



UNIVERSITÀ
DI TORINO



Salute delle api: il ruolo del biomonitoraggio ambientale

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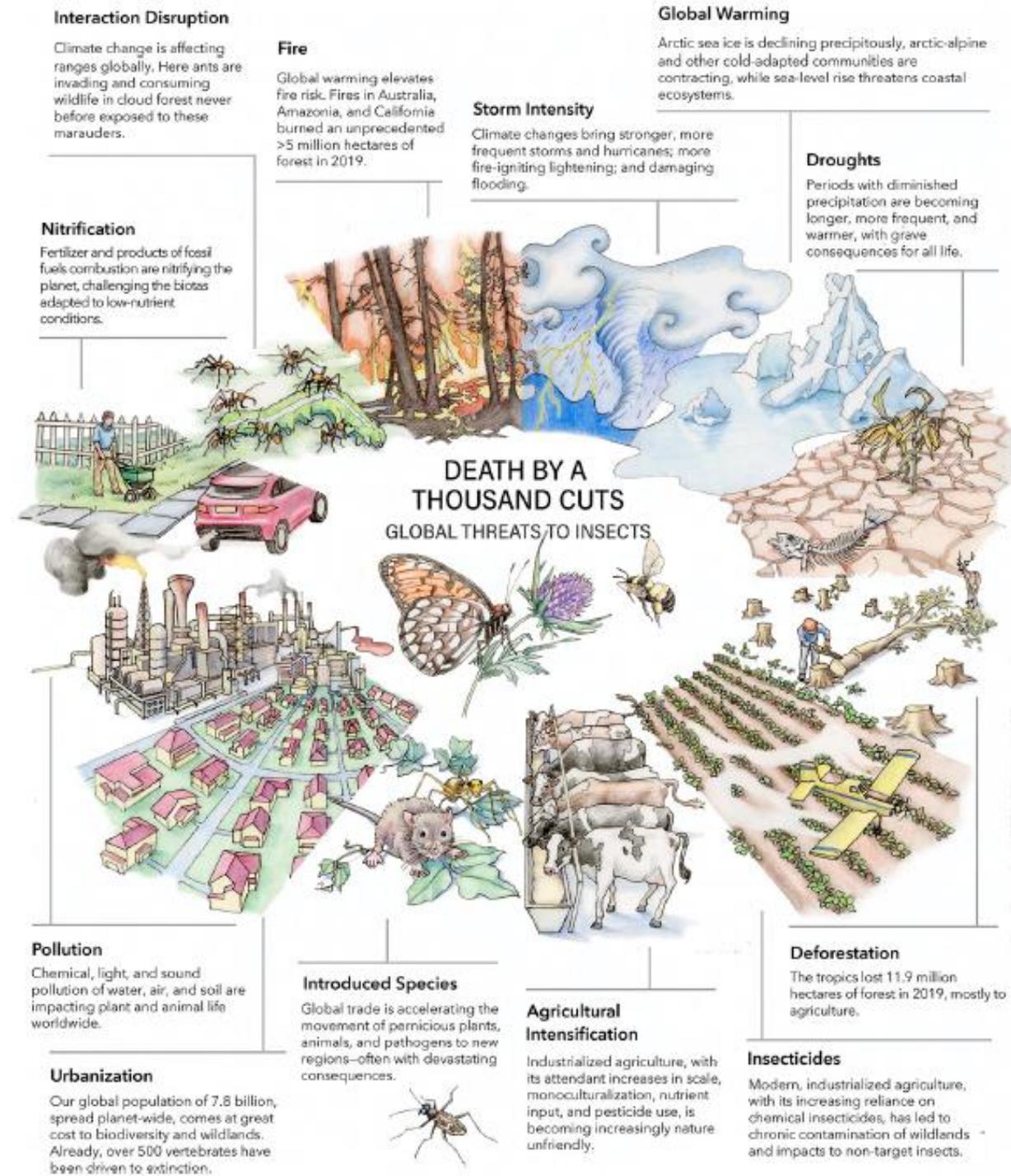


Indice

1. Salute delle api
2. La valutazione del rischio
3. L'esposizione delle api ai pesticidi: il biomonitoraggio
4. Effetti subletali, combinati, e cronici sulle api
5. Direzioni future

Minacce alla salute degli insetti

Multifattoriale



Salute delle api

Multifattoriale

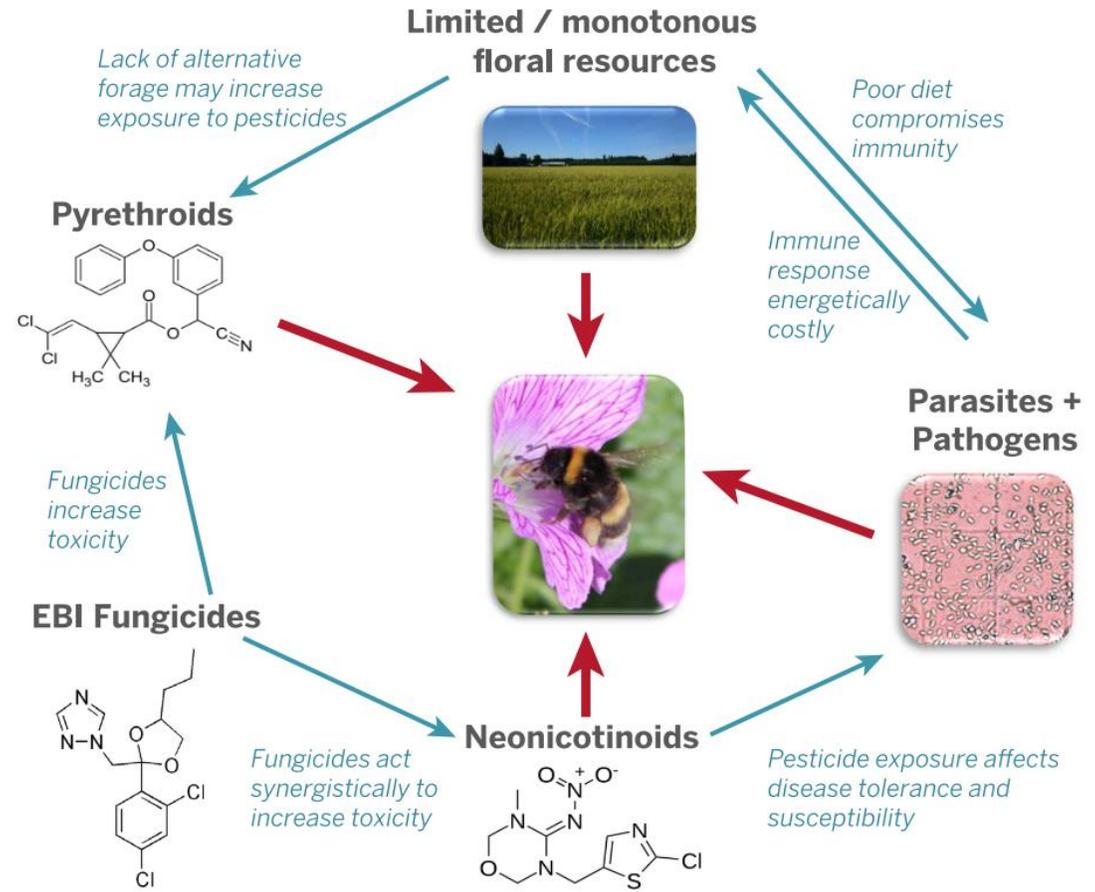
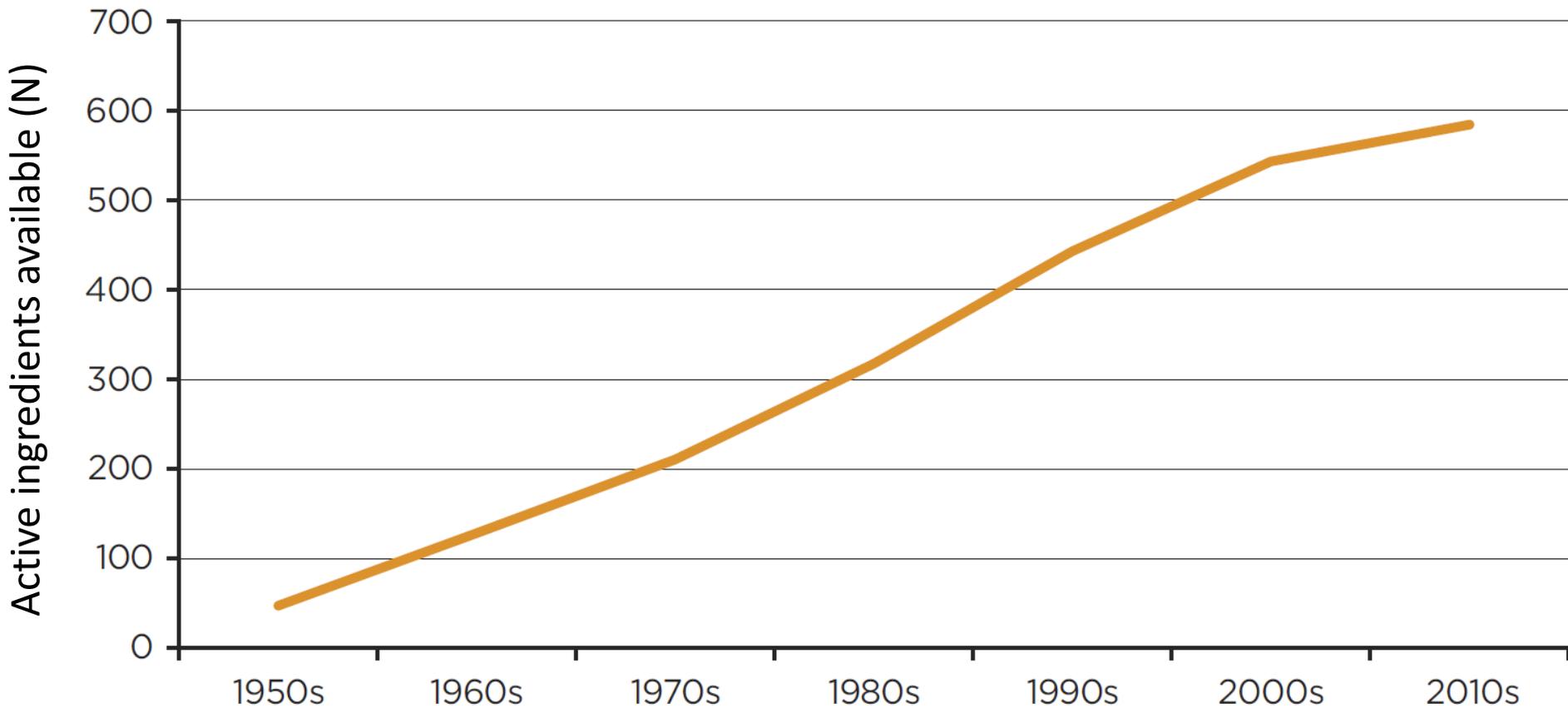


Fig. 3. Both wild and managed bees are subject to a number of significant and interacting stressors.

Il mondo dei pesticidi: in continuo cambiamento

Nuovi principi attivi



Phillips McDougall, 2019, Evolution of the Crop Protection Industry since 1960

Un campo in continuo cambiamento

Tossicità

pesticide	®	utilisation	DL50 ng/ab	Tox/DDT
DDT	Dinocide	insecticide	27 000,0	1
amitraze	Apivar	i/acaricide	12 000,0	2
coumaphos	Perizin	i/acaricide	3 000,0	9
tau-fluvalinate*	Apistan	i/acaricide	2 000,0	13,5
methiocarb	Mesurool	insecticide	230,0	117
carbofuran	Curater	insecticide	160,0	169
λ-cyhalothrine	Karate	insecticide	38,0	711
deltamethrine	Décis	insecticide	10,0	2 700
thiaméthoxam	Cruiser	insecticide	5,0	5 400
fipronil	Regent	insecticide	4,2	6 475
clothianidine	Poncho	insecticide	4,0	6 750
imidaclopride	Gaucho	insecticide	3,7	7 297

Neonicotinoids are >5000 times more toxic than DDT

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Sicurezza dei pesticidi

Usare i pesticidi nel modo **più sicuro ed efficiente** per controllare gli insetti dannosi,
proteggendo la salute degli **uomini**, degli **animali**, e dell'**ambiente**

- ✓ Il **rischio** dei nuovi pesticidi viene **valutato** prima che entrino nel mercato

Processo di autorizzazione

Regolamento 1107/2009 sull'immissione sul mercato dei prodotti fitosanitari

24.11.2009	EN	Official Journal of the European Union	L 309/1
I			
<i>(Acts adopted under the EC Treaty/Euratom Treaty whose publication is obligatory)</i>			
REGULATIONS			
REGULATION (EC) No 1107/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL			
of 21 October 2009			
concerning the placing of plant protection products on the market and repealing Council Directives			
79/117/EEC and 91/414/EEC			

Processo di autorizzazione

“Criteri di approvazione delle sostanze attive”
(Reg. 1107/2009)

“The plant protection products [...] shall...”

- “... have **no immediate or delayed harmful effects** on **human** [...] or **animal health** [...] taking into account known **cumulative and synergistic effects**”
- “...have **no unacceptable effects** on the **environment**, having particular regard to [...] its impact on **non-target species**, including on the ongoing **behaviour** of those species”
- The provisions of this Regulation are underpinned by the **precautionary principle**.
Member States shall not be prevented from applying the precautionary principle **where there is scientific uncertainty** as to the **risks** with regard to **human** or **animal health** or the **environment** [...]

Valutazione del rischio

Rischio

=

Pericolo *

Esposizione

Risk

Hazard

Exposure

Probabilità che pericolo causi un effetto avverso in un organismo secondo certi livelli di esposizione

Proprietà o qualità intrinseca di un determinato principio attivo o prodotto fitosanitario avente il potenziale di causare danni

Probabilità e livello di esposizione di un organismo a un pericolo (i.e. un pesticida ed eventuali metabolite): per es. quanto pesticida ha ingerito tale organismo

Hazard

vs.

Risk

A Hazard is something that has the potential to harm you

Risk is the likelihood of a hazard causing harm

SHARK



A shark in the sea is a hazard



Swimming with a shark is a risk

LIGHTNING



Lightning is a hazard



Standing under a tree during a thunderstorm is a risk

Risk depends on **hazard** and **exposure**.

There is no risk if there is no **hazard**.

There is no risk if there is no **exposure**.

Valutazione del rischio

Si focalizza su:

- Effetti **letali**
- Effetti nel **breve termine**
- Un **singolo** prodotto chimico

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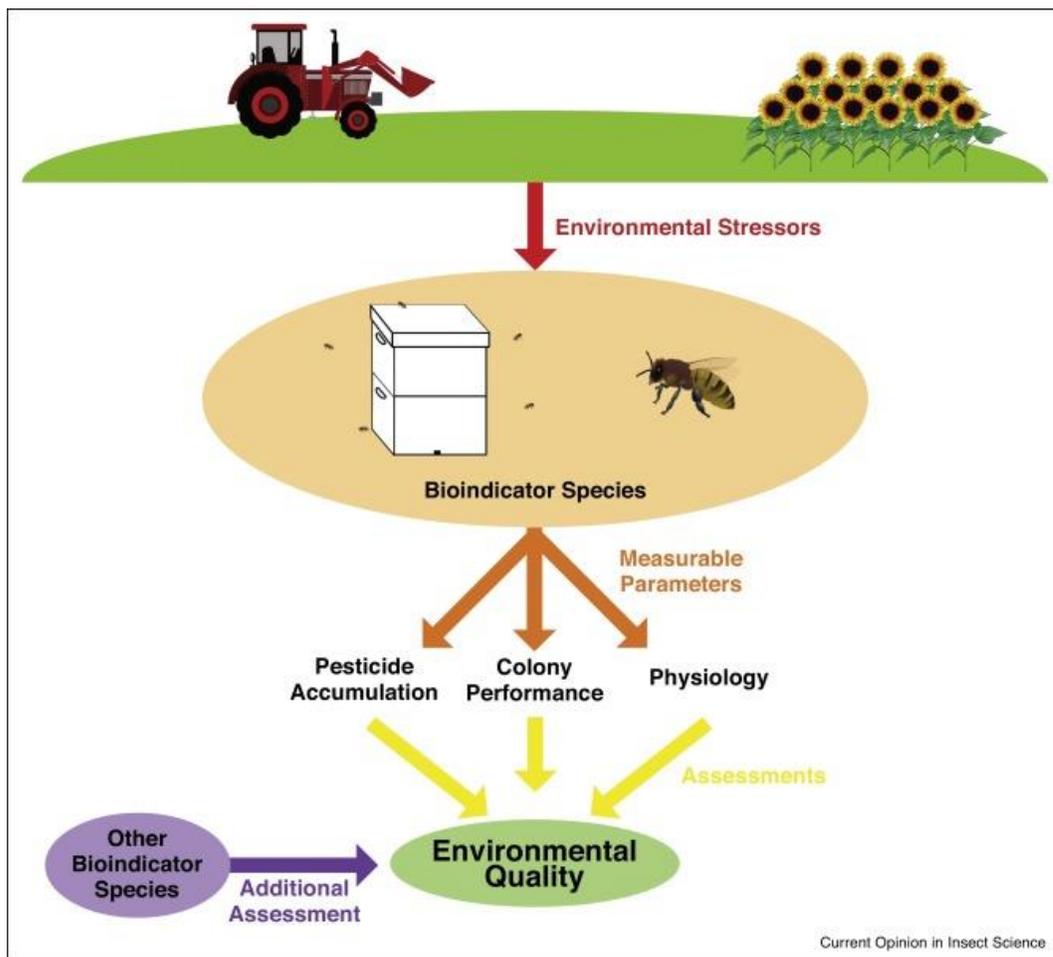
2. La valutazione del rischio

3. L'esposizione delle api ai pesticidi: il biomonitoraggio

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5. Direzioni future

Biomonitoraggio



Contaminazione ambientale

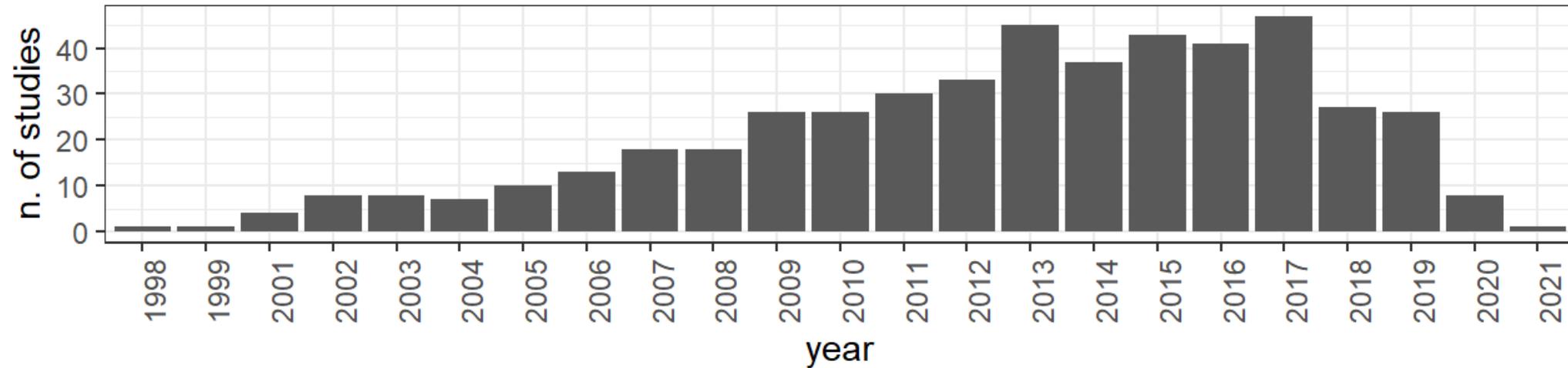
- **Metalli pesanti:** Svoboda (1961); Crane (1984)
- **Radionuclidi:** Gilbert & Lisk (1978), Balestra (1992); Fresquez et al. (1997ab);
- **Policlorobifenili (PCB):** Anderson, J. F. & M. A. Wojtas (1986); Morse et al., (1987)
- **Antibiotici:** Nagata T. (1995); Cooper et al. (1998)
- **Idrocarburi Policiclici Aromatici (IPA):** Amorena, M. et al., (2009)
- **Pesticidi:** Kevan, P.G. (1975); Kalnins, A.A. & Detroit, B.F. (1984); Atkins, E. L., & Kellum, D. (1986)

Biomonitoraggio

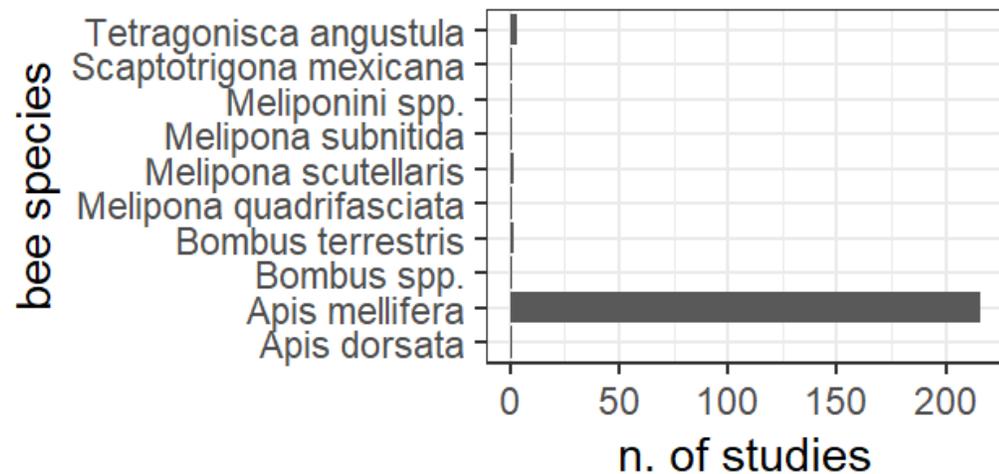
Una meta-analisi

- Analisi sistematica della letteratura scientifica (PRISMA PEO method)
- Meta-analisi
- Articoli scientifici:
 - **n = 7890**
 - **Dal 1948 al 2022**

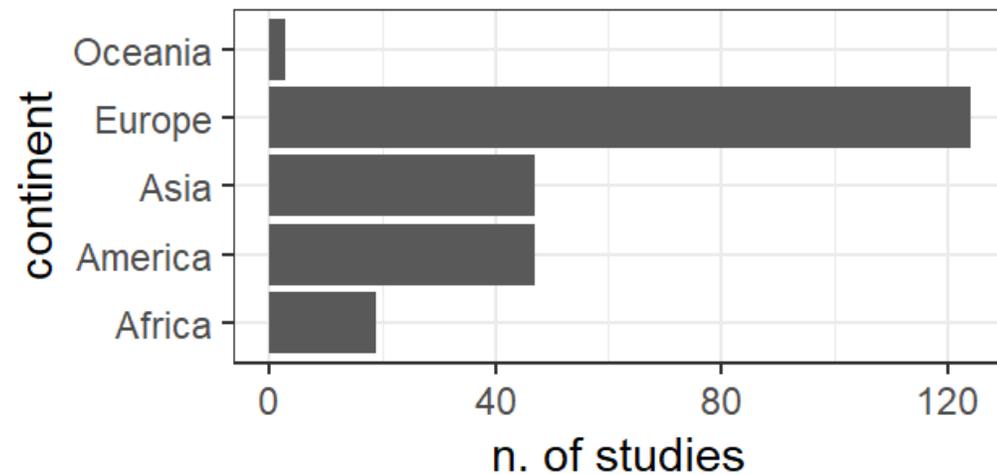
Biomonitoraggio



- **97% degli studi su *Apis mellifera***



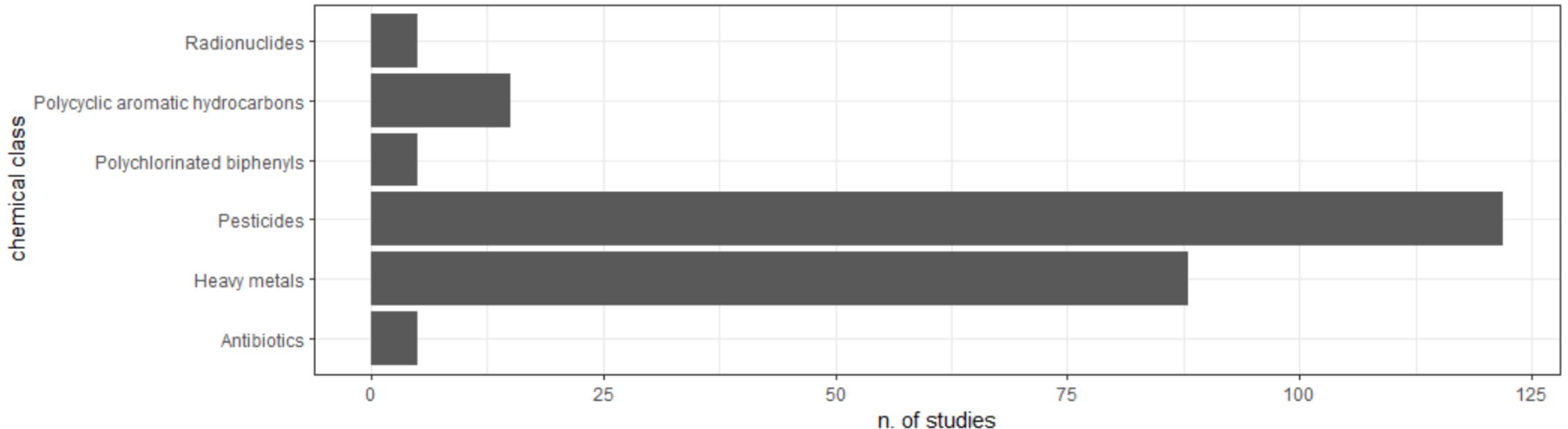
- **La maggioranza in Europa**



Biomonitoraggio

Sostanze studiate

- 6 categorie
 - più di 750 sostanze totali
 - Più di 500 pesticidi
 - Più di 50 elementi chimici tra cui 11 metalli pesanti

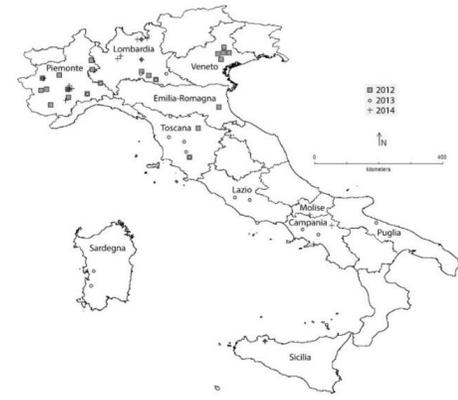
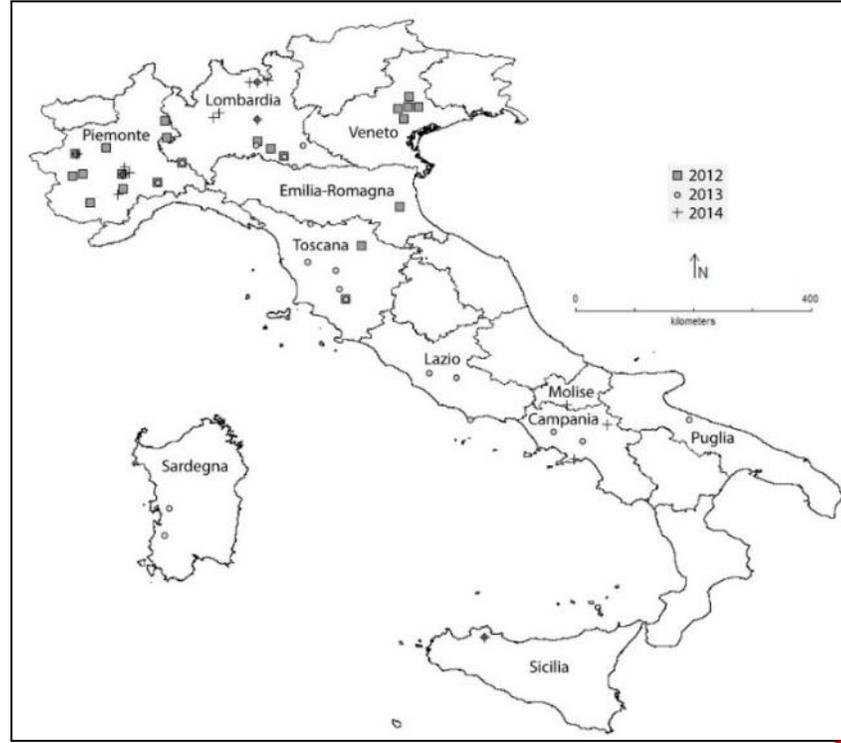


Biomonitoraggio

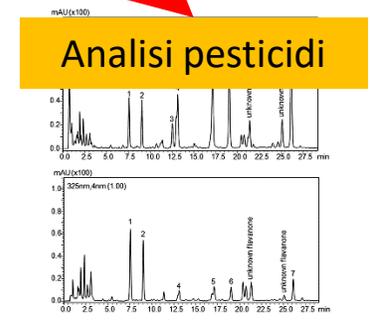
63 stati nel mondo



Biomonitoraggio



✓ 3 anni (2012-2014)

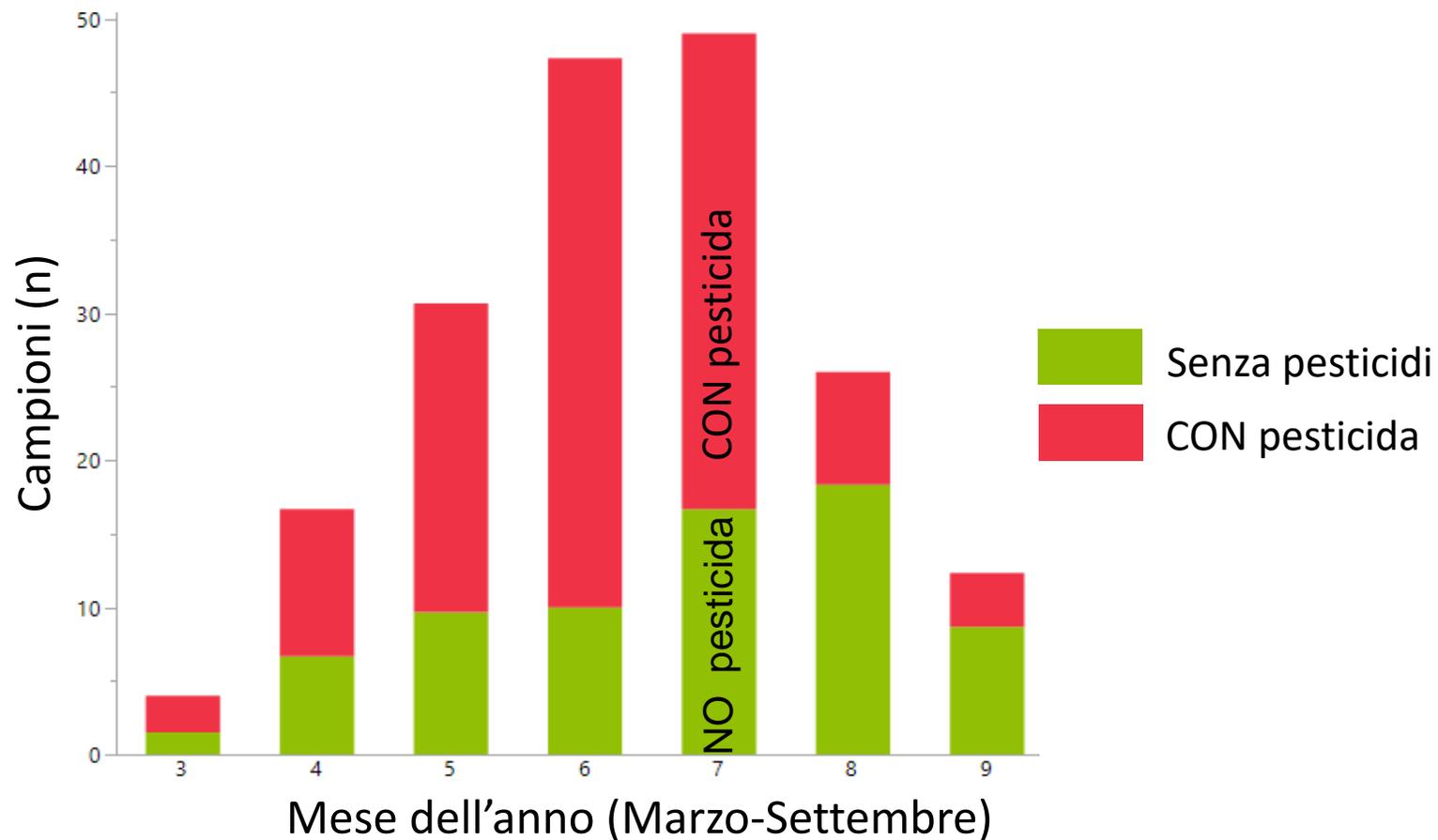


Biomonitoraggio

2012-2014



Frequente contaminazione:
✓ 62% campioni contaminati



Biomonitoraggio: Italia

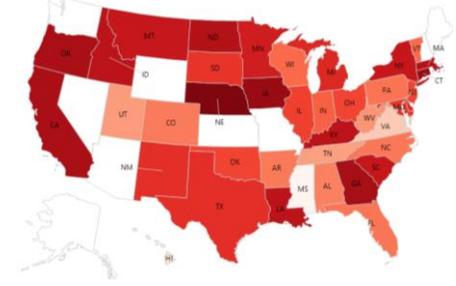
2012-2014



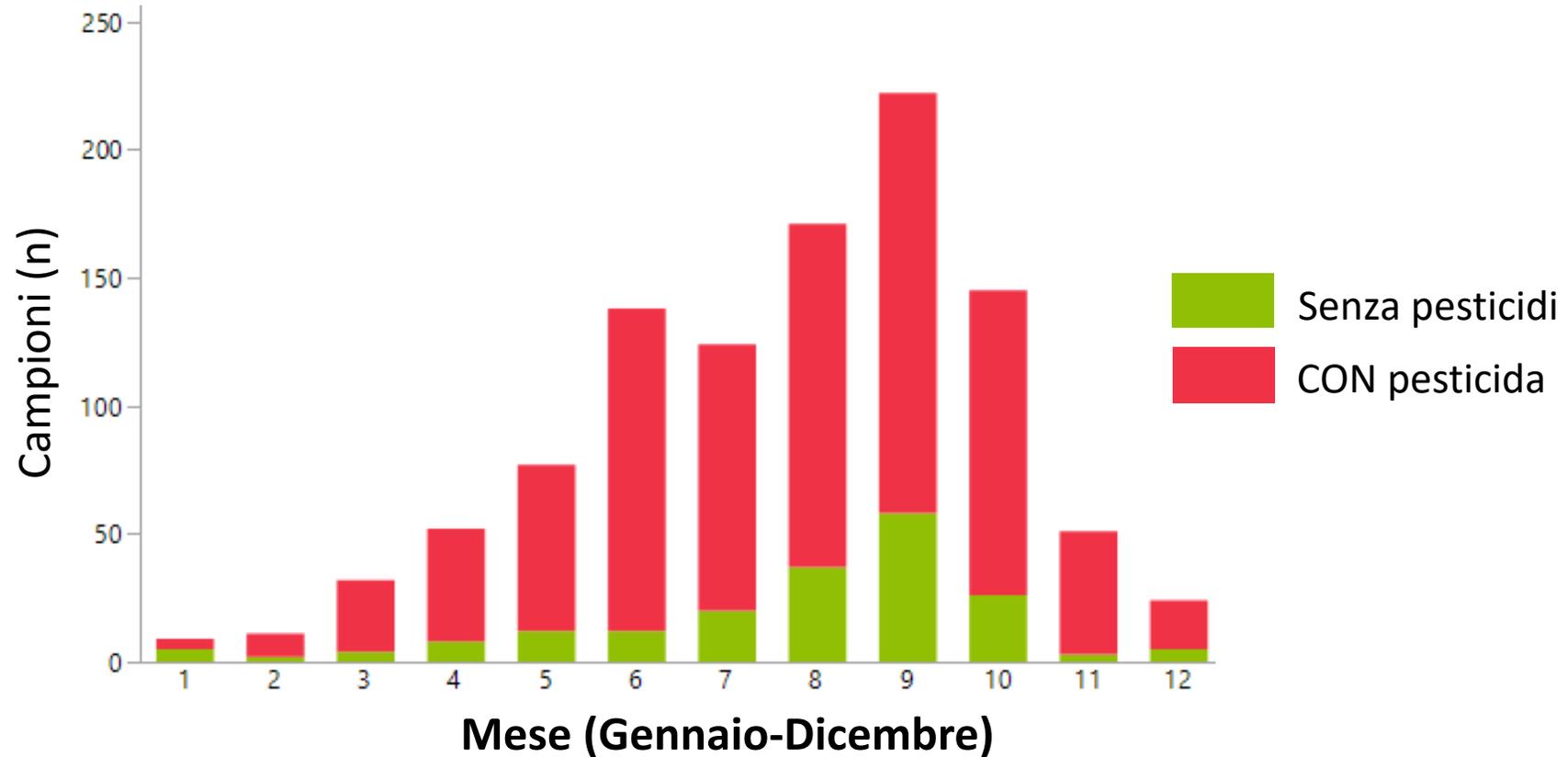
- **Principi attivi non autorizzati** (3 dei 18 trovati)
- **Concentrazioni oltre i limiti** (di prodotti autorizzati)
 - Il 13% degli apiari conteneva residui oltre i limiti di sicurezza

Biomonitoraggio: USA

2011-2017



- 7 anni
- 42 Stati US
- >5000 ispezioni

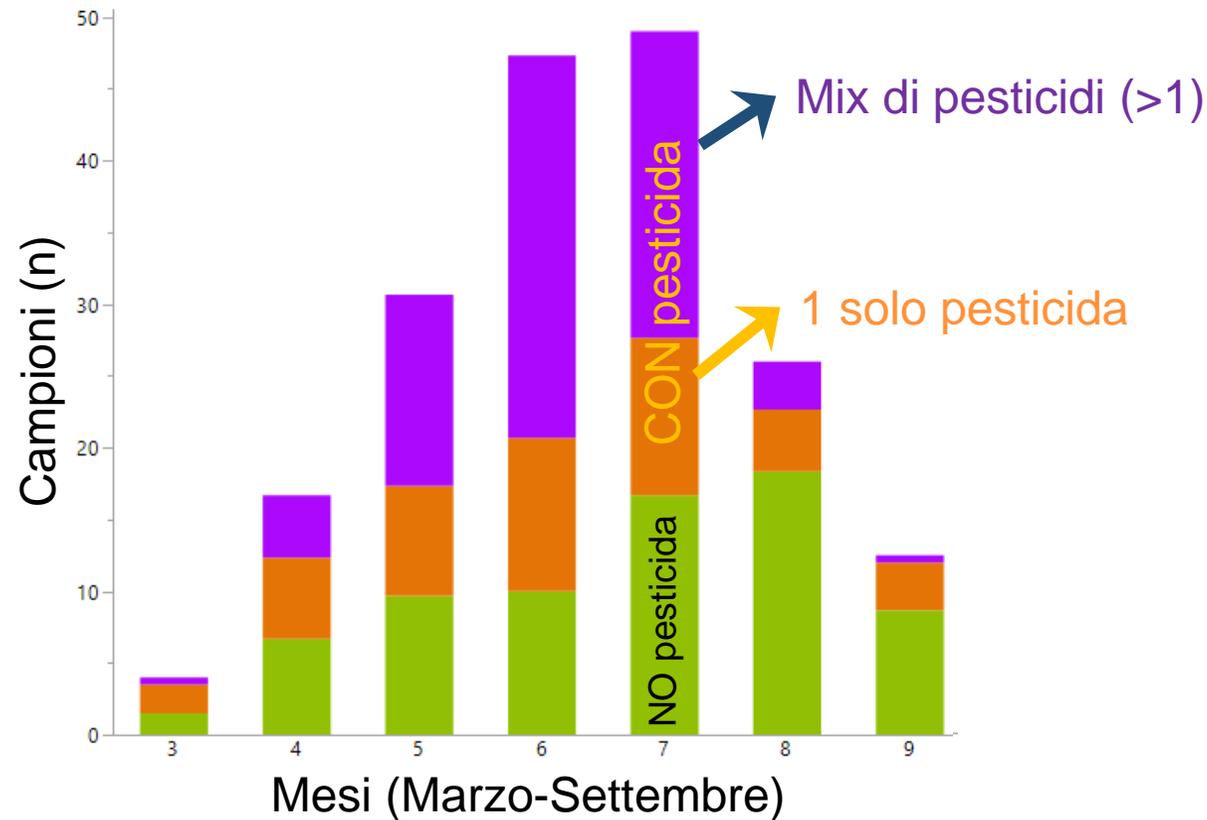


Effetti combinati

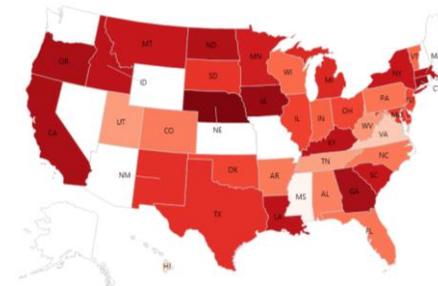


Soprattutto mix (*cocktail*) di pesticidi

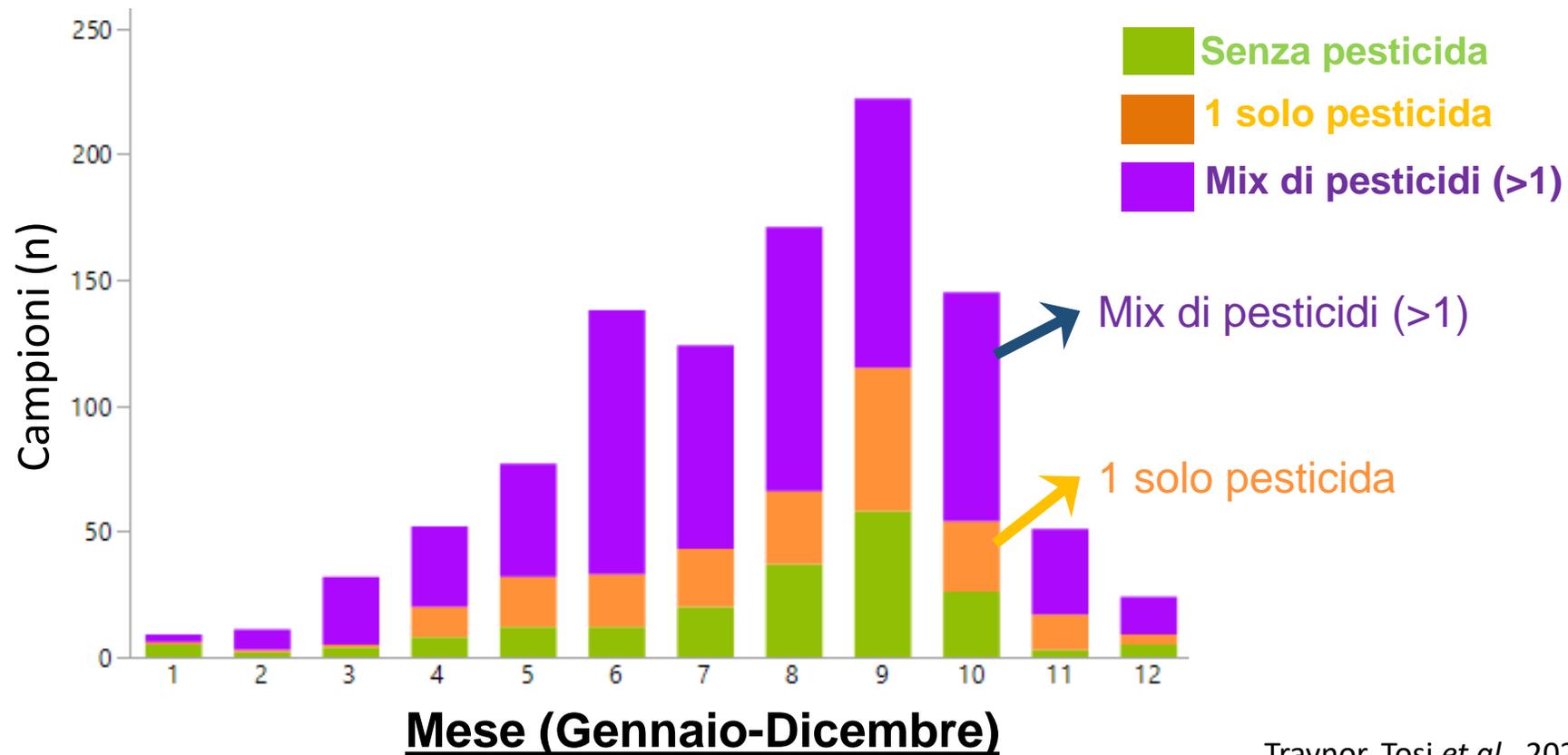
- Senza pesticida
- Con pesticida
- Mix di pesticidi



Effetti combinati

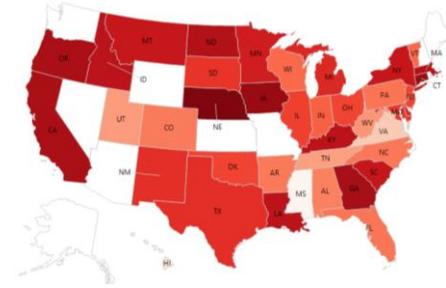


Soprattutto mix (*cocktail*) di pesticidi



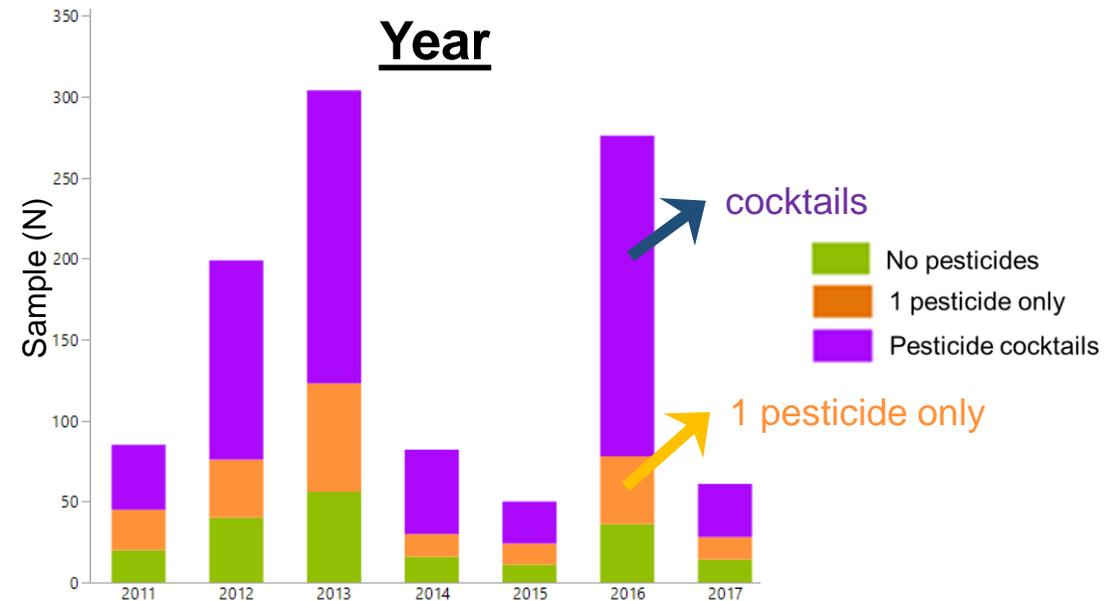


Effetti combinati



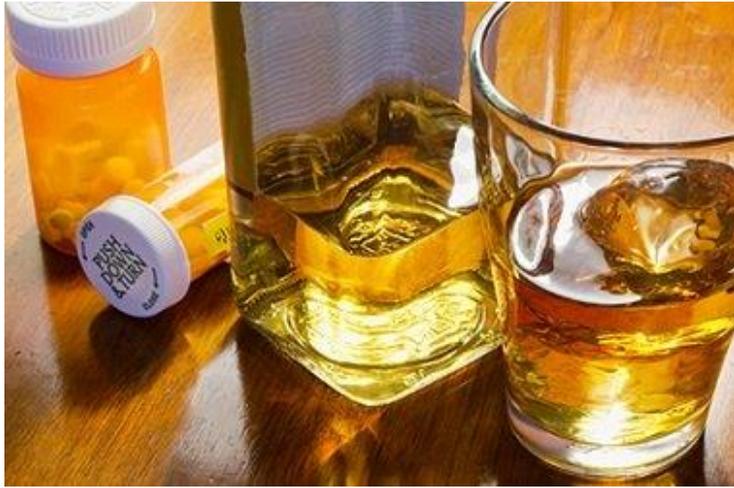
Soprattutto mix (*cocktail*) di pesticidi

- 7 anni
- 42 Stati US
- >5000 ispezioni in apiario



Effetti sinergici

$$1 + 1 \neq 2$$



Additività

Effetto combinato (A+B)

=

Somma degli effetti individuali

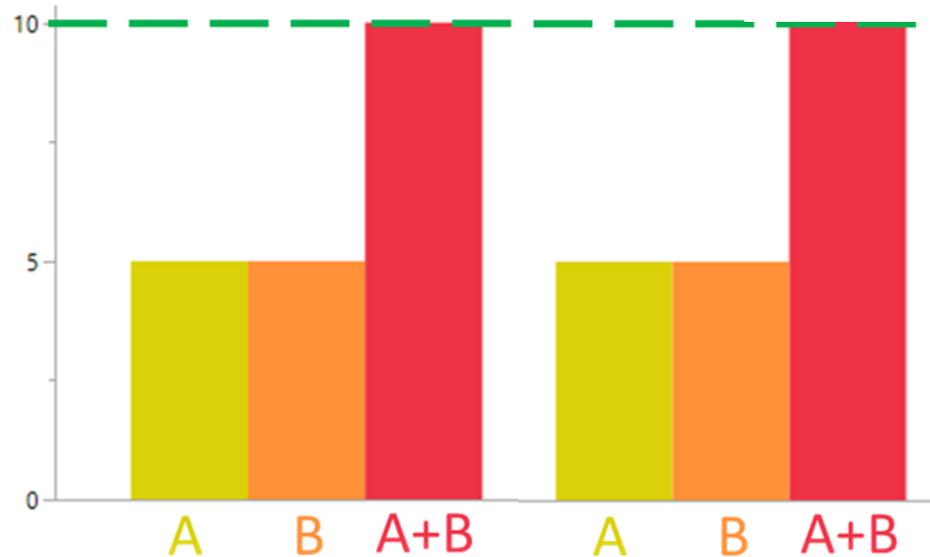
Sinergia

Effetto combinato (A+B)

>

Somma degli effetti individuali

A = stress 1
B = stress 2



Effetti combinati

Pochissime combinazioni studiate

E solo sinergie a livello di effetti letali

Contents lists available at ScienceDirect

Science of the Total Environment

ELSEVIER journal homepage: www.elsevier.com/locate/scitotenv

Review

Lethal, sublethal, and combined effects of pesticides on bees: A meta-analysis and new risk assessment tools

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^b Paris-Est University, French Agency for Food, Environmental and Occupational Health & Safety (ANSES), Laboratory for Animal Health, Maisons-Alfort, France
^c Institute for Risk Assessment Sciences (IRAS), Utrecht University, PO Box 80177, 3508, TD, Utrecht, the Netherlands
^d Department of Entomology, University of Maryland, 4112 Plant Sciences Building, College Park, MD, 20742-4454, USA
^e ANSES, Sophia Antipolis laboratory, Unit of Honey bee Pathology, European Reference Laboratory for Honeybee health, F-06902 Sophia Antipolis, France

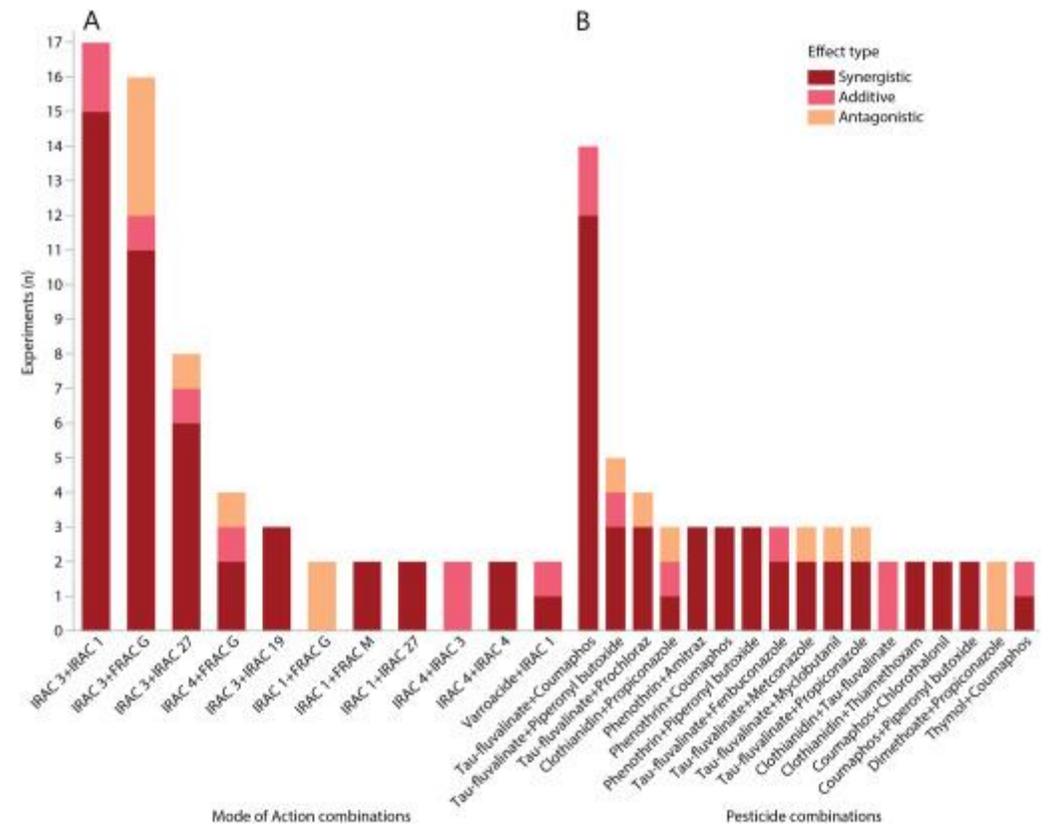
HIGHLIGHTS

- Pesticides cause adverse lethal, sublethal, and combined effects on bees.
- Risk assessments focus on lethal effects, not sublethal or combined ones.
- Vast data gap on sublethal (71 % of pesticides) and combined (~99 %) effects.
- Sublethal Toxicity Ratio (SubTR) proposed to quantify sublethal toxicity magnitude.
- Open access harmonised Lethal, Sublethal, Combined Toxicity Datasets presented.

GRAPHICAL ABSTRACT

Available knowledge	Lethal toxicity	Sublethal toxicity	Combined toxicity
Metric used:	LD ₅₀	LOAEL, SubTR*	MDR, EMR
Data available:	216 pesticides with LD50	154 pesticides with valid LOAEL, 46 pesticides with valid SubTR	161 pesticide combinations with MDR or EMR
Key data gap:	Vastly available for honey bees only	71% of pesticides with unknown sublethal toxicity	~99% of pesticide combinations with unknown toxicity

*new metric proposed



Quali effetti?

Effetti subletali



Api morte



Effetti subletali



<https://youtu.be/5zC8AN3eltw>

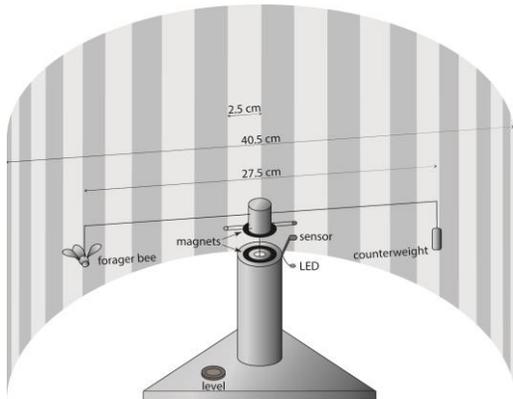
Abnormal behaviors

Name	Definition
Motion coordination deficits	Loss of coordination consisting of falling or stumbling while walking, walking in circles, or walking with erratic and irregular movements.
Hyperactivity	Excitation manifested as fast movements of legs and antennae, rapidly walking, sometimes including short jumps and flight attempts.
Trembling, shaking	Shivering, rapid twitching, or trembling of body, legs, or antennae. The bee is generally unable to move, and may flap its wings without flying for a prolonged time while also lying upside down on the floor.
Apathy	Hypoactivity consisting of remaining largely motionless or walking very slowly. Such bees also have severely reduced or delayed reactions to stimulation provided by light, movements of other bees, or air currents (e.g. generated by nearby bees).
Curved-down abdomen	The abdomen is unnaturally curved and is flexed ventrally.
Moribund	The bee appears close to death and exhibits partial paralysis with slight movements of legs and antennae. Will respond slightly to mechanical stimulation.

Effetti subletali

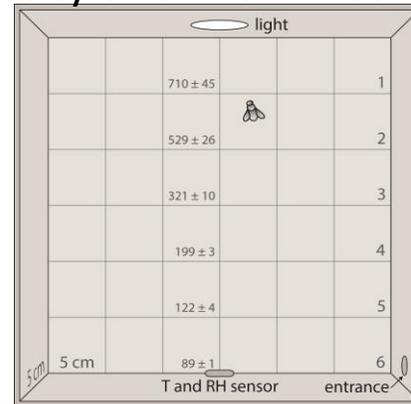
Volo

University of California San Diego



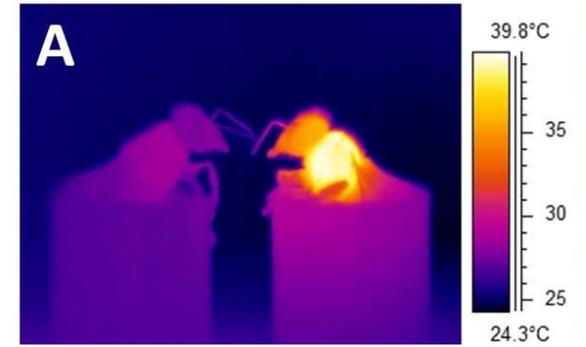
Camminare, arrampicare

University of California San Diego

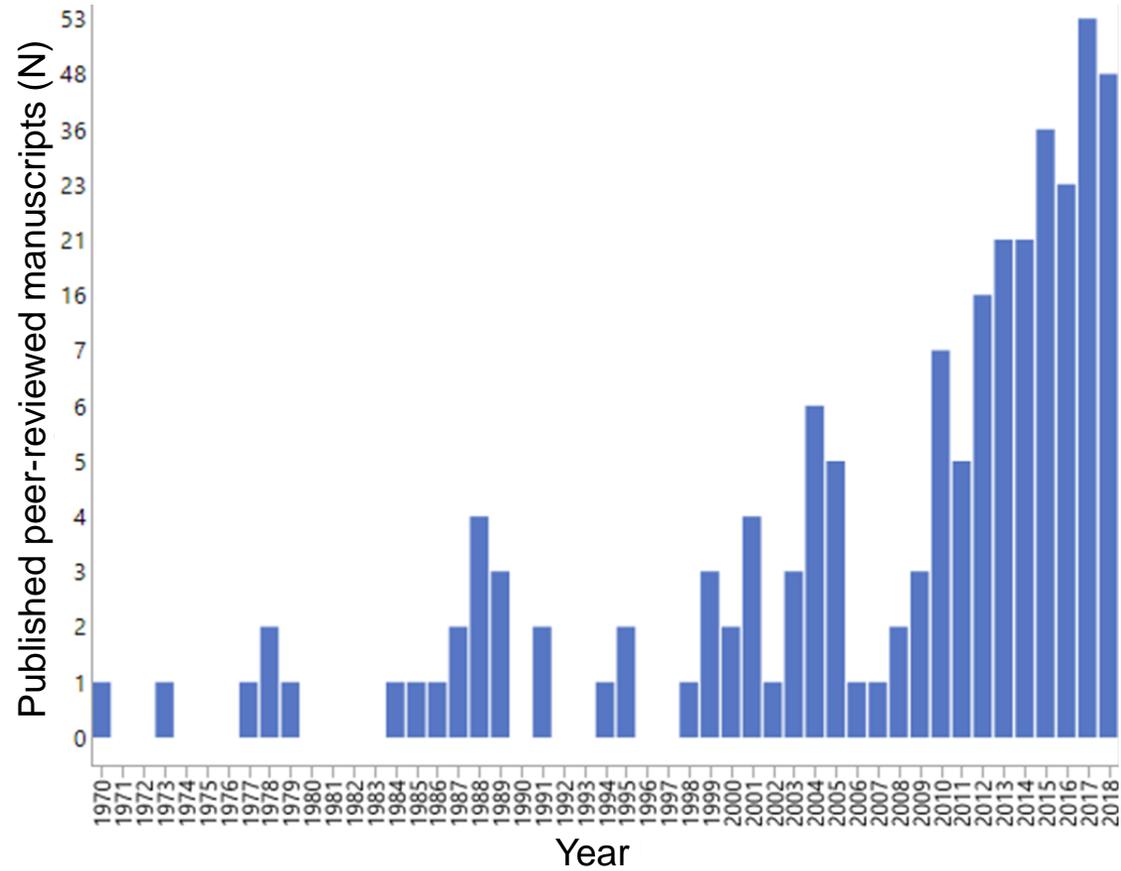


Temperatura corporea

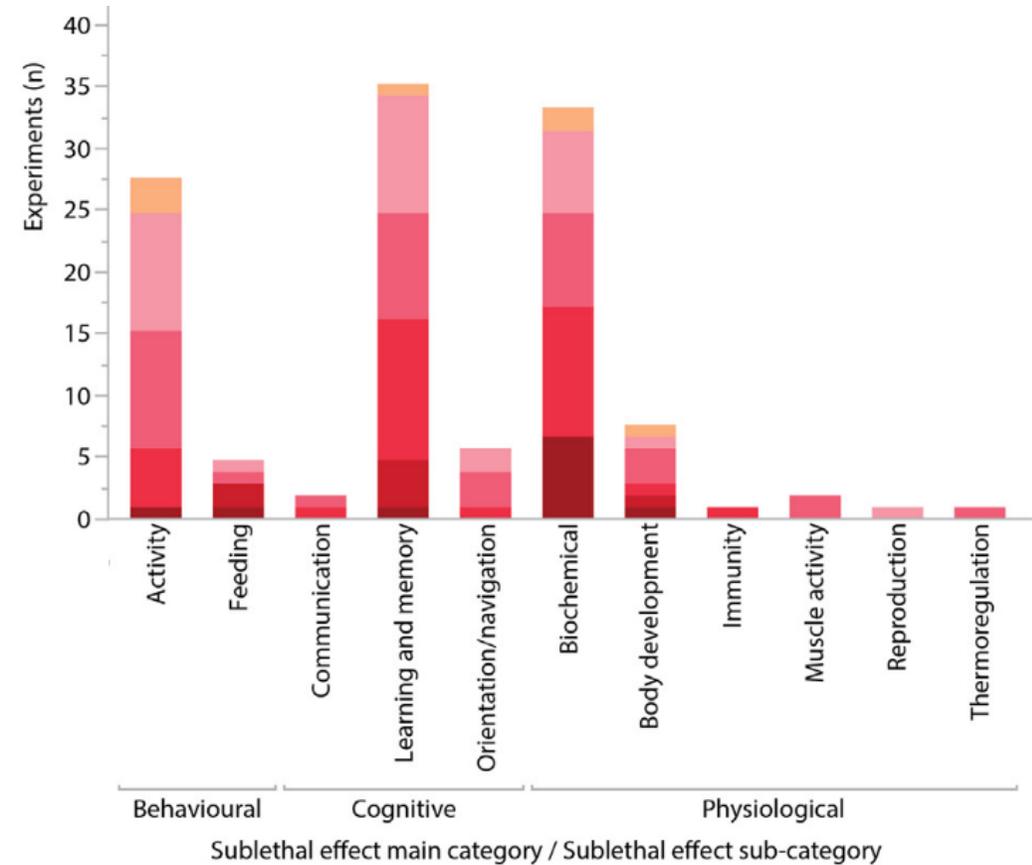
University of Pretoria (South Africa)



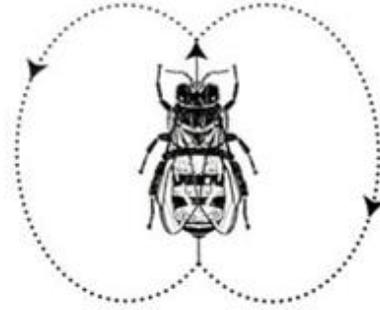
Effetti subletali



Multi effetti subletali diversi



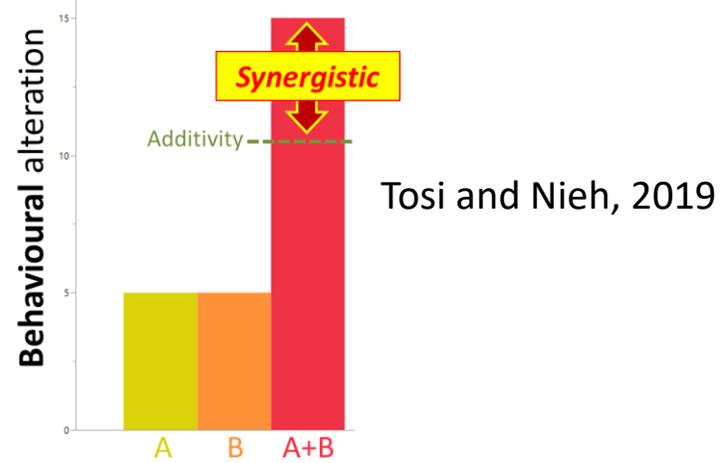
Effetti subletali



- **Subdoli**
 - ✓ Alterano la salute delle api senza ucciderle
- Avvengono a **dosi basse**, rispetto agli effetti *letali*
 - Avvengono più frequentemente
 - Sono più realistici

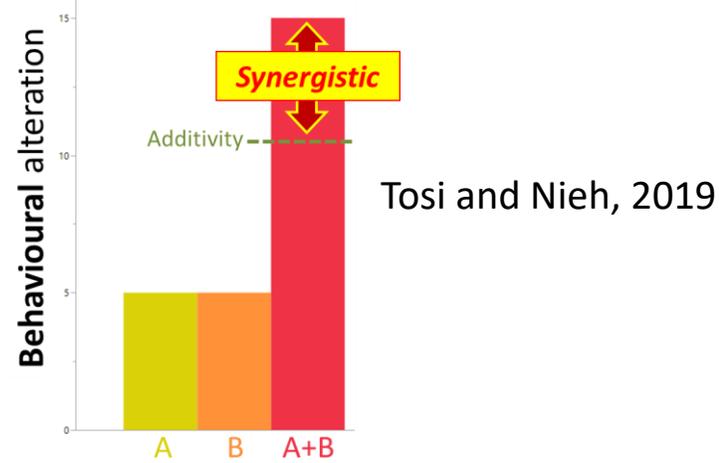
Interazioni subletali tra vari stress

Sinergia subletale

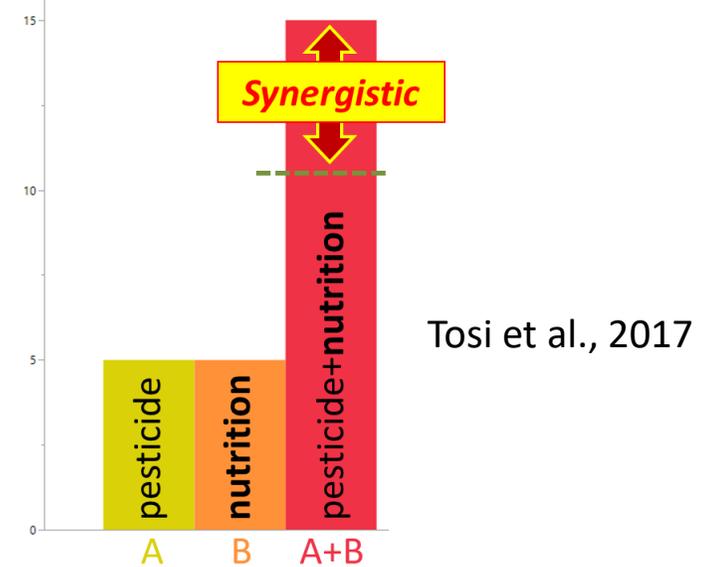


Interazioni subletali tra vari stress

Sinergia subletale

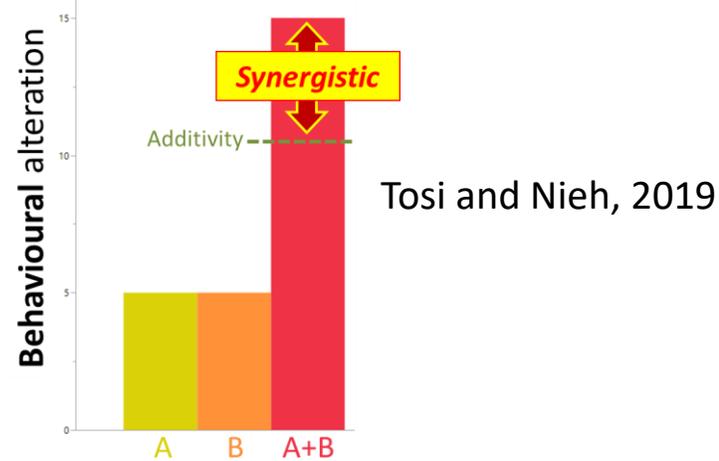


**Sinergia tra
pesticidi & stress nutrizionale**

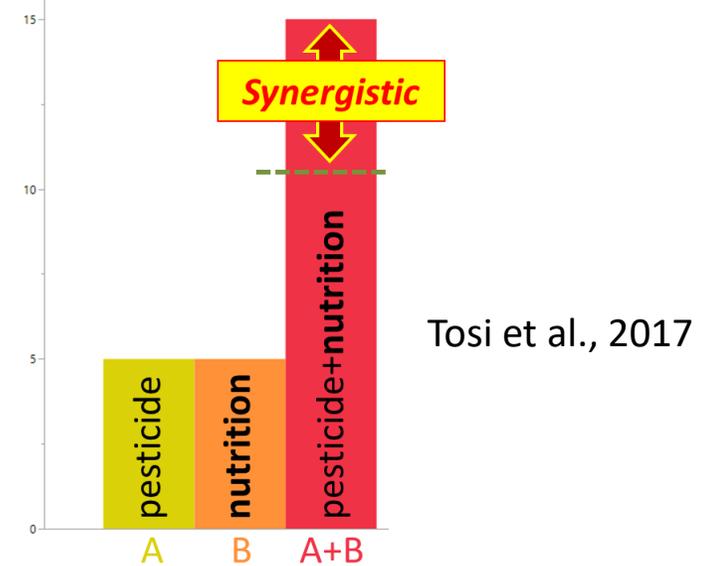


Interazioni subletali tra vari stress

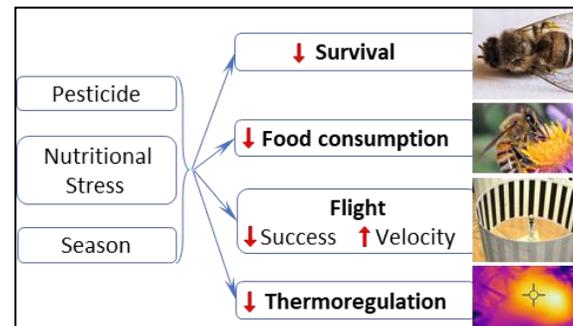
Sinergia subletale



**Sinergia tra
pesticidi & stress nutrizionale**

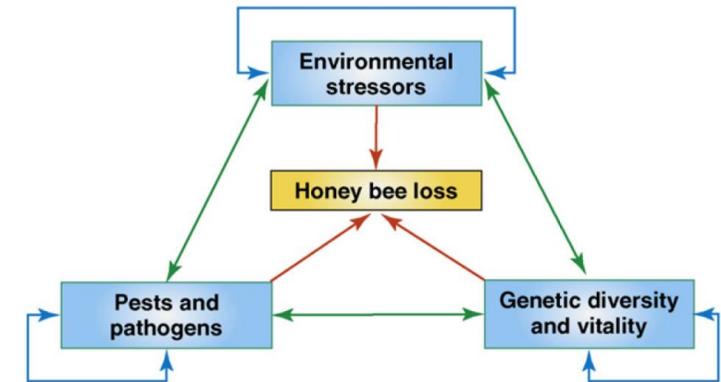
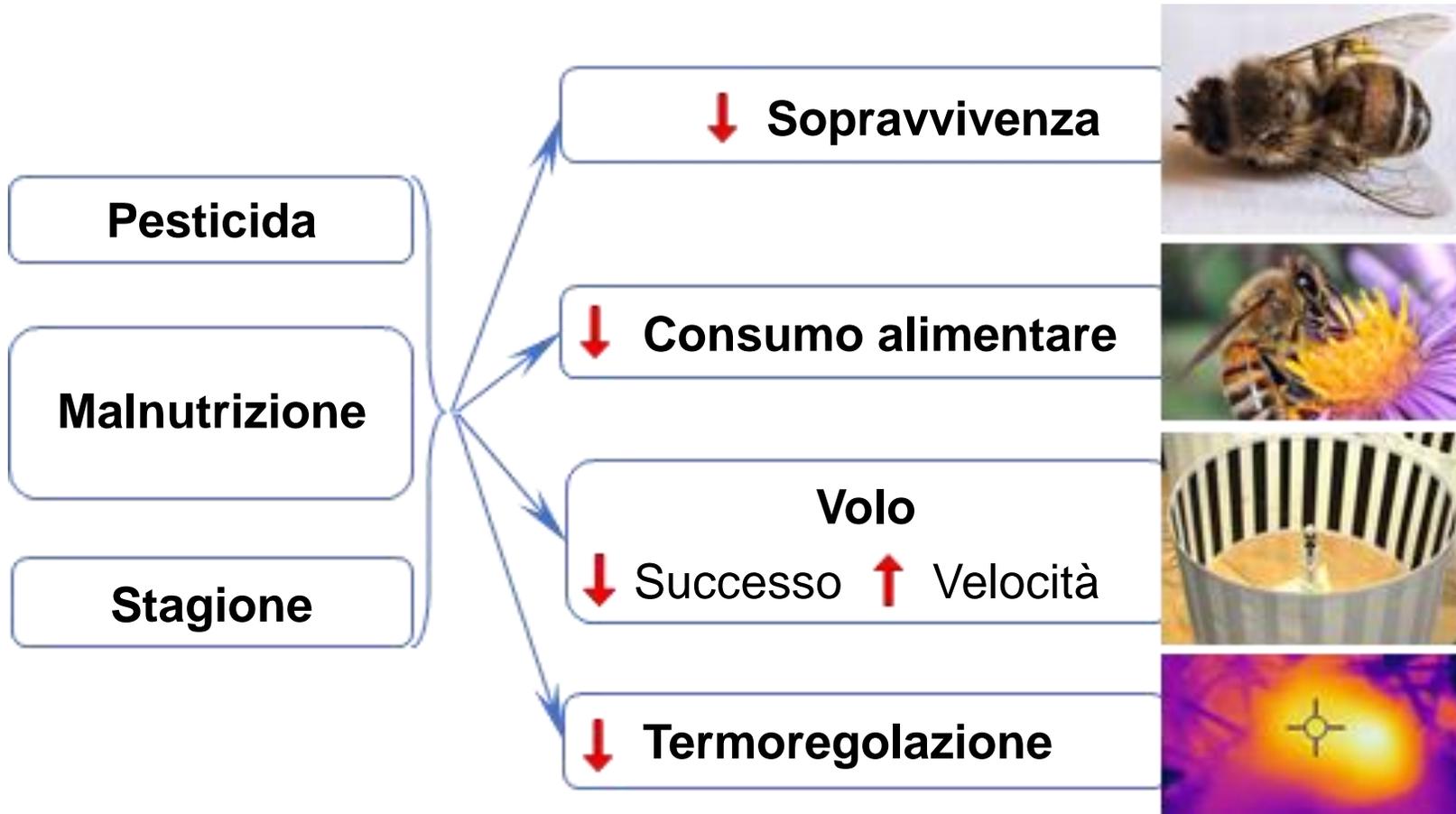


**Effetti combinati subletali di
pesticidi & nutrizione & stagione**



Tong, Nieh, Tosi, 2019

Effetti combinati subletali di pesticidi & nutrizione & stagione



Effetti cronici

Nel lungo periodo



- “Long-lasting residual activity” di un singolo trattamento fitosanitario: i.e. fino a mesi nel **polline** e nel **miele** degli alveari



- Procedure di valutazione del rischio ufficiali suggeriscono solo test con esposizioni brevi (10 giorni).

Effetti cronici

Nel lungo periodo



- Un **protocollo standard** per la valutazione del rischio dei pesticidi nel lungo periodo
- Misurare l'effetto a ~30 giorni su **sopravvivenza, comportamento, consumo alimentare**

8 Labs da 6 stati EU e USA



Effetti cronici nel lungo periodo

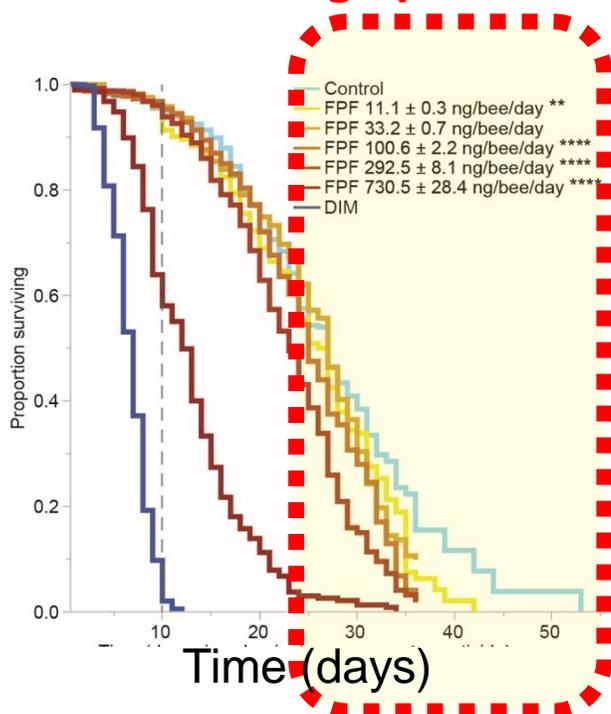


Sopravvivenza

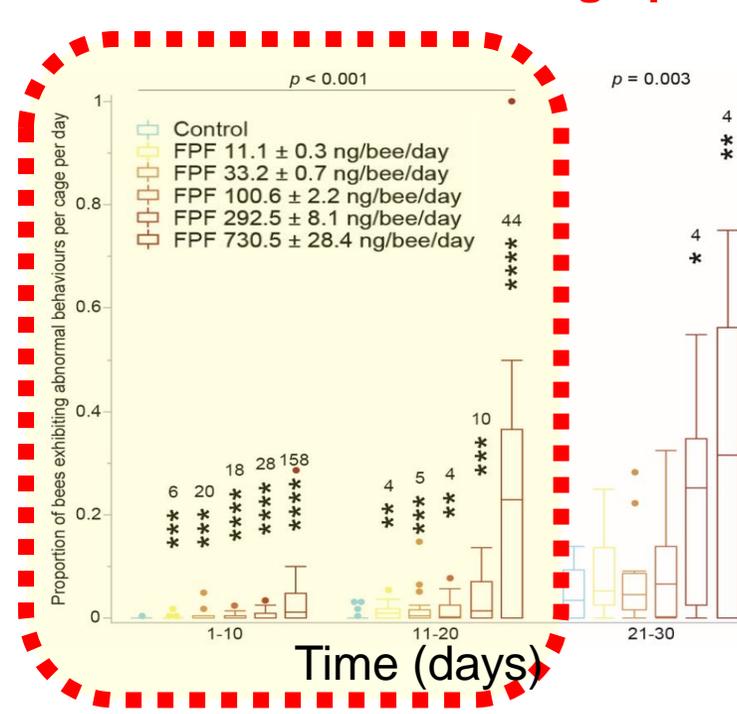
Comportamenti anomali

Consumo alimentare

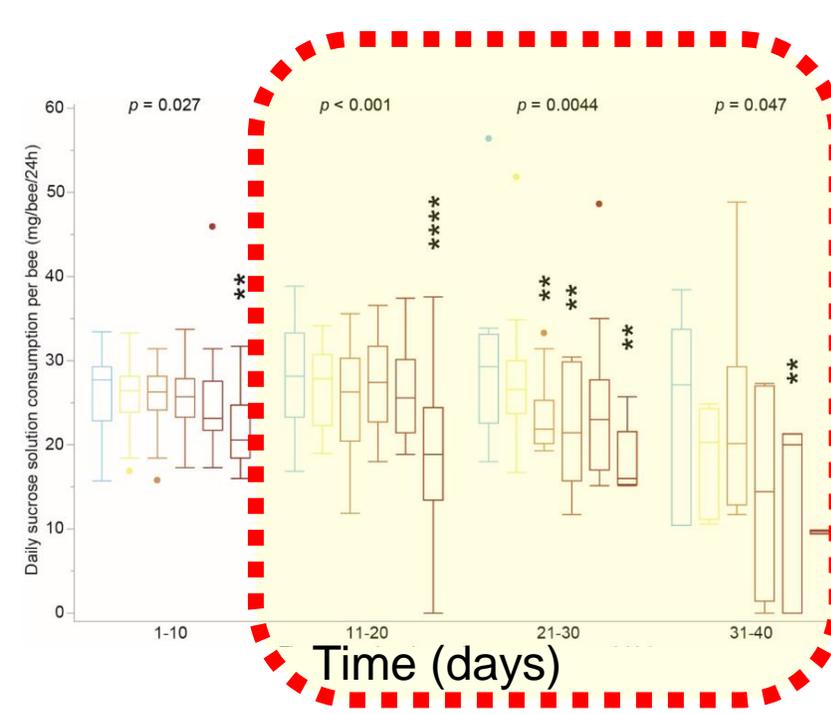
Ridotto nel **lungo periodo**



Aumentato nel **breve e lungo periodo**



Ridotto nel **lungo periodo**



Valutazione del rischio

I processi di valutazione del rischio dei pesticidi si focalizzano su:

- Effetti **letali**
- Effetti nel **breve termine**
- Un **singolo** prodotto

Però, i pesticidi possono causare:

- Effetti **subletali**
- Effetti **nel lungo termine**
- Effetti amplificati (**sinergici**) quando combinati (stress chimici, nutrizionali, etc)

“Errori di valutazione”

I 10 prodotti piu usati nel 1968 e nel 2016

Top 10 products in 1968	Top 10 products in 2016
Atrazine	Glyphosate
Toxaphene - <i>banned</i>	Metolachlor
DDT - <i>banned*</i>	Pyraclostrobin
2,4-D	Mesotrione
Methyl parathion - <i>banned</i>	Thiamethoxam 
Aldrin - <i>banned</i>	Acetochlor
Trifluralin	Azoxystrobin
Propachlor	Atrazine
Dinoseb - <i>banned</i>	Abamectin
Chloramben - <i>banned</i>	Clothianidin 

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European Union expands ban of three neonicotinoid pesticides

By Erik Stokstad | Apr. 27, 2018, 2:45 PM

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Direzioni future

Salute e comportamento di api sociali e solitarie

Allineare realtà scientifiche e regolamenti

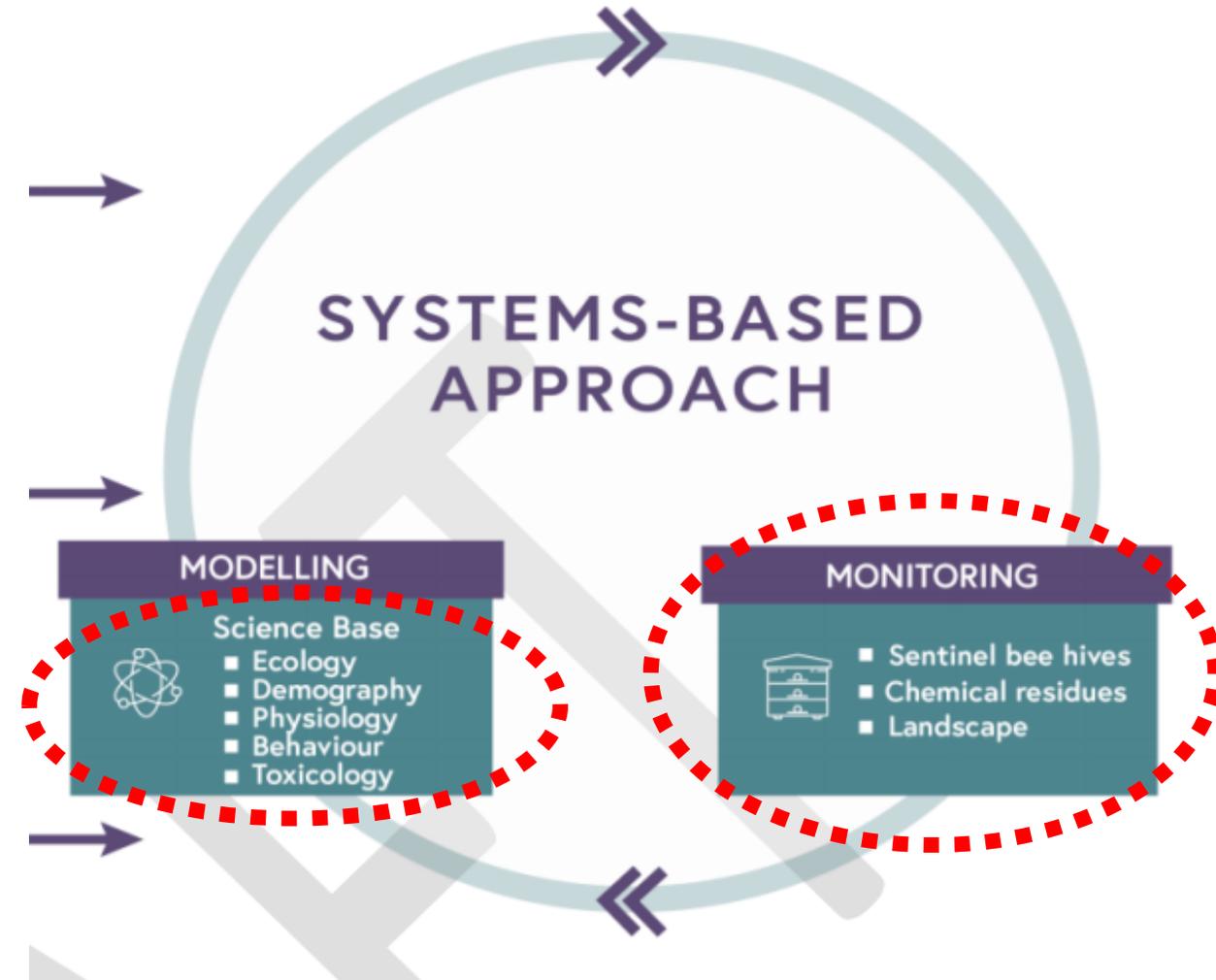
APPROVED: 14 April 2021

doi: 10.2903/j.efsa.2021.6607

A systems-based approach to the environmental risk assessment of multiple stressors in honey bees

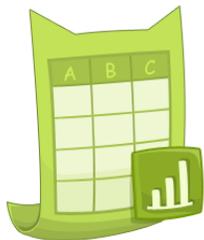
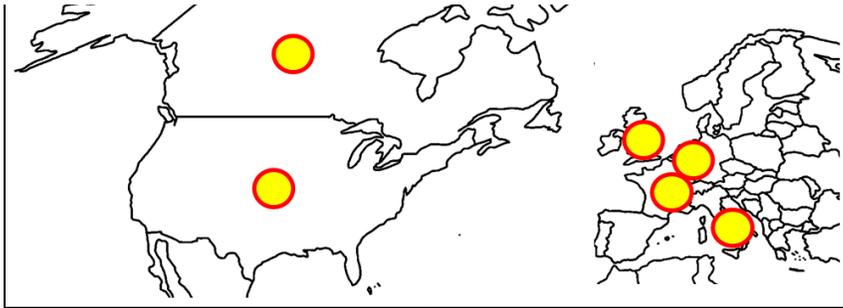
EFSA Scientific Committee,

Simon More, Vasileios Bampidis, Diane Benford, Claude Bragard, Thorhallur Halldorsson, Antonio Hernández-Jerez, Susanne Hougaard Bennekou, Kostas Koutsoumanis, Kyriaki Machera, Hanspeter Naegeli, Søren Saxmose Nielsen, Josef Schlatter, Dieter Schrenk, Vittorio Silano, Dominique Turck, Maged Younes, Gerard Arnold, Jean-Lou Dorne, Angelo Maggiore, Stephen Pagani, Csaba Szentés, Simon Terry, Simone Tosi, Domagoj Vrbos, Giorgia Zamariola and Agnes Rortais

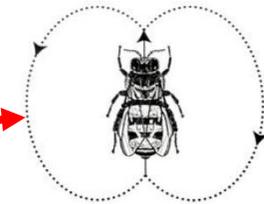
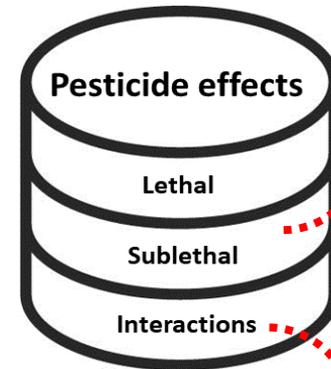


Una valutazione del rischio più «sostanziosa»

Raccolta e analisi di dati di esposizione



Database e metodologie sugli effetti subletali e combinati dei pesticidi (Tosi et al., 2022)

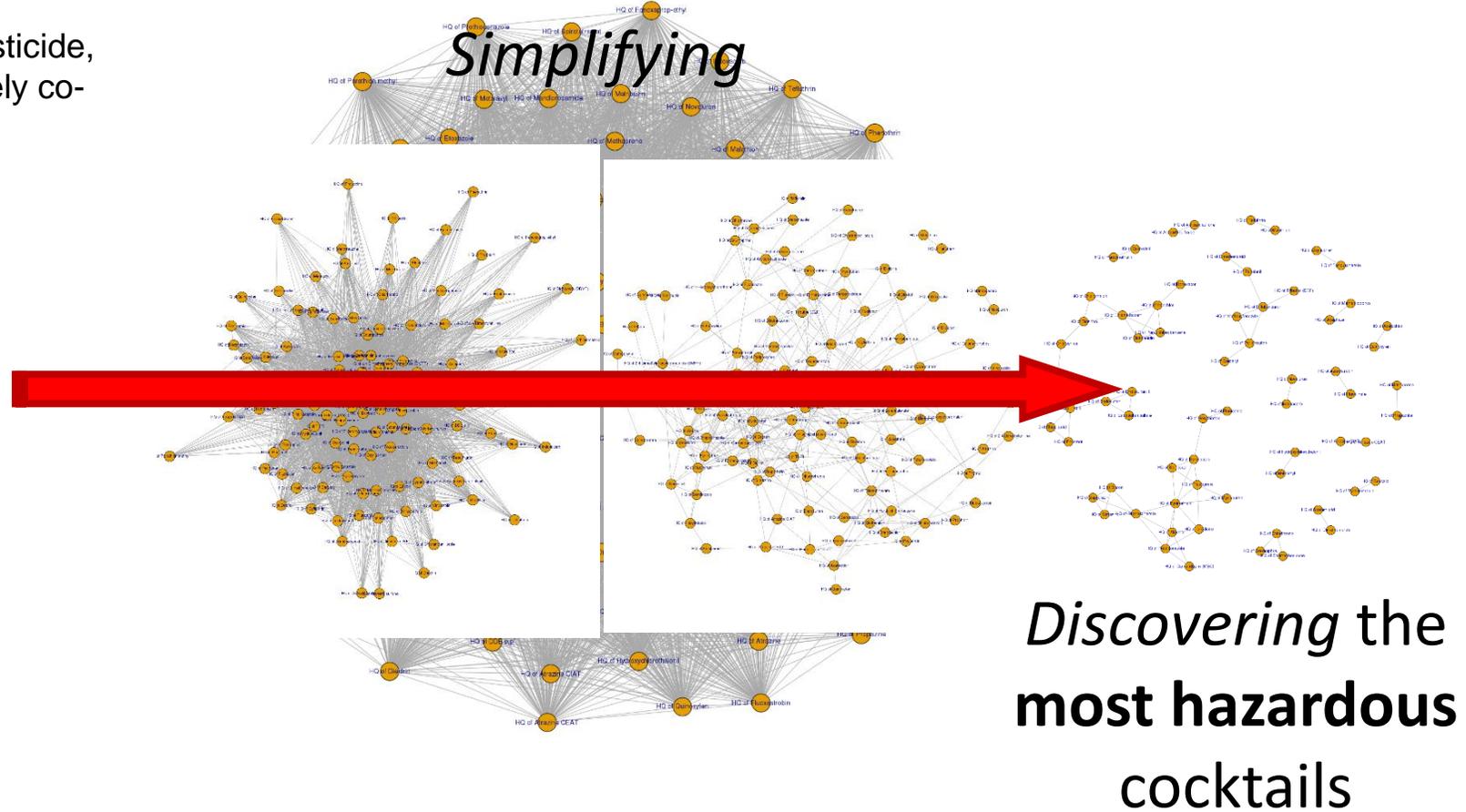


- Metodologie, struttura e gestione dati standardizzata



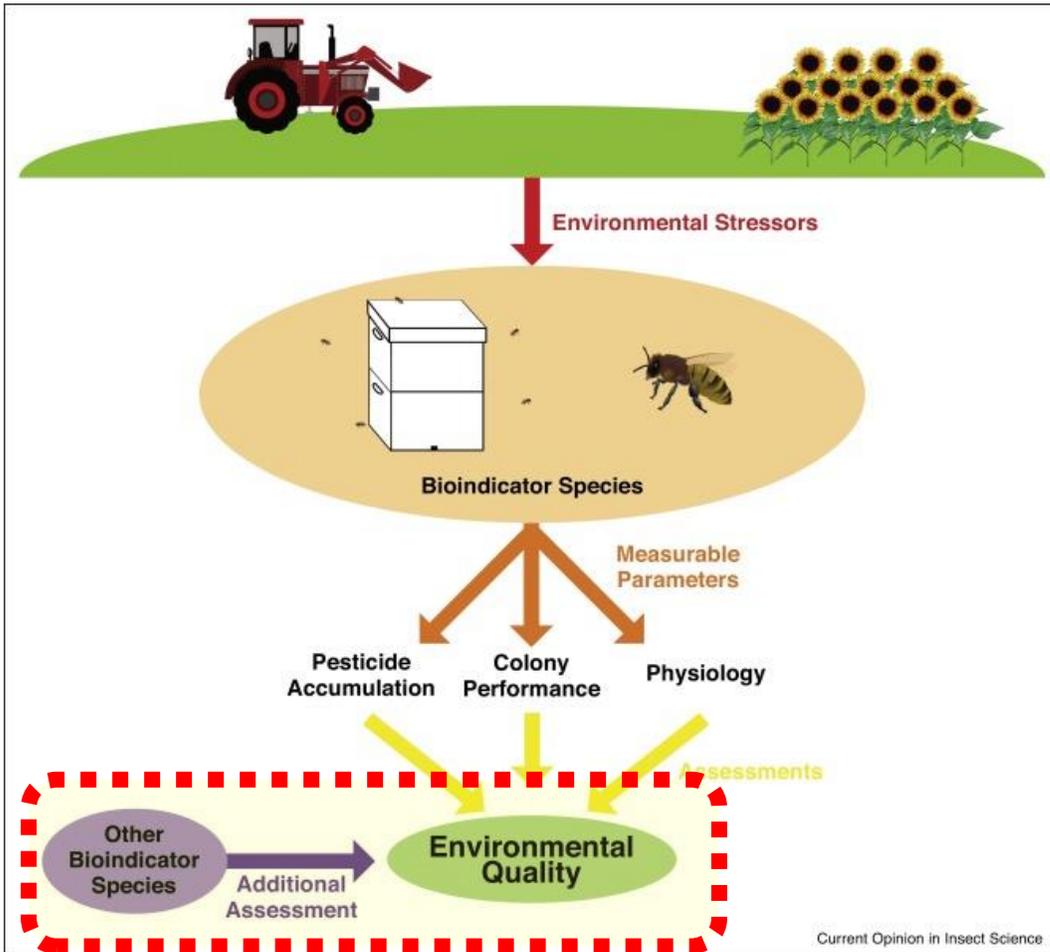
Una valutazione del rischio più «solisticata»

Each dot is a pesticide,
lines connect likely co-
exposures



Una valutazione del rischio più «sostanziosa»

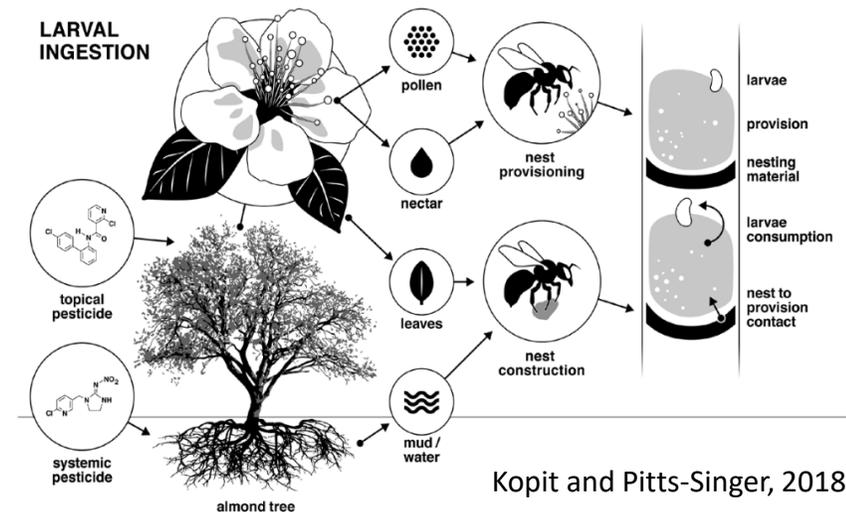
Bombi e api solitarie



“Honey bee [is] a surrogate for both *Apis* and non-*Apis* bees”
(EPA, 2014, Guidance for Assessing Pesticide Risks to Bees)



- La risposta ai pesticidi degli impollinatori **varia tra specie**
- Vie di **esposizione e stagionalità** diverse



Grazie!



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