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Original article

TICKS (*ACARI*: *IXODIDAE*) INFESTING CATTLE IN THREE NORTHEASTERN ALGERIA REGIONS DURING THE SUMMER SEASON

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Summary

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Hard ticks are ectoparasites and vectors of many pathogens. Studies on hard ticks in cattle have rarely been conducted in northeastern Algeria. This study aimed to estimate the infestation rate, distribution, and biological diversity of hard tick species infesting 122 cattle in Mila, Jijel, and Guelma (northeastern Algeria) provinces during the summer of 2019. A total of 1,927 ticks belonging to two hard tick genera (*Rhipicephalus*; 85.83%, *Hyalomma*; 14.17%) and nine species were collected. *Rhipicephalus* (*Boophilus*) *annulatus* (54.5%) and *Rhipicephalus bursa* (28.18%) were widespread in northeastern Algeria. Several species were reported for the first time in the regions studied. In addition, the intensity of tick infestation did not vary according to breed, sex and age of cattle. The information gathered could help develop more effective tick control programmes in these regions. Further studies are needed in other regions of Algeria to generate a comprehensive national tick database.

Key words: biotic factors, *Hyalomma impeltatum*, *Hyalomma anatolicum*, infestation, *Rhipicephalus sanguineus*

INTRODUCTION

Ticks cause an important direct pathogenic effect and act as vectors for many pathogens (Dantas-Torres, 2008; Vesco *et al*., 2011; Braz *et al*., 2019; Khan, 2019; Gharbi, 2020). Tickborne diseases (TBDs) are major problems for livestock in Algeria (Karim *et al*., 2017; Benchikh-Elfegoun *et al*., 2018; Ramzan *et al*., 2020). The cattle industry plays a key role in rural societies (Mottet *et al*., 2017; Ramzan *et al*., 2020). Ticks have extended their range to new regions in Algeria as a result of global warming (Gharbi, 2020; Nasreen, 2020).

In Algeria, the cattle population was estimated at 911,401 heads in 2017 (Anonymous, 2019). Several studies have been published in recent years document-

ing various aspects of ticks infesting cattle in the country (Benchikh-Elfegoun *et al*., 2018; 2019). However, most of these studies have not considered the biodiversity of northeastern Algeria's tick fauna or the bioclimatic diversity for their appropriate treatment and control. The key to disease control programmes must be based on a sound knowledge of the regional phenology of ticks and the epidemiology of the infections they transmit (Benchikh-Elfegoun *et al*., 2014). To this end, the present work aimed to estimate and compare the infestation prevalence and intensity in cattle using ecological indices among three bioclimatic stages in northeastern Algeria.

MATERIALS AND METHODS

Study region

The present study was conducted in July-August 2019 in three bioclimatic regions in northeastern Algeria: Jijel, Guelma, and Mila (Fig. 1). The province of Jijel is located in a humid bioclimatic region, with a typical hot and relatively dry season between June and August and a rainy season between November and April (Table 1). This region is characterised by a predominantly mountainous landscape with a fairly dense vegetation cover. Guelma is located in the sub-humid bioclimatic stage, and its relief is varied, with a dense forest cover, particularly in the north. Mila province is characterised by mountainous terrain in the north, foothills and hills in the centre, and a zone of the high plains in the south (Table 1).

Animals and collection of ticks

A total of 122 cattle of different age groups, breeds, and both sexes were included in this study. They were located in the three provinces: Jijel (N = 63; 51.63%), Guelma (N = 17; 13.93%) and Mila (N = 42; 34.42%). The animals (♂ and ♀),were reared according to two systems. In Mila, four semi-intensive small farms were visited: in Tadjenanet (N = 15/43; 0♂ 15♀), Bouhatem (N = 12/43; 6♂ 6♀), Chelghoum El Aid (N = 12/43; 3♂ 9♀), and Mechta Ben Srour (N = 3/42; 0♂ 3♀). In Jijel, seven localities were visited: Toualbia (N = 21/63; 1♂ 20♀), Taksena (N = 6/63; 0♂ 6♀), Liadia (N = 5/63; 1♂ 4♀), Djebel Bouhanch (N = 10/63; 0♂ 10♀), Hammara (N = 2/63; 0♂ 2♀), Isratou (N = 11/63; 5♂ 6♀), and

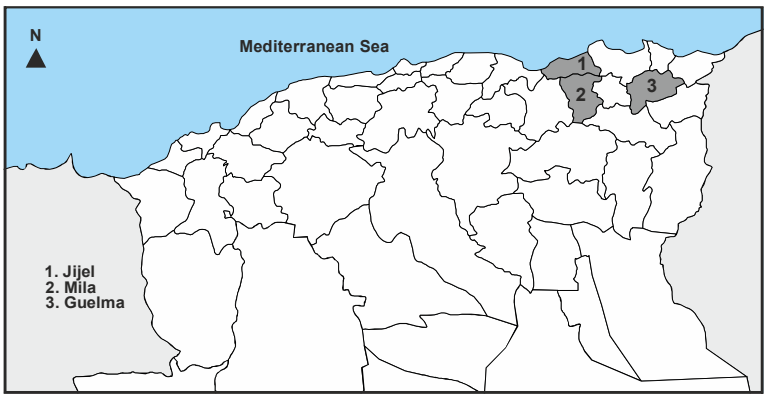

Fig. 1. Geographical location of Jijel, Guelma, and Mila provinces, northeast Algeria.

Table 1. Characteristics of Jijel, Guelma and Mila provinces, Algeria

	Jijel	Guelma	Mila
Location	36°49′N to 5°45′E	36°28′N to 7°26′E	36°27′N to 6°16′E
Area (km²)	6238	4474	3480
Mean altitude (m)	406	228	800
Range of altitude (m)	10–1589	256–1242	250–1465
Mean yearly rainfall (mm)	814	533	501
Mean temperature (°C)	18.2	18.1	13.9
Temperature range (°C)	8.3–30.3	3.6–34.5	1.6–31.1
Relative humidity range (%)	70–75	55–85	40–90
Bioclimatic status	Humid	Sub-humid	Semi-arid

Merchicha (N = 8/63; 0♂ 8♀). In Guelma, two extensive farms were visited – they were located in Houara mount (N = 11/17; 1♂ 10♀) and Boumahra (N = 6/17; 0♂ 6♀).

Local and exotic breeds were among the four breeds researched. The Brown Atlas depicts the indigenous breeds of the Maghreb region. It is Egyptian in origin, with a phenotype distinguished mostly by its tiny size, low milk production, and high adaption to the mountain. This breed has various variants; two of them, the Jijlienne and the Guelmoise, have been investigated. The remaining three breeds were exotic. The first is the Lowland Red Pied breed, which has short, low horns and pale skin, and average milk production of 700 kg annually. It is of French origin, coming from a 1966 hybridisation between Armorican with Meuse-Rhine-Issel and German Red Pied cattle. The second is the Breton cow breed Pie-Noire, a dairy breed from France (Brittany) with a pie-black hue that results from hybridisation between Durham and Frisona in 1886 and produces 3,550 kg of milk per year. The third breed is the Montbéliarde, a French cow breed resulting from hybridisation between Swiss and French breeds in the eighteenth and nineteenth centuries, a well-known milkmaid. Cattle were kept on pasture 24 hours a day, and farmers only took their cows to the stables for calving. In the three regions, farmers apply anti-tick control acaricides randomly and irregularly. In each farm, information about cattle and ticks was collected. Cattle were carefully examined once. Adult ticks were collected manually and placed in labelled vials containing 70% ethanol. The ticks were identified under a stereomicroscope using the key of Walker *et al*. (2003).

Statistical analysis

The chi-square test was used to compare prevalences, while comparisons of tick infestation intensities were made using the ANOVA test with a threshold value of 0.05 for both tests (Schwartz, 1993). Only 72 cattle were included in this analysis due to the absence of data for at least one biotic factor (i.e., sex, age or breed) from the remaining 50 bovines.

Estimation of ecological indexes

- Shannon diversity index (H'), describing tick species diversity on an animal.

$$H = -\sum pi * \log 2 * pi,$$

where pi = relative abundance of species *i*, log = usually natural logarithm.

- Maximum diversity (Hmax) (Blondel, 1979)

$$Hmax = \log 2 * S,$$

where S = species richness, log = usually natural logarithm.

- Equitability index (E)

$$E = H / H\,max,$$

where H = Shannon diversity index, Hmax = maximum diversity.

- Specific richness index (S): the number of tick species in each study area.

RESULTS

Overall tick infestation indicators

A total of 1,927 ticks were collected between July and August 2019 from cattle in the three Algerian provinces (Jijel, Guelma, and Mila). These ticks belonged to two genera, *Rhipicephalus* spp. (N = 1,654; 85.83%) and *Hyalomma* spp. (N = 273; 14.17%) and to nine species, namely, *R.* (*Boophilus*) *annulatus* (N = 1,050; 54.5%), *R. bursa* (N = 543; 28.18%), *R. sanguineus* (N = 61; 3.17%), *H. anatolicum* (N = 29; 1.5%), *H. excavatum* (N = 2; 0.1%), *H. impeltatum* (N = 1; 0.05%), *H. lusitanicum* (N = 105; 5.45%), *H. marginatum* (N = 83; 4.3%) and *H. scupense* (N = 53; 2.75%) ($p < 0.001$) (Tables 2, 3 and 4). Based on the results, the cattle in Guelma showed a particular infestation pattern. *Rhipicephalus sanguineus* was absent only in cattle from this region, whereas *H. excavatum* and *H. impeltatum* were only collected from cattle in Guelma (Table 3).

The prevalence of tick infestation in the Brown Atlas breed (32/72; 44.4%) and the Breton Black Pied breed (31/72; 43.1%) was significantly higher than in the Red Pied Lowland (6/72; 8.3%) and the Montbeliard breeds (3/72; 4.2%) ($P < 0.001$). In addition, the prevalence of tick infestation was significantly higher in female cattle (61/72; 84.7%) compared to males ($P = 0.004$) (Table 5). There was no significant difference in infestation prevalence according to age category (P=0.51)

Table 2. Adult ticks collected from cattle, number of cattle infested by ticks, infestation prevalence and intensity of ticks in Jijel (northeast Algeria).

Tick species	Adults			Number of infested cattle (prevalence %)	Intensity
	Number (%)	Female	Male		
Rhipicephalus	1142	932	210	26(41.26)	10.94
R. annulatus	907 (66)	813	94	36 (57.14)	25.2
R. bursa	227 (16.51)	114	113	36 (57.14)	6.3
R. sanguineus	8 (0.58)	5	3	6 (9.52)	1.33
Hyalomma	233	58	175	15.75(25)	3.62
H. anatolicum	21 (1.5)	2	19	9 (14.28)	2.33
H. excavatum	0	0	0	0	0
H. impeltatum	0	0	0	0	0
H. lusitanicum	93 (6.76)	30	63	16 (25.4)	5.81
H. marginatum	74 (5.38)	11	63	18 (28.57)	4.11
H. scupense	45 (3.27)	15	30	20 (31.75)	2.25
Total	1375 (100)	990	385	63 (100)	22.83

Table 3. Adult ticks collected from cattle, number of cattle infested by ticks, infestation prevalence and intensity of ticks in Guelma (northeast Algeria)

Tick species	Adults			Number of infested cattle (% prevalence)	Intensity
	Total (%)	Female	Male		
Rhipicephalus	229	167	62	14.5(85.29)	7.98
R. annulatus	127 (50.19)	122	5	17 (100)	7.47
R. bursa	102 (40.31)	45	57	12 (70.58)	8.5
R. sanguineus	0	0	0	0	0
Hyalomma	22	12	10	3.16 (18.62)	1.2
H. anatolicum	3 (1.18)	0	3	3 (17.64)	1
H. excavatum	2 (0.8)	0	2	1 (5.88)	2
H. impeltatum	1 (0.4)	0	1	1 (5.88)	1
H. lusitanicum	7 (2.77)	5	2	5 (29.41)	1.4
H. marginatum	4 (1.58)	2	2	4 (23.52)	1
H. scupense	5 (1.97)	5	0	5 (29.41)	1
Total	251 (100)	179	72	17 (100)	18.17

Table 4. Adult ticks collected from cattle, number of cattle infested by ticks, infestation prevalence and intensity of ticks in Mila (northeast Algeria)

Tick species	Adults			Number of infested cattle (% prevalence)	Intensity
	Total (%)	Female	Male		
Rhipicephalus	283	175	108	15.66(37.29)	7.43
R. annulatus	16 (5.32)	16	0	2 (4.76)	8
R. bursa	214 (71.1)	138	76	39 (92.85)	5.48
R. sanguineus	53 (17.6)	21	32	6 (14.28)	8.83
Hyalomma	18	7	11	1.5(3.57)	4.33
H. anatolicum	5 (1.66)	2	4	1 (2.38)	5
H. excavatum	0	0	0	0	0
H. impeltatum	0	0	0	0	0
H. lusitanicum	5 (1.66)	3	2	1 (2.38)	5
H. marginatum	5 (1.66)	2	2	3 (7.14)	1.66
H. scupense	3 (1)	0	3	1 (2.38)	3
Total	301 (100)	182	119	42 (100)	12.85

(Table 3). The intensity of tick infestation did not vary according to cattle breed (P=0.07), sex (P=0.3) or age (P=0.8) (Table 5). The prevalence of *Rh.* (*Boophilus*) *annulatus* (100%) in Guelma was higher than that in Jijel and Mila (57.14% and 4.76%, respectively) (P<0.001). In addition, there was no significant difference between the three study localities in the intensity of tick infestation (5, 2 and 3 in Jijel,Guelma and Mila, respectively) (P=0.55).

The total value of the Shannon index increased with the number of individuals and species between localities. Indeed, in Mila, H = 0.95 bits with 301 individuals,

Table 5. Prevalence and intensity of tick infestation according to breed, sex, and age of cattle in northeast Algeria

Category	Number of examined cattle	Number of ticks	Infestation intensity	P value	Infestation prevalence	P value
Breed						
Brown Atlas	32	410	12.8	0.07	44.4	<0.001
Breton Black Pied	31	904	29.2		43.1	
Red Pied Lowland	6	151	25.2		8.3	
Montbéliard	3	56	18.7		4.2	
Sex						
Male	11	113	10.3	0.3	15.3	0.004
Female	61	1408	23.1		84.7	
Age category						
≤4 years	31	837	27.0	0.8	43.1	0.51
>4 years	41	684	16.7		56.9	
Total	72	1521	21.12		100	

while in Guelma, S = 8 species; H = 1.06 bits and 251 samples. Finally, in Jijel, H = 1.11 bits with 1,375 samples (Fig. 2). The equitability value in the three localities indicated that individuals in these communities were not equitably distributed among the species. Furthermore, the results showed that more than half of the tick specimens belonged to a single species: *R.* (*Boophilus*) *annulatus* in Jijel; E = 0.57 and Guelma; E = 0.51, respectively. In contrast, more than 71% of tick specimens were *Rh. bursa* in Mila; E = 0.49 (Fig. 2). The diversity was slightly higher in Guelma (8 species), than in Jijel (7 species) and Mila (7 species).

Rhipicephalus spp. infestation indicators

The most widespread species was *R.* (*Boophilus*) *annulatus.* It was dominant in Jijel and Guelma regions. Its relative prevalence decreased from 66 to 50.19 and 5.32% in Jijel, Guelma, and Mila, respectively (Table 2). The prevalence of *R.* (*Boophilus*) *annulatus* was highest in Guelma, where this tick infested all cows examined. This prevalence decreases to 57.14 and 4.76% in Jijel and Mila regions, respectively. The infestation intensity of *R.* (*Boophilus*) *annulatus* was the highest in Jijel (25 ticks/cow) and lower in the Guelma and Mila at 7 and 8 ticks/cow, respectively (Tables 2, 3 and 4).

Rhipicephalus bursa was widespread, with infestation prevalence 57.14% in Jijel, while the intensity was 6 ticks/cow. More than half of the cattle (12 out of 17 cows) were infested by *R. bursa,* with an intensity of 8 ticks/cow in Guelma. In Mila, the highest prevalence was observed for *R. bursa* (92.85%), with an infestation intensity of 5 ticks/cow.

The distribution pattern of *R. sanguineus* varied widely in the studied regions. It was absent in Guelma, and its prevalence and intensity were 14.28% and 8 ticks/cow in the Mila, respectively. In Jijel, the prevalence and intensity of infestation were 9.52% and 1 tick/cow, respectively (Tables 2, 3 and 4).

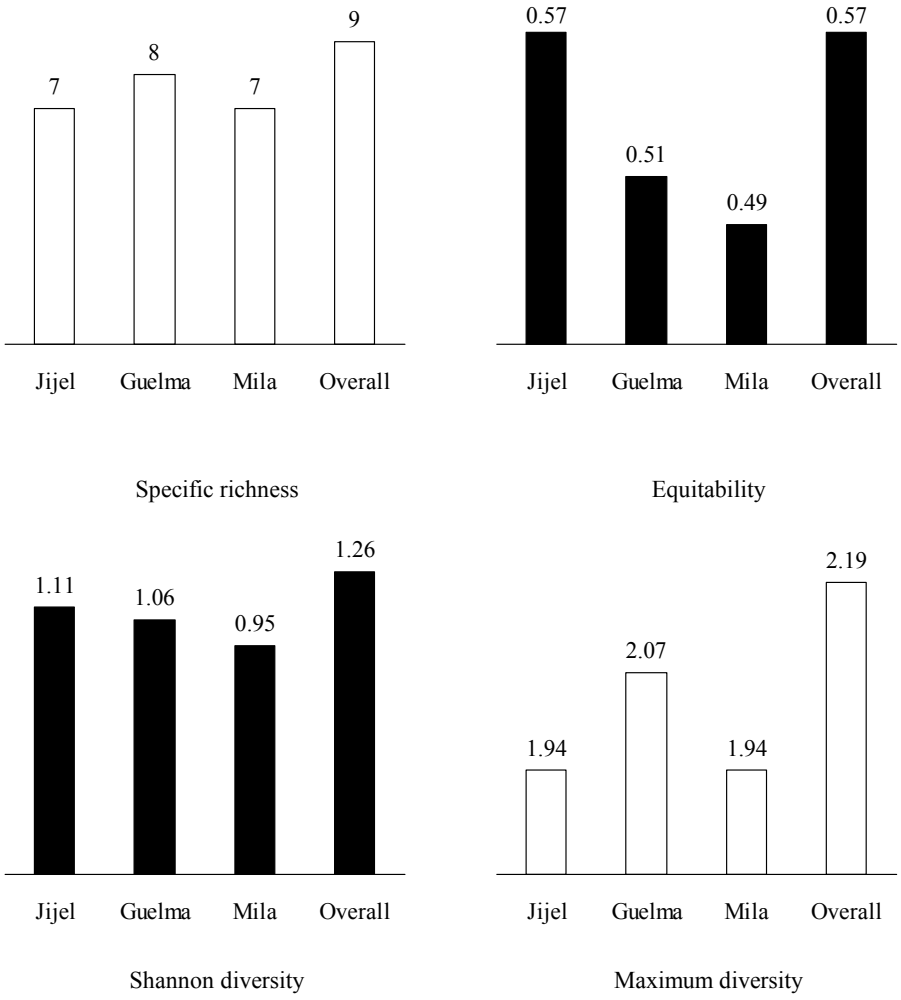

Fig. 2. Specific richness, equitability, Shannon diversity and maximum diversity for hard tick species in cattle from Jijel, Guelma, and Mila provinces, northeast Algeria.

Hyalomma spp.infestation indicators

The results show that *H. scupense* prevalence was 31.75% in Jijel with an intensity of 2 ticks/cow. These indicators were higher (P=0.004) than those reported in Guelma (29.41% and 1 tick/cow, respectively). Finally, in Mila, the prevalence and intensity of infestation were 2.38% and 3 ticks/cow, respectively.

In Jijel and Guelma, the prevalence and intensity of *H. marginatum* were 28.57% and 4 ticks/cow and 29.41%, and 1 tick/cow, respectively. A lower prevalence was recorded in Mila with 7.14% and an intensity of 1 tick/cow (P=0.056).

In Jijel, *H. lusitanicum* prevalence and intensity were 25.4% and 5 ticks/cow, respectively. In Guelma, *H. lusitanicum* infestation prevalence and intensity were 29.41% and 1 tick/cow, respectively (Tables 2 and 3). Finally, the prevalence and intensity of *H. lusitanicum* infestation in Mila were 2.38% and 5 ticks/cow, respectively.

The infestation prevalence of *H. anatolicum* was the highest in Guelma (17.64%). Its prevalence varied from 17.64% in Guelma to 14.28% in Jijel, and its intensity varies from 2 to 1 tick/cow in Jijel and Guelma, respectively. Its intensity increased to 5 ticks/cow in Mila, but it presented a lower infestation prevalence (2.38%) (Tables 2,3 and 4).

Few *H. excavatum* (n = 2) and *H. impletatum* (n = 1) were present only in Guelma with similar prevalences (5.88%) and intensities (2 and 1 tick/cow for *H. excavatum* and *H. impeltatum,* respectively) (Tables 2, 3 and 4).

DISCUSSION

Several tick species were collected for the first time in these regions: *R. sanguineus*, *H. anatolicum,* and *H. marginatum* in Jijel, *H. anatolicum* in Guelma, *R. sanguineus* in Mila and *H. impeltatum* in northeastern Algeria. Ecological indexes indicate that ticks were not equally distributed according to species; for example, *R.* (*Boophilus*) *annulatus* was dominant in Jijel, where it was present on all cattle examined, and Guelma regions while *R. bursa* was dominant in Mila. Higher infestation rates were observed in exotic cattle breeds (Brown Atlas and Breton Black Pied) and females. In this study, *R. annulatus* were commonly found on cattle, particularly in the province of Jijel, peaking in July with 19.5 ticks/cow and in Guelma, but were very rare in the province of Mila. These results are in accordance with previous observations (Benchikh-Elfegoun *et al*., 2007). It is abundant in the Mediterranean, Palearctic and Afrotropical regions (Estrada-Peña *et al*., 2018; Zamoura *et al*., 2020). According to our results, *R. bursa* was present in all regions visited, with the highest prevalence of infestation at 92.85% in Mila. *R. bursa* is widely distributed in the Mediterranean region (Galluzzo *et al*., 2021). In this study, *R. sanguineus* had a low infestation rate in Jijel, while it was higher in Mila. *R. sanguineus* is generally found between 20°N to below 30°S latitude for the temperate lineage (Dantas-Torres, 2008; Tsai, 2012; Martins, 2020; Mostafavi *et al*., 2022). *R. sanguineus* is periodically fixed on humans transmitting MSF (Mediterranean Spotted Fever) (Kuloglu *et al*., 2012). *H. anatolicum* was only reported in Algeria in Mila province (Benchikh-Elfegoun *et al*., 2014). According to the current study, the distribution area of *H. anatolicum* is expanding in Algeria. *H. anatolicum* was found in Iran at an infestation prevalence of 38.83% (Biglari *et al*., 2018). *H. anatolicum* is one of the most widespread tick species. Its distribution range covers 33 countries on three continents: Africa, Europe, and Asia (Estrada-Peña *et al*., 2013; Kamran *et al*., 2020). This study presents for the first time, *H. impeltatum* in northeastern Algeria. This result is quite surprising, as this tick species is normally present in desert regions (Bouhous *et al*., 2011; Estrada-Peña *et al*., 2013; Schulz *et al*., 2021). Due to its vector role, particular attention is paid to *H. scupence* (Gharbi *et al*., 2014; Benchikh-Elfegoun *et al*., 2018). *H. scupense* is widespread in 42 countries, including North Africa (Akyildiz *et al*., 2021). The rate of infestation

by this species has increased in recent years, and current results confirm that *H. scupence* is present in humid to arid regions, particularly in northern areas (Gharbi *et al*., 2014). In this study, *H. marginatum* and *H. lusitanicum* were abundant in Jijel. Few specimens were collected in both Guelma and Mila regions. The distribution of *H. marginatum* covers southern Europe, northern Africa, and some areas of Asia (Apanaskevich & Horak, 2008; Díaz-Sánchez *et al*., 2021). Few populations are present in the northern regions of Morocco and Algeria but not in Tunisia. They could be introduced from Western Europe (Estrada-Peña *et al*., 2004). In this study, *H. excavatum* was present only in the Guelma region; its infestation rate was very low. However, *H. excavatum* has been reported by other authors in northern Algeria (Benchikh-Elfegoun *et al*., 2018). All tick species found in this study are vectors of many different pathogens (Leulmi *et al*., 2016; Boucheikhchoukh *et al*., 2018; Abdelkadir *et al*., 2019; Rahal *et al*., 2020).

CONCLUSIONS

This study aimed to investigate the species of hard ticks infesting cattle in three regions of northeastern Algeria, namely Jijel, Guelma, and Mila. The results showed the appearance of new tick species that could be classified as having a high vector capacity. The conclusions of this work are in agreement with those of previous studies, despite the short duration of the survey. Furthermore, some species have extended their geographical range due to climate change after being completely absent for several years. Thus, further studies including other areas and both domestic and wild animals are recommended to confirm the extension of the geographical range of some species, especially in the Jijel area, where six very large hydraulic dams have been built in the last five years. This study extends our knowledge of hard ticks on livestock, and these results will be useful for controlling hard ticks and tickborne diseases in northeastern Algeria.

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