The Analysis of eTick Submission in Ontario

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Abstract

Purpose: *Ixodes scapularis*, also known as the eastern blacklegged tick, is associated with vectorborne Lyme disease in North America [1][2]. Warming temperatures due to climate change are increasing the number of areas suitable for ticks, and contributing to the expansion of tick species in Canada [3]. The purpose of this project was to identify recent trends in tick range expansion and species diversity in Ontario by analyzing 2019 to 2022 data from the web-based tick surveillance platform, eTick.ca.

Method: The eTick.ca web platform allows the public to submit tick photos for identification. We extracted data from the tick submissions for Ontario between mid-2019 and 2022, including information on the species, host type, travel history, and location. Microsoft Excel was used to generate distribution tables and graphs of tick submissions by species, month/year, and host type for Ontario. Geographic Information Systems (ArcGIS) and SaTScan software were used to identify spatial clusters of tick submissions adjusting for the human population size using Ontario census subdivisions.

Results: A total of 14,611 tick photo submissions were recorded between 2020 and 2022, excluding those with a history of recent travel. The year 2021 had the highest number of submissions (n = 7339).
Dermacentor species comprised the majority of submissions (n = 9498, 65%), followed by I. *scapularis* (n = 4810, 33%) and other species (n = 303, 2%) between 2020 and 2022. Ticks were most commonly discovered on human hosts (n = 10,084), followed by animal hosts (n = 3485), and finally, free in the environment (n=1042). Additionally, the majority of species were found in the adult stage (n = 12,821, 88%), followed by unknown stage (n = 1539, 10%) and immature stages (n = 251, 2%). Clusters of I. *scapularis* were present in the Eastern, Central, and Southern Ontario regions, while clusters of *Dermacentor* sp. were present in Southern and Central Ontario regions.

Conclusion: Spatial and temporal variations in tick submissions in Ontario were identified over the 3.5-year period since the implementation of eTick in the province. Data from eTick can be used to identify hotspots of human-tick exposure.

Résumé

Objectif : *Ixodes scapularis,* aussi connue sous le nom de tique à pattes noires, est associée à la maladie de Lyme à transmission vectorielle en Amérique du Nord [1][2]. Le réchauffement des températures dû au changement climatique augmente le nombre de zones propices aux tiques et contribue à l'expansion des espèces de tiques au Canada [3]. L'objectif de ce projet était d'identifier les tendances récentes de l'expansion de l'aire de répartition des tiques et de la diversité des espèces en Ontario en analysant les données de 2019 à 2022 de la plateforme de surveillance des tiques en ligne, eTick.ca.

Méthode : La plateforme web eTick.ca permet au public de soumettre des photos de tiques pour identification. Nous avons extrait des données des soumissions de tiques pour l'Ontario entre la mi-2019 et 2022, y compris des informations sur l'espèce, le type d'hôte, l'historique des voyages et l'emplacement. Microsoft Excel fut utilisé pour générer des tableaux de distribution et des graphiques des soumissions de tiques par espèce, mois/année et type d'hôte pour l'Ontario. Les systèmes d'information géographique (ArcGIS) et le logiciel SaTScan furent utilisés pour identifier les grappes spatiales de soumissions de tiques en ajustant la taille de la population humaine à l'aide des subdivisions de recensement de l'Ontario.

Résultats : Au total, 14 611 soumissions de photos de tiques furent enregistrées entre 2020 et 2022, en excluant les personnes ayant des antécédents de voyages récents. L'année 2021 a enregistré le plus grand nombre de soumissions (n = 7339). Les espèces *Dermacentor* représentaient la majorité des soumissions (n = 9498, 65%), suivies par I. scapularis (n = 4810, 33%) et d'autres espèces (n = 303, 2%) entre 2020 et 2022. Les tiques furent le plus souvent découvertes sur des hôtes humains (n = 10 084), suivis par des hôtes animaux (n = 3485), et enfin, libres dans l'environnement (n = 1042). De plus, la majorité des espèces ont été trouvées au stade adulte (n = 12 821, 88%), suivie du stade inconnu (n = 1539, 10%) et des stades immatures (n = 251, 2%). Des groupes d'I. scapularis étaient présents dans les régions de l'Est, du Centre et du Sud de l'Ontario, alors que des groupes de *Dermacentor sp.* étaient présents dans les régions de l'Est et du Sud de l'Ontario.

Conclusion : Des variations spatiales et temporelles dans les soumissions de tiques en Ontario ont été identifiées sur une période de 3,5 ans depuis la mise en œuvre d'eTick dans la province. Les données d'eTick peuvent être utilisées pour identifier les zones à risque d'exposition humaine aux tiques.

Introduction

Lyme disease is a vector-borne infectious disease caused by Borrelia burgdorferi genospecies of bacteria, including B. burgdorferi sensu stricto (s.s.) in North America, B. afzelii in Europe, and B. garinii in Asia [1]. These bacteria belong to the Spirochaete class, with a long corkscrew-like shape that can dive into the host's skin. Ticks play a significant role by acting as vectors to transmit the bacteria to ahost [1]. In Ontario, *Ixodes scapularis*, also known as the eastern black-legged tick, is associated with vector-borne Lyme disease [2]. Other tick species in Ontario include *Dermacentor variabilis*, the American dog tick or wood tick, which can serve as a vector for Rocky Mountain spotted fever and tularemia. Climate change has promoted warming temperatures that are more suitable for tick populations, leading to the northward expansion of the species to new regions [3]. This study aimed to identify the recent trends in tick range expansion and species diversity in Ontario using 2019 to 2022 data from eTick.ca.

Methods

Data source
The eTick.ca web platform collects passive surveillance data on ticks in Canada. This platform allows the public to submit tick photos for identification by regional expert tick identifiers and allows the researchers to monitor tick populations in Canada. We extracted data from the tick submissions for Ontario between April 2019, when the eTick platform was first implemented in the province, and December 2022. The submission data included the type and life stage of tick species, host type, travel history, date, and location. Only valid submissions (i.e. submissions with confirmed species identification and location) were included in the analysis.

Descriptive analyses
Microsoft Excel software was used to calculate the total number of tick submissions by species, year, and host type. Since submission data for 2019 were not collected for all 12 months, the descriptive trend analyses focused on submissions between 2020 and 2022, representing years when the eTick platform was fully operational between January and December.

Spatial analyses
ArcGIS software was used to map the spatial distribution of *Ixodes scapularis* and *Dermacentor species (sp.)* submissions across Ontario census subdivisions (CSDs) between 2019 and 2022 [4]. SaTScan software, which allows users to analyze spatial, temporal and space-time data using the Kulldorf spatial scan statistics [5] was used for space-time cluster analysis on *Ixodes scapularis* and *Dermacentor species* submissions from 2021, to estimate the relative risk of clusters, adjusting for the human population size of each unit. The 2021 Census Boundary Files and 2021 Census Population files were downloaded from the Statistics Canada website and combined with the tick point location data (latitude/longitude of user-reported tick encounter locations) to aggregate tick submissions by CSD, and determine the hotspots of human-tick exposure.

Results

Trends in tick species over time
Between 2020 and 2022, there were 14,611 photo submissions of ticks found on humans, animals, and free in the environment, excluding those with travel history. The total number of submissions of *Dermacentor sp.* was higher than *I. scapularis* each year (Table 1). Of all three years when the eTick platform was fully operational, 2021 had the highest total number of submissions (n = 7,339), whereas the 2020 total was 2,961, and the 2022 total was 4,311. The variation in tick encounters may be due to changes in ecological and weather conditions, differences in human and animal exposure, and/or discrepancies in the promotion of the eTick platform across various public health units over time (Figure 1). *Dermacentor sp.* (65%) made up the majority of submissions, followed by *I. scapularis* (33%) and other species (2%) for 2020, 2021, and 2022 (Figure 2). Based on the monthly eTick submissions over the last three years, the number of *I. scapularis* submissions usually reached its peak between May and October. The pattern of this species typically started to rise in March, then gradually decreased in August, and began to increase again in September, persisting until December. Similarly, the number of *Dermacentor sp.* submissions elevated around March until August, reaching its highest point in May (Figure 3).

Trends by host type
The majority of tick submissions were found on a human host (n=10,084), followed by animal hosts (n=3,485), and free in the environment (n=1,042) (Table 2, Figure 4). Ticks were more commonly found on dogs than cats.

Trends by life stage
I. scapularis, and Dermacentor sp. were commonly found in the adult stage during their peaks, which were May and October for *I. scapularis* (Figure 5), and May for Dermacentor sp., followed in both cases by unknown and immature stages (Figure 6). The peak season for immature *I. scapularis* occurred around June annually (Figure 5), whereas immature Dermacentor sp. were rarely observed (Figure 6). Adult ticks made up the majority of species found (n=12,821, 88%), followed by unknown (n=1539, 10%), and finally immature stages (n=251, 2%) (Figure 7).

Spatial distribution and spatiotemporal cluster detection
Between 2019 and 2022, 6,305 *I. scapularis* submissions (Figure 8) and 11,370 Dermacentor sp. submissions (Figure 9) were recorded across Ontario. In 2021, when the highest number of tick photo submissions were recorded, there were 2,440 *I. scapularis* submissions, corresponding to 160.7 per 100,000 population, and 5,975 *Dermacentor sp.* submissions, corresponding to7804.9 per 100,000 population.

Using retrospective space-time analysis, with submissions aggregated at the census subdivision level and adjusted for population size, high-rate clusters of I. scapularis were identified in Southern and Eastern Ontario. A large cluster spanning Eastern Ontario was detected between June and November, while three clusters in Southeastern Ontario, including clusters over the north shore of Lake Erie, the north of Toronto and the Greater Toronto Area were detected from October to November (Table 3, Figure 10). Two high-rate clusters of *Dermacentor sp.* were identified between April and July, including a large cluster encompassing the area between Windsor and the Greater Toronto Area and a smaller cluster in the Kawartha Lakes region (Table 4, Figure 11).

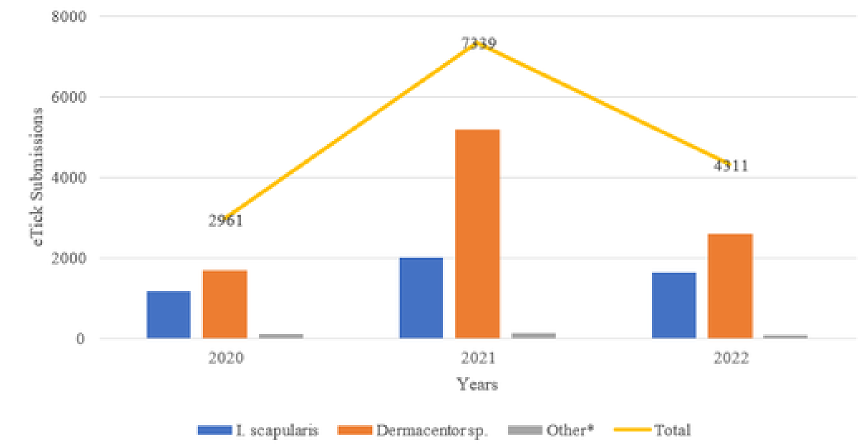

Figure 1: eTick Submission 2020 to 2022. eTick submissions from 2020 to 2022, excluding submissions with travel history. *The total number of species submissions excluding *I. scapularis, and Dermacentor sp.*

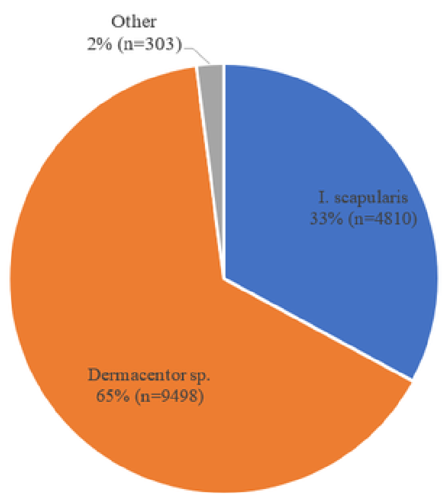

Figure 2: Total eTick Submissions from 2020 to 2022 (n = 14,611). Total eTick submissions between 2020 to 2022 found on humans, animals, and free in the environment, excluding travel history.

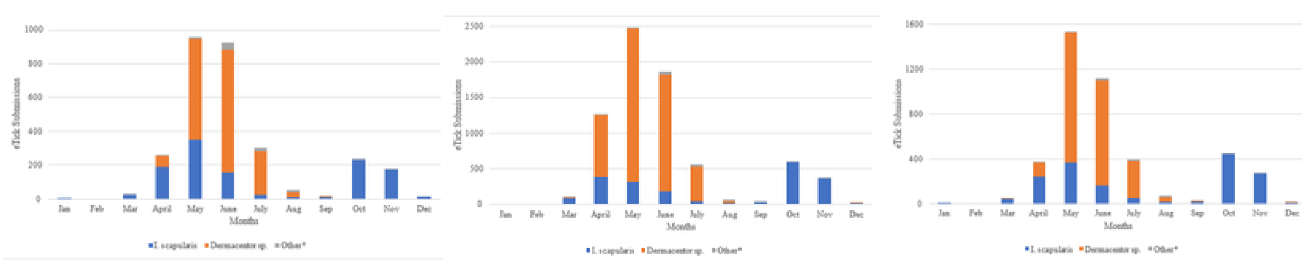

Figure 3: Monthly eTick Submission 2020, 2021, and 2022. Monthly eTick submissions for 2020, 2021, and 2022, excluding travel history. *The total number of species submissions excluding *I. scapularis, and Dermacentor sp.*

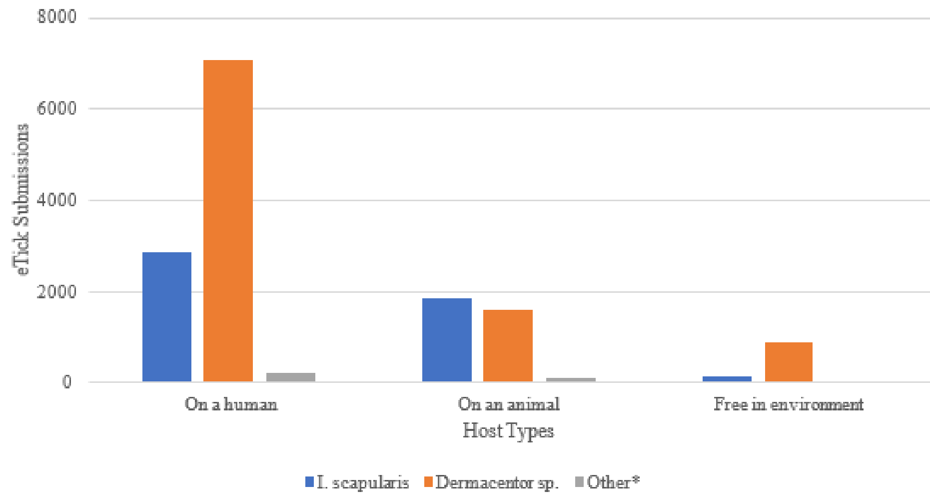

Figure 4: eTick Submissions Categroized by Host Types from 2020 to 2022. eTick submissions categorized by host types from 2020 to 2022, excluding submissions with travel history. *The total number of species submissions *excluding I. scapularis, and Dermacentor sp.*

Figure 5: Monthly Submissions of *I. scapularis* by Life Stage in 2020, 2021, 2022. Monthly submissions of *Ixodes scapularis* categorized by life stage for 2020, 2021, 2022, excluding the travel history.

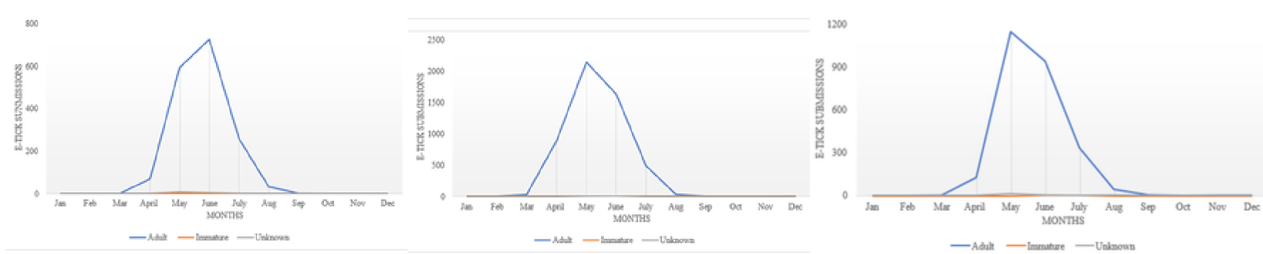

Figure 6: Monthly Submissions of *Dermacentor sp.* by Life Stage in 2020, 2021, and 2022. Monthly submissions of *Dermacentor sp.* categorized by life stage for 2020, 2021, 2022, excluding the travel history.

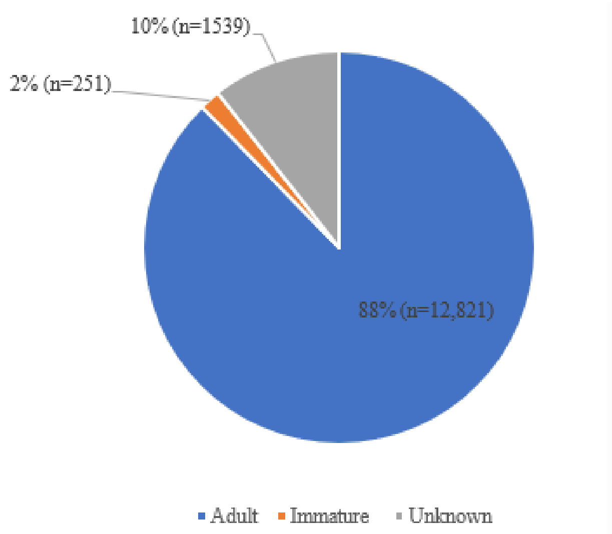

Figure 7: Total eTick Submission Categorized by Life Stage from 2020 to 2022. eTick submissions categorized by life stage from 2020 to 2022, excluding the travel history.

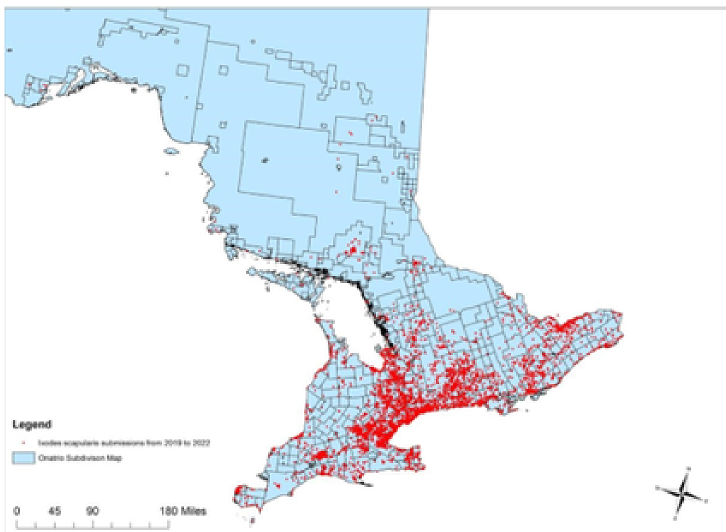

Figure 8: *Ixodes scapularis* Submission (n = 6,305) in Ontario from 2019 - 2022. *Ixodes scapularis* submissions in Ontario from 2019 to 2022 (n = 6,305)

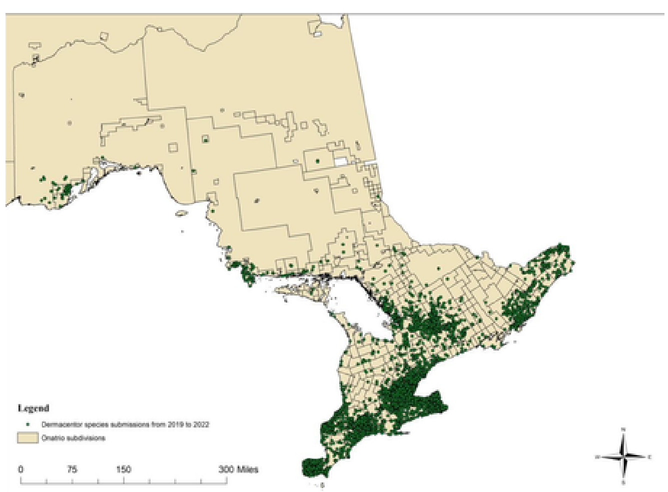

Figure 9: *Dermacentor species* submissions (n = 11,370) in Ontario from 2019 – 2022. *Dermacentor species* submissions in Ontario from 2019 to 2022 (n = 11,370)

Figure 10: : *Ixodes scapularis* Submission (n = 2,440) in Ontario from 2021. Spatiotemporal clusters of I*xodes scapularis* submissions in Ontario in 2021 (n = 2,440).

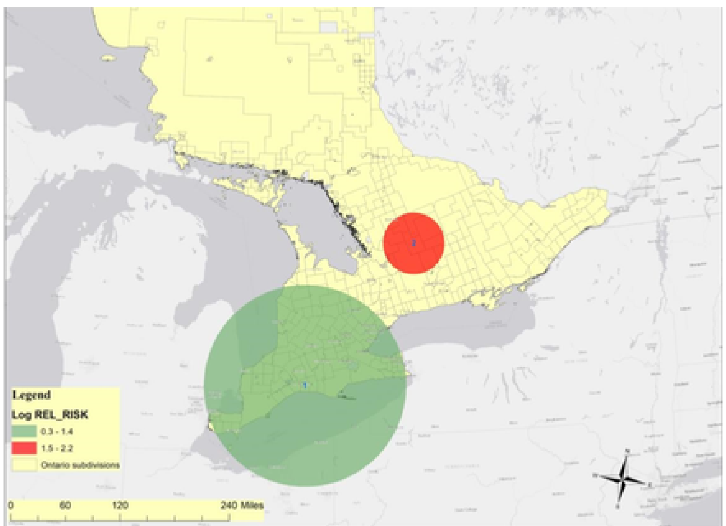

Figure 11: *Dermacentor* species Submissions (n = 5,975) in Ontario in 2021. Spatiotemporal clusters of *Dermacentor species* submissions in Ontario in 2021(n = 5,975).

Species	2020	2021	2022
I. scapularis	1173	2003	1634
Dermacentor sp.	1688	5203	2607
H. leporispalustris	1	0	0
I. cookei	72	92	38
I. marxi	8	11	4
A. americanum	11	19	16
R. sanguineus	4	2	3
A. maculatum	1	5	3
I. muris	3	4	3
H. chordeilis	0	0	3
I. kingi	0	0	0
Other*	100	133	70
Total	2961	7339	4311

Table 1: eTick Submissions 2020 – 2022. eTick Submissions 2020 to 2022, excluding travel history. *The total of species submissions excluding *I. scapularis, and Dermacentor* sp.

Species	On a human	On an animal	Free in environment
I. scapularis	2828	1846	136
Dermacentor sp.	7049	1568	881
H. leporispalustris	0	1	0
I. cookei	145	45	12
I. marxi	18	1	4
A. americanum	28	14	4
R. sanguineus	5	1	3
A. maculatum	6	2	1
I. muris	5	4	1
H. chordeilis	0	3	0
I. kingi	0	0	0
Other*	207	71	25
Total	10084	3485	1042

Table 2: eTick Submission Categorized by Host Types from 2020 – 2022. eTick submissions categorized by host types from 2020 to 2022. * The total of species submissions excluding *I.* 360 *scapularis, and Dermacentor sp.*

CLUSTER	RADIUS (KM)	START_DATE	END_DATE	OBSERVED	EXPECTED	Log_RR	REL_RISK	POPULATION
1	165.5	2021/6/1	2021/11/30	602	13.0	1.8	61.1	303283.8
2	101.7	2021/10/1	2021/11/30	312	4.3	1.9	83.8	302964.0
3	0.0	2021/10/1	2021/11/30	63	1.0	1.8	63.9	296475.3
4	16.6	2021/10/1	2021/11/30	50	1.9	1.4	26.5	118169.3

Table 3: Spatial Temporal Analysis of *Ixodes scapularis* in Ontario from 2021. Spatial Temporal Analysis of *Ixodes scapularis* Explaining the Relative Risk in Ontario from 2021.

CLUSTER	RADIUS (KM)	START DATE	END DATE	OBSERVED	EXPECTED	LOG RR	REL RISK	POPULATION
1	173	2021/4/1	2021/7/31	4656	857	1.3	21	32855.4
2	53	2021/4/1	2021/7/31	468	3	2.2	157	123.7

Table 4: Spatial Temporal Analysis of *Dermacentor species* in Ontario from 2021. Spatial Temporal Analysis of *Dermacentor species* Explaining the Relative Risk in Ontario from 2021.

Discussion

Climate change has driven an increase in tick populations across Ontario. As temperatures warm, species like *Ixodes scapularis*, which spreads Lyme disease, and other species like *Dermacentor variabilis*, which can spread Rocky Mountain spotted fever and tularemia, are increasing their range [2-3]. In our study, a wide variety of tick species have been identified through the eTick platform in the province of Ontario since 2019.

Ixodes scapularis, commonly known as the black-legged tick, is found throughout Central, Southern, and Eastern Ontario. The number of tick submissions tends to increase in May and October, indicating that these regions are at a higher risk of tick bites during peak periods. High-rate clusters of *I. scapularis* have been discovered throughout these regions, consistent with previous studies on the distribution o*f I. scapularis* and Lyme disease. A field sampling conducted by Clow et al. from May to October 2014 in Central, Eastern, and Southern Ontario detected B. burgdorferi-positive ticks, mainly clustered in Eastern Ontario [6].

Another field sampling study conducted between 2014 and 2015 suggested that the Lyme disease-carrying ticks spread across Ontario, especially in Eastern areas, at a rate of 46 km per year [7]. A suitable habitat allows *I. scapularis* populations to continue to expand. Slatculescu et al. conducted an active field sampling from 120 sites across Southern, Central and Eastern Ontario between 2015 and 2018 using niche modelling [8]. The study found that Eastern Ontario and some areas near the Great Lakes are highly suitable for Lyme disease carrying ticks due to factors such as elevation, distance to forests, proportions of agricultural land, and temperature [8].

On the other hand, *Dermacentor sp.* has received higher submissions than *I. scapularis* over the past three years. *Dermacentor sp.* is predominantly found in Southern and Central Ontario, with increased submissions around May, signalling a higher risk of tick bites during this peak period. Our finding is aligned with a study conducted between 2010 and 2018 in Ontario, which revealed that major tick submissions were located in Southern Ontario, including Brant County, Haldimand-Norfolk, Niagara Regional in the Central West region, and Lambton and Windsor-Essex County in the Southwest region [9]. *Dermacentor sp.* typically inhabits warm, low-lying areas with poorly drained soils [9]. Without a doubt, climate factors such as temperature play a crucial role in the distribution of these ticks. A study that used a correlative maximum entropy approach to predict current and future distribution suggested that *Dermacentor sp.* is likely to expand northward into Canada by 2050 due to climate change [10].

Strengths:
One of the key strengths of this research is the utilization of photo submissions as a method for data collection. This allowed us to observe the tick species, gender, and life stage. Another strength is the use of both ArcGIS and SaTScan as advanced retrospective space-time analysis methods. By integrating ArcGIS with the Kulldorff spatial scan technique, the study was able to effectively identify clusters with high submission rates. This led to the visualization of geographic locations, cluster sizes, and localized patterns in tick distribution across regions [11]. The findings from this study provide valuable insights into the spread of tick activity and have significant implications for public health interventions. Specifically, they can contribute to the development of targeted prevention and control strategies for tick-borne diseases, ultimately improving public health outcomes.

Limitations:
The use of photo submissions as data collection could be a potential limitation of this study, due to the fact that not all of the photos are clear. This may lead to mismatches, or to an inability to identify the species, which could ultimately impact the resulting distribution of ticks. Although efforts were made to adjust for population differences in spatial analysis, variations in human and animal population density within census subdivisions can introduce complexities and uncertainties to the findings. This highlights the need for careful interpretation of the results, with consideration of the study areas' demographics.

Another limitation of the study is the lack of information on human and animal behaviours that could impact tick sightings, such as outdoor activities and pet grooming practices. As a result, the interpretation of observed trends in tick distribution may be limited by the absence of behavioural data.

Future suggestion:
In order to effectively combat tick-borne diseases, it is crucial for researchers to combine pathogen surveillance with tick distribution studies. By doing so, they can better understand the risk of tick-borne diseases in high-risk areas. Researchers can identify clusters of high tick density and pathogen prevalence through this integrated approach, allowing for targeted public health interventions. By incorporating data on tick population dynamics, host preferences, and habitat distribution, researchers can also gain insight into the ecological factors contributing to tick-borne disease transmission. Ultimately, this information can help inform public health policies and interventions to reduce the incidence of tick-borne diseases and improve health outcomes for individuals and communities at risk.

Conclusion

Given the importance of *I. scapularis* as a vector of Lyme disease, and the emergence of new tick vector species and tick-borne diseases associated with climate change, it will be essential to monitor trends in tick distribution and diversity to inform public health and future research into the emergence and spread of tick-borne diseases [12].

Competing interests
The authors declare that they have no competing interests.

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