



Original Contribution

EFFECTS OF AGE, SEX, AND BODY CONDITION ON ECTOPARASITIC INSECT INFESTATION IN DOMESTIC GOATS

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ABSTRACT

PURPOSE: This study aimed to investigate the influence of sex, age, and body condition on the prevalence and intensity of ectoparasitic infestations in goats, focusing on lice and fleas, and to identify significant associations between these factors. **METHODS:** The study was conducted on 4,599 goats examined between May 2018 and November 2019. The animals were classified by sex, age (young < 2 years; adult ≥ 2 years), and body condition (good, fair, or poor). Ectoparasites were collected and identified in the laboratory, and infestation intensity (II) and degree of infestation (DI) were assessed. Statistical analyses were performed using the χ^2 test and Cramer's V coefficient. **RESULTS:** Four ectoparasitic species were identified: *Linognathus stenopsis* Burmeister, 1838, *Linognathus africanus* Kellog & Paine, 1911, *Bovicola caprae* Gurlt, 1843, and *Pulex irritans* Linnaeus, 1758. Female goats showed significantly higher infestation rates than males, with hormonal and physiological factors being potential contributors. Young goats were more frequently and heavily infested than adults, possibly due to their weaker immune systems and delicate skin. Animals in poor body condition had the highest infestation rates across all ectoparasites, with *Linognathus* lice showing the strongest association with body condition. **CONCLUSIONS:** The study demonstrated that body condition had the most significant impact on ectoparasitic infestations in goats, followed by age and sex. Maintaining good body condition and implementing effective management practices are crucial to reducing ectoparasitic burdens in goats. Further research is recommended to explore the mechanisms underlying these findings.

Key words: goats, lice, fleas, body condition, age, sex

INTRODUCTION

Ectoparasitic infestations are significant concerns for livestock health and production worldwide. Infestations of fleas and lice in goats are significant concerns, leading to economic losses due to decreased milk production, weight loss, skin damage, and increased susceptibility to secondary infections. These ectoparasites can also act as vectors for various diseases, further compromising goat health and productivity (1). Globally, the domestic goat population is estimated to be around 1.1 billion. In Bulgaria, as of November 1, 2022, the goat population was reported at 184,000 heads, marking a 14.4% decrease compared to 2021 (2).

Goats play a crucial role in human societies, especially in marginal and rural areas. They provide essential resources such as milk, meat, fibre (including cashmere and mohair), and manure, contributing to food security, income generation, and sustainable agricultural practices. Their adaptability to diverse environments makes them invaluable assets in supporting livelihoods worldwide (3).

Among goats, factors such as age, sex, and physical condition of the host have been frequently associated with variations in ectoparasite burden. Early studies, such as Seddon (4), suggest that lice infestations occur more frequently in young animals compared to adults. Similarly, Khama and Kilonzo (5) observed that *Ctenocephalides felis* Bouche, 1835 primarily infested young and juvenile goats rather than mature individuals, a trend supported by Kusiluka et al. (6), who attributed higher infestation rates in kids to their longer

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hair and delicate skin, which facilitate attachment and feeding by fleas.

Horak et al. (7) reported that kids as young as one week were already infested with *Damalinia limbata* Gervais, 1847, with infestation intensity (II) increasing rapidly. These authors also found that *Linognathus africanus* Kellog & Paine, 1911 was most prevalent in kids during their first months of life, as the host provides an ideal environment for parasite growth and reproduction. Infestation by *L. africanus* peaked at one month of age, followed by a decline, and then resurged before the animals reached one and two years of age.

Gender differences in ectoparasite infestation have also been documented. Lloyd (8) reported that higher levels of prolactin and progesterone make female animals more susceptible to infestations, compounded by the stress of reproduction, such as pregnancy and lactation. However, Kumar et al. (9) and Rashmi and Saxena (10) found no significant gender-related differences in infestation rates with *Bovicola caprae* Gurlt, 1843 and *L. africanus*. In contrast, Santos and Faccini (11) observed significant sex-dependent susceptibility to lice in goats older than one year, with females being more prone to infestation than males. Seyoum et al. (12), showed variations based on both sex and age, with higher ectoparasite infestation prevalence in male goats (64.4%) compared to females (41%), while infestation intensity by lice was higher in females (26.3%) than males (14.9%). Body condition did not significantly impact infestation rates.

Physical condition is another critical factor influencing ectoparasite burden. Sertse and Wessene (13) found that goats in poor condition were 2.1 times more likely to be heavily infested with *Linognathus* spp. compared to those in good condition. Amare et al. (14) reported similar findings, noting that goats in poor condition were 3.5 times more likely to be infested with lice than their healthier counterparts. Israel et al. (15) observed infestation rates of 59% in animals in poor condition, compared to 41.9% in animals of average condition and 43.6% in those in good condition.

Another study reported that certain tick species, such as *Rhipicephalus evertsi evertsi* Neumann, 1897, showed higher prevalence in female goats compared to males, indicating a potential sex-

related susceptibility. Age also played a role, with adult goats exhibiting higher infestation rates for specific tick species (16).

Additionally, research indicated that ectoparasite prevalence in goats was not significantly associated with sex, age, or body condition score, suggesting that other factors might influence infestation rates (17).

The literature consistently highlights that age, sex, and physical condition of the host significantly influence the prevalence, intensity, and burden of ectoparasitic insects in goats. This manuscript aims to further elucidate these relationships and explore underlying mechanisms, providing new insights based on recent data and observations.

MATERIALS AND METHODS

Anamnesis

Information on the age and sex of the animals in each herd was collected through the completion of a questionnaire by the owner. The animals were classified as young (< 2 years) or adult (\geq 2 years) following the methodology described by Gatenby (18) and Steele (19). Body condition was assessed and categorized as good (rounded body contours), moderate (visible but not sharply pronounced skeletal outlines), or poor (prominent, sharply protruding skeletal outlines under the skin), according to the criteria established by Nicholson and Butterworth (20).

Clinical study

A total of 4599 goats were examined from May 2018 to November 2019. Each animal was examined through visual inspection, and a portion of the detected insects (fleas and lice) were transported in 70° ethanol to the laboratory for identification.

The intensity of infestation (II) with lice was assessed following the method described by Brown et al. (21). This involved counting all parasites within a total of seven square-shaped areas, each measuring 10 cm², and subsequently multiplying the total count by 100. The type of infestation was characterized in the laboratory based on the number, species, sex, and developmental stage of the insects.

The degree of infestation (DI) with fleas was determined using the approach outlined by Christodoulopoulos et al. (22). The animal was positioned on its back, and fleas were counted on the least-haired regions of the body,

including the abdomen, udder, perineal area, and the medial sides of the thighs

Parasite identification

In laboratory the lice and fleas were subjected for morphological identification according to the criteria described by Wall and Shearer (1) and Blagoveshensky (23)

Statistical analysis

The influence of age, sex, and body condition on lice and flea infestation in goats was determined using the χ^2 analysis with IBM® SPSS® Statistics 26.0 software.

RESULTS AND DISCUSSION

The collected specimens were identified as *Linognathus stenopsis* Burmeister, 1838, *L. africanus*, *B. caprae* and *Pulex irritans* Linnaeus, 1758.

The results regarding the influence of age, sex, and body condition on ectoparasitic insect infestation in goats are presented in **Tables 1, 2** and **3** and illustrated in **Figures 1, 2**, and **3**. These figures also display the Cramer's V

coefficient obtained from the χ^2 analysis. This coefficient reflects the strength of association between the two factors: infestation by a specific ectoparasite species on the one hand and sex, age, or body condition on the other. The closer the Cramer's V coefficient is to 1, the stronger the association.

From **Figure 1** and **Table 1**, it is evident that sex is statistically significantly associated with infestation by *Bovicola caprae* and *Pulex irritans* ($p < 0.05$), with females being more frequently infested than males. However, for lice of the genus *Linognathus* parasitizing goats, no such dependence was observed. The Cramer's V coefficient values indicate a weak influence of the factor "sex" on infestation by the three groups of ectoparasites. Nevertheless, sex exerts a statistically significant influence on ectoparasite infestation in goats ($p < 0.05$), with female animals being more susceptible to infestation. The results of the current study are consistent with those of Horak et al. (7), Santos and Faccini (11), Israel et al. (15), Leul et al. (16), and Yakhchali and Hosseine (24).

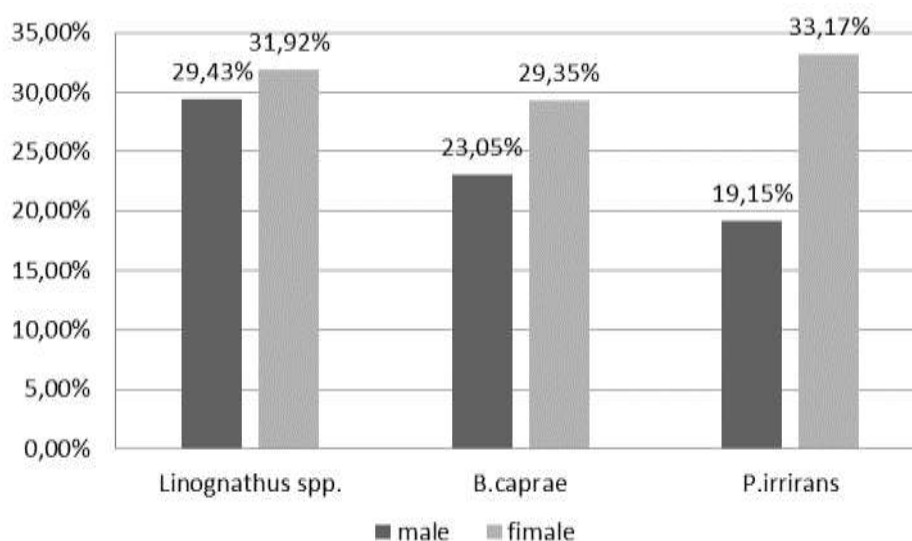


Figure 1. Extent of infestation (%) with ectoparasites in goats (n=4599) based on sex.

Table 1. Extent of infestation (%) with ectoparasites in goats (n=4599) based on sex.

Ectoparasite Species	male (n=282)	female (n=4317)	p	Cramer's V Coefficient
<i>Linognathus spp.</i>	83 (29.43%)	1378 (31.92%)	0.45	0.011
<i>Bovicola caprae</i>	65 (23.05%)	1267 (29.35%)	0.02	0.033
<i>Pulex irritans</i>	54 (19.15%)	1432 (33.17%)	0.000	0.072
Total Infested	138 (48.94%)	2470 (57.22%)	0.03	-

The higher infestation rate among females is likely attributed to higher levels of prolactin and progesterone hormones (8), which render them more susceptible to infestation. Stress associated with pregnancy, lactation, and milking also plays a role (25). Other authors, such as Kumar et al. (9), Rashmi and Saxena (10) and Seid et al. (17), found no differences in infestation characteristics between male and female hosts.

Table 2 and **Figure 2** presents data on the influence of host age on infestation by the studied ectoparasitic insects. Our study demonstrated more frequent infestation among young animals with *Linognathus* lice and *P.*

irritans fleas, with statistically significant differences between age groups ($p < 0.05$). This trend was observed for all studied ectoparasites, with 89.03% of young goats infested compared to 48.12% of adults. *Linognathus* lice infested 35.70% of young and 30.77% of adult goats. Flea infestation showed even greater differences, with 54.52% of young goats infested compared to 26.68% of adults. Conversely, biting lice exhibited the opposite trend, with 27.74% of young and 29.27% of adults infested. The Cramer's V coefficient values indicate a weak influence of age on ectoparasite infestation. However, for sucking lice and fleas, we statistically confirmed that young animals are more frequently infested.

Table 2. Extent of infestation (%) with ectoparasites in goats (n=4599) based on age.

Ectoparasite Species	Young (n=930)	Adults (n=3669)	p	Cramer's V Coefficient
<i>Linognathus</i> spp.	332 (35.70%)	1129 (30.77%)	0.004	0.042
<i>Bovicola caprae</i>	258 (27.74%)	1074 (29.27%)	0.35	0.014
<i>Pulex irritans</i>	507 (54.52%)	979 (26.68%)	0.000	0.0239
Total Infested	828 (89.03%)	1780 (48.12%)	0.000	-

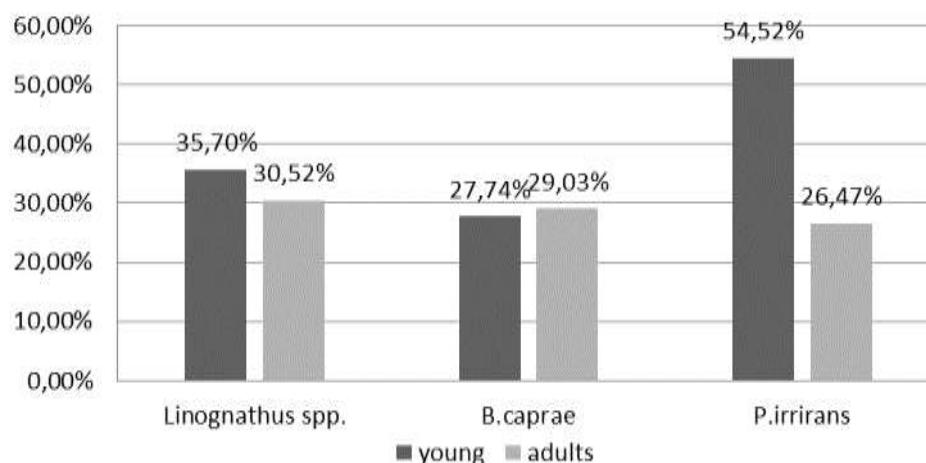


Figure 2. Extent of infestation (%) with ectoparasites in goats (n=4599) based on age.

Our findings align with those of Seddon (4), Khama and Kilonzo (5) Kusiluka et al. (6), Horak et al. (7), Kumar et al. (9), Rashmi and Saxena (10), Seyoum et al. (12), Sertse and Wessene (13), and Paul et al. (26). Only Leul et al. (16) reported higher infestation with

ectoparasites (ticks) in adult animals compared to young ones.

It is challenging to explain why ectoparasitic infestations are more frequent in young animals than in adults. However, we hypothesize that the underdeveloped immune system of

juveniles may be responsible. Additionally, their tender skin and softer coat could facilitate attachment and feeding by insects.

The data on the influence of body condition on infestation with parasitic insects in goats are reflected in **Figure 3** and **Table 3**. Statistical significance ($p < 0.05$) was established for all three groups of insects, showing that animals in poor condition were more frequently infested than those in average or good condition. The most pronounced dependence was observed for *Linognathus* lice, with only 8.22% of animals in

good condition infested compared to 80.42% in poor condition. The Cramer's V coefficient value of 0.616 confirms the strong influence of body condition on infestation. For *B. caprae*, the Cramer's V coefficient also exceeded 0.30 (0.447), demonstrating a strong influence of body condition. Although weaker, a statistically significant dependence of infestation on body condition was also found for fleas, with infestation rates of 16.32% in animals in good condition and 36.11% in those in average or poor condition.

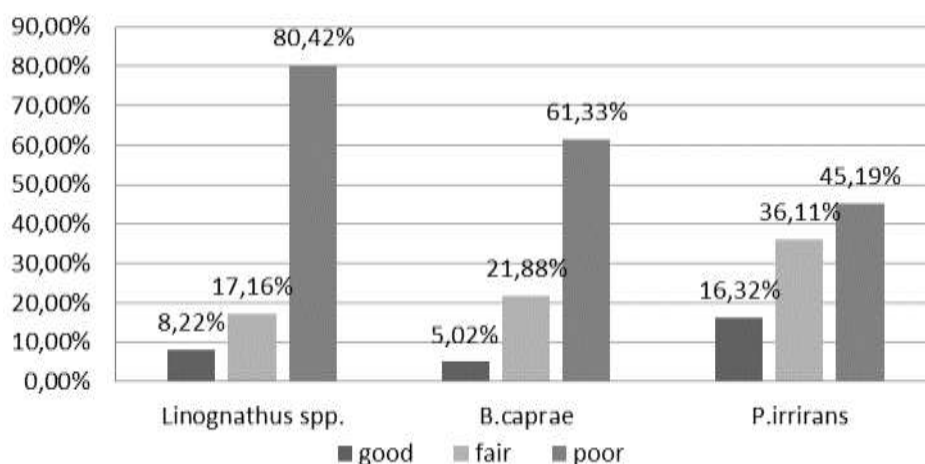


Figure 3. Extent of infestation (%) with ectoparasites in goats based on body condition

Table 3. Extent of infestation (%) with ectoparasites in goats based on body condition

Ectoparasite Species	Good (n=876)	Fair (n=2523)	Poor (n=1200)	p	Cramer's V Coefficient
<i>Linognathus</i> spp.	72 (8.22%)	433 (17.16%)	956 (80.42%)	0.000	0.616
<i>Bovicola caprae</i>	44 (5.02%)	552 (21.88%)	736 (61.33%)	0.000	0.447
<i>Pulex irritans</i>	143 (16.32%)	911 (36.11%)	432 (36.00%)	0.000	0.166
Total Infested	258 (9.89%)	1003 (38.46%)	1347 (51.65%)	0.000	-

Few authors in the available literature have reported statistically significant relationships between ectoparasitic insect infestation in goats and their body condition. Among these are Sertse and Wessene (13), Amare et al. (14), Elsaid et al. (27), and Tesfaheywet et al. (28). Conversely, other studies (12, 17) did not identify a correlation between the age of the studied goats and ectoparasitic infestation. A possible explanation for the obtained results, in our view, is the preserved reactivity of the organism in animals with good and moderate

body condition, compared to the compromised immunity in animals with poor condition. This hypothesis is further supported by the finding that body condition has the weakest influence on flea infestations. Since fleas are temporary ectoparasites and their presence on the host is limited in time, the development of immunity is less pronounced, meaning that the animal's condition has a weaker effect on the infestation level. However, more in-depth scientific studies are needed to confirm this theory.

The results of our study demonstrated that female animals included in the investigation were more heavily infested than males. Kids were more frequently infested and exhibited more severe infestations compared to adult goats. Furthermore, animals with good and moderate body condition were less frequently and less severely infested than those with poor condition.

An analysis of the results for the three factors studied in this section—sex, age, and body condition—revealed that body condition exerted the greatest influence on ectoparasitic insect infestations in goats.

CONCLUSION

The study highlights the significant influence of sex, age, and body condition on ectoparasitic infestations in goats. Female goats were found to be more heavily infested than males, likely due to hormonal and physiological factors associated with reproduction and lactation. Young goats exhibited higher infestation rates and severity compared to adults, possibly due to their underdeveloped immune systems and softer skin. Animals in poor body condition were more frequently and severely infested than those in moderate or good condition, suggesting that compromised immunity plays a pivotal role in infestation susceptibility. Among the studied factors, body condition demonstrated the greatest influence on ectoparasitic infestations, with a particularly strong association observed for *Linognathus* lice. The findings emphasize the importance of maintaining good body condition and implementing targeted management strategies to reduce ectoparasitic burdens in goats. Further in-depth research is required to validate these observations and explore additional underlying mechanisms.

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