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作品名稱 The expansion of ticks in the valley of
Poschiavo: a growing threat to the future?

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Abstract

In recent years, the ticks have reached the valley of Poschiavo and so far no study has been done to determine their diffusion. Recently, this presence has become a much discussed topic as these ticks can be carriers of pathogenes and represent a danger to humans. The goal of this work is to analyze the current situation in the valley of Poschiavo to understand in which areas the ticks are widespread, if they are carriers of pathogens and which factors could have an influence on their expansion.

Several methods have been used for data collection. Ticks were found on ungulates killed during the high hunt in autumn 2016. In spring 2017, ticks were collected in various areas of the valley using the flag method that involves dragging a cotton cloth onto the ground. Some of the collected ticks were sent to a laboratory to identify the presence of the *Borrelia burgdorferi*, the pathogen responsible for Lyme borreliosis. To understand the evolution of the presence of ticks in the valley, the doctors and veterinarians were interviewed. Finally, to identify any climate changes related to the diffusion of ticks, the evolution of the temperature and relative humidity measured by two meteorological stations in the valley of Poschiavo since 1980 have been analyzed.

Thanks to this study it was possible to highlight for the first time the presence in the valley of Poschiavo of ticks wich are bearer of the *Borrelia burgdorferi*. In fact, the bacterium was present in 26% of the analyzed ticks. Currently, the thicks populate the southern part of the valley, from the lake of Poschiavo to Campocologno, a small area in the central part of the valley and the area around Poschiavo and San Carlo. The interviews carried out showed that in recent years the ticks in the valley have increased and that the climate change could be a possible cause. In fact, since 1980 the temperature measured on the bottom of the valley has increased on average by 1.5 ° C and also the relative humidity has risen slightly. These changes could affect the diffusion of ticks in the valley of Poschiavo.

In the future the temperatures will rise further and consequently the climate of the Poschiavo valley will most likely be more suited to the life of the ticks favoring their increase.

1 Introduction

1.1 Issue

Over the last few years, the increase of ticks in our latitudes has become a reality and therefore an increasingly discussed topic ⁽¹⁾. The expansion of these mites is worrying because, when ticks are carriers of pathogens, they represent a danger to humans. In fact, they can cause diseases that threaten human's health. If ticks carry bacteria or viruses and come in touch with the human's body through a bite, they can cause disease. In Switzerland from 5 to 30% (in some areas up to 50%) of ticks are infected by the bacterium *Borrelia burgdorferi* sensu lato (s.l.) which causes the Lyme disease, more commonly known as Borreliosis. The Swiss Federal Office of Public Health estimates 10,000 cases of infections every year ⁽²⁾. The second most frequent disease in our country transmitted by ticks is the tick-borne encephalitis (TBE), a viral disease that causes between 100 and 250 medical cases per year ⁽³⁾. Over the last few years the number of cases of infections linked to these two diseases in Switzerland has increased ⁽⁴⁾. In the valley of Poschiavo (Val Poschiavo) the TBE virus is not present because no clinical cases have ever been recorded ⁽⁵⁾. On the other hand, there is no certain information about the presence of Borreliosis, because unlike TBE it is not a compulsory declaration disease ⁽⁶⁾.

I live in Poschiavo and over the last few years I noticed that in our region the theme concerning the ticks has become a more and more discussed topic. A part of the valley is occupied ⁽¹⁾by ticks and various sources (doctors, veterinarians ⁽⁷⁾ and articles from newspapers ⁽¹⁾) report an increase of these mites as well as the number of bites on men and women. However, the exact areas where ticks are present remain unknown.

This project report is a short version of the original one. Therefore just the important information have been written in here. All the tables with the full collected data as well as the thanks to the people who helped me in this research, usually inserted in the appendices, are part of the original paper handed in to the school. To view this files please contact me and I will be pleased to share them with You.

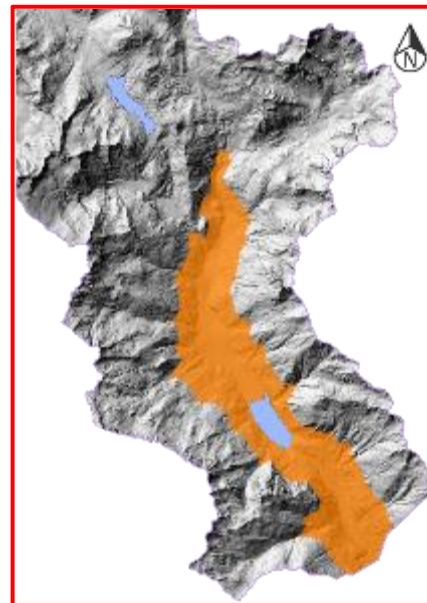
1.2 Goals and research questions

The goal of my work is to give an explanation to the phenomenon of the alleged expansion of ticks in Val Poschiavo trying to answer the following questions:

- Year after year the areas invaded by the ticks seem to have increased ⁽⁷⁾; is it possible to demonstrate the expansion of these mites or is this news unfounded?
- Recently has there been a variation of climatic factors in the valley of Poschiavo? Is the phenomenon of ticks' expansion linked to these climate changes?
- The thematic map of the Swiss Confederation (map.geo.admin.ch ⁽⁸⁾, see Map 1 and 2) represents the Poschiavo valley as a danger zone where in theory there are ticks carrying the bacterium *Borrelia burgdorferi* sensu lato. From a first contact with the author of this map it emerged that it is based on a national average: up to 1500 m.s.l.m. the ticks are carriers of the bacterium of the Borreliosis. Will it be like this also in the valley of Poschiavo, or is this valley south of the Alps an exception?
- Which areas of the valley are populated by ticks?



Map 1: The thematic map published by the Swiss Confederation shows the distribution of ticks infected by the bacterium *Borrelia burgdorferi* s.l. on the Swiss territory.



Map 2: Areas in which ticks that are infected by the bacterium *Borrelia burgdorferi* s.l. live in Val Poschiavo, according to the thematic map of the Swiss Confederation.

2 Methods and materials

2.1 Methods used for data collection

2.1.1 Climatic data

The activity of ticks and their ideal habitat are in close relation with the climate, in particular with temperature and humidity. For this reason it was decided to analyze in detail the evolution of temperature and humidity in the valley of Poschiavo. The reliable and accurate reconstruction of this data is possible starting from 1980, when the automatic survey was installed in Robbia and on the Bernina Pass.

Regarding the data, the monthly mean temperatures [$^{\circ}\text{C}$] and relative humidity [%] of the air at 2 meters above the ground measured since 1980 in the following meteorological stations in the valley of Poschiavo were used:

- Bernina Pass, 2260 m.s.l.m. ⁽⁹⁾
- Robbia, 1078 m.s.l.m. ⁽¹⁰⁾

All values have been provided by the Swiss Federal Office of Meteorology and Climatology MeteoSwiss.

2.1.2 Tick detection during the hunting season 2016

During the hunting season 2016, from the 3rd to the 11th and from the 19th to the 30th of September ⁽¹¹⁾, the game warden Mr. Arturo Plozza, checked if the wild animals killed in the whole valley and brought to the special control had ticks.



Figure 3: A tick during a blood meal on a guest

2.1.3 Interviews

During this work, interviews were made with the doctors and veterinarians of the valley to understand if and how they have already been compared with the tick phenomenon in the valley of Poschiavo.

The following doctors were interviewed:

- Dr. med. Emanuele Bontognali, doctor in Poschiavo from 1988 to 2016
- Dr. med. Hans Russi, vet in Poschiavo from 1978 to 2008
- Dr. med. Claudio Paganini, vet in Poschiavo since 2008
- Dr. med. Tarcisio Menghini, doctor in Poschiavo since 2001
- Dr. med. Mauro Albertini, doctor in Brusio since 1994

The people interviewed have worked or are currently practicing their profession of doctor or veterinarian in the valley. The same questions were asked in all the interviews, so that the results could be better compared to each other. The main questions were:

- Since when do you perform/did you perform your medical activity in the valley?
- Have you noticed an increase in medical cases related to ticks' bites during your activity?
- Which are the most populated geographic areas with ticks? Have they changed in recent years?
- In which periods of the year are ticks most active? When is it less?
- Are there any cases related to ticks cataloged?
- If so: how? Is it possible to consult them?
- Have you already done research in this field?
- Personal opinion: what could be a possible cause of the expansion/presence of ticks in the valley? Is it linked to the climate change?
- Are there any ticks carrying pathogens (Borreliosis) even in the Poschiavo valley?
- Personal experience: have you already personally come in touch with ticks?

2.1.4 Collection of ticks

The collection of ticks at different points in the valley was carried out by dragging 1 m² of cotton cloth ⁽¹²⁾ onto grass or small shrubs on the edge of trails or mountain roads. In order to better recognize the presence of these small mites, a white colored cloth has been chosen. Every 10 meters approximately the cloth was examined to see if there were any ticks ⁽¹³⁾. If so, they were gently picked with tweezers and stored in a lockable glass test tube. The ticks, in fact, stay on the blades of grass or at the ends of the branches of the bushes and wait for the passage of a guest on which they can stick. The collection method used is based on this characteristic behavior of many ticks. The moving white cloth has the task of representing the guest passing by and the ticks, feeling the presence of an object that is touching the grass, stick on its surface and believe that it has reached the skin of some animal.

The first collection served as a test to understand if the method used worked and if it were possible to collect ticks in this way. Two areas were chosen along the eastern side of the Poschiavo lake, because the interviews revealed that there are actually mites at the lake. This research was very positive and proved that the collecting method works.

After that, 18 approximate areas, where to carry out the next researches, were identified and inserted into a geographical map. The places have been selected so that they can create a limit along the valley and identify up to which altitude these mites currently live. Also the conformation of the ground and the type



Figure 4: The white cloth is dragged onto the ground



Figure 5: The cloth is examined to search ticks



Figure 6: The founded ticks are collected

of vegetation present in this areas have been considered for the choice of the places, in order to find the places with the suitable habitat for the ticks.

The ticks collected were then compared with images of these mites found on the internet and this made it possible to identify the sex and the species (*Ixodes ricinus* or *Dermacentor marginatus*) as well as the stage of development of the collected specimens.

Some of the collected ticks were sent to the laboratory "Labor team W AG" of St. Gallen, where they were analyzed to verify the presence of the bacterium *Borrelia burgdorferi* s.l., which causes the Borreliosis. It was decided to



Figura 7: Tick ready to be sent to the laboratory

concentrate the analysis only on this bacterium, because there is no scientific confirmation of its presence in the valley, because Borreliosis is not a compulsory declaration disease ⁽⁶⁾. However, clinical cases related to TBE ⁽⁵⁾ have never been registered in the valley of Poschiavo and for this reason the virus that causes this disease is not present in the valley and therefore it is not necessary to carry out analyzes in the laboratory to identify its possible presence in the ticks collected.

2.2 Analysis methods

2.2.1 Maps

Some of the information obtained were represented into geographical maps. The official website of the Swiss Confederation map.geo.admin.ch was used, where elements were drawn and inserted into the respective maps.

Tick detection during the hunting season 2016

The places where the registered animals were shot were inserted into a map. Thanks to the coordinates of the place where the animals were shot it was possible to mark these points exactly. In blue were highlighted the places where animals without ticks were shot and in red those with ticks. The deer were represented with the round symbol, the triangle-shaped was used for the roe and the square-shaped for chamois.

The controlled species of ungulates, depending on the season, move and prefer a certain area. The analyzed data were collected over a single season, which also coincides with the period of tick activity. For this reason they represent good indications regarding the distribution of ticks on the territory.

Collection of ticks

Initially the locations for tick researches were marked onto a map, trying to choose areas suitable for creating altitude limits in order to identify where these mites live.

Later, after each harvest, the scoured area was shown in a further map, marking in blue the areas where no ticks were found and in red where instead ticks were found.

Interviews

The people interviewed explained, from their point of view, the current distribution of ticks in the Poschiavo valley, mentioning roughly the boundaries and areas most populated by these mites. With this information it was possible to create a map, which represents the distribution of ticks based on the opinions of the people who provided detailed information.

Analysis and comparison of the obtained maps

The maps obtained from the collection of ticks and ticks found on the animals shot during the hunting season have been further analyzed. The places marked in red (where ticks were found) have been connected to each other, thus creating areas where the probability of the presence of mites is higher. The same procedure was applied to the blue areas (where no ticks were found) of the map, emerged from the ticks collection, in order to create the boundaries within the ticks live.

Finally, all the information on the single maps produced was merged into a single map, using the "Adobe Photoshop Elements 14" program. This work made it possible to create a final geographical map that represents the areas where the ticks are more likely to be present.

2.2.2 Graphics

To ease the interpretation of climate values in the Poschiavo valley and southern Switzerland, the large amount of data has been graphically represented.

2.2.3 Tables

Tick detection during the hunting season 2016

The shooting sites of these animals were divided according to the number of ticks found on them and the average altitudes of the individual groups were noted in a table.

Collection of ticks

The average, maximum and minimum altitudes of the research areas in which ticks were found or not and also where the different species were found have been grouped together in a table.

Interviews

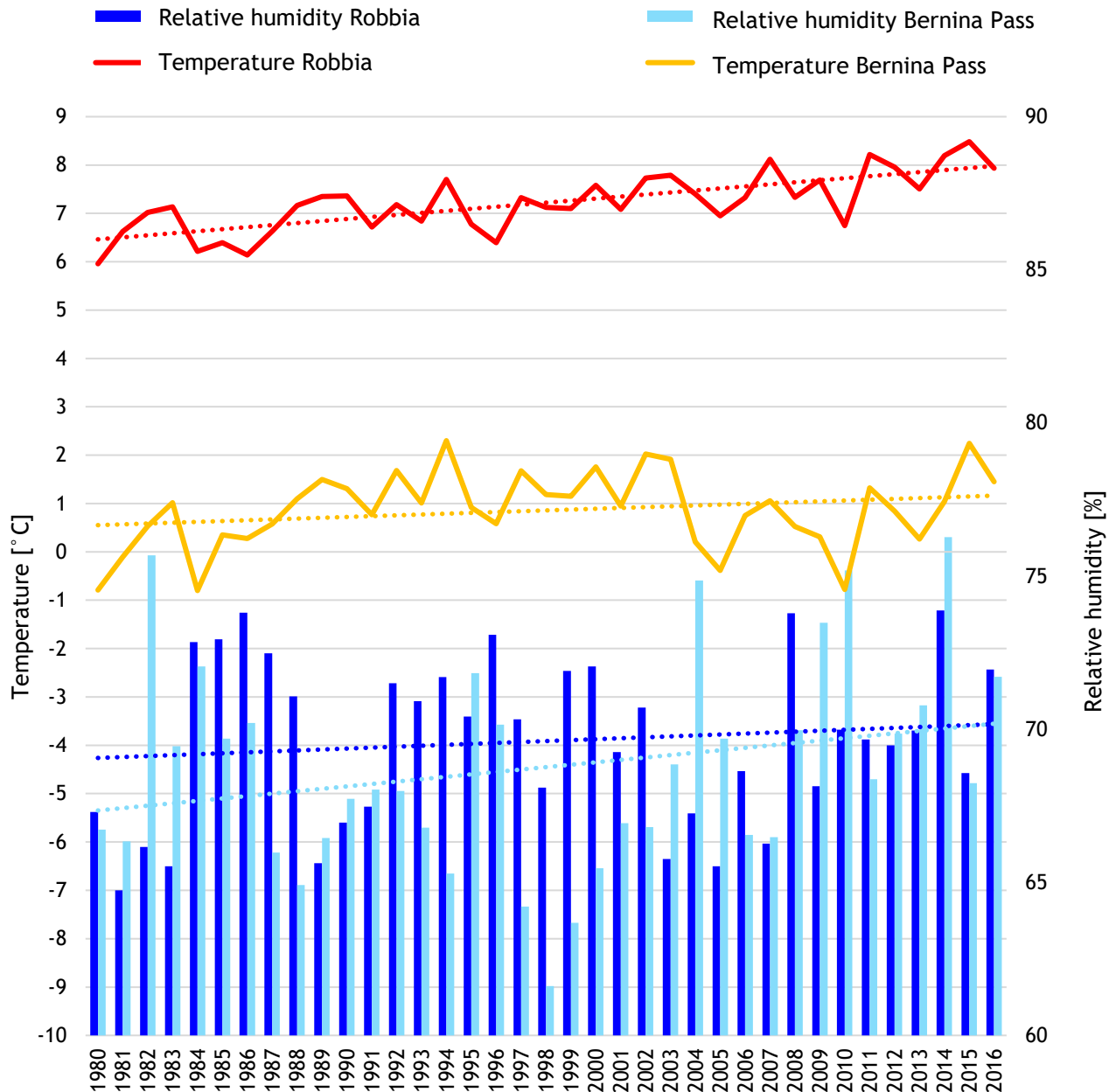
The most important common statements that emerged from interviews with doctors and veterinary in the valley were summarized in a table.

Final map

In a table the altitudes of the lowest points (to the north and south) and the higher ones (to the east and to the west) of the areas populated by the mints emerged from the different analysis have been noted. Later on the averages and the most relevant sums of these data were calculated.

3 Results

3.1 Climatic data

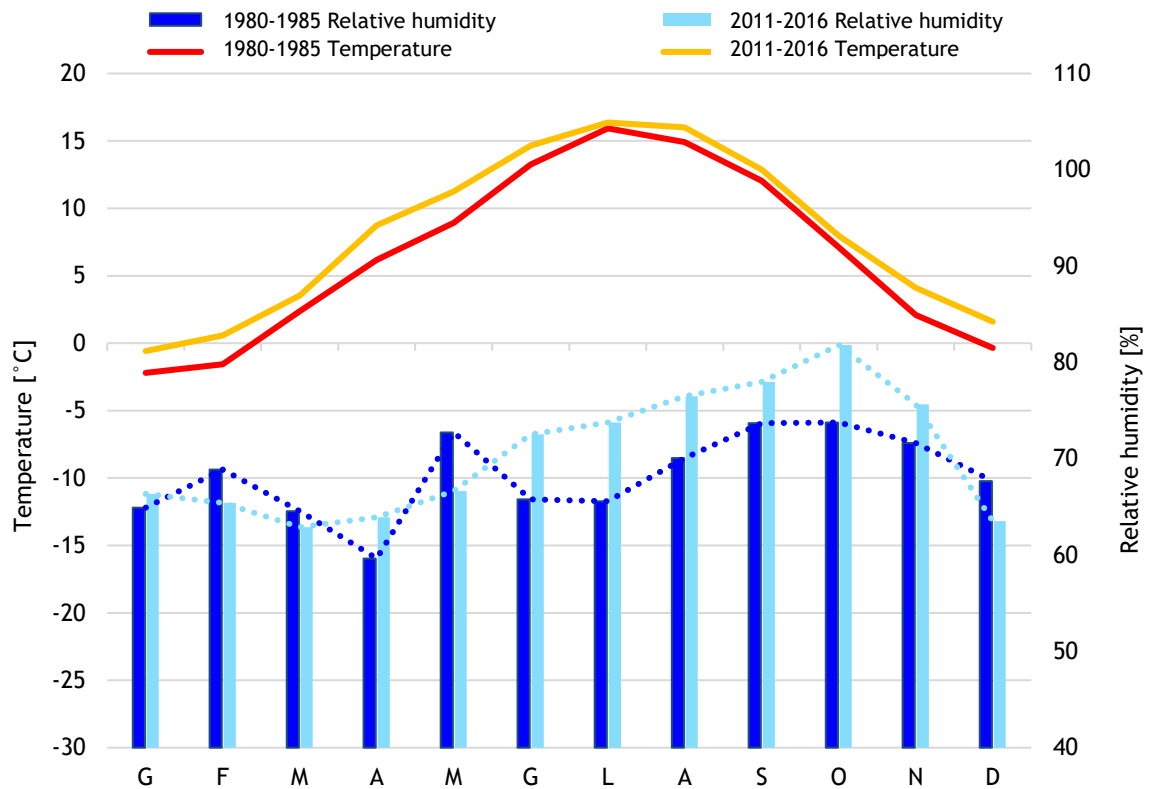


Graphic 1: The graph shows the comparison of the evolution of the average annual relative temperature and relative humidity from 1980 to 2016 measured by the meteorological station of Robbia and that of the Bernina Pass.

From this graph (Graphic 1) it has emerged that the temperature in Val Poschiavo since 1980 has increased. According to the measured data, in Robbia the temperature has increased on average by 1.5 ° C, while on the Bernina Pass by 0.6 ° C.

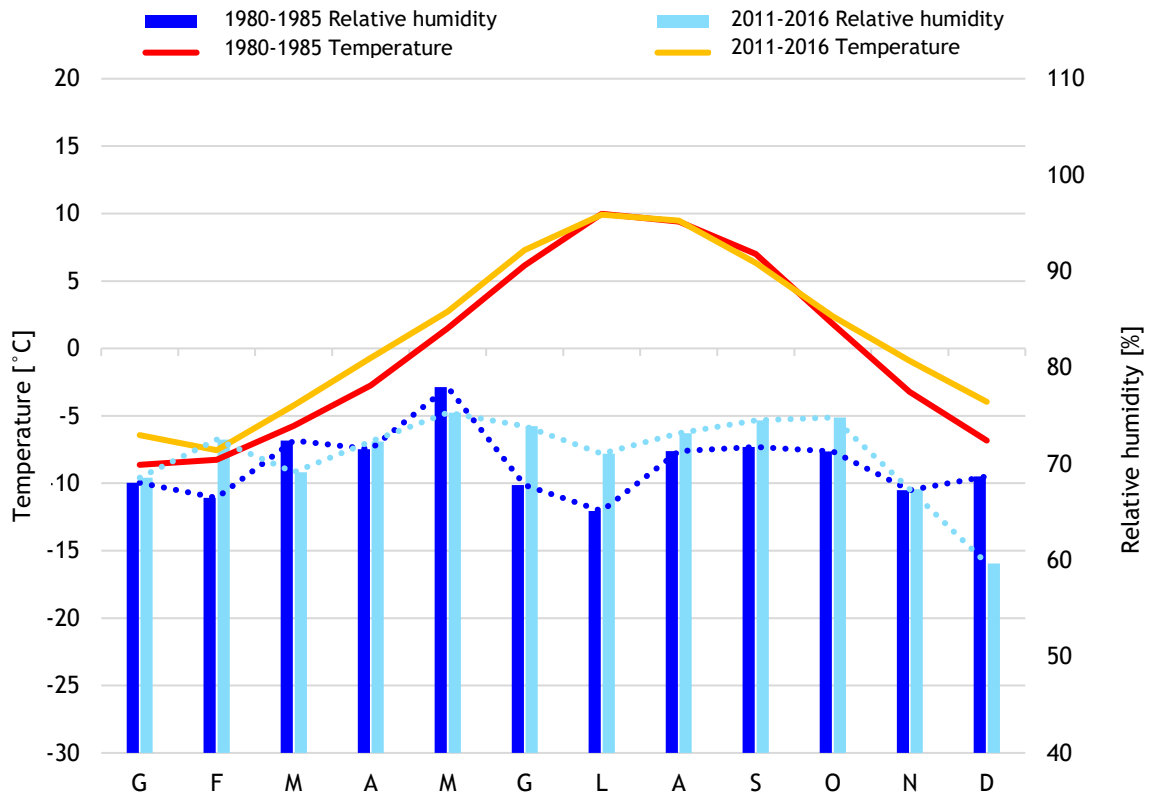
In general, the relative humidity has also increased, but less markedly. On the Bernina Pass, a greater growth was recorded compared to Robbia.

Robbia



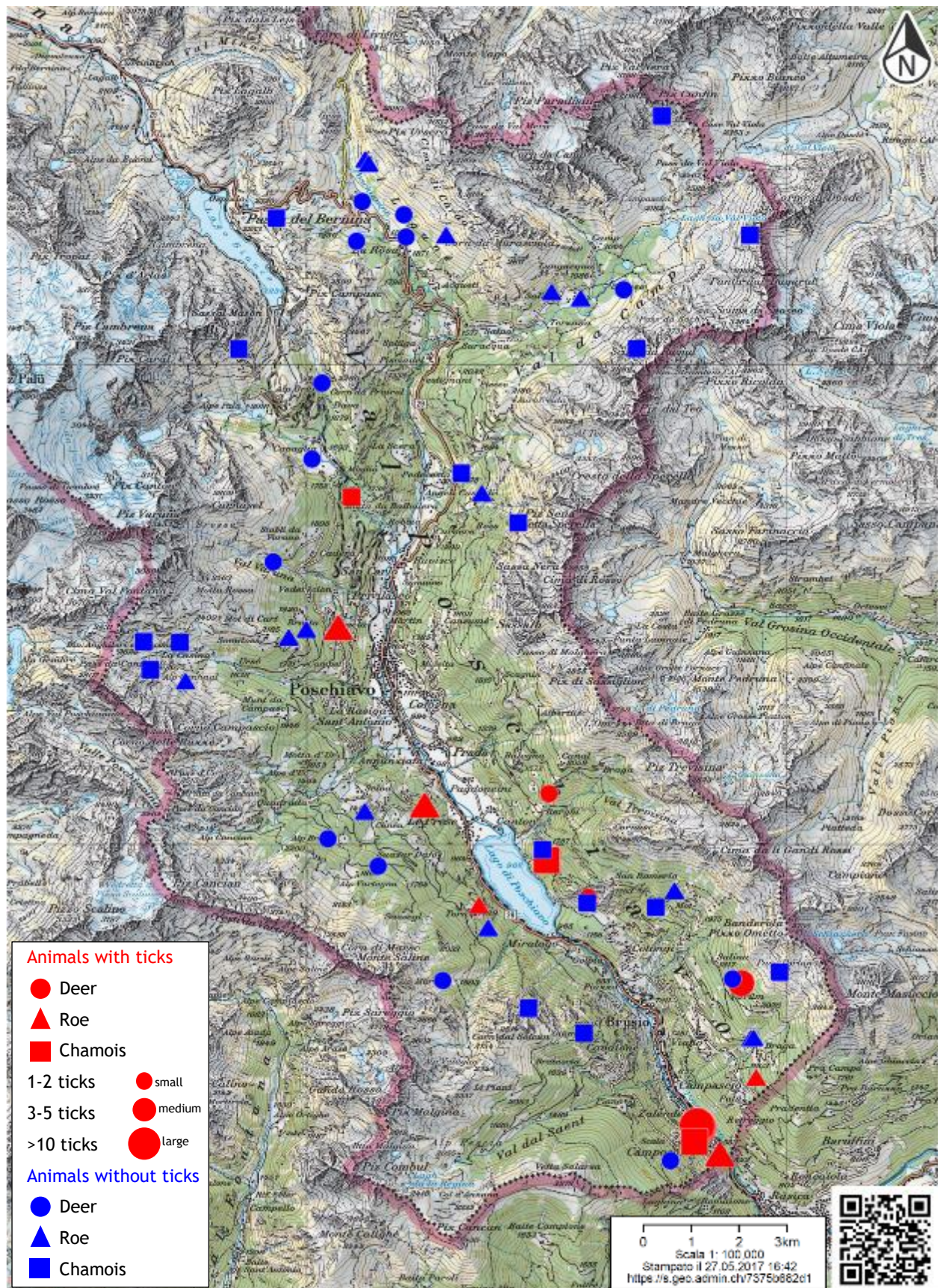
Graphic 2: The graph shows the comparison of the average monthly temperature and relative humidity between the periods 1980-1985 and 2011-2016 measured by the meteorological station of Robbia.

Bernina Pass



Graphic 3: The graph shows the comparison of the average monthly temperature and relative humidity between the periods 1980-1985 and 2011-2016 measured by the meteorological station of the Bernina Pass.

3.2 Tick detection during the hunting season 2016



Map 3: The map shows the places where 55 ungulates were killed due to the presence of ticks during the hunting season 2016.

From the map obtained (Map 3) it can be seen that the places where the animals with ticks were shot in the northern part of the Poschiavo Lake are concentrated in the valley bottom, at low altitudes. In the south part, however, these mites have also been found on animals shot in higher altitudes. The highest number of ticks was also observed on the animals shot in the Campocologno area. It is therefore possible to see that ticks are present on ungulates in the parts of the valley located at low altitudes and the more we go to the south the more the ticks increase and are also found at higher altitudes.

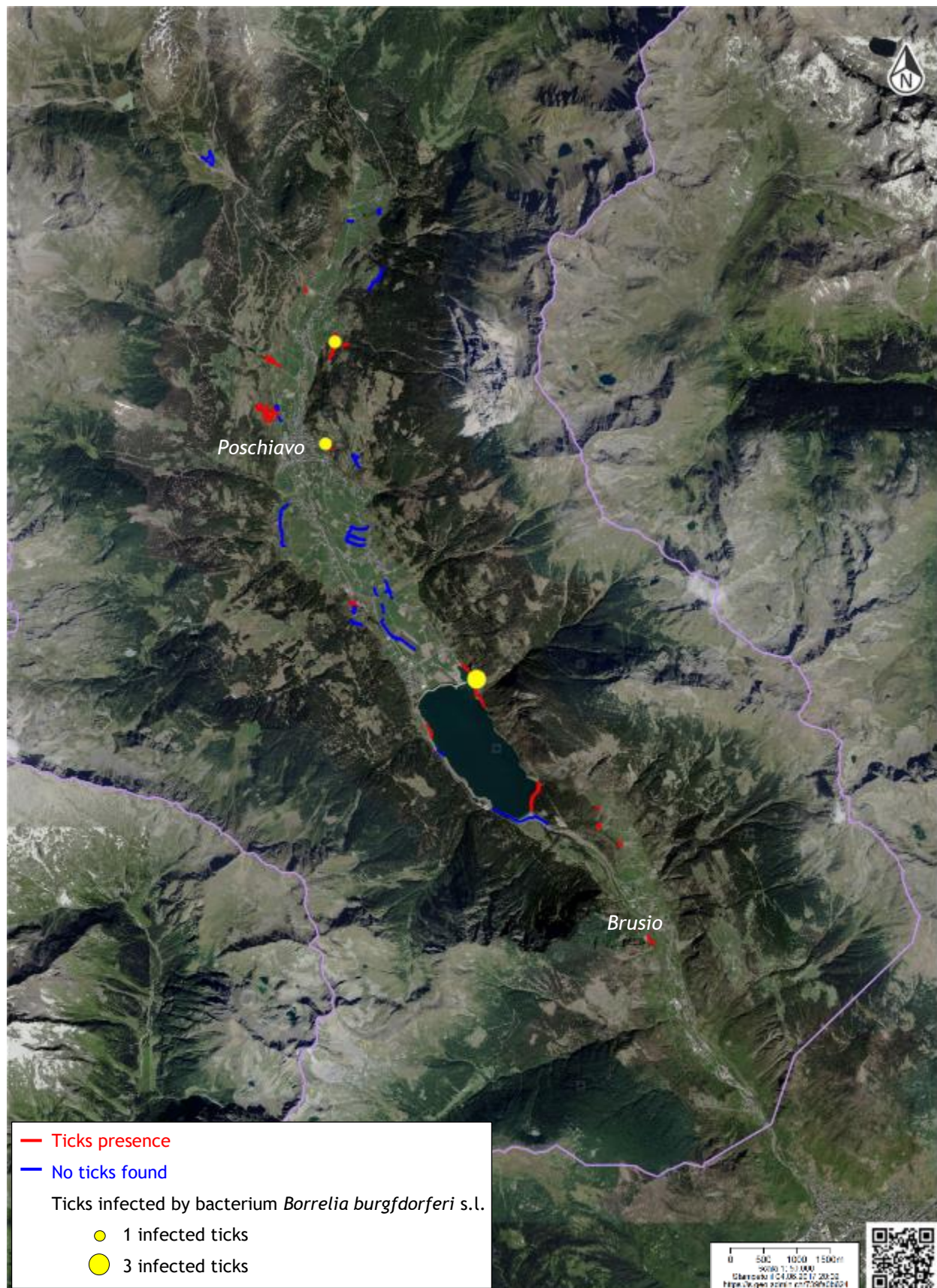
During the hunting season 2016, a total of 55 ungulates (deer, roe and chamois) were shot throughout the valley. The number of ticks found, the information regarding the place and date of the shooting as well as the species, sex and age of the animal were noted in a table. Most ticks have been found under the shoulders and thighs of the animals, where the skin is finer and easier to pierce.

	Average altitude [m.s.l.m.]
Animals with ticks	1190
from 1 to 2 ticks	1343
from 3 to 5 ticks	1215
>10 ticks	665
Animals without ticks	1976

Table 1: The table shows the average altitudes of the places where the 55 controlled ungulates were shot.

The averages of the altitudes of the shooting sites of the controlled ungulates show that when the altitude increase the number of ticks decrease.

3.3 Collection of ticks



Between April 21 and May 28, 2017, period of the year when the ticks are particularly active, 36 points in the valley of Poschiavo were examined for ticks. A total of 135 exemplary were collected, 111 belonging to the species *Ixodes ricinus* and the remaining 24 to the species *Dermacentor marginatus*. Only these two tick species have been found throughout the valley.

The collection areas have been mapped. The data of the coordinates as well as the altitudes of the places of the findings have been included in a table, in which the information regarding the species, sex and the number of ticks collected as well as the day of the research were also noted.

19 of the collected ticks were analyzed in the laboratory and 5 of them were carriers of the bacterium *Borrelia burgdorferi* sensu lato. 3 of these were collected in the northern part of the eastern side of the Poschiavo lake, near the road and trails. Another tick was found in the Sotsassa area and the last one on the edge of a dirt road above Somaino. For economic reasons it was only possible to analyze 19 ticks.

Ticks were found mostly on the grass on the edge of trails or dirt roads, where the grass reached a maximum height of 30-40 cm. The shady, cool and humid places were the most populated ones.

	Altitude [m.a.s.l.]		
	Average	Maximum	Minimum
Ticks presence	1035	1222	746
Ticks absence	1107	1695	964
<i>Dermacentor marginatus</i>	959	1084	963
<i>Ixodes ricinus</i>	1039	1222	746
Adult	1032	1222	746
Nymphs	1092	1222	963

Table 2: The table shows the average, maximum and minimum altitude of the search sites of the ticks, as well as the distribution of the different species found.

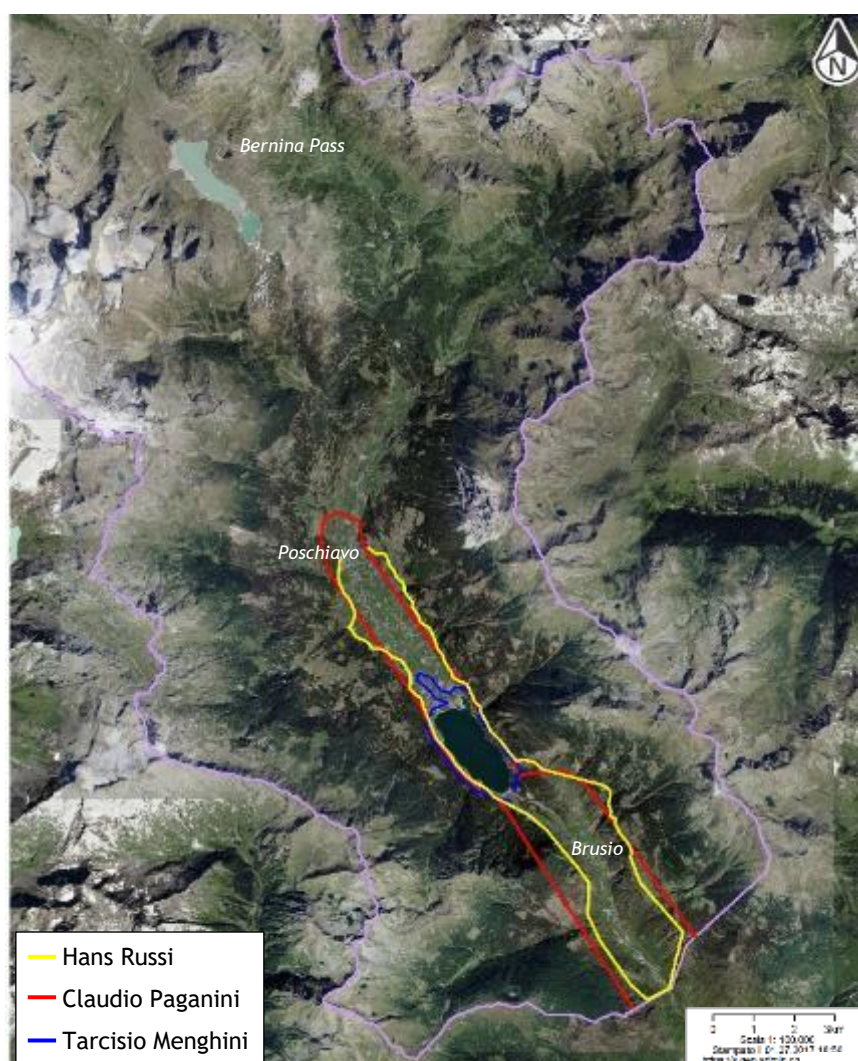
Comparing the location of the research sites showed that the average altitudes of the positive areas is lower than that of the negative areas, that's means that the ticks have been found in the searched areas located at lower altitudes.

In addition to this, the species *Dermacentor marginatus* was found only at low altitudes, unlike the species *Ixodes ricinus*, present at all altitudes. Comparing then the averages of the places of discovery of these two species, it can be observed that the *Ixodes ricinus* ticks live at higher altitudes than the ticks *Dermacentor marginatus*.

3.4 Interview

	Veterinarians		Doctors		
	Hans Russi	Claudio Paganini	Emanuele Bontognali	Tarcisio Menghini	Mauro Albertini
Place (Municipality)	Poschiavo	Poschiavo	Poschiavo	Poschiavo	Brusio
Activity period	1978-2008	Dal 2008	1988-2016	Dal 2001	Dal 1994
Increased ticks in recent years	Yes	Yes	Yes	Yes	Yes
Seasons when ticks are:					
more active	Spring Autumn	Spring Autumn	Spring Summer	Spring Summer	Spring Summer
less active	Summer	Summer	Autumn	Autumn	Autumn
Climate change responsible for the expansion and increase of ticks	Yes	Yes	Yes	Yes	Yes
Cases of Borreliosis	No	No	No	Yes	yes

Tabelle 3: The table summarizes the most relevant common statements that emerged from the interviews.

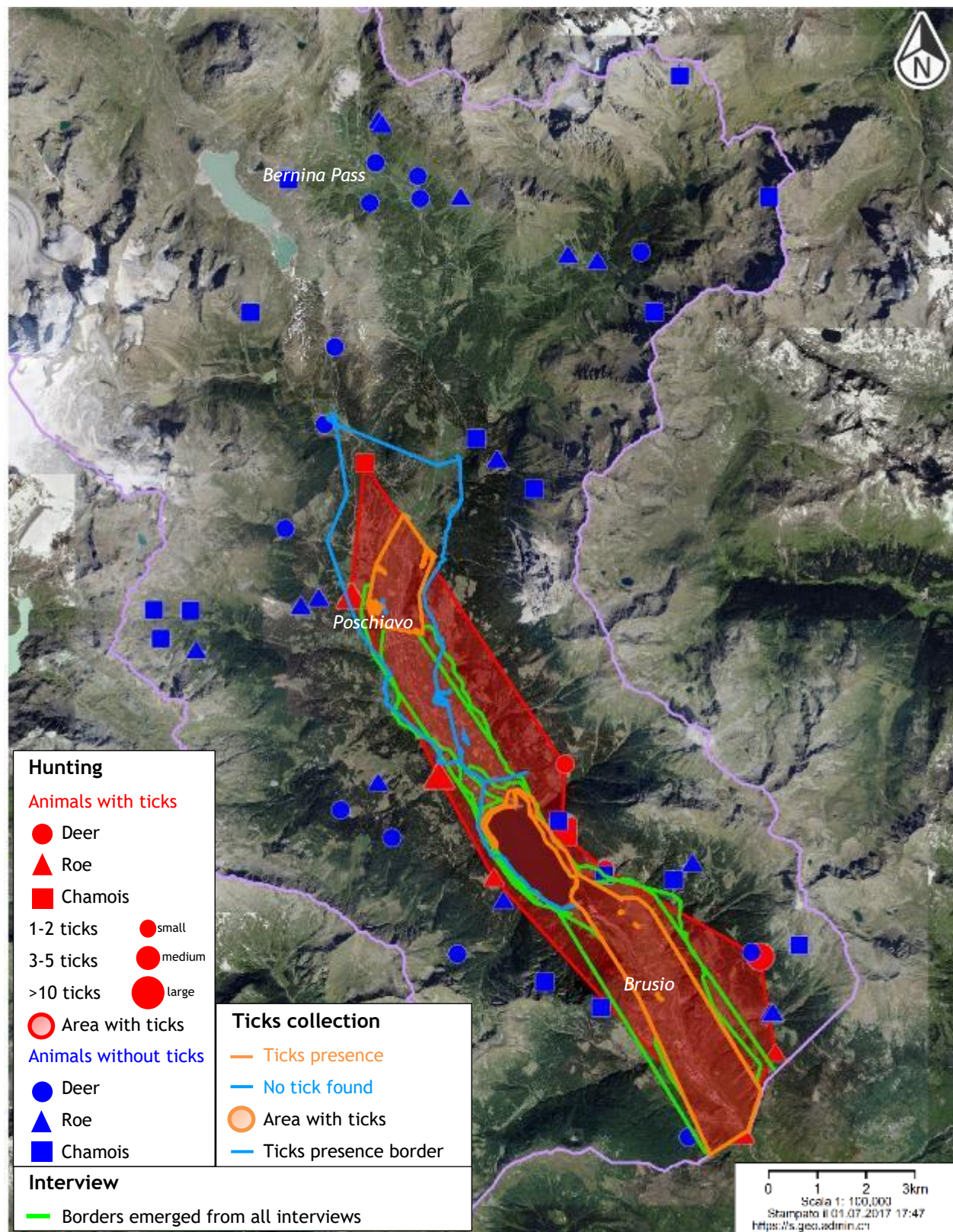


According to the opinions of the interviewed people, the ticks in the valley of Poschiavo over the last few years have increased and a possible cause is the climate change. In addition, two doctors have already found cases of Borreliosis in the valley.

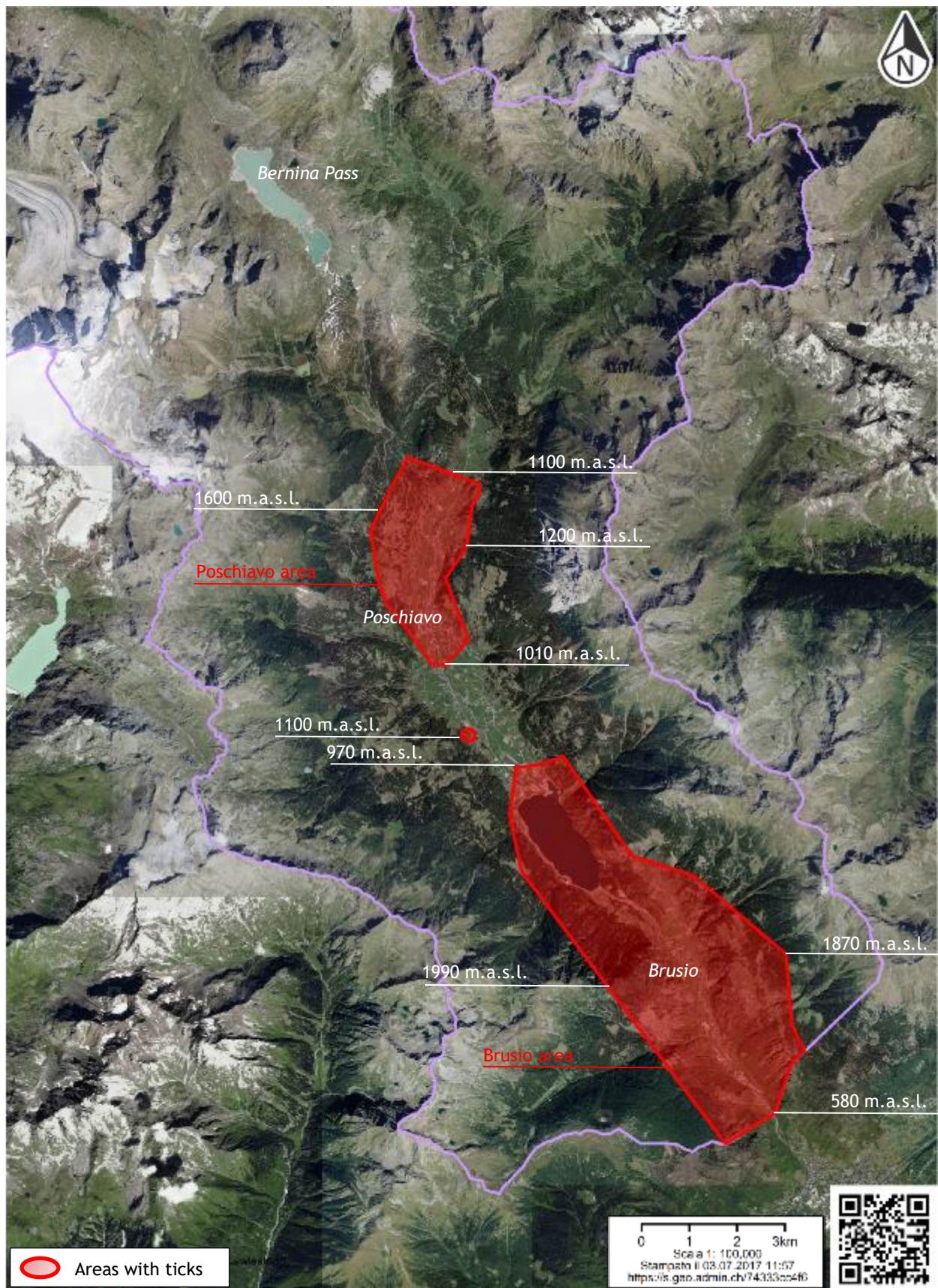
The ticks are present starting from Poschiavo, on the bottom of the valley, to Campocologno, where in the area of Brusio they reach higher altitudes.

Map 5: The map shows the approximate areas, which emerged from the various interviews with the doctors and veterinarians of the valley, where ticks are present.

3.5 Comparison and general analysis



Map 6: All the data collected during the research and the areas, which emerged from the analysis of the individual maps, are superimposed on this map.



Map 7: The map represents the final areas where the probability of the presence of ticks is higher than the rest of the territory. They result from the sum of all data. In addition, the most important sea level altitudes of each area were shown on the map.

From the sum of all the collected data it results that the ticks are mainly present in three areas in Val Poschiavo (see Map 7).

			Area Poschiavo	Area Brusio		Area Poschiavo	Area Brusio
Altitude [m.a.s.l.]	Lower points	North	1100	970			
		South	1010	580			
	Higher points	West	1600	1990		1600	1990
		East	1200	1870		1200	1870
	Sum of all points		4910	5410	Sum East and West points	2800	3860
	Average of all points		1228	1353	Average East and West points	1400	1930

Table 4: The table shows the main altitudes of the two largest areas (see Map 7) populated by ticks.

The largest area populated by mints (Brusio area) is the southern part of the valley that goes from the Poschiavo lake to the southern border of the valley. In this area the ticks reach higher altitudes than the other two identified areas. The second largest surface is the one around Poschiavo (Poschiavo area), where however the ticks are only present in lower altitudes. Moreover between these two large areas there is a small area, located at 1100 m.a.s.l.. It is the only place, that results from the collected data, with the presence of ticks throughout the central area of the valley.

4 Discussion

The data used in this research refer to the valley of Poschiavo and were collected between September 2016 and June 2017. Therefore they represent an analysis of the presence of ticks in a given region and in a limited period of time. Furthermore, there are no data available regarding the distribution of ticks antecedent to this study that can be used for comparisons. Therefore it is not possible to scientifically prove the expansion of ticks. From the interviews conducted with the doctors and veterinarians of the valley, however, it has turned out that over the last few years there has been an increase in patients who went to the doctor because of tick's bites and recently also for cases of Borreliosis.

With the collection of ticks the presence of two tick's species in Val Poschiavo was identified: *Ixodes ricinus* and *Dermacentor marginatus*. The ticks from the species *Dermacentor marginatus* lives at lower altitudes than the ones of the *Ixodes ricinus* species and therefore they are not present in the area north of the Poschiavo lake. The nymphs of the species *Ixodes ricinus* are instead present almost exclusively at higher altitudes, where the adult exemplaries decrease. This is perhaps due to the fact that only recently some ticks have managed to get so high and to lay their eggs. Therefore, the new born ticks did not have time to evolve into more advanced stages of development.

Laboratory analysis showed that in three areas of the valley, that means in the northern part of the eastern side of the Poschiavo lake, in Sotsassa and above Somaino, there are ticks carrying the bacterium *Borrelia burgdorferi* s.l., the pathogen responsible for the Borreliosis. It is interesting that 26% of the mints analyzed were carriers of the bacterium, a percentage that falls within the high end of the Swiss average between 5 and 30%. The places where the exemplaries ,wich carries the bacterium, were collected are between 963 and 1166 m.a.s.l.. This interval is part of the national average on which the thematic map of the Swiss Confederation is based, that means below 1500 m.a.s.l. this bacterium is present. It is important to clarify the fact that this map is not very precise, since not all parts of the valley highlighted as danger areas are populated by ticks.

In the valley of Poschiavo the climate is changing. The temperatures from 1980 measured by the meteorological station of Robbia have increased by about 1.5 °C, a phenomenon in line with the rest of Switzerland. This increase took place uniformly throughout the year. The relative humidity has also increased slightly, showing growth in the summer and autumn months and a decrease during the winter time. This variation explains why the ticks remain active longer in autumn, as also confirmed by the veterinary Claudio Paganini, who removed some ticks from animals in December. In addition, the increase in the temperatures found in the valley could have encouraged the increase and expansion of these mites as well as the

winters is less rigid and with less snowfall. However, we must not forget other factors that could be related to their diffusion, such as the increase in the population of ungulates and reforestation. However, a recent study has shown that the development of Borreliosis and other tick-borne diseases probably depends more on socio-economic factors than on climate change. The frequency of contact between humans and ticks is the factor that has the most important influence on tick-borne diseases. The variation in the incidence of these diseases is therefore determined only in part by climate change. The most determining factors are changes in the habitat and life cycle of tick-borne animals as well as the lifestyle of men (for example due to more frequent stays in the woods during physical activities, mountain hikes, ...) and change in socio-economic factors (such as population density, agricultural and forestry cultivation methods or antibiotic use) ⁽¹⁴⁾.

This work, however, analyzes the geographical expansion of ticks in general in the valley of Poschiavo, not focusing only on those carriers of the pathogen causing Borreliosis. For this reason the socio-economic factors mentioned above are not considered. The goal of the work related to the Borreliosis aims only to identify if in the Val Poschiavo there are ticks carrying the bacterium *Borrelia burgdorferi* sensu lato.

On the Bernina Pass, on the other hand, the average temperature has increased by around 0.6 °C, less than in Robbia and on a regular basis throughout the year. However the average temperature on the Bernina Pass is so low that makes this part of the valley inhospitable for ticks. With regard to relative humidity, a uniform increase was recorded throughout most part of the year, with the exception of a decrease in December. We can see a greater increase compared to that recorded in Robbia. In 1980 the difference in relative humidity between Robbia and the Bernina Pass was about 3%, in 2016 this is almost 0%, quite curious. From the contact with Mr. Fosco Spinedi from MeteoSwiss, it turned out that relative humidity is a difficult parameter to measure and variations of 5% or more between one instrument and another are completely normal. Furthermore, until 2014 the meteorological station on the Bernina Pass was a manual station and this involved a series of difficulties for measurements (snow, staff presence, instrumentation, station movements, etc.). Consequently, a comparison between the measurements of the weather stations of Robbia and of the Bernina Pass is only sensible starting from the introduction of the automatic survey station on the Bernina Pass, that is from 2015. It is important to clarify the fact that a comparison of relative humidity among different altitudes makes sense. In general, the relative humidity is higher in the summer months due to the presence of locally developed clouds, while it is the inverse in the winter season due to the greater frequency of foggy air at low altitudes. However, if the lowest comparison station is located in a flat area, the relative humidity undergoes the local influence of night moisture accumulation caused by poor air circulation.

This takes place more in the winter months and less in the summer. Also for this reason the relative humidity measured at Robbia (on the plaine) and on the Bernina Pass (on a slope) should not be compared.

Ticks are present in three distinct areas in the Poschiavo Valley. The municipality of Brusio and the area around the lake of Poschiavo are completely colonized, while the part around Poschiavo and San Carlo is only partially. According to the data collected in the area of Brusio these mites reach up to 1930 m.a.s.l.. At this altitude it is however unlikely that the ticks can survive, as with increasing altitude the temperature decreases, thus making these regions inhospitable for the ticks. This information is due to the finding of ticks on an animal shot during the hunting season in this area. Most likely, however, the tick attached itself to the animal at lower altitudes and then the animal moved into a higher area, where it was shot. Therefore, considering that the limit of the presence of the mites in the area of Brusio does not reach 1930 m.a.s.l., this data is however superior to the one inherent the area of Poschiavo, where instead the ticks reach only 1400 m.a.s.l. (see Map 7). This is probably due to the fact that the ticks arrived in the valley from the south, from the Valtellina, and then they expanded more in the southern part of the valley and have reached the northern part only recently. Furthermore the vegetation and the climate are different.

In the central part of the valley instead they are present only in a small part. Perhaps because in this area both the vegetation and the climate do not represent a suitable environment for the life of these mites, furthermore there are few animals suitable to become potential guests for ticks.

5 Conclusion

With the data collected in this research it is possible to show that climate change could have influenced the spread of ticks in Val Poschiavo. In fact, the temperature and the relative humidity are increasing and this favors the creation of new areas suitable for the life of ticks. So a possible consequence to these changes is perhaps the expansion and increase in the number of exemplaries. Probably also the presence of ticks carrying the bacterium of Borreliosis is linked to these phenomenon. However, there are authors who argue that the development of tick-borne diseases depends more on socio-economic factors than on climate change ⁽¹⁴⁾.

Since there are no previous studies on the presence of ticks in Val Poschiavo and the data collected in this work refer only to a precise moment, it is not possible to scientifically prove the existence of a real expansion of ticks in the valley over the last few years. However, this

work creates a good basis for a future analysis of the situation in the valley of Poschiavo. Furthermore, the pre-established objectives have been achieved. The current geographical distribution of the ticks has been mapped, it has been shown that climate change also occurs in the Poschiavo valley and that below 1166 m.a.s.l. there are ticks infected by the bacterium *Borrelia burgdorferi* s.l., data that do not fully correspond with the thematic maps on the Borreliosis of the Swiss Confederation. The data collected in this research represent very useful information for the population that is confronted with these mites. Being aware of the presence of ticks and Borreliosis can be important on one hand for the doctors of the valley in the early diagnosis of the disease and on the other hand for the population in preventing bites and therefore infections.

Observing Switzerland's climate scenarios, it seems that temperatures will continue to rise throughout the country in the future, and as a result of this change, the climate of the Val Poschiavo will most likely be more suitable for the life of ticks and encourage their growth.

To carry out this research several methods were used and the topics analyzed touched different sectors. All this helped to make the work very varied and interesting. Carrying out such research has entailed many difficulties and discouragement; in addition there were many observations, hypotheses and evaluations, but finally succeeding in achieving the desired results was a great satisfaction and a precious enrichment of knowledge.

Declaration

The undersigned ..., declares to have completed and drafted the matriculation work in person. She/he also declares that she/he has not committed plagiarism and that she/he has clearly and conscientiously indicated the parts taken from the various sources.

Place, date and signature

Poschiavo, 26.03.2018

References

1. Weitnauer, Roberto. Le zecche, un pericolo sottovalutato. *ilBernina*. 29.10.2016.
2. Borreliosi o malattia di Lyme. *Ufficio federale della sanità pubblica*. [Online] 04 04 2017. [Riportato: 23 04 2017.] <https://www.bag.admin.ch/bag/it/home/themen/mensch-gesundheit/uebertragbare-krankheiten/infektionskrankheiten-a-z/borreliose-lyme-krankheit.html>.
3. Meningoencefalite primaverile-estiva (FSME)/Meningoencefalite da zecche (TBE). *Ufficio federale della sanità pubblica*. [Online] 06 03 2017. [Riportato: 23 03 2017.] <https://www.bag.admin.ch/bag/it/home/themen/mensch-gesundheit/uebertragbare-krankheiten/infektionskrankheiten-a-z/fsme.html>.
4. Zeckenübertragene Krankheiten - Lagebericht Schweiz. *Bundesamt für Gesundheit*. [Online] Schweizerische Eidgenossenschaft, 06 12 2017. [Riportato: 30 01 2018.] <https://www.bag.admin.ch/bag/de/home/themen/mensch-gesundheit/uebertragbare-krankheiten/ausbrueche-epidemien-pandemien/aktuelle-ausbrueche-epidemien/zeckenuebertragene-krankheiten.html>.
5. Aktualisierung und neue Übertragbare Krankheiten, Darstellung der Karte mit Impfempfehlung für Frühsommer-Meningoenzephalitis per April 2013. *Bundesamt für Gesundheit*. 2013.
6. Malattie infettive e agenti patogeni soggetti all'obbligo di dichiarazione 2018. *Ufficio federale della sanità pubblica*. [Online] 28 12 2017. [Riportato: 30 01 2018.] <https://www.bag.admin.ch/bag/it/home/service/publikationen/broschueren/publikationen-uebertragbare-krankheiten/poster-mt.html>.
7. Bontognali, Emanuele medico a Poschiavo dal 1988 al 2016, Russi, Hans veterinario a Poschiavo dal 1978 al 2008 e Paganini, Claudio veterinario a Poschiavo dal 2008.
8. Zone a rischio di Borreliosi. *map.geo.admin.ch*. [Online] Confederazione Svizzera. [Riportato: 01 07 2017.] https://map.geo.admin.ch/?lang=it&topic=ech&bgLayer=ch.swisstopo.pixelkarte-farbe&layers=ch.swisstopo.zeitreihen,ch.bfs.gebaeude_wohnungs_register,ch.bav.haltstellen-oev,ch.swisstopo.swisstlm3d-wanderwege,ch.bag.zecken-lyme&layers_visibility=false,false,.
9. Rete di rilevamento automatica. *Ufficio federale di meteorologia e climatologia MeteoSvizzera*. [Online] Confederazione Svizzera, 17 08 2016. [Riportato: 10 07 2017.] <http://www.meteosvizzera.admin.ch/home/sistemi-di-rilevamento-e-previsione/stazioni-al-suolo/rete-di-rilevamento-automatica.html?station=beh>.
10. Rete di rilevamento automatica. *Ufficio federale di meteorologia e climatologia MeteoSvizzera*. [Online] Confederazione Svizzera, 17 08 2016. [Riportato: 10 07 2017.] <http://www.meteosvizzera.admin.ch/home/sistemi-di-rilevamento-e-previsione/stazioni-al-suolo/rete-di-rilevamento-automatica.html?station=rob>.
11. Jagdtermine. *Amt für Jagd und Fischerei Graubünden*. [Online] 01 07 2016. [Riportato: 27 04 2017.] https://www.gr.ch/DE/institutionen/verwaltung/bvfd/ajf/NewsDokumente/jagdtermine16_17.pdf.

12. Jouda, Fatima, Perret, Jean-Luc e Gern, Lise. *Ixodes ricinus Density, and Distrinution and Prevalence of Borrelia burgdorferi Senu Lato Infection Along an Altitudinal Gradient*. s.l. : Journal of Medical Entomology, 2004.
13. Herrmann, Coralie e Gern, Lise. *Survival of Ixodes ricinus (Acari: Ixodidae) Under Challenging Conditions of Temperature and Hunidity Is Influenced by Borrelia Burgdorferi sensu lato Infection*. s.l. : Journal of Medical Entomology, 2010.
14. Bassetti, Stefano. *"Neue" Infektionskrankheiten in der Schweiz durch den Klimawandel?* s.l. : Schweiz Med Forum, 2009.

Figures

1-7. Photo Michela Ferrari

Maps

1-2. Swisstopo basic map via map.geo.admin.ch

3-4. Swisstopo basic map via map.geo.admin.ch; coat of arms of the Swiss Confederation from https://www.admin.ch/gov/it/_jcr_content/logo/image.imagespooler.png/1443434095646/Logo%20Schweizerische%20Eidgenossenschaft.png

5. Swisstopo basic map via map.geo.admin.ch

6-7. Swisstopo basic map via map.geo.admin.ch; coat of arms of the Swiss Confederation from https://www.admin.ch/gov/it/_jcr_content/logo/image.imagespooler.png/1443434095646/Logo%20Schweizerische%20Eidgenossenschaft.png

Graphics

1-3. Basic data from “Data portal for teaching and research (IDAweb)”, source MeteoSwiss

【評語】 180020

Climate warming is a global issue. This is a very interesting work related with environmental impact through the increase of ticks in the valley of Poschiavo. The expansion of amount of ticks will cause pathogens and represent a danger to human. The detection of tick during the hunting season (2016) was compared with climatic data such as relative humidity and temperature. Among the data collected, it is possible to show that climate change could have influenced the spread of ticks in valley of Poschiavo.