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Prevalence of *Melophagus ovinus* (Diptera, *Hippoboscidae*) in sheep in the province of Tungurahua, Ecuador

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ABSTRACT

Melophagus ovinus (Diptera: Hippoboscidae) is considered one of the main ectoparasites that attack sheep, however, in Ecuador information about this parasite is limited. In this study, the prevalence of *M. ovinus* in sheep was examined in Tungurahua province, Ecuador. For this purpose, sampling was performed in some semi-intensive and backyard sheep farming systems in different locations in Tungurahua. Significant differences were detected in the prevalence of *M. ovinus* between different locations, being higher in Ambato (39.3%), followed by Quero (33.5%), Mocha (32, 3%), Pelileo (30.7%), and Tisaleo (28%). Meanwhile, a significant decrease in prevalence was observed in Patate, Cevallos, and Píllaro ranging from 7.5% to 18%, and no *M. ovinus* was detected in Baños. No relationship was observed between the number of ectoparasites and the gender or age of the host sheep. A higher incidence was observed in males (58.45%) than in females (41.55%), even though it was not statistically significant according to Pearson's Chi-squared ($p = 0.492$). Similarly, when considering the effect of the age of an animal on the incidence of *M. ovinus*, no significant association was found based on Pearson's Chi-squared ($p = 0.314$). However, the animals aged 1-3 and older than 5 years showed a higher prevalence. This study highlights the need for further studies on the prevalence of *M. ovinus* in producing areas.

Keywords

sheep ked, ectoparasite prevalence, geographical distribution, Andean

Abbreviations

M. ovinus: Melophagus ovinus
B. ovis: Bovicola ovis

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Introduction

The growth of the human population has brought about an increase in the demand for products obtained from livestock to satisfy the population's food needs. Therefore, the demand for sheep products has tended to increase since they are a source of meat, milk, and skin for a variety of uses [1]. Regarding sheep meat, worldwide production was 9,922,238 tons, of which 51.6% was produced in Asia, followed by Africa (20.8%), Oceania (11.9%), Europe (11.4%), and America with just 4.3% [2]. Among South American countries, Brazil, Argentina, and Peru contributed 38%, 20.8%, and 13.1% to meat production in this region, respectively, while in Ecuador, production was 5,838 tons representing 2.3% of the total amount produced in South America [2].

Despite the economical and nutritional importance of livestock for the Ecuadorian population, in 2019 there was a marked decrease in the number of cattle (6%), pigs (39.1%), and sheep (25%) in comparison with 2014 [3]. Some of the factors affecting livestock production were management issues, the genetic aspects of animals, and their interaction with the environment. It is well known that the climate affects animal welfare and production by influencing the quality and/or quantity of available food, the requirements of water and energy, and the amount of energy consumed [4]. Moreover, in recent years, climate change has made it necessary for both intensive and extensive production systems to promote strategies that allow adapting to environmental, social, and ecological changes and thus, moderate potential damages [5].

The prevalence of internal and external parasites is detrimental to livestock production, and ectoparasites, such as ticks, Hippoboscidae flies, lice, fleas, and scab mites can cause noticeable lesions on the coats of animals. They can also play a role in pathogen transmission and spoliation due to their blood-sucking habits [6]. According to Chilundo [7], although parasitic infections cause serious limitations to livestock production, these may be underestimated because they often do not cause clinical symptoms. However, they cause growth retardation and reduce fertility and productivity. According to Bedada et al. [8], ectoparasites are one of the main factors that affect sheep farming due to the economic losses they cause, mainly in small-scale production systems. In Ethiopia, these authors found a high prevalence of different species of ectoparasites, such as *B. ovis* (81.4%) and *M. ovinus* (19.2%), but the level of ectoparasite infestation had no relationship with age, gender, body condition, or management.

Similarly, Tamerat et al. [6] found 12 species of ectoparasites on sheep, with a higher prevalence of ticks (17.2%), followed by sarcoptiform mites (11.5%), lice (8%), and fleas (7.2%), mainly on animals showing poor body condition. According to these authors, the high prevalence of ectoparasites could negatively affect the production of small ruminants, which would then require the implementation of effective control measures to raise the production of these species. In addition to the damage to the skin or wool caused by various species of ectoparasites, they are also transmitters of pathogens. For example, *M. ovinus* is a transmitting agent of *Trypanosoma melophagium*, *Anaplasma ovis*, bluetongue virus, and various species of *Bartonella*, *Borrelia* spp., and *Rickettsia* spp., causing significant economic losses to sheep farming worldwide [9].

Considering the high incidence of ectoparasitic arthropods in sheep and their importance in the transmission of pathogens, in the present study, the prevalence of M. ovinus on sheep was investigated in Tungurahua province, Ecuador. Therefore, this study may constitute a baseline for future research that will focus on determining the possibility that these ectoparasite species are transmitting pathogens in the herds of the region.

Results

Morphological characterization of M. ovinus in sheep in Tungurahua province

All the collected specimens in the different sampling municipalities corresponded to *M. ovinus*, which presents a dorsoventrally flattened body, sunken head, thorax, and abdomen with the gnathal segments being of the prognathic type. Moreover, soft and flexible abdominal integument allows distension during feeding and larval development in females (Figure 1A). They are insects with small compound eyes, few ommatidia, and small immobile antennae located in deep antennal fossae. They are wingless because they are parasites that complete their entire life cycle on their host (Figure 1A).

In addition, they have robust legs with enlarged femurs, flattened tibiae, and short, compact tarsi with one or more basal teeth, which are shorter and more robust and with stronger tarsal claws in mammalian associated species, which allow them to cling to the skin or wool (Figure 1B). The morphological characteristics exhibited by the specimens collected in different sampling locations in the present study corresponded to those indicated by previous research. All members of Hippoboscoidea are morphologically adapted to an ectoparasitic life among the hair or feather of their hosts and, consequently, some parts of the body of these organisms have undergone modifications in response to permanent ectoparasitism [10].

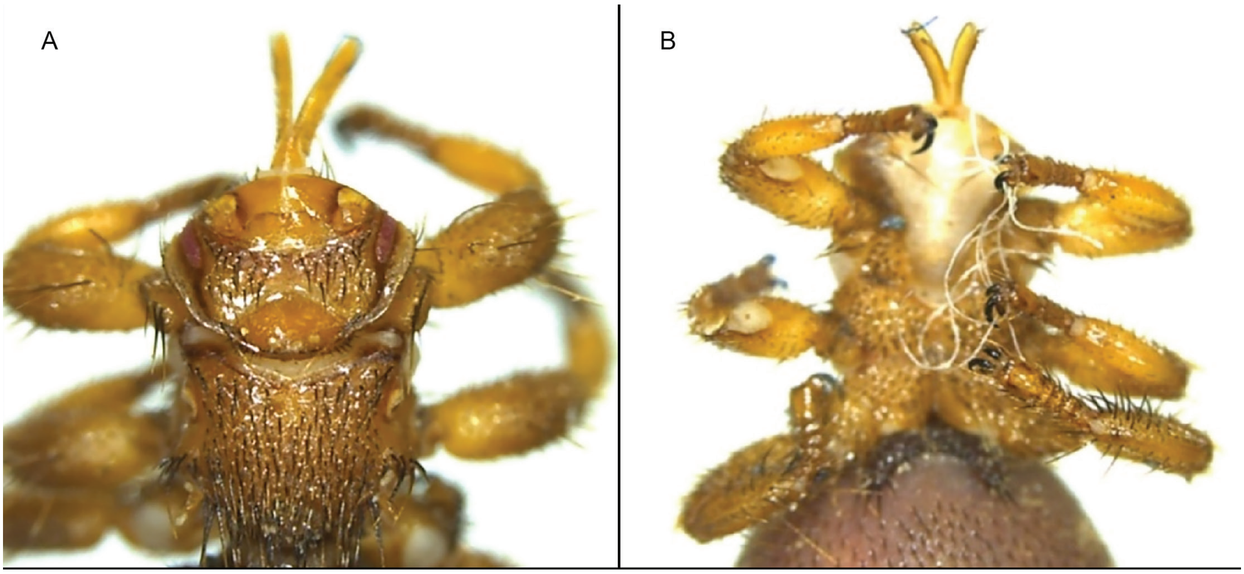

Figure 1.
Dorsal view of *M. ovinus* showing the short antennae within the antennal pit and the small compound eyes (A) and detail of the enlarged femurs, flat tibiae, and tarsi with strong nails (B).

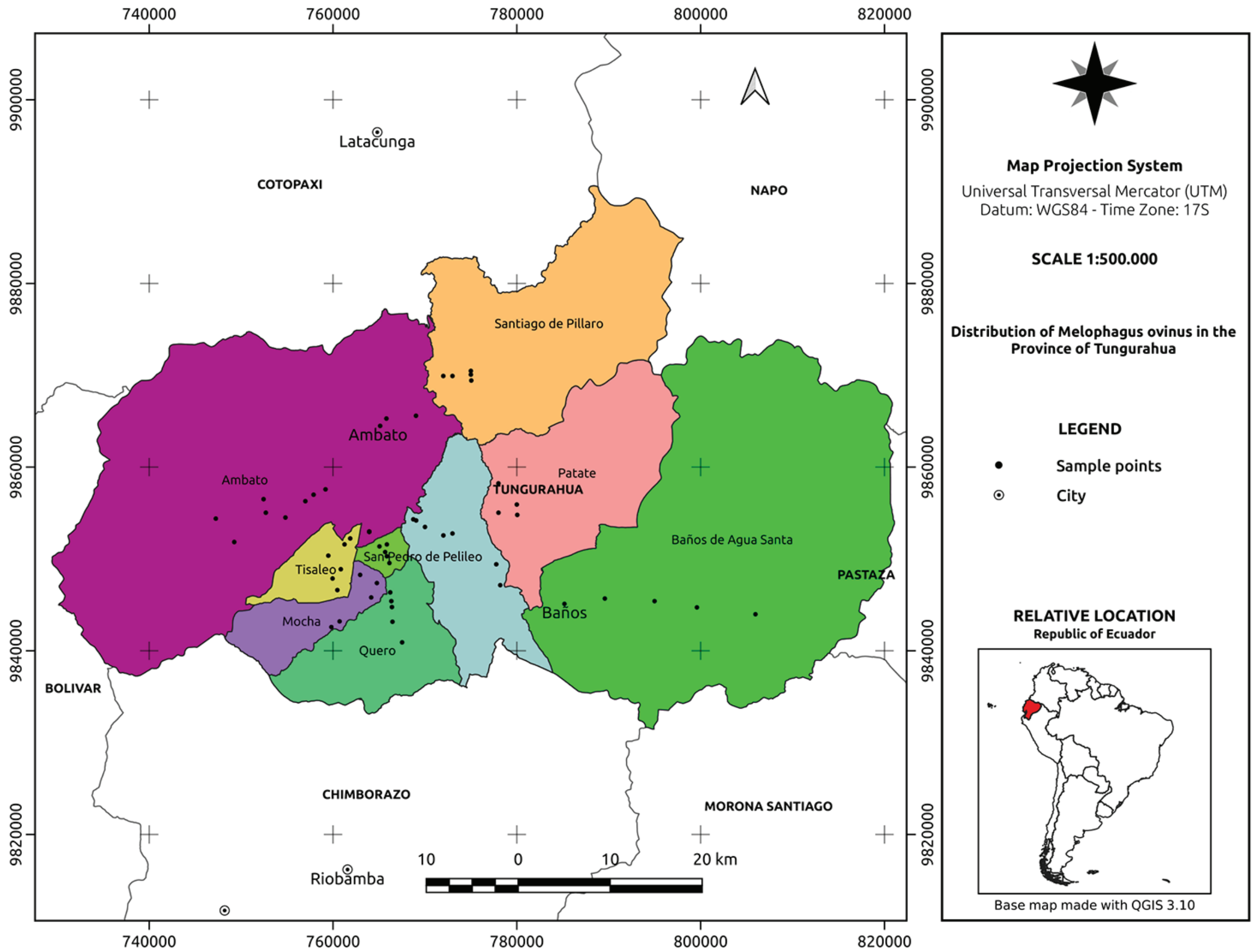

Figure 2.
Distribution map of *M. ovinus* in the different municipalities of the province of Tungurahua, Ecuador.

Hypoboscids are characterized by a dorsoventrally flattened body, a more or less flexible cuticle at the back of the body which allows the abdomen to expand after blood feeding or for keeping the larva during its development. The legs are strong with two claws to ensure the parasite has a good grip on the host, be it a bird or a mammal. In the case of M. ovinus, they have small compound eyes and antennae within an antenna cavity [11]. Hypoboscid ectoparasitism has led to the adaptation of some other structures, including prognathous buccal parts with two well-sclerotized palps called a proboscis that covers the stylets. This ends in a structure with sensillae and teeth to break the host's skin and feed on the blood. On the other hand, the legs have a pretarsus with a pair of claws, a pulvillus, and an empodium for the best hold [12].

Prevalence of M. ovinus in sheep in Tungurahua province

Significant differences were found in the prevalence of *M. ovinus* between different municipalities of Tungurahua province included in this study (Figure 3). In general, the highest prevalence was observed in the different localities of the Ambato municipality with a prevalence of 39.3%, which was statistically similar to that of the localities from Quero Municipality (33.5%), Mocha (32.3%), Pelileo (30.7%), and Tisaleo (28.0%). However, a lower prevalence was observed in Patate, Cevallos, and Píllaro, with a range of 7.5%-18%. It should be noted that no *M. ovinus* was detected in Baños. Furthermore, the greatest variation in prevalence was observed in Ambato, Cevallos, and Mocha, with the ranges of 10%-60%, 20%-50%, and 10%-50%, respectively. For the rest of the municipalities, the variation was lower (Table 1).

No relationship was found between the number of ectoparasites and the gender or age of the host sheep. A higher incidence was observed in males (58.45%) than in females (41.55%), which was not statistically significant according to Pearson's Chi-squared ($p = 0.492$). When the number of parasites by gender was analyzed, it was observed that a high percentage of animals presented 3-4 ectoparasites per animal in both genders (Table 2).

No significant association was observed between the animal's age and incidence of *M. ovinus* according to the Pearson Chi-squared ($p = 0.314$) (Table 3). However, a higher prevalence was revealed in animals aged 1-3 years and older than 5 years, with values of 31% and 29.6%, respectively, in which a high proportion presented 1-4 ectoparasites during sampling (Table 4). Based on the data in the localities considered in this study, the wide geographic distribution of *M. ovinus* in the municipalities of Tungurahua province is shown in Figure 2.

Discussion

Various studies have reported the prevalence of *M. ovinus* and other ectoparasites on sheep in Ethiopia. For example, the prevalence of *M. ovinus* reached 33.57%, which could be considered high due to its effects on animals' health and welfare [13]. This highlights the need to apply efficient sanitation practices in the stable and areas visited by the sheep for optimal control. In addition, they observed differences in prevalence due to the effect of the age and condition of animals with this being higher in young animals and animals with a poor body conditions. Although similar prevalence rates were found in the present study, no association was observed between the age of the animal and the prevalence of ectoparasite. Similarly, Mulugeta et al. [14] did not observe differences in the prevalence of *M. ovinus* and other species of ectoparasites concerning the age or gender of the host. On the other hand, they reported a higher prevalence of 52.4% in the highlands, while the prevalence decreased to 4.8% in the lowlands of medium height, and was not observed at all in low areas. This suggests that hot and humid climate conditions limit parasite distribution because temperature plays a key role in the distribution and population dynamics of *M. ovinus*. Moreover, these authors observed that *M. ovinus* was found more frequently in breeds with abundant wool, suggesting these breeds be more susceptible to parasite infestations.

Previous studies in different areas worldwide have demonstrated that temperature is considered the main environmental factor influencing *M. ovinus* distribution. However, even in regions with similar temperatures, the occurrence of this ectoparasite can vary, showing that apart from temperature, other environmental factors, such as thermal amplitude, humidity, and altitude, are likely to be involved [15]. In addition, there were other factors related to the host, including individual susceptibility and wool characteristics which could generate the necessary microclimate for parasite establishment. In this sense, the lack of correlation between similar temperatures and the abundance of *M. ovinus* in previous studies could explain the differences observed in the abundance of this species in the different municipalities of Tungurahua province with similar temperature regimes. Therefore, the observed variations could be attributed to other factors, such as herd management and differences in wool type due to the sheep breed. However, these factors need to be investigated to determine their role in the incidence of *M. ovinus* in the region.

Previous studies have shown that climatic conditions do not have a determining effect on the distribution, which further confirms this idea. Although *M. ovinus* was restricted to humid areas in the Pata-

Table 1.
Prevalence variation of *M. ovinus* in the sampled localities by municipality in Tungurahua province

Locality by municipality	Mean value ±S.D.	Maximum value	Minimum value
Ambato			
Atahualpa	9 ± 0.50	3	2
Chibuleo	28 ± 0.82	6	4
Comunidad San Isidro	10 ± 1.41	6	4
Echaleche	26 ± 0.84	6	4
Juan Benigno Vela	24 ± 0.63	5	3
Martínez	6 ± 0.00	2	2
Miñarica	17 ± 0.96	5	3
Montalvo	3 ± 0.71	2	1
Pasa	15 ± 1.71	6	2
Pilahuin	24 ± 0.84	6	4
Pisque	2 ± 0.00	2	2
Pucara Grande	5 ± 0.00	5	5
Santa Rosa	18 ± 0.89	5	3
Tamboloma	25 ± 1.47	6	2
Baños			
Lligua	0 ± 0.00	0	0
Rio Blanco	0 ± 0.00	0	0
Rio Negro	0 ± 0.00	0	0
Rio Verde	0 ± 0.00	0	0
Ulba	0 ± 0.00	0	0
Cevallos			
Agua Santa	2 ± 0.00	2	2
Andignato	6 ± 0.58	2	1
Ferrobiario	0 ± 0.00	0	0
La Florida	5 ± 1.15	3	1
Santa Rosa	6 ± 1.00	3	1
Mocha			
EL Rey	10 ± 1.15	4	2
Olalla	3 ± 0.00	3	3
Pinguili	10 ± 1.29	4	1
Primavera Alta	11 ± 1.53	5	2
Yanahurco	8 ± 1.41	5	3
Patate			
Bellavista	3 ± 0.71	2	1
Clementina	0 ± 0.00	0	0
Pelileo			
Benitez	9 ± 0.00	3	3
Chaupi	6 ± 0.00	3	3
Chilcapamba	6 ± 0.00	3	3
Pingue	6 ± 0.00	3	3
Salasaka	13 ± 0.50	4	3
San Jaloma Bajo	3 ± 0.00	3	3
Tambo	3 ± 0.00	3	3

Table 1 cont.

Pillaro					
Marco Espinel	4	±	0.58	2	1
Presidente Urbina	5	±	0.58	2	1
San Andrés	6	±	0.00	2	2
San José de Poaló	6	±	0.00	2	2
San Miguelito	6	±	0.00	2	2
Quero					
El Empalme	9	±	1.00	4	2
El Placer	11	±	0.58	4	3
Hualcanga Chico	11	±	0.58	4	3
Sabañag	14	±	1.29	5	2
Santuario	12	±	0.82	4	2
Tisaleo					
Alobamba	10	±	0.58	4	3
Barrio Olimpico	4	±	1.41	3	1
Bellavista	5	±	0.71	3	2
Quinchicoto Alto	6	±	0.00	3	3
San Diego	15	±	1.00	4	2
Santa Lucia	2	±	0.00	2	2

gonian region in Argentina, this species has recently spread to drier areas [16]. Concomitantly, studies on 123 sheep farms located in humid, mesic, and arid environments revealed that the prevalence of *M. ovinus* was higher than 72% [15].

Similarly, a study found differences in the prevalence of *M. ovinus* according to the location varying from 13.85% to 11.86% and 9.52% in Fura, Gorgo, and Dancye, respectively [17]. It was significantly lower in Wane (5.41%) and Wura (4.92%). Moreover, in Ethiopia, it was found that the prevalence of *M. ovinus* ranged from very low in Bahir-Dar at just 3% to a relatively high rate of 32.57% in Kombolcha, Ethiopia [18]. The differences were created not only by variations in climatic conditions but also by breeding practices, mainly related to the management of ecto-

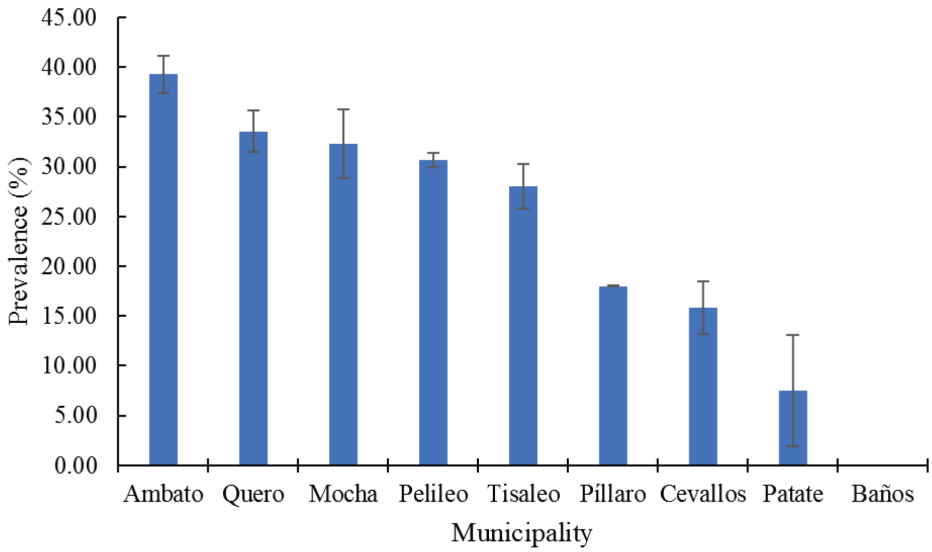

Figure 3.
Prevalence of *M. ovinus* in the different sampled municipalities of the province of Tungurahua

Table 2.
Relationship between the number of *M. ovinus* and sheep's gender

	Number of ectoparasites/animal				Pearson's *chi* square
	1-2	3-4	5-6	Total	
male	34	36	13	83 (58.45%)	0.492 [n.s]
female	15	34	10	59 (41.55%)	N
total	49 (34.51%)	70 (49.30%)	23 (16.19%)	142 (100%)	N

n.s.: not significant differences

Table 3.
Relationship between the number of *M. ovinus* and sheep's age

	Number of ectoparasites/animal				Pearson's *chi* square
	1-2	3-4	5-6	Total	
< 1 year	7	14	1	22 (15.50%)	*0.314* [n.s.]
1 – 3 years	19	19	6	44 (31.00%)	
3 – 5 years	11	16	7	34 (23.90%)	
> 5 años	12	21	9	42 (29.60%)	
Total	49 (34.50%)	70 (49.30%)	23 (16.20%)	142	

n.s.: not significant differences

Table 4.
Municipalities of Tungurahua province where the samples were taken

	Temperature (°C)	
	Maximum	**Maximum**
Baños	20	15
Cevallos	17	9
Mocha	15	7
Patate	20	13
Píllaro	17	10
Quero	16	9
Tisaleo	15	8
Ambato	20	9
Pelileo	20	8

parasites. These were influenced by the lack of knowledge among the farmers and the inadequate technical assistance provided by local governments [19].

The economic impact of *M. ovinus* and its potential to transmit pathogens highlight the need for more research on the prevalence of this ectoparasite in producing areas. Various studies have shown that apart from the physical damage and reduction in weight gain and reproduction caused by *M. ovinus* infestations, its ability to transmit different types of pathogens also highlights its economic importance for sheep farming at the national level and worldwide [20].

A series of pathogenic microorganisms can be transmitted by *M. ovinus*, including *Bartonella* spp., *Rickettsia* spp., *Candidatus Neoehrlichia mikurensis, Theileria* spp., which are the cause of different pathologies that compromise sheep productivity [21, 22]. In this case, it is suggested that the herd be regularly reviewed to detect excessive loss of fur, areas of skin irritation, and/or injuries that could be an indication of infestation with some type of ectoparasite, including, and thus, take prophylactic measures to reduce the possibility of infestation in the rest of the herd [23].

Materials and Methods

The prevalence of M. ovinus was estimated in sheep reared in semi-intensive and backyard systems. Random samplings were performed from April to July 2021 in different locations in the municipalities of Ambato, Baños, Cevallos, Mocha, Patate, Pelileo, Píllaro, Quero, and Tisaleo in the Tungurahua province, Ecuador (Table 4). Prevalence was expressed as the proportion of the population that showed positive results for *M. ovinus* at a given time [24], according to the following formula:

Prevalence=(Number of cases in the population at a given moment)/(Total population defined at the same moment in time)

Stratified sampling was used, which consisted of dividing the population into strata (based on age, gender, and condition of the animal) and samples were taken from each stratum [25]. The sample size was calculated using the formula given by Thrusfield [26] considering a precision level of 5% and a confidence interval of 95%. There are no previous studies on the prevalence of *M. ovinus* in the study area. Therefore, an expected prevalence of 50% of ectoparasites in small ruminants was assumed.

$$n = \frac{(1{,}96)^2 * P_{exp} * (1 - P_{\text{exp}})}{d^2} = 384 \text{ animals}$$

Where "n" represents sample size, "P_{exp}" denotes Expected prevalence, and "d" is the expected absolute precision.

The animals under study were examined by the visual inspection of the back, folds, head, and neck to detect the presence of ectoparasites. Once the samples were obtained, they were placed in bottles with 70% alcohol until being processed in the laboratory. In addition to the samples, information on the gender and age (young, adult, and old) of the examined animals was recorded. In the laboratory, samples were assessed under a stereomicroscope to verify the morphological characteristics of the species according to Zhao et al. [27].

The obtained data were tabulated, including information on the sample number, sampling date, canton and sampling location, geographic coordinates, the number of parasites found, as well as the age and gender of the animal. Comparisons of prevalence between diverse localities, genders, and age groups were made using the statistical package Statistix version 10.0. In addition, photographs of the different regions of the body were taken. Finally, a distribution map was prepared, each sampling site was georeferenced, and the geographic coordinate data were plotted using QGIS version 3.18.

Authors' Contributions

CV, ATB and SC conceived and planned the study. ATB carried out the samplings and contributed to sample preparation. CV, SC and GV contributed to the interpretation of the results and took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis and manuscript.

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Competing Interests

The authors declare that there is no conflict of interest

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