Repellency effect of flumethrin pour-on formulation against vectors of Crimean–Congo haemorrhagic fever

Eslam Moradi Asl [1,2], Hassan Vatandoost [2,3], Zakie Telmadarreiy [2], Mehdi Mohebali [4], Mohammad Reza Abai [2,3]

[1]Department of Public Health, School of Public Health, Ardabil University of Medical Sciences, Ardabil, Islamic Republic of Iran. [2]Department of Medical Entomology and Vector Control, School of Public Health and National Institute of Health Research, Tehran University of Medical Sciences, Tehran, Islamic Republic of Iran (Correspondence to: H. Vatandoost: hvatandoost1@yahoo.com, vatando@tums.ac.ir). [3]Department of Chemical Pollutants and Pesticides, Institute for Environmental Research, Tehran University of Medical Sciences, Tehran, Islamic Republic of Iran. [4]Department of Medical Parasitology and Mycology, School of Public Health and National Institute of Health Research, Tehran University of Medical Sciences, Tehran, Islamic Republic of Iran.

Abstract

Background: Ticks are able to transmit important diseases to humans, including Rocky Mountain spotted fever, Q fever, Crimean–Congo haemorrhagic fever, summer Russian encephalitis, and relapsing fever.

Aims: To determine the repellency effect of 1% flumethrin pour-on formulation against hard ticks.

Methods: The concentration of flumethrin pour-on formulation was 1 mg/10 kg body weight and was administered on the dorsal midline from the head to the base of the tail. The livestock included cows, goats, oxen and sheep in 2 villages in Ardabil Province, Islamic Republic of Iran.

Results: We studied 200 livestock comprising 5 age groups (< 2, 3–4, 5–6, 7–8 and >8 years). The main hard ticks identified were Hyalomma species (62.5%) and Rhipicephalus bursa (37.5%). In the treatment village, the maximum number of ticks per animal was 11.6 in oxen, 9.5 in sheep, 8.9 in goats and 8.6 in cattle. The repellency effect of flumethrin remained for 2 months.

Conclusions: Flumethrin provided 2 months protection against hard ticks. Therefore, it could be used in the livestock industry. Control of ticks is important for prevention of disease transmission.

Keywords: flumethrin, Islamic Republic of Iran, livestock, repellency, ticks

Citation: Moradi Asl E; Vatandoost H; Telmadarreiy Z; Mohebali M; Reza Abai M. Repellency effect of flumethrin pour-on formulation against vectors of Crimean–Congo haemorrhagic fever. East Mediterr Health J. 2018;24(11):1082–1087. https://doi.org/10.26719/emhj.18.004

Received; 19/10/16; accepted: 02/08/17

Introduction

Ticks are important in human and veterinary medicine. Hard ticks include > 650 species. Diseases that are transmitted by ticks have a major economic impact on the livestock industry worldwide. Ticks are able to transmit several important diseases to humans, including Rocky Mountain spotted fever, Q fever, Crimean–Congo haemorrhagic fever (CCHF), summer Russian encephalitis, and relapsing fever (*1–4*). Control of ticks is important for prevention of disease transmission. Chemical methods are the most commonly used for control of ectoparasites. Chemical insecticides, biological control, environmental management and repellent agents are the most important methods for tick control. However, the stability of some insecticides in nature and their adverse effects on humans and the environment are major concerns (*5*, *6*). For farmers and consumers, the important factors for insecticides are ease of application, low cost and long-term protection. Repellent compounds are derived from plant oils, smoke and tars, and they can be used for killing and repelling insects. Before World War II, there were 4 major repellents that had been in use for repellency of insects and animals for several years: Citronella oil was used for head lice; dimethyl phthalate was discovered in 1929; indole was invented in 1937; and Rutgers 612 was evaluated in 1939 (*7*). A total of 901 products are available: 872 synthetic oils and 29 plant oils. The United States Department of Agriculture tested some repellents against 4 types of cockroaches in Germany during 1953–1973 (*8*).

Flumethrin is a pyrethroid insecticide. It is used externally in veterinary medicine against parasitic insects and ticks on cattle, sheep, goats, horses and dogs, as well as for control of parasitic mites in honeybee colonies. Flumethrin is applied in a line from the base of the skull along both sides of the spine to the tail in cattle. The median lethal dose for rats by ingestion is 500–1000 mg/kg. Flumethrin is toxic to fish and aquatic animals (*9*). It acts on the nervous system of the target arthropods (*10–12*).

Methods

Study area

This study was conducted in 2014–2015 in Meshkinshahr County, which is located in the centre of Ardabil Province, in the northwest of the Islamic Republic of Iran (Figure 1). This region has a cool climate (maximum 35°C) during the hot summer months. The winter is cold (minimum −25°C). A total of 25 000 people are involved with rearing livestock.

Figure 1 Map of study area: Ardebil Province, Northwestern Islamic Republic of Iran

Study design

This was a case–control study of the repellency effect of 1% flumethrin pour-on against vectors of CCHF. The efficacy of flumethrin was evaluated in in 2 randomly selected villages with similar ecological features, Ur as treatment village and Majandeh as control village. One hundred livestock were selected randomly from each village, including cattle, sheep, oxen and goats, in 5 age groups (< 2, 3–4, 5–6, 7–8 and > 8 years). Tick survival rate was determined by examining the whole body of the animals at different times. In the treatment village, 50 livestock were sprayed with 1% flumethrin pour-on. The same number of livestock without flumethrin was checked as controls. The number of ticks on the livestock was counted prior to the experiment. At 1, 2, 3, 7, 14, 30 and 60 days after application, the tick density was determined. The control village was similar to the treatment village, in terms of lifestyle, livestock keeping, number and type of livestock and living conditions, and climate. Livestock in the control village were not treated with flumethrin.

The results were analysed using the χ^2 test and *t* test.

Tick identification

All the collected ticks were identified according to the valid identification keys of Janbakhsh (1956), Hoogsteraal (1956) and Walker et al. (2007).

Results

Animal infestation

During the study period, 1975 ticks were collected and identified. In Ur, the maximum number of ticks per animal was 11.6 in oxen, 9.5 in sheep, 8.9 in goats and 8.6 in cattle (Table 1). The highest infestation rates were observed in age groups < 4 years.

Tick species

We identified 200 hard ticks morphologically: 80 *Hyalomma marginatum* (40%), 25 *Hyalomma anatolicum* (12.5%), 15 *Hyelomma dromedarii* (7.5%), 5 *Hyelomma detritum* (2.5%) and 75 *Rhipicephalus bursa* (37.5%).

Repellency of flumethrin

The repellency of flumethrin for up to 60 days is shown in Figure 2. The repellency of flumethrin according to age of livestock is shown in Table 2. This ranged from 100% for animals aged > 8 years to 91.2% for those aged 5–6 years. The repellency effect of flumethrin in different types of livestock is shown in Table 3. This ranged from 97.3% for goats to 90.5% for oxen.

Discussion

We studied the repellent effect of flumethrin insecticide. Tick infestation of cattle was related to the age of host animals, with old cattle having fewer ticks. We showed that there was a direct relationship between livestock age and efficacy of flumethrin. The repellency effect of 1% flumethrin pour-on showed a significant difference in oxen and sheep ($P < 0.01$). However, there was no significant difference between the number of ticks remaining on cows compared with other livestock ($P > 0.01$).

Other studies have shown that 1% flumethrin pour-on also provides long-term protection of livestock

Table 1 Frequency of ticks on livestock in the study area

	2 < age	3–4	5–6	7–8	> 8	Total of ticks	Total of livestock	Tick/livestock frequency
Villages	Ur-Majandeh	Ur-Majandeh	Ur-Majandeh	Ur-Majandeh	Ur-Majandeh	Ur-Majandeh	Ur-Majandeh	Ur-Majandeh
Livestock	86–149	117–195	42–95	37–159	27–27	309–625	36–51	8.6–11.4
Cow	82–58	179–109	78–74	53–35	8–21	400–297	42–36	9.5–9.5
Sheep	53–17	46–39	15–7	0–0	10–0	124–63	14–9	8.9–7
Oxen	10–0	31–15	33–19	19–30	0–0	93–64	8–4	11.6–16
Total	231–224	373–358	168–195	109–224	45–48	926–1049	100–100	9.26–10.49

Table 2 **Repellency effect of flumethrin according to age of livestock**

Age (years)	Repellency Index	Time of tick survey before and after application of flumethrin							
		Before	1 day	2 days	3 days	7 days	14 days	30 days	60 days
< 2	Survivors (ticks)	231	187	143	93	60	26	17	4
	Repellency (%)	–	19.7	39.1	57.8	70.6	87.9	92.3	98.1
3–4	Survivors (ticks)	373	303	232	148	76	43	21	17
	Repellency (%)	–	17.4	37.3	57.4	76.4	87.3	94	94.8
5–6	Survivors (ticks)	168	162	130	96	61	39	25	14
	Repellency (%)	–	9.2	27.8	43.2	61	76.3	85.2	91.2
7–8	Survivors (ticks)	109	97	74	54	33	21	15	5
	Repellency (%)	–	11.7	33.3	48.1	65.7	79.3	85.6	94.9
> 8	Survivors (ticks)	45	41	32	23	15	6	3	0
	Repellency (%)	–	9.6	30.1	46.5	62.3	85.7	93	100
Total		926	–	–	–	–	–	–	–

Table 3 **Repellency effect of flumethrin according to type of livestock**

Livestock	Repellency Index	Time of controls before and after application of flumethrin							
		Before	1 day	2 days	3 days	7 days	14 days	30 days	60 days
Oxen	Survivors (ticks)	93	80	60	39	22	19	15	8
	Repellency (%)	–	14.6	36.6	56.1	73.2	78	83.1	90.5
Cattle	Survivors (ticks)	309	251	199	137	83	55	30	14
	Repellency (%)	–	19.4	36.7	53.6	69.6	80.9	89.8	95
Sheep	Survivors (ticks)	400	337	260	174	98	83	26	15
	Repellency (%)	–	16.4	36.1	54.5	72.3	77.7	93.2	95.8
Goats	Survivors (ticks)	124	122	92	64	42	18	10	3
	Repellency (%)	–	2.4	27.1	46	61.7	84.4	91.6	97.3
Total	Survivors (ticks)	926	790	611	414	245	175	81	40
	Repellency (%)	–	15.3	35.1	53.2	70	79.7	90.9	95.2

against ticks worldwide (*13*, *14*). In Jeddah, Saudi Arabia, 1% flumethrin pour-on was used to control *H. dromedarii* in dromedaries. For animals with high density of ticks, 2 ml/10 kg body weight was used, and 1 ml/10 kg for those with only mild contamination. In comparison with control animals, there was a high level of tick control with both doses (*15*). In another study in Riyadh, Saudi Arabia, 2 insecticides, 1% flumethrin pour-on formulation and 20% coumaphos WP formulation, were used topically against different stages of *H. dromedarii* on camels (*16*). The toxicity of flumethrin was 8 times higher than that of coumaphos against ticks. Some studies have shown that 1% flumethrin pour-on has 95–100% lethality for ectoparasites (*17*). Flumethrin can prevent disease transmission by ticks, fleas, mites and other ectoparasites due to its repellent property (preventing blood feeding) (*17*). In the present study, the repellent property of flumethrin was evaluated against hard ticks on cows, sheep, water oxen and goats. Flumethrin repelled hard ticks of *Hyalomma* species and *Rhipicephalus bursa* from livestock for 2 months.

In other studies, a combination of different toxicants increased the lethal and retention properties of this toxicant for a long time (*18*). A combination of flumethrin and imidacloprid was administered to dogs in a collar, and after 6 and 12 hours, the insecticides had 94–100% repellent and lethal effects on *Dermacentor variabilis* and *Amblyomma americanum* ticks. The protection time of these animals against ticks was estimated at 28–48 days. The repellent rate of flumethrin was estimated at > 2 months under field conditions (*19–22*). In a study in Namibia of sheep contaminated with *Hyalomma truncatum* treated with 1% flumethrin pour-on, ticks disappeared for 4 weeks and full protection was provided (*23*).

Flumethrin is effective against a broad range of ectoparasites. In endemic areas for visceral leishmaniasis it can have repellent and antinutritional properties against the sandfly vector *Phlebotomus* (Larrossius group). In a study from Southern Italy, 4.5% flumethrin and 10% imidacloprid achieved 90.5–100% prevention of dog leishmaniasis. It had a significant antinutritional effect on *Phlebotomus* and reduced *Leishmania infantum* in young dogs. This combination achieved 8 months of protection in comparison to 5 months with deltamethrin (*24*). Another study examined the effect of 1% flumethrin pour-on on visceral leishmaniasis in dogs. The ratio

index of blood feeding by *Phlebotomus* in the dogs treated with flumethrin pour-on was 12.26–25%, compared with 53.8–58.7% in the control group. This difference was significant. Also, the index of preventing blood feeding by *Phlebotomus* was 75–87.74 and 41.29–46.45% in the treatment and control groups, respectively. Again, this difference was significant (*25*).

Conclusion

We recommend the use of 1% flumethrin pour-on formulation for livestock every 2 months in cold and mountainous climates (like Northwest Islamic Republic of Iran). Appropriate use of this insecticide at the recommended dose provides effective protection against important ticks on livestock.

Acknowledgements

Our special thanks go to all the women whose participation made this research possible. We thank the Tehran University of Medical Sciences for their funding and the Iranian Legal Medicine Organization for their support.

Funding: This study was funded by Tehran University of Medical Sciences.

Competing interests: None declared.

Effet répulsif de la fluméthrine en application épicutanée contre les vecteurs de la fièvre hémorragique de Crimée-Congo

Résumé

Contexte : Les tiques peuvent transmettre des maladies graves aux humains, y compris la fièvre pourprée des montagnes Rocheuses, la fièvre Q, la fièvre hémorragique de Crimée-Congo, l'encéphalite verno-estivale russe et la fièvre récurrente.

Objectif : La présente étude visait à déterminer l'effet répulsif de la fluméthrine 1 % en application épicutanée contre les tiques dures.

Méthodes : La concentration de la formulation de fluméthrine épicutanée était de 1 mg/10 kg de poids. Elle était administrée sur la ligne médiane dorsale, de la tête à la base de la queue. Les animaux étudiés comprenaient des vaches, des chèvres, des bœufs et des moutons de deux villages de la province d'Ardabil, en République islamique d'Iran.

Résultats : Nous avons examiné 200 animaux appartenant à cinq groupes d'âge (<2, 3-4, 5-6, 7-8 et >8 ans). Les principales tiques dures identifiées appartenaient aux espèces *Hyalomma* (62,5 %) et *Rhipicephalus bursa* (37,5 %). Dans le village où le traitement était appliqué, le nombre maximum de tiques par animal était de 11,6 pour les bœufs ; 9,5 pour les moutons ; 8,9 pour les chèvres ; et 8,6 pour les bovins. L'effet répulsif de la fluméthrine s'est dissipé au bout de deux mois.

Conclusion : La fluméthrine offre une protection de deux mois contre les tiques dures. Elle pourrait donc être utilisée dans l'industrie de l'élevage. Le contrôle des tiques est un aspect important de la prévention de la transmission de la maladie.

التأثير المُنَفِّر لصبّ مستحضر فلوميثرين المضاد لنواقل حُمَّى القرم–الكونجو النزفية

اسلام مرادى اصل، حسن وطن روست، زكي تلهاداري، مهدي محبعلى، محمد رضا عبائي

الخلاصة

الخلفية: يمكن للقُراد نقل أمراض هامة إلى الإنسان، ومنها حُمَّى الجبال الصخرية المُبَقّعة، وحمى كيو، وحمى القرم–الكونجو النزفية، والتهاب الدماغ الروسي الصيفي، والحمى الراجعة.

الأهداف: تهدف الدراسة إلى التعرف على التأثير المُنَفِّر لصب مستحضر فلوميثرين بتركيز ١٪ على القُراد القاسي.

طرق البحث: كان تركيز مستحضر فلوميثرين ١ ميلي جرام/ ١٠ كيلو جرام من وزن الحيوان، ويُصَبّ على طول الخط الظهري المتوسط بدءًا من الرأس حتى قاعدة الذيل. وتضمنت الماشية الأبقار والماعز والثيران والأغنام في قريتين من قرى ولاية أردبيل في جمهورية إيران الإسلامية.

النتائج: درسنا ٢٠٠ رأس ماشية تنتمي إلى ٥ فئات عمرية (أصغر من سنتين، ٣–٤ سنوات، ٥–٦ سنوات، ٧–٨ سنوات، أكبر من ٨ سنوات). كانت أنواع القُراد القاسي التي أمكن التعرف عليها هي قراد الحَذْراء (٥ , ٦٢٪) والقراد مَرْوَحِيُّ الرأس الكبيرِ (٥ , ٣٧٪). وبلغ العدد الأقصى للقراد في كل حيوان ٦ , ١١ في الثيران، و٥ , ٩ في الغنم، و٩ , ٨ في الماعز، و٦ , ٨ في البقر. وقد تواصل التأثير المُنَفِّر لمستحضر فلوميثرين لمدة شهرين.

الاستنتاجات: يقدم فلوميثرين حماية تدوم شهرين من القراد القاسي. لذا يمكن استخدامه في تربية الماشية. فمكافحة القراد عمل مهم للوقاية من انتقال الأمراض.

References

1. Vatandoost H. Hanafi Bojd AA. Ectoparasites of medical and veterinary importance. Tehran: Tehran University of Medical Sciences; 2002: 45–50 (in Persian).
2. Servis M. Medical entomology. Tehran: Tehran University; 1995 (in Persian).
3. Oormazdi H. Medical parasitology: arthropods. Iran: Bahar Publications; 1995:178–190 (in Persian).
4. Kia E, Moghddas-Sani H, Hassanpoor H, Vatandoost H, Zahabiun F, Akhavan A, et al. Ectoparasites of rodents captured in bandar abbas, southern iran. Iran J Arthropod Borne Dis. 2009;3(2):44–9. PMID:22808381
5. Rozendaal, Jan A. Vector control: methods for use by individuals and communities. Geneva: World Health Organization; 1997 (http://apps.who.int/iris/handle/10665/41968, accessed 23 March 2018).
6. Tapia-Perez G, García-Vazquez Z, Montaldo H, George J. Inheritance of resistance to flumethrin in the Mexican Aldama strain of the cattle tick Boophilus microplus (Acari: Ixodidae). Exp Appl Acarol. 2003;31(1-2):135–49. https://doi.org/10.1023/B:APPA.0000005143.90681.82 PMID:14756408
7. Prakash S, Srivastava CP, Kumar S, Pandey KS, Kaushik MP, Rao KMN. N,N-diethylphenylacetamide–a new repellent for Periplaneta americana (Dictyoptera: Blattidae), Blattella germanica, and Supella longipalpa (Dictyoptera: Blattellidae). J Med Entomol. 1990 Nov;27(6):962–7. https://doi.org/10.1093/jmedent/27.6.962 PMID:2280397
8. Klun JA, Ma D, Gupta R. Optically active arthropod repellents for use against disease vectors. J Med Entomol. 2000 Jan;37(1):182–6. https://doi.org/10.1603/0022-2585-37.1.182 PMID:15218925
9. Nabian S, Rahbari S, Changizi A, Shayan P. The distribution of Hyalomma spp. ticks from domestic ruminants in Iran. Med Vet Entomol. 2009 Sep;23(3):281–3. https://doi.org/10.1111/j.1365-2915.2009.00804.x PMID:19712158
10. Fourie LJ, Kok DJ, Peter RJ. Influence of sheep breed and application site on the efficacy of a flumethrin pour-on formulation against ticks. J S Afr Vet Assoc. 2001 Sep;72(3):143–6. https://doi.org/10.4102/jsava.v72i3.637 PMID:11811701
11. Aghighi Z, Assmar M, Piazak N, Javadian E, Seyedi Rashti MA. Kia EB, et al. Distribution of soft ticks and their natural infection with Borrelia in a focus of relapsing fever in Iran. Iran J Arthropod Borne Dis. 2007;1(2):14–8. http://www.sid.ir/FileServer/JE/120220070203.
12. Telmadarraiy Z, Bahrami A, Vatandoost H. A survey on fauna of ticks in West Azerbaijan Province, Iran. Iran J Public Health. 2004;33(4):65–9.
13. Liebisch A, Beder G. [Control of ticks (Ixodidae: Dermacentor marginatus) in sheep with flumethrin 1% pour-on]. Vet Med Rev. 1988;1:9–17 (in German).
14. Parrodi F, Bhushan C, Neri S, Ramirez E. Efficacy of fluazuron and flumethrin combination pour-on formulation against Boophilus microplus on artificially and naturally interested cattle. Proceeding of the 26th World Buiatrics Congress, Santiago, Chile; 2010.
15. el-Azazy OM. Camel tick (Acari:Ixodidae) control with pour-on application of flumethrin. Vet Parasitol. 1996 Dec 31;67(3-4):281–4. https://doi.org/10.1016/S0304-4017(96)00938-7 PMID:9017876
16. Alahmed AM, Hussein HI, Kheir SM, Al-Rajhy D. Efficacy of flumethrin and coumaphos against the camel tick Hyalomma dromedarii L. (Acari: Ixodidae). J Egypt Soc Parasitol. 2001 Dec;31(3):791–8. PMID:11775105
17. Josephus JF, Ivan GH. Christa d V, Katrin D, Bettina S. Comparative speed of kill, repellent (anti-feeding) and acaricidal efficacy of an imidacloprid/flumethrin collar (Seresto®)and a Fipronil/(S)-methoprene/eprinomectin/praziquantel spot-on (Broadline®) against Ixodes ricinus (Linné, 1758) on cats. Parasitol Res. 2015;114(Suppl 1):S109–16. https://doi.org/10.1007/s00436-015-4517-9 PMID:26152412
18. Ivan GH, Josephus J. Dorothee St. Efficacy of slow-release collar formulations of imidacloprid/flumethrin and deltamethrin and of spot-on formulations of fipronil/(s)-methoprene, dinotefuran/pyriproxyfen/permethrin and (s)–methoprene/amitraz/fipronil against Rhipicephalus sanguineus and Ctenocephalides felis felis on dogs. Parasit Vectors. 2012 Apr 22;5:79. https://doi.org/10.1186/1756-3305-5-79 PMID:22520338
19. Ohmes CM, Hostetler J, Davis WL, Settje T, McMinn A, Everett WR. Comparative efficacy of an imidacloprid/ flumethrin collar (Seresto®) and an oral fluralaner chewable tablet (Bravecto®) against tick (Dermacentor variabilis and Amblyomma americanum) infestations on dogs: a randomized controlled trial. Parasitol Res. 2015;114:95–108. https://doi.org/10.1007/s00436-015-4516-x PMID:26152411
20. Stanneck D, Rass J, Radeloff I, Kruedewagen E, Le Sueur C, Hellmann K, et al. Evaluation of the long-term efficacy and safety of an imidacloprid 10%/flumethrin 4.5% polymer matrix collar (Seresto®) in dogs and cats naturally infested with fleas and/or ticks in multicentre clinical field studies in Europe. Parasit Vectors. 2012 Mar 31;5:66. https://doi.org/10.1186/1756-3305-5-66 PMID:22463745
21. Stanneck D, Kruedewagen EM, Fourie JJ, Horak IG, Davis W, Krieger KJ. Efficacy of an imidacloprid/flumethrin collar against fleas, ticks, mites and lice on dogs. Parasit Vectors. 2012 May 30;5:102. https://doi.org/10.1186/1756-3305-5-102 PMID:22647530
22. Stanneck D, Ebbinghaus-Kintscher U, Schoenhense E, Kruedewagen EM, Turberg A, Leisewitz A, et al. The synergistic action of imidacloprid and flumethrin and their release kinetics from collars applied for ectoparasite control in dogs and cats. Parasit Vectors. 2012 Apr 12;5:73. https://doi.org/10.1186/1756-3305-5-73 PMID:22498105

23. Hamel HD. Efficacy of flumethrin 1% pour-on against Hyalomma truncatum in Karakul sheep in Namibia. Vet Med Rev. 1987;1:43–50.

24. Brianti E, Gaglio G, Napoli E, Falsone L, Prudente C, Solari Basano F, et al. Efficacy of a slow-release imidacloprid (10%)/flumethrin (4.5%) collar for the prevention of canine leishmaniasis. Parasit Vectors. 2014 Jul 14;7(1):327. https://doi.org/10.1186/1756-3305-7-327 PMID:25023573

25. Jalilnavaz MR, Abai MR, Vatandoost H, Mohebali M, Akhavan AA, Zarei Z et al. Application of flumethrin pour-on on reservoir dogs and its efficacy against sand flies in endemic focus of visceral leishmaniosis, Meshkinshahr. Iran J Arthropod Borne Dis. 2016;19(1):35–42.