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Switched Tularemia historical foci forecasted by Genetic Algorithm for Rule-Set Production modeling approach in Georgia, based the data from 2017-2022

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Introduction

Tularemia is a zoonotic disease caused by the gram-negative bacterium *Francisella tularensis*, which is broadly spread across the northern hemisphere. It is endemic to Georgia in the eastern and south parts and usually presented in 5 out of 11 regions. Because, the spread of tularemia cases switched towards the middle, through the last decades, the object of the study was to conducted comparison analysis to better understand how the ecological niche modeling (ENM) results reflected to the surveillance data over the coming years.

- Tularemia in Georgia was described for the first time in 1946, while it was first observed in Samtskhe-Javakheti, namely in Akhalkalaki village Kartsakhi in the Soviet border area during the epidemic.

Methodology

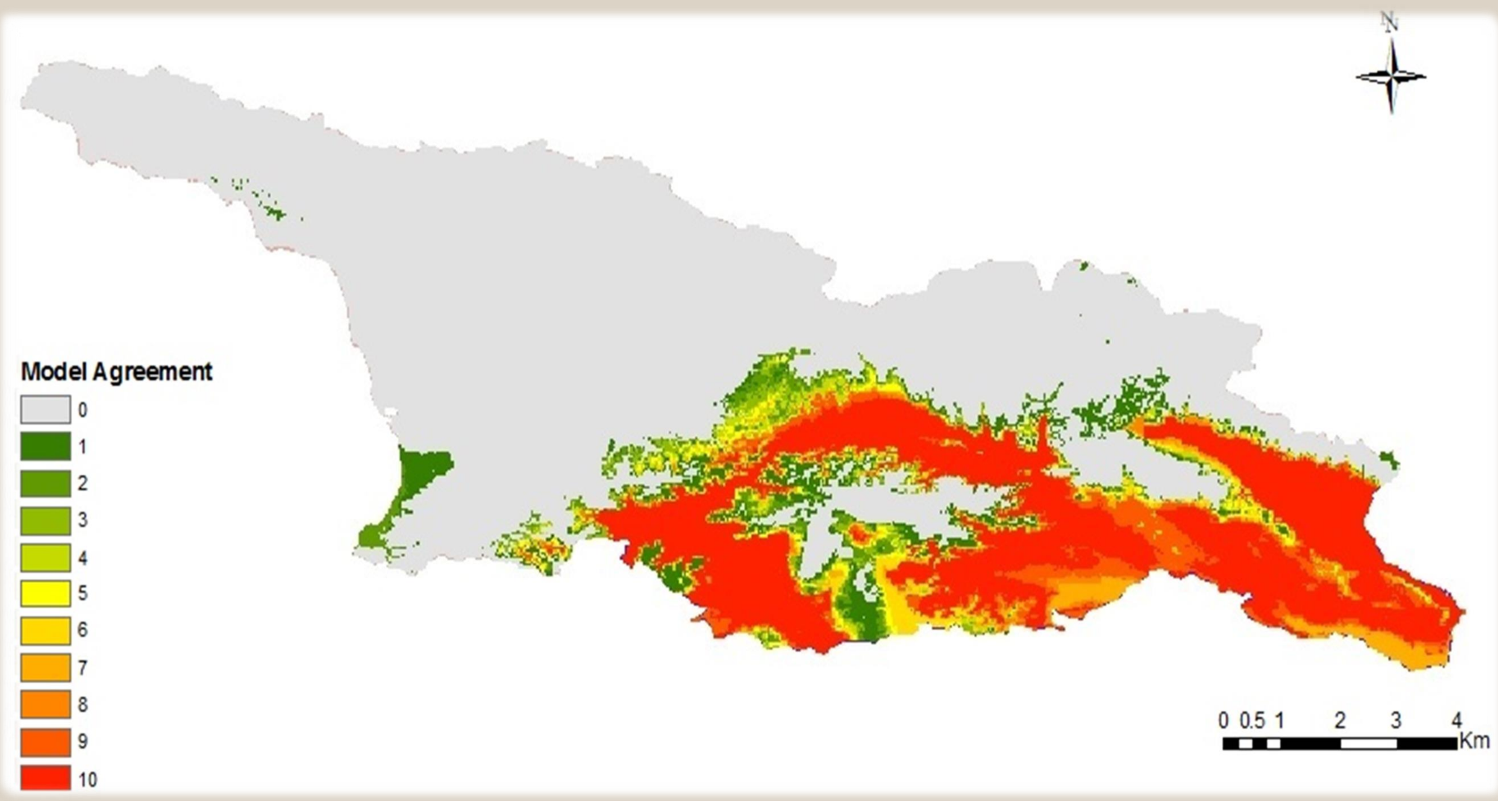
The results of the ENM of Georgia, which was carried out according to the data of 1946-2022 collected within the framework of DTRA funded Atlas project, using the Genetic Algorithm for Rule-Set Production (GARP), were used. To predict high risk areas multiple bioclimatic variables such as: annual mean temperature; annual temperature range; annual precipitation; precipitations of wettest and driest month (Table 1) were used conjunction with the Global Positioning System coordinates of positive tularemia historical cases. These results were compared with 2017-2022 tularemia surveillance data, obtained from the Electronic Integrated Disease Surveillance System of Georgia. Routine surveillance and outbreak data, totally 21 positive cases were used to perform the descriptive analysis.

Table 1. *Environmental/bioclimatic variables used to develop ecological niche models*

Environmental Variables	Name	Source
Annual Mean Temperature (^{O}C)	BIO1	WorldCli
Annual Temperature Range (^{O}C)	BIO7	WorldCli
Annual Precipitation (mm)	BIO12	WorldCli
Precipitation of Wettest Month (mm)	BIO13	WorldCli
Precipitation of Driest Month (mm)	BIO14	WorldCli
Elevation	Elevation	WorldCli

- To perform the analysis, the 2015 forecast results (Map 1) were compared with the 2017-2022 tularemia surveillance data of Georgia obtained from the Electronic Integrated Disease Surveillance System (EIDSS).
- The spatially unique points were randomly divided into a 75% training and 25% testing dataset. The top ten subgroup models from each GARP experiment were exported to ArcGIS and summed to calculate the accuracy metric (AUC) for Francisella tularensis niche modeling.

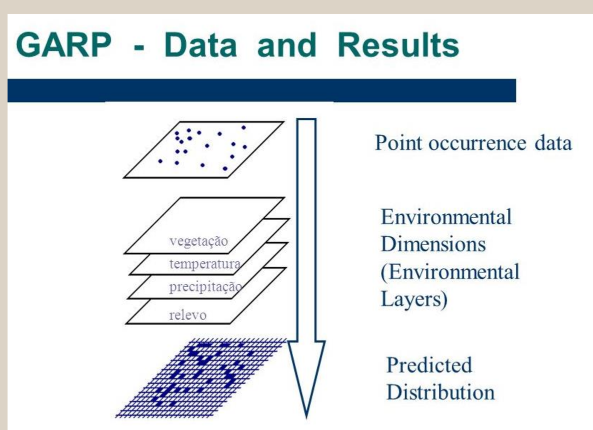
Map 1. *Potential distribution of Francisella tularensis in Georgia, 2015.*



Results

Table 2. *Epidemiological characteristics of positive cases of tularemia, Georgia, 2017-2022.*

Descriptors of cases	n=21
Median age (range)	35(14-65)
Gender	**n(%)**
Male	20(95.2)
Region	**n(%)**
Kakheti	1 (4.8)
Shida Kartli	4 (19.0)
Samtskhe-Javakheti	2 (9.5)
Tbilisi	3 (14.3)
Imereti	11 (52.4)
Year	**n(%)**
2017	13(61.9)
2018	0
2019	2(9.5)
2020	2(9.5)
2021	2(9.5)
2022	2(9.5)
all	21(100)



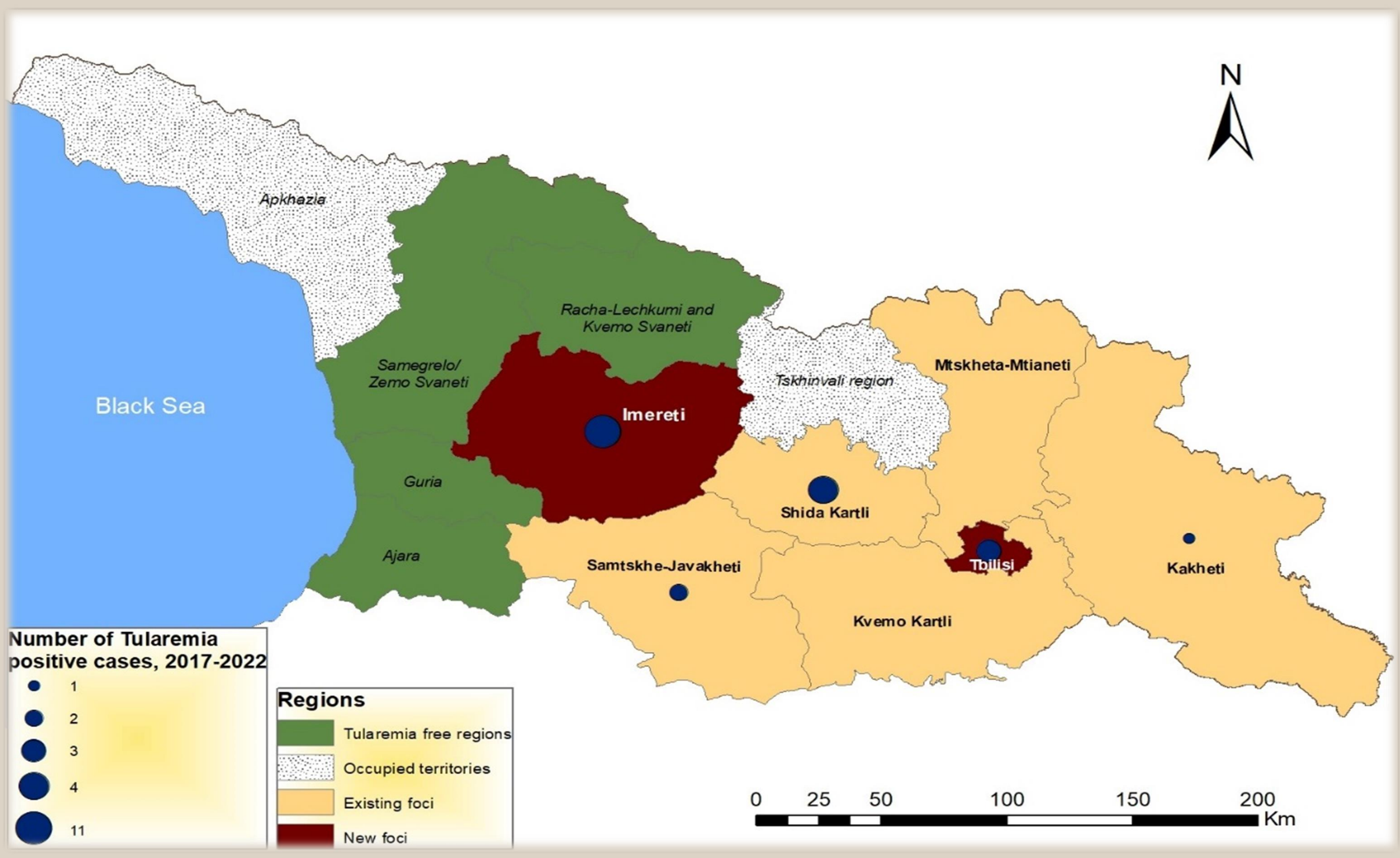
The GARP modeling had previously predicted the existence of new tularemia possible foci in the west of the country and in the capital. During the years 2017-2022, 21 cases of tularemia were identified through the surveillance system of Georgia (Table 2). .

- The male to female ratio: 20:1
- Median of age: 35 years
- Range:14-65

17(81%) cases were revealed from the regions that were predicted by GARP modeling and where historically no case of tularemia have been reported before (Map 2).

- 2(9.5%) new cases found in Tbilisi, capital of Georgia
- 15(71.5%) cases in one of the western regions Imereti
- 13(62%) cases from two outbreaks in the Region, in 2017.

Map 2. *Regional distribution of old and new foci of tularemia, Georgia, 2017-2022.*



Out of the total number of cases in 2017-2022, 13 (62%) cases were recorded during the two outbreaks of tularemia in Georgia during 2017. Out of these, one outbreak with 9 (42.8%) positive cases was detected in the predicted new area (Figure 1)..

Figure 1. *Number and percentage of tularemia positive cases by year, Georgia, 2017-2022.*

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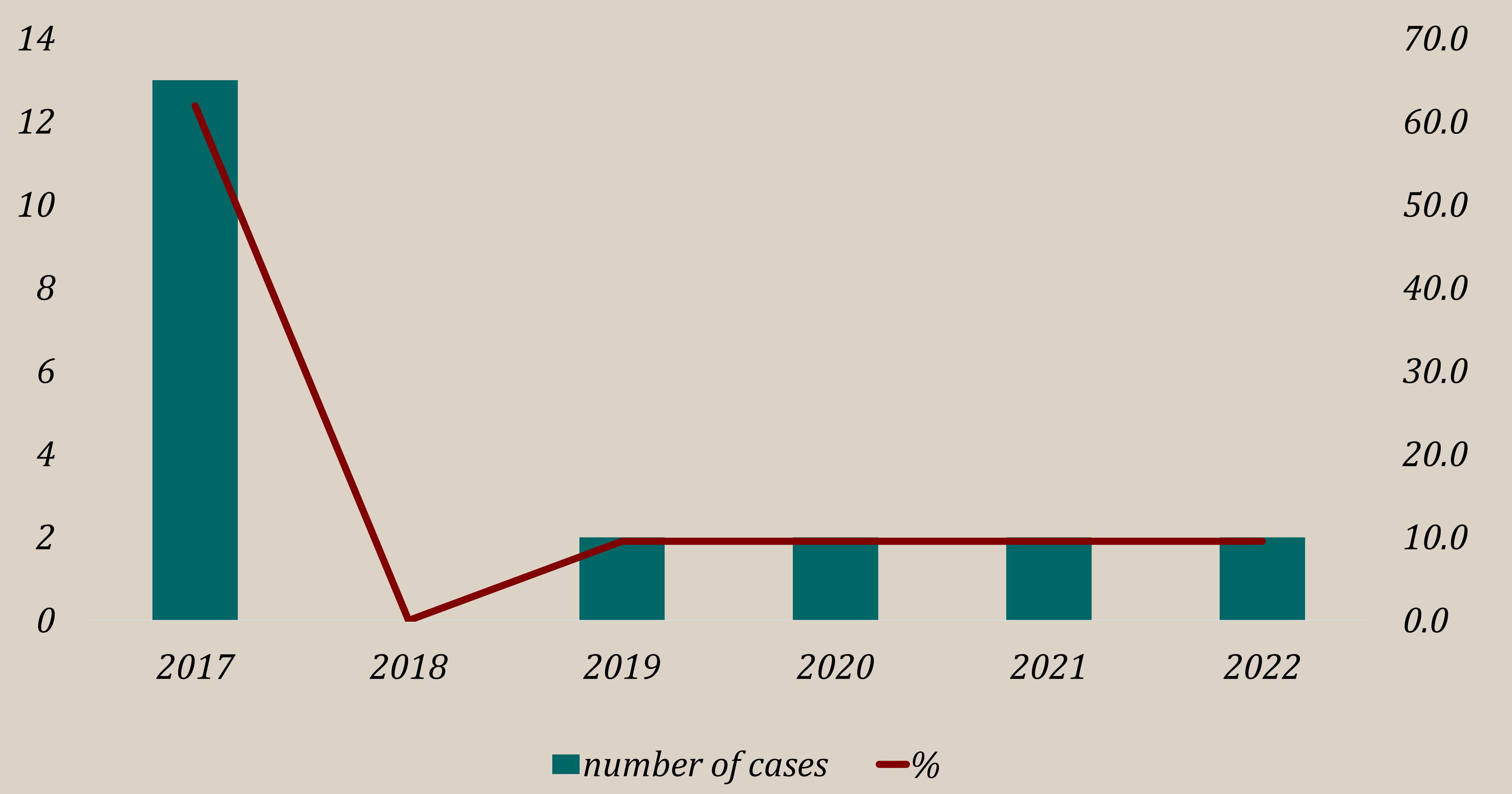

Conclusion

It seems that due to changes in global ecology, species may change their distribution area due to migration. As predicted, and the resulting comparison analysis showed, the formation of a new Tularemia foci occurred. Based on the received we plan to expand environmental sampling to aid accurate tularemia prevention and control in Georgia and conduct additional studies to investigate the reason of emergence of new foci.

- During the years 2017-2022, no cases were recorded from the historical centers of tularemia, namely Mtsketa-Mtianeti and Kvemo Kartli
- When studying environmental samples, 2 new regions should be taken into account, which will contribute to proper prevention and control of tularemia in Georgia.

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