The use of *Torymus sinensis* against *Dryocosmus kuriphilus*

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Evaluation and Regulation of the use of Biological Control Agents in the EPPO Region
Budapest, 2015-11-23/24

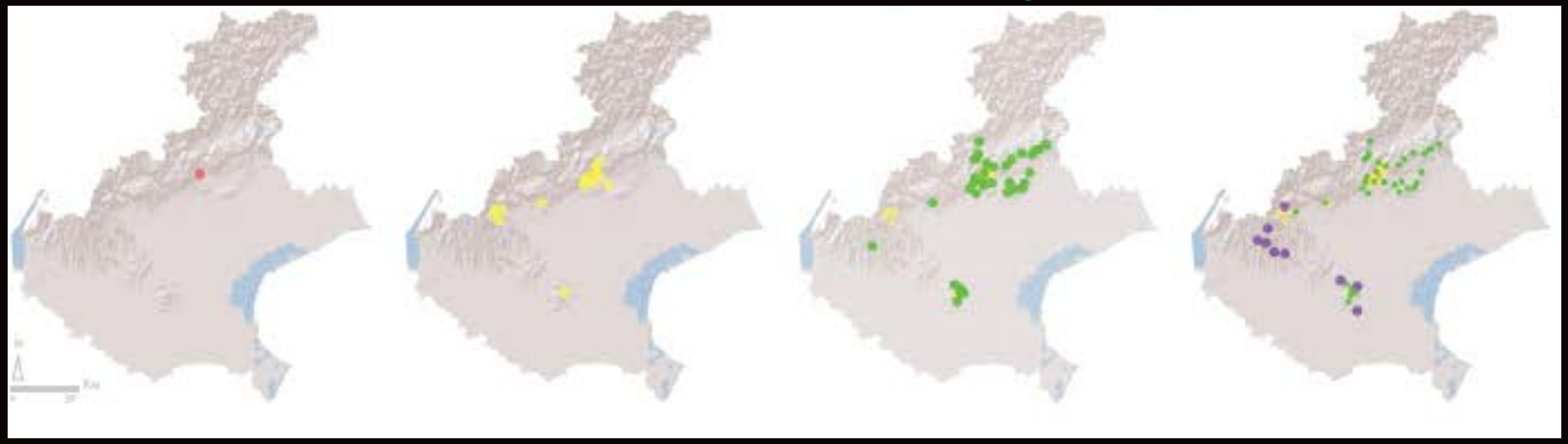
The protagonists

The host
Dryocosmus kuriphilus
The Asian Chestnut Gall Wasp
Invasive specialist herbivore of chestnut

The parasitoid
Torymus sinensis
The major natural enemy of ACGW
Introduced as biocontrol agent

Host invasion and distribution in the Veneto Region

2007 2008 2009 2010

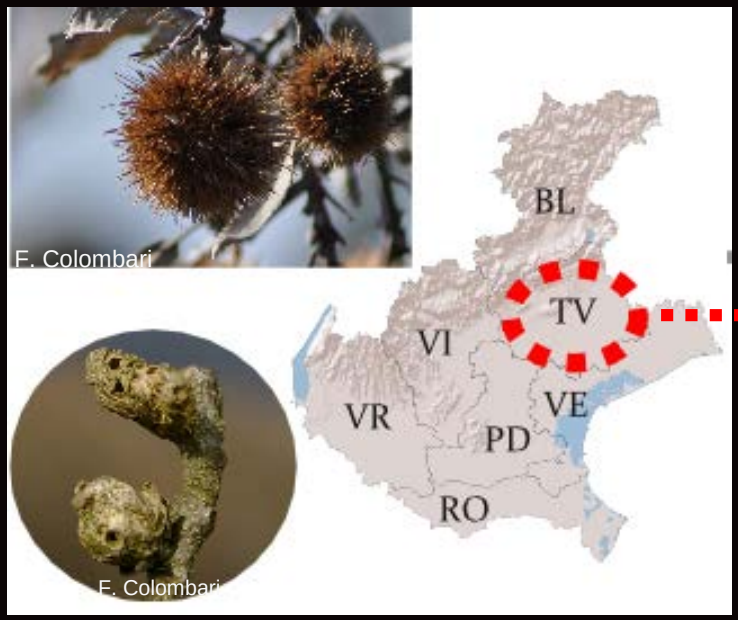


2011

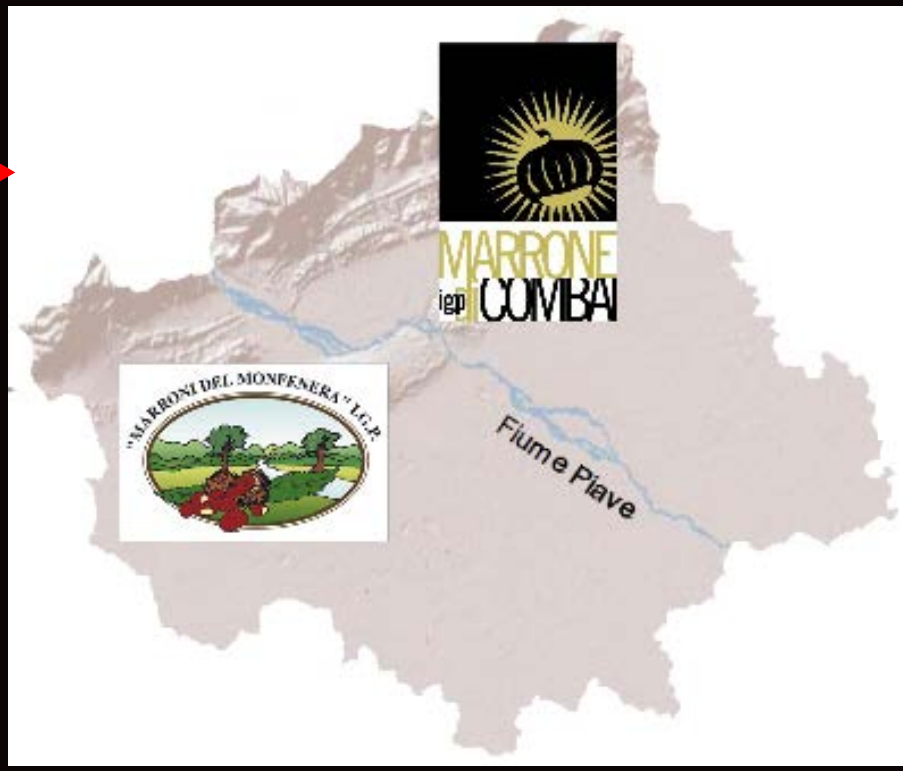
2012

ACGW distribution range = European Chestnut distribution range

ACGW infestation levels and nut yields



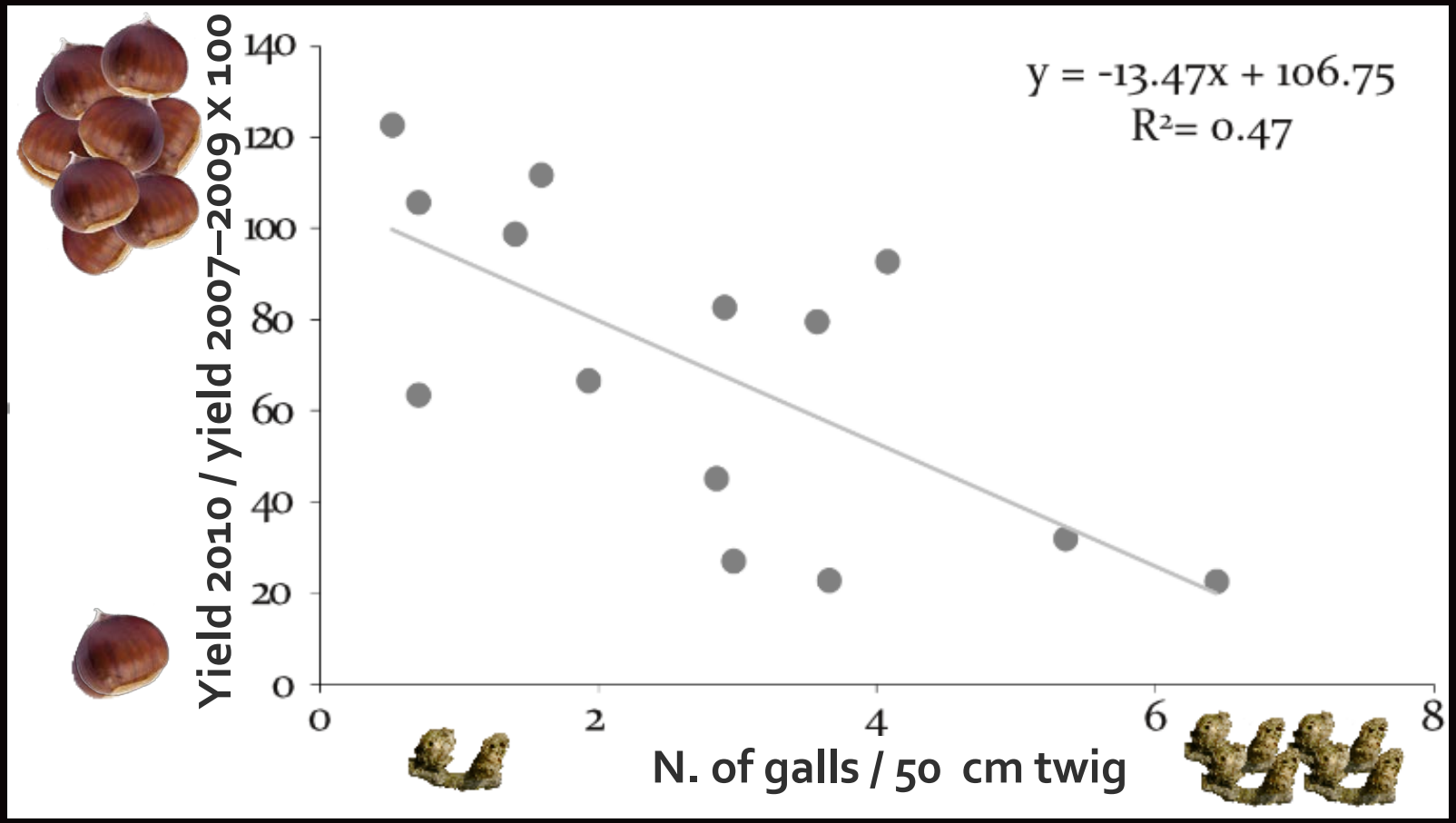
Colonization by ACGW → 2010



15 chestnut orchards:
- **4 years of yield records (2007–2010)**
- **n. galls / 50 cm twig (winter 2010-2011)**

ACGW infestation levels and nut yields

N. galls / 50 cm twig = 4- 6 → nut yield reduction = 50%
N. galls / 50 cm twig > 6 → nut yield reduction ≥ 80%

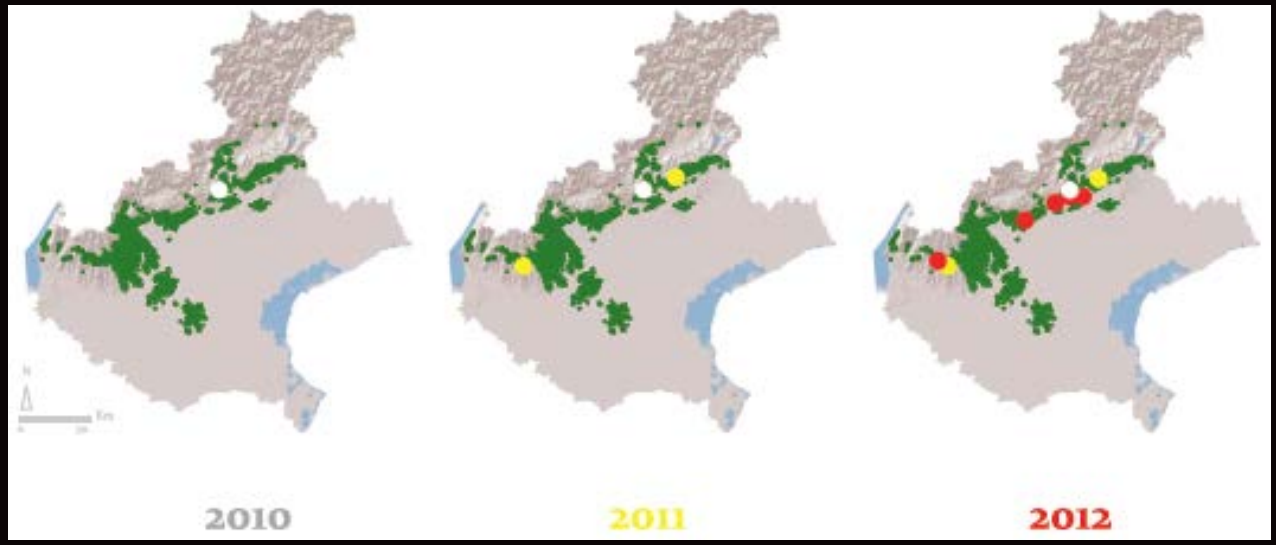


Battisti et al., 2014

The classical biological control program

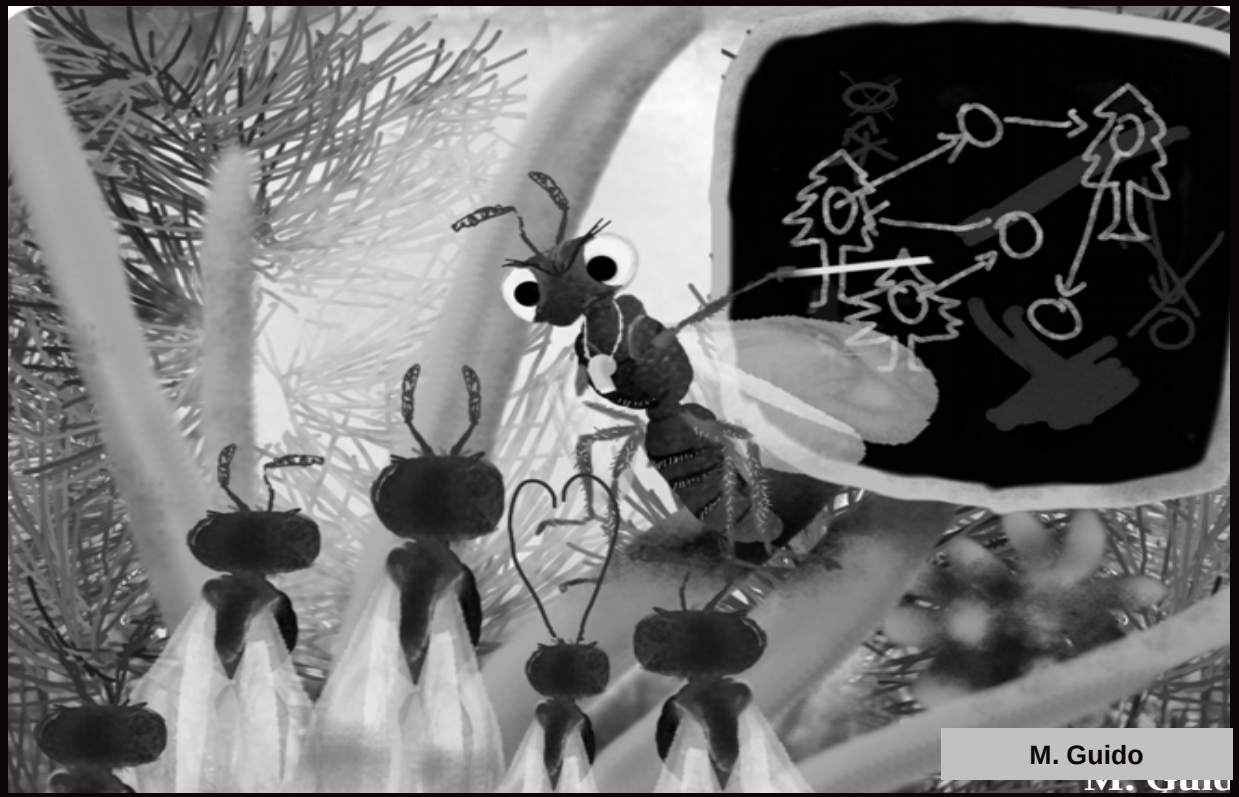
2010 - 2012

8 parasitoid releases



Successful biological control

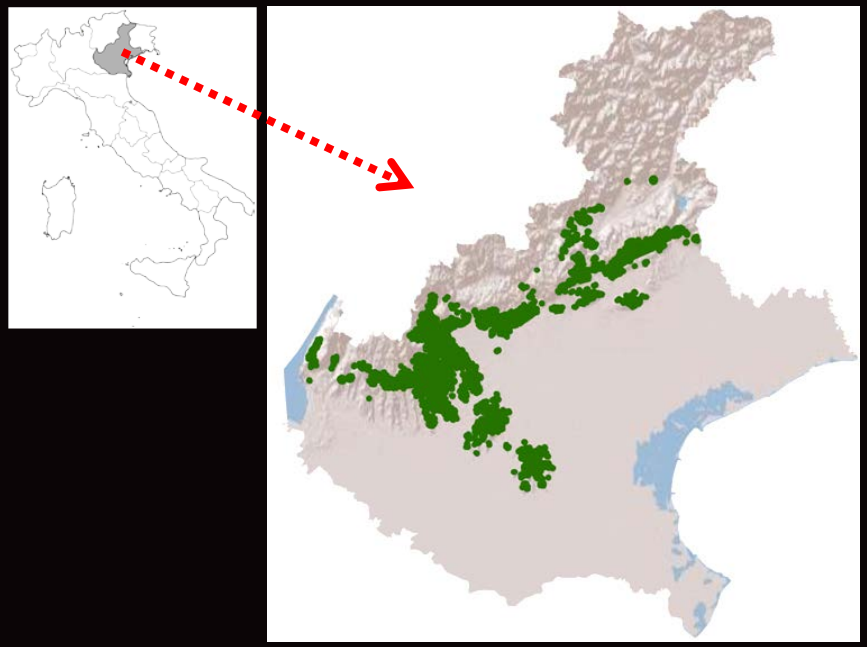
Natural enemies disperse without continued human management



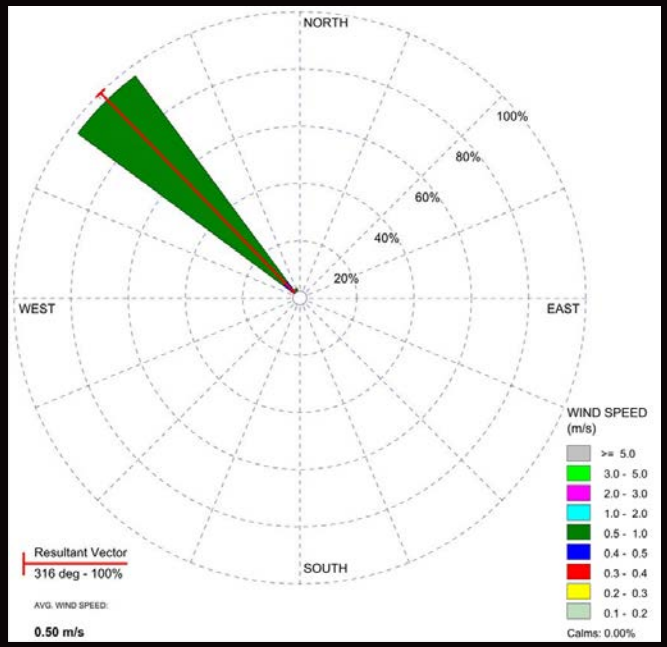
T. sinensis has been hypothesized to expand its geographic range alongside expanding chestnut gall wasp populations

Hypotheses

distribution of host patches…

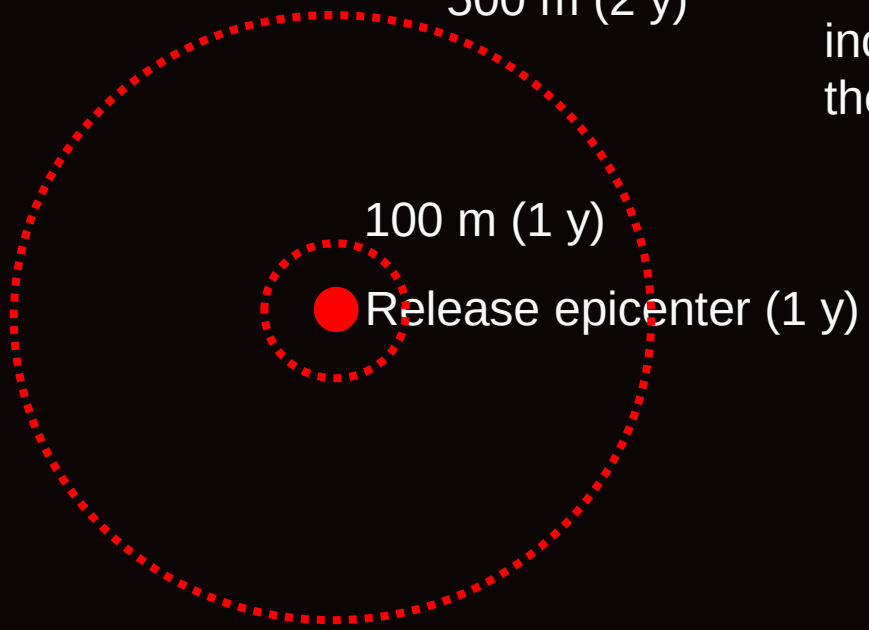


the prevailing wind directions…

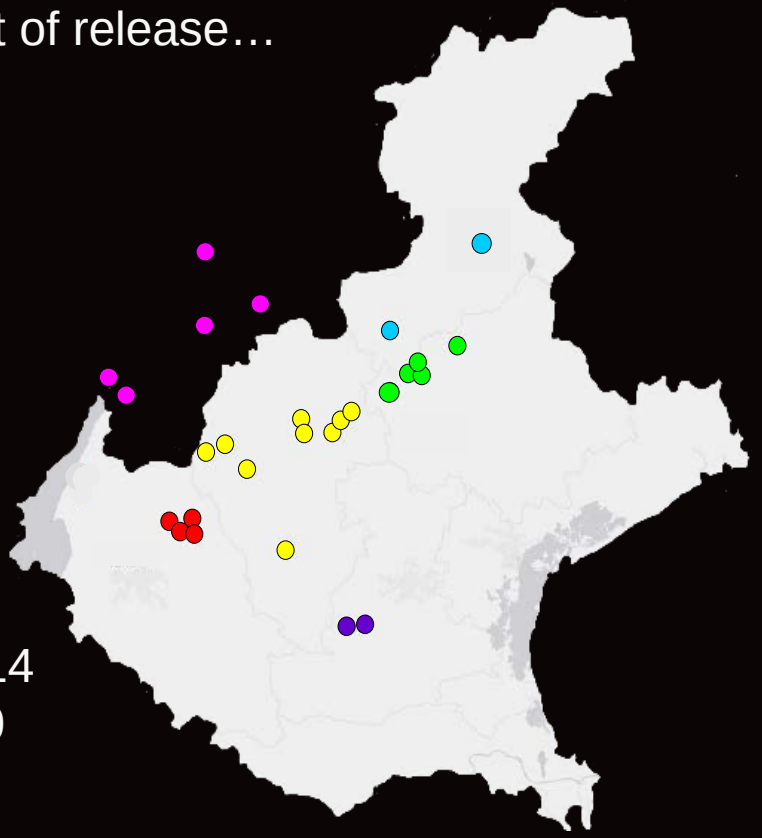


…would interactively influence and accelerate the spread of the biocontrol agent

Assessing short and long distance dispersal



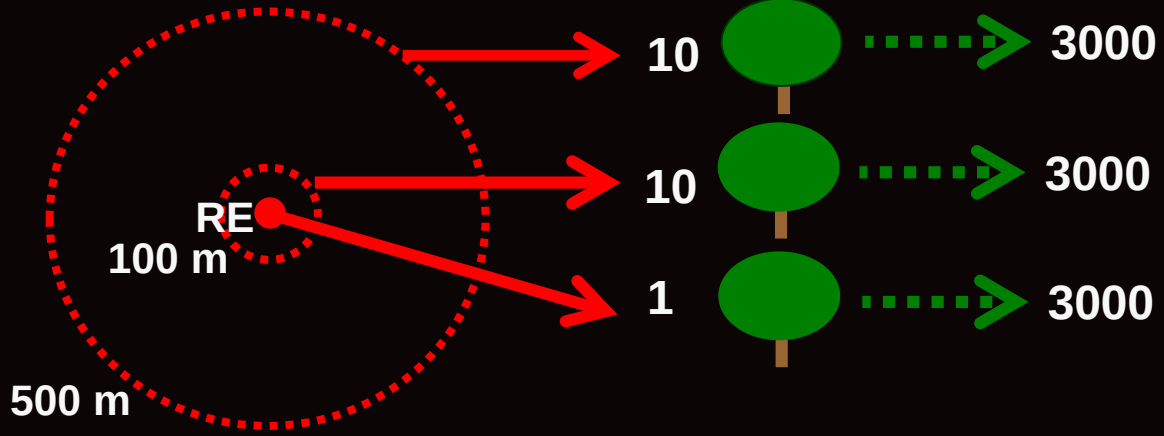
We assessed short distance dispersal by monitoring the abundance of *T. sinensis* at increasing distances (100 and 500 m) from the point of release…

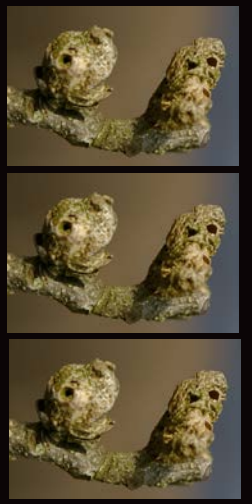


… and long distance dispersal by monitoring 14 non-release sites at distances up to about 100 km from the nearest release site

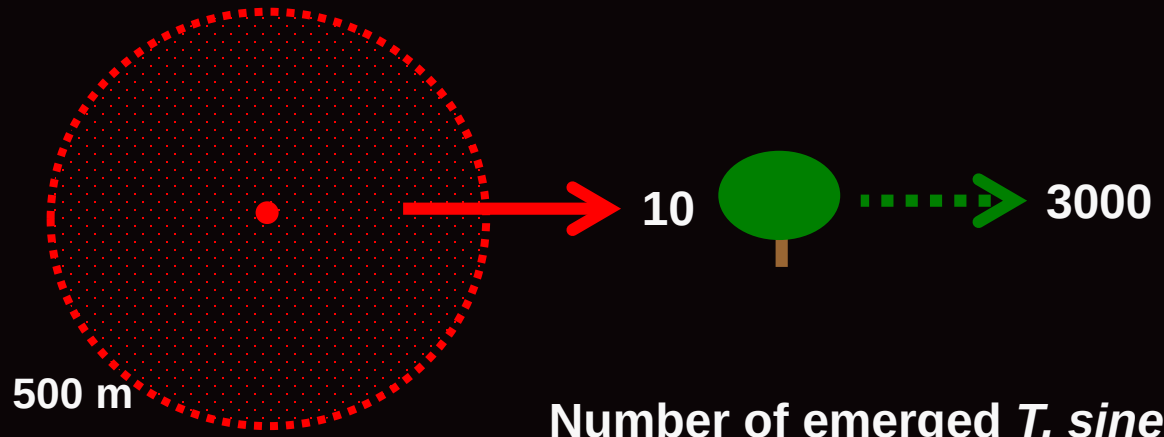
Gall collection and parasitoid rearing

Release





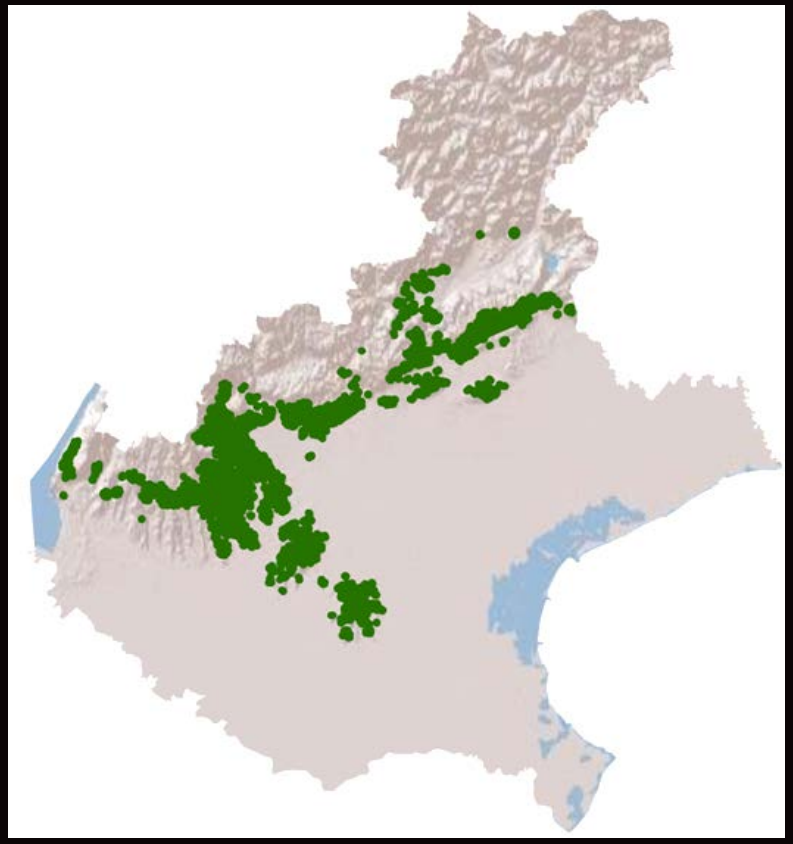
Non-release

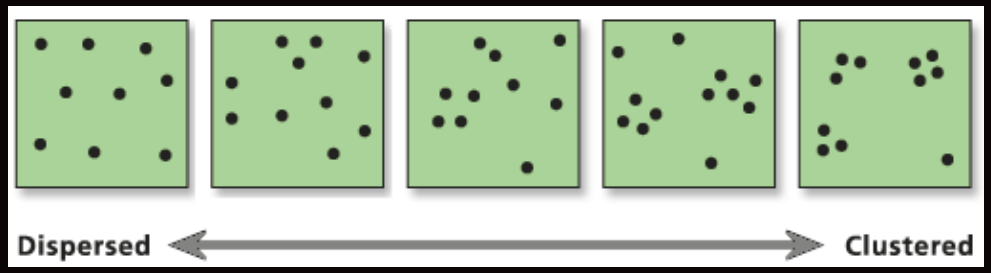


Number of emerged *T. sinensis* / 100 galls

Spatial analyses

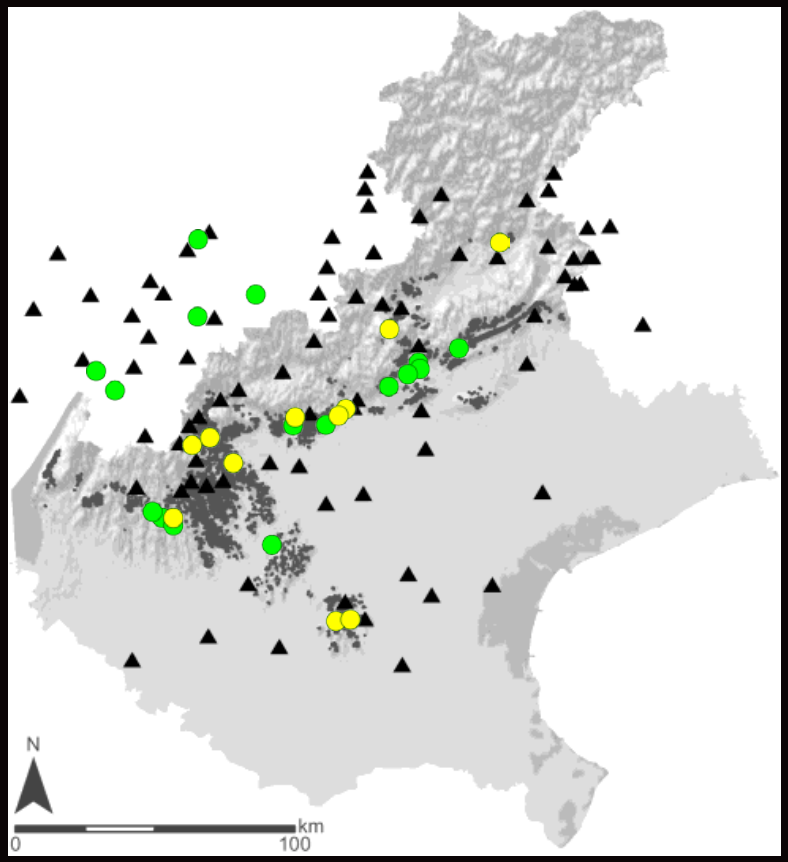
Host patches



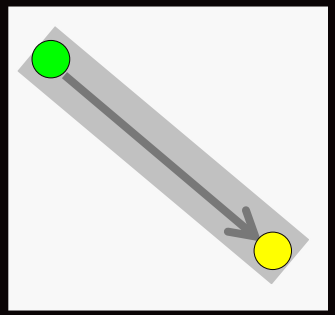


Wind modeling

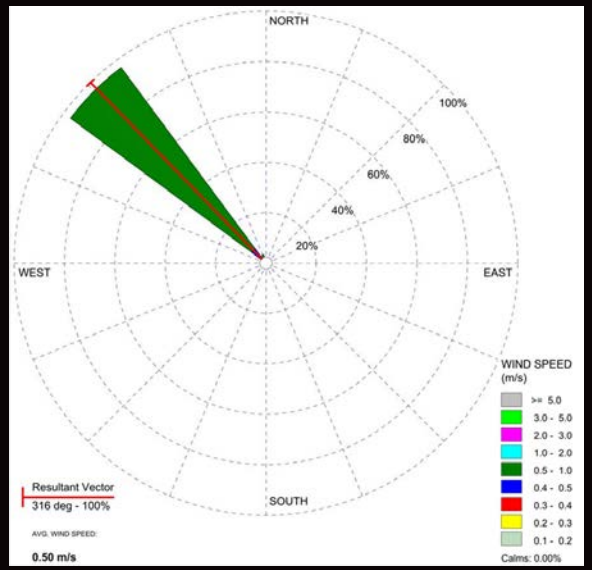
WindNinja



Weather stations considered

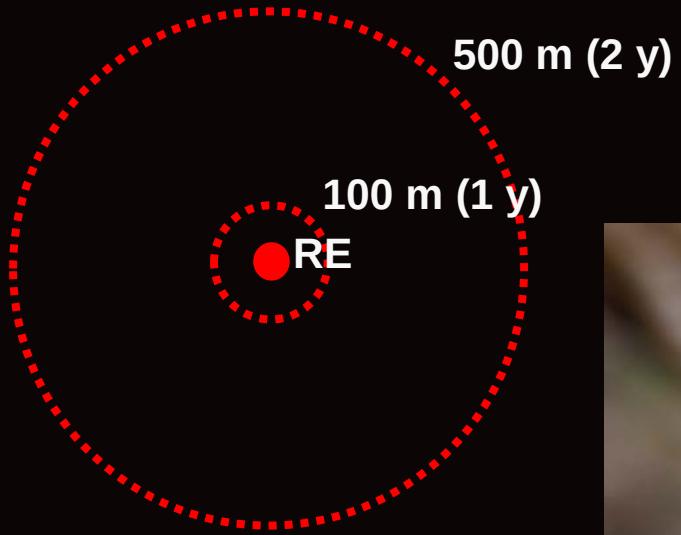


ArcGis



WRPlot

Establishment and short distance spread at release sites



No significant differences in parasitoid abundance

T. sinensis successfully established at all the release sites and persisted and reproduced

Establishment and short distance spread at release sites

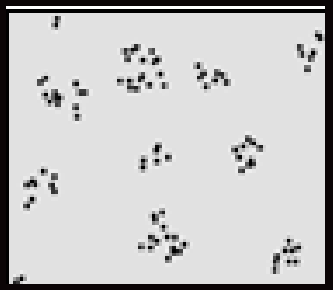
Spread distances of 100 and 500 m

Active flight

Demonstrated possible up to 650 m

Establishment and short distance spread at release sites

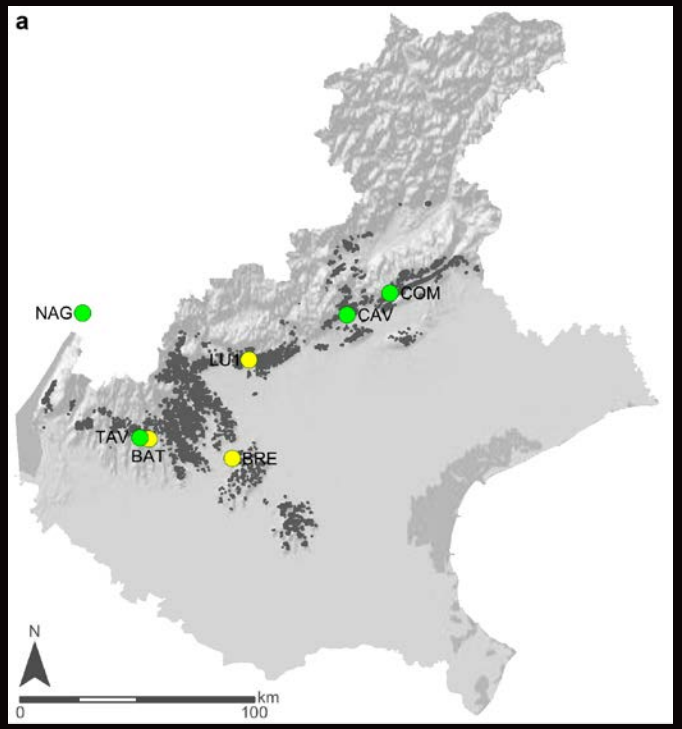
Active flight on short distances influenced by chestnut patch characteristics



Small size (< 10 ha)
Complex shape (i.e. high perimeter-area ratio)
Contiguity or short distances
Clustered pattern

Establishment and long distance spread to non-release sites

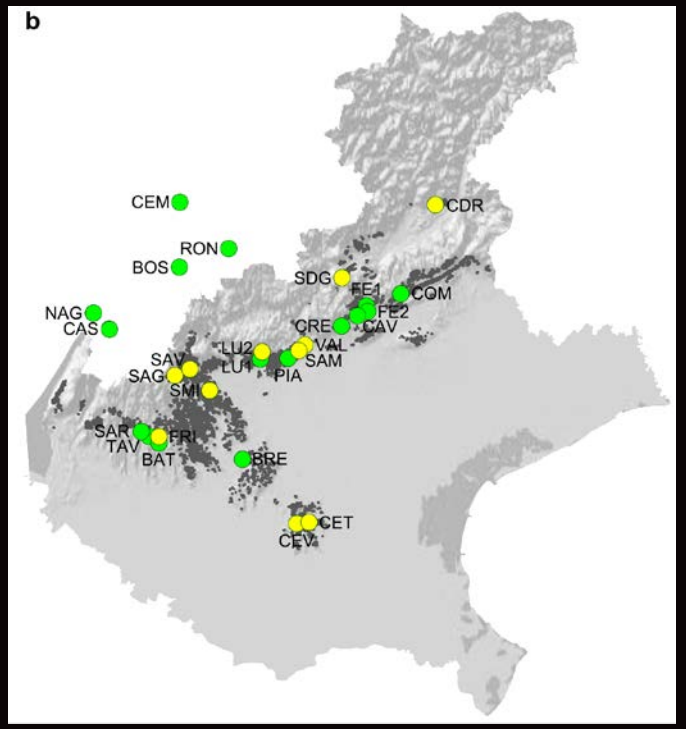
2012



release sites

non-release sites

2013



2012: 3 out of 16 non-release sites, at distances of 2.6 to 84.1 km from the nearest and farthest point of release, yielded *T. sinensis*

2013: *T. sinensis* adults emerged from galls collected at another 11 non-release sites, 0.65 to 110.5 kilometers away from the nearest and farthest site where the parasitoid was confirmed as established in the previous year

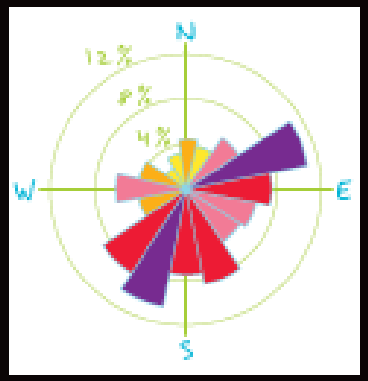
Establishment and long distance spread to non-release sites

No significant differences in parasitoid abundance between galls collected at release and non-release sites

No significant relationships between the number of emerged *T. sinensis* and both the size of the patch and gall density

Wind modeling and long distance spread

14 cases of long distance spread



Wind directions offered the most plausible explanation of parasitoid movement at large distances

> 70 km in a few days

Conclusions

High spread capability of *T. sinensis*

↓

Combination of short- and long distance flights

↓

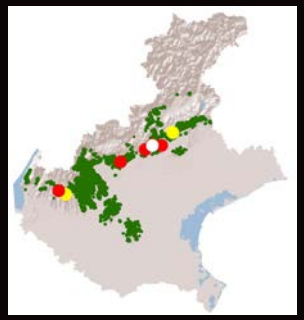
STRATIFIED DISPERSAL

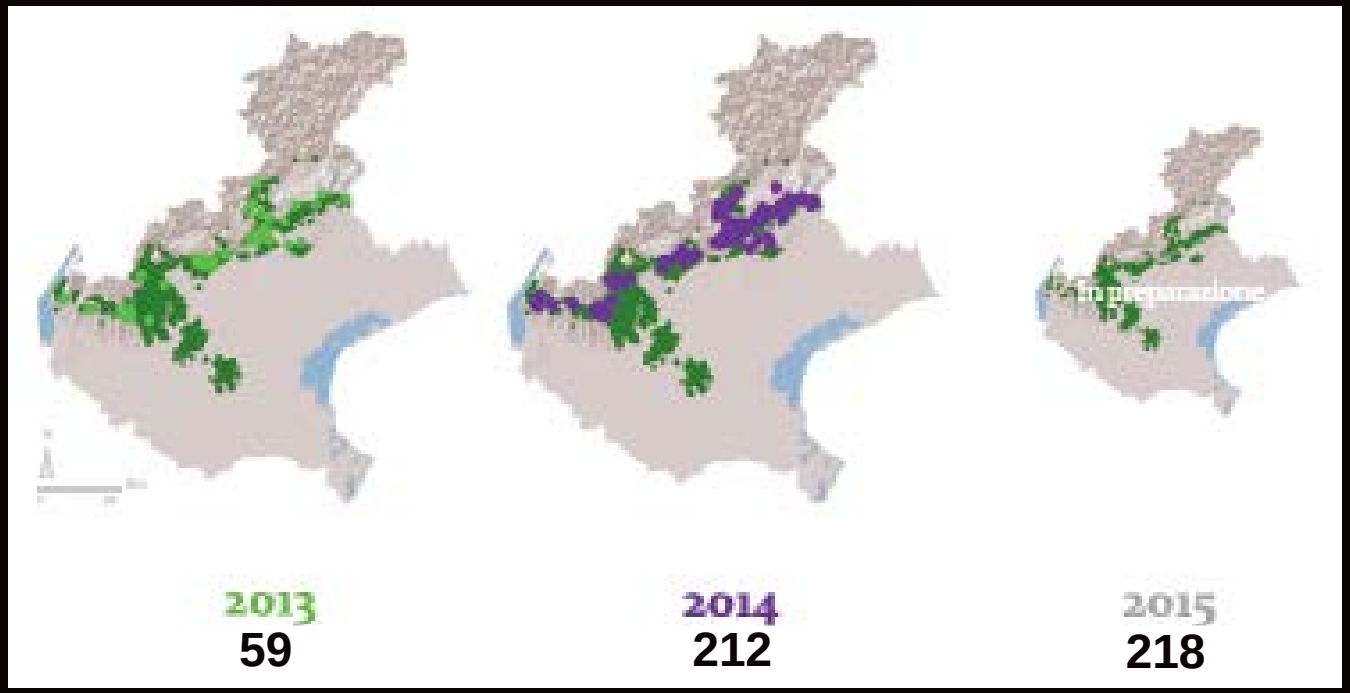
↓

Affected by resource concentration and wind

Colombari F, Battisti A (2015)
‘Spread of the introduced biocontrol agent *Torymus sinensis* in north-eastern Italy: dispersal through active flight or assisted by wind?’
Accepted for publication in Biocontrol

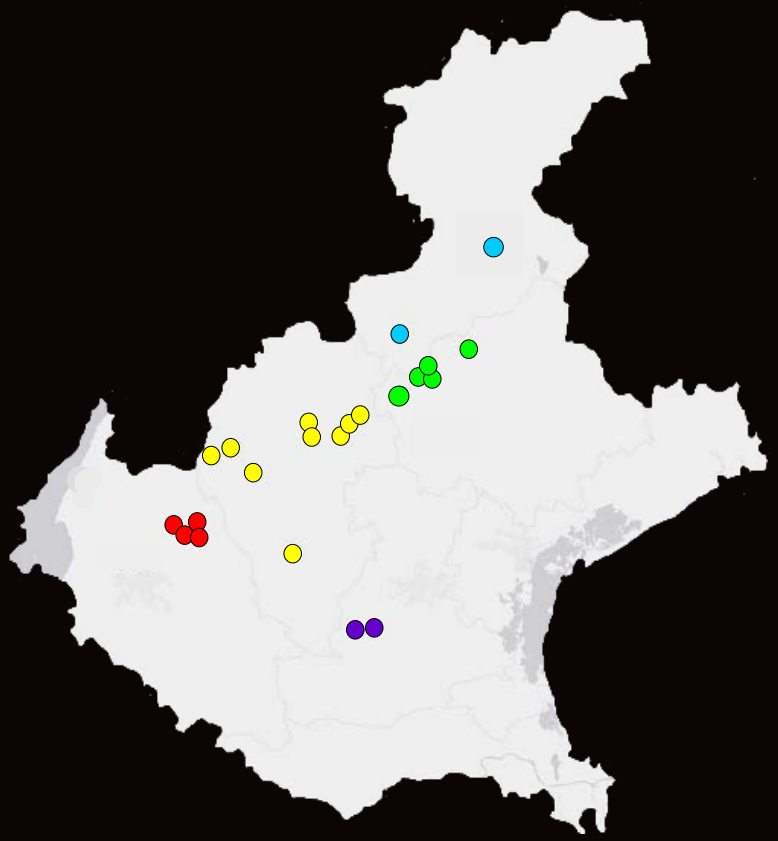
The classical biological control program





497 releases

Study sites



2010/2011 - 2015/2016

2010 / 2011: **1** release + **1** non-release
2011 / 2012: **3** release + **16** non-release
2012 / 2013: **7** release + **14** non-release
2013 / 2014: **31** release + **9** non-release
2014 / 2015: **14** release + **8** non-release
2015 / 2016: **11** release + **9** non-release

Parasitization rate (spring 2015)

82.39

13.00

4.24

0.51

Native parasitoids

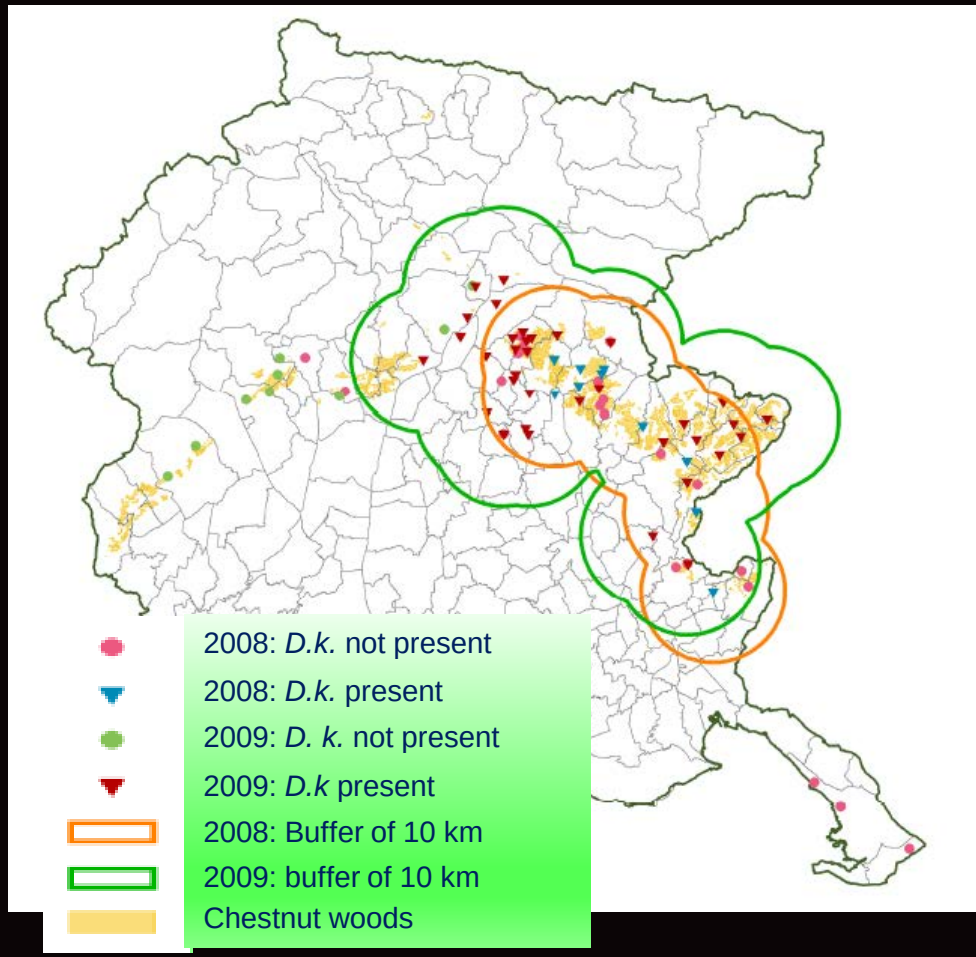

F. Colombari

< 0.5 adult parasitoids / 100 galls

Release sites → < 10% of *T. sinensis*
(2015 – work in progress)

A case study in a region without massive *T. sinensis* releases (do not nothing – but monitoring wood dynamics)

- ✓ first galls in 2008
- ✓ few chestnut orchards, and prevalence of mixed woods (*Quercus, Castanea, Fraxinus*)
- ✓ no great economic interests on chestnut production
- ✓ not well known non-target effects of *Torymus sinensis*
- ✓ *T. sinensis* released only in a few small areas (by privates)

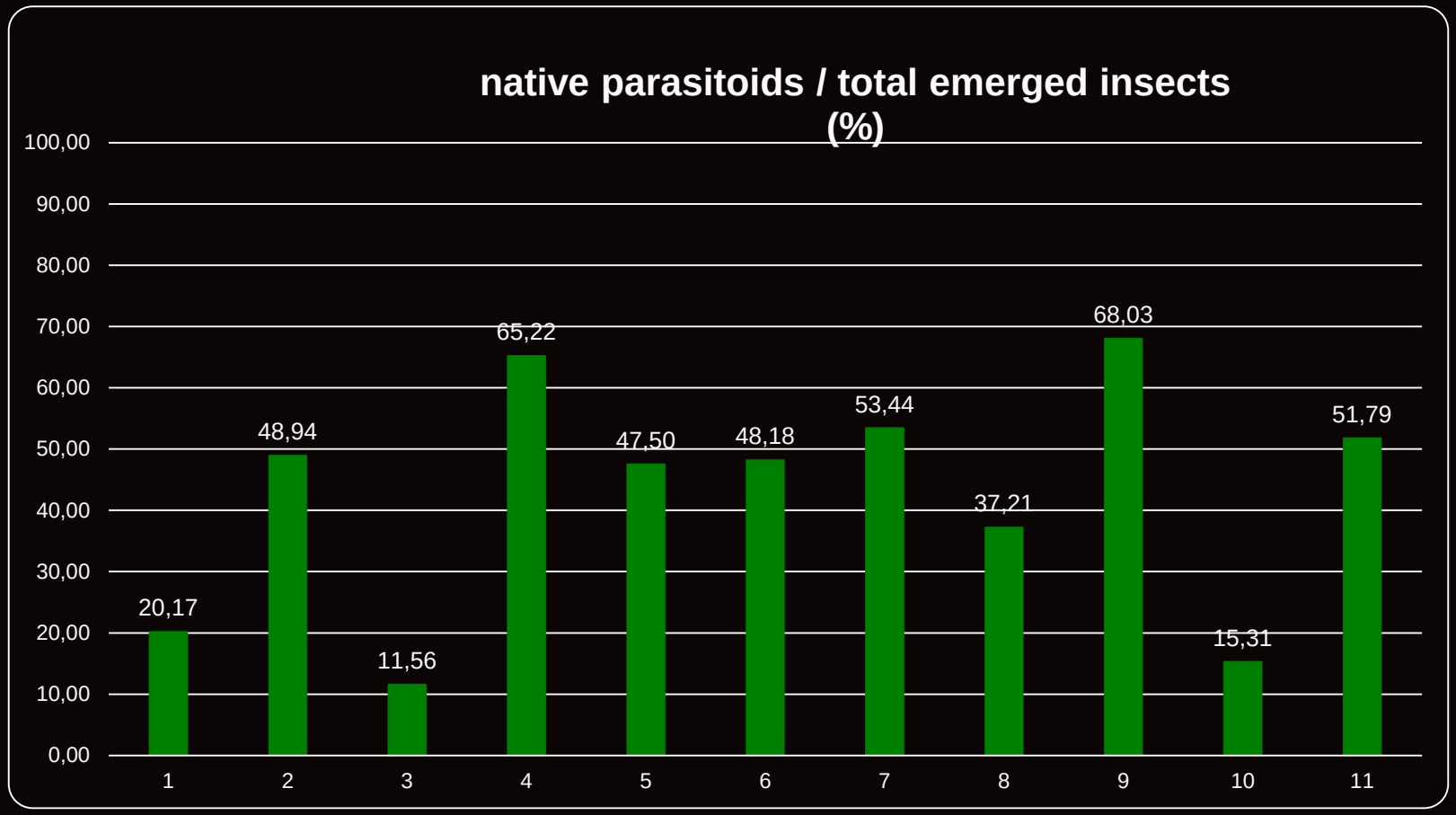


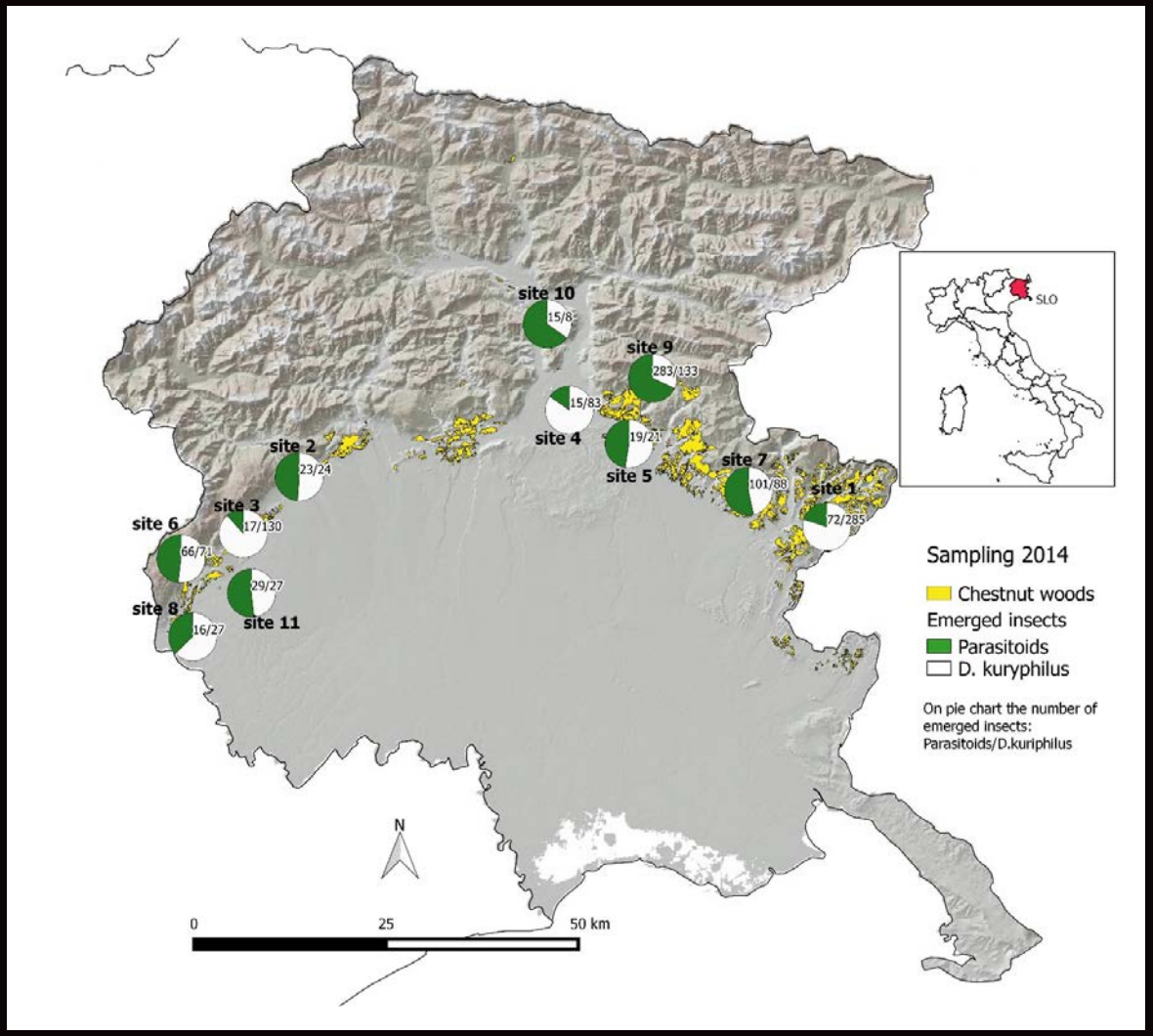
Surveys in 2014
(after six years from first *D. kuriphilus* findings)

- samples of 400-600 newly formed galls collected in 11 sites;
- 3 samples taken from each site between late May and early August);
- the galls were randomly collected in 10 chestnut stands in mixed forests and in one chestnut orchard.

TAXA (still under identifying)	SITES										
	1	2	3	4	5	6	7	8	9	10	11
Torymus cfr. *flavipes*	X	X	X	X	X	X	X	X	X	X	
Torymus sp. A		X	X	X	X	X	X	X	X		X
Torymus sp. B				X							X
Torymus cfr. *auratus*	X					X			X		
Megastigmus cfr. *dorsalis*	X	X	X		X	X	X	X	X	X	X
Eupelmus cfr. *urozonus*	X			X	X	X	X	X	X		X
Eupelmus sp. A	X			X	X	X	X	X	X	X	
Eupelmus sp. B					X				X	X	X
Mesopolobus cfr. *tibialis*							X		X		X
Mesopolobus sp. A						X	X		X	X	
Mesopolobus sp. B									X		
cfr. *Pteromalidae*									X		
cfr. *Cecidostiba*										X	
cfr. *Baryscapus*	X	X			X	X			X		
cfr. *Eulophidae*				X		X					
cfr. *Pediobius*		X									
Eurytoma cfr. *brunniventris*					X	X	X		X	X	X
Sycophila cfr. *biguttata*									X		

2014 surveys – first results




site 10
15/8
site 9
283/133
15/83
site 4
19/21
site 5
site 2
23/24
site 7
101/88
site 1
72/285
site 3
17/130
site 6
66/71
29/27
site 8
16/27
site 11
SLO
Sampling 2014
Chestnut woods
Emerged insects
Parasitoids
D. kuryphilus
On pie chart the number of emerged insects: Parasitoids/D.kuriphilus
N
0
25
50 km

The evidences after six years of infestation

- native parasitoids of cynipid gall makers of *Quercus* are affecting *D. kuriphilus* galls;
- *Megastigmus dorsalis*, *Torymus* cfr. *flavipes* and *Eupelmus urozonus* showed to be the most common taxa;
- there are strong differences between sites in the incidence of emerged parasitoids (from 12% till 68% within sampled sites);
- a large number of galls were affected by *Gmomoniopsis* sp. fungi (an average of about 30% of the galls);
- … 2015 has been a good season for chestnut production in woods (good weather conditions? Other?).

General considerations

- *T. sinensis* is effective to control *D. kuriphilus*;
- high parasitization rates after few (3-4 years);
- native parasitoids are shifting from *Quercus* complex to *Castanea*, but great differences observed among sites;
- Ferracini et al. (Biocontrol, 2015) showed that *T. sinensis* is no strictly monophagous (e.g. *Biorhiza pallida*), but no severe non-target effects have ever been reported;
- an evaluation of the potential for hybridization between *T. sinensis* and congeneric species is required.

Thank you for your attention