Seminar for the Pragmatick WG3

USING GIS FOR STUDYING TICKS AND TBD: PARAMETERS NEEDED FOR MODELLING AND RISK ASSESSMENT

Where to start from?

2/10/2023

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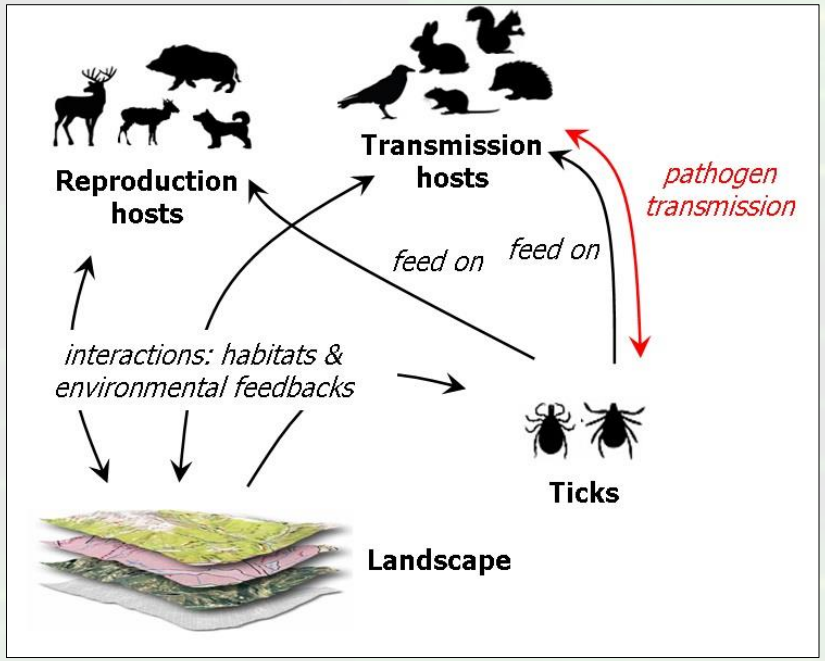
Knowing the spatial distribution of competent vectors helps to understand the risk of TBD

Many countries lack spatial data and longitudinal study on vector distribution and activity, making mapping at a continental scale difficult due to data gaps.

When planning research, it is necessary to collect certain information.

What data is that? Where to start from?



What is GIS - Geographic Information System (GIS) database

GIS is a geographic analysis tool that analyzes differences in multiple layers of spatial data to create new spatial information that is not available by studying the data layers separately.

- tools for entering or drawing spatial objects
- spatial data management system - "smart maps"
- enables: storing, integrating, querying, displaying and analyzing data using data location / spatial information.

CAN BE USED FOR:

- various scientific researches
- Tick distribution map
- Prediction maps, disease control
- Epidemiological research - monitoring of zoonoses
- To create management plans, risk analysis...
- presentation of the biggest pollution, source of disease...

GIS ENABLES:

- Creating a unique database
- the possibility of saving, editing, analyzing, unifying, updating and displaying all collected data in one place that is linked to geographic data (map), creating questionnaires (user-created surveys), displaying results, monitoring...

Old 2D maps vs geocoded GIS maps

There is no so-called "background data"

No correlation with other data

Correlation with other data

incidence of diseases, weather conditions, habitats...

How GIS functions

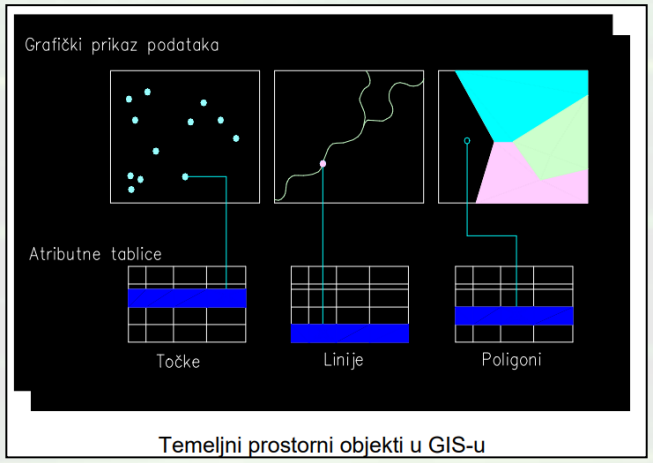
2 geographic data models

Vector data model

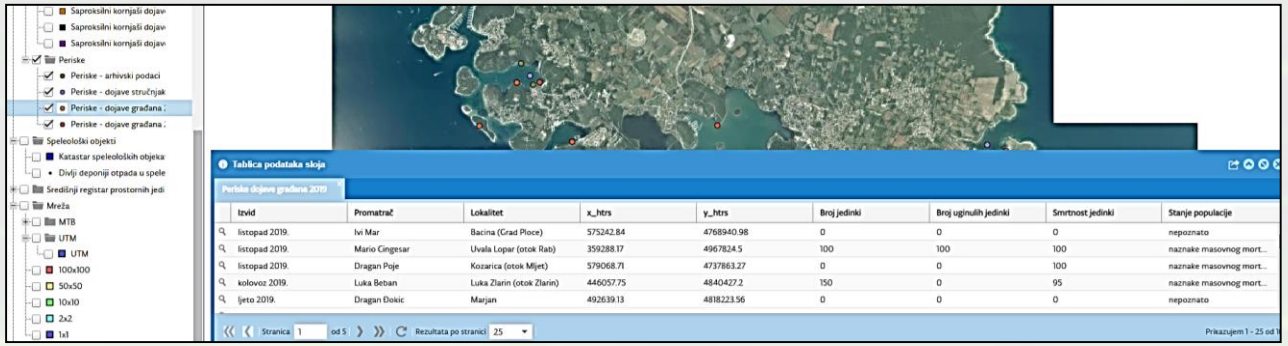
- **point data, lines and polygons** (encrypted and saved as a set composed of x and y coordinates).
- **Point location information** is saved in the form of coordinates (x and y).
- **Linear data** (roads, rivers) are mostly saved as a set of points with associated coordinates.
- **Polygonal data** (territories, lakes, cadastral parcels, etc.) is saved as a closed loop of coordinates, that is, it contains data on all the lines and nodes of which it is composed.
- Vector graphics can be scaled up to a higher **resolution** without losing quality.

Raster data model

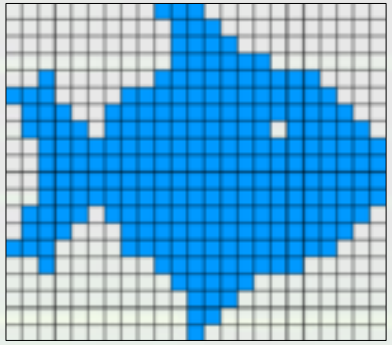
- dataset created by scanning an **existing paper map** with the addition of an image (with coordinates, so it is referenced).
- it is based on the application of image elements, i.e. dots - **pixels**, where the arrangement of pixels in the image matrix defines the appearance of the raster.
- developed to model continuous features, such as soil type, terrain slope, etc.
- A raster image cannot be scaled up to a higher resolution without losing quality.



Each piece of data is one layer



An example of an attribute table

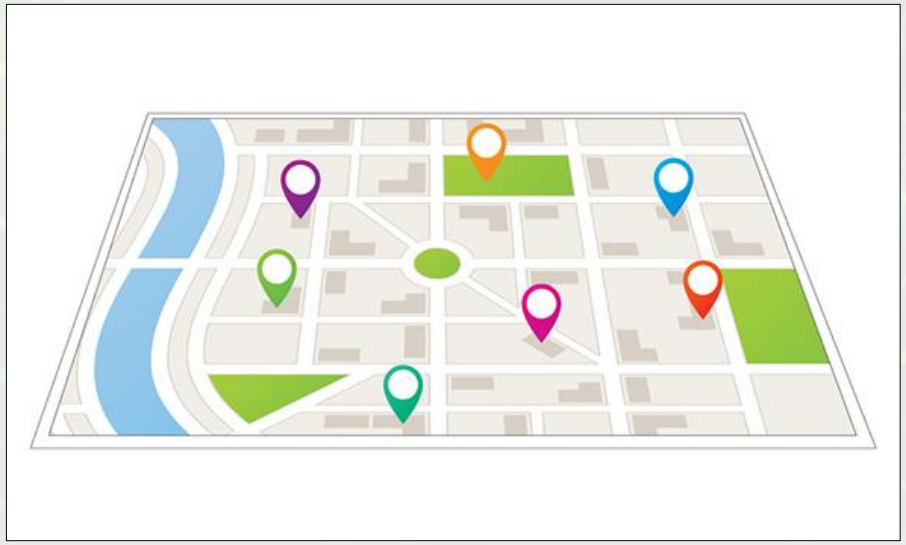


Zoomed view of grid and pixels

2 types of spatial data:

- **spatial data (location)**
- **non-spatial data or descriptive data (attributes)**

Spatial data in GIS is geocoded or georeferenced, it is connected to the coordinate system on the map.

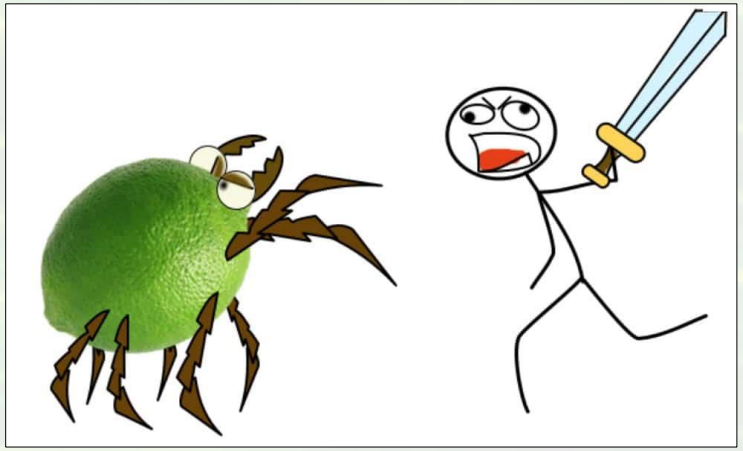


Collection of spatial data

Database – a set of data in which geographic or spatial data are stored.

European Center for Disease Prevention and Control (ECDC):

- vector distribution mapping projects in Europe to enable a continental risk assessment of VBD
- gave an overview of tick control practices
- mapped a number of priority vector tick species.



Tick surveillance methodology

- Changeable
- in the north and west of Europe - citizen scientific methods
- Portugal and eastern countries - more intensive monitoring of vegetation and animals
- It is necessary to enter data from some major countries
- **Tick surveillance is widespread, but surveillance efforts are not the best.**

European Center for Disease Prevention and Control (ECDC)

https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2023.28.26.2200666

- (2008 – 2009) **Tiger Maps project** - mapping of vector distribution in Europe started for continental VBD risk assessment.
- (2008) **VBORNE project** - review of tick, mosquito, sand fly and rodent vector control practices.
- (2010 – 2013) **VBORNET project** - protocol standardization and mapping of a number of priority vector tick species identified by expert consultation in the Nomenclature of Territorial Units for Statistical Level 3 (NUTS3) using data from literature searches and data provided by a network of volunteer entomologists.

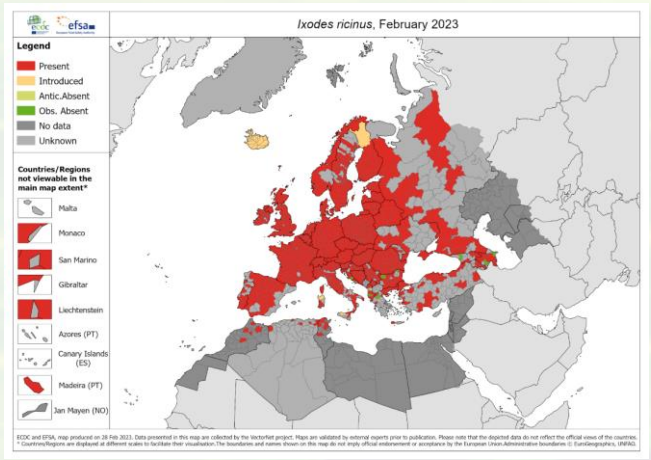
Repositories containing standardized data

- **VectorNet** - VectorNet is a project of ECDC and the European Food Safety Agency (EFSA) that aims to contribute to improving preparedness and response to vector-borne diseases, following the "One Health" approach.
- **VectorBase** (https://vectorbase.org/vectorbase/app/)
- ENHANCEd Infectious Diseases Database (**EID2**) with a focus on pathogens and vectors
- Global Biodiversity Information Facility (**GBIF**)
- **citizen science initiatives:** Mosquito Alert, Tekenradar, UK Health Safety Agency Tick Surveillance Scheme…

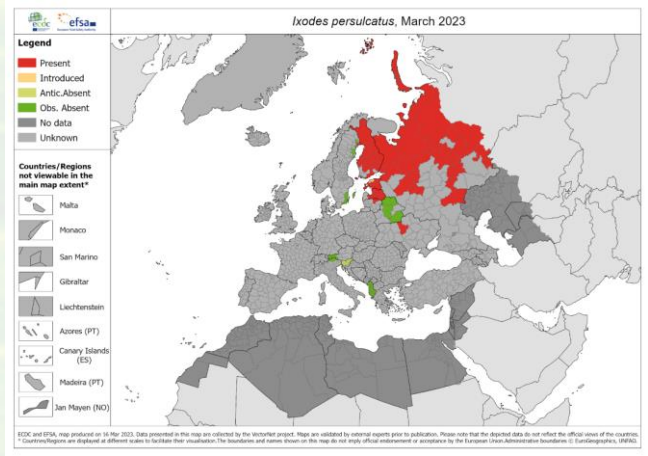
Although rich in data, they are not yet comparable to standardized databases because the sampling effort is not yet sufficiently defined.

Mapped species distribution categories within each polygon - distribution status for native species **VectorNet -** display of the current vector distribution (more recent data, comparing data after 1980) Areas outside the scope of VectorNet's geographic scope are color coded as "Out of Scope".	
present / established	species have been confirmed or assumed by expert opinion to have been determined
entered	recorded as present, but according to the expertise, it is not considered established
expected absence	concluded as absent based on expert opinion or known environmental limitations
absent / observed absent	are recorded as absent
no data	data not available
unknown	there is no information about data availability or the data is unreliable
introduced (first record of an invasive species) present / absent	Vectors may not be everywhere within the polygon as they may contain inappropriate areas. Ticks are likely to be transmitted by the host to certain locations, but they are not recorded throughout the year. The record reverts to "absent" after 5 years if searches have found no further presence records.
The spatial units on which the vector distribution status is determined are based on	NUTS3 layers of the global administrative unit of the second level (GAUL 2) where the NUTS system does not reach.

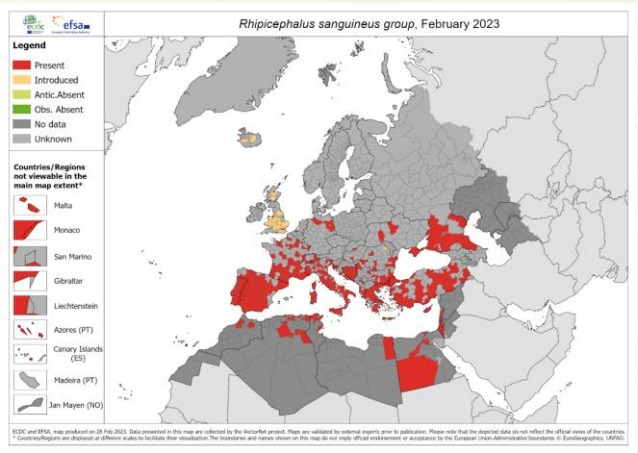
Current known distribution of tick species



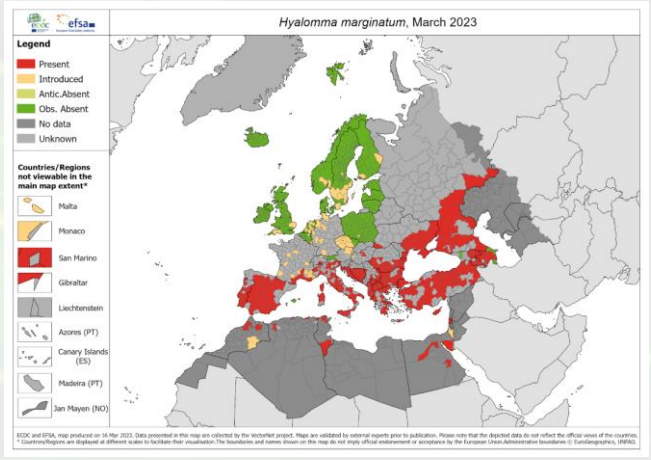
*https://www.ecdc.europa.eu/en/publications-data/**ixodes-ricinus**-current-known-distribution-february-2023*



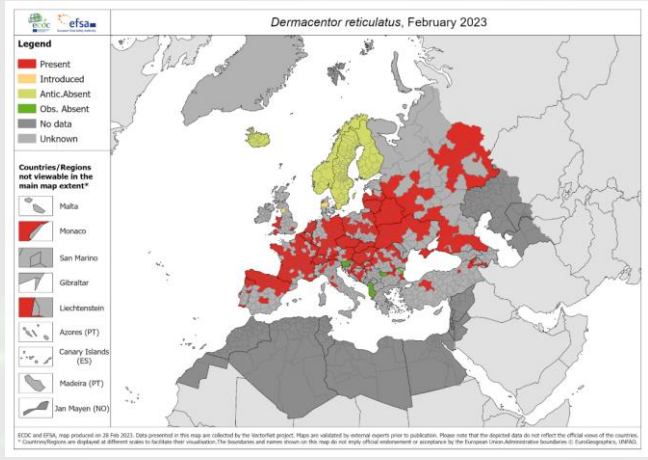
*https://www.ecdc.europa.eu/en/publications-data/**ixodes-persulcatus**-current-known-distribution-march-2023*



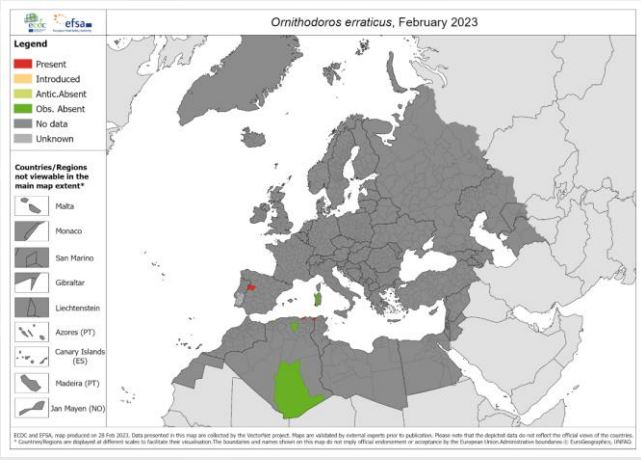
*https://www.ecdc.europa.eu/en/publications-data/**rhipicephalus-sanguineus**-current-known-distribution-february-2023*



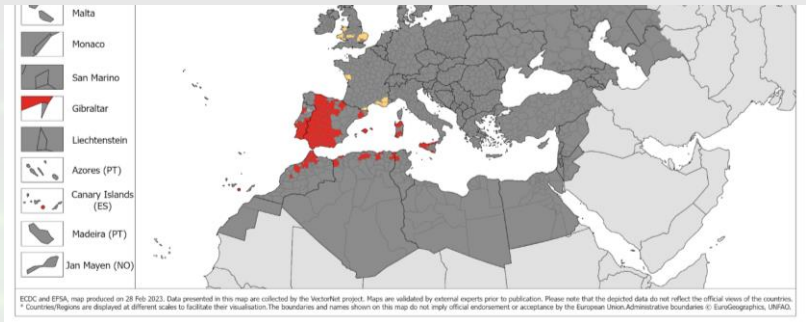
*www.ecdc.europa.eu/en/publications-data/**hyalomma-marginatum**-current-known-distribution-march-2023*



*https://www.ecdc.europa.eu/en/publications-data/**dermacentor-reticulatus**-current-known-distribution-february-2023*

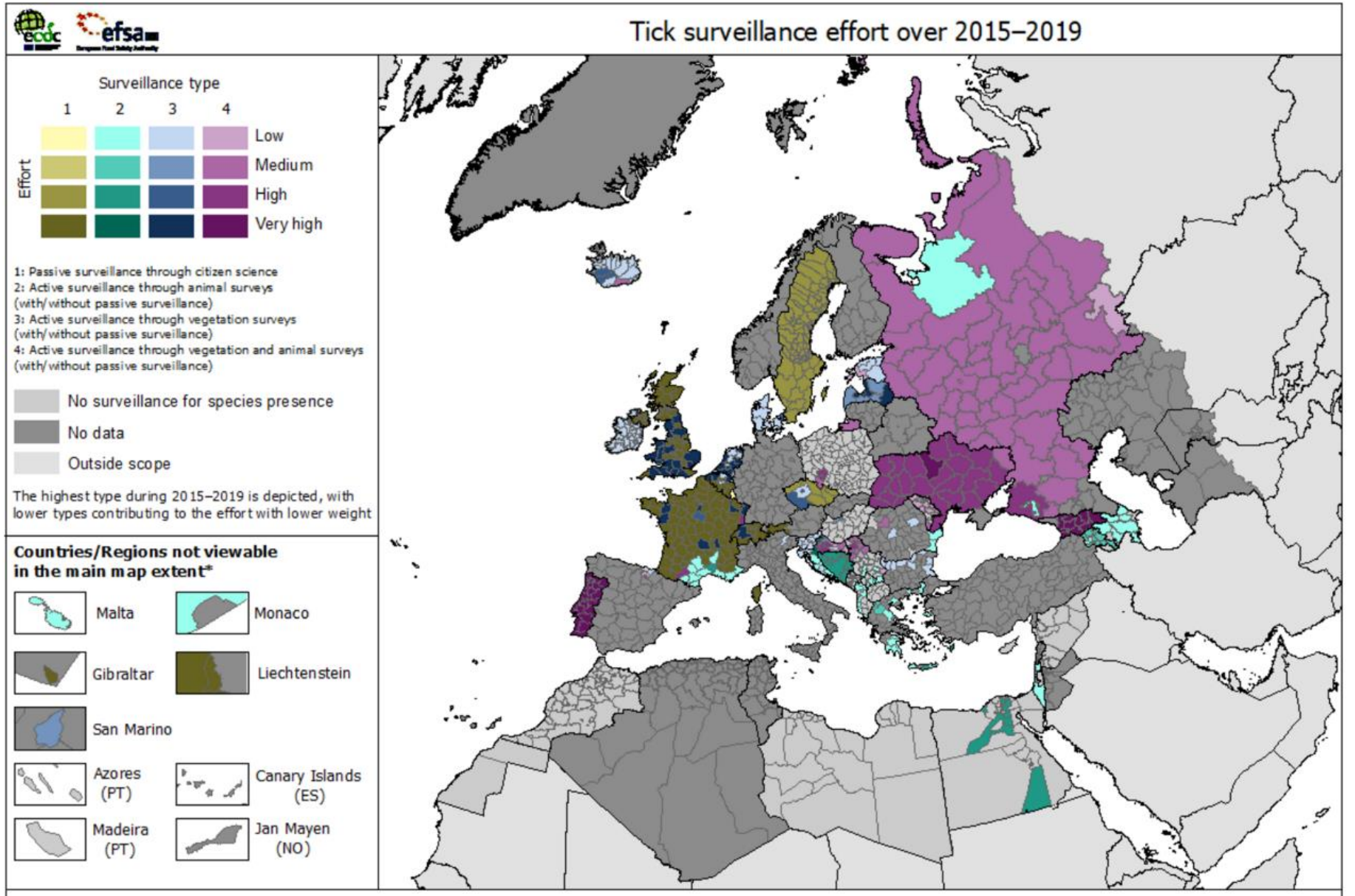


*https://www.ecdc.europa.eu/en/publications-data/**ornithodorus-erraticus**-current-known-distribution-march-2021*

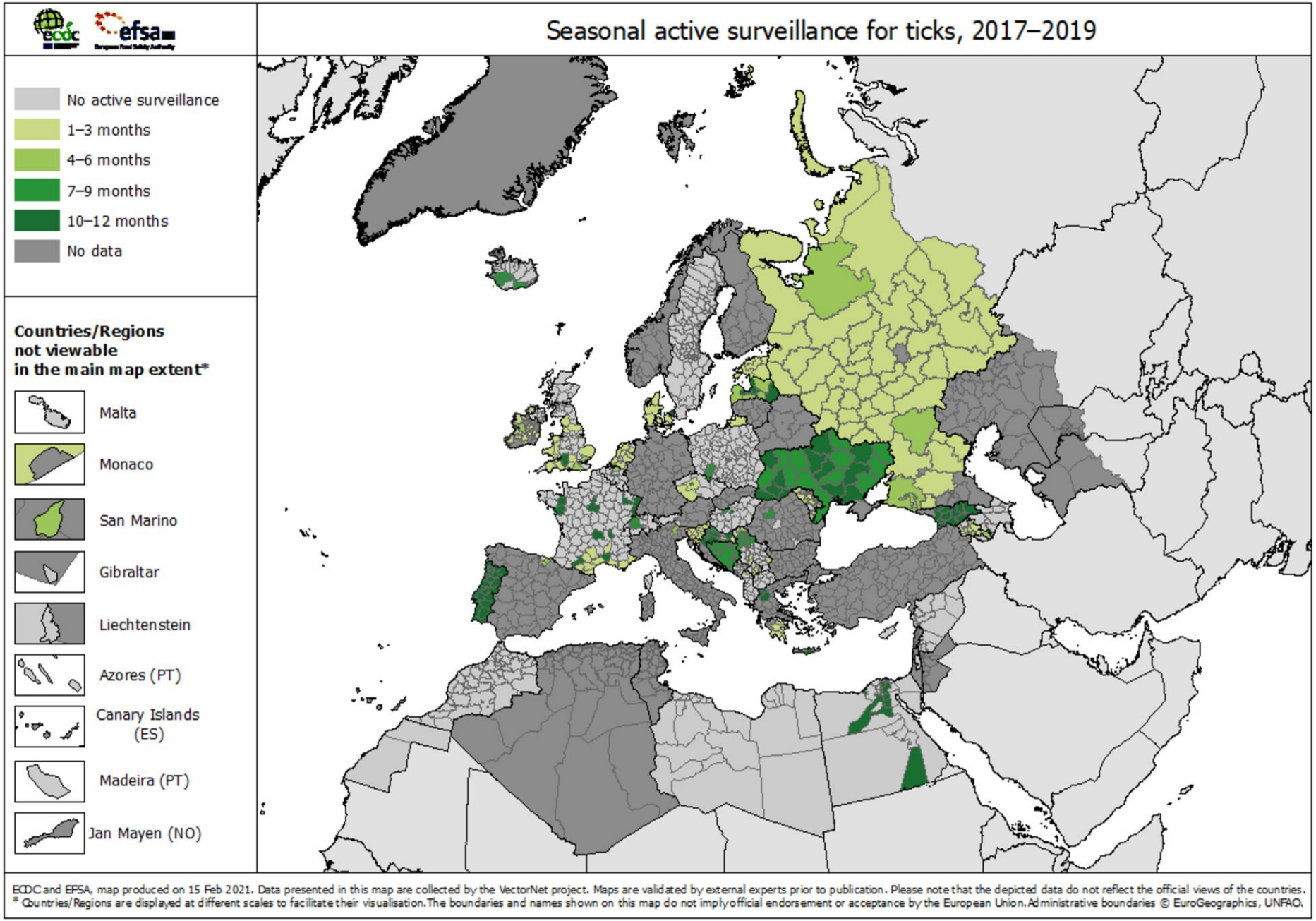


*https://www.ecdc.europa.eu/en/publications-data/**hyalomma-lusitanicum**-current-known-distribution-february-2023*

Tick surveillance effort



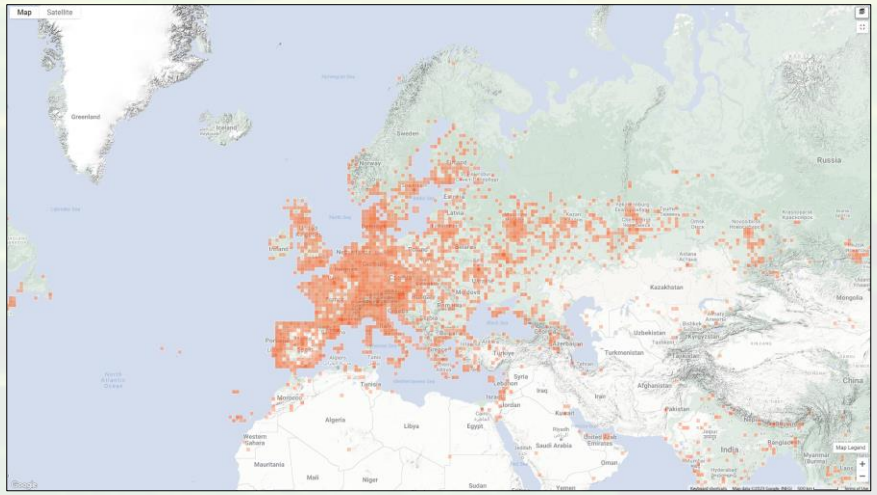
https://www.ecdc.europa.eu/en/publications-data/tick-surveillance-effort-2015-2019



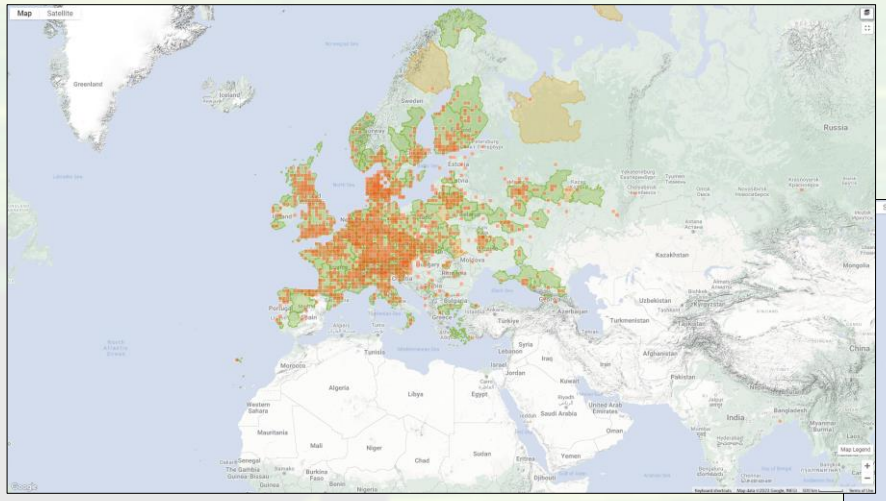
https://www.ecdc.europa.eu/en/publications-data/tick-surveillance-effort-2017-2019

iNaturalist

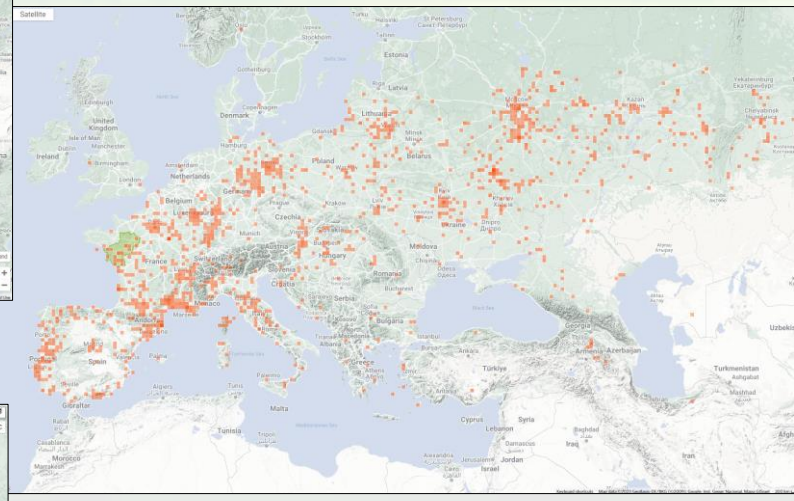
US non-governmental social network of naturalists, citizen scientists and biologists who map and share observations of biodiversity around the world



Distribution map of ticks from the family **Ixodidae**, iNaturalist
https://www.inaturalist.org/taxa/51673-Ixodidae



Distribution map of tick species ***Ixodes ricinus***, iNaturalist
https://www.inaturalist.org/taxa/51674-Ixodes



Distribution map of ticks from the genus **Dermacentor**, iNaturalist
https://www.inaturalist.org/taxa/52156-Dermacentor

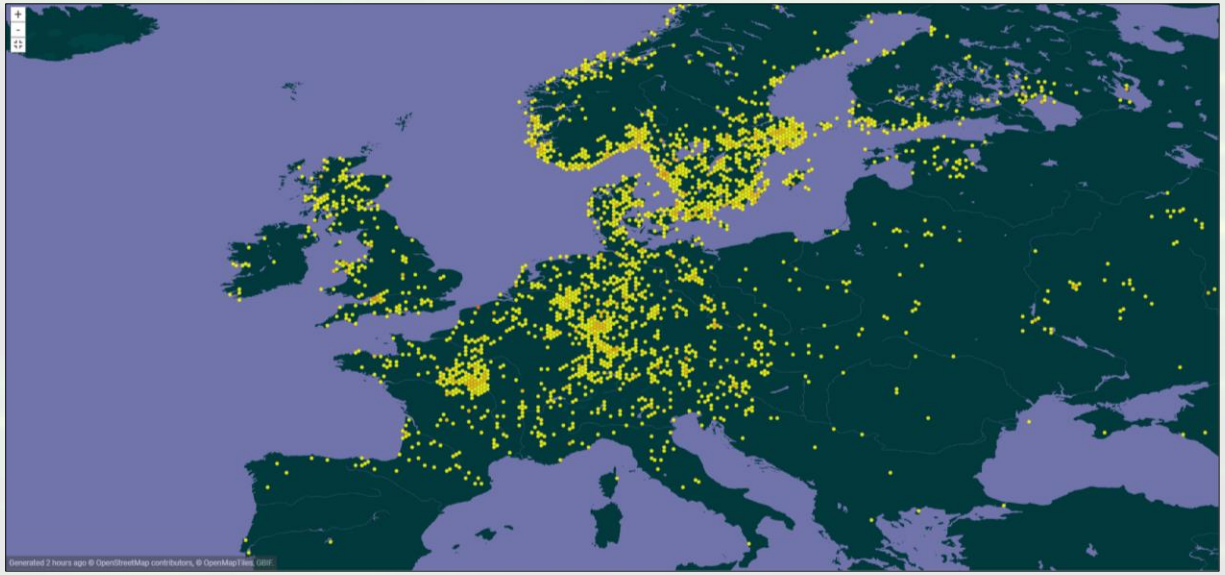
Distribution map of ticks from the genus **Rhipicephalus**, iNaturalist
https://www.inaturalist.org/taxa/172349-Rhipicephalus

Distribution map of tick species ***Rhipicephalus sanguineus***, iNaturalist
https://www.inaturalist.org/taxa/229905-Rhipicephalus-sanguineus

GBIF - Global Biodiversity Information Facility

an international organization that makes scientific data on biodiversity available online using web services

GBIF, species distribution map ***Rhipicephalus sanguineus***
https://www.gbif.org/species/2183597



GBIF, distribution map ***Ixodes ricinus***
https://www.gbif.org/species/2182588

Thanks to their close connections with the ecosystem, ticks are ideal for monitoring using GIS and RS applications.

GIS and remote sensing (RS) from aircraft and satellites are a powerful toolkit for disease surveillance, enabling the prediction of potential disease outbreaks and targeted intervention programs.

Habitats with ticks can be accurately identified topographically (unlike, for example, mosquitoes that can travel long distances from their breeding sites). These features enable great precision in spatial analyzes of the distribution of ticks and TBDs, and in the creation of prognostic maps.

MODELLING

Any model of the real world is a simplification of reality because it only includes selected data relevant to the model.

The way we choose to display and analyze information depends on the application of real-world object models.

Spatial data: to describe our world must include answers to key questions: What? Where? When?

GIS considers the relationship between landscape and health. Properties of objects (line, polygon, point) are actually models of real phenomena in the

Inputs for modeling: GIS contains tools for spatial modeling and the occurrence of, for example, ticks or TBD in space and time.

CREATING A RISK ASSESSMENT

Risk assessment for infections

Risk assessment is a procedure that determines the level of danger, harm and effort in terms of disease occurrence, spread of vectors, vector hosts, etc...

Basic risk factors for infection

- Country
- Location
- Time of year
- Duration of exposure to the tick (The TBE virus can be immediately transmitted to humans with a single tick bite.)
- Activity (outdoor activity can put you at risk of coming into contact with ticks; for example, if you take part in activities in grassy areas where ticks are commonly found

Information to a healthcare professional, pharmacist, doctor or nurse, who can provide you with advice on whether you might be at risk of TBE infection and what you can do …

Collection of spatial data

The most important component of GIS is data sources and their availability and accuracy.

1. **primary** collection of geographic data (remote surveys – satellite images, aerial photographs, lidar images; field recording),
2. **secondary** collection of geographic data (scanning of existing maps/plans),
3. **external sources** (data transfer),
4. collection of **attribute data** (e.g. type of tick, stages of development or sex, description of location, habitat...),
5. collection of **data shared by citizens** (e.g. Google Maps),
6. data collection **through project management** (various collaborations and the like).

What affects the occurrence and density of ticks

- **Klimatske promjene** utječu na rasprostranjenost različitih vrsta krpelja i njihovih domaćina i time mijenjaju učestalost TBD koje prenose krpelji i rizik od zoonoza.
- **Mikroklima** može utjecati i na razvoj krpelja i na prevalenciju patogena → važno za predviđanje rizika od zoonoza.
- Odnosi između krpelja i onih njihovih domaćina koji su super-širitelji patogena su se tijekom evolucije razvili na način da im se što više preklapanju staništa.
- **Biotički i abiotički čimbenici.**

When collecting ticks in the field, it is necessary to monitor

Abiotic factors:

time parameters; T (8 and 24 °C), humidity (80%) - measured 30 cm above the ground
cloud cover (sunny, partly cloudy, cloudy)
wind speed (calm, slightly windy, windy, or numerically expressed)
Date, time of collection, coordinates of collection....

Biotic factors:

Ecology of ticks (unimodal/bimodal, nidocolic/non-iconic)
habitat type (forest or meadow), habitat structure
host reservoir (+presence of tick-borne pathogens), changes in tick microbiota dynamics
human activities...
Abundance of roe deer, red deer, mountain hare and hare (+ correlation with incidence of CME in humans).

Understanding how variations in microclimatic conditions affect the prevalence of pathogens carried by searcher ticks is important for predicting zoonotic risks under the influence of climate change.

Important information in modeling and creating an assessment of the risk transmitted by ticks

- Interviewing **local residents** about their exposure to ticks, knowledge and perceptions about ticks
- Interviewing **a doctor**: the presence of disease in an area
- **Molecular analyzes** of pathogen detection
- Data on ticks from **previous research**, collections, web, microclimatic measurements, pedological and sociological research of plants in selected places, Classification of plant communities at the level of sub-association...
- Distribution estimation **using GIS**.

Tick vector competence in relation to pathogen transmission in Europe

Table 3: Anaplasmoses in the EU and in the Mediterranean basin transmitted by hard ticks

Anaplasma spp	Disease	Host range	Tick involved (in EU and in the Mediterranean basin)
A. phagocytophilum	Tick borne fever	sheep	*Ixodes ricinus, Ha. punctata, I. persulcatus, I. trianguliceps, Rh sanguineus*
	Pasture fever	cattle, wild ruminants	
	Human granulocytic anaplasmosis	human	
	Equine granulocytic anaplasmosis	horse, lama, rodents	
	Canine granulocytic anaplasmosis	dogs	*Ixodes ricinus, Ha. punctata, I. persulcatus, I. trianguliceps, Rh sanguineus*
A. marginale	Bovine anaplasmosis	ruminants	*I. ricinus, I. persulcatus, Rh. sanguineus, Rh. bursa, Rh. annulatus*
A. centrale	Bovine anaplasmosis	cattle	*I. ricinus, I. persulcatus, Rh. sanguineus, Rh. bursa, Rh. annulatus*
A. bovis	Bovine mononuclear or agranulocytic anaplasmosis	cattle, small mammals	*Hy. excavatum, Rh. sanguineus, Rh. turanicus*
A. ovis	Ovine anaplasmosis	goat, sheep, clattle	*Rh. bursa*
A. platys	Canine infectious cyclic trombocytopenia	dog	*Rh. sanguineus, Rh. turanicus*

A: Anaplasma; I: Ixodes; Rh: Rhipicephalus; Ha: Haemaphysalis; Hy: Hyalomma.

Table 4: Rickettsioses in the EU and in the Mediterranean basin.

Rickettsia spp	Disease	Host range	Tick involved
R. conorii conorii	Mediterranean spotted fever (MSF)	dog, human, rabbit, rodents	*Rh. sanguineus, I. ricinus, I. hexagonus, D. reticulatus, D. marginatus*
R. c. israeliensis	Israelian Spotted fever		*Rh. sanguineus*
R. sibirica sibirica	Siberian tick typhus		*D. nuttallii, D. marginatus, D. salivarum. Ha. concinna*
R. s. mongolitimonae	Lymphadenopathy[1]		*Hyalomma spp.*
R. s. caspica	Astrakhan fever	human, dog, rabbit	*Rh. sanguineus, Rh. pumilio*
R. slovaca			*D. marginatus, D. reticulatus*
R. massiliae	Spotted fever		*Rh. sanguineus, Rh. turanicus, Rh mushamae, Rh. lunulatus*
R. aeschlimannii			*Hy. marginatum, Hy. rufipes, Hy. aegyptium, I. ricinus, Ha. punctata, Rh. bursa, Rh. sanguineus, Rh. turanicus*
R. helvetica	(perimyocarditis, meningitis)[1]	human	*I. ricinus*

R: Rickettsia; E: Ehrlichia; Rh: Rhipicephalus; I: Ixodes; Hy: Hyalomma; Ha: Haemaphysalis; Am: Amblyomma

[1] No official disease name has been identified however it is considered as part of spotted fever

BASIC PARAMETERS NEEDED FOR MODELING, SURVEILLANCE SYSTEM AND RISK ASSESSMENT

… and weights for tick control efforts

Basic information

Date
Collection time

Collection method	
0	flagging
1	from a man
2	wild animal (Which?)
3	domestic animal (Which?)
4	pet (Which one?)
…	…

Collector
Doctor
veterinarian
authorized person
citizen…

Description of the weather
sunny
cloudy
partly cloudy
rain

Temperature data
collected directly in the field (near the ground)
daily, monthly indexes, annual sum T
T analysis software (e.g. TableCurve contains more than 3600 built-in equations and automatically sorts and plots custom equations according to selected criteria)

Environmental conditions	
Vegetation period	
Beginning of vegetation	with the first period of the year when the daily (24-hour) average temperature is ≥ 5.0 °C, if this period is not followed by an equally long or longer continuous period with an average daily temperature < 5.0 °C.
End of vegetation	is calculated accordingly, i.e. the last day of vegetation is the day before the first 24-hour period with an average temperature < 5.0 °C. Thus, the duration of the growing season is, in general, the number of days from the first day to the last day when the mean daily temperature is ≥ 5.0 °C.

Types of vegetation (favorite habitats of the species)	
0	open habitats / agricultural areas
1	mixed and deciduous forests
2	Luzulo-Fagetum milietosum - moist habitat (with well-developed plant and shrub layers, medium to high soil capacity for water as well as moderately nutritious and moderately acidic soil types)
3	SeslerioFestucion pallescentis
4	Molinio-Arrhenatheretea
…	plant communities with unknown tick abundance
	urban parks / gardens...

Information about ticks

A type of tick
Ixodes ricinus
Ixodes frontalis
Ixodes gibbosus
…

Stage of development / gender
female
male
nymph
larva

Knowledge of the ecology of the species at the regional level			
patterns of tick activity / seasonality	**knowing the optimal conditions for the species e.g. *I. ricinus***	**Activity patterns**	**Activity of larvae**
bimodal (Mediterranean)	T: For example, ↑T (24 °C) and ↑ relative humidity (97 %) positively affect tick development compared to lower temperatures (15 °C) and lower relative humidity (75 %).	eg temperate areas with a dominant peak in spring and a smaller peak in autumn, winter – hibernation	time of year
unimodal (Portugal, Eastern Europe)	Data required for risk assessment: While air T has a large effect on nymphs and larvae, soil T is important for adult ticks. The temperature optimum for adults is determined at around 19-23 °C for air temperature and around 13-15 °C for soil temperature.	The activity of nymphs and larvae is higher in forest habitats than in meadows and they are considered the key movers.	type of habitat

Population density no. ticks/100m2	
0	very low number of ticks
1-2	low number of ticks
3-10	mean number of ticks
11-40	high number of ticks
41-50	very high number of ticks
…	…

Feeding patterns
forests with a dense layer of shrubs, young trees and thickets, while dry pine forests are usually unsuitable as a tick habitat
Monotropic ticks - immature and adult ticks feed on the same type of host, eg ruminants.

Habitat
public green space
barn and surroundings
abandoned agricultural land
ecotone…
lawn
garden
maqui
wood

Microlocation
e.g. for *I. ricnus* -forests with a dense layer of shrubs, young trees and thickets, while dry pine forests are usually unsuitable as a tick habitat
- Endophilic (nidiculous – nest, lair...) and exophilic (live outdoors): waiting for a host on vegetation, transmitting diseases over long distances, ticks that actively seek a host (Hyalomma) that actively and quickly run towards and at the host.

Other relevant data

Maps of supervision and distribution of administrative units
agreement with distribution data and recorded surveillance or agreement with
discrepancy when data is present but surveillance is not reported
discrepancy where surveillance is reported but distribution data are incomplete

Data analysis techniques
Gap analysis techniques - used to delineate suitable areas at a larger level
Habitat suitability models generate local-scale information that can be useful for planning and conducting research

Data collection sources
individual researchers
published literature (along with following protocols for individual sampling methodologies for each group)
national and regional surveillance databases
the use of standardized field sampling designed to refine distributions and fill gaps
historical data

	Categories of surveillance
1	passive surveillance through citizen science
2	active monitoring through animal research (with/without passive monitoring)
3	active monitoring through vegetation research (with/without passive monitoring)
4	active monitoring through research of vegetation and animals (with/without passive monitoring)

Risk of exposure to tick bites and activities in tick habitat
socioeconomic indicators of society
population (density, composition...)
education
urban / non-urban environment
type of settlement: building, family houses...
city park, forest, garden, nature reserve...
description of people's stay in their free time
type of settlement: building, family houses, tourist - sports zone, student settlement, economic zone - ...
high-risk occupations (animal producers, vet...)
In GIS-based studies, changes in environmental factors can be easily analyzed to predict I. ricinus density throughout the nature reserve, which can be used to inform tourists about hot spots with high tick density.

Risk assessment for TBD infections on the European level
Relevant parameters for comparison

OVERVIEW OF SPECIES VECTOR/DISEASE SYSTEM, AND PRIORITY MITIGATION STRATEGY OBJECTIVES	
Tick control	Is there control, to what extent, under whose supervision?
Legislation	Mandatory / not mandatory measures
Monitoring	Does it exist or not, is it implemented sporadically (through projects etc.) or systematically, at what level is the affected location, region, country and in what way?
Public education	Occasional, done by municipalities, Institutes of public health, municipalities…
	Preapredness plan for disease control (in case of VBD), control: nuisanse, diseases, spread of vectors
Is the report of illnes mandatory	yes / no
proven human cases	Boreliosis, KME...
Information sources	National monitoring, scientific works, maps, carries out morphological and molecular proof of the mentioned parasites in animals and humans

DATA REQUIRED TO PROVIDE A VECTOR RISK ASSESSMENT
Do we have enough data to assess the risk?
Which pathogens are transmitted by which tick in the region?
Previous cases of disease (human and animal infections)
Prevalence
Has the risk of exposure been measured?
Difference in risk in rural/urban/suburban areas
Are there controls?

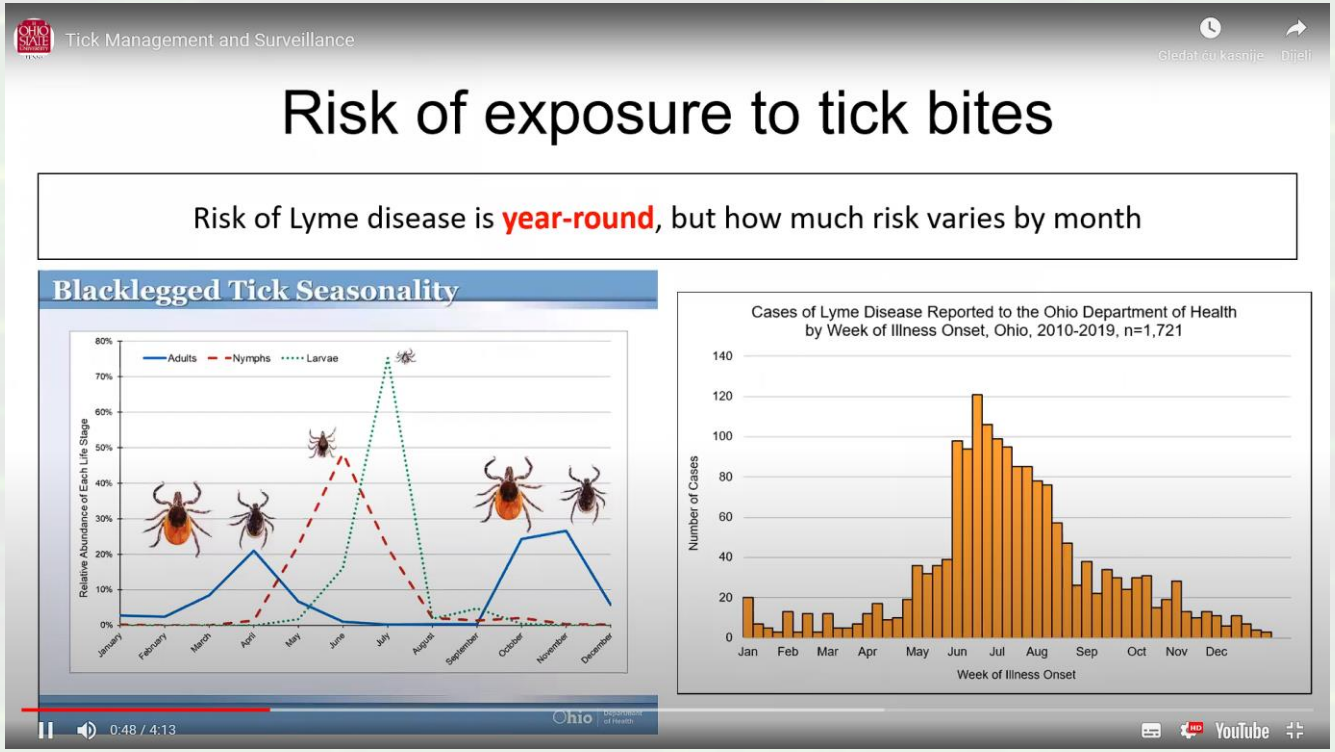
Overview of existing vector data for ticks
Which vector
Local transmission?
Where?
When?
…

OVERVIEW OF DATA AND INFORMATION RESOURCES
Regionally oriented research work + other research groups in countries
Evolutionary Ecology Group – EVECO, Pragmatick …
publicly available maps: ECDC, I naturalist, GBIF
scientific papers....

Overview of existing vector data for ticks
Which vector
Local transmission?
Where?
When?
…

OVERVIEW OF EXISTING TICK VECTOR DATA	
Present in the country	established / basis for / not present
Where it is present	(urban / busy / rural) - urban/suburban
Number and distribution	Where? How much? ...
Species control	there are controls, targeted, sporadic / non-existent
Vector competence	
Local transmission?	yes / no / probably
Frequency	
Human cases	
Cases in animals	
Risk of exposure	
Difference in rural/urban/suburban	
Public awareness	education, animal owners, preventive measures, hunters, other interest groups
Preventive?	For example Availability of vaccines
Protection measures (people, animals)	Humans: personal protective measures (repellents), vaccination... (E.g. For dogs: veterinarians recommend the use of preventive drugs, mechanical, chemical or medical methods can be applied)
Data on animal infections	whether there is a unified database at the state level, localized data, whether doctors and veterinarians collect data on TBD.

Suggestions for reducing the risk of transmission
Education, animal husbandry, hunters, doctors, especially in rural areas
Knowledge in rural areas is low (dogs are a reservoir)
Preventive measure should be done by citizens as a mandatory measure
What are the restrictions, what are the regulations…



Data on the number of tick hosts and their predators

Annual hunting statistics
location
knowledge of the host (e.g. for I. ricinus: deer, wild boar,
the presence of pathogens
recorded annual number of mammals killed (directly proportional to their actual density
correlation between killed animals and frequency of KME
number of active hunters / (No. of issued hunting permits)

Domestic animal statistics
location
host species
the presence of pathogens
eg livestock - expected presence of *Hyalomma* sp.

Pet statistics
location
host species
the presence of pathogens

Information about diseases	
Annual incidence of the disease	**Report of illness**
annual number of cases e.g. KME in humans per 100,000 inhabitants	mandatory / optional
reported by doctors treating patients	which one?
laboratory analyses	yes / no

MEDICINSKI FAKULTET SVEUČILIŠTA U RIJECI

Faculty of Medicine of the University of Rijeka
PhD school programme „Biomedicine and Healthcare”
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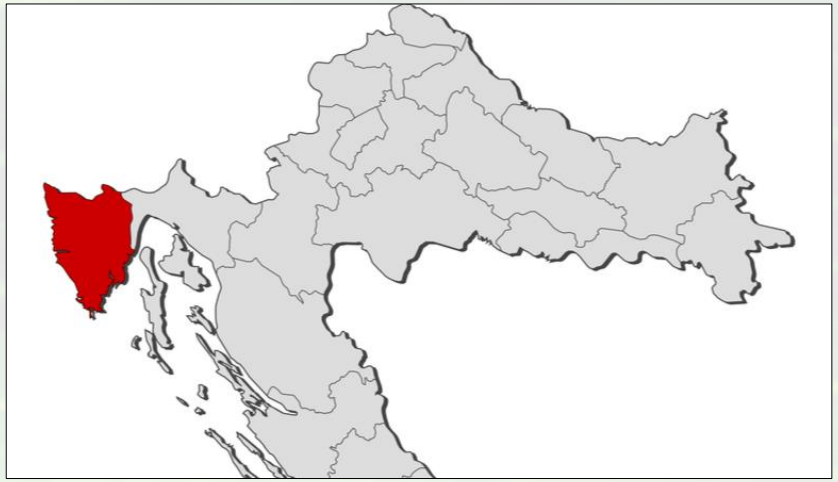
ZAVOD ZA JAVNO ZDRAVSTVO
ISTARSKE ŽUPANIJE
ISTITUTO DI SANITÀ PUBBLICA
DELLA REGIONE ISTRIANA

Identification of tick species in the Istria County and determination of the presence of pathogenic microorganisms

- ✓ increasing role of ticks as vectors in transmission of zoonotic diseases to humans
- ✓ lack of data about their prevalence in Istria
- ✓ The aim of this research is to collect data on the distribution of ticks species in Istria and to investigate their role in the transmission of pathogens to humans



INPUTS

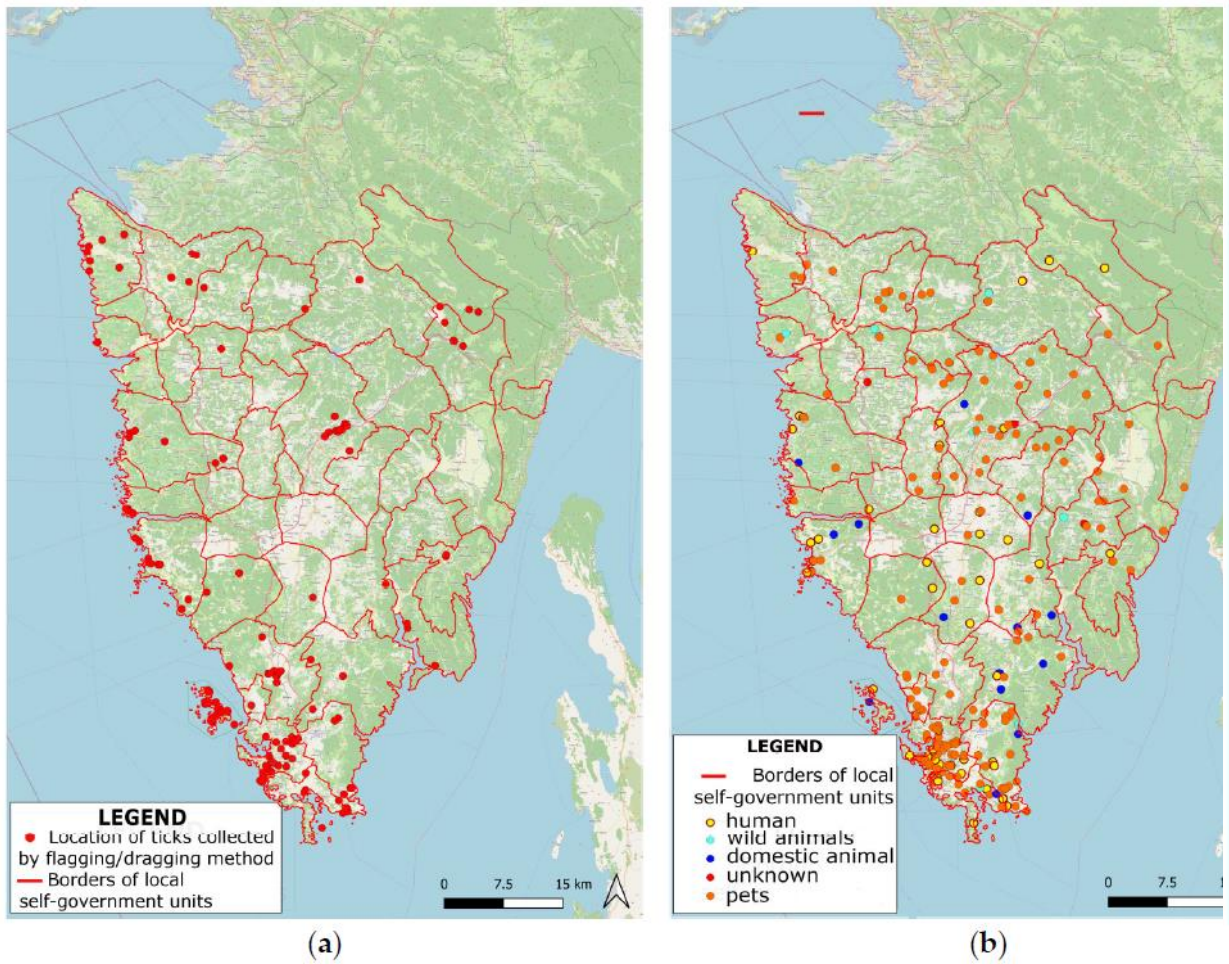
Code book

Collection method	flagging	1 correct answer
	from a man	
	from the animal	
Habitat	ecotone	More correct answers
	lawn	
	the edge of the lawn	
	ticket	
	flower garden	
	sum	
	makeup	
	public green space	
	barn and surroundings	
	abandoned agricultural land	
	olive grove	
	other: enter	
Description of the weather	sunny	1 correct answer
	cloudy	
	partly cloudy	
	rain	
Presence of ticks	that	1 correct answer
	not	
Species	Ixodes ricinus	1 correct answer
	Ixodes frontalis	
	Ixodes vespertilionis	
	Ixodes hexagonus	
	Ixodes gibbosus	
	Rhiphicephalus sanguineus	
	Rhipicephalus turanicus	
	Hyalomma marginatum	
	Dermacentor marginatus	
	Haemaphysalis punctata	
	other: enter	
Gender / developmental stage	male	1 correct answer
	female	
	nymph	
	larva	
Collector	citizen	1 correct answer
	Doctor	
	veterinarian	
	Hunting society	
	authorized person	
	other: enter	

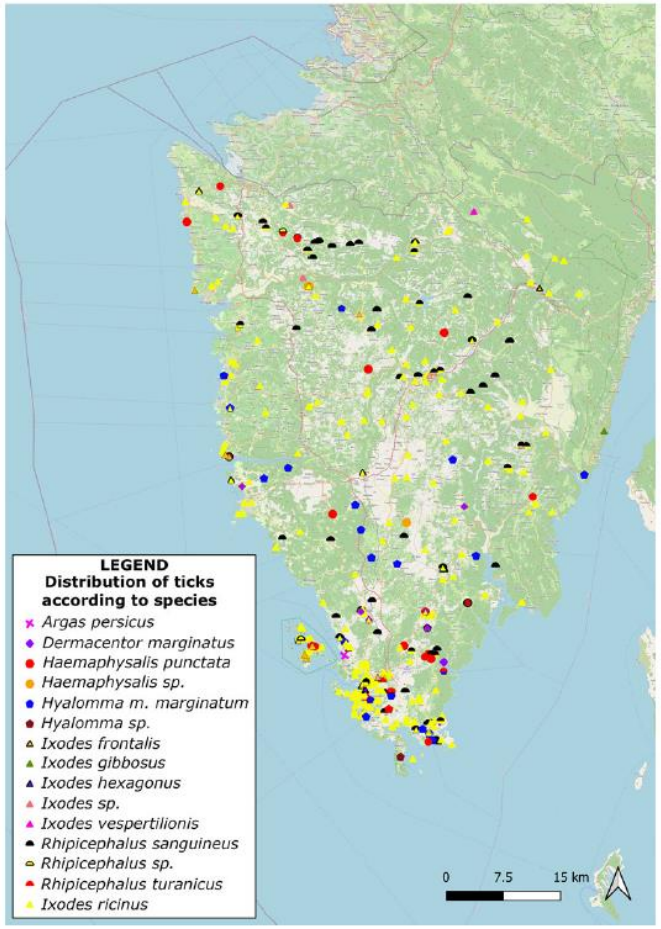
		human	pats		wild animals					domestic animals				unknown animal			
Host / Tick	**stadij razvoja / spol**		dog	cat	hedgehog	rabbit	roe deer	deer	wild boar	goat	hors	pig	donkey		**total**	**total per species**	**Percent %**
Argas persicus	F		1												**1**	***1***	**0.11**
Haemaphysalis punctata	M	4	1							6	1				**12**	***16***	**1.72**
	F	2								1					**3**		
	N		1												**1**		
Haemaphysalis sp.	M	1	2												**3**	***5***	**0.54**
	F	1	1												**2**		
Hyalomma marginatum marginatum	M	4	2								86	1	3		**96**	***136***	**14.64**
	F	10									22		8		**40**		
Hyalomma sp.	M	2									5				**7**	***20***	**2.15**
	F	1	2								10				**13**		
Ixodes ricinus	M	8	66	11	1	1	8				7				**102**	***446***	**48.01**
	F	24	133	62	2	2	14				73			2	**312**		
	N	28	1	1										2	**32**		
Ixodes sp.	M							4							**4**	***24***	**2.58**
	F		4	1			2	12							**19**		
	N		1												**1**		
Ixodes gibbosus	F		1												**1**	**1**	
Ixodes hexagonus	F			3											**3**	**3**	
Ixodes frontalis	F	2													**2**	**2**	
Ixodes vespertilionis	N	1													**1**	**1**	
Rhiphycephalus sanguineus	M		87		1						2				**90**	***253***	**27.23**
	F		142	2	1						4			1	**150**		
	N		10												**10**		
	L		2				1								**3**		
Dermacentor marginatus	M											3			**3**	***7***	**0.75**
	F	2							1			1			**4**		
Rhiphycephalus turanicus	M		5								1				**6**	***11***	**1.18**
	F		4												**4**		
	N		1												**1**		
unknown			3												**3**	***3***	**0.32**
Total tick number		**90**	**470**	**80**	**5**	**3**	**25**	**16**	**1**	**7**	**211**	**5**	**11**	**5**	**929**	**929**	
Host Infestation percent		**9.69**	**50.59**	**8.61**	**0.54**	**0.32**	**2.69**	**1.72**	**0.11**	**0.75**	**22.71**	**0.54**	**1.18**	**0.54**			**100**

Outcomes - Results

Geographic location of the sampling area in the region of Istria, Croatia



Distribution of ticks collected using (a) flagging / dragging method and (b) animal / human host method across the region of Istria



Spatial distribution of different tick species collected using flagging / dragging and animal / human host methods within the region of Istria

After lab analysis: distribution of TBD…

Conclusion

- Ticks are important carriers of pathogens in human and veterinary medicine and have been identified as re-emerging threats to health.
- The prevalence of ticks is correlated with environmental and climatic factors.
- Knowing the spatio-temporal distribution of competent vectors helps in identifying the risk of infectious diseases.
- The distribution of ticks can be monitored with GIS (geoinformation) tools. GIS manages spatial data with the possibility of predicting the emergence of infectious disease vectors, and ticks are an ideal example due to their close connection with the ecosystem.
- In many European countries, there is a lack of spatial data on the distribution and activity of ticks as vectors of zoonoses, which makes it impossible to monitor their distribution and, consequently, to model and create risk assessments of the occurrence of infectious diseases.
- The spatial distribution of ticks helps in the visualization, integration and analysis of different data sets and thus can help identify high-risk areas or effectively inform disease prevention and control services.
- Better tick surveillance would enable better public and veterinary risk assessments and ensure better preparedness for tick-borne diseases.