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Research Paper

Seroprevalence of Antibodies Against *Anaplasma* spp. in Algerian Sheep and Associated Risk Factors

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ABSTRACT

Introduction: This study aimed to determine the seroprevalence and identify the main risk factors associated with exposure to *Anaplasma* spp. in sheep from two Algerian regions, Médéa and Bordj Bou Arréridj.

Materials & Methods: Between March and November 2021, a total of 361 blood samples were collected from sheep during both the spring and autumn seasons. The sera were analyzed using a competitive enzyme-linked immunosorbent assay (MSP5-cELISA), which detects antibodies against *Anaplasma* spp. but does not distinguish between species.

Results: The overall seroprevalence reached 73.13%, with a significantly higher rate observed in Médéa (81%) compared to Bordj Bou Arréridj (70.12%) (odds ratio [OR]=1.82). Multivariate logistic regression analysis revealed that age (12–24 months), sampling season (spring), sub-humid climatic conditions, and tick infestation were significantly associated with *Anaplasma* spp. seropositivity. Among these, tick infestation emerged as the strongest predictor (adjusted OR=11.98, P<0.0001). No significant associations were detected with sex or the breeding system.

Conclusion: These results demonstrate a high level of exposure to *Anaplasma* spp. among Algerian sheep and provide the first cELISA-based serological evidence for these regions. The findings underscore the role of environmental factors—particularly climatic conditions and vector presence—in shaping the epidemiological dynamics of anaplasmosis in small ruminants. As MSP5-based serology detects antibodies rather than active infection, these data reflect historical exposure rather than current infection status. Future research should integrate molecular confirmation (polymerase chain reaction (PCR) and sequencing) and longitudinal follow-up to identify circulating *Anaplasma* species, assess infection seasonality, and design effective, region-specific vector control strategies to mitigate the economic impact of ovine anaplasmosis in Algeria.

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1. Introduction

Sheep farming plays a crucial role in North African agriculture, contributing significantly to the local economy and the livelihoods of rural communities [1]. In Algeria, it also supports the preservation of the steppe ecosystem by providing essential animal products that sustain human well-being [2].

However, sheep are exposed to numerous health challenges, and their productivity is often compromised by infectious and parasitic diseases, many of which are vector-borne and transmitted by hematophagous arthropods such as ticks. These pathogens cause major economic losses by reducing flock productivity and animal health [3].

Among tick-borne pathogens, bacteria of the genus *Anaplasma* have gained increasing attention because of their global distribution, economic impact, and zoonotic potential [4]. *Anaplasma* spp. are gram-negative, obligate intracellular bacteria belonging to the family Anaplasmataceae, order Rickettsiales, and class Alphaproteobacteria. They infect various host cells, particularly erythrocytes, leukocytes, and endothelial cells and cause anaplasmosis, a disease characterized by fever, anemia, weight loss, and, in severe cases, death.

Small ruminants can serve as hosts for several *Anaplasma* species, most notably *Anaplasma ovis*, and occasionally *Anaplasma marginale* or *Anaplasma phagocytophilum* under specific epidemiological conditions [5]. However, *A. ovis* remains the primary etiological agent of ovine anaplasmosis. It is a strict intraerythrocytic bacterium that infects sheep, goats, and certain wild ungulates [6].

Ovine anaplasmosis is mainly transmitted by ticks of the order Ixodida, particularly *Rhipicephalus bursa*, *Hyalomma lusitanicum*, and *Dermacentor silvarum* [7]. Clinical signs are often nonspecific and may include fever, lethargy, anorexia, anemia, jaundice, nasal discharge, weight loss, and abortion [8]. These symptoms, however, can overlap with those of other tick-borne hemoparasitic infections such as babesiosis and theileriosis, which makes clinical diagnosis alone unreliable.

The disease is widespread among small ruminants and has a broad geographical distribution, having been reported in Mediterranean countries, the Middle East, the USA, Asia, and Africa [9]. Animals that survive the acute phase of the disease often remain chronically infected, with low bacteremia levels undetectable by conventional stained blood smears [10]. In such cases, diagnosis relies mainly on indirect methods such as serological testing. Therefore, the detection of anti-*A. ovis* antibodies through serology is an essential tool for effective monitoring and management of flock health [11].

Serological approaches, particularly competitive enzyme-linked immunosorbent assay (cELISA), are valuable for epidemiological surveillance. The test used in this study (Anaplasma Antibody Test Kit, version 2, VMRD, Pullman, WA, USA) detects antibodies against the major surface protein MSP5, which is conserved across several *Anaplasma* species [12]. Although initially developed for detecting antibodies to *A. marginale*, this assay also identifies *A. ovis* due to the shared MSP5 epitope. However, it does not allow species differentiation and may cross-react among *A. marginale*, *A. ovis*, and *A. phagocytophilum*. This limitation should therefore be considered when interpreting serological results.

This study aims to address existing knowledge gaps by assessing the seroprevalence of antibodies against *A. ovis* in sheep using the MSP5-based cELISA, an approach still underused in Algeria. In contrast to previous research mainly focused on the northeastern part of the country, this work investigates geographically underrepresented regions to provide a more comprehensive epidemiological overview. It also explores potential risk factors associated with seropositivity, such as management practices, season, and sanitary conditions. By combining a sensitive diagnostic tool with a multifactorial risk analysis, this study contributes novel insights into the epidemiology of ovine anaplasmosis and supports the development of targeted control strategies adapted to local contexts.

2. Materials and Methods

2.1. Study area

This study was conducted from March to November 2021 in two regions of Algeria: Médéa and Bordj Bou Arréridj (Figure 1); Located respectively in the north and central-north of the country, both regions present distinct agro-ecological characteristics influencing tick dynamics and, consequently, the epidemiology of *Anaplasma* spp. infection. Bordj Bou Arréridj, situated in the eastern High Plateaus southeast of Algiers, has a semi-arid climate with cold winters and hot, dry summers. Temperatures vary significantly by season, with moderately warm springs (15–25 ˚C) and a gradually cooling autumn (25–10 ˚C). Such dry conditions are

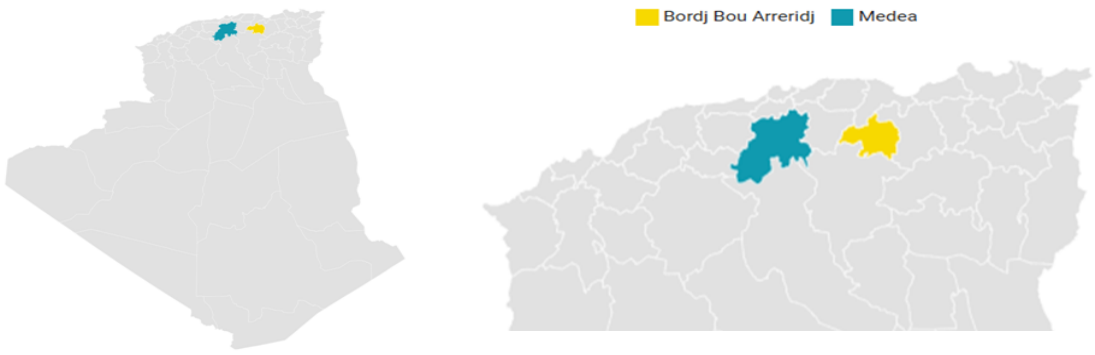

Figure 1. Study area showing the sampled regions (Médéa Medea and Bordj Bou Arréridj)

known to favor *Rhipicephalus* and *Hyalomma* tick species, which are important *Anaplasma* vectors. Médéa, a predominantly mountainous area in the Tellian Atlas, has a sub-humid climate characterized by cooler temperatures (10–22 ˚C in spring; 10–20 ˚C in autumn) and higher humidity, which provides suitable conditions for tick survival and activity.

2.2. Samples collection

A total of 361 blood samples were collected from sheep: 261 from Bordj Bou Arréridj region and 100 from Médéa during two distinct seasons (spring and autumn). The difference in sample size reflects flock population density and accessibility to farms, as the Bordj Bou Arréridj region has a larger sheep population and greater farm availability. This distribution was nevertheless considered in subsequent statistical analyses to minimize potential bias in prevalence comparisons.

For each animal, a data collection form was completed to record individual and environmental factors, including age, sex, farming system, general health status, tick infestation at the time of sampling, season, and local climatic conditions.

Among the 361 animals sampled, 258 were females (71.46%) and 103 were males (28.53%). Age was categorized as: <12 months (34.9%), 12–24 months (43.49%), and >2 years (21.6%). In terms of season, 241 samples (66.75%) were collected in spring and 120 samples (33.24%) in autumn.

Blood was drawn from the jugular vein into plain tubes without anticoagulant. After coagulation, samples were centrifuged at 2,000 rpm for 10 minutes (adjusted from 1,000 rpm to ensure complete serum separation). Serum was then aliquoted and stored at -20 ˚C until serological analysis.

2.3. Competitive ELISA (cELISA)

All sera were tested for antibodies against *Anaplasma* spp. using a commercial competitive ELISA kit (Anaplasma Antibody Test Kit, cELISA v2, VMRD, Pullman, WA, USA). The assay targets antibodies directed against the major surface protein MSP5, which is highly conserved among *A. marginale*, *A. ovis*, and *A. phagocytophilum* [12]. The test was performed following the manufacturer's instructions.

Optical density (OD) was measured at 630 nm using an ELX800 ELISA microplate reader (BioTek Instruments, Inc., USA). The percentage of inhibition was calculated as follows (Equation 1):

1. %inhibition=100×(1−OD of sample/OD of negative control).

Samples were classified as negative if % inhibition<30% and positive if % inhibition ≥30%.

Positive and negative controls supplied with the kit were used to validate each assay plate. No additional field controls were required, as the commercial controls provided by the manufacturer are species-independent and recommended for small ruminants.

Although initially developed for bovine anaplasmosis, the MSP5-based cELISA has been validated for *A. ovis* detection in sheep, showing high sensitivity and specificity (>90%) in previous studies [11, 13]. Nevertheless, it does not allow differentiation between *A. marginale*, *A. ovis*, or *A. phagocytophilum*, nor does it distinguish current infection from past exposure. This limitation was considered in data interpretation.

2.4. Data analysis

Seroprevalence was calculated as the proportion of positive samples among all tested animals. Associations between categorical variables were evaluated using the chi-square (χ^2) test.

Univariate and multivariate logistic regression analyses were performed to assess associations between *Anaplasma* spp. seropositivity (binary outcome) and potential risk factors (age, sex, season, region, climate, farming system, tick infestation, and health status). Odds ratios (ORs) with 95% confidence intervals (CIs) were reported. The ORs presented in the abstract correspond to adjusted values derived from the final multivariate model.

A directed acyclic graph (DAG) was constructed to identify confounders and guide variable selection for multivariate analysis. The DAG included variables such as region, season, climate, age, tick infestation, and management system. It was developed using the "dagitty" package in R (version 4.3.2, 64-bit) to clarify causal assumptions and strengthen model interpretation.

All analyses were conducted in R software (version 4.3.2; R Foundation for Statistical Computing, Vienna, Austria). A $P<0.05$ was considered statistically significant.

The geographical map was generated using GADM.

3. Results

3.1. Geographical distribution of *Anaplasma* seropositivity in sheep

Out of a total of 361 sheep tested for antibodies against *Anaplasma* spp., 264 were positive, yielding an overall seroprevalence of 73.13% (95% CI, 69.6%–75.7%) (Table 1). In Bordj Bou Arréridj, 183 of 261 samples were positive (70.12%; 95% CI, 64.5%–75.7%), while in Médéa, 81 of 100 samples tested positive (81%; 95% CI, 73.3%–88.7%). These results indicate widespread circulation of *Anaplasma* spp. in both regions, with a higher seroprevalence observed in Médéa (Table 1).

3.2. Univariate analysis of risk factors associated with seropositivity

A univariate analysis was conducted to explore the association between seropositivity and potential risk factors (Table 2). Variables significant at $P<0.20$ were further assessed using multivariate logistic regression to control for confounding effects identified in the DAG (region, age, season, climate, and tick infestation).

Seroprevalence of *Anaplasma* spp. antibodies was significantly higher in Médéa (81.0%) compared to Bordj Bou Arréridj (70.1%), with an adjusted odds ratio (aOR)=1.82 (95% CI, 1.03%, 3.2%, P=0.037), indicating a higher risk of exposure in Médéa.

Age significantly influenced antibody prevalence. The 12–24 months age group showed the highest seropositivity (80.9% aOR=2.07, 95% CI, 1.26%, 3.39%, P=0.005), while animals under 12 months showed lower prevalence (63.5%).

Gender and breeding type were not significantly associated with seropositivity ($P>0.05$). Males and females had comparable rates (71.8% vs 73.6%), as did animals raised under extensive and semi-extensive systems (73.4% vs 71.4%). Season had a notable effect, with animals sampled in spring showing a higher positivity rate (76.8%) than those sampled in autumn (65.8%), with an aOR of 1.72, 95% CI, 1.06%, 2.77%, P=0.027, suggesting a seasonal influence likely related to tick activity.

Climatic conditions were also significant. In sub-humid areas, seroprevalence reached 76.4%, compared to 59.4% in semi-arid zones (aOR=2.21, 95% CI, 1.27%, 3.83%, P=0.004), indicating higher risk in wetter environments favoring tick survival.

Health status showed a positive but non-significant association with seropositivity (P=0.076). Animals in moderate or poor condition had higher odds of exposure (aOR=1.75, 95% CI, 0.99%, 3.09%), suggesting a potential trend worth further investigation.

Tick infestation emerged as the most influential risk factor. Among 241 infested animals, 89.2% were seropositive, compared to 40.8% of non-infested animals (aOR=11.98, 95% CI, 6.94%, 20.68%, $P<0.0001$), confirming the major role of ticks in *Anaplasma* spp. transmission.

3.3. Causal framework: directed acyclic graph (DAG)

The directed acyclic graph (Figure 2) illustrates hypothesized relationships between variables influencing seropositivity. The model identifies tick infestation, age, season, and climate as direct determinants, while region and breeding type act indirectly through their effects on environmental exposure and animal health.

Table 1. Serological prevalence of *Anaplasma* spp. infection in sheep by region

Region	Number of Sheep Tested	Prevalence (%)	95% CI
Bordj Bou Arreridj	261	70.12 (183/261)	64.5, 75.7
Medea	100	81 (81/100)	73.3, 88.7
Total	361	73.13 (264/361)	69.60, 75.7

The DAG guided the selection of confounders included in the multivariate logistic regression model, ensuring that associations were adjusted for key interacting variables.

3.4. Multiple correspondence analysis (MCA): risk group visualization

The biplot shown in Figure 3 presents the projection of individuals onto the first two dimensions obtained from a MCA, using simulated data categorized into three risk groups. These groups are defined as follows: the high-risk group (in red) includes animals infested with ticks, living in a sub-humid climate, and aged between 12 and 24 months; the moderate-risk group (in orange) includes animals with various other combinations of factors; and the low-risk group (in green) consists of animals not infested with ticks, living in a semi-arid climate, and younger than 12 months.

The individuals in the high-risk group are tightly clustered in a specific area of the factorial space. This strong spatial concentration suggests a robust association between this profile and risk indicators such as seropositivity. The consistency of this group's position implies that its defining characteristics contribute significantly to explaining the variability in the dataset.

In contrast, individuals in the low-risk group are located in a clearly distinct region, well separated from the high-risk group. This spatial separation reflects a protective profile, likely due to the absence of ticks, the favorable environmental conditions, and the younger age of the animals. Their positioning on the plot supports the assumption that these factors are associated with lower risk levels.

The moderate-risk group appears more dispersed across the factorial space. This wide distribution indicates a high degree of heterogeneity within the group,

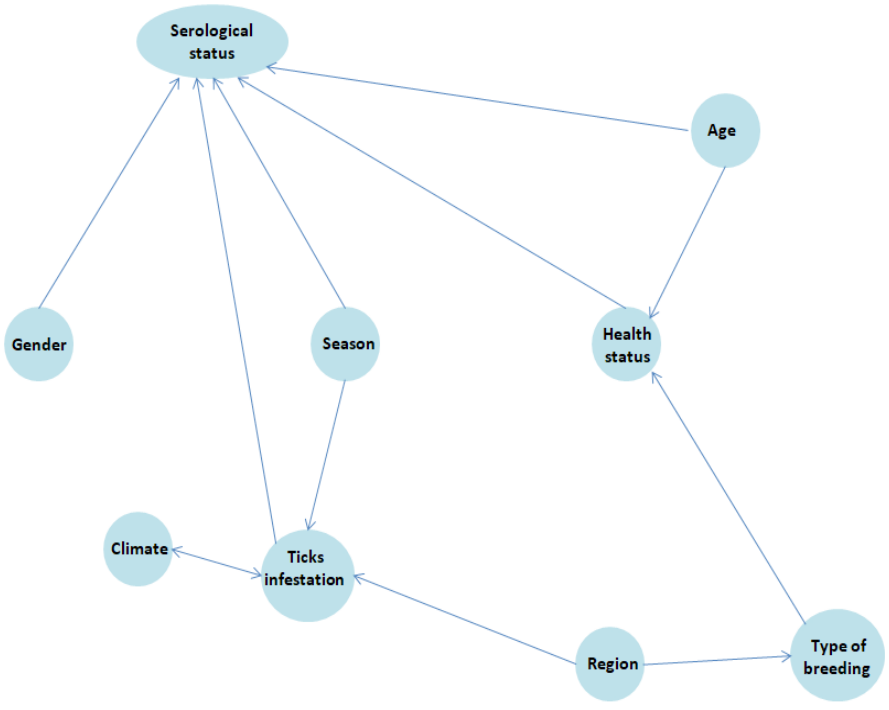

Figure 2. DAG representing hypothesized causal pathways influencing seropositivity

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Table 2. Risk factors analysis for *Anaplasma* spp. seropositivity by cELISA

Risk Factors		No. Sampled	No. (%) Positive	95% CI on Prevalence	aOR	95% CI on aOR	P*
Overall total		361	264(73.13)	68.6, 77.6	-	-	-
Region	Bordj Bou Arreridj (BBA)	261	183(70.12)	64.5, 75.7	0.55	0.31, 0.97	0.037
	Medea	100	81(81)	73.3, 88.7	1.82	1.03, 3.2	-
Age	<12 months	126	80 (63.5)	55.1, 71.9	0.482	0.29, 0.77	0.005
	12-24 months	157	127(80.9)	74.7, 87	2.070	1.26, 3.39	-
	>2 years	78	57(73.1)	63.2, 82.9	0.997	0.56, 1.75	0.995
Gender	Male	103	74(71.8)	63.2, 80.5	0.813	0.55, 1.52	0.728
	Female	258	190(73.6)	68.3, 79	1.095	0.656, 1.825	-
Season	Spring	241	185(76.8)	71.4, 82.1	1.715	1.059, 2.77	0.027*
	Autumn	120	79(65.8)	57.3, 74.3	0.583	0.36, 0.94	-
Type of breeding	Extensive	312	229(73.4)	68.5, 78.3	1.104	0.56, 2.15	0.773
	Semi-Extensive	49	35(71.4)	58.8, 84.1	0.906	0.46, 1.77	-
Climate	Semi-arid	69	41(59.4)	47.8, 71.	0.453	0.26, 0.77	0.004**
	Sub-humid	292	223(76.4)	71.5, 81.2	2.207	1.27, 3.83	-
Health status	Good	234	162(69.2)	63.3, 75.1	0.551	0.33, 0.93	0.076
	Moderate	98	79(80.6)	72.8, 88.4	1.753	0.99, 3.09	-
	Poor	29	23(79.3)	61.6, 90.15	1.447	0.57, 3.67	0.447
Ticks infestation	Yes	241	215(89.2)	85.3, 93.1	11.98	6.94, 20.68	<0.0001**
	No	120	49(40.8)	32, 49.6	0.083	0.04, 0.14	

OR: Odds Ratio; CI: Confidence interval (95%).

*Probability value indicating statistical significance (P<0.05 significant).

encompassing diverse combinations of intermediate or less clearly defined risk factors. The overlap of this group with both the low- and high-risk regions reflects its transitional nature and the uncertainty surrounding its classification.

The ellipses surrounding each group represent the concentration and variability of individuals within each category, likely corresponding to 95% confidence intervals around group centroids. While the high- and low-risk groups form relatively well-defined clusters, the moderate-risk group shows substantial overlap with the others, reinforcing the idea of less distinctive profiles.

In summary, this MCA biplot provides a useful visual tool for exploring the structure of categorical data and understanding the relationships between different risk profiles. It highlights clear separations between high- and low-risk groups, while also emphasizing the complexity and diversity within the moderate-risk category.

4. Discussion

To our knowledge, this study provides the first sero-epidemiological data on antibodies against *Anaplasma* spp. in sheep from Médéa and Bordj Bou Arréridj, two major sheep-farming regions in northern Algeria. It follows on from previous work carried out in other regions of Algeria and contributes to a better understanding of the

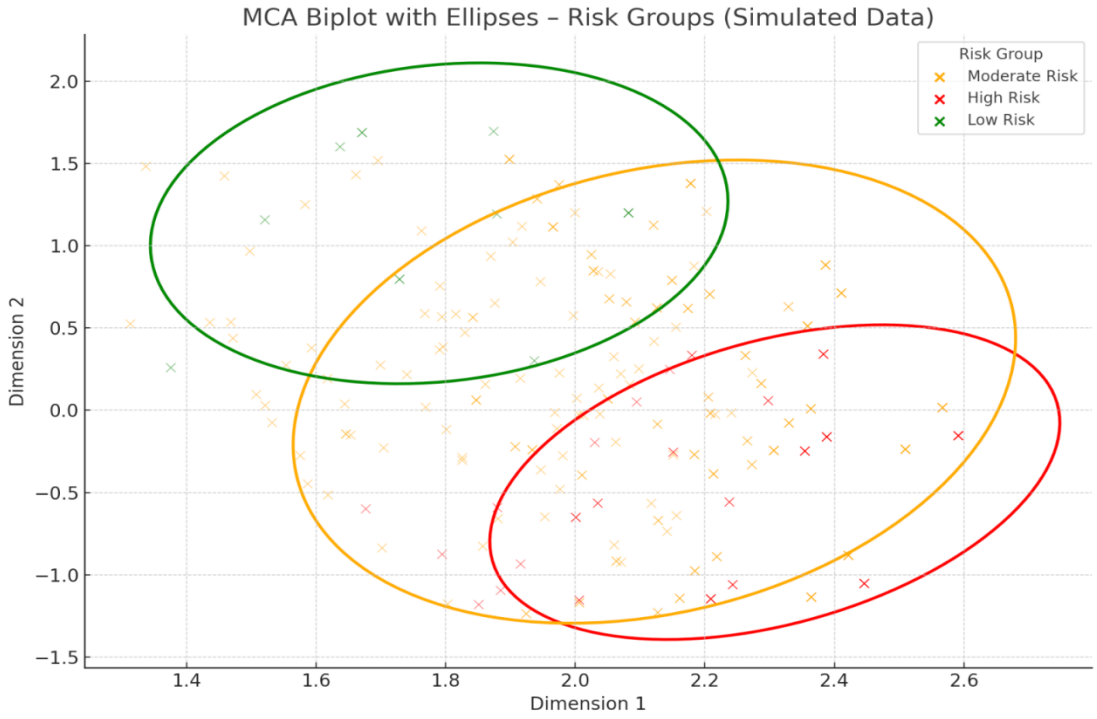

Figure 3. MCA biplot showing risk groups: the high-risk group (in red); the moderate-risk group (in orange), and the low-risk group (in green)

geographical distribution of anaplasmosis in the Algerian sheep herd. However, as similar surveys have already been performed in other parts of the country [14–16], our findings should be interpreted as a regional extension of previous work rather than a nationwide first report.

The competitive ELISA (cELISA) employed in this study targets the major surface protein 5 (MSP5), which is conserved among *A. marginale*, *A. centrale*, and *A. ovis* [13]. Although the test has shown excellent sensitivity (100%) and specificity (99.7%) in detecting *A. marginale* infections in cattle [17], such performance values cannot be directly extrapolated to *A. ovis* in sheep, as the test was not originally validated for this host–pathogen pair. Furthermore, MSP5-based assays may cross-react with other *Anaplasma* species, notably *A. phagocytophilum*. Compared to molecular diagnostic techniques such as polymerase chain reaction (PCR), which detect only active infections, cELISA also detects exposure to *Anaplasma* spp. rather than active infection and cannot differentiate between species or infection stages [18].

The overall seroprevalence observed (73.12%)—81% in Médéa and 70.12% in Bordj Bou Arréridj—indicates widespread exposure of sheep populations to *Anaplasma* spp. in both areas. These findings are consistent with previous Algerian studies reporting 78.02% in goats from El Tarf and Guelma [14], and 61.7% in sheep and 54.2% in goats from Souk Ahras [17]. This alignment suggests a broadly similar circulation of the pathogen among small ruminants across different regions, despite variations in host species and environmental conditions. Conversely, a recent meta-analysis by Nahal et al. [16] estimated an average prevalence of 30% in Algerian sheep, with strong regional disparities (26% in the northeast vs 9% in the north-central area).

Such high seroprevalence in our study, particularly in Médéa, may be explained by local ecological and farming factors favoring tick vectors.

Recent investigations have provided important insights into the epidemiology of *A. ovis* across North Africa. In Tunisia, M'ghirbi et al. [19] reported that *A. ovis* is endemic in small ruminants across three bioclimatic zones. In their survey of 263 apparently healthy sheep and goats, the prevalence reached 80.4% in sheep, as determined by duplex PCR targeting the *msp4* gene, with an overall *Anaplasma* spp. prevalence of 78.3%. Complementary findings were obtained by El-Hamdi et al. [20], who conducted a five-month longitudinal study in Tunisian flocks. They documented fluctuating molecular prevalence and incidence of new infections ranging from approximately 2% to 11%, along with a steady increase in seroprevalence reaching 52.6% in lambs by November, indicating ongoing transmission within herds. In Al-

geria, a recent meta-analysis covering studies from 2004 to 2023 estimated an overall *Anaplasma* spp. infection rate of 28% (95% CI=17–41), with infection levels of approximately 30% in sheep; *A. ovis* was among the species identified [20]. Furthermore, a molecular survey conducted in the Oum El Bouaghi region of Algeria revealed *A. ovis* infection in 10.8% of sheep, while *A. marginale* and *A. platys* were detected at lower rates (1.7% and 0.2%, respectively), and *A. phagocytophilum* was not observed in the sampled population [21].

The differences among studies are largely due to variation in diagnostic techniques (microscopy, PCR, or cELISA), sampling season, and management conditions [18, 22]. For clarity, prevalence values from selected North African and Mediterranean studies using different diagnostic methods are summarized in Table S1 (Supplementary Material).

At the international level, wide disparities have been reported, ranging from 71.8–88.9% in Morocco [23], to 43.9–58.8% in Turkey [24, 25], 41.7-66.6% in Iraq and Sudan [9], and 37–82.5% in European countries [9]. Such variability reflects differences in ecological settings, animal management, vector abundance, diagnostic methods, and host populations.

Age was identified as a significant factor in our study: animals aged 12–24 months showed the highest seropositivity (80.9%), followed by those over 2 years (73.1%), and the lowest in animals under 12 months (63.5%) (P<0.01).

This gradient is consistent with results from Algeria [14, 26] and Nigeria [27], and likely reflects cumulative exposure to infected ticks and gradual immune maturation in older animals.

No significant difference was found between males (71.8%) and females (73.6%). This agrees with previous Algerian findings [14, 16, 26] and supports the notion that sex plays a minor role compared to environmental or management factors [28].

Season was shown to be an important determinant, with higher prevalence in spring (76.8%) than in autumn (65.8%). This likely corresponds to increased tick activity during spring under favorable climatic conditions [29]. However, in the absence of entomological or climatic data (e.g. tick density, rainfall, or temperature records), this explanation remains hypothetical and should be verified in future investigations incorporating environmental monitoring [30].

Climate was another risk factor: prevalence was significantly higher in the sub-humid zone (76.4%) than in the semi-arid zone (59.4%) (OR=2.21; P=0.004). This observation is consistent with the fact that humid environments favor tick survival and reproduction [23, 21].

By contrast, the breeding system (extensive vs. semi-extensive) had no significant effect in our study, with similar prevalence in extensive and semi-extensive systems. Nonetheless, studies conducted in Morocco and Tunisia have reported higher infection rates in extensively managed herds, probably due to increased contact with tick habitats [23].

Although not statistically significant (P=0.076), animals in moderate or poor body condition exhibited slightly higher seroprevalence (80.6% and 79.3%, respectively) than those in good condition (69.2%). This pattern may suggest that compromised health could increase susceptibility, or, conversely, that chronic infection contributes to poorer body condition [10]. However, this interpretation remains hypothetical and warrants further research combining clinical and molecular data. Tick infestation emerged as the strongest predictor of seropositivity, with an odds ratio of 11.98 (P<0.0001), confirming the central role of tick vectors in *Anaplasma* spp. transmission.

The use of MCA for visualizing and interpreting categorical risk profiles remains a powerful exploratory tool, especially when combined with biplots for cluster visualization [22] In Figure 3, the distinct spatial grouping of individuals supports the hypothesis that risk-related variables co-vary systematically, producing clearly delineated profiles across the factorial space.

The tight clustering of the high-risk group indicates a strong co-association between infestation status, climatic conditions, and age, consistent with findings by Abdi and Valentin [31], who demonstrated that MCA effectively captures multidimensional dependence structures in epidemiological datasets.

The dispersion of the moderate-risk group aligns with patterns observed in other ecological or veterinary risk models, where mixed or transitional categories often reflect heterogeneous exposure levels [32]. Such intermediate clustering patterns suggest that the moderate-risk category might encompass animals under partial protective conditions or variable exposure environments, warranting further multilevel modeling.

Finally, the use of confidence ellipses to visualize intra-group variability is a methodological enhancement that aids in quantifying uncertainty around category centroids [29]. This approach has gained attraction in recent applied research for its clarity in representing risk gradients and category overlap zones in complex ecological datasets.

5. Conclusion

In conclusion, this study provides new insights into the exposure of sheep to *Anaplasma* spp. in northern Algeria, revealing a high seroprevalence and clear associations with age, season, climate, and tick infestation. These findings highlight the need for strengthened tick surveillance and targeted control programs, including regular acaricide treatment, improved pasture management, and farmer awareness campaigns on tick prevention. Veterinarians should consider anaplasmosis in differential diagnoses of anemia or wasting syndromes in small ruminants, especially during high-risk seasons.

Because the MSP5-based cELISA detects antibodies at the genus level, the results mainly reflect previous exposure rather than ongoing infection. Therefore, molecular confirmation (PCR and sequencing) is needed to identify circulating *Anaplasma* species and genotypes. In addition, longitudinal monitoring of herds would help assess infection dynamics, seasonality, and reinfection patterns, providing essential data for sustainable control strategies in Algerian sheep populations.

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Compliance with ethical guidelines

Blood samples were collected with the consent of sheep owners. No animal was harmed, and all procedures followed national veterinary regulations and good animal welfare practices.

Data availability

The datasets generated and analyzed during this study are available from the corresponding author upon reasonable request.

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Authors' contributions.

Conceptualization, investigation, and data curation: Mira Rima Haddoum; Statistical analysis: Safia Zenia, Nassim Ouchene and Nadjet Amina Khelifi Touhami; Data analysis and final approval: Nassim Ouchene and Nadjet Amina Khelifi Touhami; Validation and supervision: Farida Ghalmi and Naouelle Azzag; Writing the original draft: Mira Rima Haddoum, Nassim Ouchene, and Nadjet Amina Khelifi Touhami; Review and editing: Mira Rima Haddoum, Omar Salhi, Mohamed Rahal, and Abdelaziz Lounas.

Conflict of interest

The authors declared no conflict of interest.

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Table S1. Comparative prevalence of *A. ovis* infection in small ruminants from different regions and diagnostic methods

Country / Region	Host Species	Diagnostic Method	Reported Prevalence (%)	Ref.
Algeria (El Tarf, Guelma)	Goats	cELISA	78.02	[16]
Algeria (Souk Ahras)	Sheep / Goats	cELISA	61.7 / 54.2	[17]
Algeria (National meta-analysis)	Sheep	Mixed methods	30	[18]
Morocco	Sheep	PCR	71.8	[19]
Morocco	Sheep	Microscopy	88.9	[19]
Tunisia	Sheep	PCR	52.3	[19]
Italy (Sicily)	Sheep	PCR	37	[10]
Turkey	Sheep	PCR	43.9–58.8	[20, 21]
Iraq	Sheep	PCR	66.6	[9]
Sudan	Sheep	Microscopy	41.7	[9]