Seasonal Population Dynamics of the Common Lice Species Infesting the Domestic Goat in Bulgaria

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Keywords: *temperature, precipitation, correlation, lice, goats, Bulgaria.*

Abstract. Background and aim. *Lice are among the most common ectoparasites in goats. They cause health problems, including weight loss, hypoproteinemia, nutritional deficiencies, reduced vitality and anemia. The present study aims to investigate the seasonal dynamics of the most common species of lice in naturally infested goats and the influence of temperature and precipitation levels on it.*

Materials and methods. *The seasonal dynamics were monitored by examining twenty goats, ten from each of two different small herds in the Stara Zagora region. At the beginning of each month, over a period of two years (from January 2018 to December 2019), the individual and average intensity of infestation were determined dynamically.*

Results. *Our findings reveal that parasitosis caused by Bovicola caprae and Linognathus stenopsis persists throughout the year, with clear seasonal patterns. Infestation intensity peaks in March, following the coldest months (December–February) when average temperatures are around 2–3°C. During the warmer months (June–August), when temperatures rise to 21–25°C, infestation intensity significantly declines. Statistical analysis confirmed a moderate negative correlation between infestation intensity and ambient temperature ($r = -0.411$, $P < 0.0001$), while no significant correlation was found with precipitation ($r = 0.023$, $P = 0.7184$)*

Conclusion. *The observed seasonal dynamics of both lice species on goats clearly demonstrate that winter provides optimal conditions for the development of their populations, confirming that phthirapterosis in goats in our region has a pronounced winter seasonality.*

Introduction

Lice are among the most common ectoparasites in goats. They are cited as one of the causes of weight loss, hypoproteinemia, nutritional deficiencies, reduced vitality, and anemia during the winter months (Chavham, 2023). Additionally, they cause health problems, behavioral changes and reproductive disorders such as the birth of offspring with reduced weight and vitality and decreased fertility (Doley et al., 2023). Temporary ectoparasites (such as ticks and fleas) are more strongly influenced by environmental abiotic factors and less by the host (Ming et al., 2023). Obligatory ectoparasites are highly host-specific and entirely dependent on the host to complete their biological cycle (Taylor et al., 2015), but they are also affected by environmental conditions (Ajith et al., 2020) like temperature and humidity (Adly et al., 2021). The region of Stara Zagora is located in the northern part of the Upper Thracian Plain, at 42°25' N latitude and 25°39' E longitude, at an altitude of 280 meters (according to data from the Regional Cadastre, Stara Zagora). The area falls within the boundaries of the Upper Thracian climatic subregion. The predominant climate in the region is transitional, between temperate continental and continental Mediterranean.

There is almost no debate among researchers that the infestation intensity (II) with lice in goats is influenced by climatic conditions across different seasons, which determines the seasonality of phthirapterosis. Only a few reports suggest that no such dependency exists (Santos et al., 2006). Most authors believe that climate and seasons affect the II with lice (Nedelchev, 1985; Yakhchali and Hosseine, 2006; Paul et al., 2012; Fomicheva, 2013; Maguini et al., 2018), with a particular emphasis on average monthly temperature and photoperiod, while attributing less importance to average monthly precipitation levels and relative humidity (Adesh et al., 2011). The main species causing phthirapterosis in Bulgaria are *Linognathus stenopsis* (Burmeister, 1838) and *Bovicola caprae* (Gurlt, 1843) (Nizamov, 2023). The last study on the seasonal dynamics of lice population numbers in domestic goats (*Capra hircus,* Linnaeus, 1758) in the country was conducted nearly 40 years ago (Nedelchev, 1985).

The purpose of this study is to examine how temperature and precipitation levels affect the seasonal dynamics of the most prevalent species of lice in naturally infested goats. These findings can help understand and predict seasonal lice infestation patterns on goats, which could be valuable for implementing targeted treatment plans in animal husbandry.

Material and Methods

Material

The seasonal dynamics were studied by examining twenty goats of the Bulgarian White Dairy Goat

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breed. Ten randomly selected female goats, aged 2 to 8 years, were identified by ear tag numbers and originated from a privately owned herd of 23 animals in the village of Yazdach, Stara Zagora region. This herd was managed under a pasture-based system, and a natural infestation with *Linognathus stenopsis* was confirmed.

The second group of ten goats belonged to the herd at the training facility of Trakia University, Stara Zagora. This herd consisted of 17 animals and was maintained under a confined housing system. Experimental animals were selected from female individuals aged 2 to 8 years and were identified by their ear tag numbers. A natural infestation with *Bovicola caprae* was confirmed in this herd.

Examination methods

Goats under examination were checked for nits and adult lice. Some detected insects were collected with tweezers and stored in containers with 70° ethanol. All collected insects were transported to the laboratory. Species identification was done according to morphological features described by Price and Graham (1997). A DMi1 S/M 424790 Leica® microscope (Leica Microsystems CMS GmbH) was used for the microscopic exams.

Lice infestation was determined using the method of Brown et al. (2005) by counting all insects in a total of 7 square-shaped fields, each with an area of 10 cm². The total number of parasites found was then multiplied by 100.

At the beginning of each month, over a two-year period (January 2018 – December 2019), the individual and average intensity of infestation were dynamically assessed by counting the number of parasites on the same ten animals. During the study, the animals were not treated with insecticidal products.

Throughout this two-year period, the influence of climate-geographical factors was tracked monthly, specifically, the average monthly temperature and monthly precipitation levels (according to data from the Hydrology and Meteorology Station in Stara Zagora). This station is located 20 km from the first herd in the village of Yazdach and 5 km from the herd of Trakia University.

Statistical analysis of data

Infestation intensity (II) was calculated using the method described by Brown et al. (2005). This involved counting the number of lice in 7 designated 10 cm² areas on each goat, with the total count multiplied by 100 to obtain an estimated whole-body infestation value.

The Spearman rank correlation coefficient was used to evaluate the relationship between the studied environmental parameters and the intensity of invasion with *L. stenopsis* and *B. caprae*. Calculations were made with MedCalc 15.8 Statistical Software Package (Belgium).

Results

After identifying the insects, it was found that the first of the studied herds was infested with the species *Bovicola caprae* and the second with *Linognathus stenopsis*. Our results show that the parasitosis caused by these two species of lice persists year-round.

Table 1 presents the monthly values of the total and average infestation intensity (II) of biting lice (*Bovicola caprae*) across the 10 studied goats during the two-year experimental period.

An analysis of the data in Table 1 shows that, during the winter months, the number of lice on

Table 1. Monthly values of the total and average intensity of natural infestation with *B. caprae* in 10 goats from a farm in Stara Zagora

Month	Year 2018		Year 2019	
	Detected number	Mean II	Detected number	Mean II
January	228	22. 8	181	18. 1
February	380	38. 0	400	40. 0
March	623	62. 3	708	70. 8
April	462	46. 2	524	52. 4
May	253	25. 3	184	18. 4
June	104	10. 4	58	5. 8
July	113	11. 3	29	2. 9
August	70	7. 0	15	1. 5
September	59	5. 9	23	2. 3
October	73	7. 3	20	2. 0
November	54	5. 4	15	1. 5
December	127	12. 7	73	7. 3

II – Intensity of infestation.

all experimental animals, as well as the average II, reached their highest values. The infestation intensity peaks in March. The average II is highest after the coldest winter months (December, January, and February), when average monthly temperatures are around 2–3°C, and lowest following the warmest summer months (June, July, and August), when air temperatures range from 21 to 25°C. In spring and summer, their numbers gradually decrease, reaching a minimum in autumn, only to rise again in winter.

After statistical processing of the results, it was found (Table 2 and Fig. 1) that there is a significant ($P < 0.0001$) moderate negative correlation between II with *B. caprae* and ambient temperature (r = –0.411), which demonstrates that II increases at lower temperatures. Fig. 2 shows the variation in mean precipitation and mean infestation intensity of *B. caprae* in the Stara Zagora region between January 2018 and December 2019. Based on linear regression analysis and calculation of the Spearman coefficient (r = 0.023), there is no correlation between the two studied parameters.Table 3 presents the monthly values obtained for the total number of insects and the average infestation intensity of blood-sucking lice (*L. stenopsis*) on the 10 studied goats over the two-year period.

Data analysis in Table 3 shows that the highest II is observed in March. During the winter months, the number of lice on all experimental animals, as well as the average II, reaches its highest values. In spring and summer, these values gradually decrease, reaching a minimum in September, followed by an increase in II throughout autumn and winter. The lowest annual average monthly temperatures are followed by a peak in II.

Similar to the studies on *B. caprae*, the average II with *L. stenopsis* also showed (Table 2 and Fig. 3) a significant ($P < 0.0001$) moderate negative correlation with ambient temperature (r = –0.411). However, there is no correlation (r = 0.036) between precipitation levels and infestation intensity (Table 2 and Fig. 4).

Table 2. Correlation between environmental conditions and infestation intensity

Lice species	Environmental factor	Spearman rho (r)	95% confidence interval	*P* value
L. stenopsis	Ambient Temperature	–0.411	–0.511 to –0.300	< 0.0001
	Precipitation	0.036	–0.0914 to 0.162	0.5828
B. caprae	Ambient Temperature	–0.411	–0.511 to –0.300	< 0.0001
	Precipitation	0.023	–0.104 to 0.150	0.7184

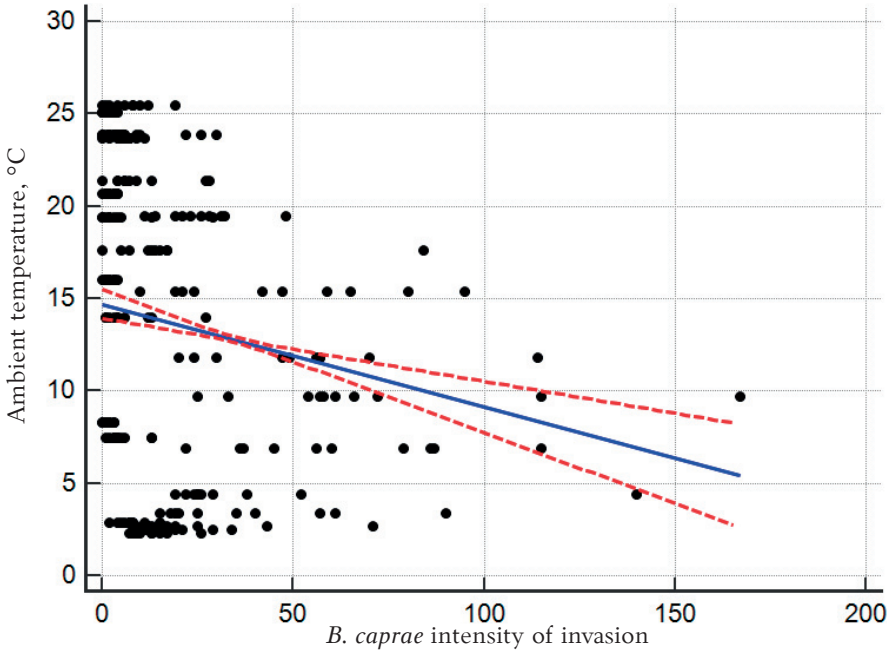

Fig. 1. Scatter plot of *Bovicola caprae* infestation intensity vs. ambient temperature

Dots: Each dot represents the monthly average infestation intensity (II) of *Bovicola caprae* during the study period (January 2018 – December 2019). Blue line: This is the regression line, showing the relationship between temperature and infestation intensity. It slopes downward, indicating a negative correlation (as temperature decreases, infestation increases). Red lines: These represent the 95% confidence intervals, indicating the range within which the true relationship likely falls.

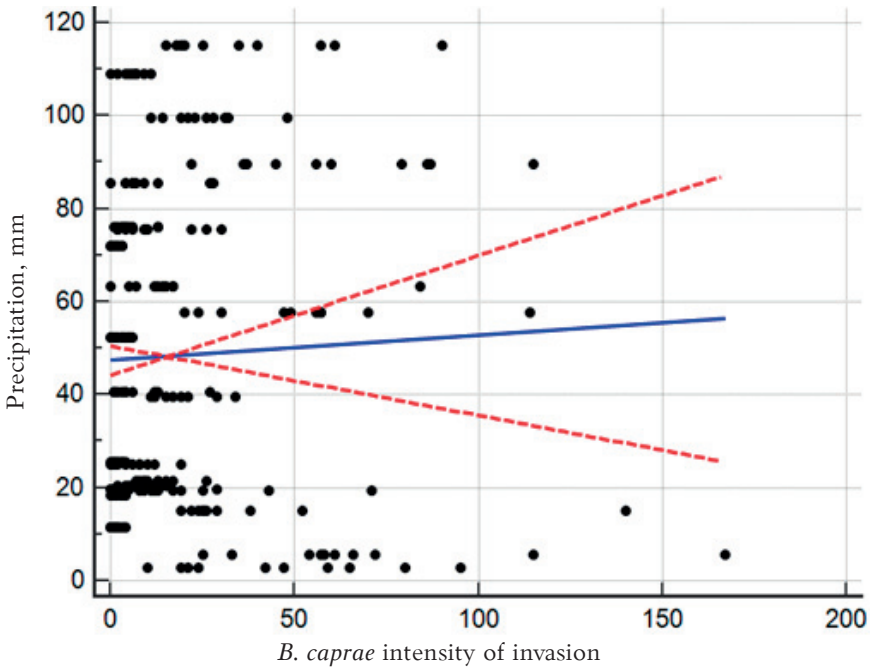

Fig. 2. Scatter plot of *Bovicola caprae* infestation intensity vs. precipitation

Dots: Each dot represents the monthly average infestation intensity (II) of *Bovicola caprae*. Blue line: This is the regression line, which is nearly flat, indicating no significant correlation between precipitation levels and infestation intensity. Red lines: The 95% confidence intervals, showing the statistical range of the relationship.

Table 3. Monthly values of the total and average intensity of natural infestation with *L. stenopsis* in 10 goats from a farm in Stara Zagora

Month	Year 2018		Year 2019	
	Detected number	Mean II	Detected number	Mean II
January	188	18. 8	245	24. 5
February	391	39. 1	429	42. 9
March	792	79. 2	903	90. 3
April	455	45. 5	441	44. 1
May	273	27. 3	273	27. 3
June	148	14. 8	127	12. 7
July	168	16. 8	121	12. 1
August	102	10. 2	93	9. 3
September	88	8. 8	57	5. 7
October	102	10. 2	92	9. 2
November	122	12. 2	132	13. 2
December	237	23. 7	339	33. 9

II – Intensity of infestation

Discussion

Most publications regarding the seasonal dynamics of lice populations in goats show a marked winter seasonality, with infestations occurring when temperatures are low, humidity is high, and daylight hours are short (Yakhchali and Hosseine, 2006; Paul et al., 2012; Fomicheva, 2013; Maguini et al., 2018), which is also confirmed by the present study. However, other scientific articles about the seasonal dynamics of lice on goats show that populations, such as *Damalinia limbata* (Gervais, 1847) and *Linognathus stenopsis*, often fluctuate seasonally, with peaks in infestation rates during the warmer months. The life cycle and fecundity of lice are particularly influenced

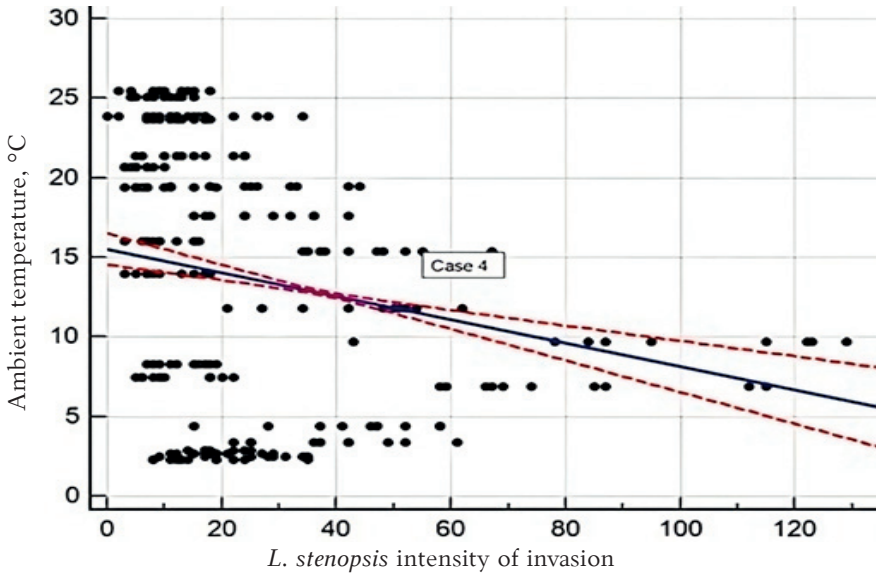

Fig. 3. Scatter plot of *Linognathus stenopsis* infestation intensity vs. ambient temperature

Dots: Each dot shows the monthly average infestation intensity (II) of *Linognathus stenopsis*. Blue line: The regression line, showing a negative correlation. Infestation increases as temperature decreases. Red lines: The 95% confidence intervals, representing the uncertainty in the relationship.

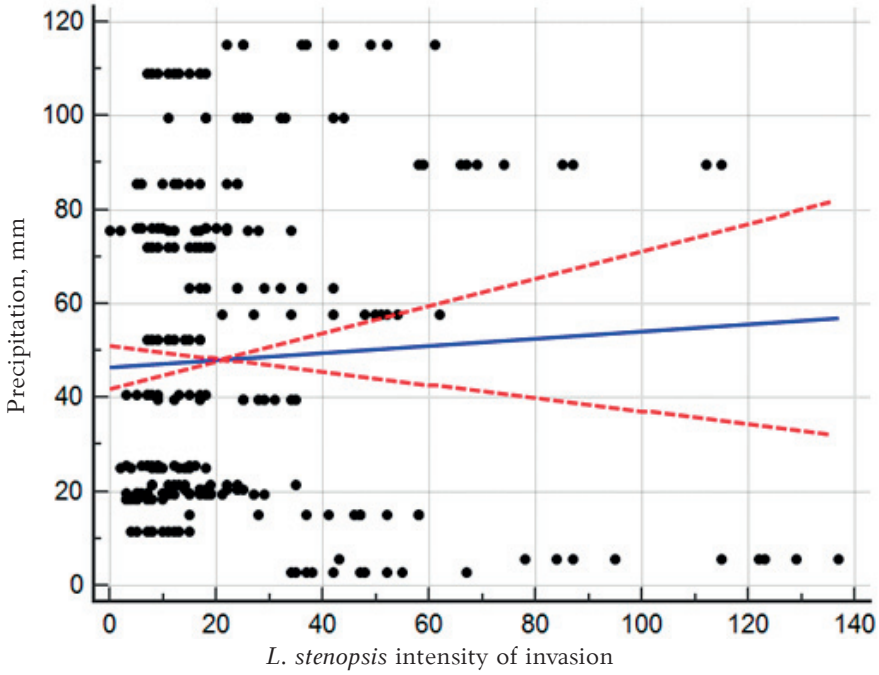

Fig. 4. Scatter plot of *Linognathus stenopsis* infestation intensity vs. precipitation

Dots: Each dot corresponds to the monthly average infestation intensity (II) of Linognathus stenopsis. Blue line: The regression line, which remains flat, indicating no significant relationship between precipitation and infestation. Red lines: The 95% confidence intervals, illustrating the variability in the data.

by ambient temperatures, as higher temperatures can accelerate their reproduction, leading to population spikes in summer (Brown et al., 2005). These contrasting results are likely due to differences in the climate zones where the studies were conducted. However, when comparing other studies on the epidemiology of phthirapterosis in goats, similar seasonal dynamics are observed across various geographic latitudes (Nedelchev, 1985; Fomicheva, 2013; Meduini et al., 2018).

A previous study on the seasonal dynamics of lice in goats in Bulgaria (Nedelchev, 1985) also reported a clear winter seasonality of parasitosis. The highest infestation intensity was recorded in January–

February, unlike the present study, which showed a later peak in March. Possible reasons could include differences in the study years (almost 40 years apart), global climate warming, as well as the influence of other factors on II, such as diet, age, sex, condition, and immunological status.

Although we selected herds representing the two main goat-rearing systems in Bulgaria – grazing and stall-based housing – we did not observe substantial differences in infestation intensity (II) between these management systems for either *Bovicola caprae* or *Linognathus stenopsis*. This is likely due to the fact that lice are stationary ectoparasites transmitted primarily through direct contact. Therefore, the management system has a minimal effect on their transmission dynamics. Future research will further explore the influence of age, sex, and body condition on infestation intensity in goats, as this study does not provide results on these factors.

Although no correlation was found between precipitation levels and lice II, it is known that temperature and humidity do not act independently; their effects are closely interconnected. We also assume that precipitation levels have some impact on lice II, as they amplify the effect of temperature. In higher humidity, low temperatures feel even lower.

Conclusion

This study demonstrates that the seasonal dynamics of lice (*Bovicola caprae* and *Linognathus stenopsis*) in goats in the Stara Zagora region are closely associated with seasonal changes, with a pronounced winter peak in infestation intensity. The results confirm a moderate negative correlation between intensity of infestation and ambient temperature, with the highest infestation rates occurring after the coldest months, specifically in March. In contrast, no significant correlation was found between intensity of infestation and precipitation levels.

Overall, this study provides valuable insights for seasonal lice management strategies in goat husbandry, indicating that preventive measures might be most effective when implemented before winter.

Acknowledgments

I wish to thank all of my colleagues from the Veterinary Microbiology, Infectious and Parasitic Diseases Department for the support and the professional help with the preparation of the manuscript. The study is funded by the scientific project No. 11/18 of the Trakia Univerisity.

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