INTERNATIONAL POTATO CENTER
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Modeling for natural enemy distribution and potential efficacy in biocontrol

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Outline

Introduction

- IPM and classical biological control
- Invasive potato pests and their distribution
- Selection of parasitoids for classical biocontrol
- Factors affecting establishment of natural enemies

Potential establishment and control efficacy analysis

- Parasitoid phenology modelling and potential distribution assessment using ILCYM

Establishment and control efficacy mapping results

- Case 1: CBC of leafminer fly
- Case 2: CBC of PTMs
- Case 3: CBC of Tuta absoluta

Conclusions

Concepts

Integrated Pest management

“A system that keeps harmful organism below the economic damage level based on ecologically, economically and toxicologically acceptable methods, taking into account the specific ecology of crops as well as harmful organism” (IOBC, 1973)

Biological control

“The action of parasitoids, predators and pathogens in maintaining another organism’s activity at a lower average than would occur in their absence” (Debach, 1964).

Classical biological control

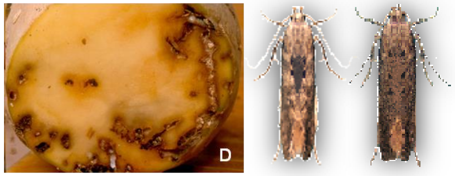
Introduction of ecologically adapted natural enemies from the area of origin of the target pest.

Invasive potato pests

Tuta absoluta

Liriomyza huidobrensis

Phthorimaea operculella

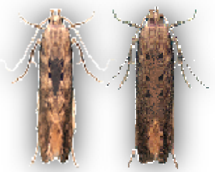


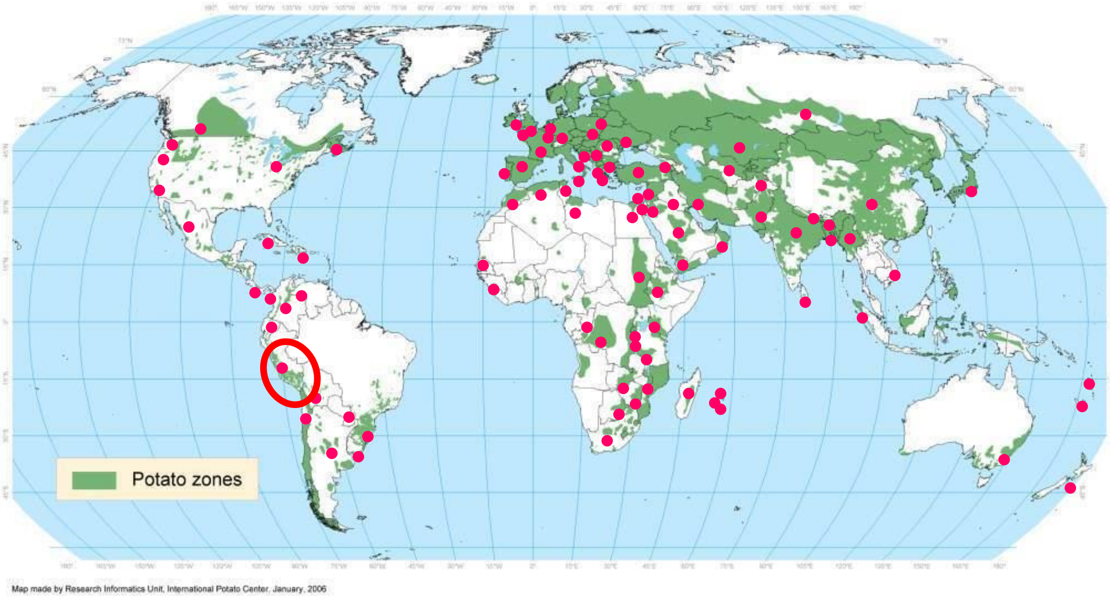
Tecia solanivora

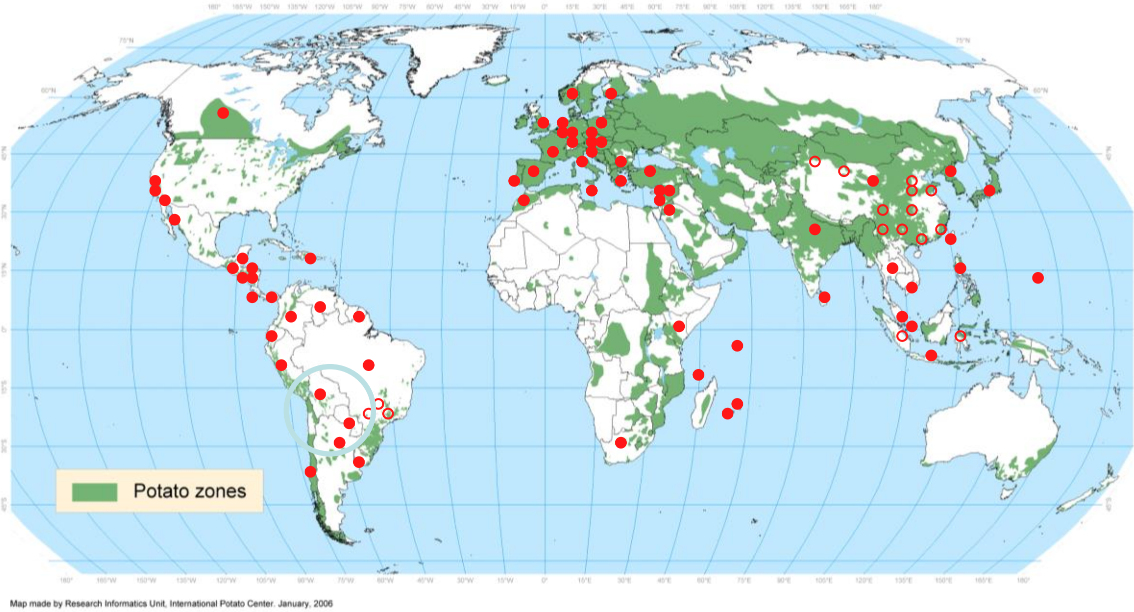
Neotropic: Center of origen of main potato pests

Many potato pests have coevolved in the center of potato origin and have become invasive pests worldwide

Global distribution of main potato pests







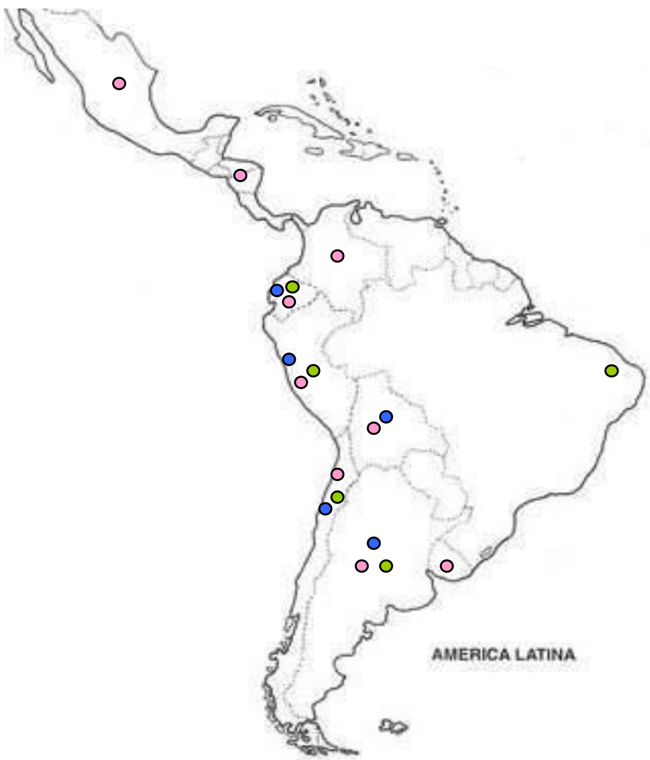
Selection of parasitoids for classical biocontrol

Halticoptera arduine

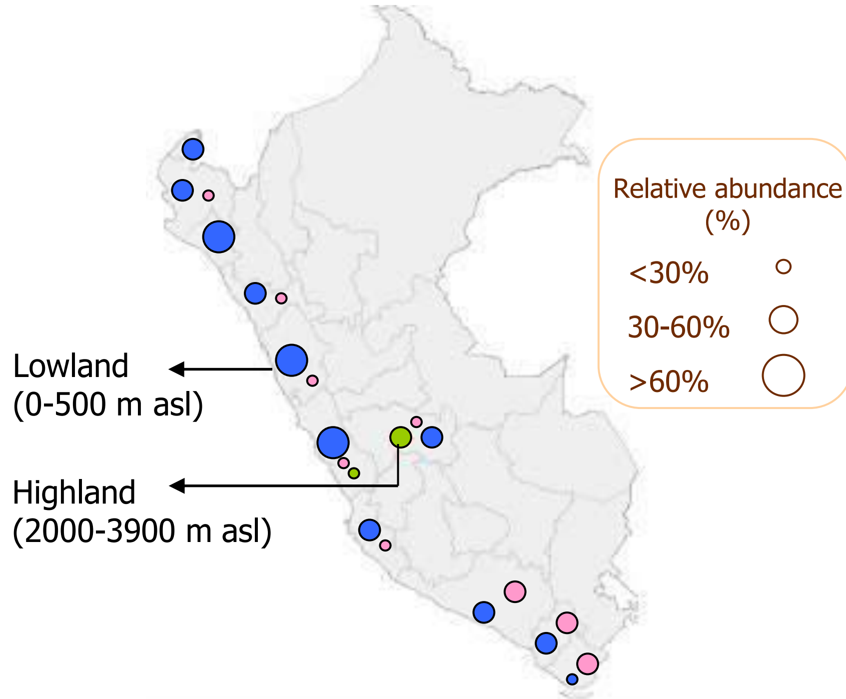
Phaedrotoma scabriventris

Chrysocharis flacilla

Neotropical region



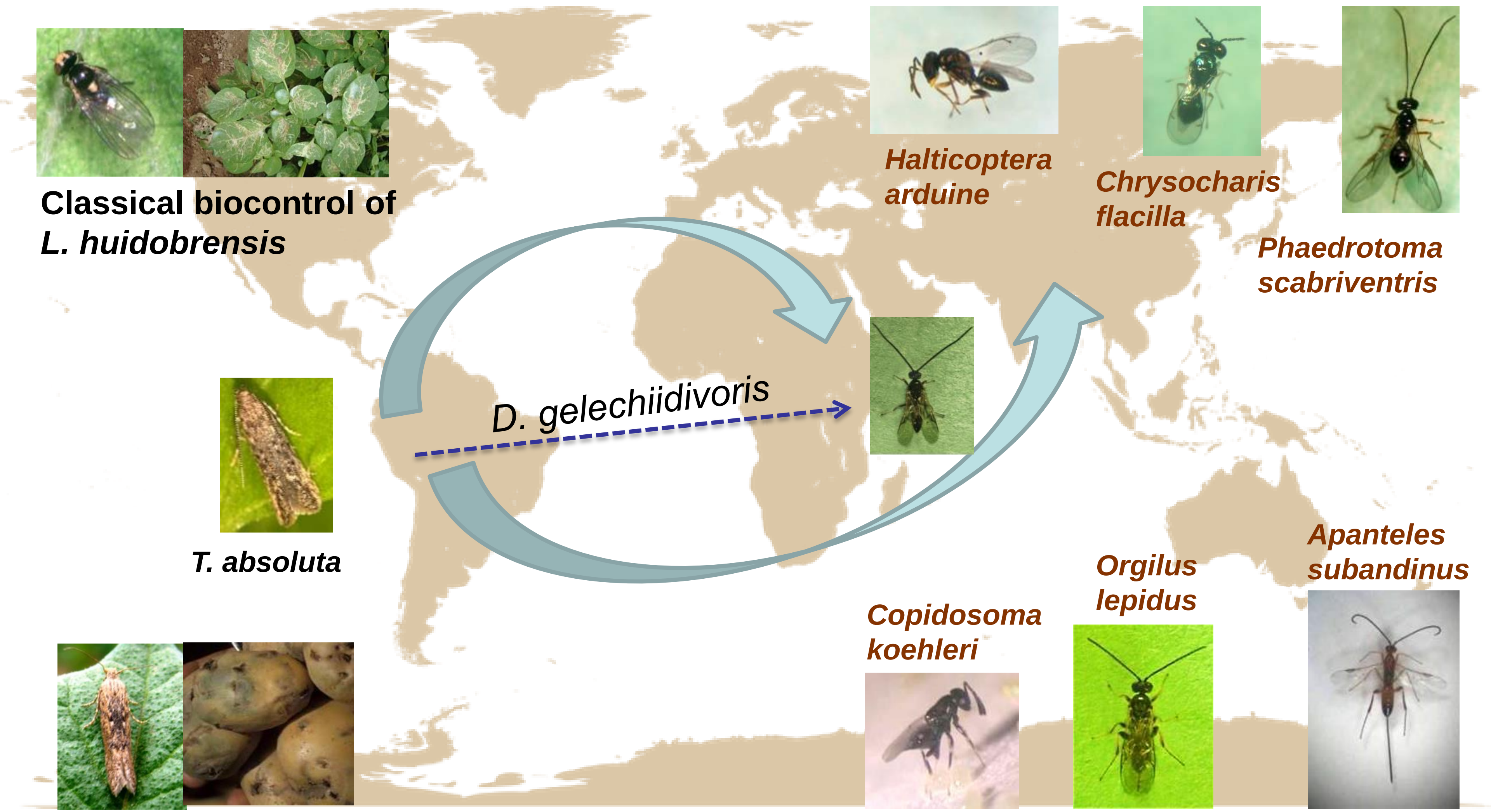
Peru



Adapted to tropical and subtropical regions

Selected **species** have **different environmental preferences!**

Classical biological of invasive potato pests by exporting parasitoids to Africa and Asia



Classical biocontrol of
P. operculella

Factors affecting establishment of natural enemies

Biotic factors

- Availability of target host/prey in space and time
- Presence of competitors
- Access to food

Abiotic factors

- Temperature, Humidity

  T° is the main factor affecting the establishment of exotic species in new environments

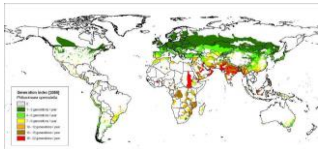
"Climate matching"

- Similarities and differences of climatic conditions between the countries of collections and release
- It is not a realible basis for predicting **survival** and **establishment**

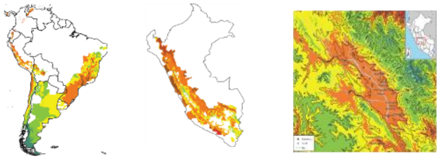
Objective

To model the distribution, establishment and potential efficacy and potential population growth of main potato pest parasitoids in potato-based production systems

Parasitoid mapping using ILCYM



Potential distribution at global, regional and local level



Mapping

Current climate: 2000

(1950-2000: www.worldclim.org/)

With and without crop shapes

Future climate: 2050

Down-scaled data SRES-A1B, IPCC (2007): http://gisweb.ciat.cgiar.org/GCMPage

$$\textbf{ERI}=\frac{\left(\sum_{i=1}^{365}\widehat{Ro}_i\right)/365}{max\left(\widehat{Ro}_i\right)}$$

$$\textbf{GI}=\frac{\left(\sum_{i=1}^{365}365\,/\widehat{GL}_i\right)}{365}$$

EI

GI

AI

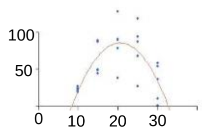
$$\textbf{AI}=\log_{10}\left(\prod_{i=1}^{365}\hat{\lambda}_i\right)$$

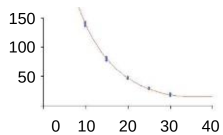
Indices

Model validation

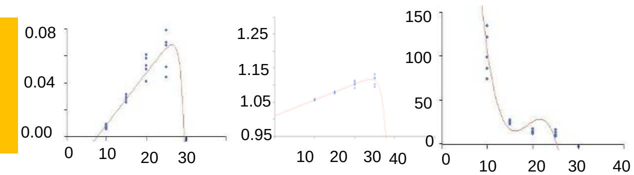
Model builder

Simulation of life-table parameters



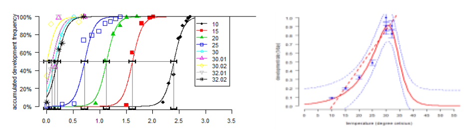


Net reproduction rate, generation time

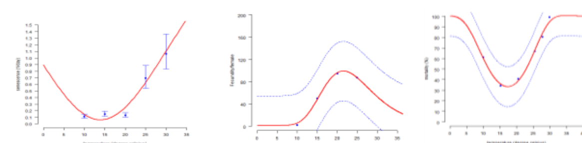


intrinsic and finite rate of increase, double time

Temperature-based phenology models



Development rate and time



Survival rate, oviposition, mortality

Life-table studies

A constant and fluctuating temperatures: oviposition, survival time, development time, mortality

(www.cipotato.org/ilcym)

Case study 1:

Classical biocontrol of *L. huidobrensis*

Dossier

Compiled upon request of the
KENYAN MINISTRY OF AGRICULTURE

about

Halticoptera arduine (Walter)
Chrysocharis flacilla Walker
Phaedrotoma scabriventris Nixon

parasitoids of the invasive leafminer fly
Liriomyza huidobrensis Blanchard

according to FAO Code of Conduct for the Import and Release of Exotic Biological Control Agents

International Potato Center, February 2008

CENTRO INTERNACIONAL DE LA PAPA
CIP

Changes in regional establishment and distribution in Africa

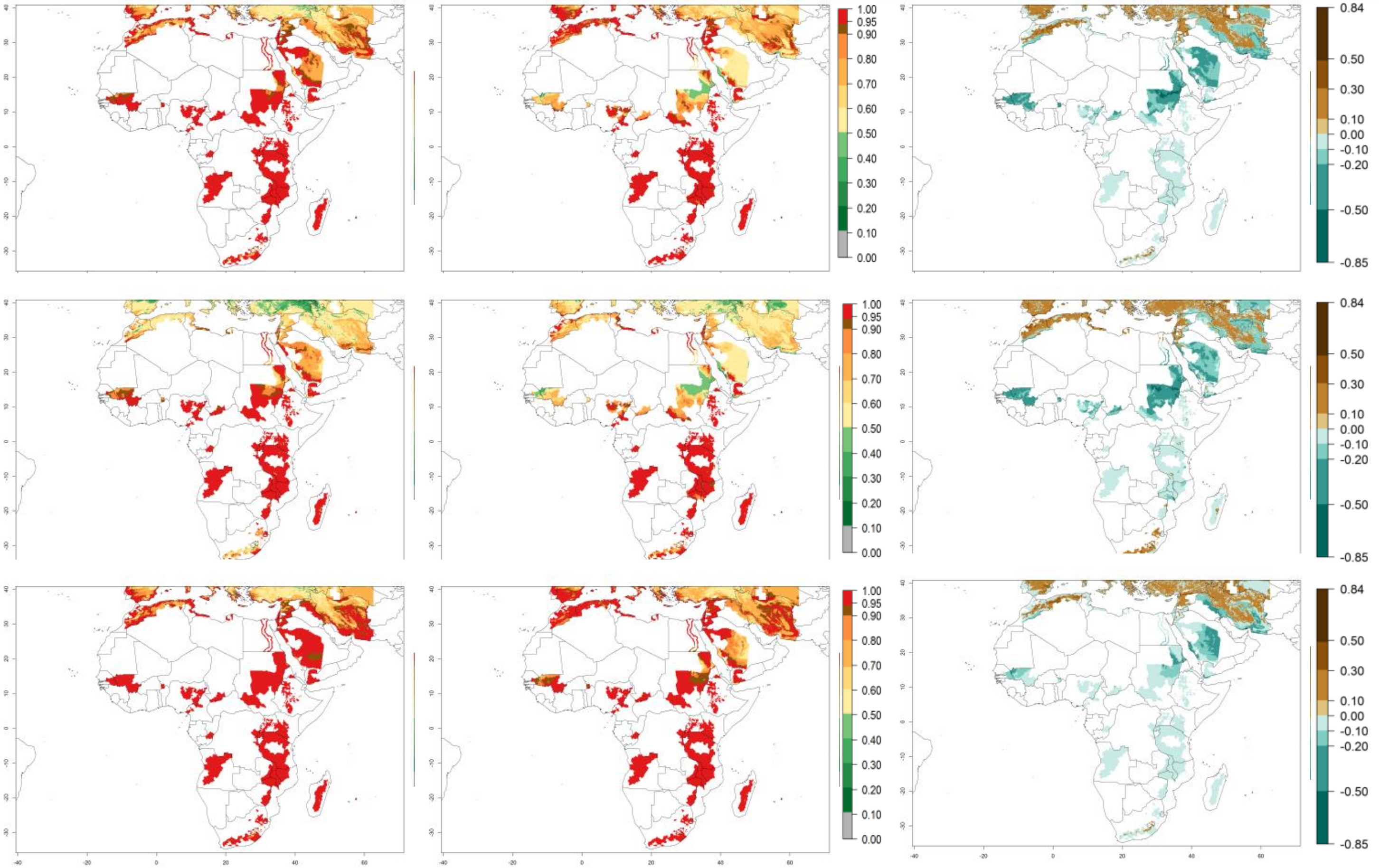
(displayed for potato production regions of Africa with an ERI>0.7 of its primary host *Liriomyza huidobrensis*)

	2000	2050	Index change (2000-2050)

Halticoptera arduine

Chrysocharis flacilla

Phaedrotoma escabriventris



✓A successful establishment (EI>0.95) of the three parasitoid species can be expected in most African countries under the year 2000 temperature conditions.

✓Parasitoids will maintain a high establishment potential (EI>0.95) under climate change temperature scenarios for the year 2050

(Mujica et al. 2016. In Pest Risk Atlas for Africa)

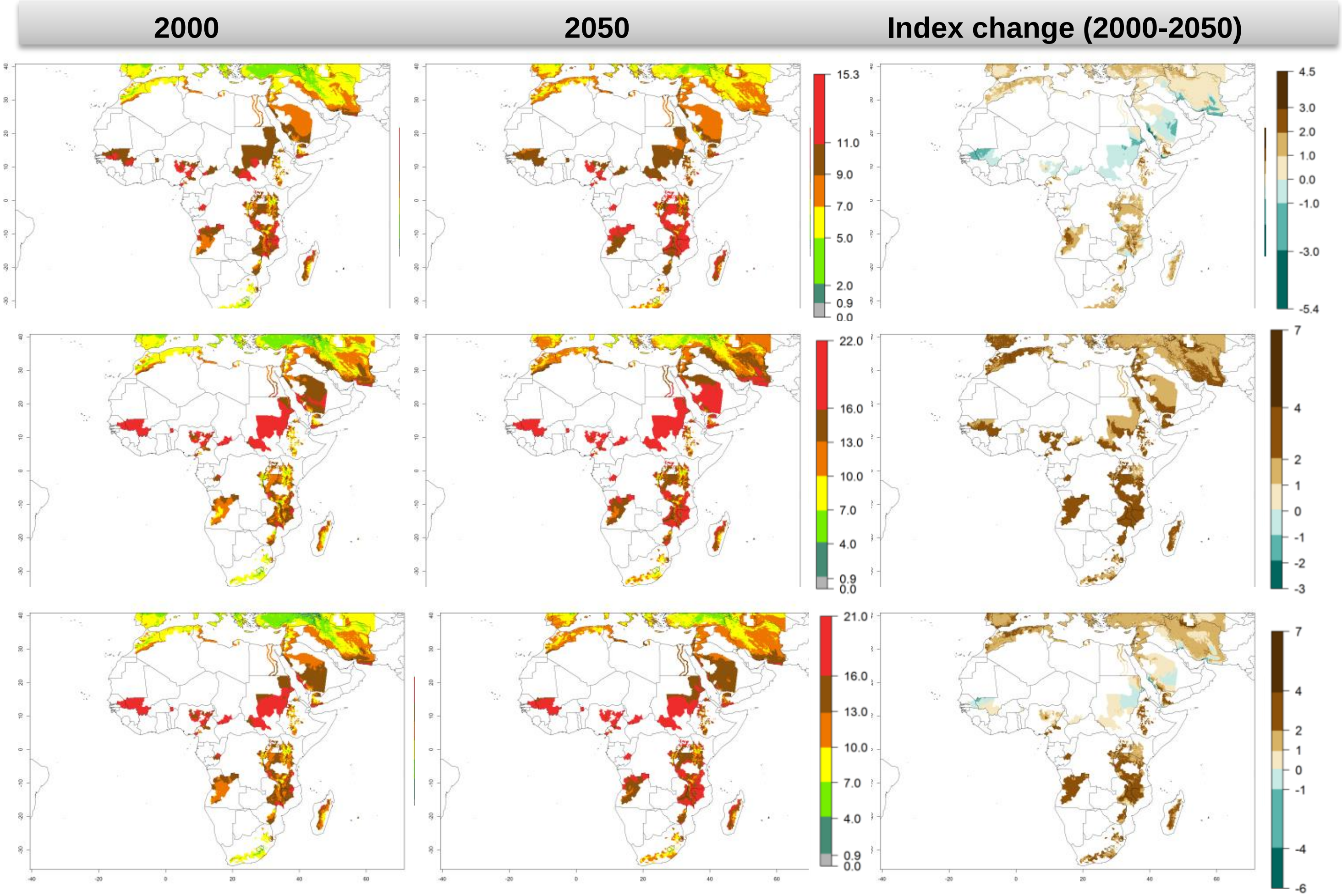
Changes in regional abundance in Africa

(displayed for potato production regions of Africa with an ERI>0.7 of its primary host *Liriomyza huidobrensis*)

Halticoptera arduine

Chrysocharis flacilla

Phaedrotoma escabriventris



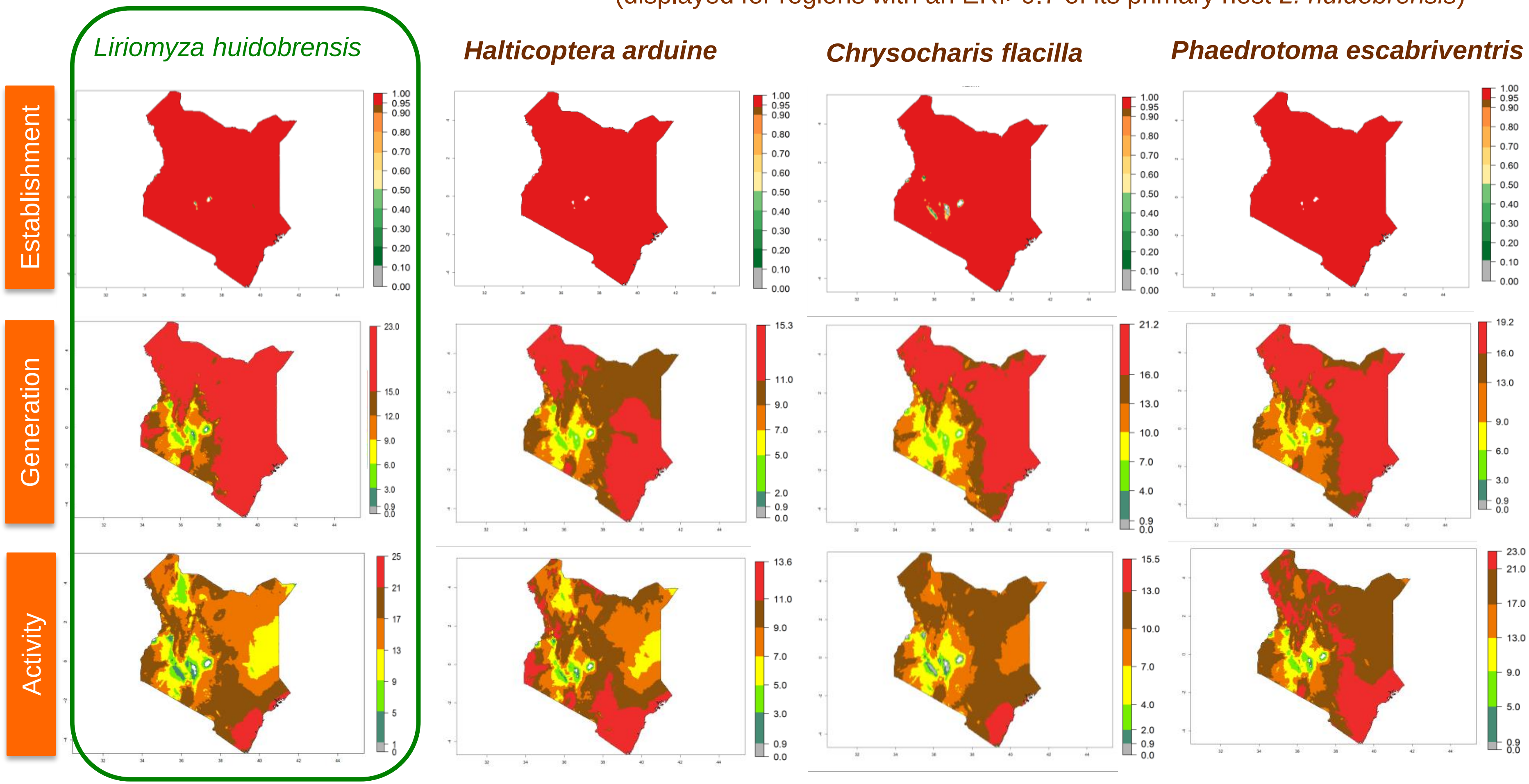
✓The GI for the year 2000 estimates between 11–21 and 7-16 generations per year in tropical and subtropical African regions.

✓Predictions for the year 2050 climate change scenario estimate an increase of 1–3 generations per year for almost all Africa for the three species.

(Mujica et al. 2016. In Pest Risk Atlas for Africa)

Introduction of LMF parasitoids in vegetable production systems in Kenya

(displayed for regions with an ERI>0.7 of its primary host *L. huidobrensis*)



✓ The three parasitoid species have a good potential to establish and successfully control the leafminer fly in crop production systems in Africa under the year 2000 temperature conditions.

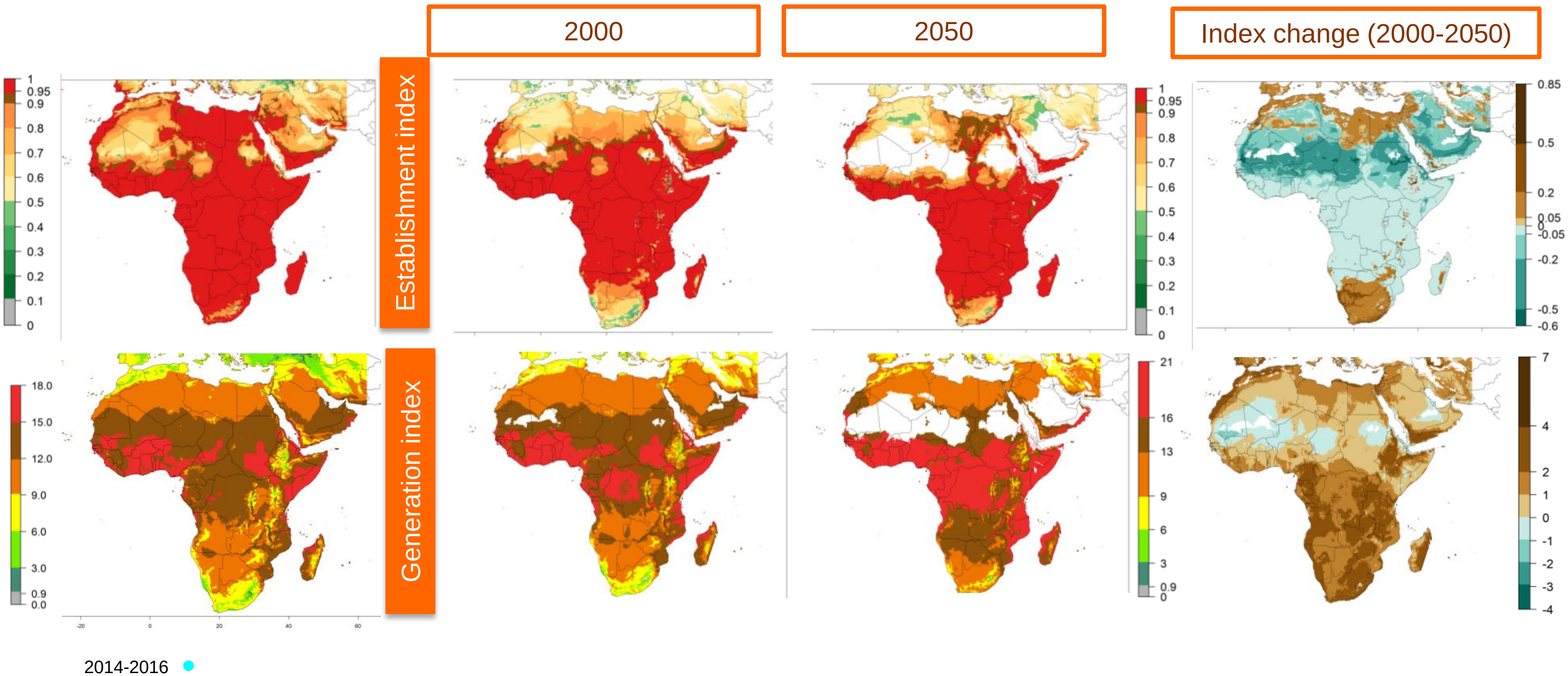
(Mujica et al. 2016. In Pest Risk Atlas for Africa)

Case study 2:

Classical biocontrol of *T. absoluta*

African map: Introduction of *D. gelechiidivoris*

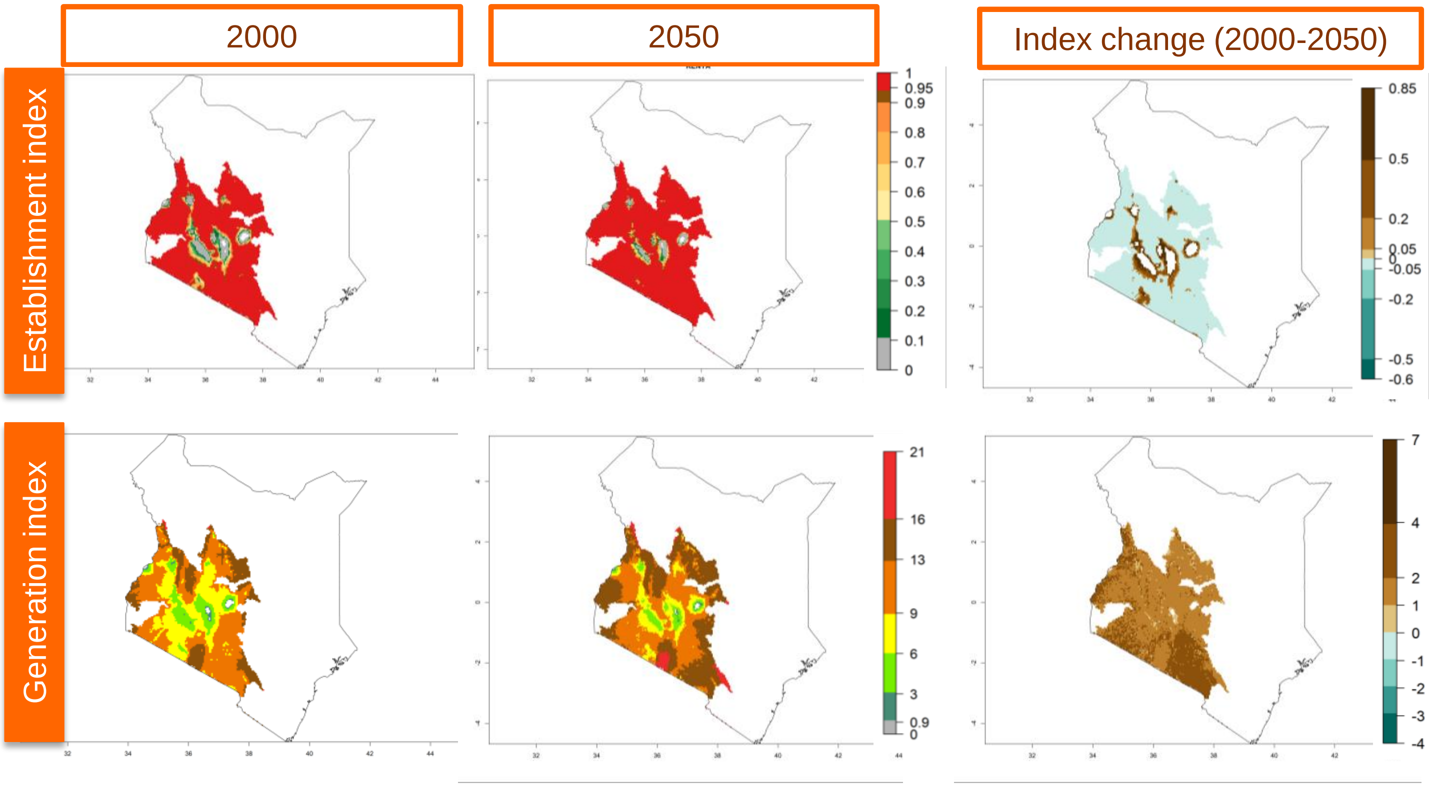
(displayed for regions with an ERI>0.7 of its primary host *Tuta absoluta*)

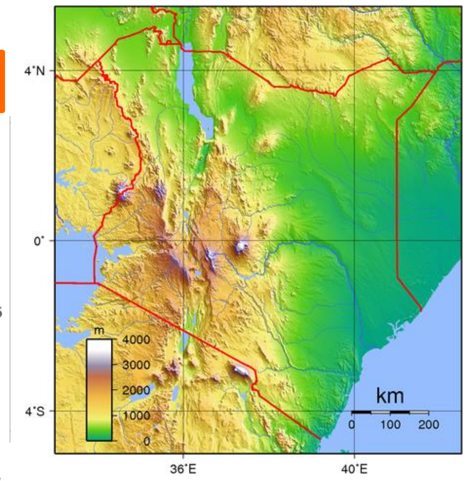


- ✓ The GI for the year 2000 estimates between 16-21 and 9-16 generations per year in most tropical and subtropical African regions.
- ✓ Predictions for the year 2050 climate change scenario estimate an increase of 2-4 generations per year for most *Tuta* infested regions in Africa.

Country map : Introduction of *D. gelechiidivoris* in Kenya

(displayed for regions with an ERI>0.7 of its primary host *Tuta absoluta*)





- ✓ Under climate change the parasitoid will maintain a high establishment potential and its total range of distribution will potentially expand to higher altitudes
- ✓ *D. gelechiidivoris* will increase more rapidly under middle altitudes (2-4 generations/year) in comparison with highland zones (1-2 generation/year)

Conclusions

- Exotic parasitoids have a good potential to establish and successfully control main pests in potato production regions, in which the pests are causing significant economic damage and where efficient natural parasitoids are currently absent.

- Our predictions are in accordance with the successful introduction and establishment of leafminer fly parasitoids (*H. arduine, C. flacilla,* and *P. scabriventris)* in cropping systems at different altitudes of Kenya.

- ILCYM is a new support tool to identify suitable release areas for natural enemies and to project its potential efficacies to control pests in a given environment according to the prevailing temperature.

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www.cipotato.org

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