

WEBINAR



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TULANET

**Postdoctoral
Programme**
for Research Institutes

Risk of Vector-Transmitted Animal Diseases and Plant Pests in a Changing Climate

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Introduction



- My name is Leonard Opare
- I am Ghanaian
- I am an Entomologist
- I have a PhD in Zoology and Ecology
- My interests are insect ecology, behavioral entomology, and insect pathology
- I work at the Risk Assessment Unit of Ruokavirasto



List of Original Articles

- I. **Opare, L. O.**, Holm, S., and Esperk, T. (2022). Temperature-modified density effects in the black soldier fly: Low larval density leads to large size, short development time and high fat content. *Journal of Insects as Food and Feed*, 8, 783–802.
- II. **Opare, L. O.**, Meister, H., Holm, S., Kaasik, A., and Esperk, T. (2023). High larval densities and high temperatures lead to a stronger immune response in the black soldier fly. *Journal of Insects as Food and Feed*, 9, 1177–1186.
- III. **Opare, L. O.**, Jensen A. B., Lecocq, A., Holm, S., and Esperk, T. (2024). Exposure to entomopathogenic fungus and high larval density induce a strong immune response and life-history costs in black soldier fly, a commercially important insect. *Entomologia Experimentalis et Applicata*, 1–10.
- IV. **Opare, L. O.**, Holm, S., and Esperk, T. (2024). Interaction effects of substrate fermentation and larval density on black soldier fly life-history traits. *Journal of Insects as Food and Feed*, 1–12.

The system



A tractable model, four environmental levers

Black soldier fly — a fast life cycle you can rear, manipulate and measure under fully controlled conditions.



Temperature
sets the pace



Larval density
the modulator



Fungal challenge
survival cost



Substrate
diet & microbes

The Findings



Temperature sets the pace of development

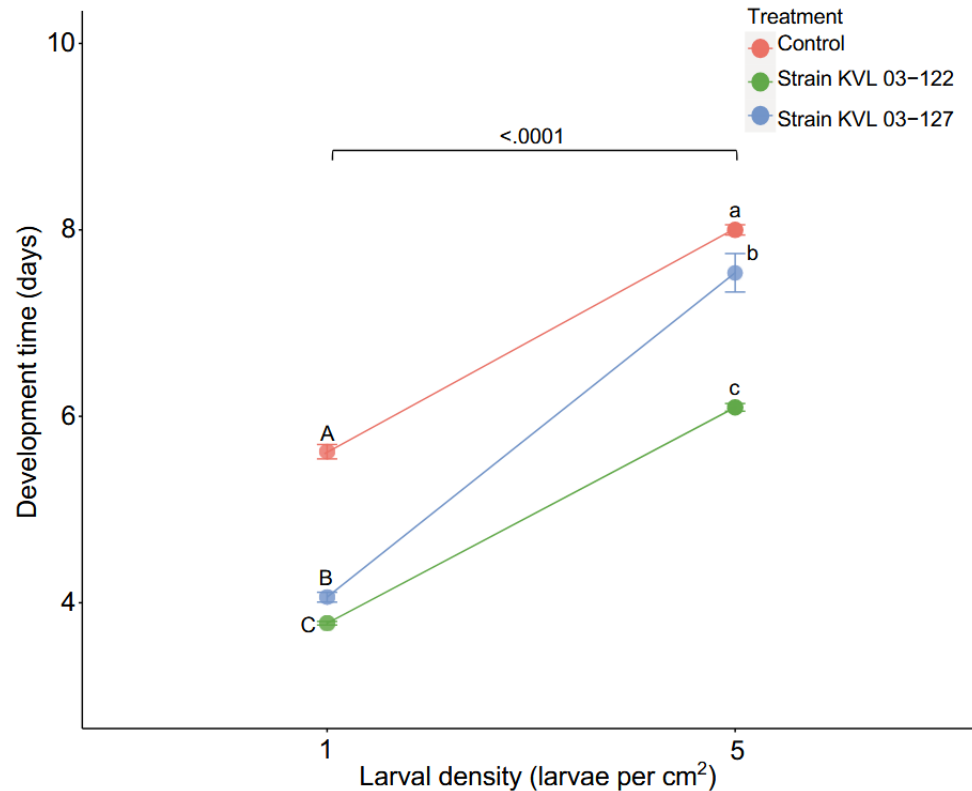
- Warmer rearing speeds development — but only within limits.
- The response is a curve, not a line: performance peaks, then collapses at the extremes.
- Faster is not free. Speed trades off against survival and immune function.

So what — *the shape of that curve is what we can reuse at larger scales.*

The Findings



The drivers interact



- Larval density changed how every other factor played out
- Fungal challenge acted through density, not independently
- Substrate shifted performance on top of temperature

So what — *environmental drivers never act alone; interactions decide outcomes*

The lesson



- Environment , temperature above all, is a quantifiable, predictable regulator of insect performance.
- If we can understand how temperature governs one insect, we can ask the same of many, across landscapes, and across decades.

Introduction

One idea, two scales



PhD

One insect, up close

Thermal and environmental biology of the black soldier fly show how the environment governs development and survival.

MECHANISM



PREDICTION



Postdoc

Many insects, across space

Case 1 · Plant Pests

Invasive pest establishment

Case 2 · Insect vectors

Culicoides incursion

Plant Pests on the move



Could *Conotrachelus nenuphar* establish in northern Europe?

Conotrachelus nenuphar — the plum curculio

A North American weevil

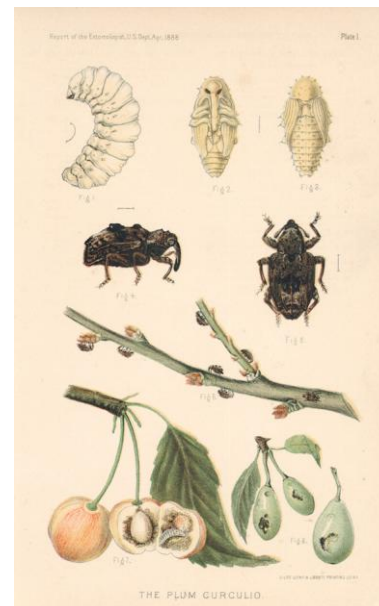
- Coleoptera: Curculionidae.
- Native to eastern North America; a major pest of stone and pome fruit for more than a century (Quaintance & Jenne 1912; Chapman 1938).



Wide host range in Rosaceae

- Attacks cherry, plum, peach, apple and related hosts.
- Eggs are laid under the skin of developing fruitlets; larvae feed inside the fruit.

[Clemson University - USDA Cooperative Extension Slide Series](#), [Bugwood.org](#)



[Conotrachelus nenuphar](#)

Northern strain

- One generation per year, obligate winter diapause
- Occurs in the northern USA and southern Canada
- Colder winters than anywhere in Europe but warmer summers than Scandinavia or the Baltics

Absent from Europe so far

No established European populations. Listed among the 20 EU priority pests under Commission Delegated Regulation (EU) 2019/1702.

A legal obligation — with an escape clause

Regulation (EU) 2016/2031

- Every Member State must run annual surveys for each priority pest
- Contingency planning and measures to prevent introduction and spread
- Aimed at early detection of outbreaks

The exemption

- Obligations fall away where it can be demonstrated unequivocally that the pest cannot establish or spread
- Grounds: unsuitable ecoclimatic conditions, or absence of host plants
- The burden of proof sits with the Member State

So the practical question is a spatial one

- Where in northern Europe are summer temperatures actually sufficient for *C. nenuphar* to complete a generation?
- Wherever they are not, limited official plant-health resources can be redirected to pests that genuinely threaten that territory.

Existing assessments disagree

EFSA (2018a, 2019, 2025)

Climate is unlikely to limit establishment in Europe; the pest could establish wherever suitable hosts occur.

- Reasoning rests largely on matching **Köppen–Geiger** climate types between the native range and the EU
- A coarse screening tool blind to variation within a climate type

Boberg & Björklund (2020b), Sweden

Summer temperatures permit completion of the life cycle in a single season only in the south of the country.

- **Based on accumulated GDD under current climate**
- The authors flagged limited data and considerable uncertainty

The gap: no assessment yet combines stage-specific thermal thresholds, intraspecific variation and a pan-European domain and none has looked at future climate at all.

AIM OF THE STUDY

Build a stochastic phenology model that carries intraspecific variation through every life stage of the northern strain and use it to locate the potential northern range limit in Europe, now and at mid-century.

Why sour cherry (*Prunus cerasus*) as the modelled host?

Widely distributed

Sour cherry is grown across the whole European domain of interest.

A conservative choice

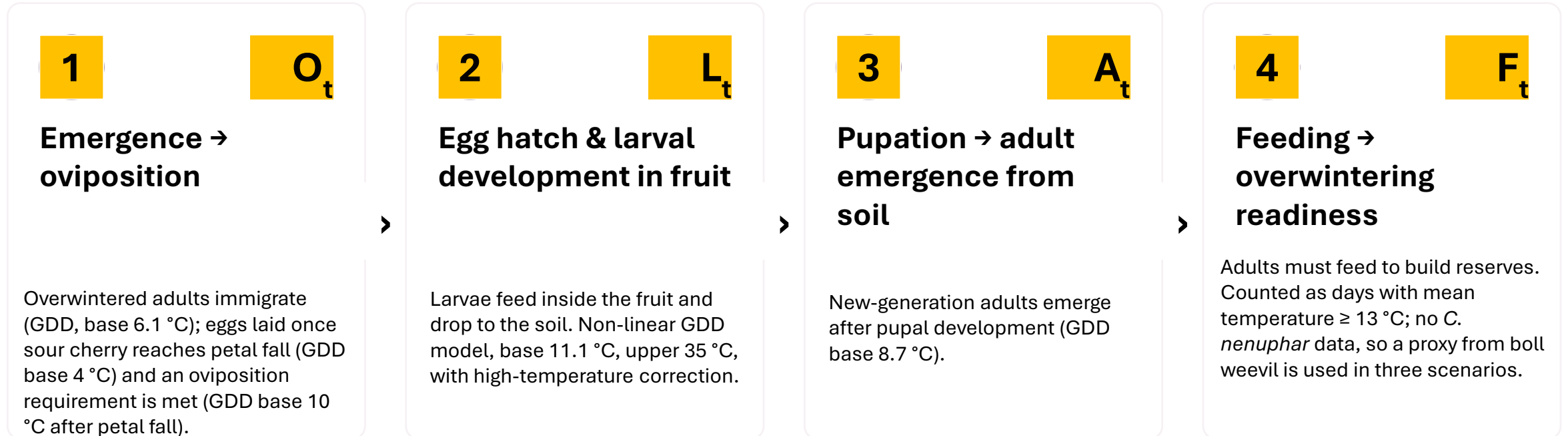
Development on sour cherry is among the fastest reported so if the cycle cannot close here, it is even less likely on poorer hosts.

aijn.eu



A stochastic phenology model in four steps

Stochastic phenology models are mathematical tools that predict the timing of biological life-cycle events



Piñero & Prokopy 2006 · PEP725
· Reissig et al. 1998

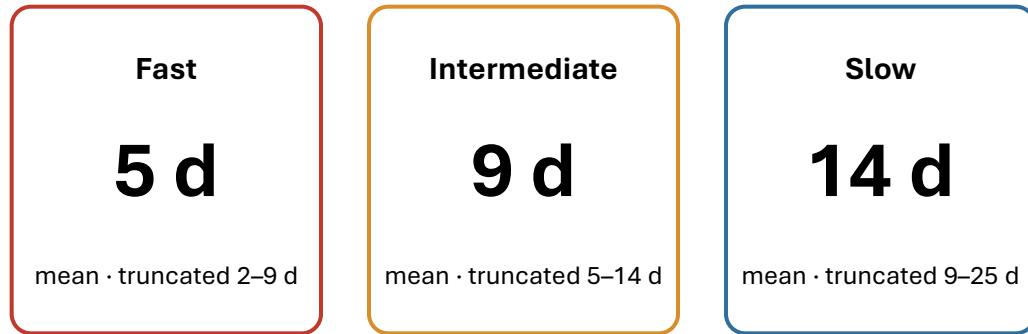
Selby & Whalon 2014 · Lan et al.
2004

Selby & Whalon 2014

Spurgeon & Raulston 2006 ·
Spurgeon et al. 2018



Uncertainty in step 4: three F_t scenarios



Climate inputs

Current ERA5 daily mean air temperature, 0.25°, 2006–2025 (central & northern Europe)

Future 8-member CMIP6 ensemble, SSP2-4.5, 2041–2060, year-specific daily series; GCMs screened with GCMeval for northern Europe; resampled to 0.5°

Validation ERA5 1940–1959 over the US–Canada border region

Scoring thermal suitability

Two complementary outputs per grid cell

Mean life-cycle completion proportion

Share of simulated individuals that reach overwintering readiness, averaged over the 20-year period.

A measure of general thermal suitability.

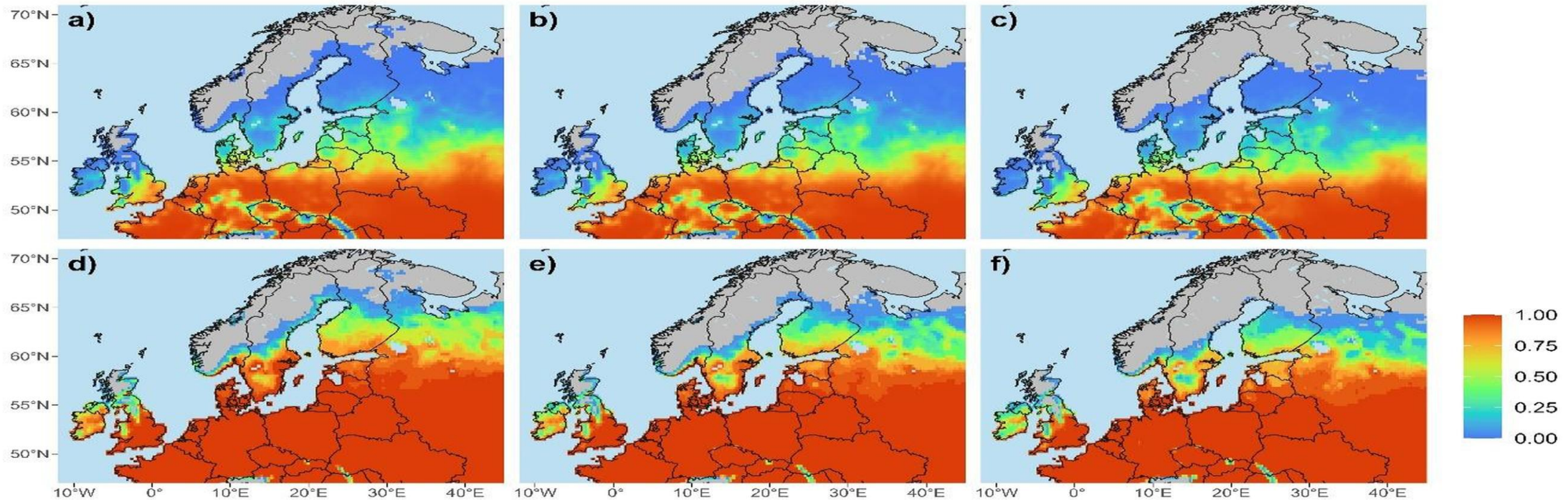
Proportion of successful years

Share of years in which at least one individual completes the cycle.

Captures interannual variability because establishment needs success in essentially every year, not a warm average.



Central Europe suitable, the far north is not



([Tuomula et al., 2026](#))

Thermally suitable

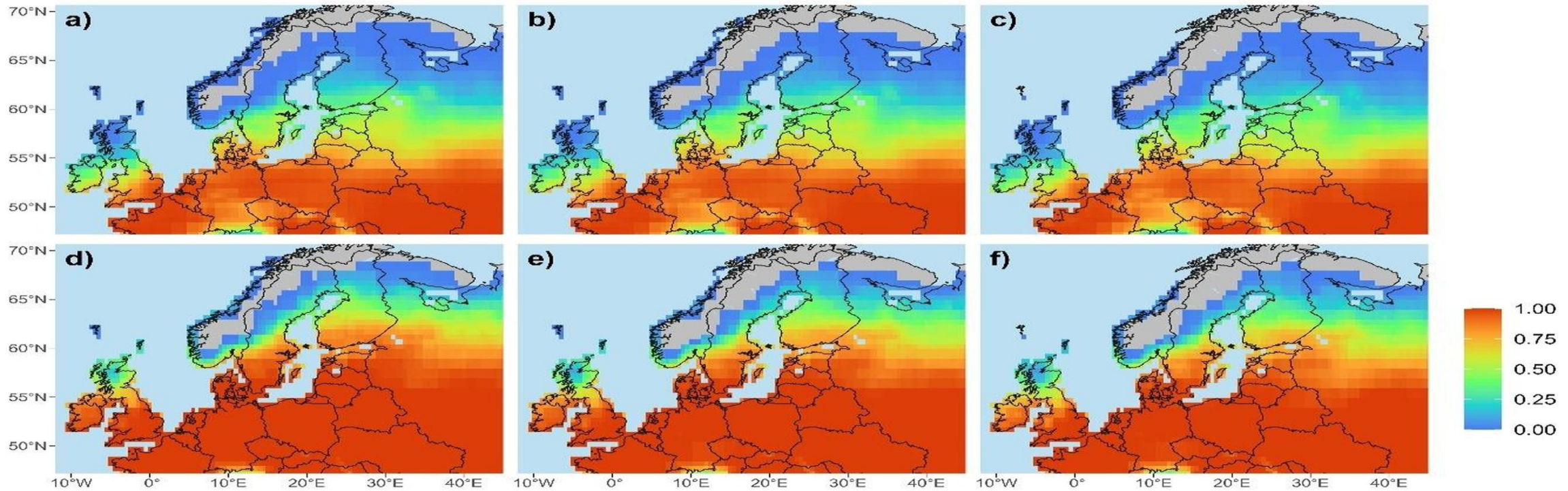
Both metrics close to 1 across much of central Europe, declining northwards through the United Kingdom, northern Germany and Poland.

Establishment unlikely

Finland, Scotland and most of Estonia, Ireland, Norway and Sweden: most individuals fail, and in several years none reached readiness under any Ft scenario.



The transition region moves north



([Tuomula et al., 2026](#))

Newly marginal-to-suitable

In Estonia, southern Ireland and southern Sweden roughly half or more of simulated individuals reach readiness, with success in all or nearly all model-years.

Still unlikely

Suitability rises in southern and central Finland, but a large share of individuals still fail and several model-years produce none at all under any Ft scenario.

What the model shows

1 Not all of northern Europe is thermally suitable

Under 2006–2025 temperatures, **Finland, most of Ireland and Sweden and parts of the Baltic region cannot support completion of the northern strain's life cycle on sour cherry** in a normal year.

3 Intraspecific variation changes the answer

Representing thermal requirements as distributions rather than means, with **stage-specific thresholds, produces a different conclusion from coarse climate-type screening.**

5 First look at future climate

2 Warming shifts the limit, but not far enough

Future climate projections raise suitability across the north and push the transition band into the Baltics, Denmark and southern Scandinavia **yet establishment remains unlikely across Finland.**

4 Enough detail to act on

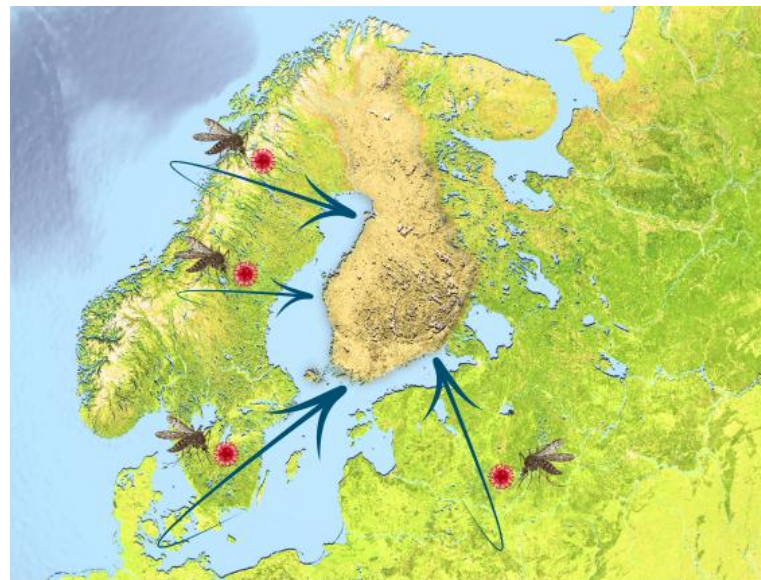
The results give risk managers area-specific, reproducible evidence for deciding where official surveillance for *C. nenuphar* is warranted



RIMA Project

Risk Assessment Unit · Finnish Meteorological Institute

Modelling the introduction and risk areas of
vector-borne diseases in Finland



Bluetongue virus as the model disease · *Culicoides* biting midges as the vector

The vector : *Culicoides* spp.



- *Culicoides* spp are haematophagous biting midges, approx. 1400 described species
- These midges are 1–3 mm, small enough to ride the wind for tens to hundreds of kilometres
- The northern European vector burden falls on ***Culicoides obsoletus*** and ***Culicoides pulicaris*** complexes



(Culicoides female biting midge, showing wing pattern and piercing mouthparts)



- Females bite mammals for blood meals to nourish their eggs
- Several viruses are transmitted as a result such as **Bluetongue virus**, **Schmallenberg virus** and **Epizootic hemorrhagic disease virus**
- Whether they transmit the virus and number of generations depends on **temperature**

Bluetongue virus disease



- Bluetongue (BT) is a viral disease of domestic and wild ruminants, including sheep, cattle, goats, deer, buffalo, and camelids
- It is caused by the bluetongue virus (BTV)
- It is primarily spread by the bite of infected **Culicoides biting midges** (present in Finland)



[CSIRO SciencelImage 1264 Bluetongue disease in sheep](#)



Typical clinical signs include:

- Fever
- Swelling of the face, lips, and tongue
- Mouth ulcers and erosions
- Lameness due to inflammation around the hooves
- Oedematous, congested and haemorrhagic lungs



Bluetongue disease – female sheep
(<http://www.boulesdefourrure.fr>)

Control

- Vaccination where available
- Vector control
- Movement restrictions on susceptible animals
- Surveillance and rapid detection of outbreaks



Bluetongue vaccines, before and after use
(<http://www.boulesdefourrure.fr>)



BTV-3 reached the Nordic countries in 2024

863

Danish holdings
affected, 2024

97

Norwegian outbreaks, 2024
~30% mortality in affected flocks

500+

Swedish herds
affected, 2025

Autumn 2025 — the first Finnish signal

- During enhanced bulk-tank milk screening in Southwest Finland.
- BTV-3 antibodies confirmed in two animals in one holding, verified by the EU reference laboratory; no virus detected.
- It appeared in exactly the coastal region a wind-borne introduction from the south-west would reach first.



Finland has the vectors.

It has no map of where an incursion would land.

- Bluetongue virus does not need to be carried in by trade.
- Infected *Culicoides* are lifted into the atmospheric boundary layer and delivered on regional airflows.
- Finland lies close to an actively infected region, holds competent resident vectors, and has no quantitative estimate of where those arrivals would concentrate.

1

Competent vectors, already present

Native *Obsoletus* and *Pulicaris* groups are widespread across Finland

2

No spatial risk information

Nothing currently states which coastlines, which weeks, or which holdings are most exposed to arrival.

3

The decisions are spatial

Where to place traps. Which herds to vaccinate first. When to act. All three need a map, not a yes or no.



SILAM

- The System for Integrated modeLling of Atmospheric composition — a global-to-mesoscale dispersion model developed at the Finnish Meteorological Institute.
- Originally built for radiological emergency preparedness, then extended to air quality, wildfire smoke, and natural aerosols.
- Importantly here natural pollen.

Why SILAM?



SILAM was used by ([Siljamo et al., 2020](#)) to test whether records of the **Harlequin ladybug**, *Harmonia axyridis* from 2004 and 2005 were associated with atmospheric events



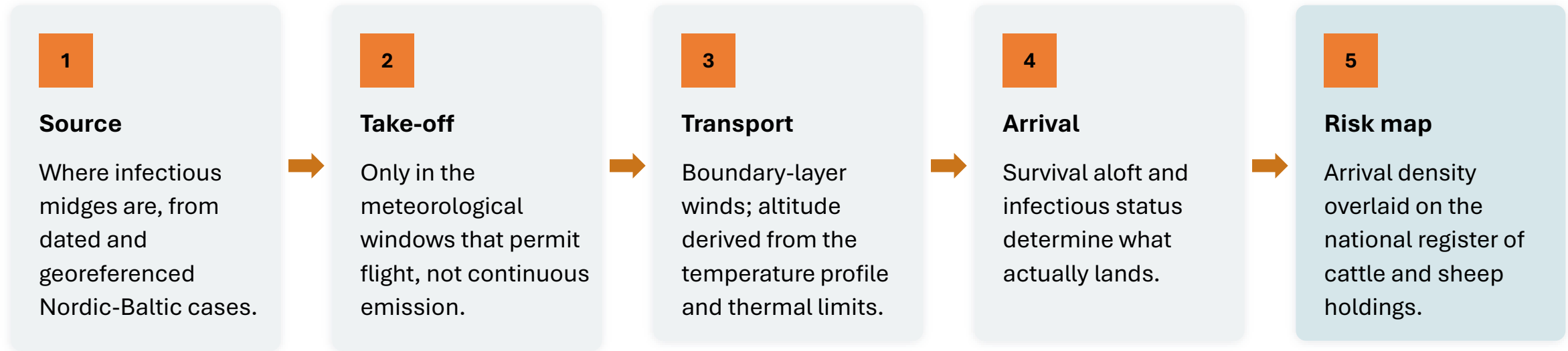
[Harlequin Ladybird \(Harmonia axyridis\)](#)

Their results revealed that air flows assisted dispersal over the English Channel from Belgium, the Netherlands and France



From passive particles to active insects

RIMA replaces its passive-particle treatment with an explicit insect module.



The model is the deliverable as much as the map is: an insect-dispersal capability inside an operational forecasting system, not a one-off study.

Meanwhile, in Vuosaari....



- Trap siting, timing and weather conditions all shape what you actually catch
- Models tell you where to look but somebody still has to go and look

VALIDATION



- Finland has no outbreak to fit to.
- The model is therefore tested against other countries' incursions, where location and date are already known.

The test set

- **BTV-3 through north-western Europe, 2023–2024**

The spread out of the Netherlands, with a documented sequence of country-level introductions.

- **Denmark, Norway and Sweden, first detections 2024**

Three arrivals within weeks of each other in August and September, each georeferenced and dated.

Forward runs

From the known source regions: predict where and when infectious midges arrive.



Inverse footprints

From each observed detection: reconstruct the candidate source areas.



DELIVERABLES



1

National arrival maps

Relative probability of infectious-midge arrival across Finland, across several transmission seasons, with confidence bounds.

2

Holdings ranked by exposure

Cattle and sheep holdings and animal numbers ordered by predicted arrival density, from the national register.

3

Surveillance targeting

Where to place traps and concentrate sampling effort, and in which weeks.

5

A reusable model component

An insect-dispersal module inside SILAM

6

Publications and outreach



Ohjelman esittely (ENG)

- Postdoctoral Programme for Research Institutes in Finland will recruit 85 new postdoctoral researchers to 12 Finnish government research institutes between 2025 and 2028.
 - The Programme aims to boost research, development, and innovation in key areas for society and business. Postdoctoral researchers will drive impactful, high-level research bridging science, industry, and administration.
 - The Programme fosters networking and cross-sector mobility, supported by Finland's long-term research and development funding
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- #tulaneppostdoc -tunniste käytössä sosiaalisessa mediassa kaikessa viestinnässä



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Thank you for you attention!

Questions are welcome