Supplemental Material

Nested species distribution models of *Chlamydiales* in tick host *Ixodes ricinus* in Switzerland

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Supp. File 1 – Prospective campaign

In order to select the sites visited during the prospective campaign, we proceeded in four steps:

1. Based on the already available ticks occurrences (data from the Swiss army field campaign and data from the smartphone application for 2015 to 2017), we run a MAXENT model to obtain a first map of suitability for ticks.
2. We performed a PCA on the environmental predictors extracted in the pixels predicted as potentially suitable for ticks (suitability from step 1 greater than 0.2).
3. We computed a k-means classification on the components of the PCA. This allowed us to define 5 environmental clusters on the Swiss territory (Figure 1).
4. We manually selected the sampling sites:
    - in areas defined as potentially suitable for ticks (suitability predicted at step 1 greater than 0.2),
    - such as to sample sites in each environmental cluster defined at step 2,
    - such as to maximise the number of sites that can be visited during one day (i.e. the sites can be link together by roads or paths),
    - so as to complete the dataset already available regarding the presence of *Chlamydiales* bacteria (data from the Swiss army field campaign).

As a result, 96 sites were visited and ticks were found in 81 of them, corresponding to 228 ticks. In addition, some relatives of the authors provided ticks they had collected. By this way, 28 additional ticks were received, from 14 new sites. In total, the prospective campaign therefore provided 256 ticks from 95 sites.

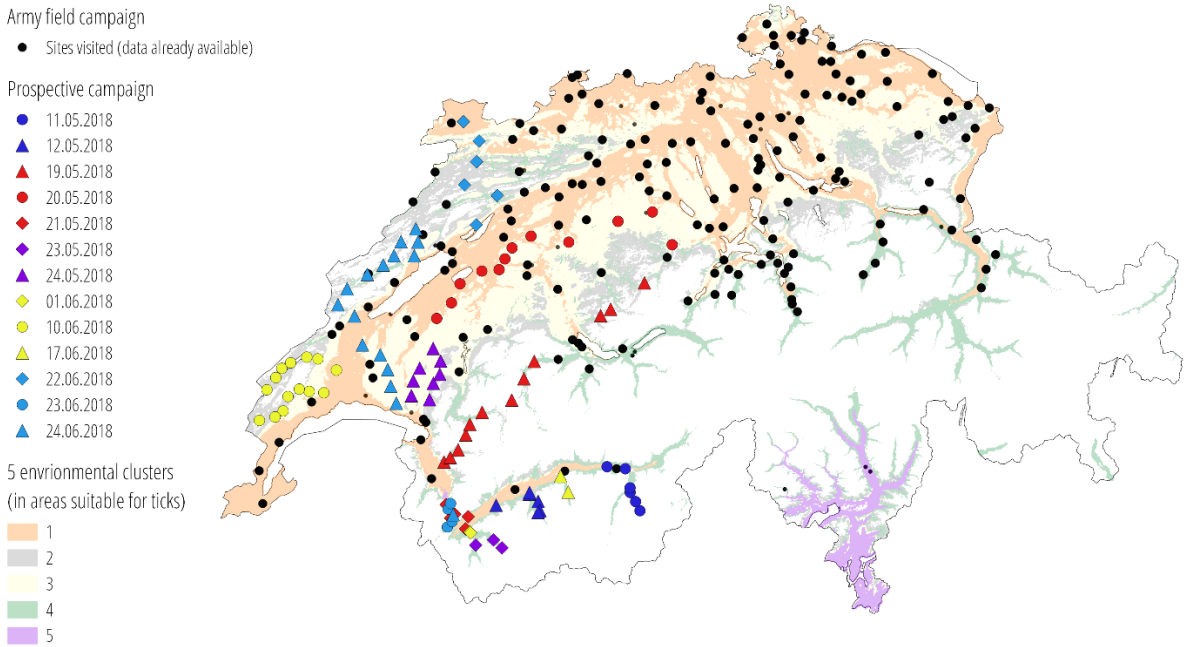
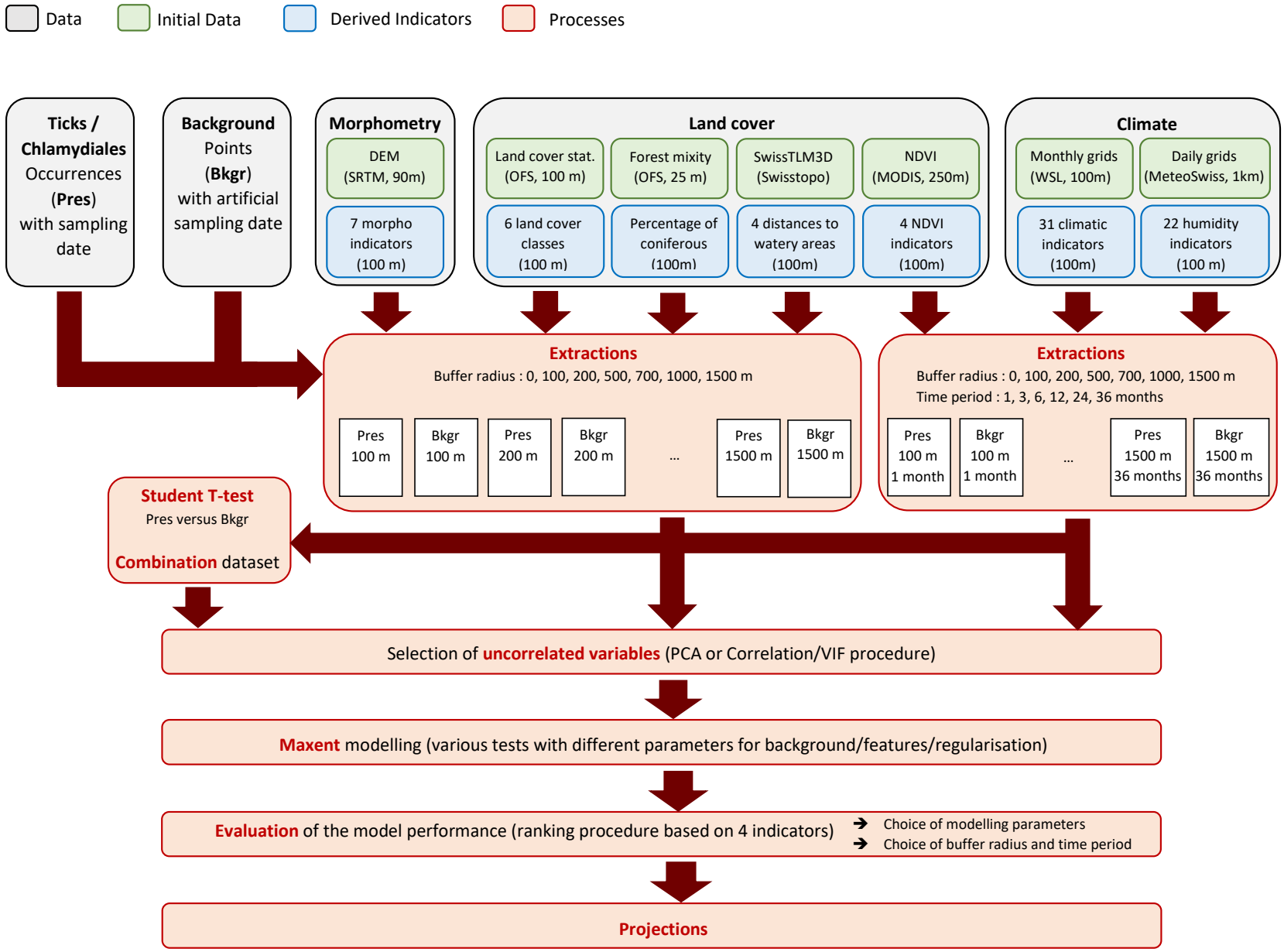


Figure 1: Map of the environmental clusters defined with the k-means performed on the PCA-components of the environmental predictors, and location of the sites visited during the prospective campaign.

Supp. File 2 – Method



Supp. File 3 – Environmental data

Morphometry

Initial data

- SRTM Digital Elevation Model
- **Spatial resolution**: 90 m
- **Source**: NASA Shuttle Radar Topography Mission (https://www2.jpl.nasa.gov/srtm/), with hole-filled version processed by the CIAT Agroecosystems Resilience project (Jarvis, 2008)
- **URL:** http://srtm.csi.cgiar.org/

Pre-processing

- The two tiles covering Switzerland were downloaded and merged using the QGIS 2.14.7 software (function merge from GDAL).
- The merged dataset was then resampled at a 100-m resolution and cropped to the Swiss extent using the SAGA "resampling" tool accessed from QGIS 2.14.7 and using the interpolation method: mean value (cell-area weighted).
- Null values were assigned for all pixels outside the Swiss borders.

Slope, Aspect, General Curvature (GC)

- **Method**: These indicators were computed in SAGA GIS 2.3. using the tool "Terrain Analysis > Morphometry > Slope, Aspect, Curvature", with the method "9 parameter 2nd order polynom" (Thorne *et al.*, 1987) and the units defined in degrees.

Morphometric Protection Index (MPI)

- **Definition**: This indicator provides a dimensionless index expressing how well an area is protected from the surrounding relief, based on the analysis of the environment surrounding each pixel up to a given distance. It is equivalent to the positive openness described by Yokoyama et al. (2002).
- **Method**: This indicator was computed in SAGA GIS 2.3.2 using the tool "Terrain Analysis > Morphometry > Morphometric Protection Index and the default parameters (the relief in the surrounding 2km of each pixel is taken into account).

Terrain Ruggedness Index (RI)

- **Definition**: This indicator compares the elevation of one pixel with the elevation of the neighbouring pixels to provide a measure of terrain heterogeneity (Riley *et al.*, 1999).
- **Method**: This indicator was computed in SAGA GIS 2.3.2 using the tool "Terrain Analysis > Morphometry > Terrain Ruggedness Index" with the default parameters (Radius (Cells)=1 indicating that one neighbour cell is considered in each direction).

Sky-view factor (SVF)

- **Definition**: This indicator provides an indication of the portion of sky that is obstructed by the surrounding relief: 0 = completely obstructed, 1=completely visible (Böhner and Antonić, 2009, p. 8)
- **Method**: This indicator was computed in SAGA GIS 2.3.2 using the tool "Terrain Analysis > Lighting, Visibility > Sky view factor" with the default parameters (Maximum search radius = 10 km).

Topographic Wetness Index (TWI)

- **Definition**: This indicator is defined from the ratio of the catchment area (area draining water to a given cell) to the local slope (indicator of the capacity to evacuate the water received) and is used as a proxy of soil moisture (Kopecký and Čížková, 2010).
- **Method**: First we computed the specific catchment area in SAGA GIS 2.3.2 using the tool "Terrain Analysis > Hydrology > Flow Width and Specific Catchment Area" with the default parameters (Aspect method). The TWI was then computed in SAGA GIS 2.3.2 using the tool "Terrain Analysis > Hydrology > Topographic Wetness Index" with the default parameters (Standard method).

Land Cover

Land cover classification

- Land cover classification in 6 classes : artificial areas, grass and herb vegetation, brush vegetation, tree vegetation, bare land and watery areas
- **Spatial resolution** : 100 m
- **Source**: Swiss Federal Statistical Office (OFS, 2017)
- **URL:** https://www.bfs.admin.ch/bfs/fr/home/statistiques/espace-environnement/nomenclatures/arealstatistik/nolc2004.html
- **Processing:** the only processing was to rasterise the data using the function rasterise in QGIS 2.14.7 (the initial data was available as a .csv file)

Percentage of coniferous in forest

Initial Data

- Raster file classifying the forests of Switzerland into four classes: pure coniferous, mixed coniferous, mixed broadleaved and pure broadleaved.
- **Spatial resolution**: 25 m, but with a grid translated by 12.5m as compared to the other data.
- **Source**: Swiss Federal Statistical Office (OFS, 2013)
- **URL:** https://www.bfs.admin.ch/bfs/fr/home/services/geostat/geodonnees-statistique-federale/sol-utilisation-couverture/donnees-derivees-autres-donnees/mixite-forets.html

Processing

- First, the raster with a spatial resolution of 25m was resampled in QGIS 2.14.7 to a raster with a spatial resolution of 12.5 m using the function "resample" with the nearest neighbour method.
- A percentage of conifers was then assigned to each 12.5m pixel according to the classification proposed by OFS:
    - 0 = no-forest => 0 % coniferous
    - 1 = coniferous forest => considered 100% coniferous
    - 2 = mixed forest predominantly coniferous => considered 70% coniferous
    - 3 = mixed forest predominantly broadleaved => considered 30% coniferous
    - 4 = broadleaved forest => considered 0% coniferous
    - 9 = unclassified => considered no forest => 0% coniferous
- The 12.5 m raster was aggregated to a 100 m target grid, by computing for each target cell the average percentage of coniferous using the tool "zonal statistics" in QGIS 2.14.7.
- The resulting grid was rasterised using the "rasterise" function in QGIS 2.14.7.

Distances to water areas

Initial Data

- Vector landscape model SwissTLM3D from 2016
- **Source**: Swiss Federal Office of Topography (O'Sullivan *et al.*, 2008)
- **URL:** https://shop.swisstopo.admin.ch/en/products/landscape/tlm3D

Processing

- All the elements characterising watery areas were extracted from the landscape model
    - For running water: the lines "Fliessgewaesser" and the polygons "Fliessgewaesser" extracted from the LandCover (Bodenbedeckung) polygons
    - For stagnant water: the lines "Stehendes Gewasser" and the polygons " "Stehendes Gewasser" extracted from the land cover (Bodenbedeckung) polygons
    - For the wetlands: the polygons "Feuchtgebiet" extracted from the land cover (Bodenbedeckung) polygons
- The vector layers were rasterised using the "rasterise" function in QGIS 2.14.7.
- For each pixel, the minimal Euclidean distance to each water category was then computed using the function "Raster > Analysis > Proximity" in QGIS 2.14.7. This resulted in three raster layers, representing the minimum distance to running water elements, stagnant water and wetlands, respectively.
- Finally, the minimum of the three raster files was used as the minimal distance to any watery element.

Vegetation Indexes

Initial Data

- MODIS Terra 16-days composite NDVI
- **Definition**: The 16-day composite NDVI is produced on 16-day intervals and provide an indicator of the greenness of the vegetation during these 16 days. NDVI is derived from the reflectance in the red and near-infrared (NIR) bands obtained from the images of the MODIS satellite.

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

A large amount of red wavelengths are absorbed by the vegetation during photosynthesis, while the near infrared is reflected, in a proportion that depends in particular on the leaf area index. Land covered by vegetation will therefore show a large difference between NIR and red reflectance, resulting in high NDVI values.

- **Units**: The valid range of value is -2000 to 10'000 with a scale factor of 0.0001 (i.e. a value of -2000 correspond to a NDVI of -0.2, whereas a value of 10'000 indicates a NDVI equals to 1.0)
- **Spatial resolution**: 250 m
- **Source**: NASA Moderate Resolution Imaging Spectoradiometer (MODIS) (Huete *et al.*, 1999)
- **URL:** https://modis.gsfc.nasa.gov/data/dataprod/mod13.php
- **Download:** https://search.earthdata.nasa.gov/

Processing

- We downloaded all images for the years 2006 to 2019.
- The hdf4 files were converted to .tif format using the "gdal_translate" function in R (R Development Core Team, 2008)
- The MODIS data being in sinusoidal projection, rasters were reprojected in the CH1903/LV03 projection system using the "projectRaster" function of the "raster" package in R

- The files were cropped and resampled to a 100m resolution using the “crop” and “resample” function from the “raster” package in R
- For each pixel, the monthly mean values were then computed in R.
- Finally, remaining null values were replaced by the average value of the neighbouring pixels using the “focal” function from the “raster” package in R.

Derived variables

Four indicators were derived for the period of interest (1, 3, 12, 24 or 36 months before the sampling date).

1. Average of monthly mean NDVI (***meanNDVIm***)
2. Minimum of monthly mean NDVI (***minNDVIm***)
3. Maximum of monthly mean NDVI (***maxNDVIm***)
4. Range of monthly mean NDVI (***RgeNDVIm***)

Climate

Temperature and precipitation

Initial Data

- Monthly mean, maximum and minimum temperature and monthly sum of precipitation
- **Spatial resolution**: 100 m
- **Source**: grids computed by the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), based on data from MeteoSwiss weather stations and a 100 m resolution digital elevation model aggregated from the DHM25 of SwissTopo. The computation was performed using Daymet software (Thornton *et al.,* 1997) and the reported mean absolute error (crossvalidation) is ~1°C for temperature and ~10-15% for precipitation (personal communication from WSL).
- **URL:** https://www.wsl.ch/de/projekte/climate-data-portal.html
  DHM25 Swisstopo**:** https://shop.swisstopo.admin.ch/fr/products/height_models/dhm25
  MeteoSwiss: https://www.meteoswiss.admin.ch/home/measurement-values.html

Derived variables

First, 15 indicators were derived for the period of interest (1, 3, 12, 24 or 36 months before the sampling date). Some of these indicators are very close to the worldclim bioclimatic variables (https://worldclim.org/data/bioclim.html). They were computed in R using two custom R functions (one defined for the treatment of data frame and the other for raster layers). The two functions are available in: https://github.com/estellerochat/SDM-Chlamydiales.

1. Average of the monthly mean temperatures over the period of interest (***meantmean***)
2. Maximum of the monthly maximal temperatures over the period of interest (***maxtmax***)
3. Minimum of the monthly maximal temperatures over the period of interest (***mintmax***)
4. Maximum of the monthly minimal temperature over the period of interest (***maxtmin***)
5. Minimum of the monthly minimal temperatures over the period of interest (***mintmin***)
6. Average of the monthly range of temperatures (***meanMoRge***)
7. Global range of temperature (maxtmax-mintmin) (***tRge***)
8. Isothermality (100*meanMoRge / tRge) (***isotherm***)
9. Temperature seasonality (standard deviation*100) (***tseason***)
10. Mean temperature of the coldest month (***mintmean***)
11. Mean temperature of the warmest month (***maxtmean***)
12. Total sum of precipitation (***sumprec***)
13. Maximum of the monthly sums of precipitation over the period of interest (***maxprec***)
14. Minimum of the monthly sums of precipitation over the period of interest (***minprec***)
15. Precipitation seasonality (Coefficient of Variation CV = sd/mean*100) (***pseason***)

Secondly, 16 additional indicators were derived when the period of interest was exceeding 3 months (i.e. 6, 12, 24 or 36 months) (CM="consecutive months")

1. Average of the monthly mean temperature of the 3 coldest CM (***meantmean3cold***)
2. Average of the monthly minimal temperature of the 3 coldest CM (***meantmin3cold***)
3. Average of the monthly maximal temperature of the 3 coldest CM (***meantmax3cold***)
4. Sum of precipitation of the 3 coldest CM (***prec3cold***)
5. Average of the monthly mean temperature of the 3 warmest CM (***meantmean3warm***)
6. Average of the monthly minimal temperature of the 3 warmest CM (***meantmin3warm***)
7. Average of the monthly maximal temperature of the 3 warmest CM (***meantmax3warm***)
8. Sum of precipitation of the 3 warmest CM (***prec3warm***)
9. Average of the monthly mean temperature of the 3 wettest CM (***meantmean3wet***)
10. Average of the monthly minimal temperature of the 3 wettest CM (***meantmin3wet***)
11. Average of the monthly maximal temperature of the 3 wettest CM (***meantmax3warm***)
12. Sum of precipitation of the 3 wettest CM (***prec3wet***)
13. Average of the monthly mean temperature of the 3 driest CM (***meantmean3dry***)
14. Average of the monthly minimal temperature of the 3 driest CM (***meantmin3dry***)
15. Average of the monthly maximal temperature of the 3 driest CM (***meantmax3dry***)
16. Sum of precipitation of the 3 driest CM (***meantmean3dry***)

Humidity variables

Initial Data

- Daily mean, maximum and minimum temperature
- **Spatial resolution**: 1 km
- **Source**: MeteoSwiss
- **URL:** https://www.meteoswiss.admin.ch/home/climate/swiss-climate-in-detail/raeumliche-klimaanalysen.html

Processing

- The daily grids were imported in R
- The daily relative humidity was computed using the same procedure as in Zimmermann *et al.* (2001)
    - Compute the average daytime temperature following Running *et al.* (1987)

$$t_{day} = 0.394\ t_{min} + 0.606\ t_{max}$$

    - Compute ambient vapour pressure using the Tetens equation for temperatures above 0°C (Murray, 1966) and minimum temperature as an approximation of dew point temperature (Running *et al.*, 1987)

$$VP_{amb} = 610.78 \exp\left(\frac{17.269\ t_{min}}{237.3 + \ t_{min}}\right)$$

    - Compute the potential vapour pressure of saturated air for daytime temperature using the Tetens equation for temperatures above 0°C (Murray, 1966) and the previously computed average daytime temperature:

$$VP_{sat} = 610.78\ exp\left(\frac{17.269\ t_{day}}{237.3 + \ t_{day}}\right)$$

    - Compute the relative Humidity (in %)

$$RH = \frac{VP_{amb}}{VP_{sat}} * 100$$

- The daily relative humidity grids were then aggregated to compute four monthly grids:

1. Monthly mean of RH
2. Monthly median of RH
3. Monthly quantile 0.25 of RH
4. Monthly quantile 0.75 of RH

Derived variables

22 indicators were derived for the period of interest (1, 3, 12, 24 or 36 months before sampling date). They were computed in R using two custom R functions (one defined for the treatment of data frame and the other for raster layers). The two functions are available in: https://github.com/estellerochat/SDM-Chlamydiales.

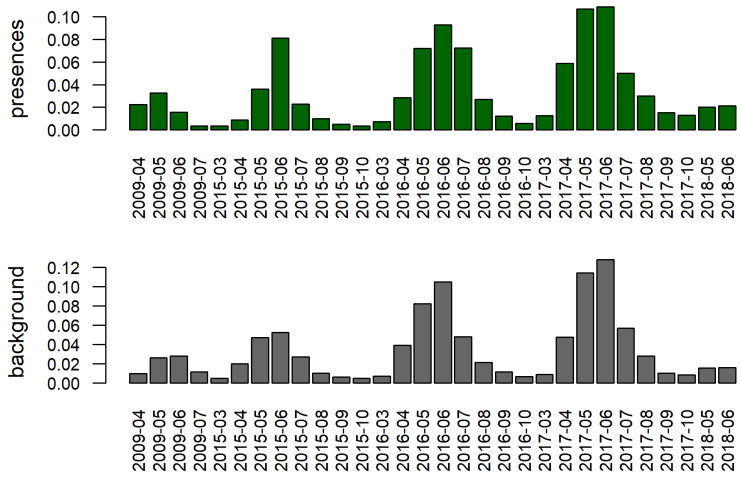
1. Average of monthly mean RH (***meanRHmean***)
2. Average of monthly median RH (***meanRHq050***)
3. Minimum of monthly mean RH (***minRHmean***)
4. Maximum of monthly mean RH (***maxRHmean***)
5. Minimum of monthly 0.25 quantile of RH (***minRHq025***)
6. Minimum of monthly 0.75 quantile of RH (***minRHq075***)
7. Maximum of monthly 0.75 quantile of RH (***maxRHq075*)**
8. Range of monthly RH (***RHrge***)
9. Average of the monthly ranges of RH (***RHMoRge***)
10. Mean daily RH (***meanRHD*)**
11. Median daily RH (***medRHD*)**
12. Minimum daily RH (***minRHD***)
13. Maximum daily RH (***maxRHD*)**
14. Range of daily RH (***rangeRHD***)
15. Quantile 0.25 of daily RH (***q025RHD***)
16. Quantile 0.75 of daily RH(***q075RHD***)
17. Number of days with RH<70% (***ndRHDinf70***)
18. Number of days with RH<80% (***ndRHDinf80***)
19. Number of days with RH>90% (***ndRHDsup90***)
20. Maximum number of consecutive days with RH< 70% (***ncdRHDinf70***)
21. Maximum number of consecutive days with RH< 80% (***ncdRHDinf80***)
22. Maximum number of consecutive days with RH>90% (***ncdRHDsup90***)

Supp. File 4 - Background datasets

Ixodes ricinus

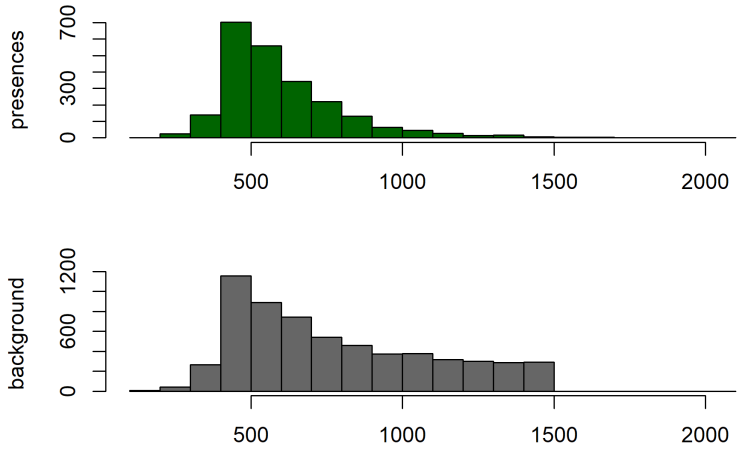
Sampling date

Distribution of sampling dates (month and year) of the occurrence dataset (presences, 2293 points) and selected background points below 1500 m (6050 points).



Altitude

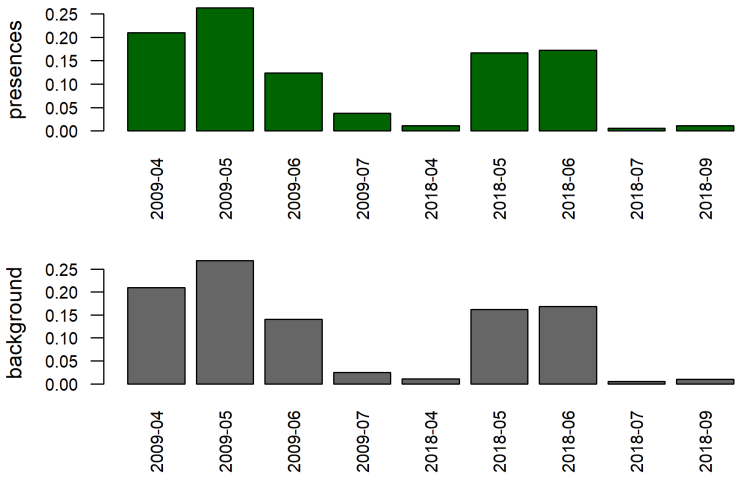
Distribution of altitude values of the occurrence dataset (presences, 2293 points) selected background points below 1500 m (6050 points).



Chlamydiales

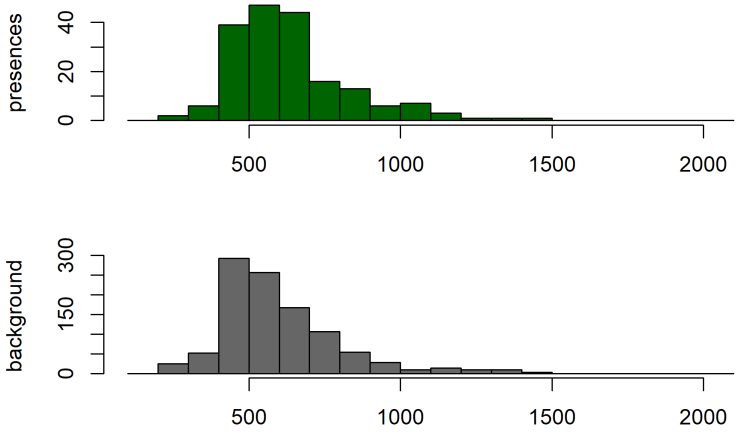
Sampling date

Distribution of sampling dates (month and year) of the occurrence dataset (presences, 186 points) and background points (1029 points).



Altitude

Distribution of altitude values of the occurrence dataset (presences, 186 points) and background points (1029 points).



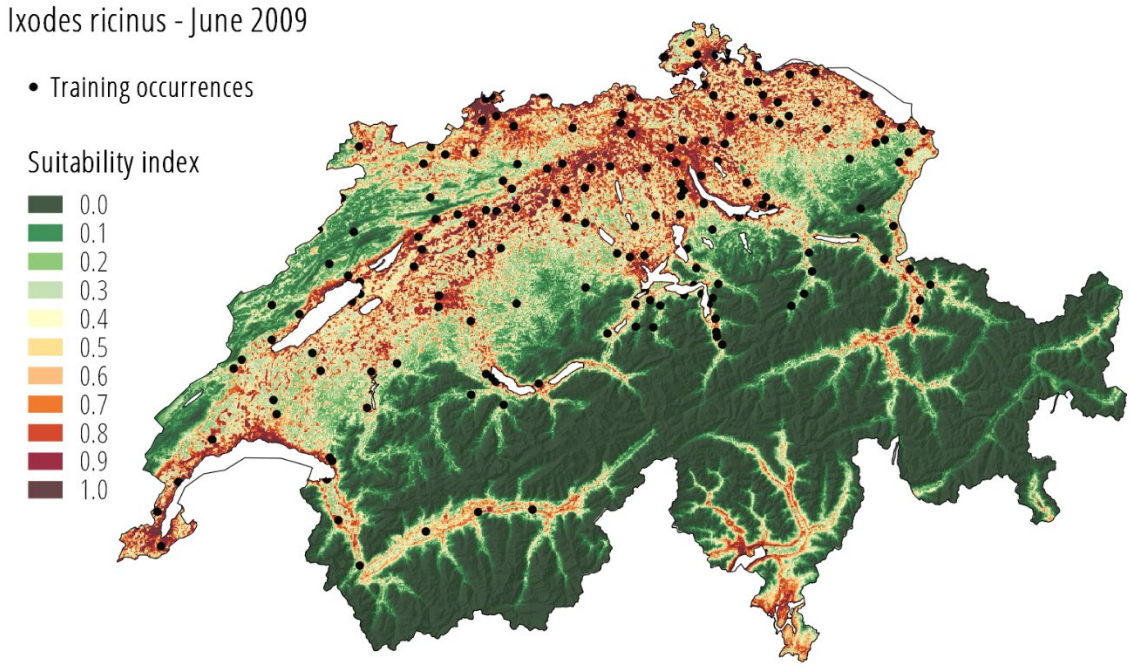
Supp. File 5 – *Ixodes ricinus* models

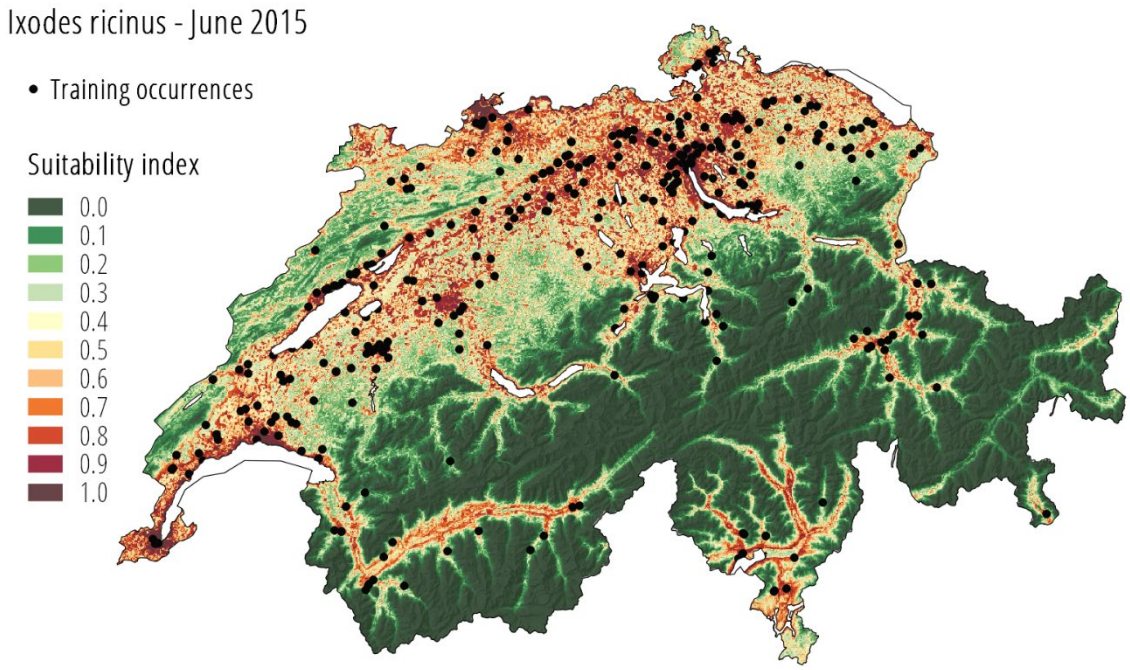
This tab provides the list of all models tested for the distribution of *Ixodes ricinus*. The mean and standard deviation (sd) values over the 20 runs are given for each of the evaluation parameters. ***reg*** is the value of the regularization multiplier. ***features*** indicate the features used (l=linear, lp=linear and product, lq = linear and quadratic, lpq=linear product and quadratic). ***OE_test*** is the omission error on the testing dataset and ***OE_indep*** on the independent dataset. **# coeff** is the number of non-zeros coefficients estimated by the model. The ranks (1-4) correspond to the ranking procedure defined in the method section. The final rank gives the final ranking of the models (1=best model, parameters selected for the final modelling).

Variables Selection	PCA %variance	reg	features	# env. predictors	rank1 AUC_test	rank2 OE_test	rank3 OE_indep	rank4 #coeffs	ranks sum	final rank	mean AUC_test	mean # coeff.	mean OE_test	mean OE_indep	mean AUC_train	mean BIC	sd AUC_test	sd # coeff	sd OE_test	sd OE_indep	sd AUC_train	sd BIC
corr/VIF	-	1	l	27	48	55	54	33	190	54	0.711	23.600	0.335	0.390	0.717	29766	0.009	1.095	0.046	0.049	0.003	14.130
corr/VIF	-	1	lp	27	41	53	56	55	205	56	0.733	92.550	0.312	0.428	0.752	30235	0.012	6.194	0.049	0.073	0.004	74.669
corr/VIF	-	1	lq	27	38	49	49	40	176	51	0.738	32.600	0.282	0.344	0.742	29724	0.009	1.729	0.058	0.062	0.003	19.955
corr/VIF	-	1	lpq	27	34	44	53	54	185	53	0.747	92.200	0.270	0.377	0.768	30120	0.012	5.187	0.040	0.052	0.004	53.552
corr/VIF	-	5	l	27	49	54	50	13	166	49	0.710	14.950	0.323	0.349	0.715	29662	0.010	1.099	0.045	0.039	0.003	16.042
corr/VIF	-	5	lp	27	46	56	55	37	194	55	0.721	28.350	0.336	0.397	0.728	29696	0.011	2.368	0.044	0.052	0.003	23.684
corr/VIF	-	5	lq	27	42	51	48	27	168	50	0.730	20.950	0.303	0.331	0.732	29622	0.010	1.504	0.049	0.048	0.003	16.430
corr/VIF	-	5	lpq	27	36	52	52	41	181	52	0.741	32.700	0.305	0.360	0.746	29641	0.008	2.638	0.045	0.050	0.003	25.442
PCA	50%	1	l	3	55	2	2	1	60	3	0.663	3.000	0.147	0.161	0.659	29756	0.010	0.000	0.049	0.042	0.004	11.505
PCA	50%	1	lp	3	56	1	1	2	60	4	0.660	5.600	0.140	0.154	0.660	29766	0.009	0.503	0.057	0.057	0.003	14.468
PCA	50%	1	lq	3	52	47	46	3	148	45	0.678	5.700	0.280	0.298	0.678	29656	0.010	0.470	0.053	0.052	0.003	14.073
PCA	50%	1	lpq	3	53	5	29	5	92	18	0.674	7.650	0.213	0.228	0.679	29665	0.011	0.988	0.079	0.083	0.004	14.545
PCA	70%	1	l	6	54	3	15	4	76	8	0.666	6.000	0.185	0.211	0.667	29757	0.008	0.000	0.069	0.067	0.003	9.190
PCA	70%	1	lp	6	51	15	47	21	134	43	0.691	19.100	0.234	0.300	0.703	29725	0.007	0.852	0.048	0.071	0.003	11.890
PCA	70%	1	lq	6	50	13	45	9	117	35	0.709	11.800	0.233	0.272	0.714	29591	0.011	0.410	0.068	0.086	0.004	18.314
PCA	70%	1	lpq	6	47	32	51	29	159	48	0.720	21.750	0.253	0.358	0.729	29588	0.008	1.209	0.065	0.107	0.003	21.109
PCA	80%	1	l	10	44	41	35	8	128	40	0.724	10.000	0.266	0.244	0.723	29658	0.010	0.000	0.059	0.060	0.004	13.431
PCA	80%	1	lp	10	32	36	41	44	153	47	0.749	42.250	0.255	0.258	0.757	29766	0.010	2.403	0.042	0.052	0.003	28.257
PCA	80%	1	lq	10	19	40	38	23	120	38	0.763	19.600	0.265	0.251	0.766	29475	0.011	0.503	0.037	0.039	0.004	25.669
PCA	80%	1	lpq	10	10	10	27	50	97	22	0.780	53.000	0.230	0.224	0.793	29582	0.008	1.522	0.046	0.045	0.003	23.603
PCA	80%	2	l	10	45	42	36	7	130	41	0.723	9.900	0.268	0.247	0.724	29644	0.010	0.308	0.060	0.049	0.003	14.195
PCA	80%	2	lp	10	33	38	39	42	152	46	0.747	33.450	0.262	0.254	0.754	29681	0.007	1.504	0.045	0.048	0.003	15.620
PCA	80%	2	lq	10	23	24	30	22	99	23	0.761	19.250	0.242	0.229	0.765	29447	0.008	0.851	0.058	0.056	0.003	17.258
PCA	80%	2	lpq	10	11	17	34	46	108	29	0.777	44.150	0.238	0.232	0.785	29505	0.009	2.412	0.043	0.044	0.003	26.689
PCA	80%	5	l	10	43	34	31	6	114	33	0.724	9.400	0.254	0.229	0.722	29621	0.010	0.598	0.040	0.029	0.003	15.508
PCA	80%	5	lp	10	39	19	14	19	91	17	0.736	17.150	0.240	0.211	0.739	29605	0.011	1.785	0.048	0.047	0.004	22.917
PCA	80%	5	lq	10	30	18	22	12	82	11	0.755	13.900	0.239	0.219	0.757	29410	0.011	1.210	0.050	0.047	0.004	26.847
PCA	80%	5	lpq	10	22	27	33	26	108	28	0.761	20.050	0.247	0.231	0.764	29410	0.012	1.276	0.057	0.058	0.004	24.385
PCA	90%	2	l	17	31	26	11	18	86	14	0.750	17.000	0.244	0.205	0.750	29575	0.009	0.000	0.040	0.033	0.003	14.684
PCA	90%	2	lp	17	6	9	20	51	86	15	0.788	80.150	0.230	0.219	0.799	29805	0.010	4.171	0.041	0.034	0.004	28.721
PCA	90%	2	lq	17	12	12	37	39	100	25	0.776	31.400	0.232	0.251	0.785	29450	0.009	0.883	0.036	0.040	0.003	18.655
PCA	90%	2	lpq	17	1	7	24	52	84	12	0.804	84.500	0.221	0.223	0.820	29678	0.007	2.911	0.036	0.034	0.002	33.233
PCA	90%	5	l	17	35	22	12	16	85	13	0.746	16.450	0.242	0.207	0.748	29544	0.010	0.759	0.032	0.028	0.004	16.702
PCA	90%	5	lp	17	26	46	32	38	142	44	0.758	30.950	0.274	0.230	0.771	29503	0.012	2.259	0.057	0.053	0.004	31.500
PCA	90%	5	lq	17	17	21	42	31	111	32	0.770	22.050	0.241	0.258	0.777	29381	0.009	0.999	0.055	0.058	0.003	19.958
PCA	90%	5	lpq	17	8	4	26	43	81	10	0.783	34.800	0.209	0.224	0.789	29386	0.007	2.285	0.033	0.037	0.003	25.914
PCA	90%	10	l	17	37	29	21	10	97	20	0.739	12.200	0.252	0.219	0.740	29540	0.007	0.768	0.065	0.052	0.003	14.725
PCA	90%	10	lp	17	40	30	25	15	110	30	0.736	15.400	0.252	0.224	0.745	29531	0.011	1.353	0.050	0.041	0.003	15.650
PCA	90%	10	lq	17	21	33	43	11	108	27	0.763	13.400	0.253	0.263	0.761	29396	0.008	0.883	0.042	0.038	0.003	20.097
PCA	90%	10	lpq	17	25	37	44	14	120	37	0.759	15.150	0.259	0.267	0.764	29391	0.012	1.496	0.051	0.044	0.004	29.106
PCA	95%	5	l	24	20	43	8	30	101	26	0.763	21.950	0.270	0.202	0.773	29436	0.011	0.887	0.046	0.044	0.004	21.012
PCA	95%	5	lp	24	7	31	3	47	88	16	0.783	46.550	0.252	0.187	0.791	29492	0.011	3.605	0.041	0.036	0.004	25.573
PCA	95%	5	lq	24	9	6	5	36	56	1	0.781	26.750	0.220	0.195	0.789	29338	0.009	1.070	0.035	0.032	0.003	23.083
PCA	95%	5	lpq	24	4	16	9	48	77	9	0.795	48.700	0.235	0.203	0.806	29385	0.011	3.294	0.043	0.042	0.004	33.093
PCA	95%	10	l	24	29	48	17	17	111	31	0.756	16.900	0.280	0.214	0.762	29445	0.009	1.165	0.031	0.023	0.003	20.928
PCA	95%	10	lp	24	27	50	28	25	130	42	0.758	19.800	0.286	0.225	0.764	29451	0.010	1.322	0.051	0.046	0.003	15.838
PCA	95%	10	lq	24	16	14	7	20	57	2	0.770	18.100	0.233	0.202	0.777	29335	0.009	0.718	0.047	0.038	0.003	16.012
PCA	95%	10	lpq	24	18	23	10	24	75	7	0.770	19.650	0.242	0.204	0.778	29346	0.009	1.348	0.048	0.043	0.003	17.929
PCA	100%	5	l	69	15	35	4	45	99	24	0.773	42.550	0.255	0.187	0.784	29519	0.010	2.212	0.031	0.030	0.004	27.079
PCA	100%	5	lp	69	3	20	19	53	95	19	0.795	91.750	0.240	0.217	0.811	29721	0.011	5.129	0.047	0.037	0.004	52.228
PCA	100%	5	lq	69	5	8	6	49	68	5	0.790	48.900	0.226	0.201	0.799	29432	0.008	2.654	0.033	0.045	0.003	27.838
PCA	100%	5	lpq	69	2	25	40	56	123	39	0.803	93.800	0.243	0.255	0.824	29622	0.008	4.895	0.029	0.036	0.003	46.856
PCA	100%	10	l	69	24	45	18	28	115	34	0.760	21.700	0.272	0.215	0.764	29462	0.011	1.780	0.047	0.036	0.004	23.307
PCA	100%	10	lp	69	28	39	16	35	118	36	0.757	25.550	0.263	0.211	0.768	29467	0.010	2.911	0.036	0.030	0.003	21.902
PCA	100%	10	lq	69	14	28	23	32	97	21	0.774	23.150	0.248	0.222	0.777	29375	0.009	1.725	0.040	0.030	0.003	21.992
PCA	100%	10	lpq	69	13	11	13	34	71	6	0.774	25.450	0.230	0.210	0.779	29382	0.008	1.959	0.030	0.030	0.004	26.113

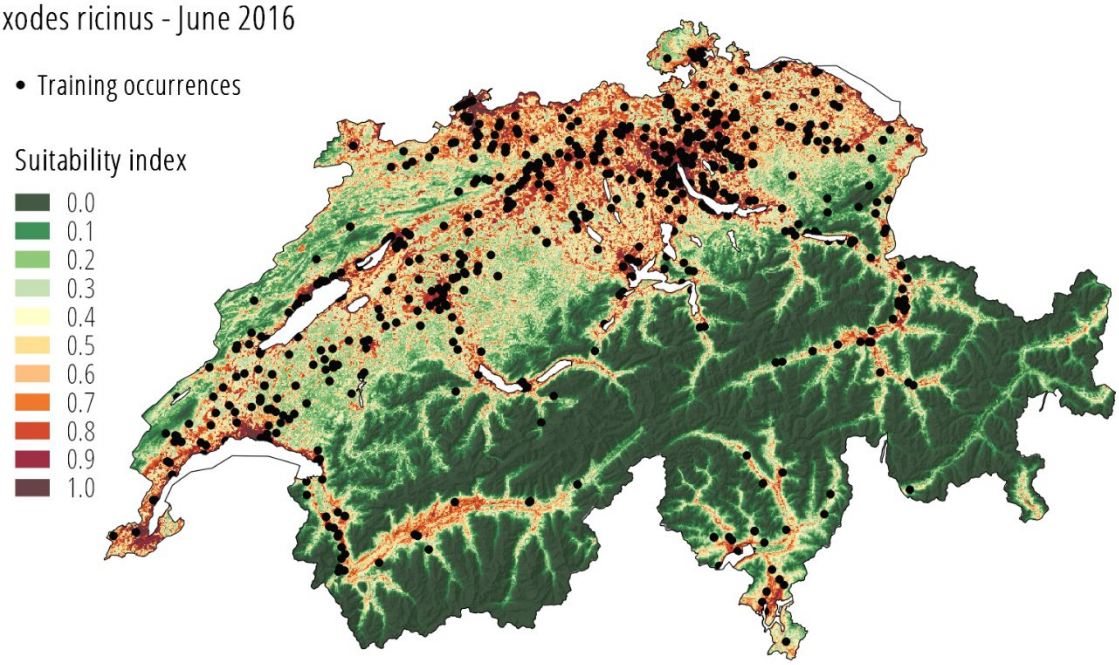
Supp. File 6 – *Ixodes ricinus* suitability maps

Maps of suitability predicted based on the “best” model presented in the paper.

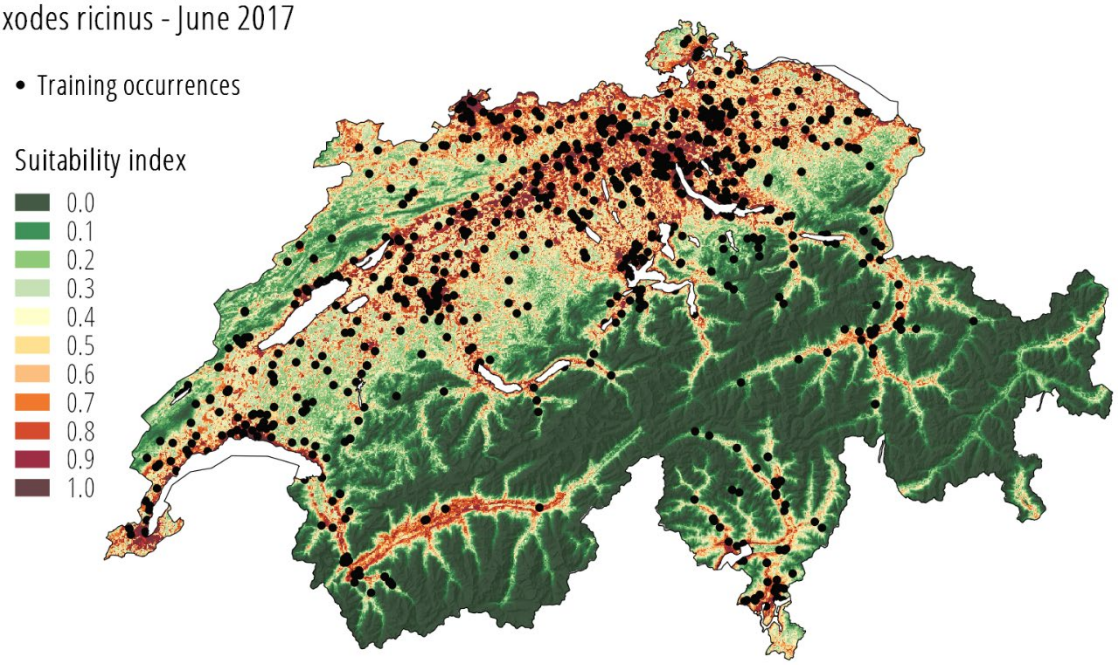




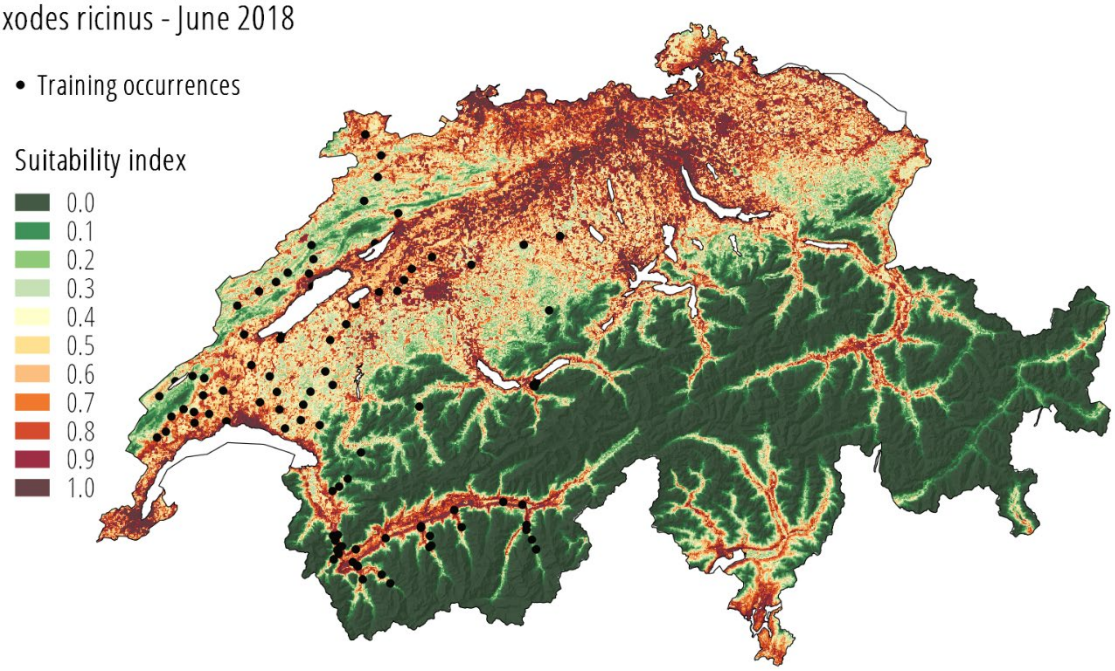
Ixodes ricinus - June 2016



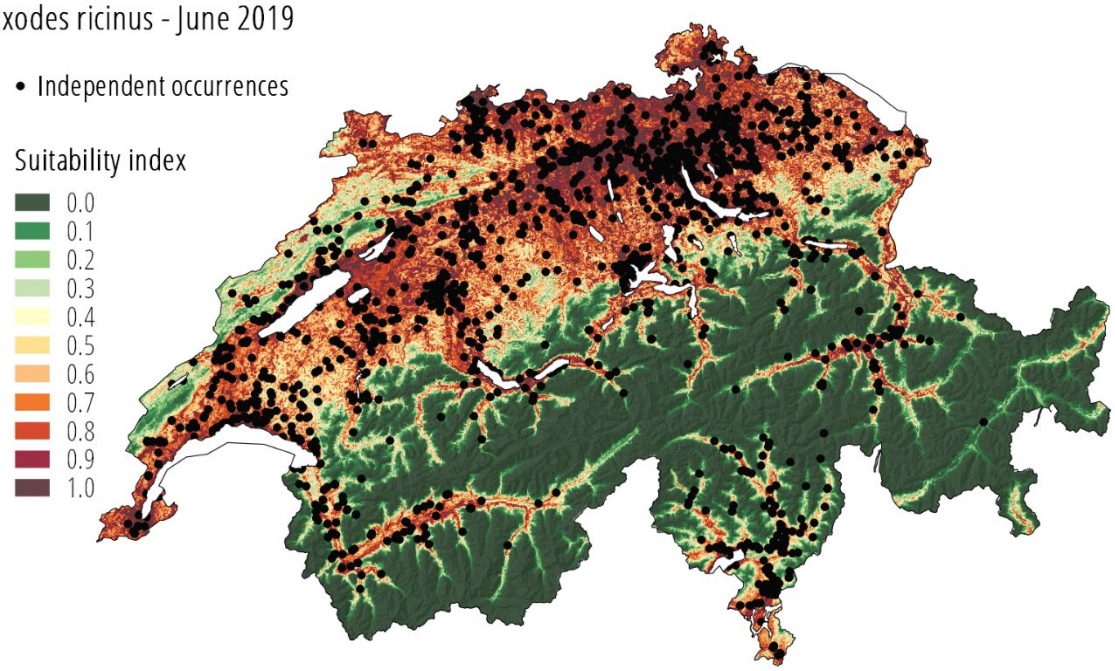
Ixodes ricinus - June 2017



Ixodes ricinus - June 2018



Ixodes ricinus - June 2019



Supp. File 7 – *Chlamydiales* models

This tab provides the list of all models tested for the distribution of *Chlamydiales*. The mean and standard deviation (sd) values over the 20 runs are given for each of the evaluation parameters. ***reg***. Is the value of the regularization parameter. ***feat.*** indicates the features used (l=linear, lp=linear and product, lq = linear and quadratic, lpq=linear product and quadratic). ***med suit. P 2009*** (resp. 2018) is the median of the suitability predicted on presences points from 2009 (resp. 2018). **med suit. "A" 2009** (resp. 2018) is the median of the suitability predicted at sites where no *Chlamydiales* were found ("absences") in 2009 (resp. 2018). **# coeff** is the number of non-zeros coefficients estimated by the model. The ranks (1-4) correspond to the ranking procedure defined in the method section. The final rank givse the final ranking of the models (1=best model, parameters selected for the final modelling).

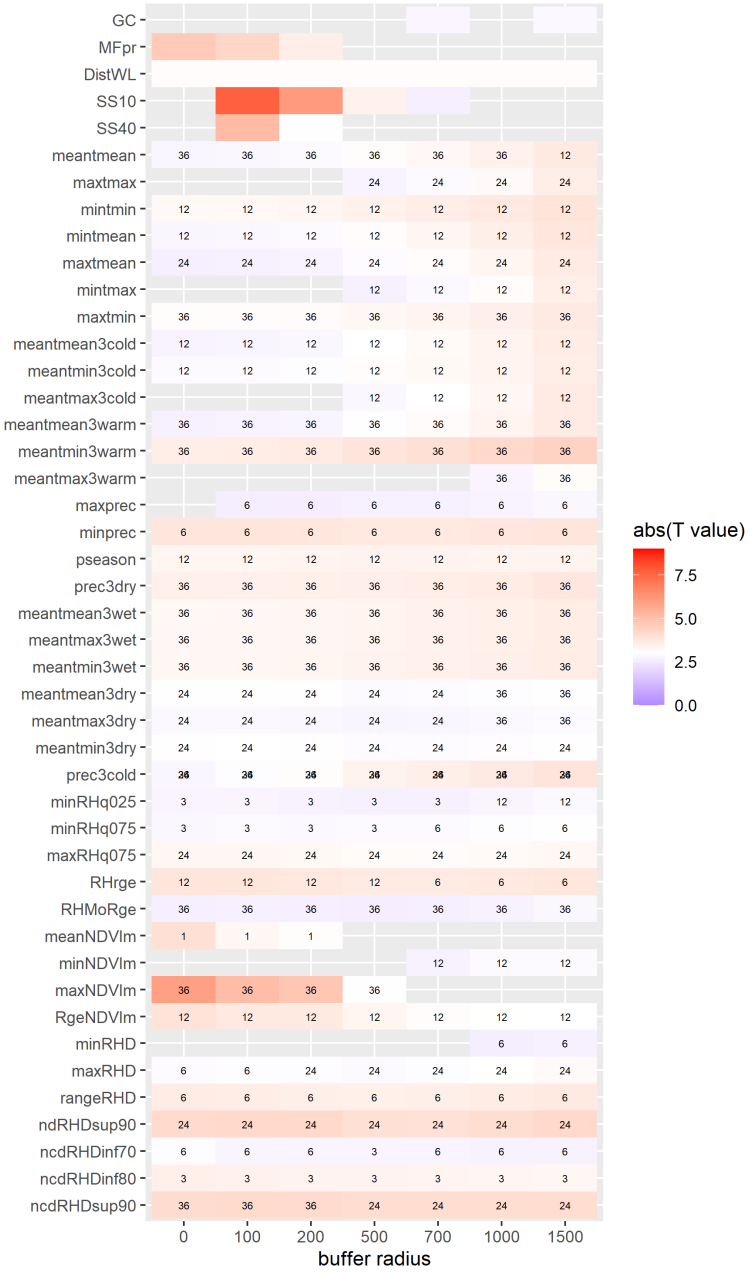
Variables Selection	PCA %var.	reg	feat.	# env	rank1 AUCtest	rank2 diff 2009	rank3 diff 2018	rank4 #coeffs	sum of ranks	final rank	mean AUCtest	mean #coeff.	mean med suit. P 2009	mean med suit. "A" 2009	diff 2009	mean med suit. P 2018	mean med suit."A"2018	diff 2018	mean AUCtrain	mean BIC
corr/VIF	-	1	l	26	15	32	32	26	105	24	0.699	23.65	0.407	0.322	0.085	0.429	0.234	0.195	0.733	1958.07
corr/VIF	-	1	lp	26	21	4	6	53	84	6	0.693	118.20	0.477	0.241	0.235	0.470	0.073	0.397	0.846	3152.50
corr/VIF	-	1	lq	26	1	16	15	35	67	1	0.744	36.20	0.467	0.346	0.121	0.458	0.150	0.308	0.789	2200.49
corr/VIF	-	1	lpq	26	23	3	4	54	84	7	0.690	121.55	0.485	0.242	0.243	0.479	0.058	0.421	0.863	3128.88
corr/VIF	-	5	l	26	32	31	34	20	117	34	0.679	17.90	0.422	0.336	0.085	0.450	0.263	0.186	0.732	1923.77
corr/VIF	-	5	lp	26	5	23	28	40	96	15	0.714	41.70	0.445	0.341	0.104	0.416	0.195	0.221	0.786	2044.63
corr/VIF	-	5	lq	26	2	33	27	25	87	10	0.730	22.60	0.460	0.376	0.084	0.470	0.246	0.223	0.771	1920.40
corr/VIF	-	5	lpq	26	3	24	24	42	93	13	0.726	46.35	0.462	0.359	0.103	0.440	0.192	0.248	0.794	2099.72
PCA	50%	1	l	4	56	52	55	1	164	55	0.584	3.00	0.407	0.358	0.049	0.490	0.424	0.066	0.604	1902.96
PCA	50%	1	lp	4	55	51	56	3	165	56	0.595	5.75	0.413	0.363	0.050	0.467	0.416	0.051	0.602	1916.03
PCA	50%	1	lq	4	54	47	49	4	154	52	0.611	5.95	0.417	0.361	0.056	0.453	0.314	0.139	0.653	1902.24
PCA	50%	1	lpq	4	52	35	53	7	147	50	0.622	8.55	0.426	0.343	0.083	0.422	0.293	0.129	0.650	1913.39
PCA	70%	1	l	6	53	42	54	2	151	51	0.622	4.95	0.414	0.348	0.066	0.490	0.369	0.121	0.640	1901.84
PCA	70%	1	lp	6	51	45	52	15	163	54	0.637	14.15	0.408	0.348	0.060	0.474	0.342	0.132	0.654	1949.90
PCA	70%	1	lq	6	39	41	42	9	131	39	0.673	9.70	0.438	0.369	0.069	0.477	0.307	0.170	0.714	1897.24
PCA	70%	1	lpq	6	35	40	41	21	137	45	0.676	18.20	0.443	0.371	0.072	0.450	0.280	0.170	0.719	1941.72
PCA	80%	1	l	9	49	34	45	6	134	41	0.652	7.90	0.417	0.334	0.083	0.468	0.317	0.151	0.672	1906.33
PCA	80%	1	lp	9	16	27	25	33	101	19	0.697	33.15	0.393	0.299	0.093	0.448	0.205	0.244	0.756	2144.63
PCA	80%	1	lq	9	25	26	31	16	98	16	0.687	15.30	0.416	0.318	0.098	0.446	0.250	0.196	0.729	2013.86
PCA	80%	1	lpq	9	6	30	16	37	89	11	0.708	39.10	0.401	0.314	0.087	0.450	0.148	0.301	0.781	2303.41
PCA	90%	1	l	14	46	38	37	13	134	42	0.665	12.60	0.412	0.333	0.079	0.452	0.273	0.179	0.694	1921.21
PCA	90%	1	lp	14	47	6	17	49	119	35	0.663	79.50	0.437	0.235	0.202	0.393	0.108	0.285	0.790	3111.37
PCA	90%	1	lq	14	27	46	33	29	135	43	0.685	24.85	0.404	0.346	0.058	0.410	0.223	0.187	0.748	2052.67
PCA	90%	1	lpq	14	12	5	8	50	75	2	0.702	87.20	0.441	0.232	0.209	0.417	0.080	0.337	0.815	3053.53
PCA	90%	2	l	14	38	39	39	12	128	37	0.674	12.25	0.418	0.344	0.074	0.455	0.284	0.172	0.692	1916.91
PCA	90%	2	lp	14	24	10	19	45	98	17	0.688	67.65	0.441	0.268	0.173	0.431	0.150	0.281	0.780	2956.55
PCA	90%	2	lq	14	11	48	38	28	125	36	0.703	24.15	0.427	0.371	0.055	0.420	0.245	0.175	0.741	1977.26
PCA	90%	2	lpq	14	34	9	14	47	104	22	0.676	76.10	0.454	0.274	0.180	0.431	0.121	0.310	0.816	2985.31
PCA	90%	5	l	14	43	37	44	11	135	44	0.668	11.55	0.435	0.356	0.080	0.463	0.306	0.157	0.686	1912.04
PCA	90%	5	lp	14	17	14	23	41	95	14	0.697	42.90	0.469	0.327	0.141	0.467	0.213	0.253	0.762	2245.18
PCA	90%	5	lq	14	26	49	43	23	141	49	0.686	21.15	0.439	0.387	0.052	0.440	0.275	0.165	0.744	1949.26
PCA	90%	5	lpq	14	4	13	21	43	81	4	0.715	49.35	0.493	0.352	0.142	0.465	0.207	0.257	0.791	2266.37
PCA	90%	10	l	14	48	36	48	8	140	48	0.663	9.45	0.448	0.368	0.081	0.466	0.324	0.141	0.676	1901.83
PCA	90%	10	lp	14	33	17	35	27	112	32	0.678	23.95	0.477	0.359	0.118	0.470	0.285	0.185	0.728	1990.70
PCA	90%	10	lq	14	30	44	47	18	139	46	0.681	15.65	0.462	0.401	0.061	0.456	0.308	0.148	0.724	1910.89
PCA	90%	10	lpq	14	19	20	36	30	105	25	0.694	26.75	0.481	0.374	0.107	0.474	0.292	0.181	0.753	2000.00
PCA	95%	5	l	19	36	29	46	17	128	38	0.675	15.35	0.435	0.348	0.088	0.425	0.277	0.149	0.700	1924.01
PCA	95%	5	lp	19	41	11	18	46	116	33	0.671	73.50	0.489	0.319	0.170	0.467	0.186	0.281	0.802	2591.90
PCA	95%	5	lq	19	18	50	40	31	139	47	0.695	29.35	0.452	0.401	0.051	0.423	0.253	0.171	0.747	2034.82
PCA	95%	5	lpq	19	28	12	11	48	99	18	0.683	78.90	0.496	0.354	0.142	0.498	0.174	0.324	0.827	2717.13
PCA	95%	10	l	19	40	28	50	14	132	40	0.672	12.90	0.453	0.366	0.088	0.452	0.316	0.137	0.689	1911.28
PCA	95%	10	lp	19	29	15	29	34	107	27	0.682	35.95	0.486	0.363	0.123	0.479	0.277	0.202	0.744	2058.26
PCA	95%	10	lq	19	37	43	51	24	155	53	0.675	21.20	0.471	0.406	0.065	0.430	0.296	0.134	0.735	1938.55
PCA	95%	10	lpq	19	13	25	30	39	107	28	0.700	40.05	0.496	0.394	0.103	0.476	0.279	0.197	0.768	2145.56
PCA	100%	5	l	47	8	19	20	36	83	5	0.704	37.90	0.435	0.323	0.112	0.458	0.177	0.281	0.771	2063.43
PCA	100%	5	lp	47	50	1	2	55	108	29	0.639	211.95	0.674	0.292	0.382	0.583	0.098	0.485	0.918	3663.34
PCA	100%	5	lq	47	7	21	13	44	85	8	0.708	59.40	0.444	0.337	0.107	0.481	0.166	0.315	0.798	2214.48
PCA	100%	5	lpq	47	44	2	1	56	103	21	0.668	219.40	0.680	0.310	0.370	0.582	0.096	0.486	0.922	3676.00
PCA	100%	10	l	47	9	18	26	32	85	9	0.704	30.55	0.473	0.356	0.116	0.482	0.247	0.235	0.754	1975.76
PCA	100%	10	lp	47	42	7	9	52	110	30	0.668	113.05	0.537	0.342	0.196	0.532	0.196	0.336	0.850	2576.08
PCA	100%	10	lq	47	10	22	22	38	92	12	0.703	39.80	0.483	0.378	0.105	0.496	0.240	0.256	0.778	2020.73
PCA	100%	10	lpq	47	31	8	12	51	102	20	0.680	110.85	0.548	0.364	0.184	0.531	0.209	0.322	0.855	2628.10

Supp. File 8 - *Chlamydiales* : T-test and selection of variables

For the signification of the acronym names, please refer to Supp. File A2.3.

T-test

For each variable and buffer radius, the heatmap below shows the results of the T-test. Only results that were significant according to the p-value of the T-test are shown (grey area = no significant results). The numbers on the cells indicate the time period considered before sampling date (in number of months) which resulted in the highest T-value for the given combination of variable and buffer radius. Numerical values are available in the following table.



variable	buffer	time period (months)	mean1	sd1	mean0	sd0	P-value	T-value
SS10	B100m		7.76	11.79	16.76	25.282	6.49E-14	7.70
maxNDVIm	P	36	8335.76	530.03	8052.00	883.681	5.65E-09	-5.96
SS40	B100m		62.72	21.58	53.03	32.526	4.12E-07	-5.16
MFpr	P		39.37	30.52	27.86	31.863	4.21E-06	-4.70
meantmin3warm	B1500m	36	12.87	0.95	13.21	1.040	1.52E-05	4.40
ndRHDsup90	B200m	24	21.11	12.51	25.24	10.579	3.29E-05	4.23
ncdRHDsup90	B100m	36	3.12	1.35	3.57	1.328	4.44E-05	4.16
meanNDVIm	P	1	7296.71	940.89	6985.76	1156.039	8.18E-05	-3.99
RgeNDVIm	P	12	6378.89	1537.42	5883.24	1788.431	1.02E-04	-3.94
mintmin	B1500m	12	-4.82	1.25	-4.43	1.277	1.31E-04	3.88
prec3cold	B1500m	24	24.16	11.73	20.70	7.944	1.44E-04	-3.87
prec3cold	B1500m	36	24.16	11.73	20.70	7.944	1.44E-04	-3.87
RHrge	B100m	12	31.09	4.69	32.52	4.758	1.62E-04	3.83
minprec	B1500m	6	2.80	0.97	2.50	1.022	1.62E-04	-3.83
mintmean	B1500m	12	-2.23	1.07	-1.90	1.114	1.87E-04	3.79
prec3dry	B1500m	36	13.99	3.25	13.00	3.443	2.00E-04	-3.77
meantmean	B1500m	12	9.14	1.13	9.47	1.200	2.60E-04	3.70
rangeRHD	B1500m	6	44.68	4.29	45.95	4.292	2.62E-04	3.70
maxtmin	B1500m	36	15.26	1.19	15.61	1.083	2.81E-04	3.69
maxtmean	B1500m	24	18.01	1.21	18.37	1.300	2.90E-04	3.67
meantmean3warm	B1500m	36	18.08	1.19	18.43	1.293	2.90E-04	3.67
meantmax3cold	B1500m	12	2.57	1.04	2.89	1.264	2.97E-04	3.66
meantmean3cold	B1500m	12	-0.36	1.09	-0.03	1.259	3.48E-04	3.62
meantmax3wet	B1500m	36	18.00	6.71	19.84	4.413	3.78E-04	3.61
meantmin3wet	B1500m	36	9.03	5.41	10.51	3.595	3.84E-04	3.61
meantmean3wet	B1500m	36	13.29	5.98	14.93	3.945	3.85E-04	3.61
meantmin3cold	B1500m	12	-3.12	1.20	-2.77	1.354	4.18E-04	3.57
maxtmax	B1500m	24	23.61	1.45	24.02	1.518	4.49E-04	3.55
mintmax	B1500m	12	0.59	1.00	0.88	1.133	4.54E-04	3.55
ncdRHDinf80	P	3	29.71	9.04	27.14	9.929	5.31E-04	-3.51
pseason	B500m	12	47.02	10.59	44.24	8.316	8.06E-04	-3.40
maxRHq075	P	24	87.44	3.05	88.22	2.569	1.15E-03	3.29
maxRHD	B1500m	24	94.83	1.67	95.24	1.330	1.68E-03	3.18
meantmax3warm	B1500m	36	23.81	1.42	24.16	1.498	1.89E-03	3.14
DistWL	B1000m		2554.14	2311.95	3163.80	3062.125	1.89E-03	3.13
meantmean3dry	B1500m	36	4.37	3.72	5.27	3.591	2.44E-03	3.06
meantmin3dry	B1500m	24	7.54	4.17	8.55	4.132	2.53E-03	3.05
minRHq075	B1500m	6	67.80	2.81	67.12	3.235	3.19E-03	-2.97
ncdRHDinf70	P	6	16.00	6.65	14.44	6.435	3.37E-03	-2.96
meantmax3dry	B1500m	36	0.90	3.47	1.71	3.268	3.59E-03	2.94
minNDVIm	B1000m	12	1562.21	1297.28	1866.53	1461.392	4.22E-03	2.89
minRHq025	B1500m	12	56.33	3.66	55.49	3.983	4.66E-03	-2.85
GC	B1500m		0.00	0.00	0.00	0.000	4.76E-03	2.85
RHMoRge	B1500m	36	11.81	1.62	12.17	1.544	5.11E-03	2.83
maxprec	B1500m	6	16.33	6.61	14.89	4.944	5.19E-03	-2.82
minRHD	B1500m	6	49.55	3.37	48.82	3.792	7.75E-03	-2.68

mean1 is the mean of the values for occurrences points, ***mean0*** the mean of the values for background points, ***sd1*** the standard deviation of the values for occurrences points and ***sd0*** the standard deviation of the values for background points.

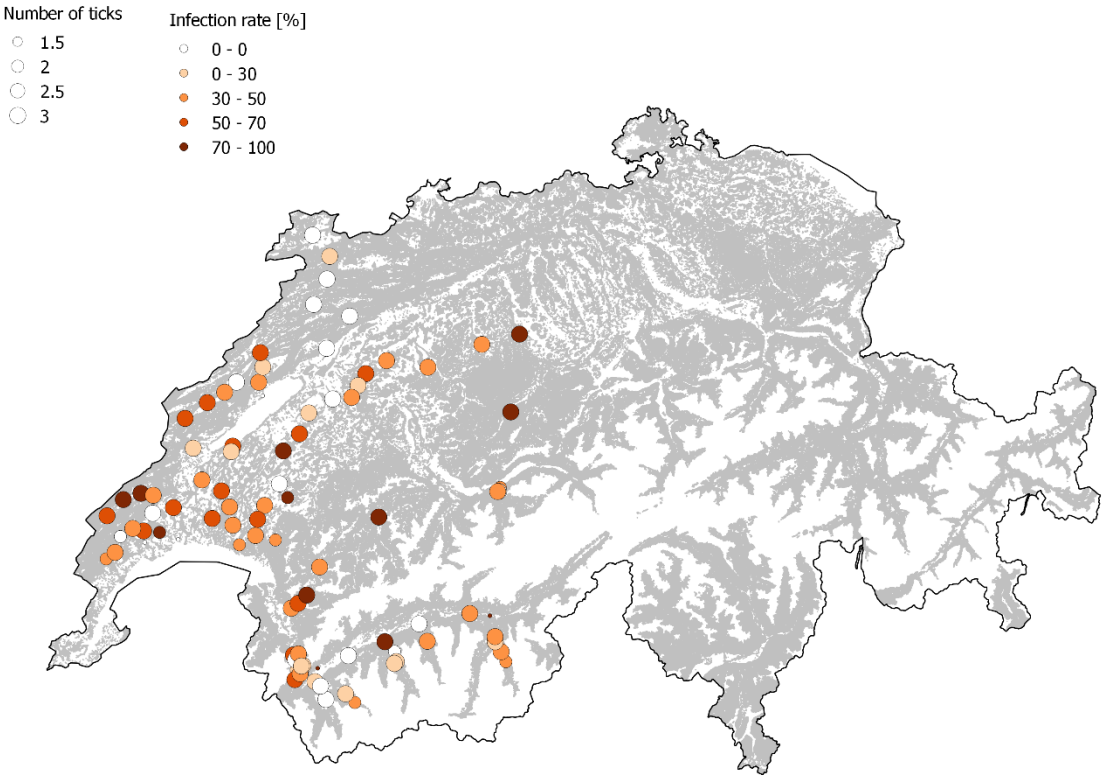
Uncorrelated variables used in the model

1. MFpr_P
2. ncdRHDinf80_P_3
3. ncdRHDinf70_P_6
4. maxRHq075_P_24
5. SS10_B100m
6. SS40_B100m
7. ncdRHDsup90_B100m_36
8. ndRHDsup90_B200m_24
9. DistWL_B1000m
10. GC_B1500m
11. minRHq075_B1500m_6
12. rangeRHD_B1500m_6
13. prec3cold_B1500m_24
14. maxRHD_B1500m_24
15. prec3dry_B1500m_36
16. meantmax3wet_B1500m_36
17. meantmean3dry_B1500m_36

Supp. File 9 - Infection rates

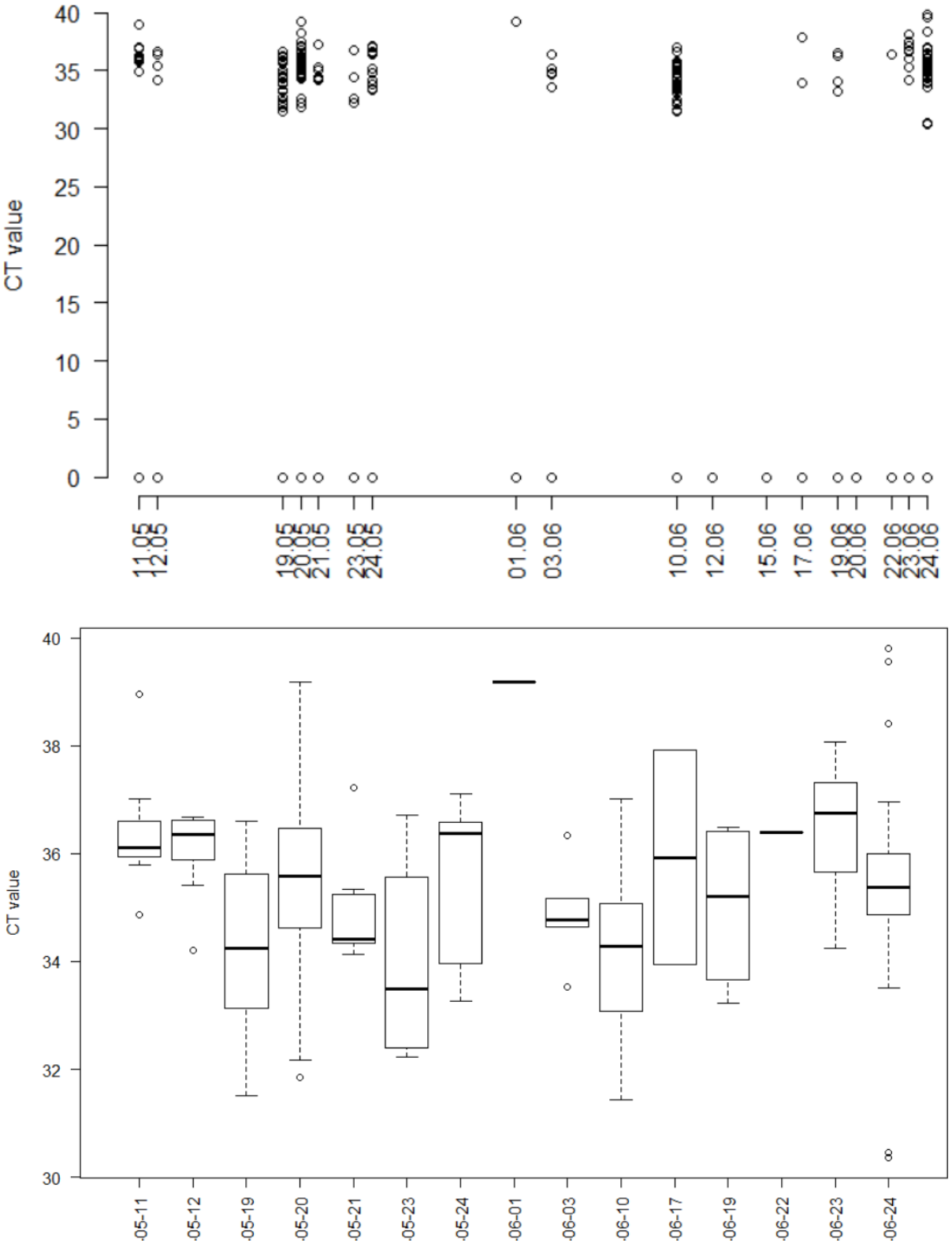
Infection rate prospective campaign: spatial distribution

The infection rate indicates no spatial clustering.



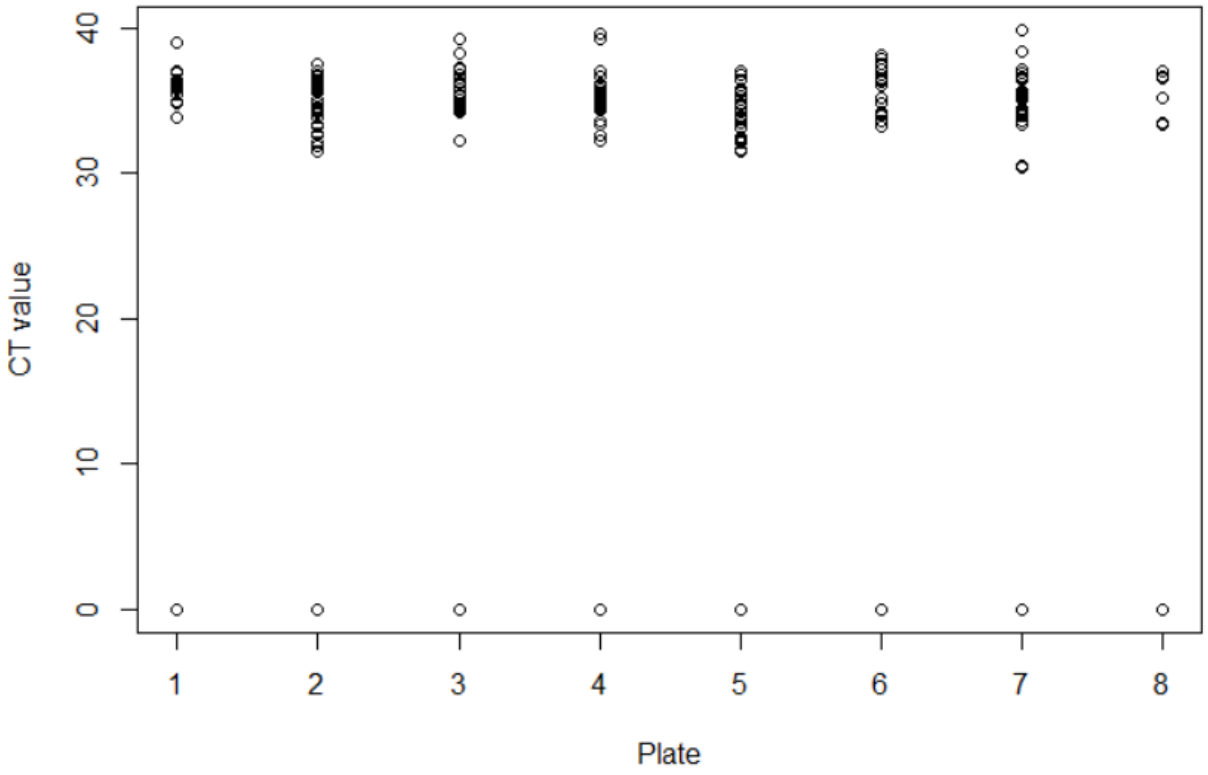
CT value as a function of sampling date

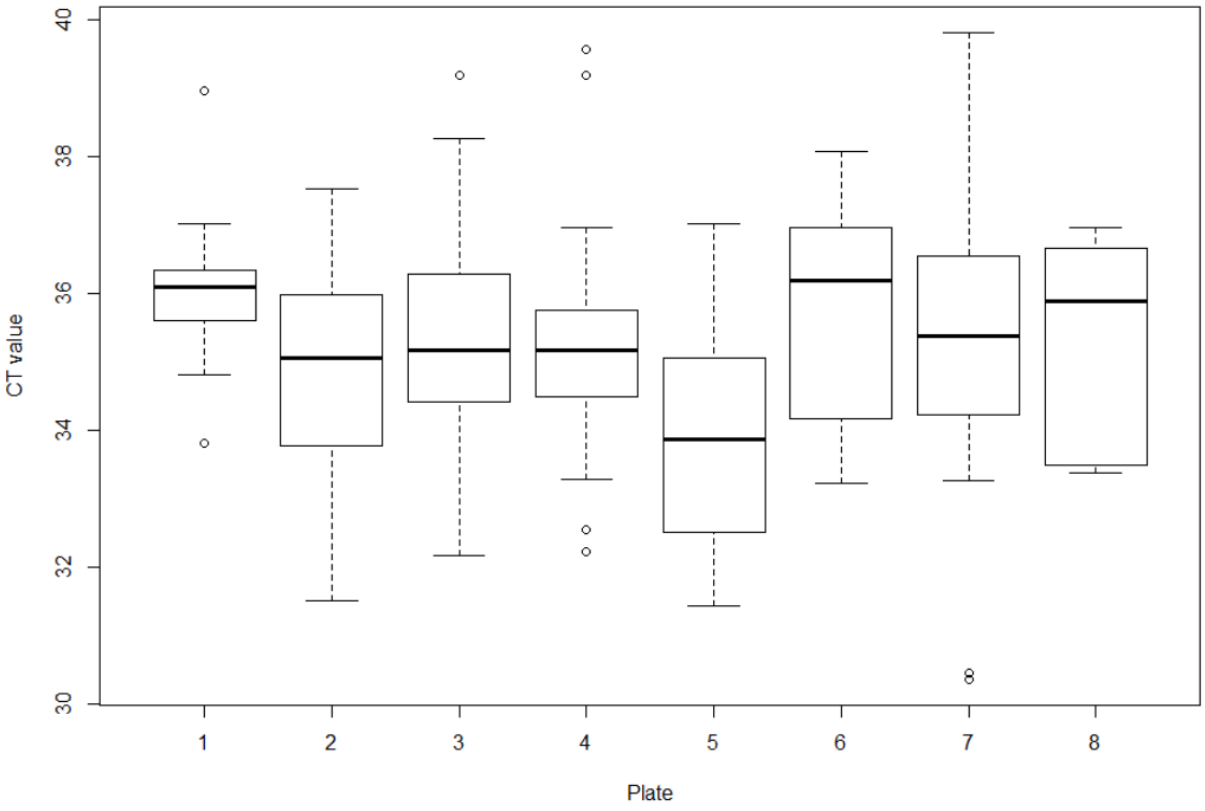
Results indicate no concentration of positive values for a given sampling date or a succession of dates. Negative results are also obtained for each sampling date.



CT value vs Plate

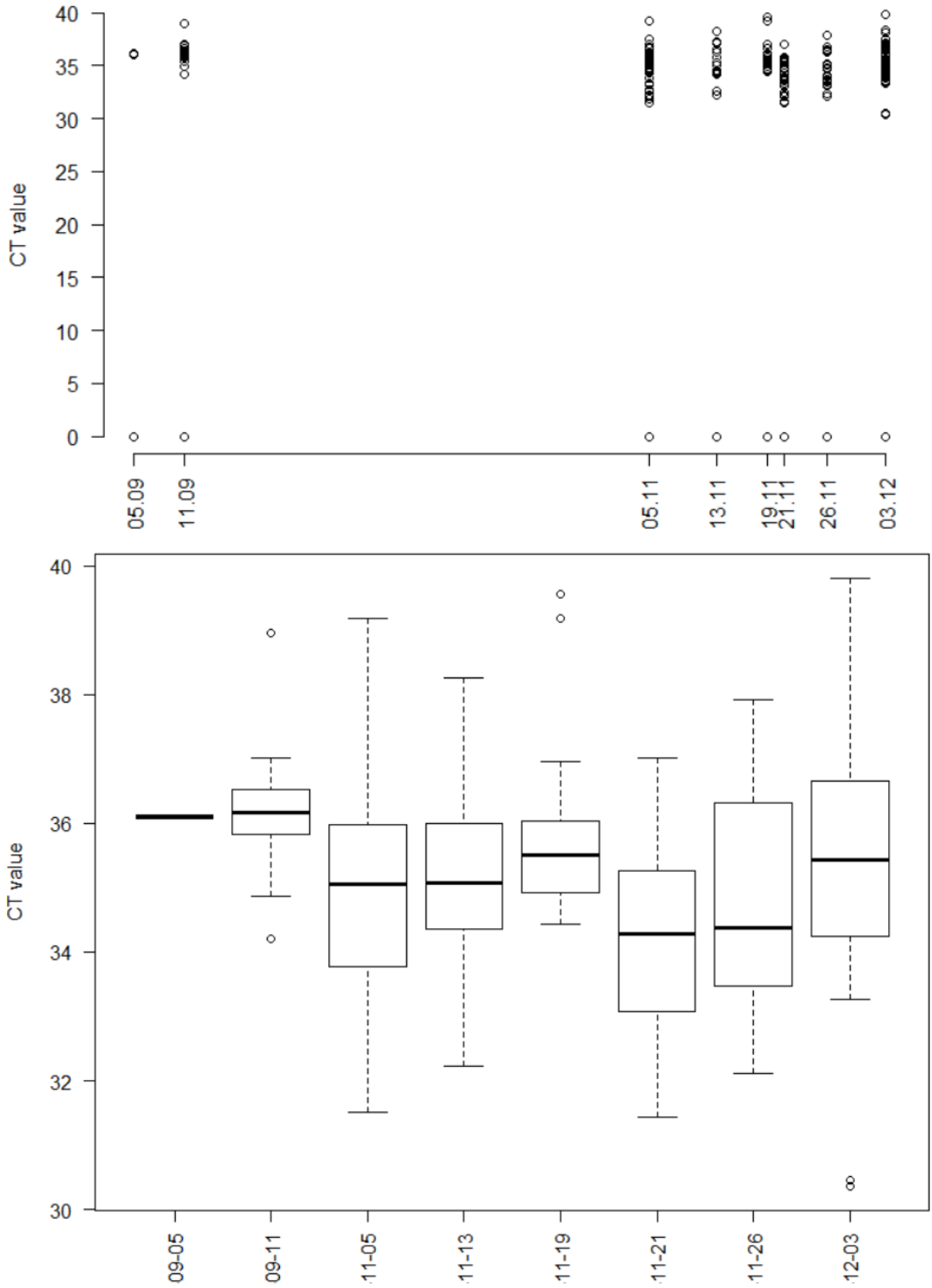
Results indicate no concentration of positive values for some plates. Negative results are also obtained on each plate.





CT value vs DNA Extraction Date

Results indicate no concentration of positive values for a given DNA-extraction date. Negative results are obtained for each extraction date.



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