BDEE 2021 – MARCH 2021

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MACROECOLOGICAL PATTERNS OF FRUIT INFESTATION RATES BY THE INVASIVE FLY *DROSOPHILA SUZUKII* IN THE RESERVOIR HOST PLANT *SAMBUCUS NIGRA*

Romain Ulmer, Olivier Chabrerie, Couty Aude, Eslin Patrice and contributors

Drosophila suzukii: an invasive pest of fruit crops

- Asian species, introduced in Europe and USA in late 2000s' (Cini et al., 2012).
- Highly polyphagous, many plant species can be used as host (Poyet et al., 2015).
  ➔ This includes species of agro-economical importance such as strawberries, blueberries, raspberries, *etc.*
- Knowledge about its ecology in natural environments remains scarce (Wang et al. 2016, Briem et al 2018)

Cini, A., Ioriatti, C., & Anfora, G. (2012). A review of the invasion of *Drosophila suzukii* in Europe and a draft research agenda for integrated pest management.
Poyet, M., Le Roux, V., Gibert, P., Meirland, A., Prévost, G., Eslin, P., & Chabrerie, O. (2015). PloS one, 10(11), e0142785.
Wang, X. G., Stewart, T. J., Biondi, A., Chavez, B. A., Ingels, C., Caprile, J., ... & Daane, K. M. (2016). Journal of Pest Science, 89(3), 701-712.
Briem, F., Dominic, A. R., … & Vogt, H. (2018). Explorative data analysis of Drosophila suzukii trap catches from a seven-year monitoring program in Southwest Germany. Insects, 9(4), 125.

Wild host plant species

- Important reservoir for the pest (Poyet et al. 2015, Kennis et al. 2016).

- Intra-specific heterogeneity in infestation rate among geographical areas.

  → caused by a heterogeneity of environmental conditions ?

- Latitudinal clines come with environmental clines, mainly macroclimatic cline (temperature, rainfall, etc.).
- Organisms respond through gradients of their life-history traits (Woods et al. 2012, Blanckenhorn et al. 2018) and interactions (Garibaldi et al. 2011).

➔ These gradients could be very important in the distribution of *D. suzukii* populations (Dos Santos et al. 2017), particularly in the current context of global climatic changes.

- Poyet M, Roux VL, et al (2015) The Wide Potential Trophic Niche of the Asiatic Fruit Fly *Drosophila suzukii:* The Key of Its Invasion Success in Temperate Europe? PLOS ONE 10:e0142785.
- Kenis M, Tonina L, Eschen R, et al (2016) Non-crop plants used as hosts by *Drosophila suzukii* in Europe. Journal of Pest Science 89:735–748.
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Aims

- Do host plants conserve their level of suitability as host for the invasive pest fly in various sites and environmental conditions (macroclimatic, landscape, local)?
- What are the roles of the environmental factors (local, landscape, macroclimatic) in the matching success between *D. suzukii* and its major host plants?
- Hypothesis: Geographic and climatic clines determine the level of fruit production by wild plant hosts, which should affect the infestation success of *D. suzukii*. But local conditions and landscape composition may also drive the local pest population levels or condition their access to the host plant.

- Approach: we used the elderberry *Sambucus nigra* as model host plant. It's a widespread species and an important reservoir host for *D. suzukii*.

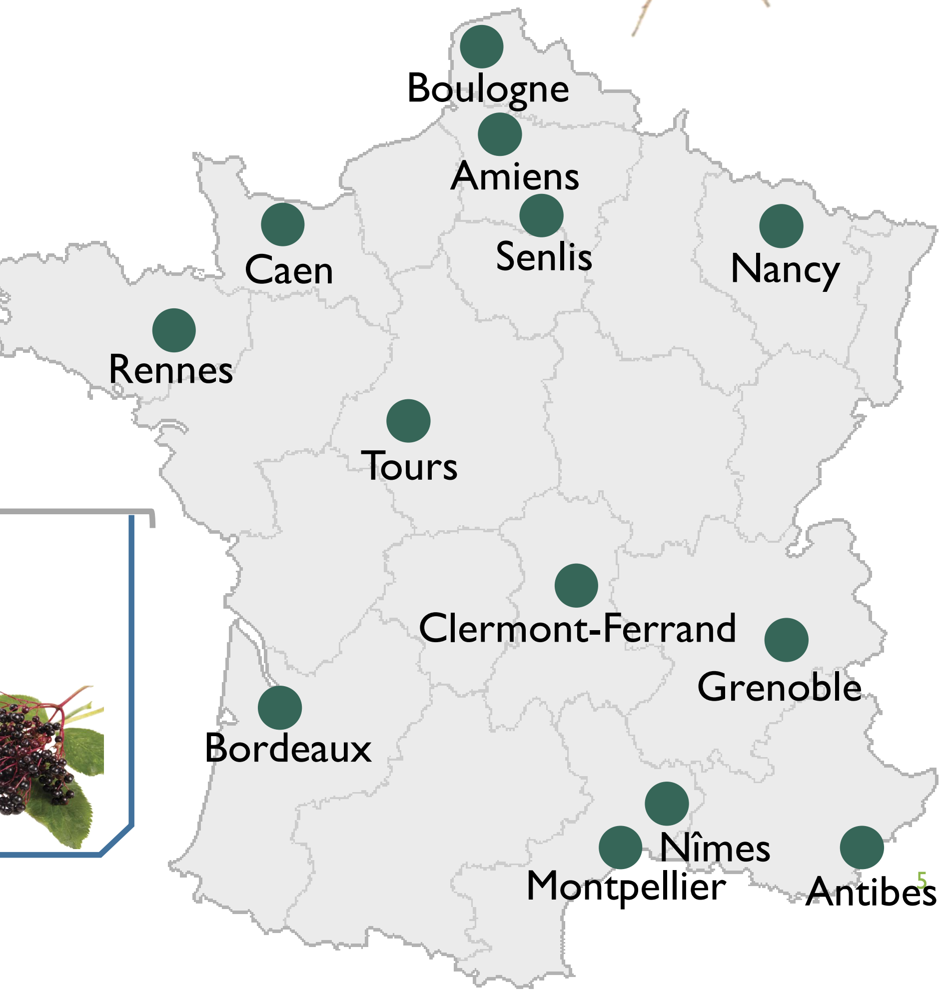
Material and method

- Sampling of elderberry corymbs in 13 regions of France between July and September 2020 (~15 corymb per region): 215 samples gathering 36 267 fruits of *Sambucus nigra*.

- Corymbs were kept in mesh covered box until emergence of adults *D. suzukii*.

- Parameter measured: *D. suzukii* emergence rate from wild elderberry.

- Explicative variables: environmental variables measured at different scales and elderberry traits.



Material and method

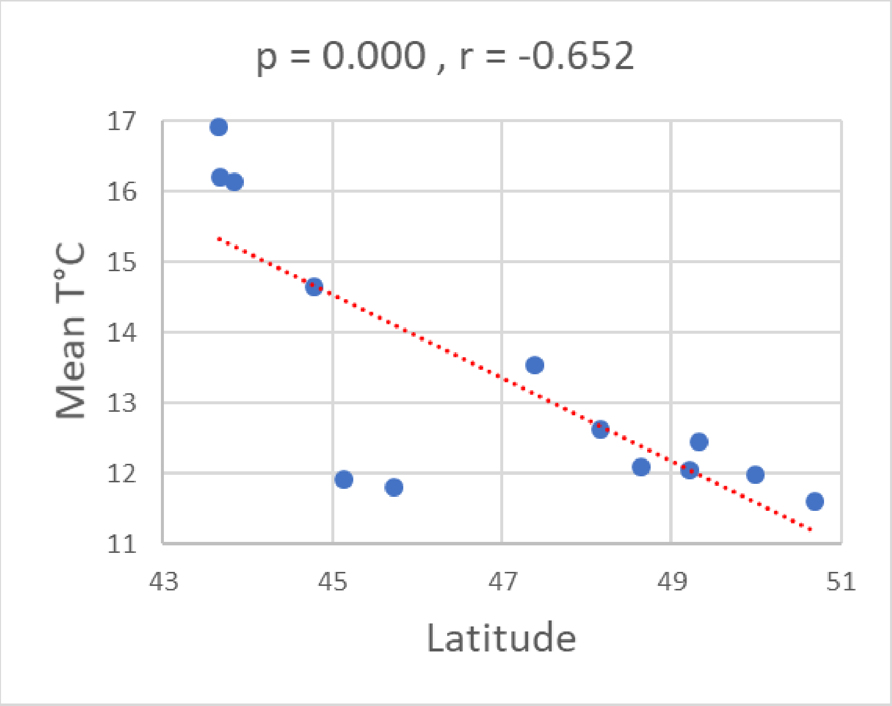
- Environmental variables :
  - Macroclimate (min, max, mean T°C, cumulative T°C and rainfall, frost days) between 01/01/2020 and the sampling day.
  - Landscape (area covered by buildings, forest, crop, road, orchards, water and heath and hedgerow and river length in 100, 500 and 1000 m-radius buffers around each sampling site).
  - Local abiotic and biotic conditions (slope, orientation, altitude, habitat surroundings of the sampled tree, fleshy-fruited plant species composition in the vicinity).
- Life history traits of the host plant : height of the tree, number of corymbs on the tree, size of the sampled corymb, number of fruits of each maturity stage on the corymb, mean diameter of the fruits, size of the leaves.

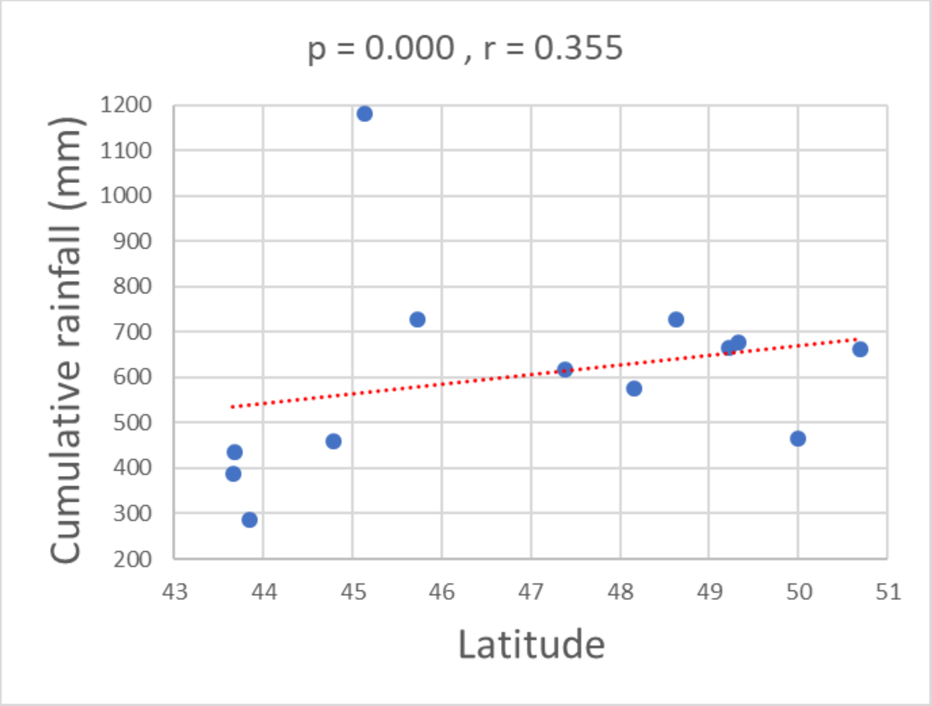
Statistical analysis :

- GLMM at the sampling site scale (region set as a random factor), n=215
- GLM at the region scale, n=13

Results

- 36 200 fruits from 215 sampled sites. Total of 3 891 emerging *D. suzukii*.
- Infestation rate (in %): mean = 9.74, min = 0.83 (Nîmes), max = 23.4 (Boulogne-sur-Mer).
- Correlation between latitude and macroclimate variables (temperature and rainfall).





Results

- Global linear mixed model at the sampling site scale (n=215). Dependent variable = number of emerging adults *D. suzukii*.
- Positive effect of the latitude and the number of fruits on the corymb.

Parameter	F	Estimation	s.e.	ddl	t	Sig.
Constant	17,235	-155,900326	37,553146	194	-4,151	0,000
Latitude	15,920	3,186290	0,798564	194	3,990	0,000
nFruits	58,461	0,146184	0,019119	194	7,646	0,000

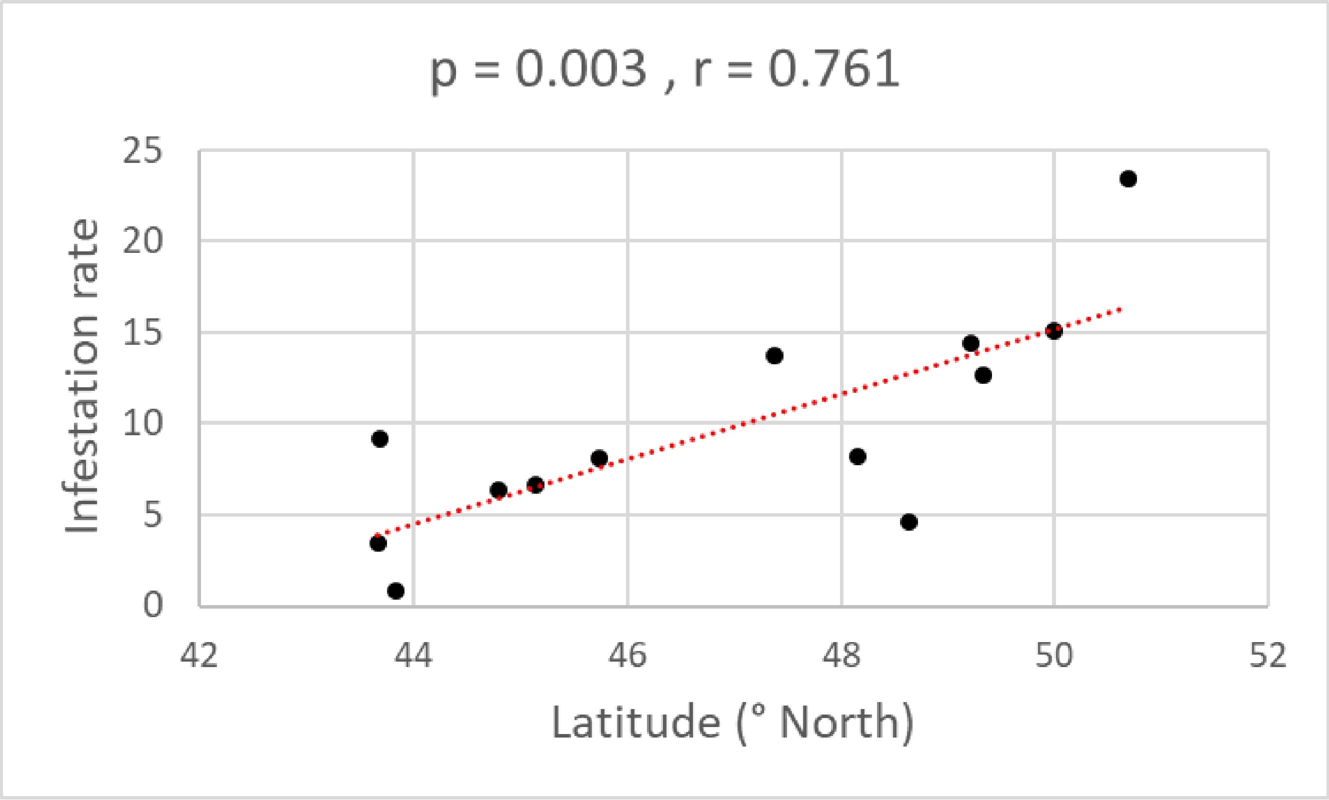
Results

- Global linear mixed model at the sampling site scale (n=215). Dependent variable = infestation rate.
- Positive effect of the number of ripe (black fruits) and the forest covered area in a 100 m radius around the site. Negative effect of the mean maximum temperature.

Parameter	F	Estimation	s.e.	ddl	t	Sig.
Constant	15,933	38,711173	9,698192	14,805	3,992	0,001
Black fruit	10,066	0,037739	0,011895	189,476	3,173	0,002
Tmax	13,190	-2,003369	0,551621	13,880	-3,632	0,003
Forest100	6,098	0,000253	0,000103	123,841	2,469	0,015

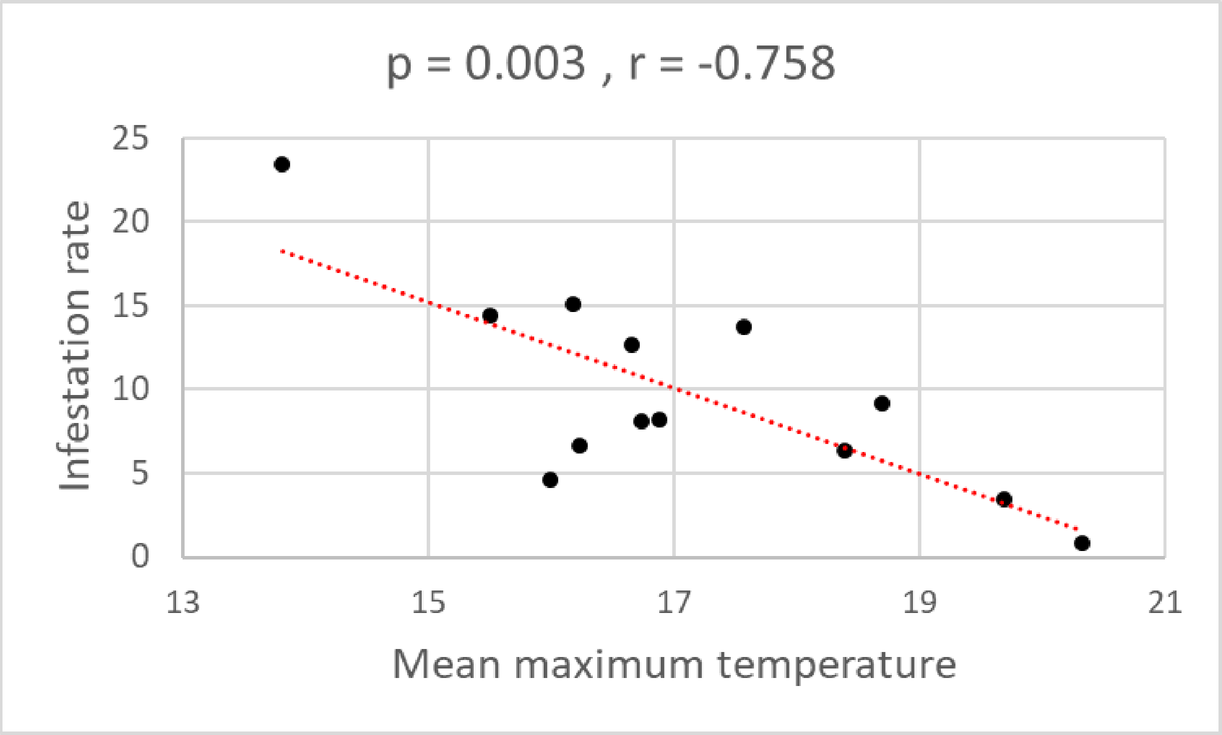
Results

- Positive correlation between the mean infestation rate (Number of emerging adult x 100 / number of fruit on the corymb) and the latitude



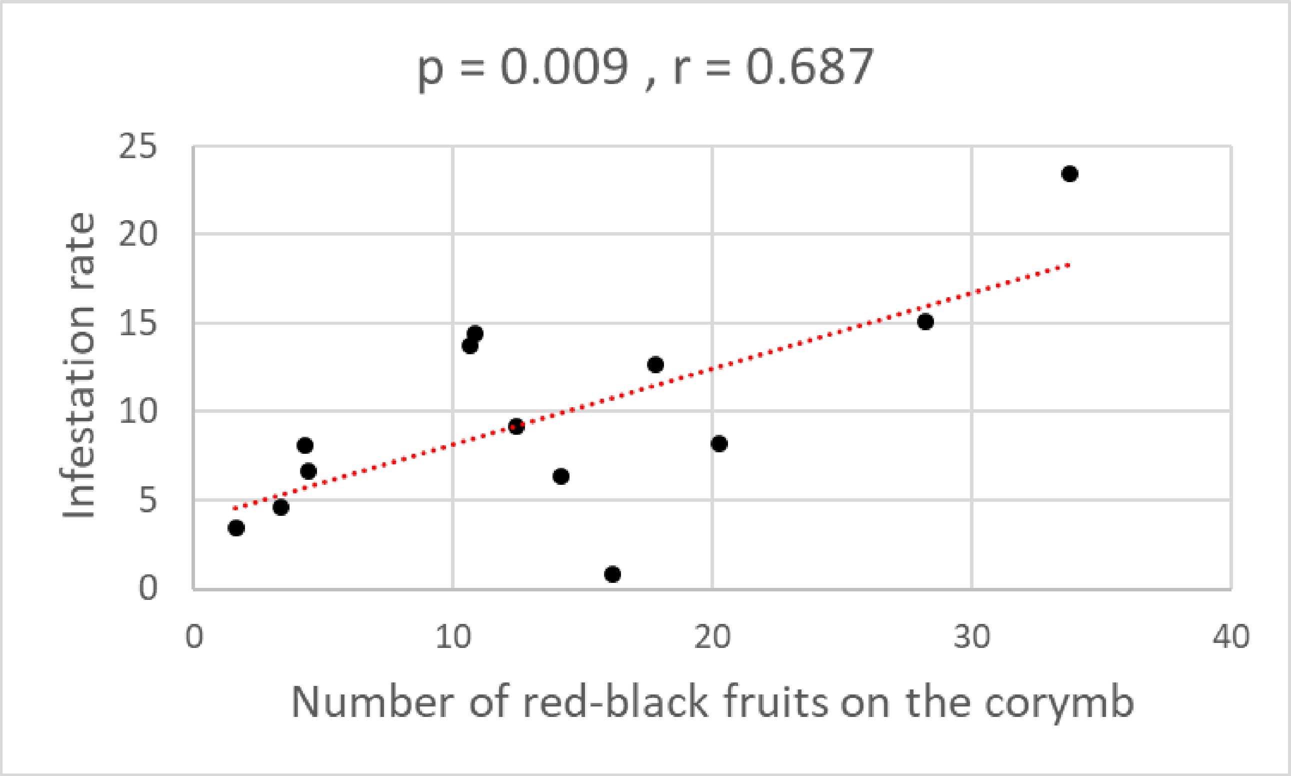
Results

- Negative correlation between the mean infestation rate (Number of emerging adult x 100 / number of fruit on the corymb) and the mean maximum temperature (mean of the daily maximum temperature between 01/01/2020 an the day of sampling)



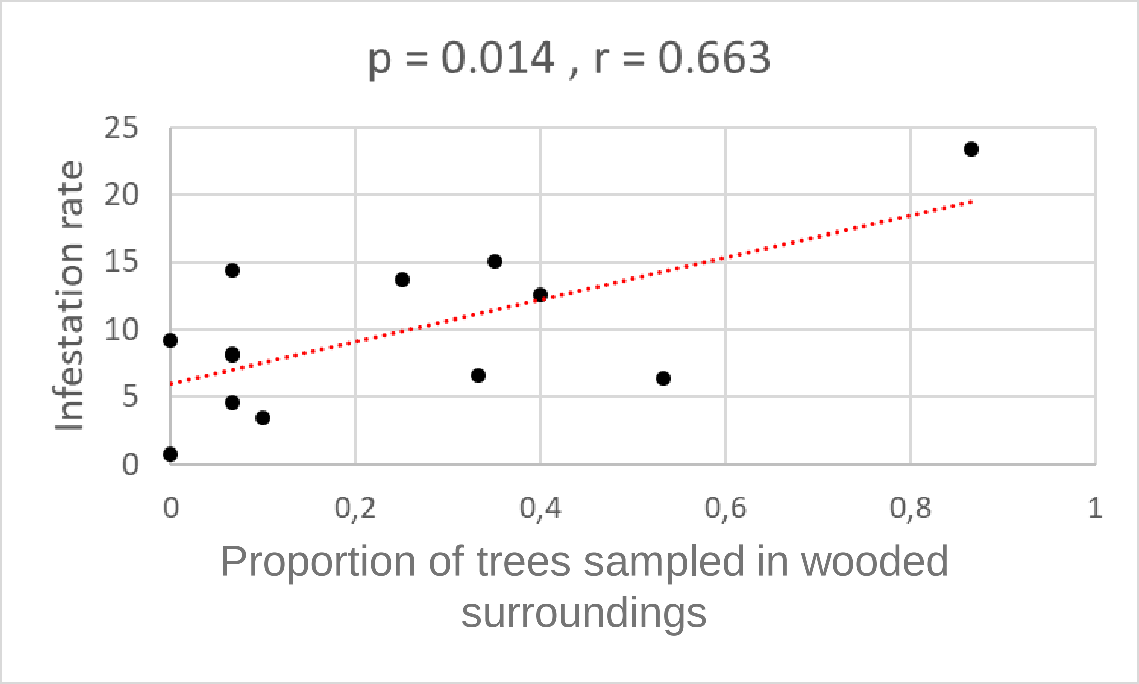
Results

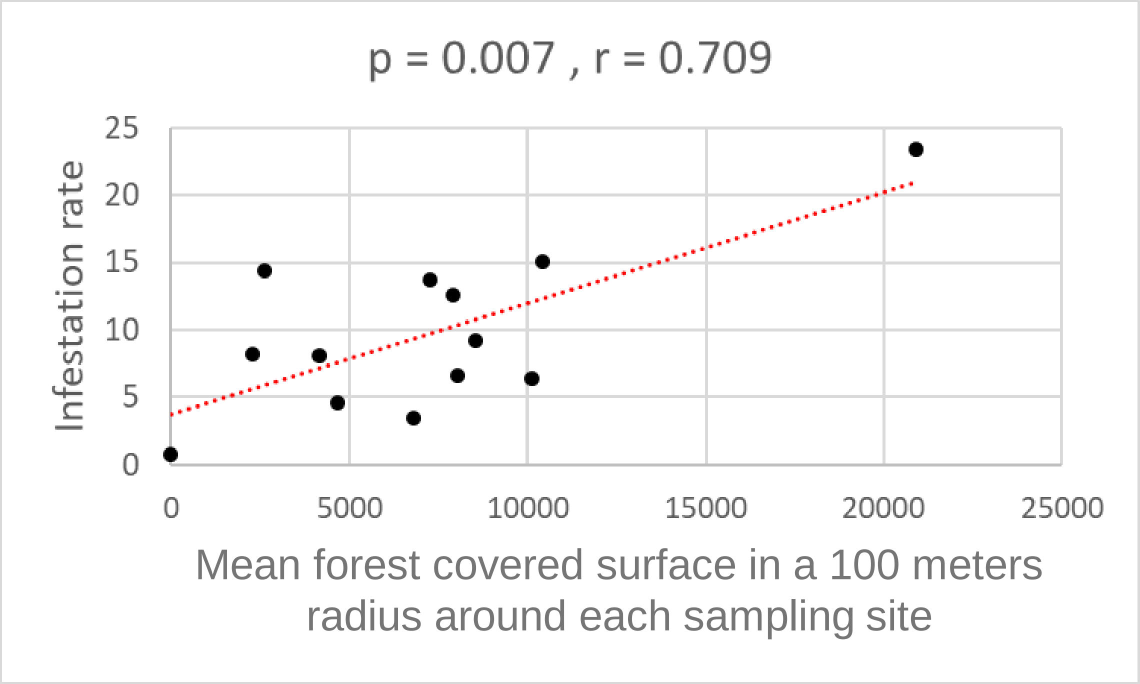
- Positive correlation between the mean infestation rate (Number of emerging adult x 100 / number of fruit on the corymb) and the number of fruits close to full maturation (color reddish-black) on the corymb



Results

- Correlation between the mean infestation rate (Number of emerging adult x 100 / number of fruit on the corymb) and the frequency of forest habitats in the very close surroundings (<10 m) and in a 100 m radius around the sampling site





Discussion

- We showed that the infestation rate of a plant generally considered as a good host for *D. suzukii* (Poyet et al. 2015, Kenis et al. 2016) can range from 0.83 to 23.5 depending on the geographical region.

- Latitude was the main factor explaining the infestation rate in our models, as well as macroclimatic variables often highly correlated to the latitudinal cline.

- In controlled conditions, the optimal temperature for *D. suzukii* development and reproduction is around 22°C (Tochen et al 2014). Warmer temperature were negatively correlated with fruit infestation in our study, showing that other factors play more important roles.

- Poyet M, Roux VL, et al (2015) The Wide Potential Trophic Niche of the Asiatic Fruit Fly *Drosophila suzukii:* The Key of Its Invasion Success in Temperate Europe? PLOS ONE 10:e0142785.
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Discussion and Conclusion

- There was a positive correlation between infestation rate and the quantity of fruits close to maturity which is concordant with other studies showing *D. suzukii* preference for fruits that have not reached full maturity (Asplen et al. 2015).

- The presence of semi-natural landscape such as forest patches in the surrounding landscape led to higher infestation rates. Previous works have shown that forest cover increases *D. suzukii* population (Haro-Barchin et al. 2018, Santoiemma et al. 2018; Delbac et al. 2020). Interestingly, factors such as the presence of fruits crops or orchards in the surroundings were less correlated with the infestation rate.

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Discussion and Conclusion

- Plants are often classified as host or non host. This oversimplified division overlook a great variability of the plant-insect interactions (Ekholm et al. 2020). These interaction can show important variations along different environmental gradients such as the latitudinal one (Alonso 1999, Garibaldi et al. 2011). Moreover, exotic species can respond differently than native ones to the local environmental gradients (Tamburini et al. 2020).

- Knowing which environmental variables shape the suitability of wild plants as hosts for *D. suzukii* is crucial to predict their arrival in crops from nearby semi-natural habitats (Tonina et al. 2018).

- Our work contributes to enhancing our understanding of *D. suzukii* ecology, the history of its invasion process as well as its future. Studying the impact of macroclimate is important to predict how infestation rates might change in the context of global climatic changes.

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