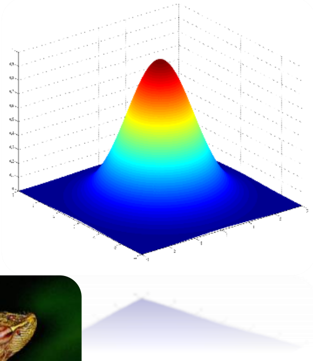
European Xylella conference on 2019

Mark-recapture experiments to estimate the dispersal capacity of *Philaenus spumarius*



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Spread of *P. spumarius*

- Only the adults individuals are able to disperse

- Little previous knowledge on capability of dispersal of *P. spumarius*
  - *Weaver and King 1954*
    - *P. spumarius* can travel for more than 30 m in a single flight.
    - Observation of marked specimens revealed around 90 m in 24 h
    - Adults usually flight within 60 cm from ground but can as high as 6 m
  - *Lago 2019*
    - Flight mill experiment: distance travelled (in a single flight) at least 1.99 km in 1h40 min

Approaches to the analysis of dispersal behaviour

- From the trajectories of particular dispersers (Lagrangian approach)
  - Dispersal end points are not confined to the sampling sites
  - Possibility of correlating disperser traits with dispersal capacities
  - Number of dispersal units sampled is limited because tagging and tracking individual dispersers is costly

- From the amount and/or diversity of dispersers at particular sampling points (Eulerian approach)
  - Dispersal end points are confined to the sampling sites
  - Less expensive
  - Not time limit due to high costly tracking

[*Bullock et al., 2006*]

An experiment on the dispersal capacity of *P. spumarius*

- Objective of the experiment:
  - Assessing the dispersal capacity of *P. spumarius* in two different landscapes
    a) Not managed meadow area
    b) Managed olive orchard

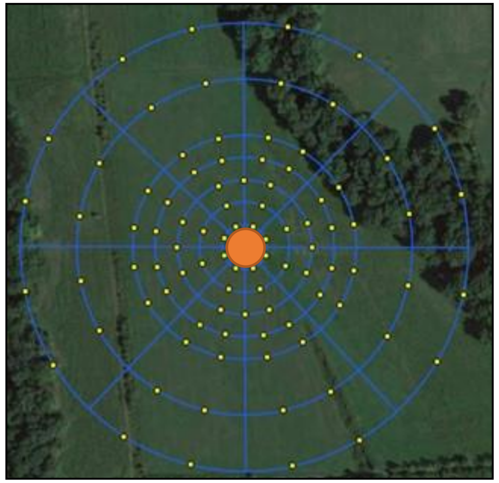
Piemonte region

Apulia region

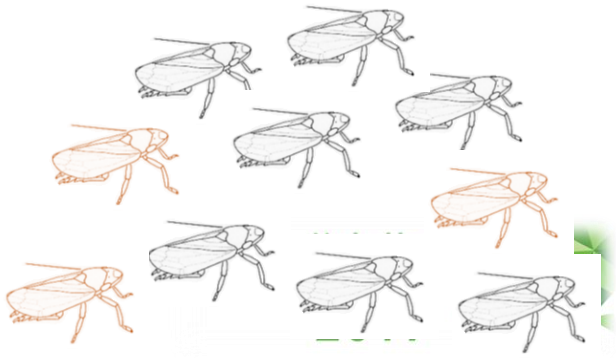
Mark-Release-Recapture experiment:
protocol

- **Mark**
  - *P. spumarius* placed in a cage and treated with an aqueous solution of 70% albumin, vaporized for 2 consecutive days directly on the insects and the host plants

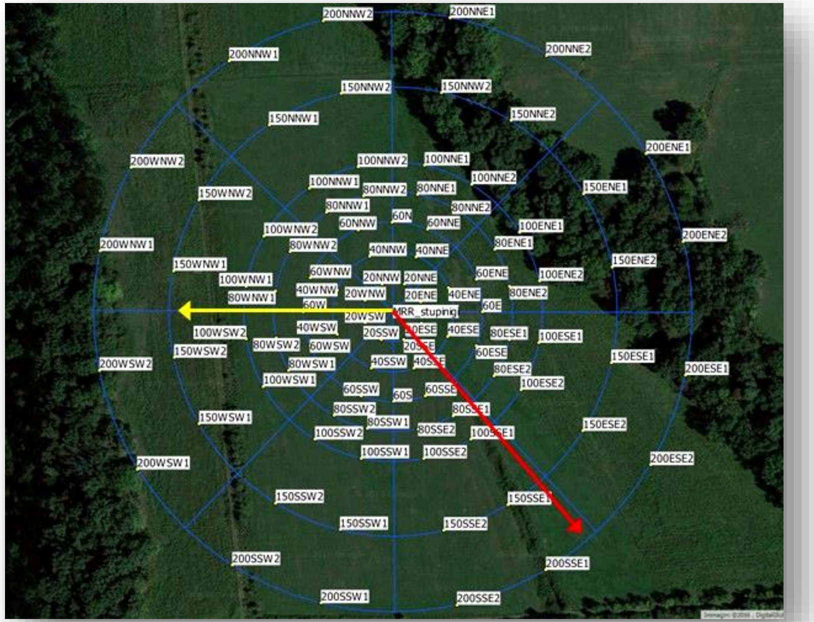
- **Release**
  - Marked individuals were released at a <u>single point in the center</u> of the study area
  - Placed on the ground/branches, inside an open container along the entire perimeter, so as to avoid a possible "escape effect" with consequent excessive initial displacement due to the "escape from disturbance", or a possible induced directional displacement [*Blackmer et al., 2006*]

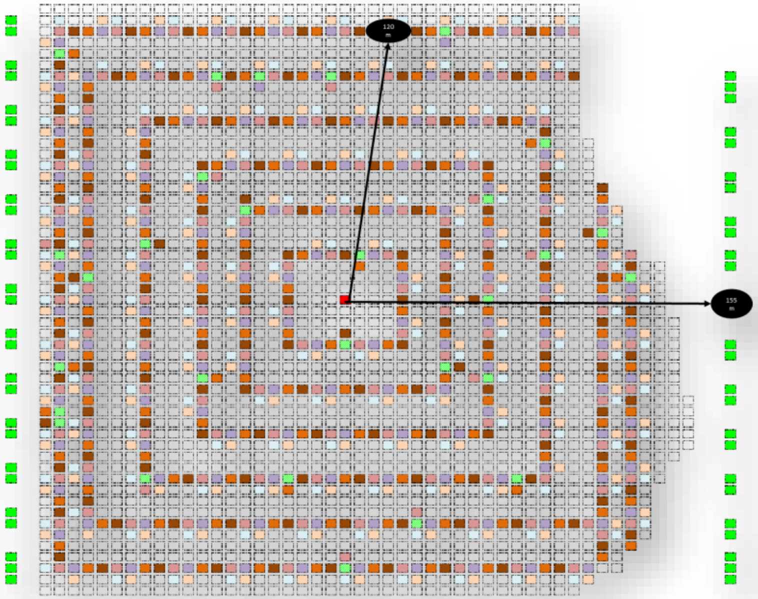


- **Recapture**
  - Samplings were carried out using a net (allows to keep the insect in conditions suitable for the detection of albumin by means of ELISA analysis)
  - Samples stored at -80° C, to be subjected to ELISA analysis later



Mark-Release-Recapture experiment:
sampling scheme





Date	Times of recaptures	Temporal range of recaptures (days from the release)
2016, September	4	[2-15]
2017, June	6	[3-17]
2017, September	6	[2-14]

Date	Times of recaptures	Temporal range of recaptures (days from the release)
2016, July	4	[7-17]
2017, May	6	[2-17]
2017, July	6	[3-17]
2017, October	6	[2-14]

Spread modelling

Dispersal distance: the Euclidian distance between the 'starting' and 'ending' points of a dispersal period

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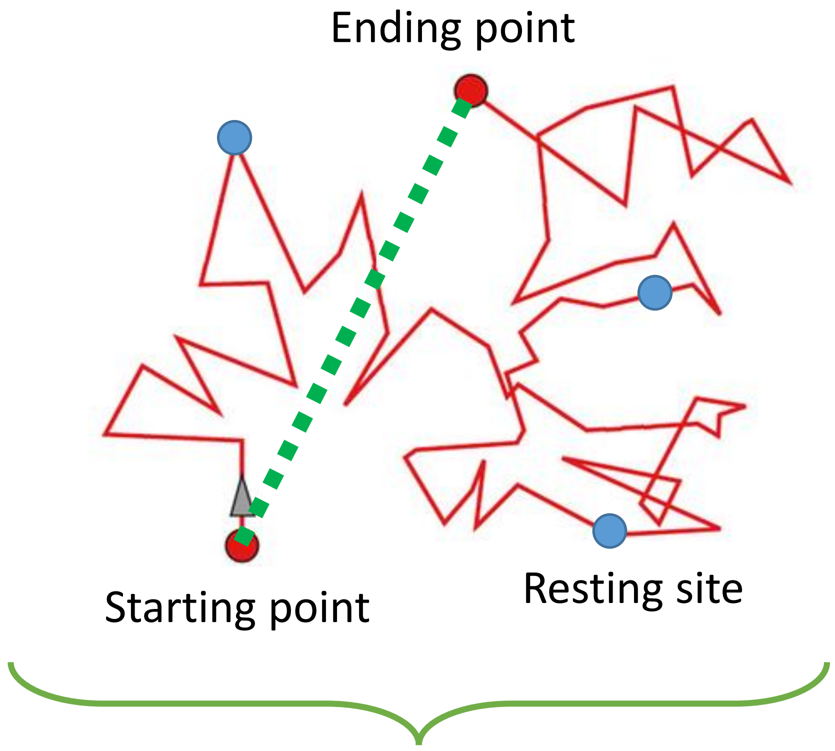
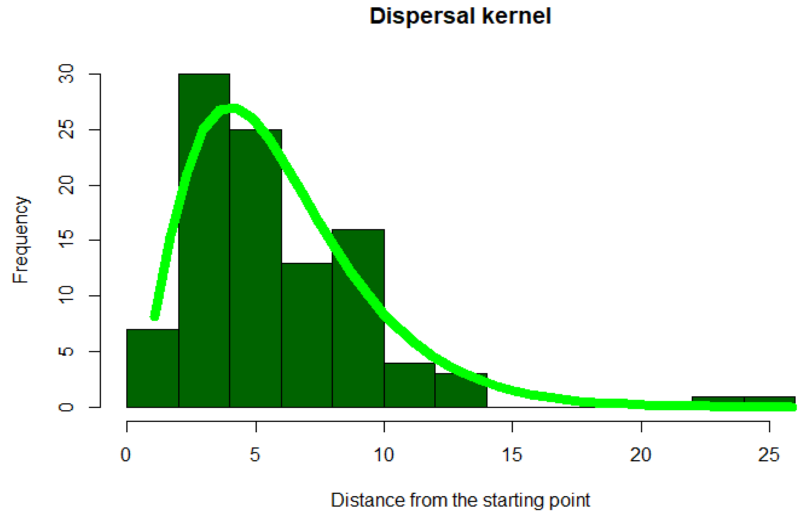
Travelled distance: the actual distance traveled to arrive from the 'starting' to the 'ending' points in a dispersal period

Dispersal kernel: The statistical distribution of dispersal distance in a population





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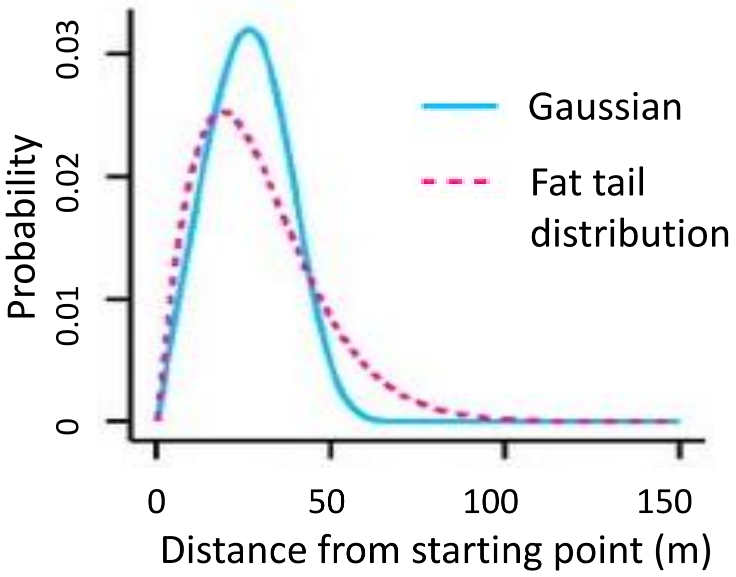
Dispersal kernel

- Population-level descriptor of the movement in space
  - In a vector-transmitted disease it allows to study the spread of a the disease through the spread of the vector
  - In epidemiological modelling it allows to describe the spread of he disease
- The basic dispersal kernel is defined as encompassing only the movement and survival of the individuals during dispersal period
  - More complex models can include assumptions related to movement and species biology
- Several types of dispersal kernel [*Nathan et al. 2012*]
  - E.g. tails (thin/fat), long-distance dispersal



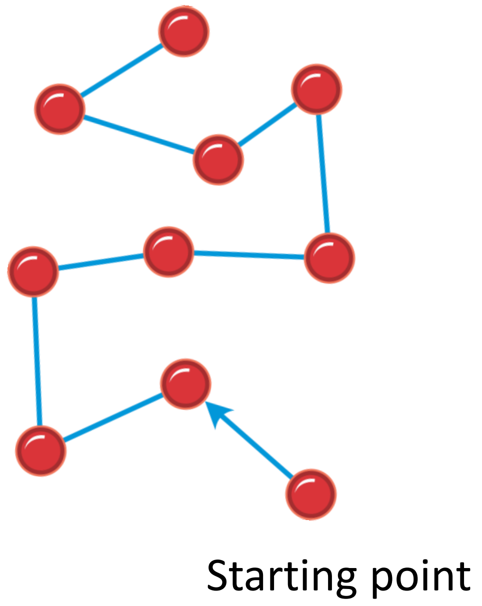
Estimation of dispersal rate

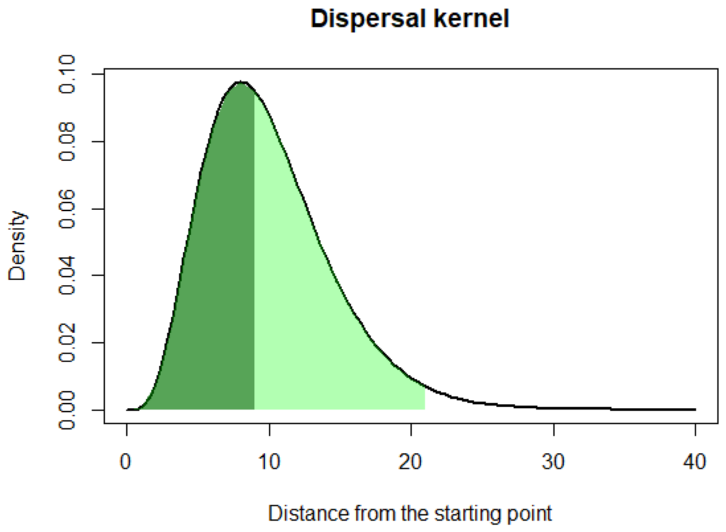
- We adopted the Brownian motion as the descriptor of the movement of *P. spumarium*
- The dispersal kernel representing the probability to find an individual at the radial distance r from the starting (release) point at time t

$$k_D(r,t) = \frac{1}{2Dt}\exp\left[-\frac{r^2}{4Dt}\right]$$

- D is the diffusion rate

- Median distance at time t (dark green)
- Radius that encompass 98% of dispersing vectors at time t (light green)





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Estimation of dispersal rate:
Naïve Methods

- Applied by Tufto et al. (2012)
- Based on the simplified estimation approach of Turchin (1998)
  - Estimation of $\widehat{D}(t)$ for each sampling time point (t)
  - $MSD(t)$: Mean Square Displacement at time point (t)
  - Overall mean of $\widehat{D}(t)$

Estimation of dispersal rate:
Optimization Methodology

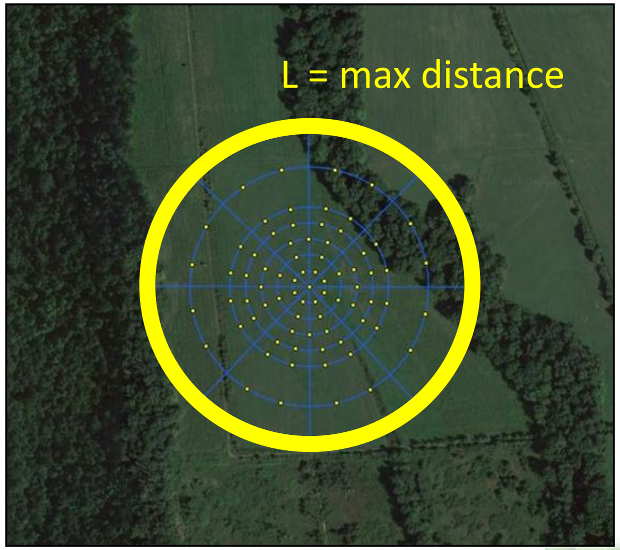
Unbounded

- Minimization of the difference between the theoretical dispersal kernel and the empirical function
- Fitting procedure based on the relation $MSD_t = E[r_t^2] = 4Dt$

Bounded

- The recaptures are 'bounded' (maximum distance of sampling points, L)
  - Probability that an individual is at radial distance r at time t, given that the individual is within $[0, L]$ distance from the starting point

$$p(r, t | 0 \leq r \leq L)$$



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Conclusion

			Intermediate-aggregation			
			Meadow		Olive orchard	
	Day	Radius (r)	2016/09 2017/06	2017/09	2016/07 2017/06	2017/ 07-10
Naïve Methods	1	98%	41	103	33	55
Unbounded optimization	1	98%	36	67	28	48
Bounded optimization	1	98%	36	139	29	52
n			28	16	21	15

- Different behavior between 'Meadow' and 'olive orchard'
  - Lower spread in the olive orchard
- Naïve Methods overestimates the spread rate
- Due to bounded correction, estimates increases less than 10% of the unbounded value.
  - Only in one case there is a huge effect of applying the bounded correction (from 67 m to 139 m)
  - Impact of bounded corrections depend on distribution of dispersal distances
    - High when the number of recaptured individuals near L (maximum distance) is high
    - Low when most of individuals are found close to the starting point and far from L

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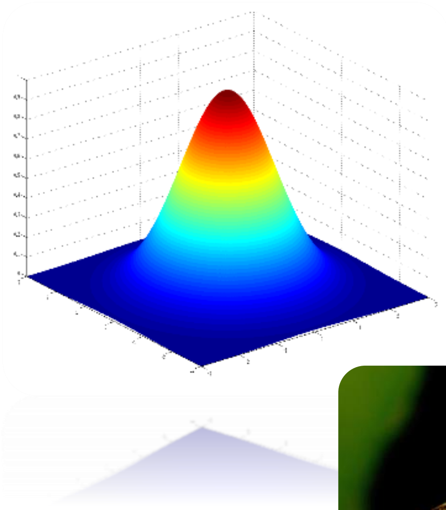

Thanks for your attention