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Knowledge and perception on ticks and tick-borne diseases among veterinary medicine students from the North African countries of Algeria, Egypt, and Tunisia

Médiha Khamassi Khbou [a,b,*], Ouarda Ayadi [c], Amira Adel Al-Hosary [d], Mohamed Aziz Darghouth [b], Mohamed Gharbi [b]

[a] *Laboratory of Infectious Animal Diseases, Zoonosis, and Sanitary Regulation, Univ. Manouba, Institution of Agricultural Research and Higher Education, National School of Veterinary Medicine of Sidi Thabet, Sidi Thabet 2020, Tunisia*
[b] *Laboratory of Parasitology, Univ. Manouba, Institution of Agricultural Research and Higher Education, National School of Veterinary Medicine of Sidi Thabet, Sidi Thabet 2020, Tunisia*
[c] *Laboratoire PADESCA, Institut des Sciences Vétérinaires, El Khroub, Université des Frères Mentouri-Constantine 1, Algeria*
[d] *Department of Animal Medicine (Infectious Diseases), Faculty of Veterinary Medicine, Assiut University, Assiut, P.O. Box 71526, Egypt*

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ABSTRACT

Ticks are important vectors of both animal and human pathogens. The epidemiology of tick-borne diseases (TBDs) has dramatically changed in several regions in the world. As parasitology is a continuously growing field, assessing the knowledge of veterinary medicine students provides useful indicators and information on the level of intervention required to adapt parasitological courses to meet the demands in a changing world.
This study aimed to assess, in three North African veterinary education establishments, the basic parasitology knowledge of veterinary medicine students. Such a study is essential to build up core competencies regarding ticks and TBDs, and to suggest suitable adjustment measures to parasitology courses.
The present study was based on a self-administered and anonymous questionnaire on ticks and TBDs basic knowledge and perception. The survey was completed by 558 veterinary medicine students in Algeria, Egypt, and Tunisia in 2018. The students were divided into two groups: the "before" group – students who had not yet completed the parasitology course, and the "after" group – students who had already completed it.
In all studied countries, the "after" students' group gave significantly more correct answers (83.16%) than the "before" students' group (16.84%) ($p < 0.001$). Similarly, the percentage of "no answer" was higher in the "before" students' group (51.02%) compared to the "after" students' group (48.98%) ($p < 0.001$). The most frequent false answers provided by the "after" students' group regarded the number of tick species present in their own countries (5.14% of correct answers), and the most common tick species in their countries (18.11% of correct answers).
Almost 58.38% (216/370) of the "after" students' group knew that ticks transmit zoonotic pathogens to humans; among them, only 63 (29.17%) gave the correct names of the zoonotic diseases in their country.

* Corresponding author at: Laboratory of Infectious Animal Diseases, Zoonosis, and Sanitary Regulation, Univ. Manouba, Institution of Agricultural Research and Higher Education, National School of Veterinary Medicine of Sidi Thabet, Sidi Thabet 2020, Tunisia.
E-mail addresses: mediha.khamassi@enmv.uma.tn, (M. Khamassi Khbou), ayadioird@yahoo.com, (O. Ayadi), amiraal-hosary@aun.edu.eg, (A.A. Al-Hosary), damaziz@yahoo.fr, (M.A. Darghouth), gharbim2000@yahoo.fr. (M. Gharbi).

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Among the three countries, more than 80% of the “after” students' group thought that climate has an influences on ticks. According to this group, the most frequent factor that has influences on ticks' abundance is heat (53.02%).
As North African countries share several similitudes, we suggest creating a network of parasitological teachers where common teaching sources and resources could be developed for both teachers and students in the region. This network would allow the exchange of teaching approaches and materials to introduce harmonization into veterinary parasitological courses across North African countries. This is particularly important when considering the increasing incidence of ticks and TBDs in the region.

1. Introduction

Ticks are important vectors of several pathogens responsible for the animal and human diseases (de la Fuente et al., 2008). As with other aspects of the parasitological field of study, interest in tick biology and tick-borne diseases (TBDs) epidemiology has grown significantly in the last decade. This can be associated with progress in molecular biology tools, and the emergence of several new vector-borne diseases (Penzhorn, 2018). Moreover, the epidemiology of TBDs has dramatically changed in several regions in the world, which has been linked to increased globalization, climate change, and expansion of human activities (Dantas-Torres et al., 2012). Indeed, changes in climate, habitat, and hosts have been found to be major drivers of ticks and TBDs expansion and invasion (Ogden and Lindsay, 2016). Predictive models on tick distribution hypothesize that new tick species will establish in areas where they have never been seen before (Nadolny and Gaff, 2018). Veterinarians play an important role in the detection and control of infectious diseases, and are also an important source of information to help raise public awareness among animal owners (OIE, 2013). Control of ticks and TBDs should be implemented at national and international levels. Networks of well-trained scientists should be integrated within control strategies, along with the continued exchange of information and skills.

North Africa is the geographical region grouping all countries from Morocco at the West, to Egypt at the East (World Atlas, 2018). Despite wide geographic disparities, North African countries share common features: a Mediterranean climate, vicinity to South Europe, permeable borders.

In most North African countries, the core parasitology course precedes the clinical and practical courses. It is delivered using a classic disciplinary approach, which is not formally structured by learning outcomes. Students get an overview of general parasite morphology and biology through theoretical and practical courses; the teaching program thereafter focuses on the classic knowledge fields regarding parasitic diseases: epidemiology, clinical manifestations, pathology, immunology, diagnostics, and control. During clinical classes, students face real clinical cases and tend to solve problems concerning diagnostic, therapy, and control measures in the hospital of their veterinary education establishment (VEE). However, when the number of students per class is high, the benefits attained from these clinical courses are poor.

The implementation of control measures against parasitic diseases requires good basic and operational knowledge of both tick biology and the pathogens they transmit (Jabbar and Gasser, 2018). Nowadays, veterinary studies must meet certain criteria to provide enough operational and efficient veterinarians in the field from the first day of professional practice – this is called “day 1 competency” (OIE, 2012). Parasitological teaching should be implemented according to the international references of the World Organisation for Animal Health (OIE) to provide sufficient knowledge, skills and attitudes. The OIE recommended skills are focused on public health competencies of veterinarians (OIE, 2011). Parasitology course programs should cover different fields such as parasite life cycles, symptoms and gross lesions, immunologic aspects, diagnostic tools, and control with a focus on parasites impacting animal welfare and public health (OIE, 2013).

Increasing awareness among professionals in the field, as well as the general populations, is of paramount importance to establish effective control measures against pathogens. Assessing the knowledge of veterinary students could provide useful information on the levels of interventions required to adapt parasitological courses to meet the demands of a changing world. Therefore, the aim of this study was to assess, in three VEEs of Algeria, Tunisia, and Egypt, the basic knowledge of veterinary students. This will be essential to build up core competencies regarding ticks and TBDs and to suggest thereafter adjustment measures.

2. Material and methods

The present study is a self-administered questionnaire on ticks and TBD basic knowledge and perception that was provided to veterinary students in Algeria, Egypt, and Tunisia in 2018 (Fig. 1). Unannounced visits were made to the targeted classes and before distributing paper-format questionnaires to students, teachers presented it and insisted on: (i) the purpose of the study (ii) the questionnaire is anonymous and voluntary (iii) their answers will have no impact on their graduation (iv) it will take approximately 30 min to reply.

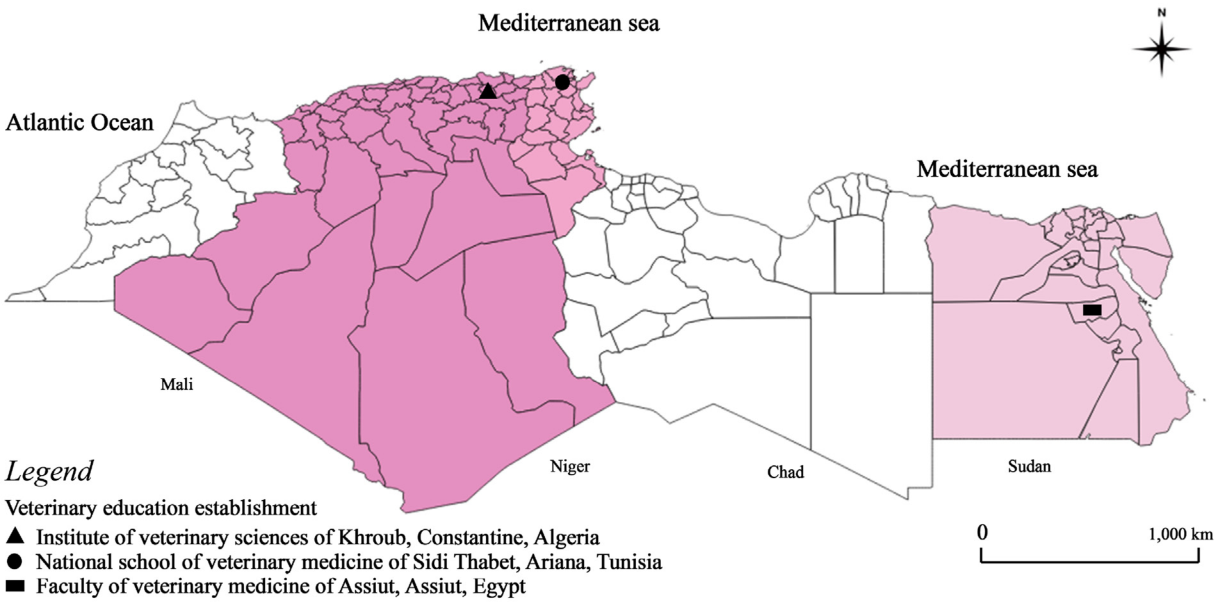

Fig. 1. The map of the North Africa and locations of the three involved veterinary education establishments (Name, District, Country).

Table 1
Number of questioned veterinary medicine students and data on total population and veterinary education establishments in Algeria, Tunisia, and Egypt, respectively.

Country	The total human population during 2018[a]	Number of veterinary education establishments (VEE) in the country	Involved veterinary education establishments in the survey (University, district)	Year of creation	Number of undergraduate study years (preclinical/clinical)	Year of parasitology course	Study year involved in the survey	Number of questioned students /total number during 2017–2018	Total number of females/total number of males during 2017–2018
Algeria	42,616,732	7	National institute of veterinary sciences (Frères Mentouri University, Constantine)	1986	5 (3/2)	3rd, 4th	1st 2nd 5th	23/36 26/187 116/124	21/15 110/77 35/89
Tunisia	11,771,685	1	National school of veterinary medicine (University of Manouba, Sidi Thabet)	1974	5 (3/2)	3rd	2nd 4th 5th	50/61 34/42 34/52	48/13 30/12 34/18
Egypt	101,002,148	17	Faculty of veterinary medicine (Assiut University, Assiut)	1961	5 (3/2)	3rd	1st 2nd 4th 5th	36/228 53/167 68/207 118/279	134/94 104/63 146/61 206/73

[a] www.worldmeters.info

All the students from both preclinical and clinical classes participated, excepting those taking part in the parasitology course during that year (Table 1). This category of students was excluded to avoid unfair bias, as they would have received the course information more recently than other students. Thus, the students were divided into two groups: those who had already received the parasitology course (the year before for 4th level and two years before for the 5th level classes) and those who had not. A total of 165, 118 and 275 students answered the questionnaire from the National Institute of Veterinary Sciences (Frères Mentouri University, Constantine, Algeria), the National School of Veterinary Medicine (University of Manouba, Sidi Thabet, Tunisia) and from the Faculty of Veterinary Medicine (Assiut University, Assiut, Egypt), respectively. The questionnaire consisted of 26 questions – seven for students' characterization and 19 for assessing ticks and TBDs' basic knowledge (Table 2). Only five questions were of the end-closed type. The responses to open questions were classified and categorized to reduce variability, and the answers to 11 of the open questions were classified as correct or wrong according to the state of the art (Table 2).

Table 2
Questions asked to students and the expected correct answers according to the state of the art.

Topic *Asked questions*	Expected correct answers	References
Identification of the student *Please mention your date of birth?* *Please check the box (Male/Female)?* *Where you are living (district)?* *What is your study level?*	N.A.	N.A.
Student's choices *Why did you choose veterinary studies?* *What is (are) your preferred animal species?* *Which animal species do you own?*	N.A.	N.A.
Students' knowledge about ticks and tick-borne pathogens		
Did you hear about ticks?	N.A.	
On which occasion did you hear about ticks?	N.A.	
How many tick species exist in your country?	15–23	(Estrada-Peña et al., 2004; Walker et al., 2003)
What are the most frequent tick species in your country?	**Tunisia:** *Rhipicephalus* (*annulatus, bursa, sanguineus, turanicus*), *Hyalomma* (*dromedarii, excavatum, marginatum, scupense*), *Haemaphysalis* (*sulcata, punctata*), *Ixodes ricinus* **Algeria:** *Rhipicephalus* (*sanguineus, turanicus*), *Hyalomma* (*dromedarii, excavatum, impeltatum, lusitanicum, marginatum, scupense*), *Haemaphysalis* (*sulcata*), *Ixodes ricinus* **Egypt:** *Rhipicephalus* (*annulatus, sanguineus*), *Hyalomma* (*anatolicum, dromedarii, excavatum*)	(Estrada-Peña et al., 2004; Walker et al., 2003)
Which animal species do ticks infest?	Livestock (cattle, sheep, goats, horses, dromedaries), dogs Wild animals (lizards, birds, small mammals, large mammals)	(Colebrook and Wall, 2004) (André, 2018)
How do animals get ticks?	From contact with infested animals From soil during grazing From infested barns	(Estrada-Peña and de la Fuente, 2014)
What is (are) the pathogenic role of ticks?	Blood spoliation/Anaemia Pathogens transmission Skin lesions and irritation	(Jongejan and Uilenberg, 1994)
What is (are) the name(s) of tick-borne disease(s) in your country	Anaplasmosis, Babesiosis, Theileriosis	(Ben Said et al., 2018; Gharbi et al., 2020; Schnittger et al., 2012)
On which period of the year, these tick-borne diseases are transmitted in your country?	Depends on the pathogen species and the region	(Walker et al., 2003)
Do ticks transmit zoonotic agents to humans?	Yes	(de la Fuente et al., 2008)
If yes, mention those you know	*Babesia divergens*, *Borrelia burgdorferi* s.l.,, *Coxiella burnetii*, *Rickettsia* spp., *Francisella tularensis*, Crimean Congo haemorrhagic fever virus	(Boulanger et al., 2019)
What are the control measures against ticks?	Acaricide application on animals and their barns	(Sonenshine et al., 2002)
Is treatment efficient against ticks?	Yes	(De Meneghi et al., 2016)
What are the names of the anti-tick drugs available in your country?	Active compounds: deltamethrin, cypermethrin, carbamate, amitraz, fipronil	(Nicholson et al., 2019)
What are the negative effects of these drugs?	Residues, Toxicity for humans or environment and animals, Increase resistance of ticks to drugs, Allergy/skin irritation/hypersensitivity	(Kunz and Kemp, 1994)
Perception on climate's impact on ticks and tick control		
Do you think that climate influences on ticks?	Yes	(Ogden and Lindsay, 2016)
How does climate influence ticks?	Increase/decrease of the tick population Increase/decrease of the geographic area	(Domşa et al., 2016)
What is/are the benefit(s) from the tick control?	Decrease of TBP impact, Improvement of animal health and production, Protection of public health	(Rajput et al., 2006)
Why some farmers don't implement tick control measures?	Ignorance, Financial constraints	(Mugambi et al., 2012; Moyo and Masika, 2009)

N.A.: not applicable.

Student responses were entered into an Excel spreadsheet and analysed using SPSS software (version 21, IBM, USA). Descriptive statistics were performed and comparisons between the “before” and the “after” groups were tested using a Chi Square or Fisher test for small samples, at $p < 0.05$ threshold.

Table 3
Demographic description of questioned veterinary medicine students among three veterinary education establishments in Algeria, Tunisia, and Egypt, respectively.

		Algeria	Tunisia	Egypt	Totals
Age per class					
	1st Class (Mean ± SD)[Min-Max]	19.54 ± 1 [17–23]	21.63 ± 0.82 [20–25]	18.71 ± 0.64 [17–20]	109
	2nd Class (Mean ± SD)[Min-Max]	20.91 ± 1.3 [18–23.	N.C.	20.9 ± 1.28 [19–24]	79
	4th Class (Mean ± SD)[Min-Max]	N.C.	23.45 ± 0.66 [22–27]	21.3 ± 0.73 [20−23]	102
	5th Class (Mean ± SD)[Min-Max]	23.62 ± 0.85 [18–26]	24.25 ± 0.8 [23–28]	22.56 ± 1.23 [21–25]	268
Number in the group/ Total number of students (%)					
Level regarding parasitological courses (%)					
	Before	49/165 (29.7) ^{x,ab}	50/118 (42.4) ^{x,aa}	89/275 (32.4) ^{x,ab}	188/558 (33.7) ^{ab}
	After	116/165 (70.3)	68/118 (57.6)	186/275 (67.6)	370/558 (66.3)
Gender (%)					
	Female	94/165 (57) ^{x,aa}	89/118 (75.4) ^{y,ab}	211/275 (76.7) ^{z,ab}	394/558 (70.6) ^{ab}
	Male	71/165 (43)	29/118 (24.6)	64/275 (23.3)	164/558 (29.4)
District of origin (%)					
	> 50 km around the veterinary school	82/165 (49.7) ^{x,ab}	53/118 (44.9) ^{y,aa}	97/275 (35.3) ^{z,ab}	232 (41.6) ^{ab}
	≤ 50 km around the veterinary school	81/165 (49.1)	65/118 (55.1)	114/275 (41.5)	260 (46.6)
	No response	2/165 (1.2)	0/118	64/275 (23.3)	66 (11.8)
Reasons for choosing veterinary studies (%)					
	I didn't choose, it was by chance	30/165 (18.2) ^{x,ab}	6/118 (5.1) ^{y,ab}	138/275 (50.2) ^{z,ab}	174/558 (31.2) ^{ab}
	I love animals	53/165 (32.1)	44/118 (37.3)	39/275 (14.2)	136/558 (24.4)
	No response	37/165 (22.4)	23/118 (19.5)	47/275 (17.1)	107/558 (19.2)
	I love the veterinary job	20/165 (12.1)	9/118 (7.6)	20/275 (7.3)	49/558 (8.8)
	I love science/medicine	14/165 (8.5)	10/118 (8.5)	15/275 (5.5)	39/558 (7)
	Other	11/165 (6.7)	26/118 (22)	16/275 (5.8)	53/558 (9.5)
Preferred animal species (%)					
	Dogs	55/194 (28.4) ^{x,ab}	61/192 (31.8) ^{y,ab}	93/390 (23.9) ^{z,ab}	209/776 (26.9) ^{ab}
	Cats	53/194 (27.3)	37/192 (19.3)	74/390 (19)	164/776 (21.1)
	Horse	40/194 (20.6)	32/192 (16.7)	91/390 (23.3)	163/776 (21)
	Other species	25/194 (12.9)	40/192 (20.8)	99/390 (25.4)	164/776 (21.1)
	Cattle	21/194 (10.8)	22/192 (11.5)	33/390 (8.5)	76/776 (9.8)
Owning animals at home (%)					
	Yes	92/165 (55.8) ^{x,aa}	90/118 (76.3) ^{y,ab}	121/275 (44) ^{z,aa}	303/558 (54.3) ^{aa}
	No	73/165 (44.2)	28/118 (23.7)	154/275 (56)	255/558 (45.7)
Animals' species owned at home (%)					
	Cats	51/92 (55.4) ^{x,ab}	67/90 (74.4) ^{y,ab}	56/121 (46.3) ^{z,ab}	174/303 (57.4) ^{ab}
	Dogs	29/92 (31.5)	32/90 (35.6)	22/121 (18.2)	83/303 (27.3)
	Farm animals	5/92 (5.4)	13/90 (14.4)	29/121 (24)	47/303 (15.5)
	Birds game	14/92 (15.2)	9/90 (10)	10/121 (8.3)	33/303 (10.9)
	Poultry	1/92 (1.1)	7/90 (7.8)	21/121 (17.4)	29/303 (9.6)
	Other species	12/92 (13)	14/90 (15.6)	15/121 (12.4)	41/303 (13.5)

xyz: Percentages between countries (Algeria, Tunisia, Egypt) within the same line are significantly different at $p \le 0.05$.
ab: Percentages within the same column within the same country are significantly different at $p \le 0.05$.
N.C.: not concerned.

3. Results

3.1. Characteristics of sampled students and their choices

A total number of 558 veterinary students responded to the questionnaire from the three VEEs in Algeria, Egypt, and Tunisia. The female:male gender ratio of the students was 2.4 with an overall mean age of 22.16 ± 1.4 years (Table 3).

The percentages of participating students from districts near (≤50 km) to the VEE were significantly higher than those coming from more distant districts in both Tunisia and Egypt ($p < 0.001$).

Table 4
Classification of veterinary medicine students' overall answers on knowledge about ticks and tick-borne pathogens in three veterinary education establishments in Algeria, Tunisia, and Egypt, before and after getting courses of parasitology.

Number of answers in the group/Total of answers in the country (%)								
	Algeria		Tunisia		Egypt		Overall	
	Before	After	Before	After	Before	After	Before	After
Correct	42/478 (8.8)^{x,ab}	436/478 (91.2)^{y,ab}	144/606 (23.7)^{x,ab}	462/606 (76.3)^{y,ab}	127/775 (16.4)^{x,ab}	648/775 (83.6)^{y,ab}	313/1859 (16.8)^{x,ab}	1546/1859 (83.2)^{y,ab}
Wrong	14/220 (6.4)	206/220 (93.6)	42/207 (20.3)	165/207 (79.7)	46/603 (7.6)	557/603 (92.4)	102/1030 (9.9)	928/1030 (90.1)
No answers	443/1018 (43.5)	575/1018 (56.5)	328/428 (76.6)	100/428 (23.4)	731/1498 (48.8)	767/1498 (51.2)	1502/2944 (51)	1442/2944 (49)

xy: Percentages between groups (before, after) within the same country are significantly different at $p \le 0.05$.
ab: Percentages within the same column within the same group of the same country are significantly different at $p \le 0.05$.

In Algeria and Tunisia, 32.1 and 37.3% of students, respectively, claimed to have chosen veterinary studies because they love animals, in contrast to 14.2% in Egypt ($p < 0.001$). In Egypt, half of the surveyed students (50.2%) followed veterinary studies by chance. This is due to the electronic coordination system for admission to universities, which depends on their total scores in high school.

Dogs were considered by the majority of students as the preferred domestic animal species in the three countries (28.4, 22.8 and 31.8% in Algeria, Egypt, and Tunisia, respectively, $p \le 0.05$). Cats were cited as the second most preferred animal species by students from Algeria and Tunisia (27.3 and 19.3%, respectively), while horses were cited by Egyptian students (22.3%) ($p = 0.005$) (Table 3).

More than half of students (54.3%, 303/559) reported to own domestic animals and the most frequently owned species across all three countries was cats, representing 46.2, 55.4, and 74.4% of owned pets in Egypt, Algeria, and Tunisia, respectively ($p < 0.001$) (Table 3).

3.2. Students' knowledge about ticks and tick-borne pathogens

In all three countries, the “after” students' group gave significantly more correct answers to the questions (83.16%) than the “before” students' group (16.84%) ($p < 0.001$). Similarly, the percentage of no answer was significantly higher ($p < 0.001$) in the “before” students' group (51.02%) compared to the “after” students' group (48.98%) (Table 4). The rate of wrong responses among students that chose veterinary medicine studies because their love to animals or to the veterinary job (34.12%, 336/982) was significantly lower than the rate of students that have other motives (65.8%, 646/982) ($p < 0.001$).

3.2.1. Knowledge about ticks

The most frequent false answers provided by the “after” students' group concerned the number of tick species present in their own countries (5.14% of correct answers), and the most common tick species occurring in their countries (18.11% of correct answers) (Table 5).

3.2.2. Knowledge about tick-borne pathogens

Correct names for the main TBDs in the three countries were given by 42.97% (166/370) of the total “after” students' group in comparison to the total “before” students' group 4.26% (8/188). Among the 166 students that gave correct answers in the “after” group, 132 (79.5%) and 123 (74%) cited babesiosis and theileriosis, respectively. Out of the 370 students in the “after”' group, 253 (68.38%) were not able to identify the season of high TBD prevalence in their country, whereas 3.51% (13/370) correctly identified the season. Almost 58.38% (216/370) of the “after” students' group knew that ticks transmit zoonotic pathogens to humans, but among them, only 29.17% (63/216) gave the correct names of the zoonotic diseases in their country. Most Tunisian students (28/33) cited borreliosis as a zoonotic TBD, while most Egyptian students reported tularemia (15/28) and Q fever (10/28) (Table 5).

3.2.3. Knowledge about ticks' control

More than half (63.51%, 235/370) of the “after” students' group correctly answered questions concerning control measures for ticks, with half (50.6%, 119/235) considering that animal treatment is the main control measure. Less than half [45% (83/186); 37.07% (43/116); and 27.94% (19/68)] of the “after” students' group from Egypt, Algeria and Tunisia, respectively, think that animal treatment is an efficient tick control method ($p < 0.001$) (Table 5).

In the “after” students' group, 34.32% (127/370) gave wrong answers for the names of anti-tick drugs available in their countries, both active and commercial compound names were cited. More than half (51.35%) of the “after” students' group did not answer the question about negative acaricide effects. For those who did, intoxication was the most cited negative effect (48.5%, 64/132).

Table 5

Knowledge about ticks and tick-borne pathogens among veterinary medicine students in three veterinary education establishments in Algeria, Tunisia, and Egypt, respectively, before and after getting courses of parasitology.

Number in the group/Number of questioned students (%)								
Topic of the question (Answers)	Algeria		Tunisia		Egypt		Overalls	
	Before (n = 49)	After (n = 116)	Before (n = 50)	After (n = 68)	Before (n = 89)	After (n = 186)	Before (n = 188)	After (n = 370)
Hearing about ticks								
Yes	28/49 (57.2)[x,aa]	96/116 (82.7)[y,ab]	45/50 (90) [x,ab]	67/68 (98.5) [x,ab]	34/89 (38.2) [x,aa]	172/186 (92.5) [y,ab]	107/188 (56.9) [x,aa]	335/370 (90.5) [y,ab]
No	21/49 (42.8)	20/116 (17.3)	5/50 (10)	1/68 (1.5)	55/89 (61.8)	14/186 (7.5)	81/188 (43.1)	35/370 (9.5)
The occasion hearing about ticks								
During parasitological courses or veterinary studies	2/28 (7) [x,ab]	70/96 (72.9) [y,ab]	5/45 (11) [x,aa]	44/67 (65.6) [y,ab]	8/34 (23) [x,aa]	82/172 (44.1) [y,ab]	15/107 (14) [x,ab]	196/335 (58.5) [y,ab]
During childhood or scholarship	4/28 (14)	7/96 (7.3)	4/45 (9)	2/67 (2.9)	7/34 (21)	3/172 (1.6)	15/107 (14)	12/335 (3.6)
I saw ticks on my own animal or the animal of parent/friend	13/28 (46)	12/96 (12.5)	19/45 (42)	14/67 (20.9)	7/34 (21)	4/172 (2.2)	39/107 (36.5)	30/335 (8.9)
Through mass media or general culture	2/28 (7)	0/96 (0)	9/45 (20)	3/67 (4.5)	3/34 (9)	3/172 (1.6)	14/107 (13.1)	6/335 (1.8)
No answer	7/28 (25)	7/96 (7.3)	6/45 (13)	3/67 (4.5)	9/34 (26)	60/172 (39.8)	22/107 (20.6)	70/335 (20.9)
Other	0/28 (0)	0/96 (0)	2/45 (5)	1/67 (1.5)	0/34 (0)	20/172 (10.8)	2/107 (1.9)	21/335 (6.3)
Number of tick species in your country								
Correct answers	6/49 (12) [x,ab]	2/116 (1.7) [y,ab]	2/50 (4) [x,ab]	8/68 (11.8) [y,ab]	0/89 (0) [x,ab]	9/186 (5) [y,ab]	8/188 (4.3) [x,ab]	19/370 (5.1) [y,ab]
Wrong answers	0/49 (0)	33/116 (28.5)	6/50 (12)	34/68 (50)	9/89 (10.1)	57/186 (28.7)	15/188 (8)	124/370 (33.5)
No answer	43/49 (88)	81/116 (69.8)	42/50 (84)	26/68 (38.2)	80/89 (89.9)	120/186 (66.3)	165/188 (87.7)	227/370 (61.4)
The most frequent tick species in your country								
Correct answers	0/49 (0) [x,ab]	4/116 (3.4) [y,ab]	0/50 (0) [x,ab]	59*/68 (47.2) [y,ab]	2/89 (2.3) [x,ab]	4/186 (2.2) [y,ab]	2/188 (1.1) [x,ab]	67*/370 (18.1) [y,ab]
Ixodes spp.	*0*	*2*	*0*	*27*	*0*	*0*	*0*	*29*
Rhipicephalus spp.	*0*	*1*	*0*	*46*	*0*	*0*	*0*	*47*
Hyalomma spp.	*0*	*0*	*0*	*23*	*0*	*0*	*0*	*23*
Boophilus spp.	*0*	*1*	*0*	*0*	*2*	*4*	*2*	*5*
Amblyomma spp.	*0*	*0*	*0*	*3*	*0*	*0*	*0*	*3*
Wrong answers	1/49 (2)	3/116 (2.6)	2/50 (4)	3/68 (1.4)	7/89 (7.8)	67/186 (35.6)	10/188 (5.3)	73/370 (19.7)
No answer	48/49 (98)	109/116 (94)	48/50 (96)	6/68 (4.4)	80/89 (87.9)	115/186 (60.2)	176/188 (93.6)	230/370 (62.2)
Animal species that could be infested by ticks								
Correct answers	17/49 (35) [x,ab]	96/116 (82.8) [y,ab]	46/50 (92) [x,ab]	67/68 (98.5) [x,ab]	19/89 (21.3) [x,ab]	114/186 (59.2) [y,ab]	82/188 (43.6) [x,ab]	277/370 (74.9) [y,ab]
Wrong answers	2/49 (4)	10/116 (8.6)	0/50 (0)	0/68 (0)	0/89 (0)	10/186 (0)	2/188 (1.1)	20/370 (5.4)
No answer	30/49 (61)	10/116 (8.6)	4/50 (8)	1/68 (1.5)	70/89 (78.7)	62/186 (40.8)	104/188 (55.3)	73/370 (19.7)
Ways animals getting ticks								
Correct answers	4/49 (8) [x,ab]	91*/116 (79.8) [y,ab]	26*/50 (58) [x,ab]	34*/68 (50) [y,ab]	55*/89 (61.8) [x,ab]	118*/186 (63.4) [y,ab]	85/188 (45.2) [x,ab]	243/370 (65.7) [y,ab]
Wrong answers	0/49 (0)	2/116 (1.7)	5/50 (10)	27/68 (39.7)	1/89 (1.1)	31/186 (16.7)	6/188 (0.5)	60/370 (16.2)
No answer	45/49 (92)	23/116 (19.8)	19/50 (42)	7/68 (10.3)	33/89 (37.1)	37/186 (19.9)	97/188 (51.6)	67/370 (18.1)
The pathogenic role(s) of ticks								
Correct answers	6*/50 (12) [x,ab]	83*/116 (71.6) [y,ab]	29*/50 (58) [x,ab]	64*/68 (94.1) [y,ab]	14*/89 (15.7) [x,ab]	118*/186 (63.4) [y,ab]	49/188 (26.1) [x,ab]	265/370 (71.6) [y,ab]
Wrong answers	0/50 (0)	1/116 (0.9)	1/50 (2)	3/68 (4.4)	0/89	18/186 (9.7)	1/188 (0.5)	22/370 (6)
No answer	43/50 (88)	32/116 (27.6)	20/50 (40)	1/68 (1.5)	75/89 (84.3)	50/186 (26.9)	138/188 (73.4)	83/370 (22.4)
The name(s) of tick-borne disease(s) in the country								
Correct answers	0/49 (2) [x,ab]	33*/116 (28.4) [y,ab]	0/50 (0) [x,ab]	64*/68 (94.1) [y,ab]	7*/89 (7.9) [x,ab]	69*/186 (37.1) [y,aa]	8*/188 (4.3) [x,ab]	166*/370 (43) [y,ab]
Babesiosis	*0*	*24*	*0*	*45*	*7*	*63*	*7*	*132*
Theileriosis	*0*	*17*	*0*	*43*	*6*	*63*	*6*	*123*
Anaplasmosis	*0*	*6*	*0*	*8*	*3*	*7*	*3*	*21*

(continued on next page)

Table 5 *(continued)*

Number in the group/Number of questioned students (%)								
Topic of the question (Answers)	Algeria		Tunisia		Egypt		Overalls	
	Before ($n = 49$)	After ($n = 116$)	Before ($n = 50$)	After ($n = 68$)	Before ($n = 89$)	After ($n = 186$)	Before ($n = 188$)	After ($n = 370$)
Other	*1*	*5*	*0*	*41*	*0*	*7*	*1*	*53*
Wrong answers	2/49 (4)	25/116 (21.6)	4/50 (8)	2/68 (2.9)	3/89 (3.4)	50/186 (26.9)	9/188 (4.8)	77/370 (20.8)
No answer	46/49 (94)	58/116 (50)	46/50 (92)	2/68 (2.9)	79/89 (88.8)	67/186 (36)	171/188 (91)	127/370 (34.2)
Period of the year, the cited tick-borne diseases occur in the country								
Correct answers	0/49 (0) ^{x,ab}	2/116 (1.7) ^{y,ab}	0/50 (0) ^{x,ab}	7/68(10.3) ^{y,ab}	0/89 (0) ^{x,ab}	4/186 (2.2) ^{y,ab}	0/188 (0) ^{x,ab}	13/370 (3.5) ^{y,ab}
Wrong answers	5/49 (10)	86/116 (74.1)	15/50 (30)	53/68 (77.9)	14/89 (15.7)	114/186 (61.3)	34/188 (18.1)	253/370 (68.4)
No answer	44/49 (90)	28/116 (24.2)	35/50 (70)	8/68(11.8)	75/89 (84.3)	68/186 (36.6)	154/188 (81.9)	104/370 (28.1)
Transmission of zoonotic pathogens by ticks to humans								
Yes	9/49 (18) ^{x,ab}	57/116 (49.2) ^{y,ab}	14/50 (28) ^{x,ab}	47/68 (69.2) ^{y,ab}	14/89 (15.7) ^{x,ab}	112/186 (60.2) ^{y,ab}	37/188 (19.7) ^{x,ab}	216/370 (58.4) ^{y,ab}
No	0/49 (0)	7/116 (6)	8/50 (16)	3/68 (4.4)	2/89 (2.3)	21/186 (11.3)	10/188 (5.3)	31/370 (8.4)
No answer	40/49 (82)	52/116 (44.8)	28/50 (56)	18/68 (26.4)	73/89 (82)	53/186 (28.5)	141/188 (75)	123/370 (33.3)
The name of zoonosis transmitted by ticks to humans								
Correct answers	0/9 (0) ^{x,ab}	2/57 (3.5) ^{x,ab}	0/14 (0) ^{x,ab}	33/47 (70) ^{y,ab}	4/14 (29) ^{x,aa}	28/112 (12.3) ^{x,aa}	4/37 (11) ^{x,ab}	63/216 (29.2) ^{y,ab}
Borreliosis/Lyme disease	*0*	*2*	*0*	*28*	*0*	*0*	*0*	*30*
Q fever	*0*	*0*	*0*	*1*	*2*	*10*	*2*	*11*
Tularemia	*0*	*0*	*0*	*0*	*2*	*15*	*2*	*15*
Others	*0*	*0*	*0*	*4*	*0*	*3*	*0*	*7*
Wrong answers	2/9 (22)	3/57 (5.3)	1/14 (7)	7/47 (15)	3/14 (21)	41/112 (18)	6/37 (16)	51/216 (23.6)
No answer	7/9 (78)	52/57 (91.2)	13/14 (93)	7/47 (15)	7/14 (50)	43/112 (57.5)	27/37 (73)	102/216 (47.2)
Measures to control ticks								
Correct answers	7*/49 (14) ^{x,ab}	94*/116 (81) ^{y,ab}	24*/50 (48) ^{x,ab}	53*/68 (77.9) ^{y,ab}	12*/89 (13.5) ^{x,ab}	88*/186 (47.3) ^{y,ab}	43*/188 (22.9) ^{x,ab}	235*/370 (63.5) ^{y,ab}
Wrong answers	0/49(0)	1/116 (0.9)	5/50 (10)	11/68 (16.2)	2/89 (2.2)	61/186 (32.8)	7/188 (3.7)	73/370 (19.7)
No answer	42/49(86)	21/116 (18.1)	21/50 (42)	4/68 (5.9)	75/89 (84.3)	37/186 (19.9)	138/188 (73.4)	62/370 (16.8)
Efficiency of treatment to control ticks								
Yes	4/49 (8.16) ^{x,ab}	43/116 (37.1) ^{y,ab}	19/50 (38) ^{x,ab}	19/68 (27.94) ^{y,aa}	8/89 (9) ^{x,ab}	83/186 (44.62) ^{y,ab}	31/188 (16.5) ^{x,ab}	145/370 (39.2) ^{y,ab}
No	1/49 (2.04)	22/116 (19)	1/50 (2)	35/68 (51.5)	2/89 (2.3)	19/186 (10.22)	4/188 (2.2)	76/370 (20.6)
No answer	44/49 (90)	51/116 (44)	30/50 (60)	14/68 (20.6)	79/89 (88.7)	84/186 (45.2)	153/188 (81.4)	149/370 (40.3)
The names of anti-tick drugs available in the country								
Correct answers	0/49 (0) ^{x,ab}	17/116 (14.6) ^{y,ab}	7/50 (14) ^{x,ab}	38/68 (55.9) ^{y,ab}	2/89 (2.2) ^{x,ab}	11/186 (5.9) ^{y,ab}	9/188 (4.8) ^{x,ab}	66/370 (17.9) ^{y,ab}
Wrong answers	1/49 (2)	12/116 (10.4)	2/50 (4)	21/68 (30.9)	7/89 (7.9)	94/186 (50.5)	10/188 (5.3)	127/370 (34.3)
No answer	48/49 (98)	87/116 (75)	41/50 (82)	9/68 (13.2)	80/89 (89.9)	81/186 (43.5)	169/188 (89.9)	177/370 (47.8)
The negative effects of the anti-ticks drugs								
Correct answers	1/49 (2) ^{x,ab}	12*/116 (10.3) ^{y,ab}	10/50 (20) ^{x,ab}	35*/68 (51.5) ^{y,ab}	12*/89 (13.5) ^{x,ab}	85*/186 (45.7) ^{y,ab}	23*/188 (12.2) ^{x,ab}	132*/370 (35.7) ^{y,ab}
Wrong answers	1/49 (2)	30/116 (25.9)	1/50 (2)	4/68 (5.9)	0/89	14/186 (7.5)	2/188 (1.1)	48/370 (12.9)
No answer	47/49 (96)	74/116 (63.8)	39/50 (78)	29/68 (42.6)	77/89 (86.5)	87/186 (46.8)	163/188 (86.7)	190/370 (51.4)

Italic for multiple choices frequencies within the correct answers, not included in statistic's calculation.
xy: Percentages within the same line within the same country are significantly different at $p \le 0.05$.
ab: Percentages within the same column within the same group "before" or "after" are significantly different at $p \le 0.05$.
* The sum is corresponding to total students and different from total answers for multiple choices questions.

Table 6
Perception on climate influence on ticks and control of ticks among veterinary medicine students in three veterinary education establishments in Algeria, Tunisia, and Egypt, respectively, before and after getting courses of parasitology.

Number in the group/Number of questioned students (%)								
Question (Answers)	Algeria		Tunisia		Egypt		Overalls	
	Before	After	Before	After	Before	After	Before	After
Do you think that climate influences ticks?								
Yes	13/49 (26) x,ab	97/116 (83.6) y,ab	29/50 (58) x,ab	58/68 (85) y,ab	23/89 (25.8) x,ab	143/186 (77) y,ab	65/188 (34.6) x,ab	298/370 (80.5) y,ab
No	0/49 (0)	3/116 (2.6)	1/50 (2)	2/68 (3)	1/89 (1.2)	2/186 (1)	2/188 (1.1)	7/370 (1.9)
No answer	36/49 (74)	16/116 (13.8)	20/50 (40)	8/68 (12)	65/89 (73)	41/186 (22)	121/188 (64.3)	65/370 (17.6)
How does climate influence ticks?								
Heat	7/13 (53) x,aa	69/97 (71.1) x,ab	13/29 (44.83) x,aa	24/58 (41.4) x,ab	12/23 (52.2) x,ab	65/143 (45.4) y,ab	32/65 (49.2) x,ab	158/298 (53) y,ab
Humidity	2/13 (15)	7/97 (7.2)	2/29 (6.9)	9/58 (15.5)	2/23 (8.7)	16/143 (11.2)	6/65 (9.2)	32/298 (10.7)
Other	0/13	2/97 (2.1)	4/29 (13.8)	4/58 (6.9)	0/23	50/143 (34.9)	4/65 (6.1)	56/298 (18.8)
No answer	5/13 (36)	23/97 (23)	11/29 (30)	29/58 (39)	11/23 (44)	30/143 (20.9)	27/65 (41.5)	82/298 (27.5)
What is (are) the benefit(s) from tick control?								
Decrease of TBP incidence	0/49 (0) x,ab	32/116 (27.6) y,ab	14/50 (28) x,ab	52/68 (76.5) y,ab	8/89 (9) ab	75/186 (40.3) ab	22/188 (11.7) x,ab	159/370 (43) y,ab
Improve ofgeneral animal health status	1/49 (2)	30/116 (25.9)	1/50 (2)	0/68 (0)	3/89 (3.4)	27/186 (14.5)	5/188 (2.7)	57/370 (15.4)
Improve of animal productions	1/49 (2)	9/116 (7.8)	1/50 (2)	5/68 (7.3)	2/89 (2.2)	19/186 (10.2)	4/188 (2.1)	33/370 (8.9)
Protection of public health	0/49 (0)	11/116 (9.5)	6/50 (12)	10/68 (13.2)	2/89 (2.2)	5/186 (2.7)	8/188 (4.3)	25/370 (6.8)
Other	0/49 (0)	2/116 (1.7)	13/50 (26)	15/68 (22.1)	1/89 (1.1)	48/186 (25.8)	14/188 (7.4)	65/370 (17.6)
No answer	48/49 (97)	43/116 (37.1)	10/50 (20)	4/68 (5.9)	75/89 (84.3)	52/186 (28)	133/188 (70.7)	99/370 (26.8)
Why some farmers don't implement tick control measures?								
Ignorance	2/49 (4) x,ab	52/116 (44.8) y,ab	31/50 (62) x,ab	50/68 (73.5) y,ab	13/89 (14.6) x,ab	84/186 (45.2) y,ab	46/188 (24.5) x,ab	186/370 (50.3) y,ab
Financial constraints	2/49 (4)	22/116 (19)	11/50 (22)	32/68 (47.1)	3/89 (3.3)	35/186 (18.8)	16/188 (8.5)	89/370 (24.1)
Other reasons	0/49 (0)	3/116 (2.6)	2/50 (4)	23/68 (33.8)	0/89 (0)	27/186 (14.5)	2/188 (1.1)	53/370 (14.3)
No answer	46/49 (94)	39/116 (33.6)	11/50 (22)	2/68 (2.9)	74/89 (83.1)	69/186 (37.1)	131/188 (69.7)	110/370 (29.7)

xy Percentages within the same line within the same country are significantly different at $p \le 0.05$.
ab Percentages within the same column within the same group “before” or “after” are significantly different at $p \le 0.05$.

3.3. Perception on ticks' control and climate impact on ticks

Among the three VEEs, more than 80% of students from the “after” group think that climate influences ticks (Table 6). According to this group, heat has the most important influence on ticks' abundance (53.02%).

Most students (42.97%) reported that the main benefit of ticks' control was the decrease of TBDs incidence; the second most frequently cited benefit was the improved general animal health status (15.41%). Few students (6.76%) considered that the protection of public health was a benefit of ticks' control. The majority of students in the “after”' group thought that farmers don't implement anti-tick control measures due to ignorance (50.27%) or financial constraints (24.05%) (Table 6).

4. Discussion

The present study aimed to assess basic ticks and TBD knowledge of undergraduate North African veterinary students before and after receiving a course on parasitology. The results gathered through this survey could be used for implementing new education approaches based on the associated learning outcomes. Across all three countries of the study, knowledge on ticks and TBDs improved markedly among veterinary students who had already received the parasitology course, as shown by the results presented here, even if wrong results in important knowledge as the principal tick species present in their country are still provided by the students.

The motives of students to study veterinary medicine were expressed differently across the three countries. Almost and more than a third of Tunisian and Algerian students (32.1 and 37.3% respectively), chose veterinary studies because they love animals. Similar studies in South Dakota (USA) and Queensland (Australia) reported that students chose veterinary studies mainly thanks to their experiences with animals that enhance feeling of love, concern, or interest (Heath et al., 1996; Daly and Erickson, 2012). In this study, few students (8.8%) from across the three countries chose veterinary studies because of their love for veterinary science. Similar results were reported from a Finnish study where a sample of students claimed to have chosen the course because being a veterinarian is considered prestigious (Mikkonen et al., 2009).

In this study, 50.2% and 18.2% of the Egyptian and Algerian students, respectively, did not choose veterinary studies but were automatically allocated to the courses due to their high school test results. Moreover, the rate of wrong responses (34.12%) among students that love animals or the veterinary job was significantly lower than the rate (65.8%) among students that have other motives for veterinary studies. In fact, studying veterinary medicine whilst having no interest in animals' science, or a veterinarian job could have a negative impact on the progression of the student. Indeed students that choose studies by motivation succeeded better than others (Hidi et al., 2010). The disinterest of some students to study veterinary medicine could be related to multiple factors, including a lack of knowledge about veterinary studies, the length of the veterinary curriculum, the veterinary coursework difficulty, and limited work access possibilities. Compared to European VEEs, the North African VEEs of this research have only been recently established, i.e. in 1986, 1961, and 1974 for Algeria, Egypt, and Tunisia, respectively.

Whilst dogs were cited as the preferred domestically-owned species by 26.9% of questioned students, cats were the most frequently owned pets of the students (57.4%). This reality is not specific to the veterinary students, indeed, cats are the most popular pet species in the world (O'Brien et al., 2008). Indeed, cats are easy to keep even in apartments; they have small size, and are relatively independent. We cannot confirm from this study if owning a pet is a motive for choosing the course or a consequence of studying veterinary medicine. A comparison with other students in different fields would be required to verify this.

Few students (15.5%, 47/303) own farm animals but among them, 53% (25/47) come from rural areas and chose veterinary curriculum thanks to their previous experience with farm animals. These trends mirror those reported by Ilgen et al. (2003) for American students.

Despite the enhanced knowledge of students who had already received the parasitological courses, the findings of this study highlight that there is still a lack of knowledge regarding tick species' names and frequencies, as well as the names of TBDs and the high season for the main TBDs.

Five tick genera, namely, *Dermacentor*, *Haemaphysalis*, *Hyalomma*, *Ixodes,* and *Rhipicephalus* are present in North Africa, totalling almost 20 tick species (Walker et al., 2003). The proportion of students of the “after” group that gave the correct number of tick species in their country was only 5.14%, whereas, the other students were not at all precise and just answered “many”, “multiple”, or “thousand”. We consider that it is not a big issue not to be aware of the exact number of national tick species.

However, we assume that it is important to know the names of the most frequently occurring and important ticks because control measures require specific knowledge on such species. Only 69 (12.36%) students of the “after” group provided correct names for the main tick species in their country. The low number of correct answers might be attributed to the low volume of theoretical courses. To enhance the memorization of tick species (morphology, biology, key identification techniques) more practical courses and teaching materials with high quality photos should be provided to the students. Moreover, observation of ticks fixed to animals will dramatically enhance the memorization of the above-mentioned concepts.

Out of the 69 students who provided the correct names, 68% (47/69) mentioned ticks of the *Rhipicephalus* genus. This could be explained by the fact that *R. annulatus* (syn. *Boophilus annulatus*), *R. bursa*, *R. sanguineus* sensu lato are widely distributed ticks in the region (Walker et al., 2003). *Ixodes ricinus* was cited mostly by the Tunisian students (27/59), but much less than Algerian students (2/4) and by none of the Egyptian students. *Ixodes ricinus* is the most common tick species in Europe and is responsible for transmitting *Borrelia burgdorferi,* the causative agent of Lyme borreliosis in humans. Despite, this spirochete has been reported in Tunisia (M'ghirbi et al., 2008; Younsi et al., 2001; Zhioua et al., 1999), Algeria (Benredjem et al., 2014; Leulmi et al., 2016), and once in Egypt (Mazyad et al., 2010). Contrary to the situation in European countries, *I. ricinus* represents no threat to public health in North Africa.

A high percentage of students (42.97%) answered the question about the name of the main TBDs. The majority mentioned babesiosis (132/166) and tropical theileriosis (123/166) and demonstrated that they are aware of the impact of both diseases in their respective countries. Tropical theileriosis induces high economic losses through milk yield decreases, weight loss, high treatment and control expenditure, abortion and mortality, and is therefore highlighted as a TBD of veterinary importance in North African protozoology courses. Despite anaplasmosis being reported in several North African countries (Ben Said et al., 2018) and their inclusion in bacteriology courses, few students cited them as TBDs. This may be because interest in these diseases has increased only recently, and their impacts are lower than those of tropical theileriosis.

Most of the questioned students (68%) thought that summer was the high season for TBDs, which we considered as wrong. In North Africa, most of ticks are active all the year (Walker et al., 2003). This common answer was most likely provided as a result of the students' awareness of two major summer tick species – *Hyalomma scupense* and *Rhipicephalus sanguineus* – and was in accordance with the two major TBDs cited: tropical theileriosis and canine babesiosis.

OIE recommends that veterinary parasitology curriculums should focus on the parasites impacting the health and welfare of animal species of particular relevance to that country (OIE, 2013). One third (33%) of the students of the “after” group did not know that parasites transmit zoonotic pathogens to humans. Students are expected to integrate the “one health” paradigm, which refers to their responsibility towards the environment, animal, and public health. This lack of awareness could be explained by the fact that parasitological disease courses are taught before the epidemiology, zoonosis, and basic clinical knowledge courses in North African veterinary science curricula. Due to the low percentage of good answers, the veterinary curricula in relation to TBDs should be reinforced in zoonotic diseases courses.

Among the few students who correctly named the most frequent zoonotic TBDs in their country, the Tunisian (28/33) and Algerian (2/2) students reported borreliosis, while Egyptian students cited tularemia (15/28) and Q fever (10/28). Despite tularemia is a neglected disease in North Africa with neither publication nor notification, it was considered by a few Egyptian students as frequent. It was expected that a much higher percentage of students, particularly those of the “after” group, would give correct names for the zoonotic TBDs because these diseases are also taught in other courses like bacteriology, virology and infectious diseases. The reason for such a lack of knowledge could be attributed to the huge quantity of disciplines taught during the later stages of the course, which are associated with clinical practice. This could potentially hamper the assimilation of knowledge gained previously about zoonosis. The other reason might be associated with the methods used for teaching zoonotic TBDs.

Even though 39.19% (145/370) of the surveyed students were convinced that animal treatment is efficient against ticks, few (17.84%; 66/370) were able to mention a correct name for an acaricide (neither the commercial name nor active ingredient) used in their country. These erroneous answers were provided because most cited ivermectin as an anti-tick drug. About one-third of prescribed drugs worldwide are antiparasitic molecules (Krecek, 2002) and veterinary students learn about these drugs in both pharmacology and parasitology courses. There is an evident misconception about the efficacy of avermectins to treat ticks, which might be related to their use across a wide spectrum, including for nematodes, mange parasites, and *Rhipicephalus* (*Boophilus*) tick treatment (Dantas-Torres, 2010). Studies on ivermectin action on ticks showed that its efficacy is limited because despite decreasing the reproductive capacity of engorged females, they were still able to produce viable larvae (Lopes et al., 2013; Nava et al., 2019). More than half (51.35%) of the students did not provide correct answers about the negative effects of acaricides and 13% (48/370) gave wrong answers. Although, it's evident that students lack awareness about the negative effects of acaricides, 35.68% of them mentioned: presence of residues in meat and milk, increasing resistance among parasites, toxicity for animals and/or human and/or environment, these answers are not sufficient, and this knowledge should thus be reinforced during the veterinary curriculum.

The majority of veterinary students, including those who had already received the parasitology course, were convinced that climate affects ticks, especially through temperature increase. During the last decade, several publications highlighted the impact of climate change on ticks biology and tick-borne pathogens' distribution (Estrada-Peña et al., 2016). As climate change has occupied increased media attention in recent years, it is evident that students have become aware of this phenomenon. This shows the key role of mass media in transmitting information and messages, and in contributing to health education as also argued by Wakefield et al. (2014). It could be an effective way to convince animal keepers to be active actors in anti-tick control programs and encourage their increased involvement in environmental, animal, and public health protection.

Half of the students (50.27%) reported that farmers refuse tick control implementation due to a lack of awareness and affordability. An opposite trend has been observed among farmers in Zimbabwe where controlling ticks is supported by the government (Sungirai et al., 2015). In North Africa, tick control is a voluntary choice of the animal keeper and depends on several factors including willingness to pay, awareness of benefits, financial capacities, the prevalence of infestation among animals, and the extent of obvious damages caused directly or indirectly by ticks.

Veterinary education should provide undergraduate students with the required core competencies that allow them to work professionally in a continuously changing environment. Teaching veterinary parasitology has been explored by several authors around the world (Fox et al., 2018; Jabbar and Gasser, 2018; Krecek, 2002; Penzhorn, 2018). There is a consensus that veterinary parasitology should reduce theoretical courses and increase problem-based exercises that develop student capacity to apply acquired knowledge to solve problems, and incorporate more cross-disciplinary teaching activities and modern pedagogic approaches as well as teaching technologies (virtual microscopic images) (Gottstein and Eckert, 2002; Strube et al., 2018). When PowerPoint presentations are used, multimedia principles should be incorporated as they have been found to improve short-term memory in parasitology learning (Nagmoti, 2017).

The main recommendations for parasitology teaching in North African countries are to focus on developing basic knowledge on ticks, and enhancing operational knowledge – particularly for tick-borne zoonotic pathogens and drug administration. Specific teaching on climate change should be introduced. This could be achieved through transversal teaching, which groups parasitology, infectious diseases, pharmacology, and immunology, for instance, to avoid scattered information and help students link the concepts. Efforts should be made to attract students to veterinary medicine by explaining the wide range of work possibilities and the involvement of veterinary graduates in animal health and public health preservation and protection. Veterinary surgeons should follow post-graduate courses on parasitology to update and broaden their knowledge.

As far as we know, this is the first study exploring veterinary parasitology teaching in North Africa. We suggest creating a network of parasitological teachers where common teaching sources and resources could be developed for both teachers and students from North Africa. This network could allow for the exchange of didactic and pedagogic approaches to introduce harmonization within veterinary parasitological courses across all North African countries.

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Declaration of Competing Interest

The authors declare no conflict of interest.

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