Tachinidae:

The “other” parasitoids

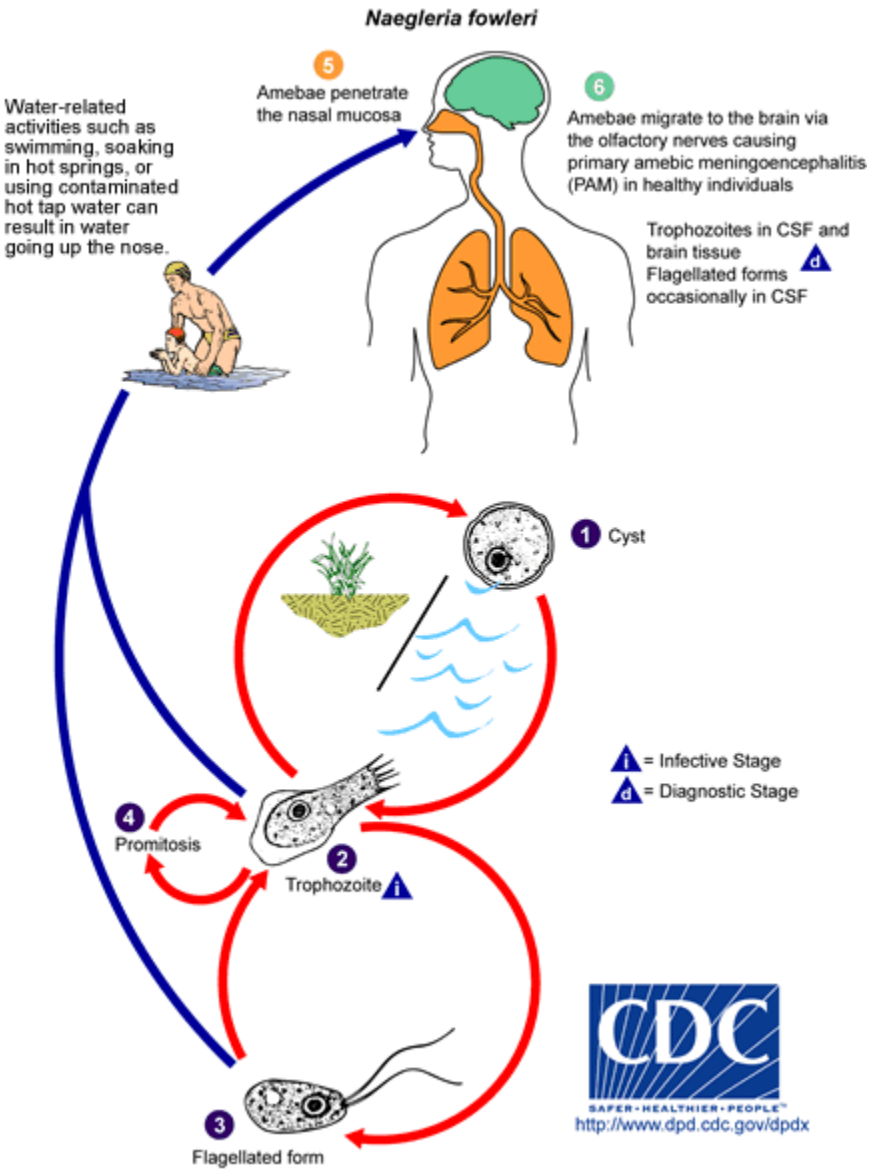
Diego Inclán
University of Padova

Outline

- Briefly (re-) introduce parasitoids & the parasitoid lifestyle
- Quick survey of dipteran parasitoids
- Introduce you to tachinid flies
  - major groups
  - oviposition strategies
  - host associations
  - host range…
- Discuss role of tachinids in biological control

Parasite vs. parasitoid

Parasite



Life cycle of a parasitoid

Alien

(1979)

Life cycle of a parasitoid

Parasite vs. parasitoid

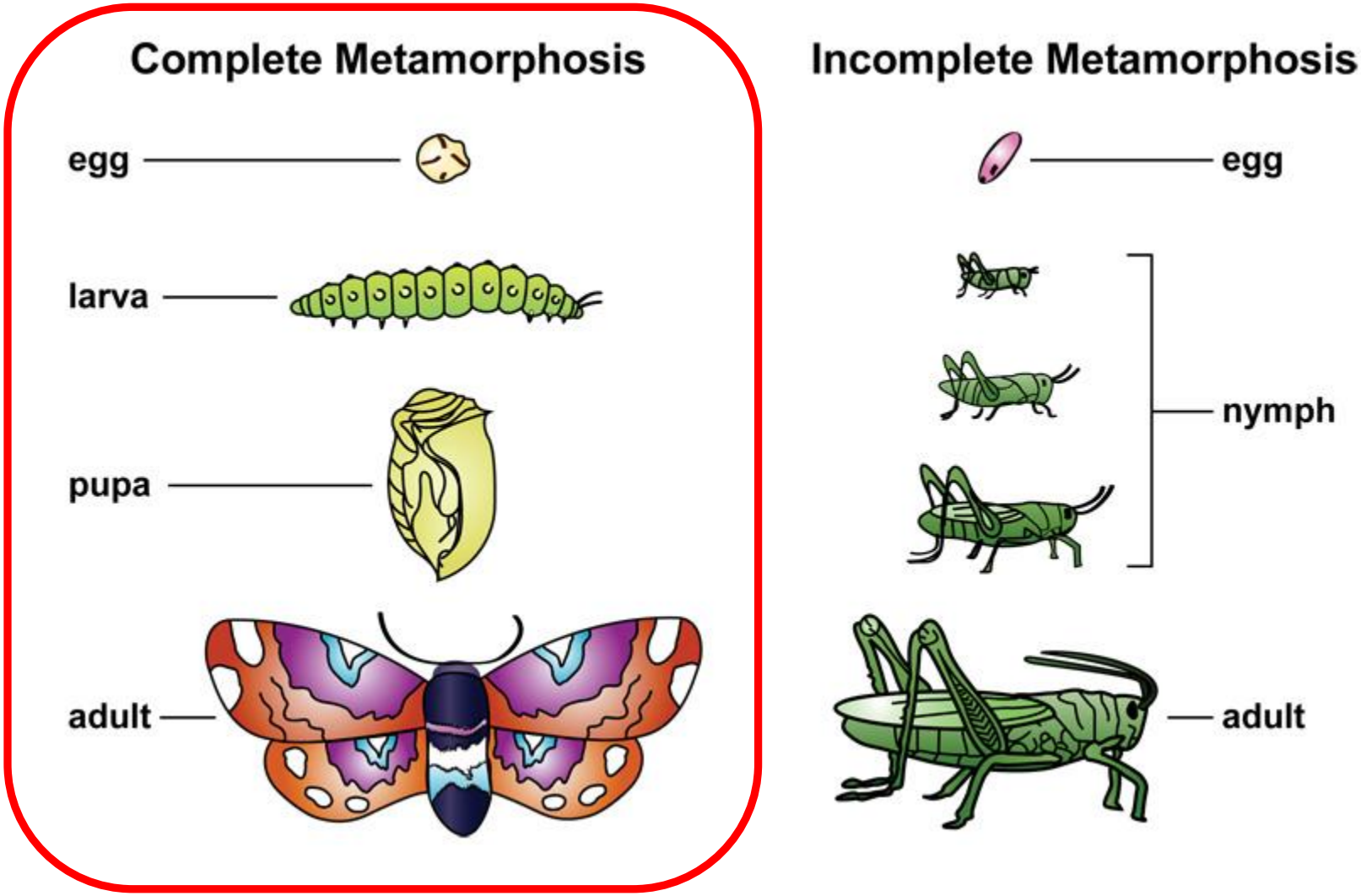
Parasite

does not kill its host

Parasitoid

kill the host

Insects life cycles

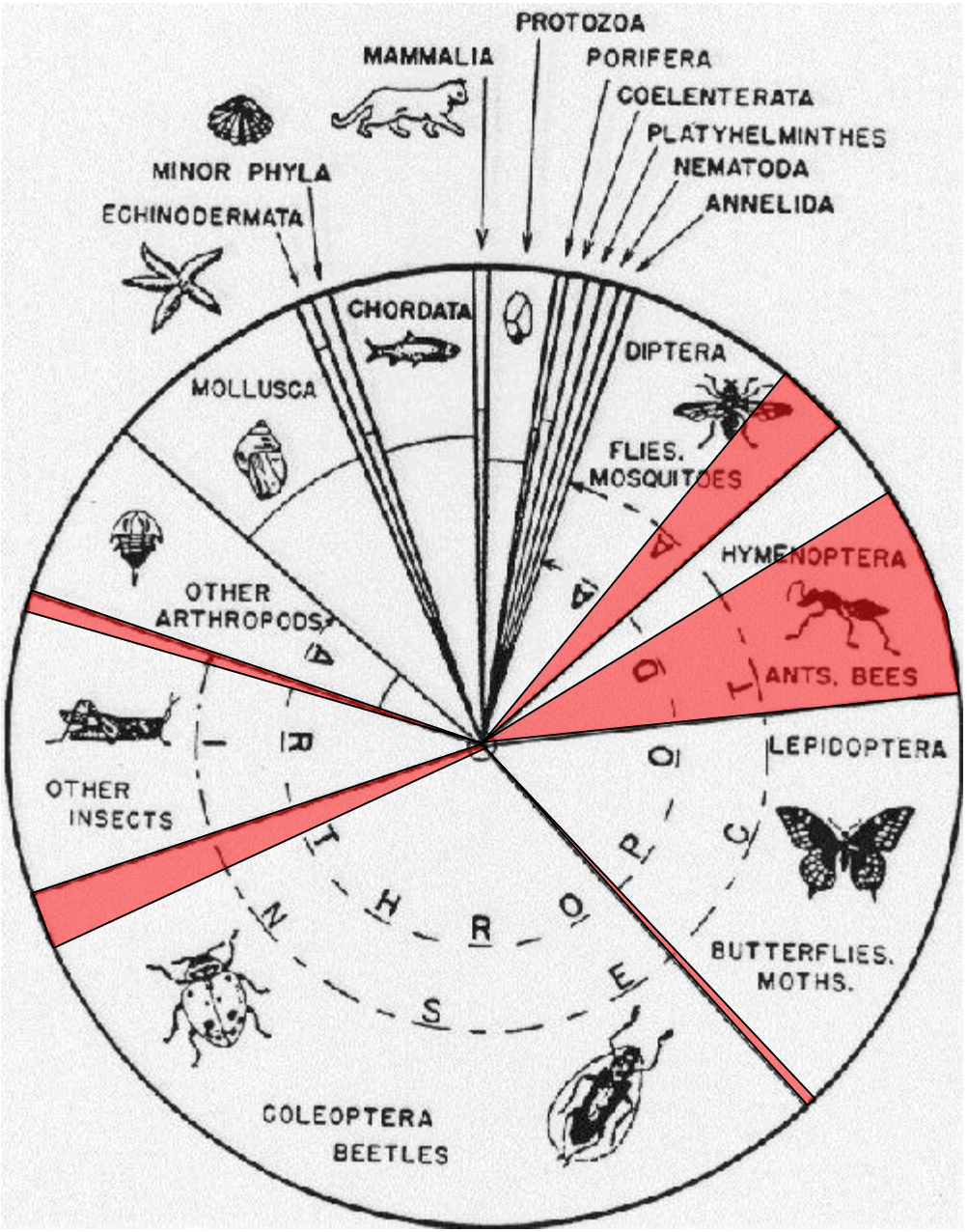


Life cycle of a parasitoid

Some facts about parasitoids

- Parasitoids are diverse (15-25% of all insect species)
- Hosts of parasitoids = virtually all terrestrial insects
- Parasitoids are among the dominant natural enemies of phytophagous insects (e.g., crop pests)
- Offer model systems for understanding community structure, coevolution & evolutionary diversification

Distribution/frequency of parasitoids among insect orders



Primary groups of parasitoids

Hymenoptera (wasps)

ca. 70% of parasitoids

Diptera (flies)

ca. 20% of parasitoids

Major groups of dipteran parasitoids

Diptera

22 families containing parasitoids

At least 21 independent derivations, perhaps 100's

Family	Described parasitoid sp	Primary hosts
Sciomyzidae	200?	Gastropods: (snails/slugs)
Nemestrinidae	300	Orth.: Acrididae
Bombyliidae	5000	primarily Hym., Col., Dip.
Pipunculidae	1000	Hom.:Auchenorrycha
Conopidae	800	Hym:Aculeata
Sarcophagidae	1250?	Lep., Orth., Hom., Col., Gastropoda + others
Tachinidae	> 8500	Lep., Hym., Col., Hem., Dip., + many others
Pyrgotidae	350	Col:Scarabaeidae
Acroceridae	500	Arach.:Aranea
Phoridae	400??	Hym., Dip., Col., Lep., Isop.,Diplopoda + others
Rhinophoridae	90	Isopoda
Calliphoridae	240?	earthworms, gastropods

Tachinidae

- > 8 500 species
- 2° largest group of Diptera
- Largest group of non-hymenopteran parasitoids

Why are tachinids so cool?

- All species are parasitoids

- Diversity of host associations (11 insect orders + other arthropods)

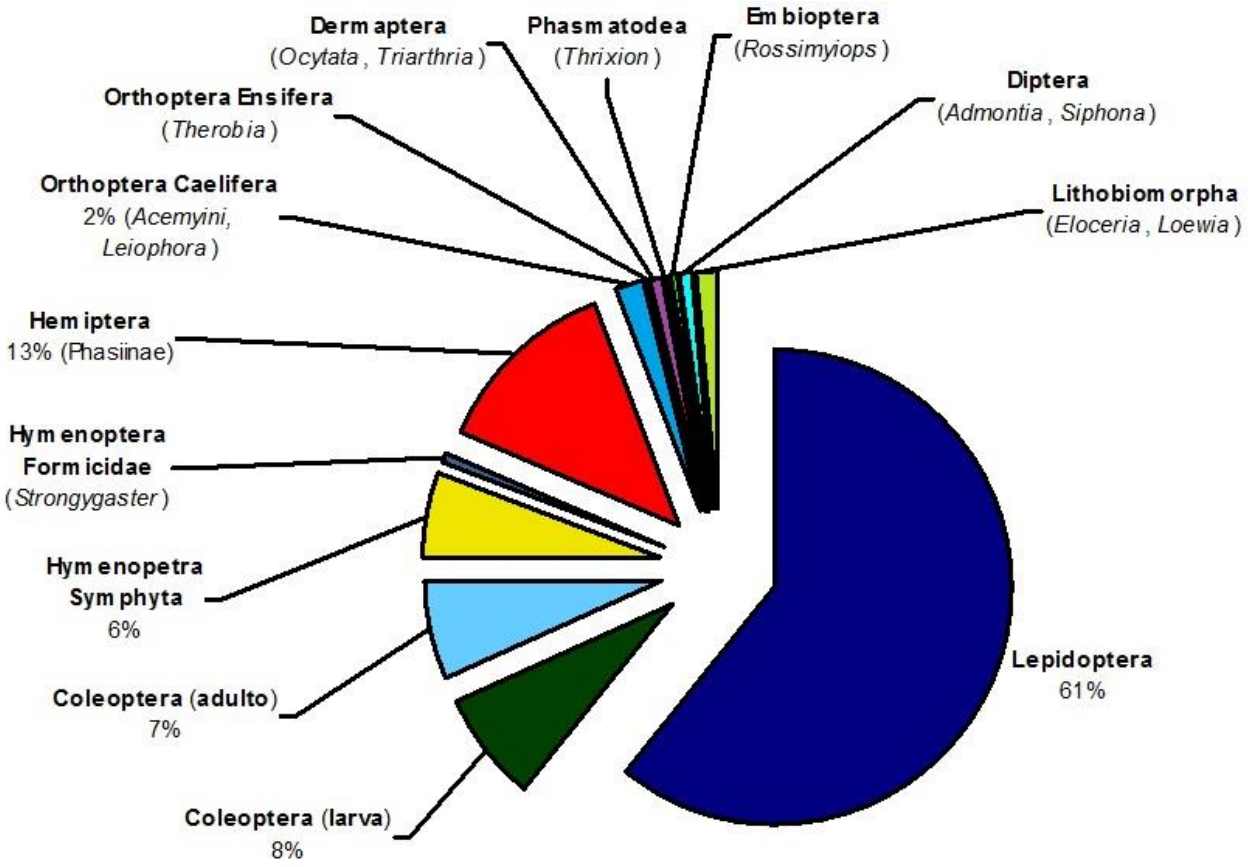
- Ecologically important (widespread, abundant)

- many species exhibit broad host ranges

- In general, their biology is poorly known

  (in Europe < 50% have known hosts)

Tachinid hosts



Hosts of Tachinids I

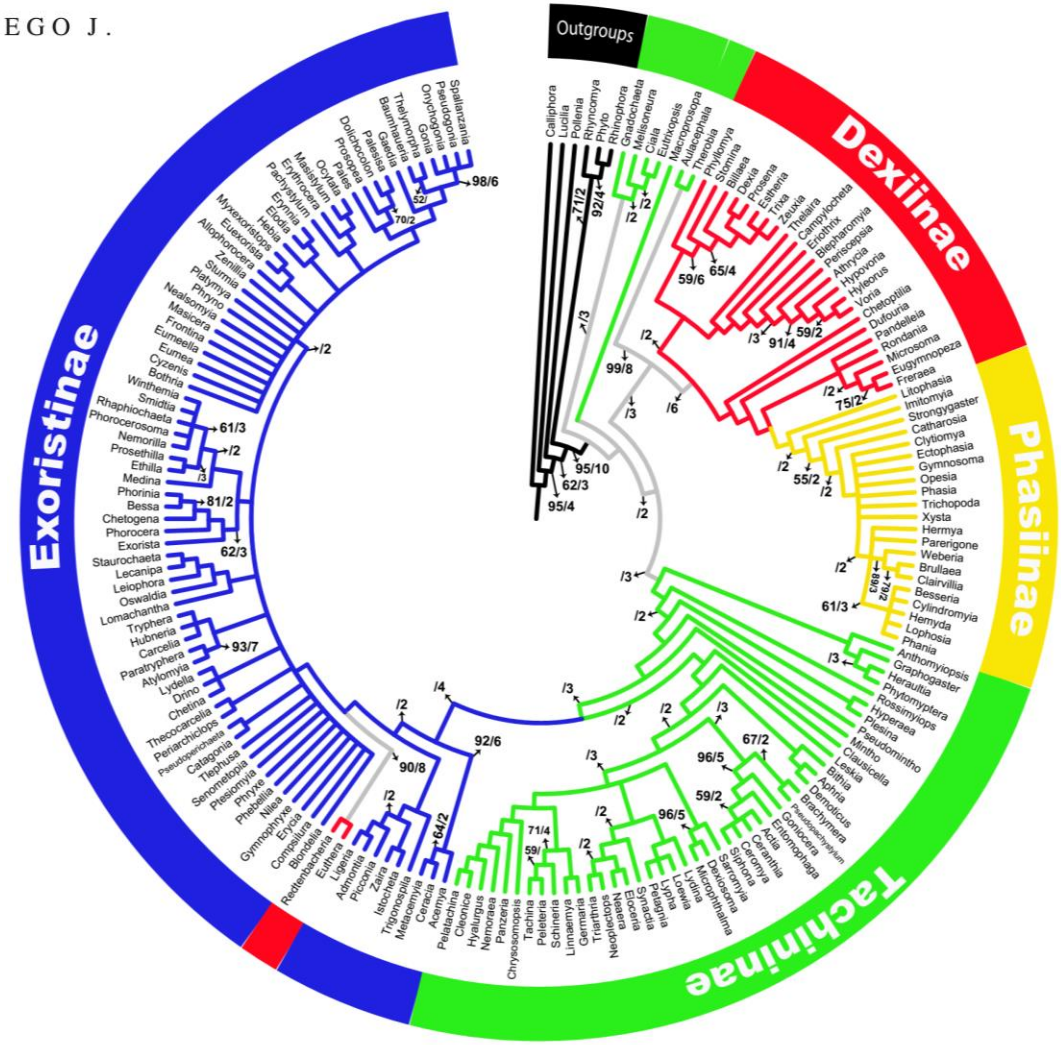
Hosts of Tachinids II

Systematic Entomology

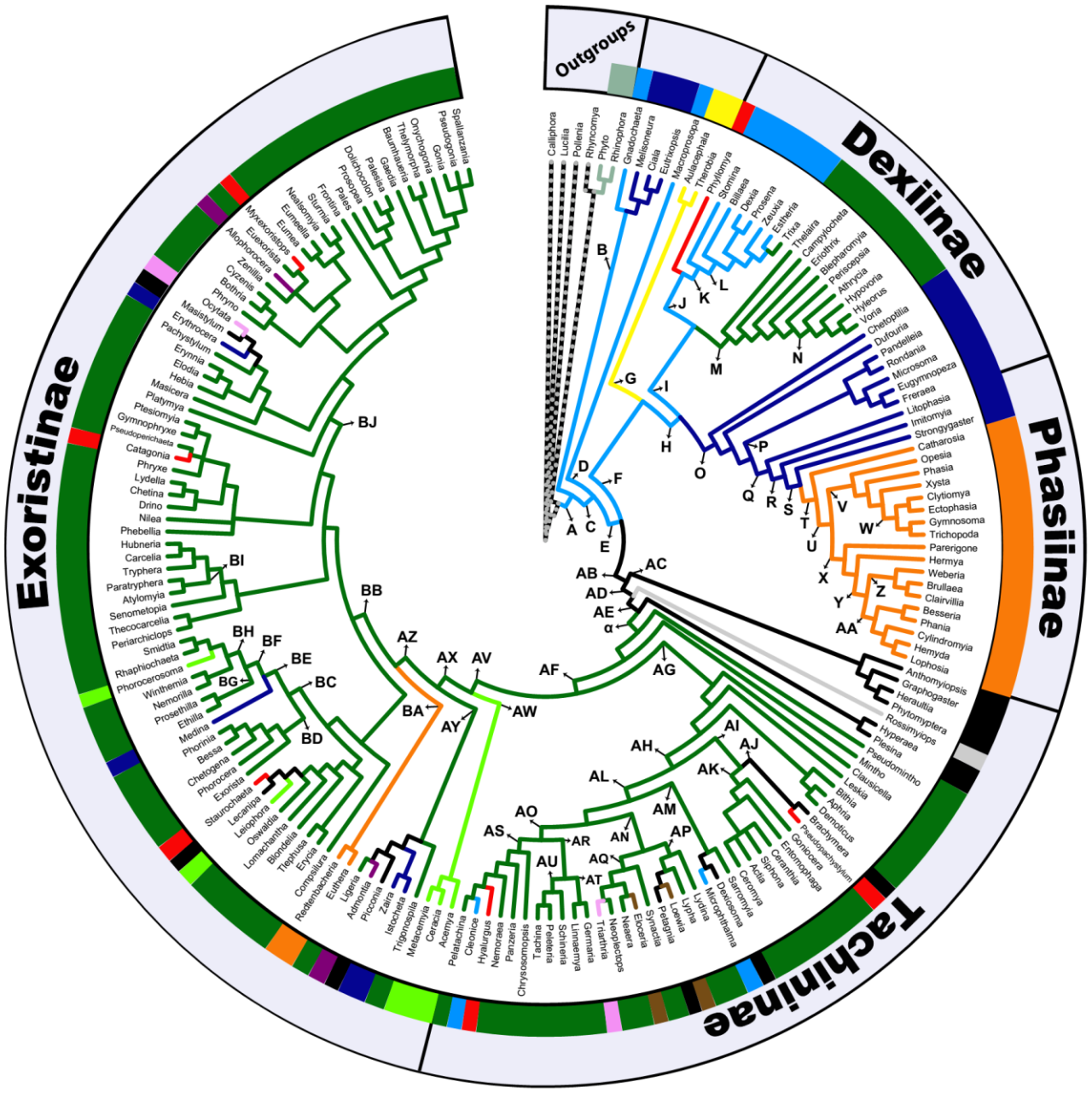
Systematic Entomology (2014), **39**, 335–353

Signal through the noise? Phylogeny of the Tachinidae (Diptera) as inferred from morphological evidence

PIERFILIPPO CERRETTI[1,2], JAMES E. O'HARA[3], D. MONTGOMERY WOOD[3], HIROSHI SHIMA[4], DIEGO J. INCLAN[5] and JOHN O. STIREMAN III[6]



Host evolution



Insecta: Heterometabola

- Embioptera
- Orthoptera Ensifera
- Orthoptera Caelifera
- Dermaptera
- Hemiptera

Insecta: Holometabola

- Coleoptera larvae
- Coleoptera adults
- Lepidoptera (folivores/ xylophagous)
- Diptera larvae
- Hymenoptera Symphyta

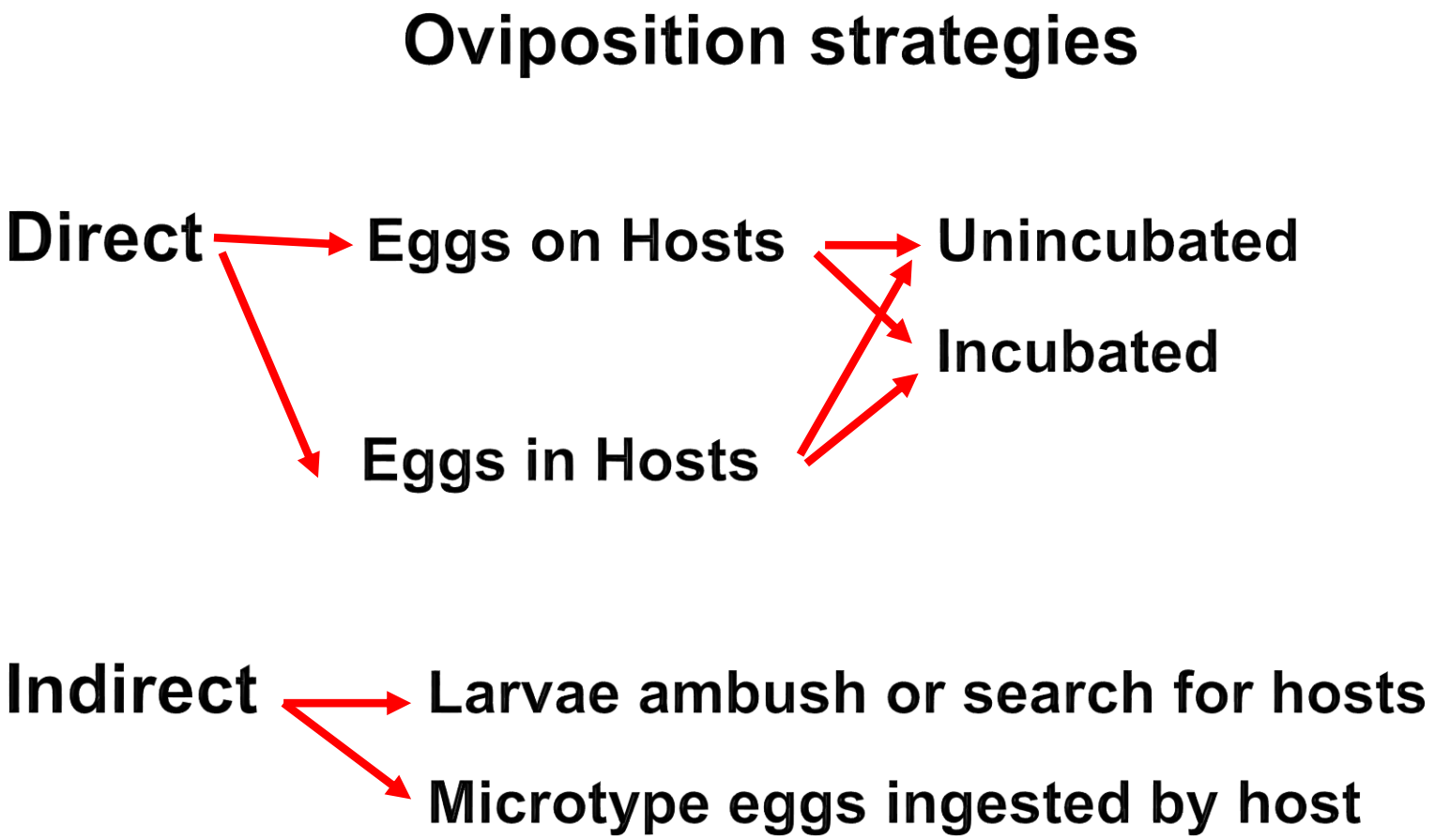
Myriapoda

- Chilopoda - Lithobiomorpha

Crustacea

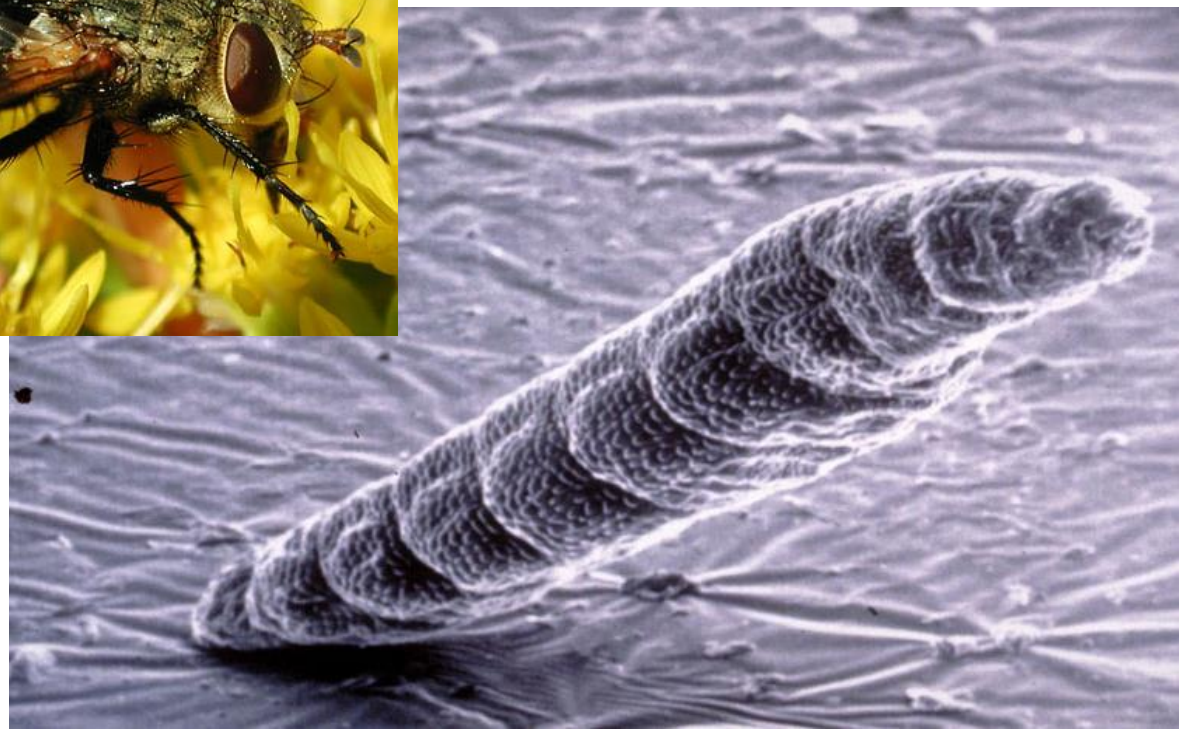
- Isopoda
- non-parasitoids
- Ambiguous

Why tachinid parasitoids are successful?

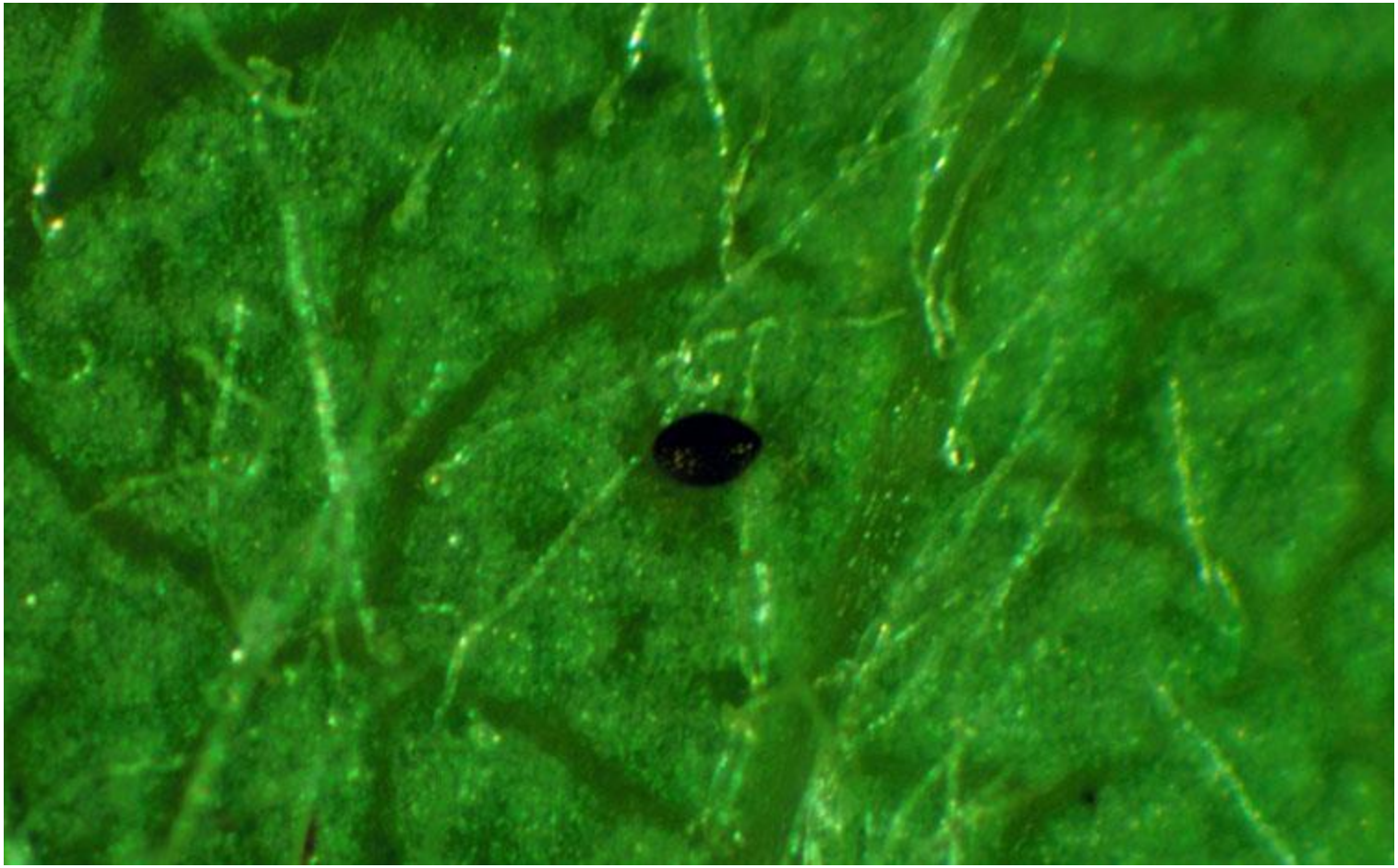


Direct (unincubated)

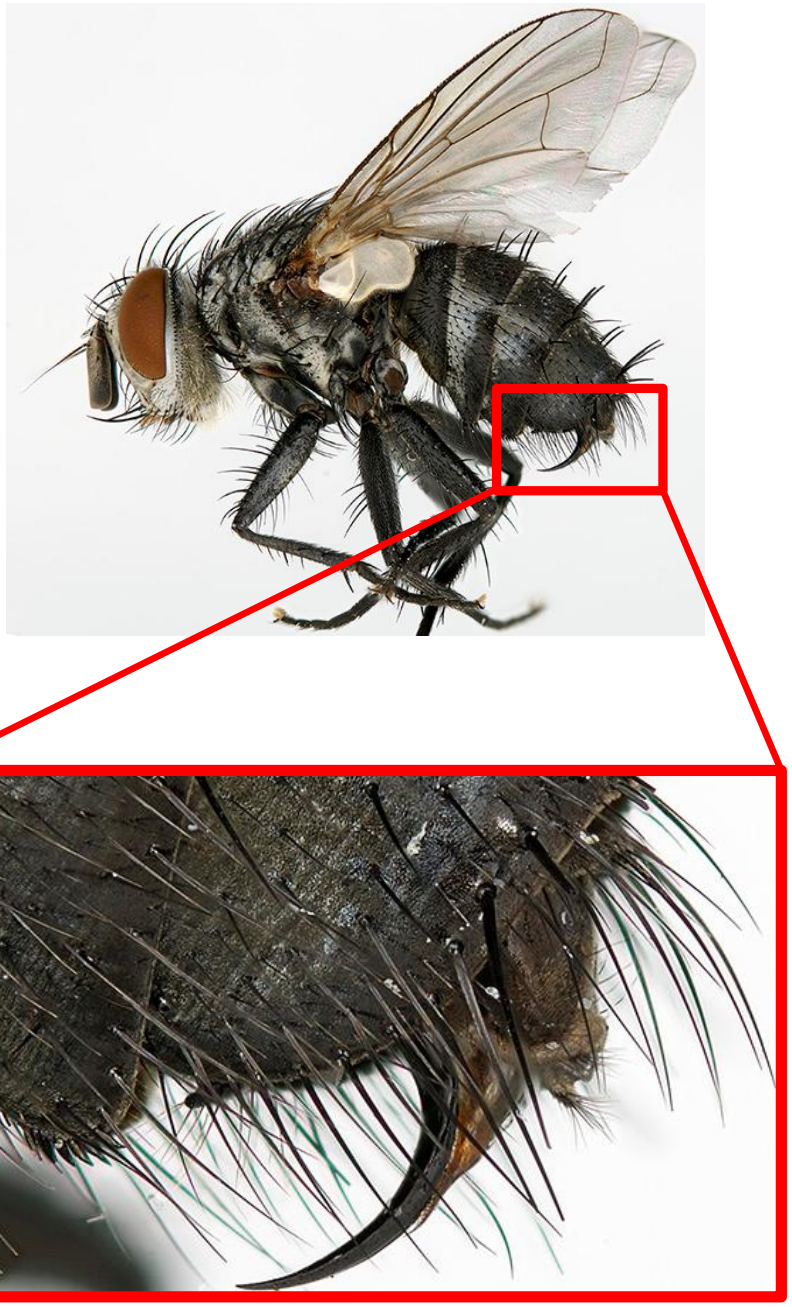
Indirect oviposition
“planidial” larvae



Indirect oviposition microtype eggs



Direct oviposition piercers

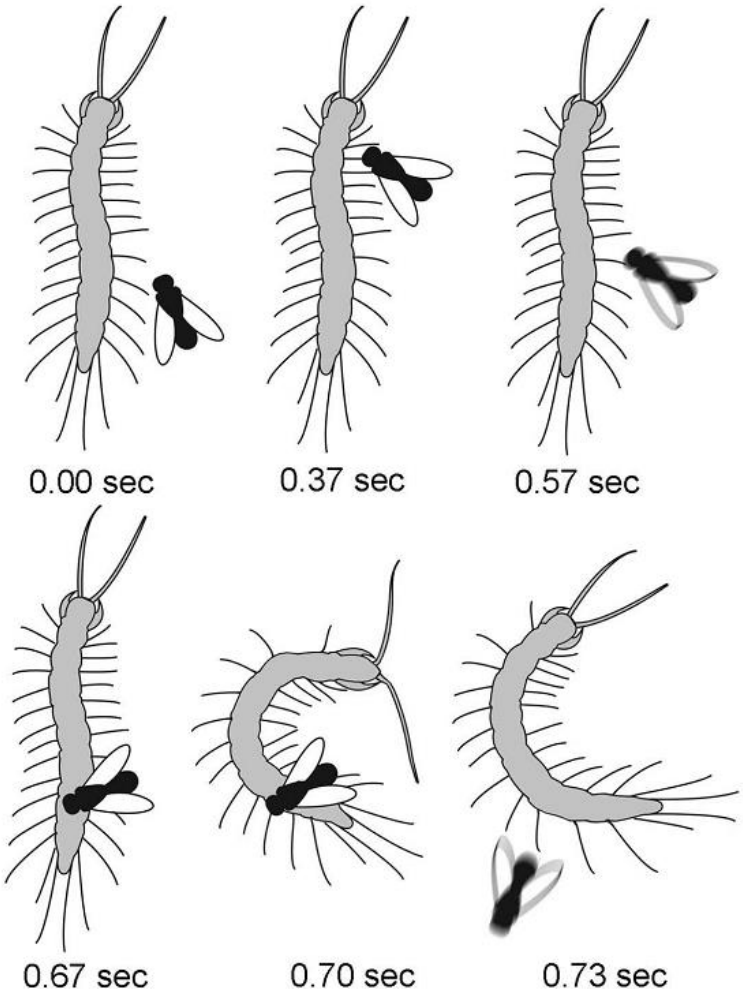


Multiple independent origins (>5)
ca. 7% of species

Oviposition Strategies & fecundity

Oviposition strategy	Egg type	taxa	Fecundity
indirect	**microtype***	Goniini	1000-4000
indirect	**incubated**	Tachinini, Dexiini, Polideini Few Exoristinae (*Lixophaga*)	800-8000
direct-external	**incubated**	"Eryciini" (Exoristinae), Blondeliini (most), Voriini, Strongygastrini	30-600
direct-external	**unincubated**	Phasiinae, Exoristiini, Winthemiini, some Blondeliini, *Aplomya*	100-200
direct-internal	**incubated**	Blondeliini (*Blondelia*, *Eucelatoria*) Dexiinae (Eutrixiini),	65-250
direct-internal	**unincubated**	Phasiinae (*Phasia,* Cylindromyini), Exoristiinae (*Phorocera*)	100-200

A fast attack!



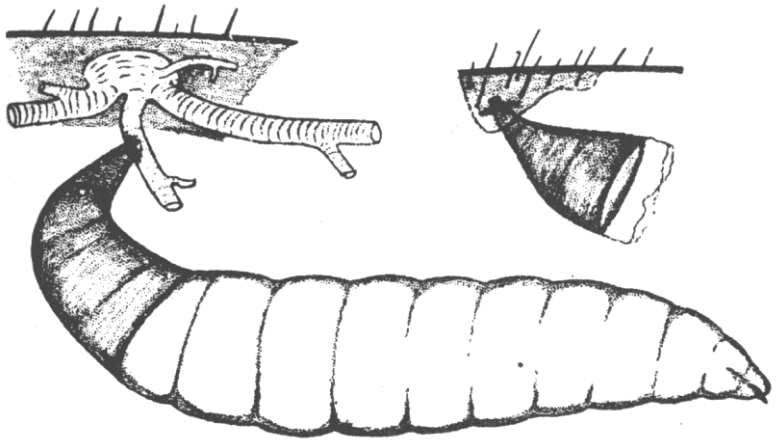
Attack of a female *Loewia foeda* on *Lithobius forficatus* (Haraldseide & Tschorsnig 2014)

Why tachinid parasitoids are successful?

Larval development

Respiratory Funnels:

Allow tachinid larvae to maintain contact with outside air and appears to allow them to evade host immune defenses (e.g. encapsulation)



(Figure from Clausen 1927)

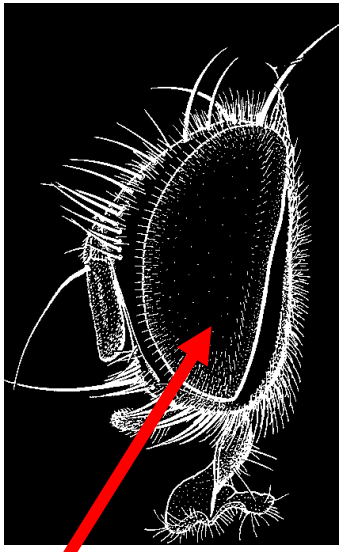
What limits host range in tachinids?

Hosts are difficult to find

Host habitat / feeding niche are of primary importance in determining patterns of host use rather than phylogenetic relationship

Central Importance of Host Location
(cues used shape host range - feedback)

(e.g. indirect ovipositors)



Highly acute visual systems

Tachinids & Biological Control

Augmentation - (relatively rare)

- *Archytas marmoratus* & corn earworm/fall armyworm
- *Leschenaultia* & tent caterpillars
- *Paratheresia claripalpis* in Brazilian sugarcane (1.5 m)
- *Myiopharus* & Mexican Bean Beetle

Rearing & artificial diets

Tachinids & Biological Control

Conservation

- tests of pesticides on tachinids (e.g. Bt)
- successional and grassy corridors
- Weedy strip cropping

Much potential given alternate hosts for many species and common reliance on sources of nectar and honey dew

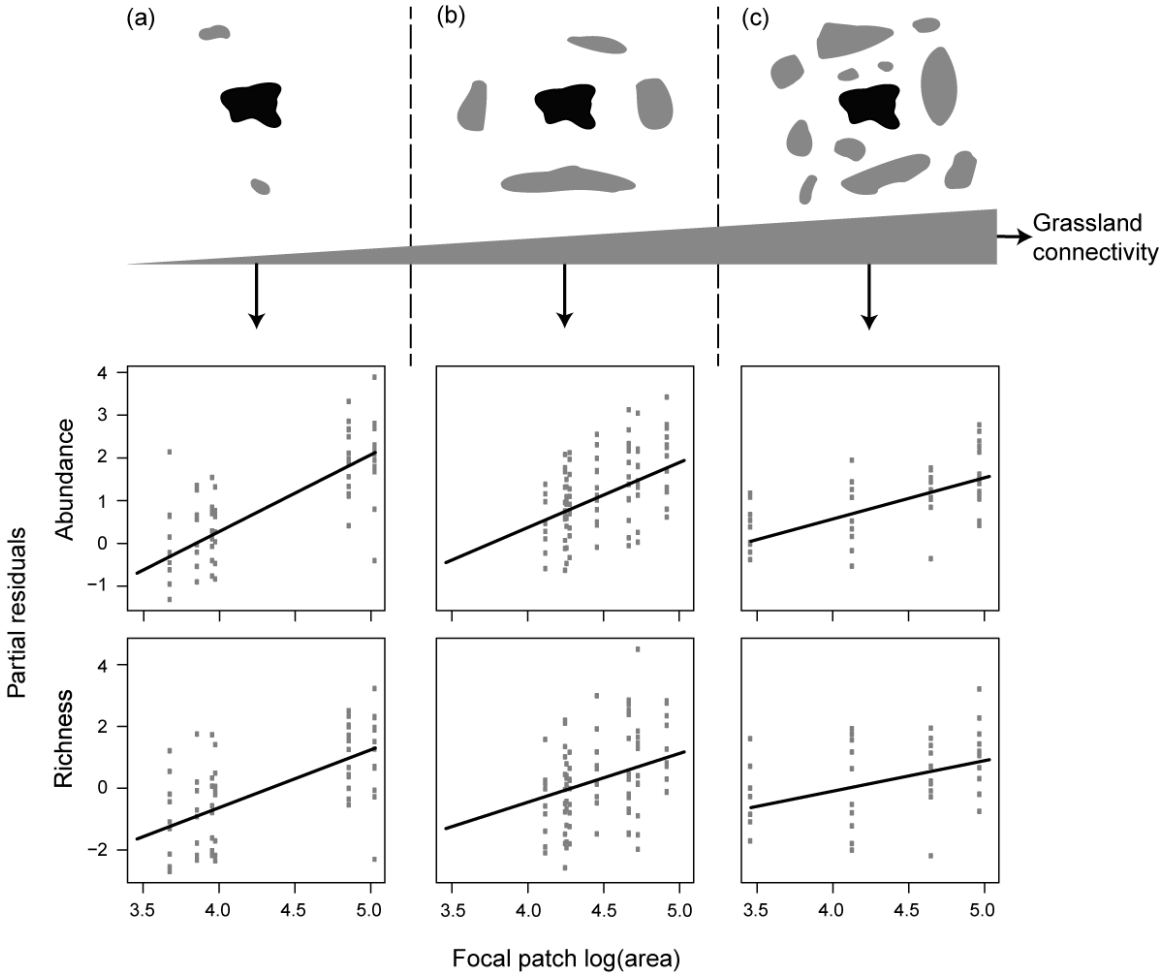
Landscape Ecol (2014) 29:879–889
DOI 10.1007/s10980-014-0024-0

RESEARCH ARTICLE

Interactive effects of area and connectivity on the diversity of tachinid parasitoids in highly fragmented landscapes

Diego J. Inclán · Pierfilippo Cerretti · Lorenzo Marini

Conservation of tachinids is correlated to the area & connectivity of seminatural habitats



Introduction Biological Control

(a partial list for North America)

Tachinid Species	Target Pest Species	Reference
EXORISTINAE		
Ametadoria harrisonae	W. grape leaf sk. (*Harrisina brillians*)	Bartlett et al. 1978
Bessa harveyi	Larch sawfly (*Pristiphora erichsonii*)	Bartlett et al. 1978
Bessa remota	Coconut moth (*Levuana iridescens)*	Bartlett et al. 1978
Blepharella lateralis	Mango shoot worm (*Penicillaria joc.*)	Nafus 1991
Blepharipa pratensis	Gypsy moth (*Lymantria dispar*)	Bartlett et al. 1978; Kenis & Vaamonde 1998
Blondelia nigripes	Gypsy moth (*Lymantria dispar*)	Kenis & Vaamonde 1998
Ceranthia samarensis	Gypsy moth (*Lymantria dispar*)	Mills & Nealis 1992; Nealis & Quednau 1996
Ceromasia auricaudata	Spruce budworm (*Choriston. fumif.*)	Bartlett et al. 1978
Compsilura concinnata	Gypsy moth (*Lymantria dispar*) W. grape leaf sk. (*Harrisina brillians*)	Bartlett et al. 1978 Kenis & Vaamonde 1998
Carcelia gnava	Satin moth (*Stilpnotia salicis*)	Bartlett et al. 1978
Carcelia illota	African bollworm (*Heliothis armigera*)	Clunie & Berry 2003 (website)
Carcelia separata	Gypsy moth (*Lymantria dispar*)	Kenis & Vaamonde 1998
Chaetoexorista javana	Oriental moth (*Cnidocampa flaves.*)	Bartlett et al. 1978
Cyzenis albicans	Winter moth (*Operophtera brumata*)	Bartlett et al. 1978
Cyzenis incrassata	Spruce budworm (*Choriston. fumif.*)	Bartlett et al. 1978
Drino spp.	Eur. spr. sawfly (*Diprion hercyniae*)	Bartlett et al. 1978
Eucelatoria bryani	African bollworm (*Heliothis armigera*)	Sankaran & Nagaraja 1979
Eucelatoria armigera	African bollworm (*Heliothis armigera*)	Clunie & Berry 2003 (website)
Euthelyconychia epilachne	Mex. bean beetle (*Epilachna variv.*)	Bartlett et al. 1978
Erynniopsis antennata	Elm leaf beetle (*Pyrrhalta luteola*)	Bartlett et al. 1978
Exorista spp.	Gypsy moth (*Lymantria dispar*)	Ticehurst et al. 1977; Bartlett et al. 1978
Froggattimyia sp.	Euc. tort. beetle (*Paropsis charybdis*)	Clunie & Berry 2003 (website)
Istocheta aldrichi	Japanese beetle (*Popillia japonica*)	Bartlett et al. 1978
Leschenaultia leucophrys	Tent caterpillar (*Malacosoma* spp.)	Bartlett et al. 1978
Lespesia archippivora	Armyworms; CEW, *Heliothis zea*	Bartlett et al. 1978; Nishida 1992
Lixophaga diatraeae	Sugarcane borer (*Diatraea sacchar.)*	Summers et al. 1976; King et al. 1981
Lixophaga sphenophori	Sugar. weevil (*Rhabdoscelus obsc.*)	Bartlett et al. 1978
Lydella jalisco	Mexican rice borer (*Eoreuma loftini)*	Legaspi et al. 2000; Lauziere et al. 2001
Lydella thompsoni	Europ. corn borer (*Ostrinia nubilalis*)	Bartlett et al. 1978
Metagonistylum minense	Sugarcane borer (*Diatraea sacchar.*)	Bartlett et al. 1978; Menhadeo 1991
Mycteromyiella spp.	Coconut stick ins. (*Graeffea crouanii*)	Bartlett et al. 1978
Myiopharus doryphorae	CO. potato bte. (*Leptinotarsa dec.)*	Tamaki et al. 1983; Lopez et al. 1993
Nealsomyia rufella	Bagworm (*Eumeta variegata*)	Gao-GuiMing et al. 2001
Nemorilla floralis	Eur. corn borer (*Ostrinia nubilalis*)	Bartlett et al. 1978
Ocytata pallipes	Europ. earwig (*Forficula auricularia*)	Bartlett et al. 1978
Palexorista laxa	African bollworm (*Heliothis armigera*)	Clunie & Berry 2003 (website)
Panzeria ampelus	Fall webworm (*Hyphantrea cunea*)	Bartlett et al. 1978
Parasetigera silvestris	Gypsy moth (*Lymantria dispar*)	Kenis & Vaamonde 1998
Sturmia inconspicua	Gypsy moth (*Lymantria dispar*)	Bartlett et al. 1978
Sturmia nidicola	Brn-tail moth (*Nygmia phaerorrh.*)	Bartlett et al. 1978
Sturmiopsis inferens	Sugarcane stalk bor.(*Chilo auricilius)*	Chandra & Avasthy 1982
Trigonospila brevifacies	Various Torticidae	Munro 1998; Shaw et al. 2001
Turanogonia smirnovi	Black cutworm (*Agrotis ipsilon*)	Clunie & Berry 2003 (website)
Voriella uniseta	LB apple moth (*Epiphyas postvitt.*)	Clunie & Berry 2003 (website)
TACHININAE		
Archytas cirphis	Nutgrass armywm. (*Spod. exempta*)	Bartlett et al. 1978
Archytas marmoratus	Corn earworm(*Helicoverpa zea*)	Mannion et al. 1994, 1995
Ceromya nigritula	Cotton leafworm (*Spodopt. litturalis)*	Bartlett et al. 1978
Eurithia consobrina	*Bertha amyworm (Mamestra config.)*	Turner and Carl 1995
Linnaemya comta	Black cutworm (*Agrotis ipsilon*)	Levine & Clement 1981; Allan & Hill 1984
Lypha dubia	E. pine shoot moth (*Rhyacion. buol.*)	Bartlett et al. 1978
Ormia depleta	Mole crickets *(Scapteriscus* spp.*)*	Frank et al. 1996
Triarthria setipennis	Europ. earwig (*Forficula auricularia*)	Bartlett et al. 1978; Barthell & Stone 1995
PHASIINAE		
Acaulona peruviana	Cotton stainer (*Dysdercus andreae*)	Bartlett et al. 1978
Bogosia rubens	Varieg. coffee bug (*Antestiopsis* sp.)	Bartlett et al. 1978

“Success” rate of established biological control agents

Tachinidae	51%
Aphelinidae	49%
Encyrtidae	39%
Braconidae	34%

Greathead 1986

Some notable cases of Introduction Biological control of Tachinidae

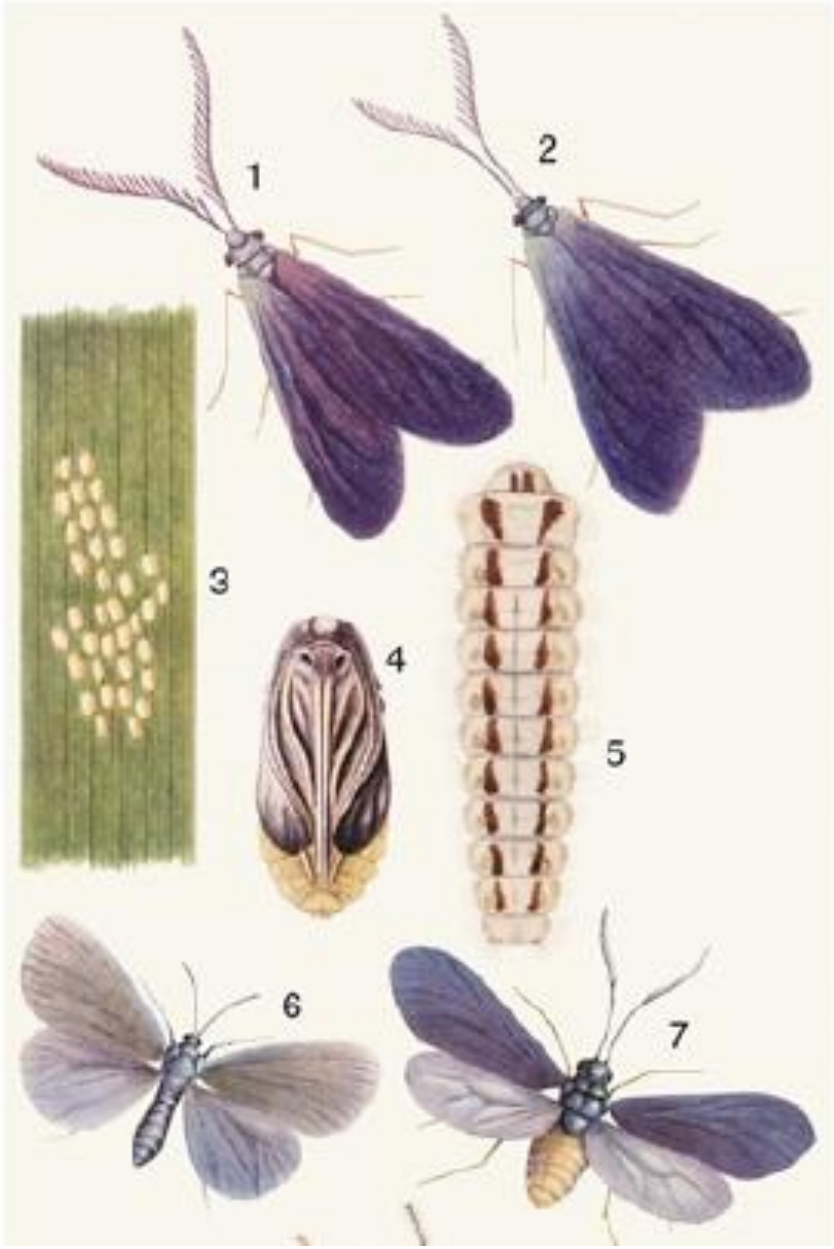
Tachinid	Host
Compsilura concinnata	*Lymantria dispar* (Gypsy moth)
Cyzenis albicans	*Operophtera brumata* (Winter moth)
Lixophaga diatraeae	*Diatrea saccharalis* (Sugarcane borer)
Trichopoda spp.	*Nezara viridula* (Green stink bug)
	Anasa tristis (Squash bug)
Bessa remota	*Levuana iridescens* (Coconut moth)

The Coconut moth

Levuana iridescens

(Sessiidae)

A coconut palm attacked by Levuana



Fiji

(1920)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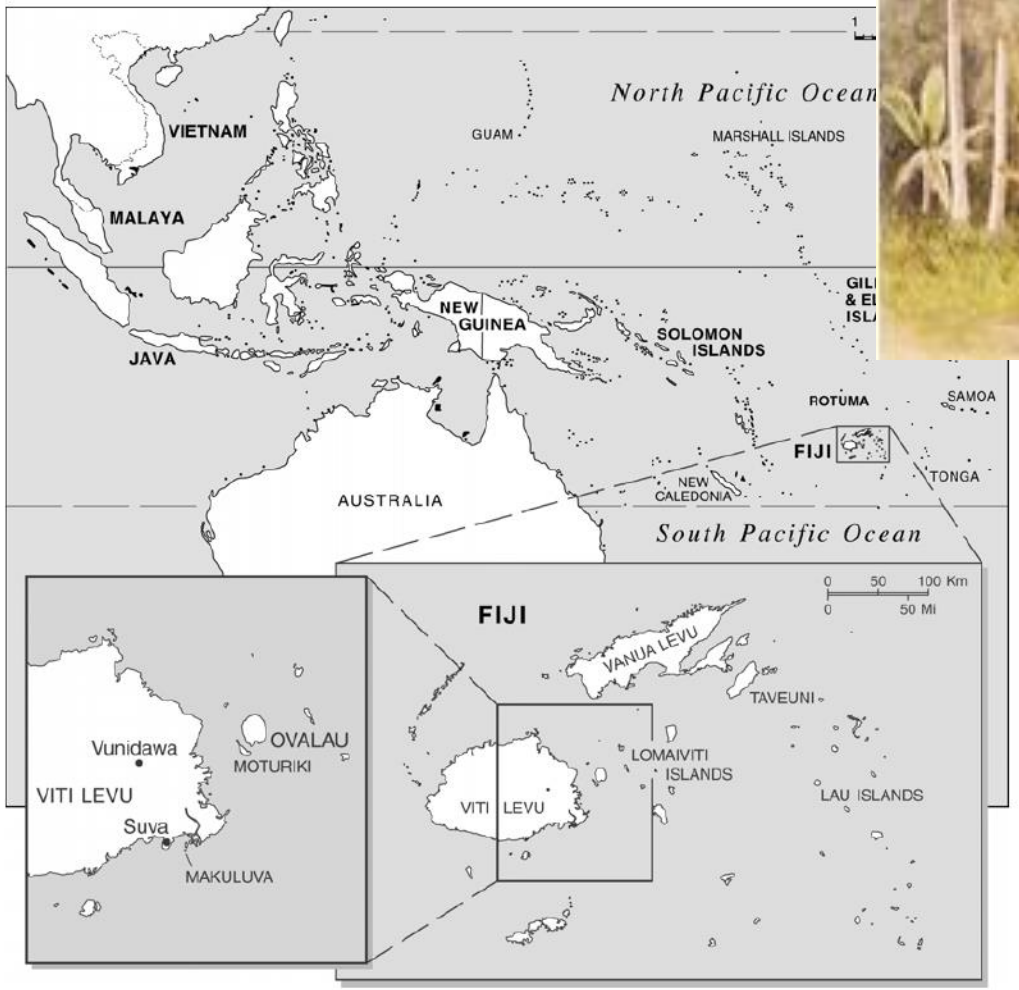
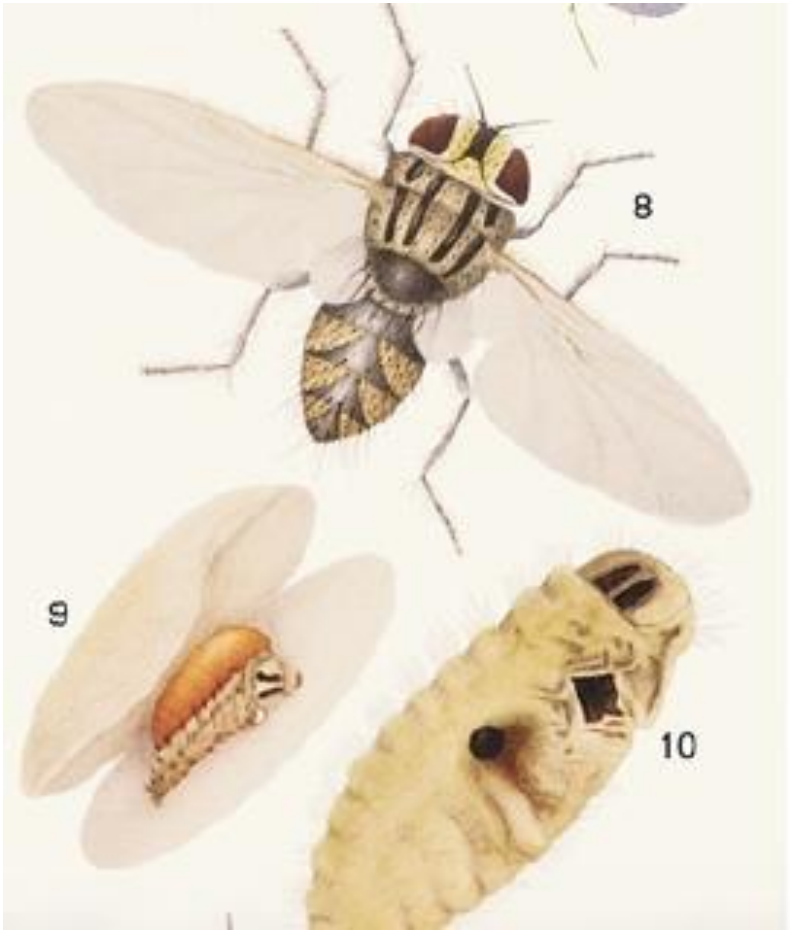
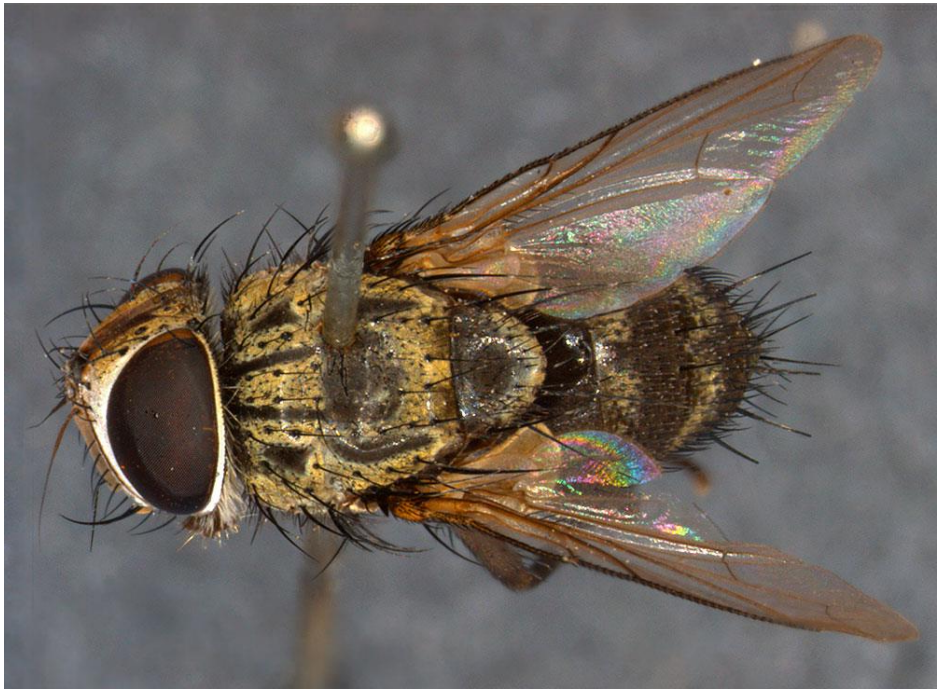
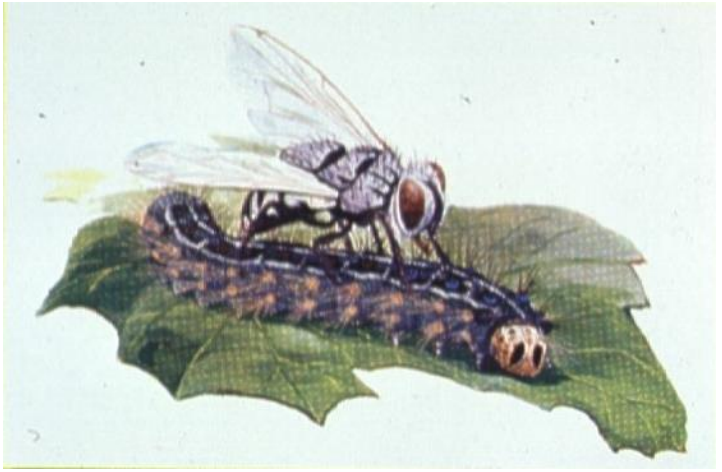

North Pacific Ocean
VIETNAM
GUAM
MARSHALL ISLANDS
MALAYA
NEW GUINEA
SOLOMON ISLANDS
JAVA
ROTUMA
SAMOA
FIJI
TONGA
NEW CALEDONIA
AUSTRALIA
South Pacific Ocean
FIJI
0 50 100 Km
0 50 Mi
VANUA LEVU
TAVEUNI
Vunidawa
OVALAU
MOTURIKI
VITI LEVU
Suva
MAKULUVA
LOMAIVITI ISLANDS
VITI LEVU
LAU ISLANDS

Bessa remota





Compsilura concinnata



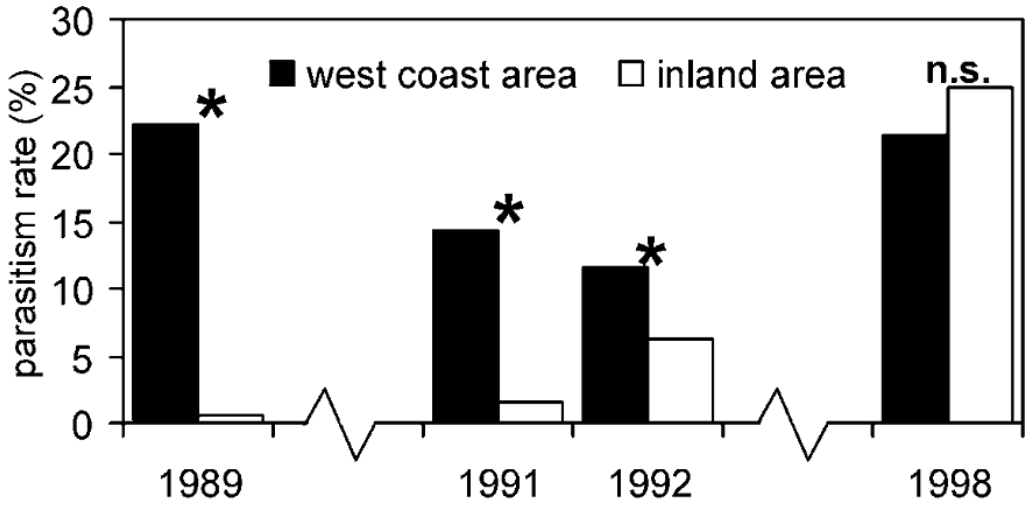
- **Introduced in USA to control *Lymantria dispar***
- **ca. 200 host species in three orders!**

- Responsible for general declines of silk moths in the Northeast?

Trichopoda pennipes introduction to Italy

- Native from America
- Use to control the green stink bug, *Nezara viridula*
- Introduced to: Hawaii, Australia, New Zealand, Argentina, South Africa & Fiji
- Accidental introduced to Italy 1988

Trichopoda pennipes introduction to Italy



BioControl **47:** 617–624, 2002.

Nezara viridula parasitism by the tachinid fly _Trichopoda pennipes_ ten years after its accidental introduction into Italy from the New World

Gianandrea SALERNO[1]*, Stefano COLAZZA[2] and Ferdinando BIN[1]

Control of invasive species

The Mexican bromeliad weevil:

New tachinid species, a potential biological control!

Wood & Cave: New Genus and Species of Weevil Parasitoid

DESCRIPTION OF A NEW GENUS AND SPECIES OF WEEVIL PARASITOID FROM HONDURAS (DIPTERA: TACHINIDAE)

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Thank you!