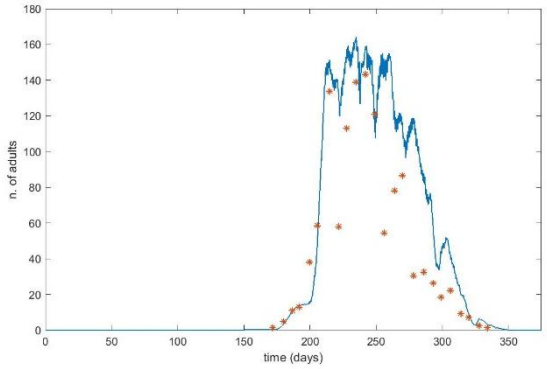
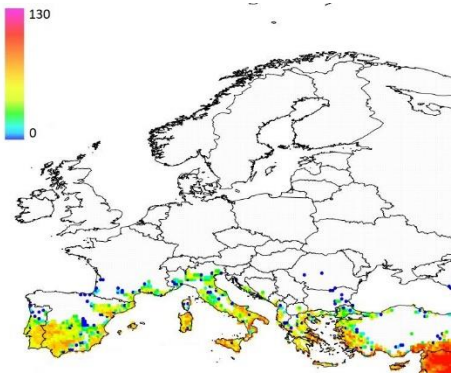
University of Modena e Reggio-Emilia, 4 December 2020

Development of mathematical models supporting sustainable agriculture in Europe





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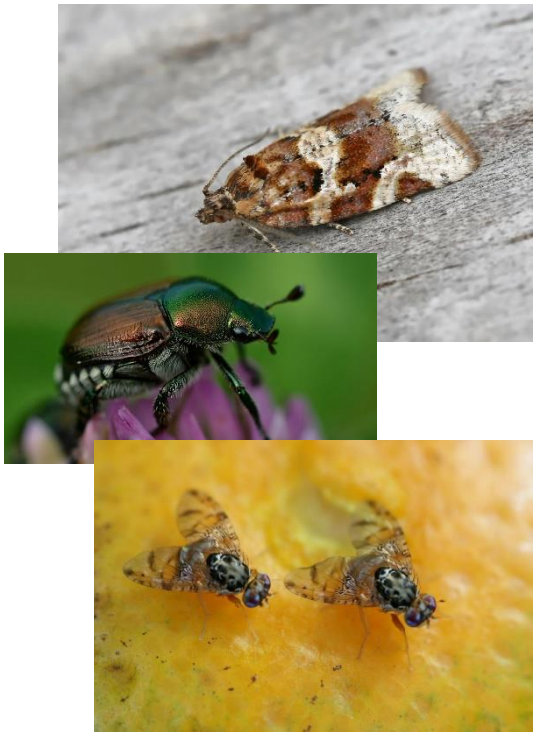
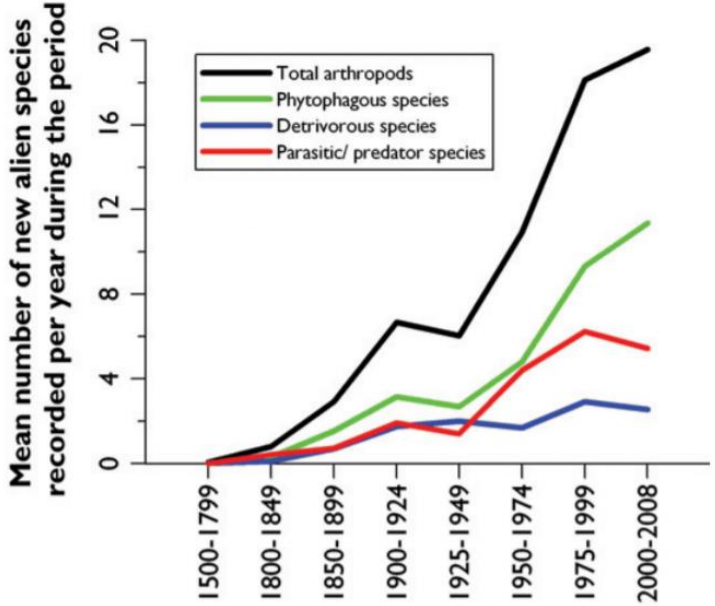
Insect pests and invasive species: a global threat

- **Economic impact**: costs to agriculture ~ 300 billions $/year worldwide
- **Environmental impact**: threat to the structure of ecological communities and ecosystem services (agricultural and forestry production, resources availability)
- **Social and health impact**: more than 100 species may cause impacts to human health





The number of new records of arthropod alien species is increasing over time

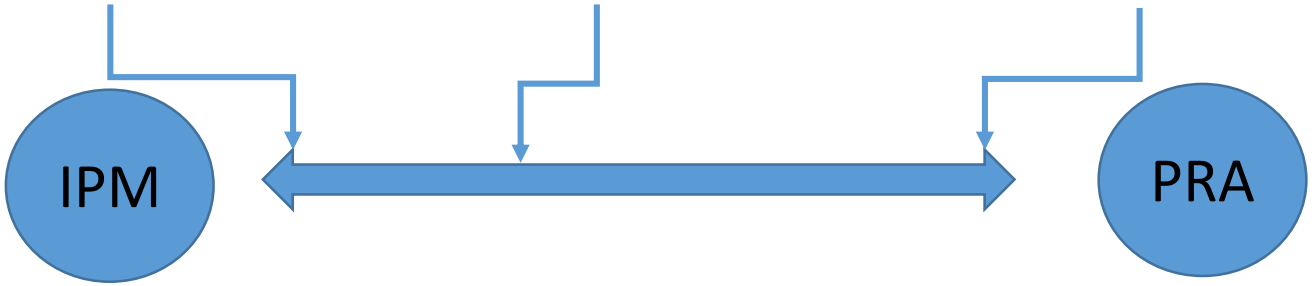
Source: Roques, 2010. Biorisk

Different areas of intervention: from PRA to IPM

Lobesia botrana

Popillia japonica

Spodoptera frugiperda



Integrated Pest Management (IPM)

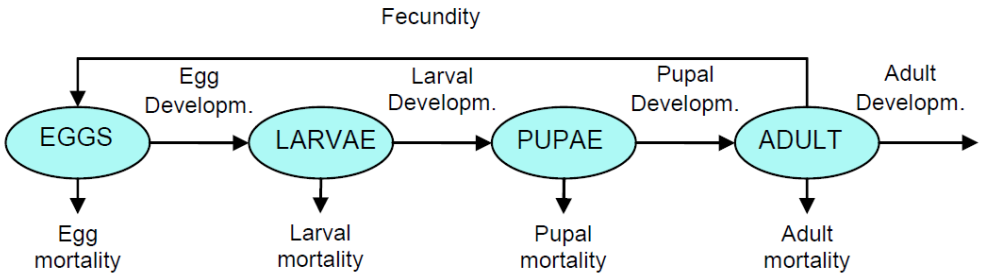
- Applied to established organisms
- Managed by privates
- Prevention and mitigation of the impacts through the implementation of monitoring and pest control actions

Pest Risk Assessment (PRA)

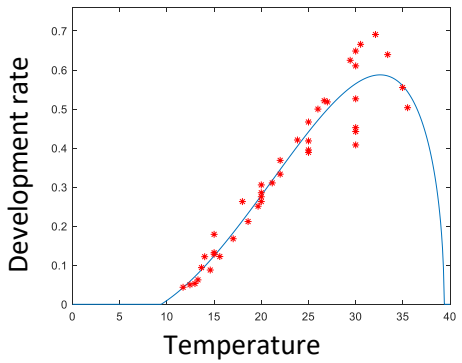
- Applied to quarantine organisms
- Managed by public bodies
- Assessment of the risks of entry, establishment, spread and impacts

Physiologically-Based models for pest management
The overall modelling approach

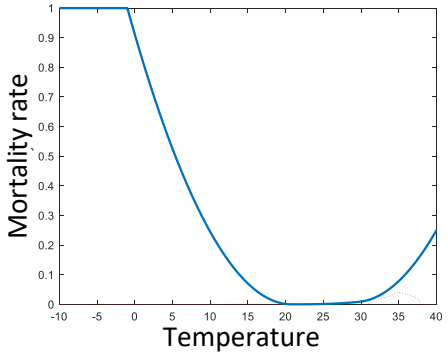
- Describe the biology, the life-cycle, the life-history strategy of the species
- Identify the main external drivers influencing pest dynamics
- Represent the influence of external drivers on insects physiology and population dynamics



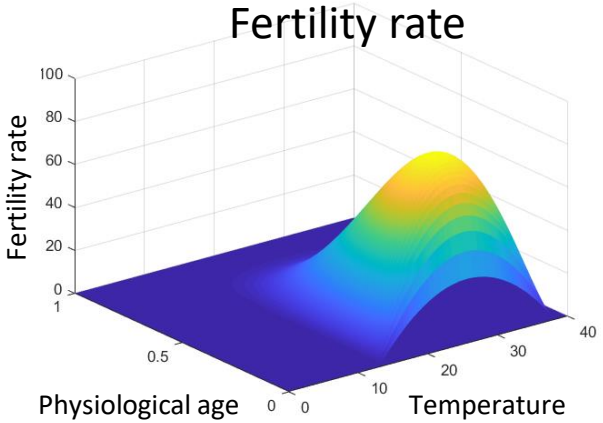
Development rate



Mortality rate



Fertility rate



Physiologically-Based models for pest management
Case studies

Applications in Integrated Pest Management

- Predict the phenology of *Popillia japonica*
- Predict the population dynamics of *Spodoptera frugiperda*

Applications in Pest Risk Assessment

- Predict the potential distribution of *Ceratitis capitata* considering the potential role of climate change

Physiologically-Based models for pest management
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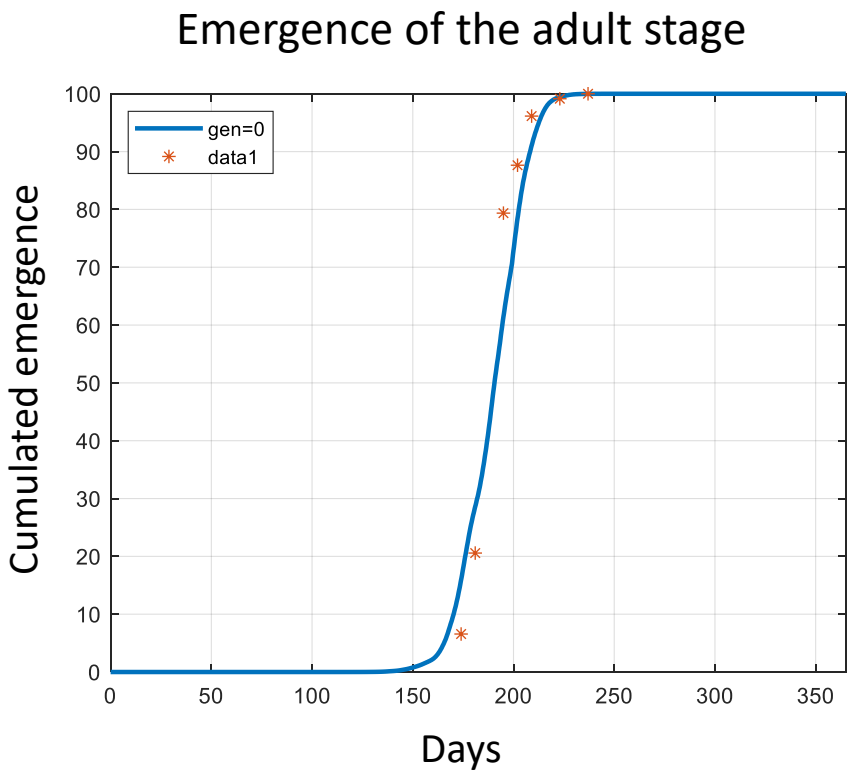
Predict the phenology of *Popillia japonica*



Model application in Integrated Pest Management

- Estimate the timing of emergence of the species
- Investigate the role of temperature on pest phenology
- Plan pest monitoring and pest control actions

Physiologically-Based models for pest management
Case studies

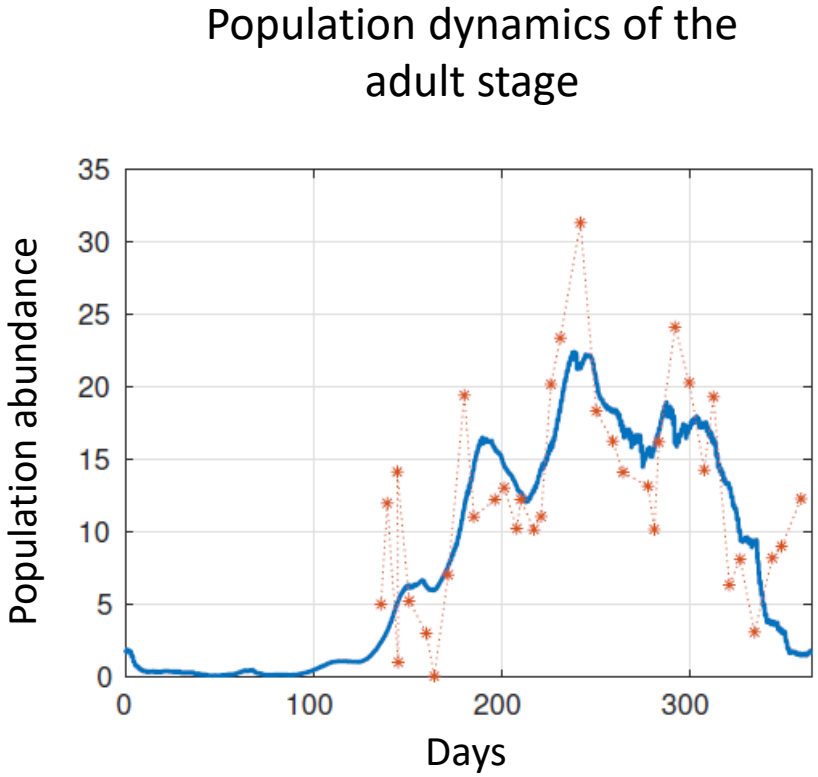
Applications in Integrated Pest Management

- Predict the phenology of *Popillia japonica*
- Predict the population dynamics of *Spodoptera frugiperda*

Applications in Pest Risk Assessment

- Predict the potential distribution and abundance of *Ceratitis capitata* considering the potential role of climate change

Predict the population dynamics of *Spodoptera frugiperda*



Model application in Integrated Pest Management

- Estimate the population dynamics of the species
- Predict the potential population abundance
- Plan pest monitoring and pest control actions

Physiologically-Based models for pest management
Case studies

Applications in Integrated Pest Management

- Predict the phenology of *Popillia japonica*
- Predict the population dynamics of *Spodoptera frugiperda*

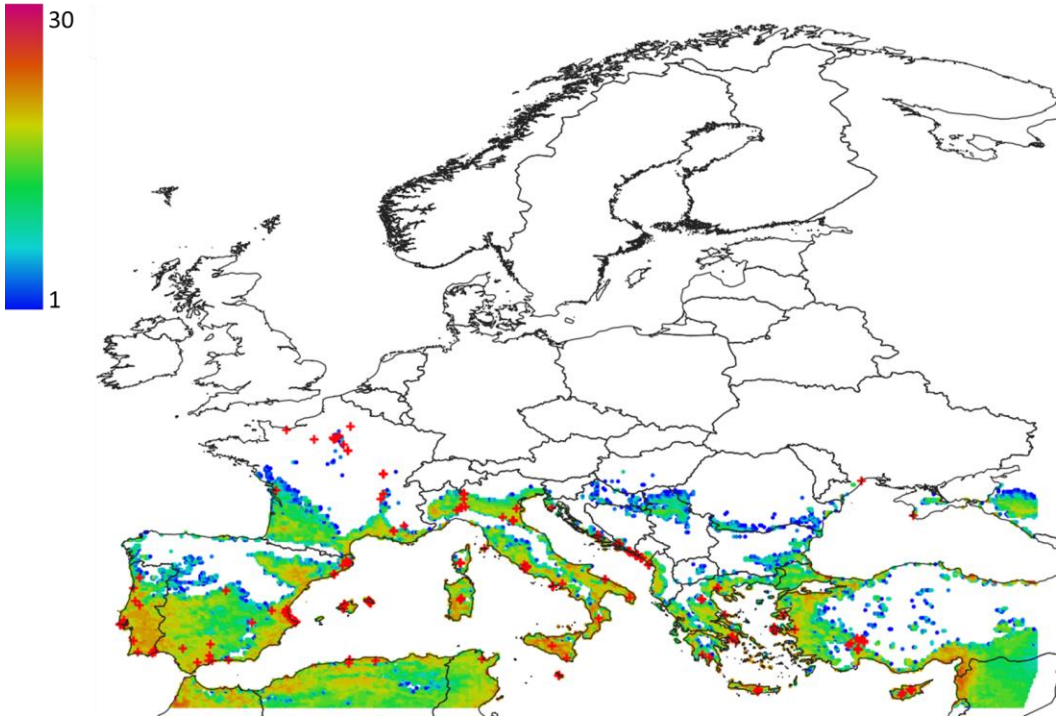
Applications in Pest Risk Assessment

- Predict the potential distribution of *Ceratitis capitata* considering the potential role of climate change

Predict the potential distribution of *Ceratitis capitata*

Pest distribution and abundance
current climate (2020)

Population abundance



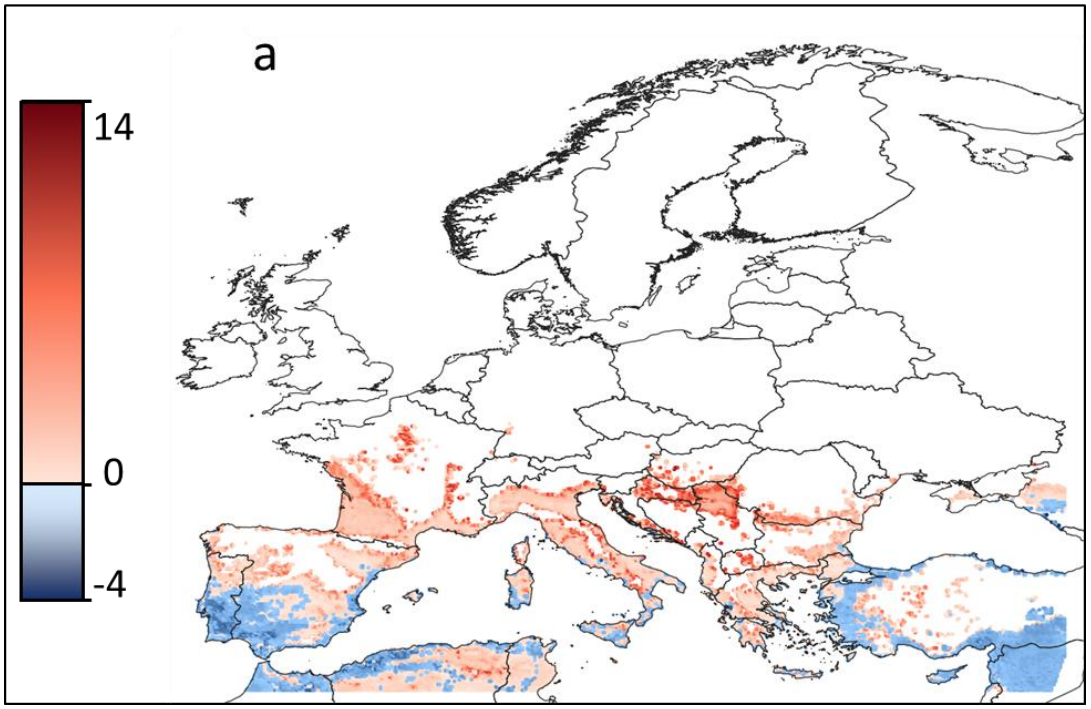
Model application in Pest Risk Assessment

- Assess the potential distribution and impacts of the species
- Identify areas at higher risk

Predict the potential distribution of *Ceratitis capitata*

Pest distribution and abundance
Future climate(2050) VS Current climate (2020)

Variation in population abundance



Model application in Pest Risk Assessment

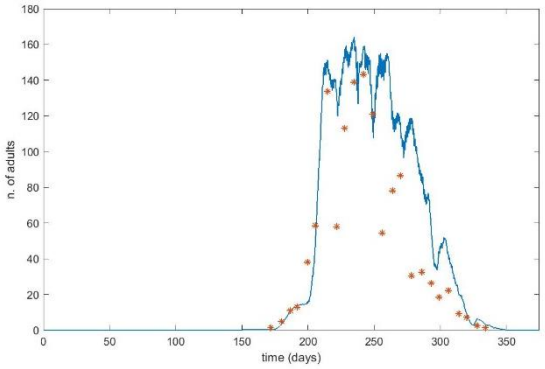
- Investigate the role of climate in ruling pest distribution and abundance
- Comparative assessment of climate scenarios for pest risk analysis

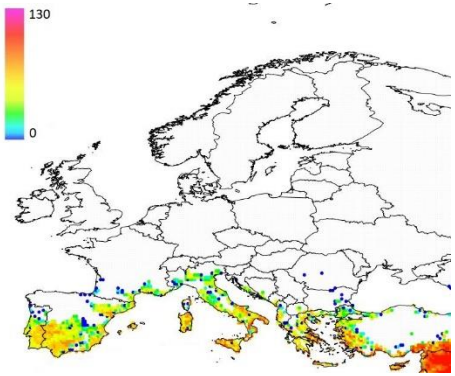
Take-home message

The physiologically based modelling approach

- Makes use of data related to the physiology and the dynamics of the species to be investigated
- Allows to represent the processes underlying a biological system and the influence of the main drivers involved
- Allow the exploration of different scenarios for guiding the decision-making process
- Is suitable for the development of tools supporting the management and control of pests for both IPM and PRA purposes

Thanks for your attention!





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