

Prevalence, infestation dynamics and assessment of ivermectin systemic scab treatment efficiency in sheep of north - eastern Algeria

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Abstract

A cross-sectional study, carried out between August 2015 and May 2016, in order, first to assess the prevalence and the seasonal sheep mange dynamics, and second to test the efficacy of ivermectin sarcoptic mange treatment. 11759 animals from 1072 flocks and livestock markets in Guelma, a north-eastern Algerian province, were followed up. The results showed that the infestation mean prevalence of flocks and animals was 25 and 10.45% respectively. Two major species of mange mites were identified: *Sarcoptes scabiei* var. *ovis* and *Psoroptes ovis*. These latter accounted respectively for 70 and 30% at flock level and 68 and 32% at individual level. A highly significant level probability was noted between the two species ($P < 0.001$). None of these species was seen during summer and spring. However, during winter and autumn, 55 and 45% of flocks were respectively infested and the prevalence of the infested sheep recorded was 25.1% in winter and 15.52% in autumn. The results from the livestock markets supported those of the cross-sectional study. The ivermectin treatment via a single injection at a 0.3 mg/kg doses per bodyweight was efficient in severely sarcoptic mange affected flocks. Two injections are, however, recommended in animals with very marked hyperkeratosis.

The present study proved a high overall and seasonal occurrence of mange mites in sheep living under Mediterranean climatic conditions. Animal breeders and veterinarians should jointly implement effective treatment strategies based on a single or a double injection at 0.3 mg/kg according to the severity of mange infestation (presence or absence of hyperkeratosis) so as to avoid economic losses inherent to this pathology.

Key words: sheep scab, prevalence, Guelma – Algeria, ivermectin, efficiency

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Introduction

With a *sheep* population of more than 28 million heads, Algeria ranks fifth in the world for sheep meat production (FAOSTAT, 2016). Sheep breeding due to its extensive type of farming, especially in the northern regions, faces numerous food and constraints and pathological problems that limit its productivity performances, namely the number of viable lambs and wool production: Although parasitosis is a serious animal health problem that impairs lamb growth and body weight ewes leading to reduced longevity and less productivity in Algeria (Benakhla et al., 2001; Boucheikhchoukh et al., 2012), the situation of parasitic diseases in sheep has not been really investigated. The sole pathologies that have been deeply studied are hepatic and rumen flukes (Mekroud, 2004), and strongylosis (Meradi, 2009). Sheep mange was shown to be the most frequently encountered in Algerian farms (Athamna et al., 2014). Its presence in animals varies between the seasons of the year: it is quiescent during spring, summer and early autumn (Urquhart et al., 1996) and most epidemics during the cold months (Athamna et al., 2014; Sedraoui, 2018). These

mites, either active on the surface or in the keratinized layer of the epidermis cause direct damage to the skin (Kassa, 1998) and indirect economic losses through the decreasing reproductive and production performance (Fthenakis et al., 2000). Moreover, a high animal mortality rate as much as 60% has been recorded (Demissie et al., 2000). Sheep mange is also of a social importance because humans can be parasitized (zoonosis) by *Sarcoptes scabiei* var. *ovis* (Soulsby, 1982).

The reported period of the evolutionary cycle of *Sarcoptes scabiei* var. *ovis* is about 10 to 14 days (Bussieras and Chermette, 1995) and 10 to 26 days (Craplet, 1964). The variation is likely due to the difficulty of observing the live parasite's development in the skin. Different observation methods used to obtain this information, metabolism levels under different temperature and relative humidity conditions, and observation of scabies mites from different hosts may be contributing factors (Arlian and Morgan, 2017). The integrated struggle against this parasitism in association with other dominant parasitic diseases such as *Oestrus ovis* and fasciolosis in a particular bioclimatic and topography conditions at the north of

Algeria had been subjected to a relevant study (Sedraoui, 2018).

Five main macrocyclic lactone used to control *internal and external* parasites are currently marketed for veterinary use: ivermectin, abamectin, doramectin, eprinomectin and moxidectin. These drugs have a large activity spectrum covering many nematodes, insects and mites, due to their structure, their associated *galenic* formulations and their significant persistency. They represent an alternative to organophosphates for mange treatment since they are safer for the environment, the animals and the farmer, easier to administer and *Sarcoptes scabiei* var. *ovis* mites do not develop resistance to their effect. However, the literature is controversial about their efficacy against sarcoptic mange.

The information on the prevalence and risk factors for sheep mange infestation in Algeria needs to be strengthened in order to apply effective control measures. Therefore, this study investigated the prevalence of mange, the seasonal occurrence of different mange mites and the recovery rate after a single ivermectin treatment of sarcoptic mange severely affected animals in northeastern Algeria, a heavily sheep loaded area.

Material and methods

The study area

The present study was conducted in different localities of Guelma (Roknia, Bouati, Ouled Ali Hammem, Heliopolis, El Fedjouj, Medjaz Amar, Hammem Debagh and Ain Hessainia) (Figure 1). This province lies between $36^{\circ} 27'58''$ North Latitude and $7^{\circ} 26'2''$ East Longitude; it is 256 meters above sea level with an average annual rainfall of 647 mm and a mean temperature of $21^{\circ} C$ (MADR, 2012). 50.81 % of the total area is reserved to agriculture (ANDI, 2015).



Figure 1: Province of Guelma and its surrounding localities.

Area of study is red colored

Experiment 1

Animals and study design

A cross-sectional study survey was conducted between August 2015 and May 2016. 11759 sheep from 1072 farms and markets were followed up. Farms using random sampling in the respective areas. 10.028 sheep belong to 992 flocks were sampled at the weekly animal's market

and 1.731 sheep were studied in 80 different flocks of the study area. The investigation was carried out three months per season, namely December to February for winter (292 flocks and 3385 animals), March to May for spring (270 flocks and 2817 animals), June to August for summer (285 flocks and 2994 animals) and September to November for fall (225 flocks and 2563 animals).

The sample size was determined according to Thrusfield method (2005) with 95% confidence interval and 5% absolute precision (Thrusfield, 2005). Due to the *lack of information* on the relative prevalence of sheep in Algeria mange in the study region, the expected prevalence rate (4.85%) was taken from the study of Mekroud, (2004). Therefore, The sample size required was 707. Thus, to increase precision and to be more accurate, 11759 sheep were selected from the target population which is largely representative.

Animal examination

During the flock inspection, animals with skin lesions such as crusts, alopecia and clinical signs of itching were identified. Samples for laboratory tests were collected from suspected mange cases and apparently healthy animals. The detection of mange mites was carried out following the technique described by Euzéby et al. (1981).

The crusts are previously weighed. One gram of crusts is taken and placed in a small bottle in which 20 ml of 10% KOH is added. After 24 hours, the mixture is poured into test tubes. These are centrifuged for 15 min at 2000 rpm. The supernatant is discarded and the pellet is resuspended in 05 ml of water.

Experiment 2

Animals and experimental design

A longitudinal survey was conducted on 415 sheep to investigate the frequency of different forms of scabies during the four seasons of the year. Thereafter, 5 flocks with total of 50 animals (10 animals each) severely affected with sarcoptic mange were considered for experimental treatment

Each animal was treated at day 0 (D0) with a generic of Ivomec (Avimec ND, Avico, Jordan) at a dose of 0.3 mg/kg of live bodyweight through a subcutaneous injection. A clinical examination was done at 7 days and 15 days post treatment according to the recommendations stated by Singh et al. (2012) and Kumar et al. (2016).

Clinical examination of the animals

The mange severity was determined by scoring five clinical symptoms/lesions namely: pruritus, erythema, crusts/scabs, alopecia, and pyoderma. Each symptom was rated on a scale ranging from 0 (absent) to severe. The five scores were added up and expressed as a *Sarcoptes*-induced Skin Lesions Score (SSLS) that could have values between 0 and 15 (Singh et al., 2012). The 50 sheep expressed a SSLS of 15/15 at the time of treatment. The clinical recovery was evaluated on SLSS improvement by calculating the mean SLSS per flock and the proportion of animals with the following five ordinal categories (C4:

very severe with $13 \leq \text{SSLS} \leq 15$, C3: severe $9 \leq \text{SSLS} \leq 12$, C2: moderate with $5 \leq \text{SSLS} \leq 8$, C1: mild with $1 \leq \text{SSLS} \leq 4$, C0: total recovery with $\text{SSLS}=0$.

Statistical analysis

The proportion of the area affected herd's in the study area was expressed as a percentage. The numerator represents the number of farms with at least one mangy animal and the denominator represents the total number of examined herds. Similarly, the prevalence of affected animals was calculated as a percentage. The numerator represents the number of animals with clinical signs of mange confirmed by the laboratory examination and the denominator represents the total number of examined animals. The comparison between the frequencies of sarcoptic and psoroptic mange, as well as the study of the frequency association between mange cases and the season as a potential risk factor were analyzed using Chi-square Test.

The ANOVA test was used to investigate post-treatment SSLS score, if any Duncan's Post-hoc Test was used to explore differences between flocks and between post-therapy stages. Chi-square Test was used for cross-table between post-therapy stage and SSLS categories in the total studied animals. The statistical significance was attributed when $P < 0.05$, $P < 0.01$ and $P < 0.001$

Results

Overall prevalence of animals and flocks affected with mange

The present study showed an overall infestation rate by mange at flock level and individual level of 12.41% (133/1072) and 5.87% (690/11759) respectively (Figure 2).

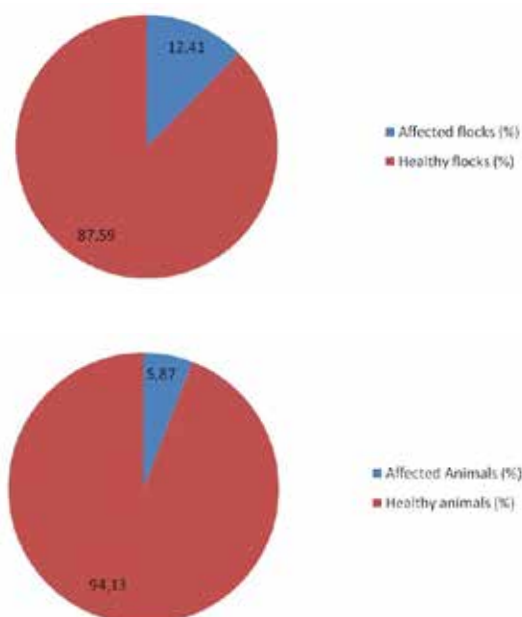


Figure 2: Prevalence of infested sheep at flock level (A) and individual level (B) by mange

Effect of the season

Figure 3 shows the seasonal prevalence of mange at flock and individual level. A significant seasonal effect on affected flocks and individuals ($P < 0.001$) was recorded. The mangy animals were totally absent in flocks during Summer.

The rate of affected flocks was 6.67% (15/225), 26.71% (78/292) and 14.81% (40/270) for autumn, winter and spring respectively and that of animals was particularly high during winter 11.85% (401/3385) versus autumn (3.55%) and spring (7.03%) as seen in Figure 3.

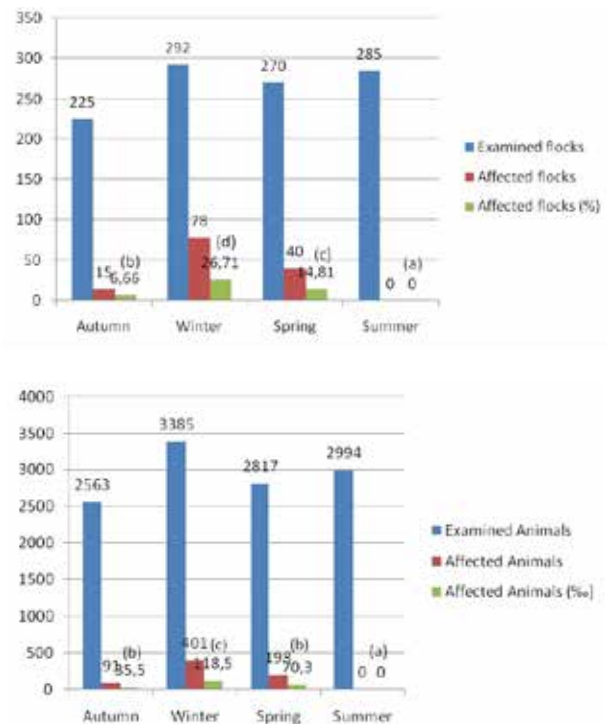


Figure 3: Seasonal frequency and prevalence at flocks level (A) and individual level (B).

Statistical significance between letters with similar colors: a- a: $P > 0.05$; a-b, b-c and c-d: $P < 0.05$; a-c and b-d: $P < 0.01$, a-d $P < 0.001$

Prevalence of different mange forms

The seasonal prevalence of the different mange forms recorded in the studied animals ($n=415$) is reported in figure 4. It was significantly dependent on the season ($P < 0.001$). The prevalence of the animals showing sarcoptic mange infestation was high during autumn (15.95%) and winter (22.48%) whereas that of those infested with psoroptic mange was lower (2.28%) in autumn and higher (16.78%) in winter. The choriopic mange was totally absent.

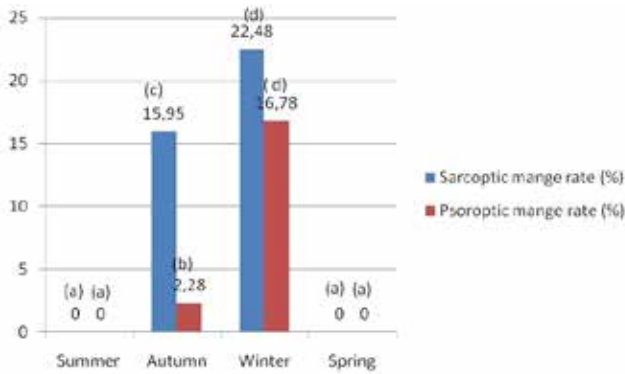


Figure 4: Seasonal prevalence of infested sheep by different mange forms (n=415)

Statistical significance between letters with similar colors: a- a: P>0.05, a-b and c-d: P<0.05, a-c P<0.01, a-d P<0.001.

Outcome of ivermectin treatment

Tables 1 and 2 show the results of the therapeutic trials. Ivermectin administration changed significantly the SSLS during the trial period (P<0.001). The average SSLS significantly decreased in the five studied farms at D8 post-therapy (6.6 ± 2.2). A regression rate of 44% without any significant difference between the farms (P>0.05) was recorded. No full recovery was reached at D8 and most animals were in the SSLS class 2 (72%, P> 0.05). At D15, the mean SSLS of the studied flocks dropped significantly to 2.5 ± 1.8 (P <0.001) with a predominance of animals that totally recovered (62%) (Tables 1 and 2). From D22 sarcoptic mange disappeared completely from the five farms with a return of the skin to a normal appearance and a start of hair regrowth from D36. However, 4 (8%) sheep of the flock flock 2 with severe SLSS relapsed at D78 had mean SSLS score significantly increased to 1 ± 1.1 (P <0.05).

The use of a single injection of Avimec ND at a dose of 0.3 mg.kg⁻¹ of live bodyweight led to the healing of affected sheep by scabies and to the total absence of associated lesions from D22 post-treatment.

Table 1: Lesion score (SSLS) and recovery rate (%) after a single ivermectin administration

		D0	D8	D15	D22	D29	D36	D50	D64	D78
H1	SSLS1	15A	7.2±1.7 a, D	2.4±1.3a, G	0 H	0 H	0 H	0 H	0 H	0H
	R1 (%)	0	48	16	100	100	100	100	100	100
H2	SSLS2	15A	8±2.2 a, D	3.5±2.0b, G	0 H	0 H	0 H	0 H	0 H	1±1.1b,G
	R2 (%)	0	53.3	23.3	100	100	100	100	100	6..6
H3	SSLS3	15A	6.7±2.7 a, D	0d,G	0G	0 G	0 G	0 G	0 G	0a, G
	R3 (%)	0	44.6	100	100	100	100	100	100	100
H4	SSLS4	15A	6.8±2.3 a, D	0d,G	0 G	0 G	0 G	0 G	0 G	0 a, G
	R4 (%)	0	45.3	100	100	100	100	100	100	100
H5	SSLS5	15A	6.6±2.3 a, D	0d,G	0 G	0 G	0 G	0 G	0 G	0 a, G
	R5 (%)	0	44	100	100	100	100	100	100	100
Averages	SSLS	15A	6.6±2.2	2.5±1.8***	0	0	0	0	0	0.2±0.6**
	R (%)	0	44	16.66	100	100	100	100	100	1.3

H: herd, D: days post-therapy, SSLS: mean SSLS of the ten studied sheep for each herd, R: Herds and average rates of SSLS recovery (SSLS 0: total recovery). Small letters: comparison of SSLS between different herds in the same post-treatment day. (a-b :P>0.05, b-d : P<0.01, a-d: P<0.1, d-h :P<0.001, g-h : P<0.05). Capital letters: comparison of SSLS between different post-treatment days in the same herd. (A-D: P<0.001, A-G: P<0.001, A-H : P<0.001, D-G : P<0.001 et D-H : P<0.001) G-H : P<0.05). ** : P<0,01, *** : P<0 1 ANOVA test for SSLS in post-treatment

Table 2: Frequency of SSLS in sheep from D0 to D78 post-treatment

	Days post-treatment							
	D0 (n=50)	D8 (n=50)	D15 (n=50)	D22 (n=50)	D29 (n=50)	D36 (n=50)	D64 (n=50)	D78 (n=50)
0	0	0	31(62%)	50(100%)	50(100%)	50(100%)	50(100%)	46(92%)
1	0	4(8%)	16(32%)	0	0	0	0	4(8%)
SSLS 2	0	36(72%)	3(6%)	0	0	0	0	0
3	0	10(20%)	0	0	0	0	0	0
4	50(100%)	0	0	0	0	0	0	0

SSLS : Sarcoptes-induced Skin Lesions Score, 0 : total recovery, n= total experimented animals

Discussion and conclusion

The first objective of the present study was to investigate sheep mange prevalence, herd's incidence and the seasonal occurrence of different mange mites in the northeastern of Algeria. Its second objective is to explore the therapeutic interest of a single injection in severely sarcoptic scabies animals.

The flocks and animals followed up showed an average rate and prevalence of about 12.41% and 5.87%, respectively. Our results are similar to those reported by Demissie et al. (2000) and Yasine et al. (2015) but are lower than those recorded by Athamna et al. (2014) in the extreme northeastern area of Algeria and Salifou et al. (2013) in West Africa. The high sheep flock contamination recorded would be due to the lack of organized and sustained prophylactic measures. The obtained scores are higher to those reported by Asghar et al. (2011), Enquebaher and Etsay (2010), Desie et al. (2010), Seid et al. (2016) and Papadopoulos and Fthenakis, (2017) who recorded a sheep infestation prevalence ranging from 0.95% to 2.8%. The disease would be very rare in Spain and Italy (Díez Baños et al., 1996; Puccini et al., 1999), even nonexistent in Belgium (Losson and Lonneux, 1993).

The discrepancy between the present study and the other described ones as to difference mange infestation rates could be due to the animal's breed, sample size, immune state and the difference in climatic conditions.

The seasonal prevalence of mangy sheep herds was the highest during winter (11.85%). Similarly, the seasonal rate infestation at flock level was 6.67%, 26.71% and 14.81%, respectively for autumn, winter and spring. The different sheep mange forms were absent of any infested animals in the summer. According to Bates (1996) a latent phase of disease in healthy flocks is seen in summer. These observations are consistent with the biological peculiarities of mites, which have less resistance during the summer months due to their sensitivity to dehydration (Lonneux 1996; Demissie et al., 2000; Losson, 2012). Moreover, previous studies in Morocco (Dakkak and Ouhelli, 1986), Ethiopia (Yasine et al., 2015) and Saudi Arabia (Wasfi and Hashim, 1986) reported that sarcoptic mange is much more common in autumn and winter than in other seasons. The flocks followed up were often maintained in extensive livestock systems. Breeders often overlook the diet aspects and animals are fed on straw and occasionally barley especially during winter. Therefore, the amount of feed is not sufficient to cover the animal's needs as to maintenance and production or even to withstand various affections (Radostits et al., 2007). Thus, mange proliferates (Enquebaher and Etsay, 2010; Seid et al., 2016). Likewise, some factors favoring the spread of mange, such as precarious housing, defective hygiene, transhumance or concentration of sheep piled up in poorly ventilated and dirty sheepfolds, as well as, the large numbers of gathered animals at markets and the transboundary crossing of uncontrolled animals. Such

conditions have proved favorable to the transmission of the disease spot, as is the case reported by random animal collection that occurs in the Saudi Arabia during the Hajj seasons (Asghar et al., 2011).

The sarcoptic mange infestation was frequently higher than that of psoroptic one during the two seasons reported to be the ones of infestation (autumn and winter). However, the chorioptic mange was absent. Our results are not in agreement with those of Al-Ezzy et al. (2015), who highlighted that the infestation by *Psoroptes ovis*, *Chorioptes ovis* and *Sarcoptes scabiei* was not affected by gender and season but they corroborate those reported in Algeria by Athamna (2003), Mitra, et al. (1993) in India, Rahbari et al. (2009) in Iran, Tadesse (2011) and Asghar et al. (2011) in Ethiopia. The sarcoptic mange infestation high frequency affecting flocks and individuals flocks is related to the highly contagious nature of *Sarcoptes scabiei* and chorioptic mange occurring only sporadically (Athamna, 2003). However, it should be noted that psoroptic mange remains the most common parasitosis encountered in Argentina (Nunez and Montaldo, 1985), the United States (Muschenheim et al., 1990; Kaufman et al., 1993), Ireland (O'Brien, 1992), Tunisia (Darghouth and Kilani, 1987), France (Rehby and Personne, 1998), Spain (Martinez et al., 1999) and Great Britain (O'Brien et al., 2001).

The use of a single injection of Avimec ND at a dose of 0.3 mg/kg of live bodyweight resulted in the healing of affected sheep by scabies and the total disappearance of associated lesions from D22 post-treatment. Our results agree with those of Ibrahim and Abu-Samra (1988), Sekar et al. (1997) and Zaman et al. (2017) in sheep species and those of Olubunmi (1995) in goat species. These authors reported the efficacy of a single injection of ivermectin at a dose of 0.2 mg/kg of live bodyweight against Sarcoptic mange with a clinical cure between 14 and 28 days post-treatment.

However, Manurung et al. (1990), Ghosh and Nanda (1997) and Sengupta et al. (1997) reported that a single injection of ivermectin at a dose of 0.2 mg/kg of live bodyweight is not sufficient and the use of double injection at 15-day interval is mandatory for the eradication of sarcoptic mange in sheep flocks. This supports what was observed in one flock (number 2) in which the disease reoccurred 78 days post-treatment in 8% of the animals that had very marked hyperkeratosis lesions. Regarding this form of scab, the concentration of ivermectin is not optimal in all keratinized layers, allowing some mites to remain live and eventually resume their development and egg lay. This justifies the use of a second injection that stimulates and strengthen the drug concentration in the epidermis.

The comparison of the treatment effect of a single injection of ivermectin with that of moxidectin or doramectin showed that moxidectin does not eradicate scabies in the ovine flock (Fthenakis et al., 2000) and that doramectin leads to a complete healing from 28 days post-treatment (Zaman et al., 2017). This latter has also been

reported efficient in porcine species (Cargill et al., 1996). However, El-Khodery, et al. (2009) concluded that the number of clinical cases that recovered after moxidectin and doramectin treatment was significantly higher than that of treated with ivermectin. The explanation would be that the residual effect is much longer for moxidectin and doramectin than for ivermectin (Bengone-Ndong and Alvinerie, 2004).

The difficulty in controlling mange in ruminant animals is related to its resistance to macrocyclic lactones, recently reported in Europe, particularly in Belgium and the UK (Lekimme et al., 2010; Mitchell et al., 2012; Doherty et al., 2018; Busin, 2018). If this is so, there will be major limitations of the use of these compounds in the future which worsen the problem due to anthelmintic resistance (Geurden et al., 2015; Busin, 2018). The development of vaccines and identification of potential chemotherapeutic targets has been hampered by the lack of transcriptomic and genomic resources for mange mites (McNair et al., 2010; Stewart et al., 2018). Special measures are needed for the diagnosis of prophylactic treatments (Lonneux et al., 1997; Burgess et al., 2012), looking for evidence of exposure to the disease and avoid unnecessary treatment of animals (Busin, 2018).

This study determined the mean occurrence and seasonal pattern of sheep mange in the bioclimatic conditions of Guelma province adding new data to previous reports on this disease in Algerian humid agro-ecological zone. Two mange mites species: *Sarcoptes* and *Psoroptes* were frequently associated with predominance of sarcoptic infestation. The wet season offers favorable conditions for the proliferation and contagion by mange mites in sheep flocks whereas the dry season does not. Sheep breeders and veterinarians should consider a well-rational-integrating control of the external and internal parasites (particularly fascioliasis and estrosis). To do so, a single or a double injection of ivermectin at a dose of 0.3 mg/kg of live bodyweight, could be used depending on the level, frequency and intensity of the infestation.

Conflict of interest

The authors declare that they have no conflict of interest

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Prevalenca, dinamika infestacije i procjena učinkovitosti sistemske terapije ivermektinom na ovčiju šugu u sjeveroistočnom Alžiru

Sažetak

Presječno istraživanje obavljeno je u periodu od avgusta 2015. do maja 2016. godine sa ciljem procjene prevalencije i sezonske dinamike ovčije šuge, kao i testiranja učinkovitosti terapije sarkoptičke šuge ivermektinom. Istraživanje je obuhvatilo 11759 ovaca iz 1072 stada i sa stočnih pijaca u Guelmu, sjeveroistočnoj provinciji u Alžiru. Rezultati su pokazali da je srednja prevalenca infestacije stada i životinja 25%, odnosno 10,45%. Identificirana su dva osnovna tipa grinja uzročnika bolesti, *Sarcoptes scabiei* var. *ovis* i *Psoroptes ovis*. Ove dvije vrste grinja su uzročnici bolesti kod 70% i 30% životinja na razini stada i 68% i 32% na individualnoj razini. Između ove dvije vrste zabilježena je visoka razina signifikantnosti ($P < 0.001$). Nijedna od ovih vrsta nije zabilježena u ljeto ili proljeće, međutim u zimu i jesen u stadima je zabilježena infestacija od 55% i 45%, dok je prevalenca infestiranih ovaca iznosila 25.1% u zimu i 15.52% u jesen. Rezultati zabilježeni na stočnim pijacama su bili slični rezultatima presječnog istraživanja. Terapija ivermektinom u obliku jedne injekcije u dozi od 0.3 mgkg^{-1} tjelesne težine se pokazala učinkovitom u stadima pogođenim teškim oblicima sarkoptičke šuge. Međutim, kod životinja sa veoma izraženom hiperkeratozom se preporučuju dvije injekcije.

Naše je istraživanje pokazalo visoku cjelokupnu i sezonsku prevalencu grinja uzročnika šuge kod ovaca koje žive u mediteranskim klimatskim uvjetima. Uzgajivači životinja i veterinari bi trebali zajednički primijeniti učinkovite terapijske strategije zasnovane na jednoj ili dvije injekcije u dozi od 0.3 mgkg^{-1} tjelesne težine, a prema težini infestacije (prisustvo ili odsustvo hiperkeratoze) kako bi se izbjegli ekonomski gubici svojstveni ovoj patologiji.

Ključne riječi: ovčja šuga, prevalenca, Guelma – Alžir, ivermektin, učinkovitost