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# SURVEY AND CHARACTERIZATION OF MESOPARASITES, ECTOPARASITES, AND HEMOPARASITES DIVERSITY IN GOATS FROM A SEMI-ARID REGION OF ALGERIA

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**ABSTRACT:**

The semi-arid regions of Algeria present unique challenges and opportunities for the study of parasitology, particularly in relation to goats. Goats are integral to the livelihoods of many rural communities in these regions, providing meat, milk, and other essential products. However, they are also susceptible to a wide range of parasites that can impact their health and productivity. This study aimed to investigate parasitic species in goats across six locations in the Laghouat region and assess their prevalence according to the several factors. A total of 144 animals (21 males and 123 females) from 11 different farms, were examined during 2022-2023. Fieldwork involved collecting goat excrement, ectoparasites, and blood samples. In the laboratory, five techniques, including direct examination, flotation, sedimentation, modified Ziehl-Nielsen techniques, blood smears, and ectoparasite observation, were used. Among the 144 animals examined, 97 showed endoparasite infestations. Coprological analysis revealed 28 endoparasites in Capra hircus goats, with the highest prevalence observed for Cryptosporidium spp. (34.7%), followed by nematode larva (22.9%), Fasciola hepatica (17.4%), Ascaris spp. (13.9%), Eimeria spp. and Eimeria granulosa, both with a prevalence of (12.5%). Eimeria parva and Skrjabinema spp. presented a similar rate of (11.1%). Ectoparasites were identified in (21.5%) of the examined goats, represented by two lice species: Linognathus africanus and Damalinia caprae, (20.8%). Piroplasmosis was detected in 20.1% of the total. Regarding the factors, season, animal's origin, treatment, type of production, and breeding system influenced endoparasites rate ($P < 0.05$). Similar results were obtained for ectoparasites, except for treatment, which did not show any significant difference. For blood parasites infestation, statistical analysis did not reveal any significant differences, except for season and breeding system ($P < 0.05$). the present study highlighted a large number and types of parasites affecting goats in Laghouat, which could lead to many pathologies and economic losses in consequences. Therefore, it is important to implement a coherent integrated pest control strategy and raising awareness among animal breeders about the multiple diseases that can affect their animals.

**Keywords:** Goats, Health, Ectoparasite, Parasites, Semi-Arid

## 1. INTRODUCTION

Today, more than a billion heads of goats are widely distributed worldwide, particularly in marginalized areas where over 90% of the global goat population is concentrated (Boumezaouet et al., 2023). There are over 1153 goat breeds on our planet, each distinguished by their size, shape, and type of production (Lohani & Bhandari., 2020).

Goats are among the most versatile livestock species (Zobel & Nawroth., 2020) and are incredibly valuable to the world as they provide meat, milk, fiber for fertilizer, and draft power (Lohani & Bhandari., 2020). The Algerian goat population comprises approximately 5 million of heads (Chekikene et al., 2021), unevenly distributed across various regions and diverse climatic and environmental conditions, primarily in steppe regions (41.1%), mountainous areas (28.8%), and Saharan regions (22.5%) (Elchikh et al., 2020). These animals survive and reproduce under a variety of extreme conditions, making them an ideal species for resource-poor farmers, often referred to as a "living bank" and "walking refrigerators" (Lohani & Bhandari., 2020). However, they are particularly susceptible to multitude diseases (Yahia et al., 2024).

Parasitic infestations due to endoparasites, ectoparasites (Majeed et al., 2015), or blood parasites (Ulucesme et al., 2023) in goats represent a big health issue worldwide (Majeed et al., 2015), leading to decreased milk and meat production, reduced performance, or mortality (Sazmand & Joachim., 2017). Research on goat parasites has garnered sustained global attention, with numerous studies aimed at better understanding these parasites and developing effective management strategies (Sutar et al., 2010 ; Rizwan et al., 2023). In contrast, in Algeria, few studies have been carried out, including those focusing on coccidia and gastrointestinal parasites of goats (Kouidri et al., 2015), on ruminant ticks (Aouadi et al., 2017), more specifically reporting cryptosporidiosis and fasciolosis in goats, respectively (Baroudi et al., 2018 ; Ouchene-Khelifi et al., 2018), on mammalian lice, including goats (Meguini et al., 2018), and on goats' cryptosporidiosis and others (Bennadji et al., 2022). In Laghouat, only three works have been conducted on goats' parasites (Benhassine, 2015 ; Saidi et al., 2020 ; Lakehal et al. 2021). Under this context, this study was performed in order to research and identify different parasitic species in goats and to evaluate their prevalence according to different factors such as season, age, sex and breeding systems.

## 2. MATERIEL AND METHODS

**Study area description:** The present study was performed in the province of Laghouat, located in the Central part of Algeria, 400 kilometers South of the capital. The region covers an area of 25,052 square kilometers. It is bordered to the North and East by Djelfa, to the Northwest by Tiaret and El Bayad, and to the South by Ghardaïa (D.P.A.T., 2010). Laghouat is characterized by a semi-arid climate. It is marked by occasionally very cold winters and extremely hot and dry summers accompanied by sandstorms. Temperature variations are significant, and precipitation is low. Winters are marked by frosts and sometimes low temperatures nearing 0°C (C.D.F., 2008).

This work was carried out in six sites within Laghouat region: Laghouat city, Bordj Senouci, Garret El Hmame, Ksar El Hirane, El Assafia, and Sidi Makhlouf. The creation of the geographical map of study sites was done by using ArcGIS 10.8 software (Figure. 1).

**Study design and animals**: In each season, 36 goats of different ages, both sexes, and

different breeds were selected in eleven farms. The animals and farms included in this study had the following characteristics (Table. 1).

**Field method:** -Feces were directly collected from the rectum using gloves and placed in sterile, numbered containers and transported to the regional Veterinary Laboratory in Laghouat in a cooler with cold accumulators to arrest the development of parasite eggs. For samples not examined on the day of collection, preservation under cold conditions (+4°C) was carried out for up to 4 days.

-Blood samples were taken from the jugular vein using syringes and collected in EDTA tubes. The samples were placed in a cooler for direct transportation to the laboratory.

-The ectoparasites collected subsequently preserved in labeled vials containing 70% ethanol.

**Methods used in the laboratory:** To conduct this work, two methods were employed: macroscopic and microscopic methods, which included five techniques that we performed; direct examination, flotation and sedimentation technique, modified Ziehl Nielsen technique, blood smear, and observation of ectoparasites, followed by their identification using identification keys.

**Parasitic indices:** It consisted to calculate the prevalence of goat parasitism for each type of parasite according to the following relationship: It is the percentage ratio P (%) of the number of hosts infested with a given species of HP parasite to the total number of hosts examined Hematoxylin and Eosin (HE) (Bush, 1997).

**P (%) = HP/ HE× 100**

**Statistical analyses:** Descriptive statistics were performed to analyze data using SPSS (version 20) statistical software. Chi-square ($\chi 2$) test was used to assess if there was a statistically significant difference in all types of parasites of the goat between sex, age, and management of animals (type of production, breeding system, Body Condition Score (BCS), animal's origin and treatment). The level of significance was set at $P<0.05$. The interpretation of the results relied on the use of Excel 2019 software to generate certain graphs.

## 3. RESULTS

**Endoparasites:** Different parasitological techniques allowed to identified 28 parasitic species (Figure. 2) including nematodes, coccidia, cestodes, trematodes and ciliates. Out of 144 examined fecal samples, 97 were infested with endoparasites (67.4%).

**Ectoparasites:** Two species of ectoparasites were identified, belonging to 1 phylum, 1 class, 1 order, and 2 families. Out of 144 individuals examined, 31 goats were found to be infested with ectoparasites, resulting in a prevalence of 21.5%. The rate of Linognathus africanus was similar to that of Damalinia caprae, (20.8%) (Figure. 3).

**Hemoparasites:** During the study period, 20.1% of goats were found to be infested with Piroplasms (Figure. 4).

**Parasitism rate according to different parameters:** Regarding the relationship between infestation by parasites in goats and some factors (season, sex, age, animal origin, treatment,

type of production, Body Condition Score, and breeding system), no statistical difference was revealed between the rates according to the sex, age, and BCS for endoparasites. However, there were significant differences observed for season, animal's origin, treatment, type of production, and breeding system ($P < 0.05$). Similar results were obtained for ectoparasites, except for treatment, which did not show any significant difference. As for the relationship between infestation by blood parasites in goats and the factors influencing their presence, the statistical analysis did not reveal any significant differences, except for season and breeding system ($P < 0.05$) (Table 2).

## 4. DISCUSSION

The results of endoparasites in this work aligned with a previous study in Burkina Faso where 12 species were identified (Ouattara & Dorchies., 2001). Coccidia were represented by 9 species: Cryptosporidium spp., Eimeria granulosa, Eimeria arloingi, Eimeria jolchijevi, Eimeria parva, Eimeria ninakohlyakimovae, Eimeria pallida, Eimeria hirci, and Eimeria caprina, as previously described in Cameroon (10 species of Coccidia in goats) (Toumba, 1989). In Egypt, the overall prevalence of Eimeria spp. was 40.63%, with the identification of four species (Abdelaziz et al., 2021). The predominant parasite was Cryptosporidium spp., which was recorded with a rate higher than those reported in Iraq (Makawi, 2023) (11.11%). Oocysts of Cryptosporidium spp. were known for having an extremely common self-infestation ability and highly infectious. This could explain their high rate encountered in this survey.

The prevalence of Fasciola hepatica is lower than those found in other studies (43.67%) (Kwestan et al., 2021 ; Tasawar et al., 2007) in Pakistan. However, it exceeds the rate reported in Egypt (3.64%) (Elseify et al., 2021). Regarding Ascaris spp., the prevalence found was 13.9%, whereas in Nepal, it was only 1% (Ghimire & Bhattarai., 2019). The prevalence of Skrjabinema spp. is significantly higher than the rate reported in Niger (Nwosu et al., 1996) (0.9%), and also higher than that reported in the North West of Algeria (Saidi et al., (2020) with a rate of 2%. However, it is nearly similar to the prevalence recorded in Ethiopia (Trefe et al., 2012) (11.5%). For Taenia spp., our result is low compared to that found in Nigeria (Eke et al., 2019) (10.14%) and in the Eastern part of Algeria (39.66%) (Azzouzi et al., 2020). For Strongyloides spp., our result is in agreement with that reported in Tiaret (4.76%) (Chakkour, 2022). However, it is significantly lower compared to the prevalence mentioned in Guinea (46%) (Ankers et al., 1997). In the North West of Algeria, a previous work revealed a high percentage of strongyle eggs at 95.5% (Saidi et al., 2020). The prevalence of Trichostrongylus spp. is much lower compared to that recorded in Togo (Bastiaensen et al., 2003) (29%). It is also lower than that found in the North West of Algeria (20%) (Saidi et al., (2020). Regarding Marshallagia spp., the rate recorded in this study is similar to that mentioned in the North West of Algeria (3.9%) (Saidi et al., (2020).
For Dicrocoelium lancealatum, the prevalence is 2.8%, while in Iran, it was cited at 25%. The rate of Balantidium coli is low compared to that found in Egypt (7.1%) (Elmadawy & Diab, 2017), and higher than that noticed in Iraq (1.66%) (Makawi, 2023). The prevalence of Ostertagi spp. recorded in this study is much lower compared to that reported in a previous study (16%) (Barré & Moutou, 1982). Chabertia spp. rate is lower than Bagalwa et al (1996) that reported (11.9%). In the North West of Algeria, data showed also a different percentage (10%) (Saidi et al., 2020). The rate of Toxocara spp. in this work is lower than that revealed previously (Bagalwa et al., 1996) (11.9%) for Toxocara vitulorum. The identified ectoparasites belong to the arthropod phylum. The species identified are Damalinia caprae and Linognathus africanus with a rate of 21.5% from the total, while in Malaysia all 30 goats

in dairy farm were infested by lice (100%) (Yusof, 2018)
The discrepancy between our results and those found around the world can be explained by several criteria; the experimental design and methodology, the geographical location (climatic and environmental factors), and the number of animals and farms monitored, which differ considerably from one study to another.

The blood smears revealed the presence of Piroplasms. All subsequent studies corroborate with these results. According to a previous work (Iqbal et al., 2011), infections with Babesia spp. are present in sheep and goats in the Southern Punjab region of Pakistan. In Senegal, the blood parasites found in small ruminants included Theileria ovis, Trypanosoma vivax, Trypanosoma congolense, and Anaplasma bovis (Gueye, 1994). The risk factors studied in this research can all influence the prevalence of parasitic infestations in livestock animals.
Parasites can be more active during specific seasons. Environmental conditions, such as temperature and humidity, can affect the survival and reproduction of parasites, as well as animal exposure to parasites (Lakehal et al., 2021; Rahmani et al., 2023). Insects and ticks are often more abundant during warm months, while louse infestations may be more common during colder periods, as observed in this study. The relationship between the sex of the animals and the parasitism rate was not significant in this study (very low number of males compared to females). (Saidi et al., 2022 ; Rahmani et al ., 2023) noticed same data in camels and in sheep, respectively. In some animal species, a difference in parasite prevalence between the 2 sexes was clearly revealed. This can be due to the difference in feeding behavior, physiological status (lactation, gestation), and social interactions between males and females (Lakehal et al., 2021; Lakehal et al. 2020).
Regarding the age of animals, it can influence their susceptibility to parasites. Young animals, due to their less developed (immature) immune systems, can be more susceptible to parasitic infestations, in agreement with previous reports (Rahmani et al., 2023). Furthermore, cumulative exposure to parasites can increase with age, which can affect the prevalence and severity of infestations in older animals, as we observed in this work. Also, animals from different geographical regions may be exposed to specific parasites associated with those regions. When an animal is moved to a new area, it can encounter parasites to which it is not adapted or against which it has no preexisting immunity.

This can increase the risk of parasitic infestation in this case. According to the therapy, some parasites can persist even after the treatment of goats, and this phenomenon is explained by the development of resistance to chemical medications, making biological control the optimal solution (Benlarbi et al., 2023). Livestock management practices can have a significant impact on the prevalence and severity of parasitic infestations. In extensive farming systems, animals spend most of their time outdoors, where they can come into direct contact with parasites present in the environment. This can increase the risk of infestation by parasites such as ticks, lice, gastrointestinal worms, and lungworms. Animals raised in intensive systems, such as confinement or cage facilities, may be less exposed to environmental parasites compared to animals on pasture. However, the high density of animals in a confined space can promote the transmission of certain parasites, such as lice and mites, which spread through direct contact (El Amine Bennadji et al., 2022). It is well known that breeding management has a clear influence on the state of resistance and the onset of most diseases. According to previous data, it is impossible to have all the conditions, namely a suitable environment, a good general atmosphere and a good diet. Compliance with certain major conditions can, however, reduce or limit the spread of the disease and the durability of the parasites in a farm (Guechtouli et al., 2022).

## 5. CONCLUSION

In conclusion, our study provides valuable insights into the prevalence and diversity of endoparasites, ectoparasites, and blood parasites affecting goats in Laghouat, Algeria. The wide range of parasites identified highlights the potential for various pathologies and economic losses in goat farming systems. Seasonality, breeding system, animal age, and origin emerged as significant factors influencing parasite prevalence, emphasizing the need for tailored pest control strategies and increased awareness among animal breeders. To mitigate the economic losses associated with parasitic diseases, it is crucial to implement coherent integrated pest control strategies and prioritize parasite management in goat farming practices. By addressing the identified risk factors and adopting appropriate control measures, such as improved livestock management practices and biological control methods, we can minimize the impact of parasitic diseases on goat health and welfare. Ultimately, collaboration among breeders, technicians, and veterinarians is essential to effectively combat parasitic diseases and ensure the sustainability of goat farming in semi-arid regions like Laghouat.

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**Conflict of Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Author Contributions**

SB, RS, MAA, MR, HG: Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Writing – Original Draft, Writing – Review & Editing. RB, NM: Investigation, Writing – Review & Editing.

**Data Availability Statement**

The datasets during and/or analyzed during the current study available from the corresponding author on reasonable request.

**Ethical Statement**

All the animal studies were conducted with the utmost regard for animal welfare, and all animal rights issues were appropriately observed. No animal suffered during the course of the work. All the experiments were carried out according to the guidelines of the Institutional Animal Care Committee of the Algerian Higher Education and Scientific Research (Agreement Number 45/DGLPAG/ DVA.SDA.14).

**Animal Welfare**

The authors confirm that they have adhered to ARRIVE Guidelines to protect animals used for scientific purposes.

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**List of tables:**

**Table 1.** Characteristics of farms and animals included in the study

| **Criteria** | **Variables** | **Total number** | Percentage **%** |
|---|---|---|---|
| | | **Animals** | |
| **Sex** | Female | 123 | 85.4% |
| | Male | 21 | 14.6% |
| **Animal's origin** | Local | 79 | 54.8% |
| | Crossbred | 14 | 9.8% |
| | Imported | 51 | 35.4% |
| **Age** | Young | 59 | 41% |
| | Adult | 85 | 59% |
| **B**ody Condition **S**core | Large | 16 | 11.1% |
| | Lean | 70 | 48.6% |
| | Normal-size | 58 | 40.3% |
| **Treatment** | Lack of treatment | 47 | 32.64% |
| | Presence of treatment | 97 | 67.36% |
| | | **Farms** | |
| **Breeding system** | Intensive | 5 | 45.45% |
| | Semi-intensive | 4 | 36.35% |
| | Extensive | 2 | 18.2% |
| **Localities** | Laghouat city | 1 | 9.1% |
| | Bordj Senouci | 4 | 36.3% |
| | Garret El Hmame | 2 | 18.2% |
| | Ksar El Hirane | 1 | 9.1% |
| | El Assafia | 2 | 18.2% |
| | Sidi Makhlouf | 1 | 9.1% |
| **Type of production** | self-consumption | 63 | 43.75% |
| | meat | 06 | 4.17% |
| | self-consumption + meat + milk production | 75 | 52.08% |

**Table 2**. Study of the influence of certain parameters on parasitic infestation among different parasites

| **Risk factor** | | **Prevalence** | | | | **P -value** | |
|---|---|---|---|---|---|---|---|
| | | Endospores ites | Ectoparasi tes | Hemiparesis tes | Endoparas ites | Ectoparasi tes | Hemoparasi tes |
| **Season** | Autumn | 33.3% | 8.3% | 2.8% | (P=0.000) | (P=0.000) | (P=0.000) |
| | Winter | 81.6% | 66.7% | 27.8% | | | |
| | Spring | 72.2% | 8.3% | 38.9% | | | |
| | Summer | 77.8% | 2.8% | 11.1% | | | |
| **Age** | Young | | 10.2% | 22% | (P=0.176) | (P=0.06) | (P=0.637) |
| | Adult | 71.8% | 29.4% | 18.8% | | | |
| **Sex** | Male | 71.4% | 19% | 19% | (P=0.667) | (P=0.511) | (P=0.579) |
| | Female | 66.7% | 22% | 20.3% | | | |
| **Animal’s origin** | Local | 75.9% | 35.4% | 21.5% | (P=0.035) | (P=0.000) | (P=0.859) |
| | Imported | 59.6% | 5.8% | 19.2% | | | |
| | Crossbred | 46.1% | 0% | 15.4% | | | |
| **Treatme nt** | Lack | 51.1% | 17% | 17% | (P=0.04) | (P=0.360) | (P=0.516) |
| | Presence | 75.3% | 23.7% | 21.6% | | | |
| **Type of production** | Self-consumption | 44.4% | 7.9% | 14.3% | (P=0.000) | (P=0.01) | (P=0.266) |
| | Meat | 100% | 16.7% | 16.7% | | | |
| | Self-consumpti | 84% | 33.3% | 25.3% | | | |
| | on+ meat+ milk | | | | | | |
| **Body Conditi** | Lean | 71.4% | 21.4% | 24.3% | (P=0.257) | (P=0.933) | (P=0.296) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **on Score** | Normal | 67.2% | 20.7% | 13.8% | | | |
| | Large | 50% | 25% | 25% | | | |
| **Breeding system** | Intensive | 47.4% | 8.8% | 15.8% | (P=0.000) | (P=0.000) | (P=0.010) |
| | Semi-intensive | 77.4% | 40.3% | 17.7% | | | |
| | Extensive | 88% | 4% | 36% | | | |

**Figure captions:**

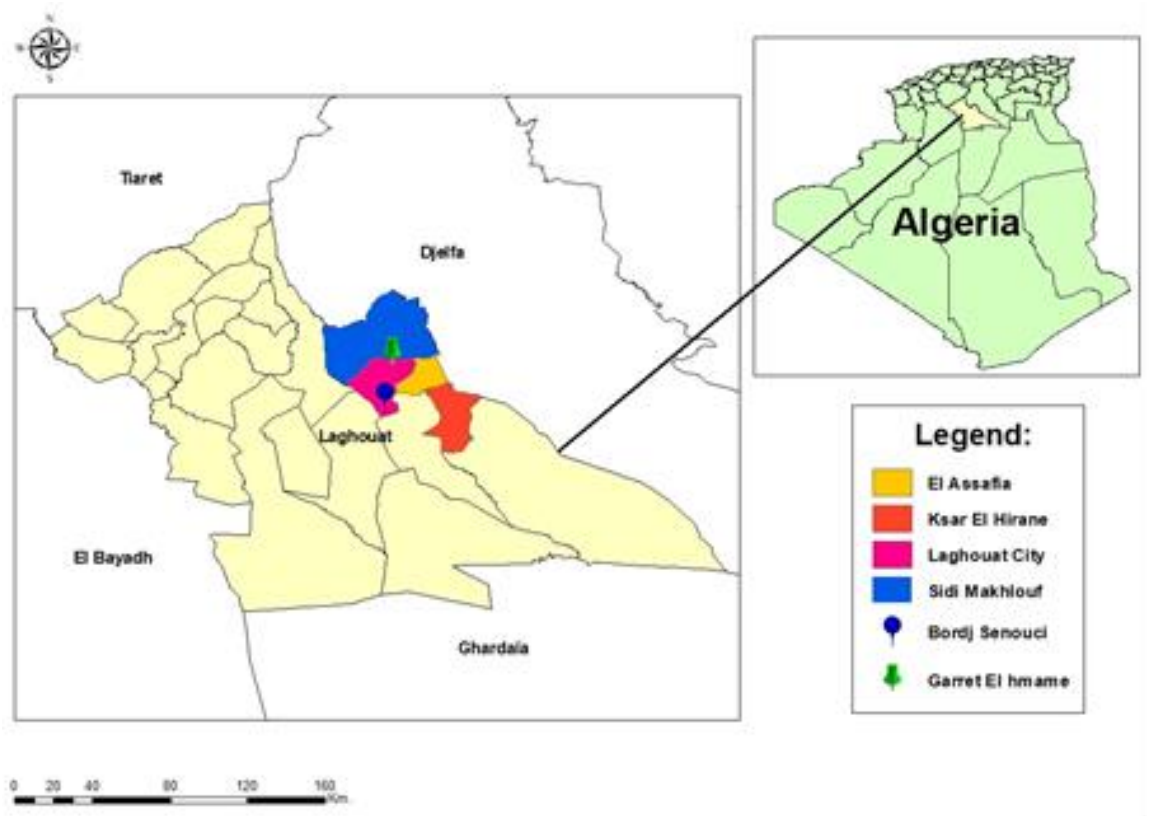


**Figure 1.** Geographical map of study sites.

Figure. 2. Microscopic identification of endoparasites (Gx400, x1000)

(a) (b) (c)

Figure. 3. Ectoparasites found in goats. (a) Damalinia caprae female. (b): Damalinia caprae male. (c) : Linognathus africanus.

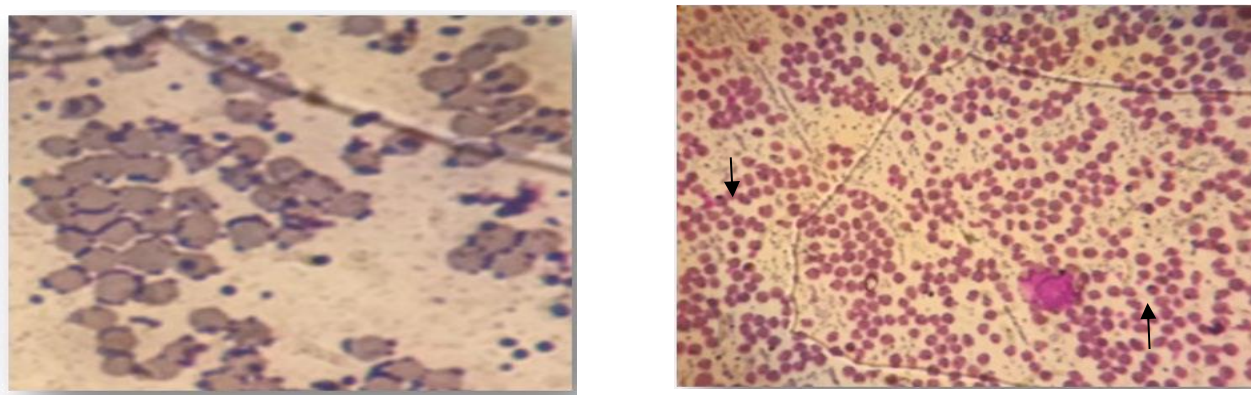

**Figure. 4.** Piroplasms found in goats (G×1000).