in these cells (22), resulting in a decrease in its serum concentration that subsequently suppresses the erythropoiesis (21).

Table 8. *Changes in biochemical parameters (mean±SD) in goats naturally infested with L. stenopsis (n=10)*

Parameter	$X_{Mean} \pm SD$			Reference ranges
	Before treatment	30 DPT	60 DPT	
Ca	2.45 ± 0.21	2.41 ± 0.59	2.88 ± 0.27	2.3 – 2.9
P	1.48 ± 0.13	1.46 ± 0.19	1.44 ± 0.26	1.4 – 2.9
Total protein	72.31 ± 3.56	73.37 ± 3.29	74.50 ± 6.36	61-75
Bilirubin	3.7 ± 0.41	6.80 ± 1.29	6.53 ± 2.50	1.7 – 7.0
ASAT	141.60 ± 9.22	154.00 ± 33.66	167.70 ± 39.94	66 – 230
ALAT	15.80 ± 2.09	11.00 ± 1.24	17.50 ± 3.43	6 -19
AP	90.60 ± 17.94	178.10 ± 42.66	130.00 ± 27.36	61- 283
Albumin	29.92 ± 1.16	33.42 ± 1.66	35.85 ± 2.07	23 – 36
Fe	17.79 ± 4.07	23.04^{b3} ± 4.45	24.54^{b3} ± 6.10	22 - 25

[a] - $p < 0.05$; [b] - $p < 0.01$; [c] - $p < 0.001$ – between groups in every interval;
[1] - $p < 0.05$; [2] - $p < 0.01$; [3] - $p < 0.001$ – compared to the initial level

CONCLUSION

The clinical manifestation of lice infestation observed in the current study is non-specific and is expressed with rubbing, scratching, broken hairs, alopecia, skin inflammation, and keratinization. Detected changes in hematological and biochemistry parameters are also non-specific, represented by normocytic hypochromic anemia and hypoferremia in *L. stenopsis* infested goats and leucocytosis, hyperproteinemia and hyperalbuminemia in *B. caprae* infested animals. Therefore, an additional parasitological procedure such as species isolation and identification should be involved for determining a correct diagnosis. In conclusion, the infestation with sucking and biting lice leads not only to local damages but also to systemic changes, which are able to impair significantly the health status and welfare of the affected animals.

REFERENCES

1. Ajitha, Y., Dimri, U., Singh, S.K., Gopalakrishnan, A. Devi G. and Verma, M.R., Lice induced immuno-oxidative wreckage of goats. *Vet. Parasitol*., 242:24-30, 2017.
2. Otter, A., Twomey, D.F., Crawshaw T.R. and Bates P., Anaemia and mortality in calves infested with the long-nosed sucking louse (*Linognathus vituli*). *Vet. Rec*., 153:176-179, 2003.
3. Sinclair, A.N., Britt, A.G., Cotton G.L. and Pitman I.H., Efects of the sheepchewing louse (*Damalinia ovis*) on the epidermis of the Australian Merino. *Aust. J. Biol. Sci*., 39:137-143, 1986.
4. Nedelchev, N. K., A study on the phthirapterosis of domestic ruminants. PhD Thesis, Sofia (BG) 1985.
5. Wall, R. and Shearer D., Veterinary Ectoparasites. Biol., Pathol. and control, 162-178, 2001.
6. Taylor, M.A., Coop R.L. and Wall R.L., *Vet. Parasitol*., 3-rd Edition, 2007.
7. Sharma, D. and Ahluwalia, S., Studies on the blood constituens of goat infestet with louse – *Linognathus africanus*. *Indian Vet. J*., 67:369-370, 1990.
8. Tadie, A., Terefe G. and Gizaw, Y., Hematological Profile of Sheep Experimentally Infested with *Bovicola ovis*. *J. Vet. Sci. & Technol*., 9:3, 2018.
9. Christodoulopoulos, G. and Theodoropoulos, G., Infestation of dairy goats with the human flea *Pulex irritans* in Central Greece. *Vet. Rec*., 152:371-372, 2003.
10. Brown, L, Linde, T.C., Fourie L.J. and Horak, I.G., Seasonal occurrence and production effects of the biting louse *Damalinia limbata* on Angora goats and 2 treatment options. *J. S. Afr. Vet. Assoc*., 76:74–78, 2005.
11. Furman, D.P. and Catts, E.P., Mallophaga (chewing lice). In: Manual of medical entomology. 4-th ed. Cambridge University Press. London, New York 56-60, 1982.
12. Blagoveshensky, D.I., Order Mallophaga – Chewing lice V: Manual for determination of insects of the European part of the USSR. T. I. Wingless, with incomplete metamorphosis. Ed.: Bei-Bienko, G.Ya. The science. Moscow - Leningrad 309-323, 1864.
13. Koynarski, V., Ivanov A., Prelezov P. and Kirkova Z., Handbook of Veterinary Parasitology. Kontrast, Stara Zagora, 213, 2014.
14. IBM SPSS Statistics 26 Documentation,. https://www.ibm.com/support/pages/node/874712, 2019.
15. Marinkov, T., Angelov, G., Aminkov, B. et al., Handbook of veterinarians, Intel Entrans, Sofia, 459, 2014.
16. Mehrotra, P. and Singh, T., Some studies on the blood constituents of sheep infested with biting louse *Damalinia ovis*. *Indian Vet. J*.,59:75-76, 1982.
17. Prelezov, P., Malophagosis in chickens – etiopathogenesis, clinical-epidemiological data and control attempts. PhD Thesis, Trakia University, Stara Zagora, 2006.
18. Nelson, W.A., Bell, J.F., Clifford, C.M. and Keirains, J.E., Interaction of ectoparasites and their hosts. *J. Med. Entomol*., 13:389-428, 1977.
19. Maxwell, M.H., Avian blood leucocyte responses to stress. *Poult. Sci. J*., 49:34-43, 1993.
20. Lasisi, O., Eyarefe O. and Adejimi, J., Anaemia and Mortality in Calves Caused by the Short-Nosed Sucking Louse (*Haematopinus eurysternus*) (Nitzsch) in Ibadan. *Nigerian Vet. J*., 31:295-299, 2010.
21. McCown J.L. and Specht, A.J., Iron homeostasis and disorders in dogs and cats: a review. *J. Am. Anim. Hosp. Assoc*., 47:151-60, 2011.
22. Weiss G. and Goodnough, L., Anemia of chronic disease. *N. Engl. J. Med*., 352:10–23, 2005.