Bridging gaps in the study of parasitoid wasps: a perspective from the global south.

Eduardo Mitio Shimbori - 29 février 2024 - CBGP

UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO

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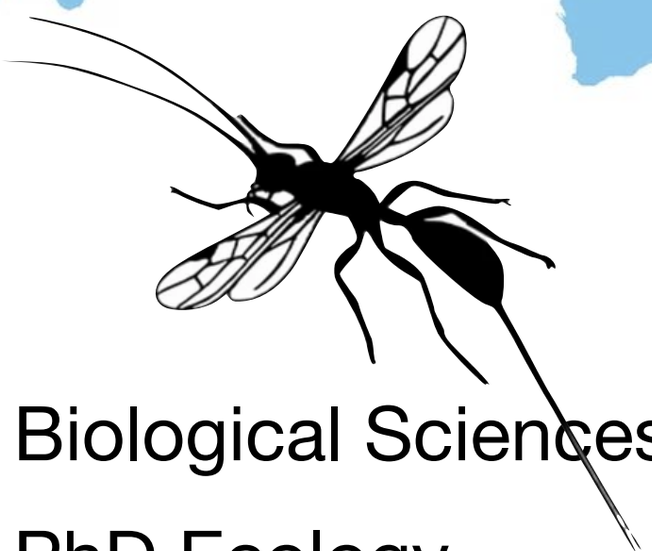
- Current: postdoc

Universidade Federal de São Carlos



- Biological Sciences
- PhD Ecology

Topics

research centred on parasitoid wasps

1.Parasitoid basics - biology, ecology and diversity

2.Braconidae basics - systematics, biology and diversity

3.The taxonomic gap and the taxonomic impediment

4.How deep is the gap?

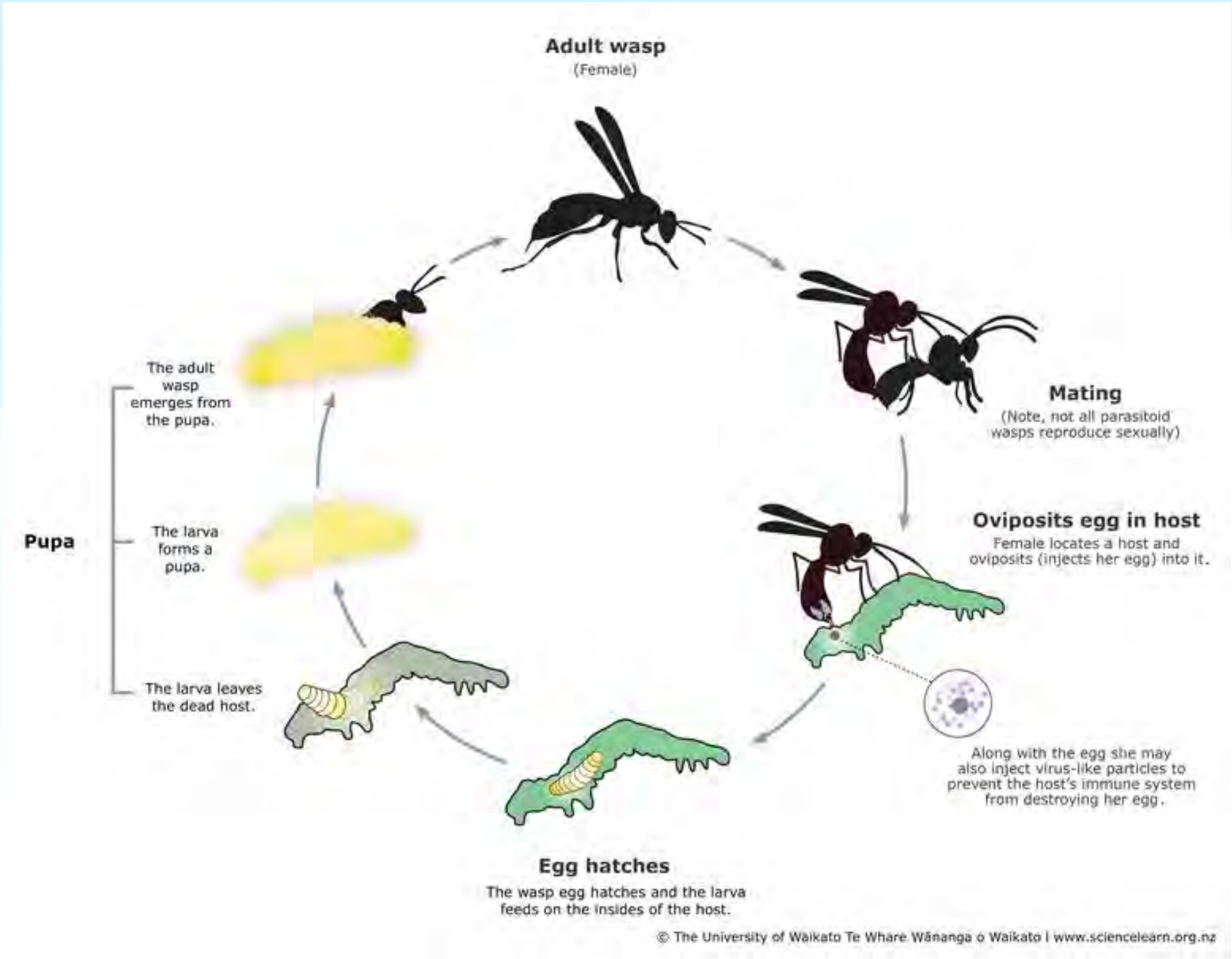
5.Can we bridge the gaps?

6.Biological control and taxonomy of parasitoids

7. Current projects

1. Parasitoids basics

Biology, ecology and diversity



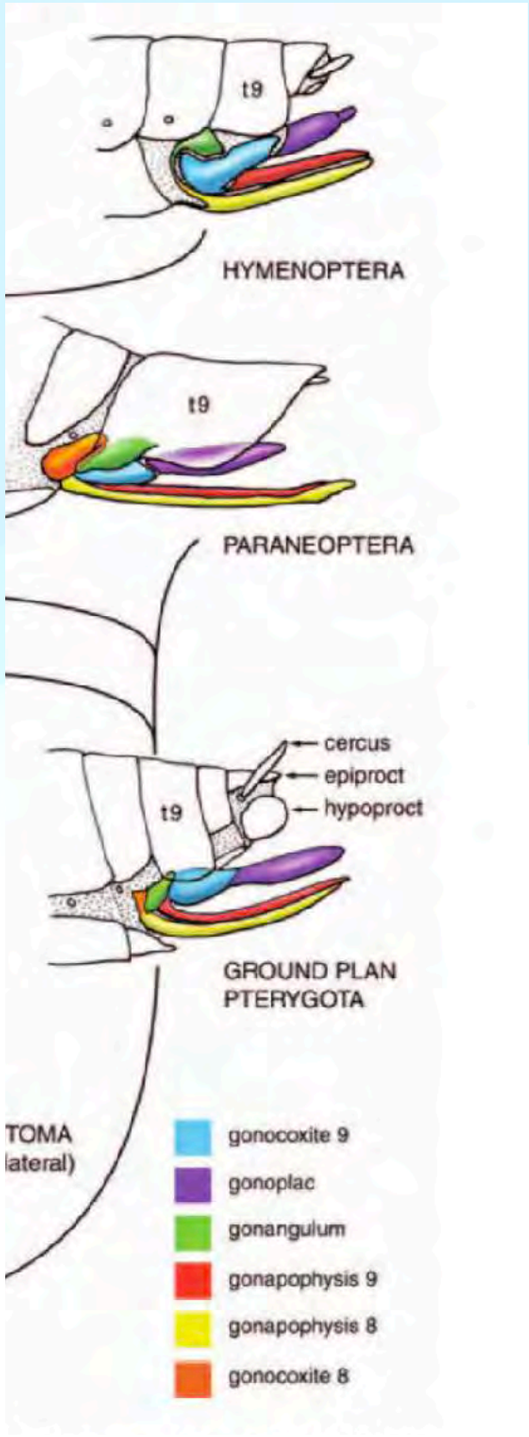
1. Parasitoids basics

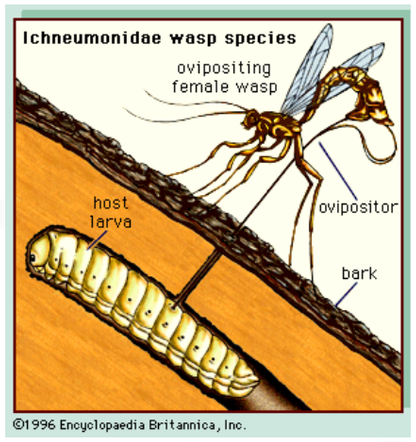
Biology, ecology and diversity

Hymenoptera: venom glands and ovipositor

Leptopilina

Venom gland (VG) and reservoir (R)





1. Parasitoids basics

Biology, ecology and diversity

Glyptapanteles sp.

Thyrinteina leucocera

Grosman et al 2008, PLoS One 3(6)

1. Parasitoids basics

Biology, ecology and diversity

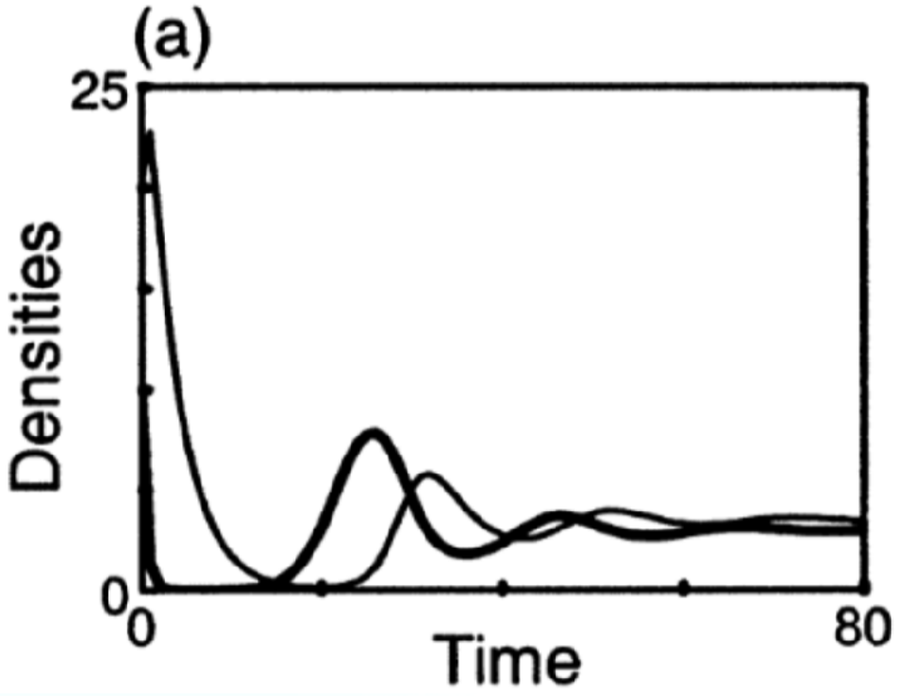
Pontoppidan et al 2009, PLoS One 4(3)

HBO

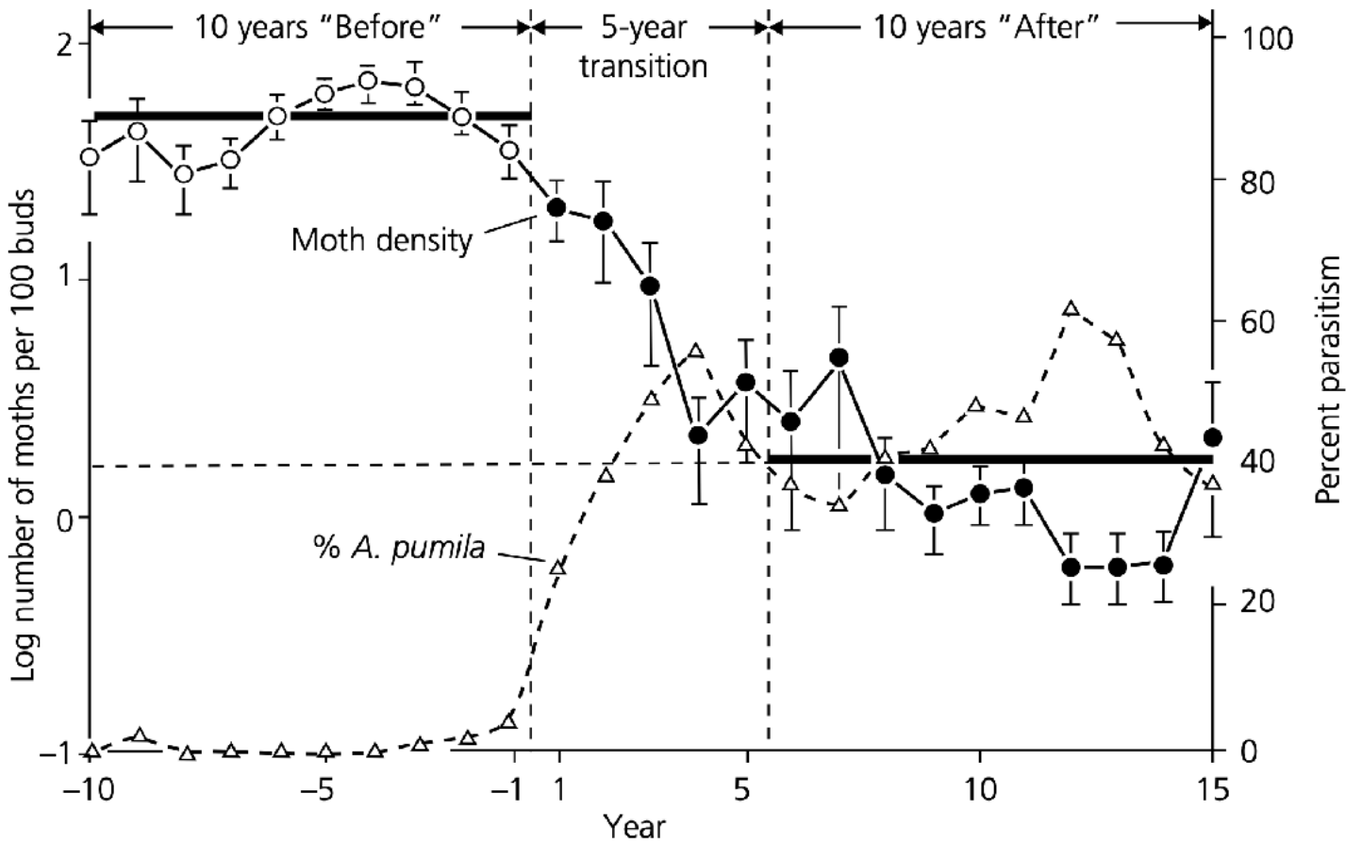
1. Parasitoids basics

Biology, ecology and diversity

Coleophora laricella **density variation in Oregon (USA) for 25 yr relative to the introduction of** ***Agathis pumila*** **(Ryan 1997)**



Simulation of the Lotcka-Volterra equation model plus logistic prey, K=10 (Murdoch et al 2003; Consumer-Resource Dynamics)



1. Parasitoids basics

Biology, ecology and diversity

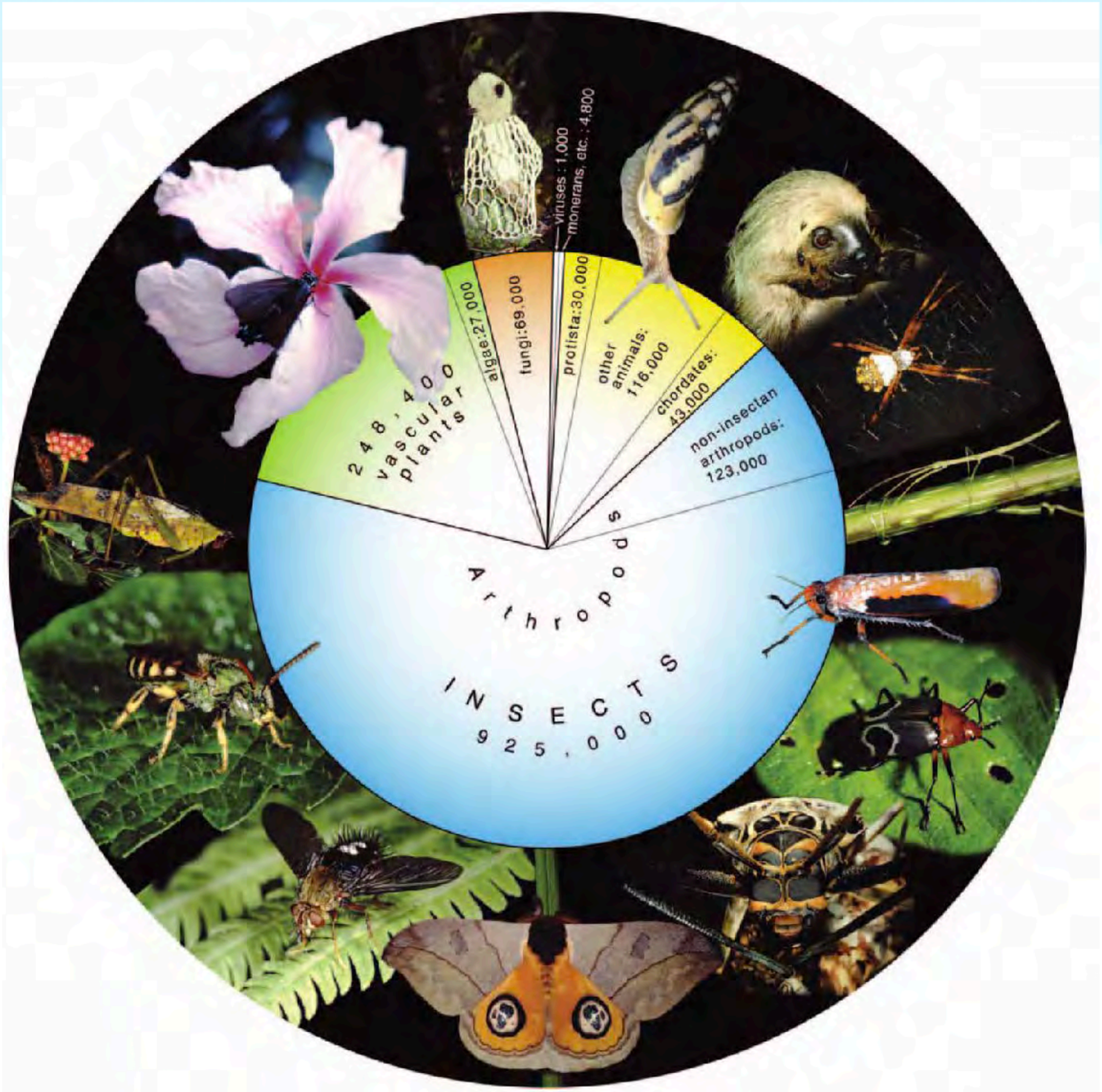
- Ecosystem services are valuable
- Natural control of pest in USA = US$ 4.5 billion/year*
- Africa: *Anagyrus lopezi* against cassava mealybug = US$8–20 billion /40 years**
- food security

* Losey & Vaughan 2006, *BioScience* 56(4)

** Zeddies et al. 2005, *Agr Econ* 24(2)

1. Parasitoids basics

Biology, ecology and diversity



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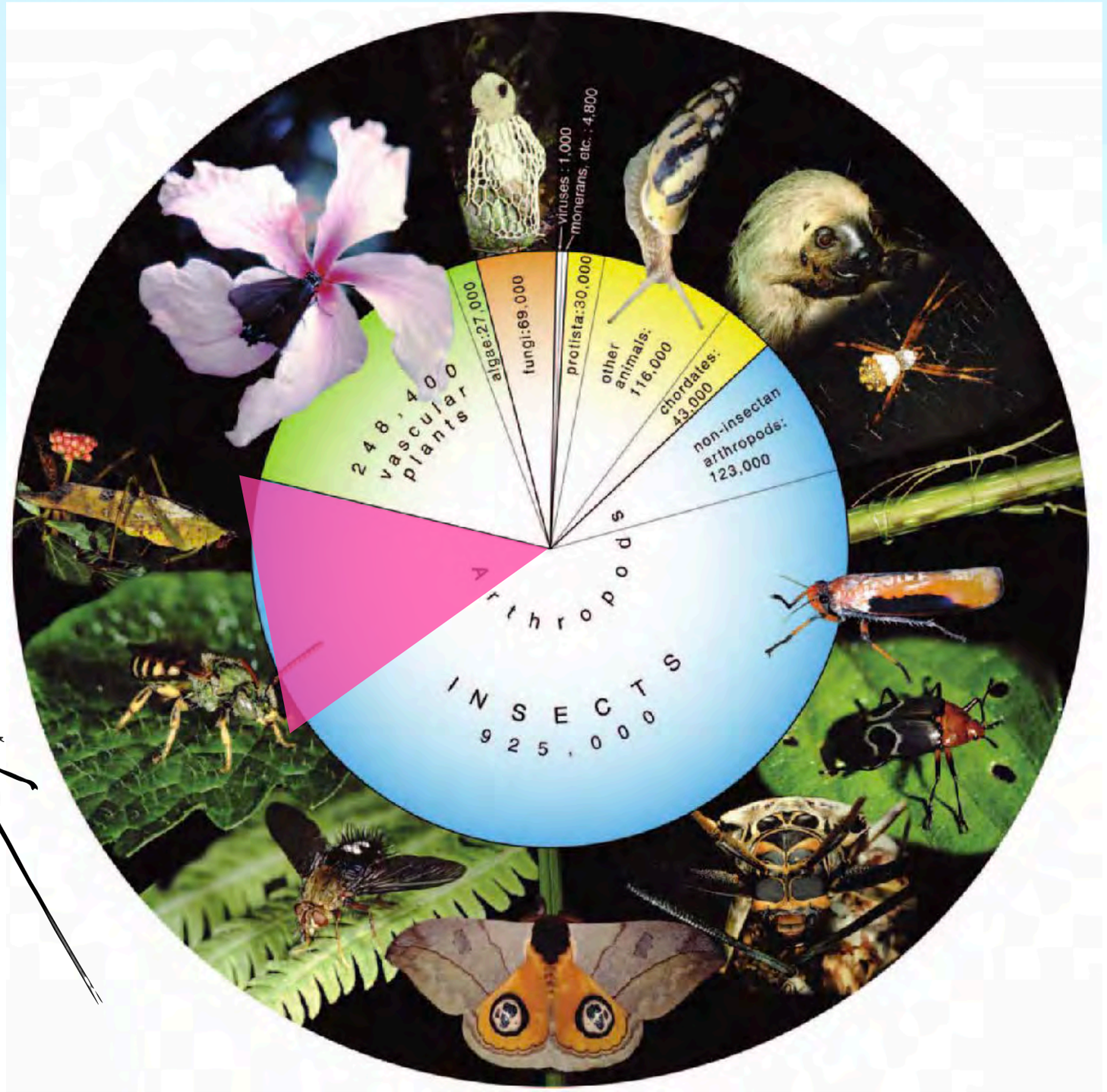
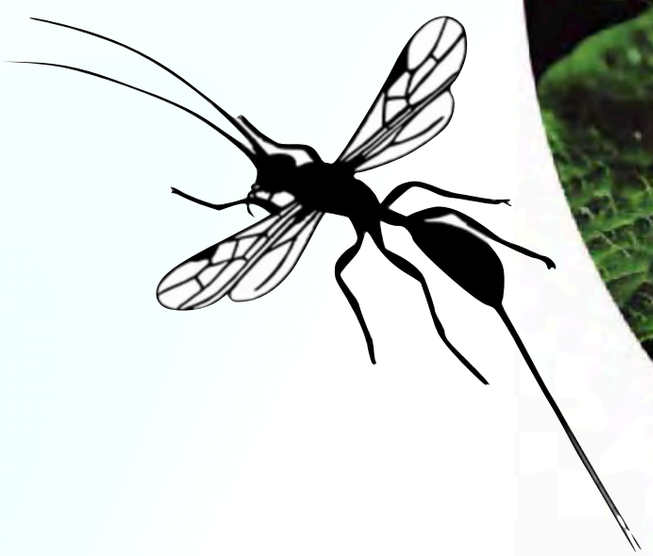
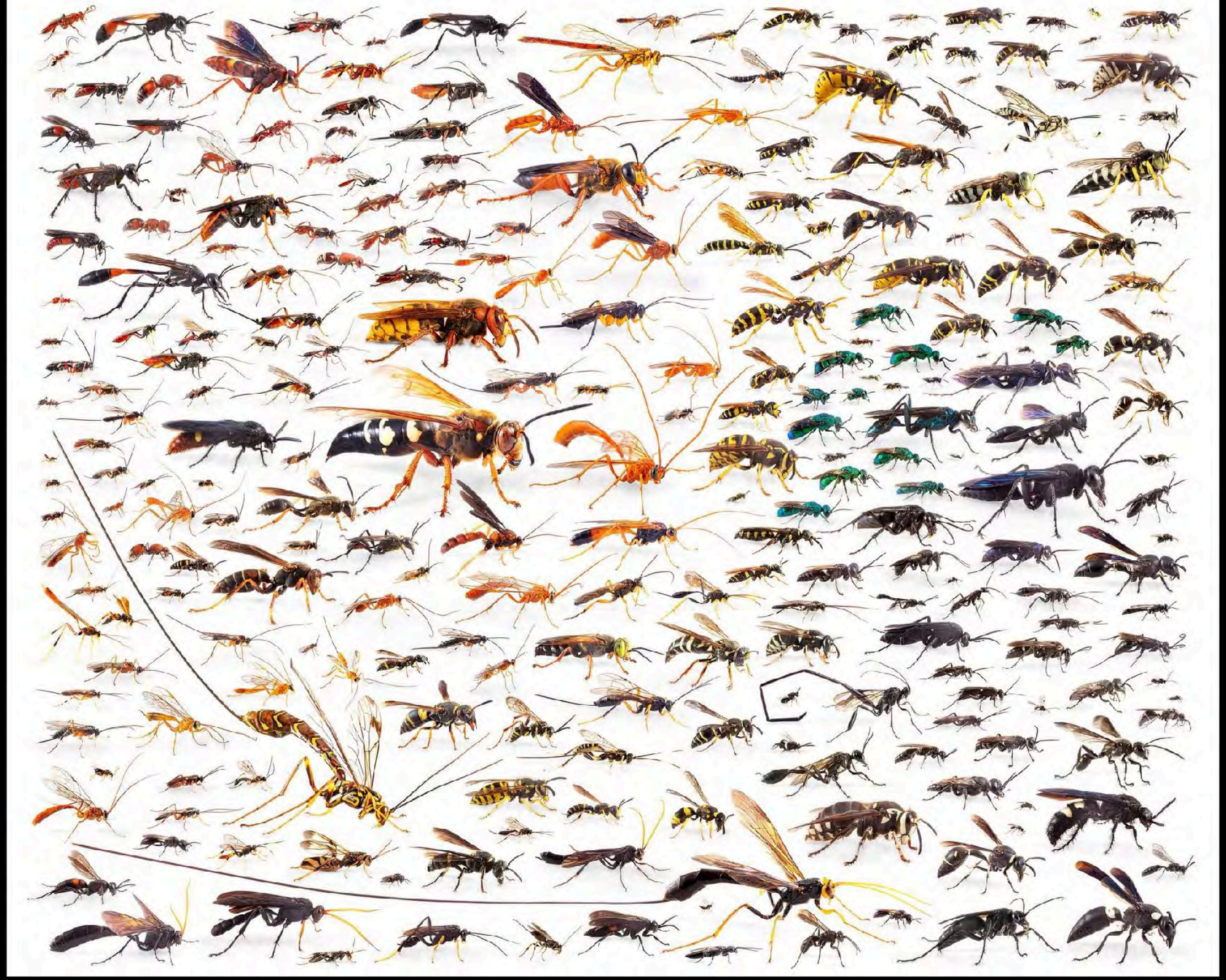
Biology, ecology and diversity





Sloan Tomlinson @thatwaspguy



Sloan Tomlinson @thatwaspguy

1. Parasitoids basics

Reasons to chose them

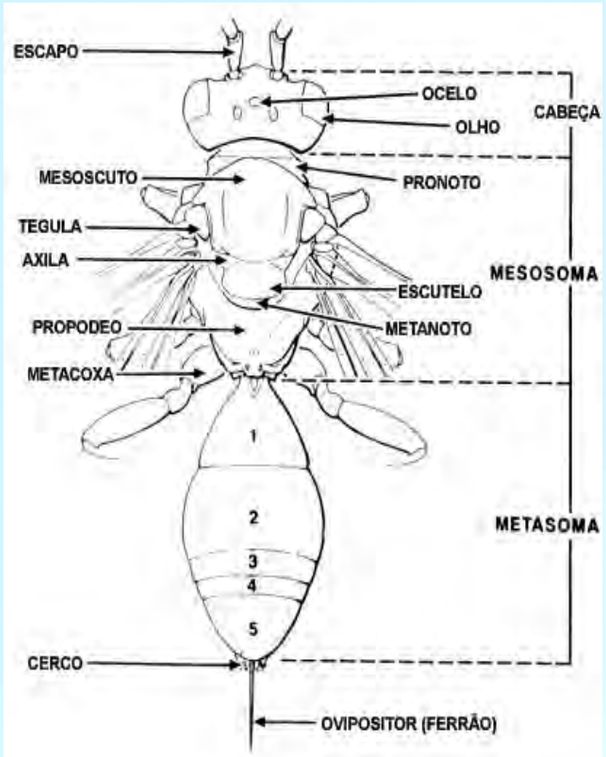
- Very cool life histories;
- A huge part of the biodiversity in any terrestrial ecosystem;
- Ability to control populations/ model insects/ biological control;
- Extreme adaptations to parasitic life, including manipulation of host behaviour;
- Having a grad student friend needing help with field-work and sample sorting 🤦

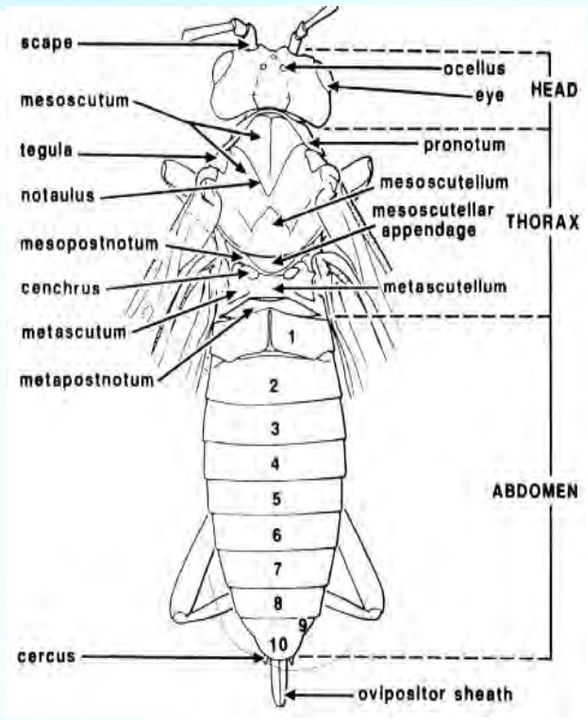
2. Braconidae

Phylogeny, morphology and biology

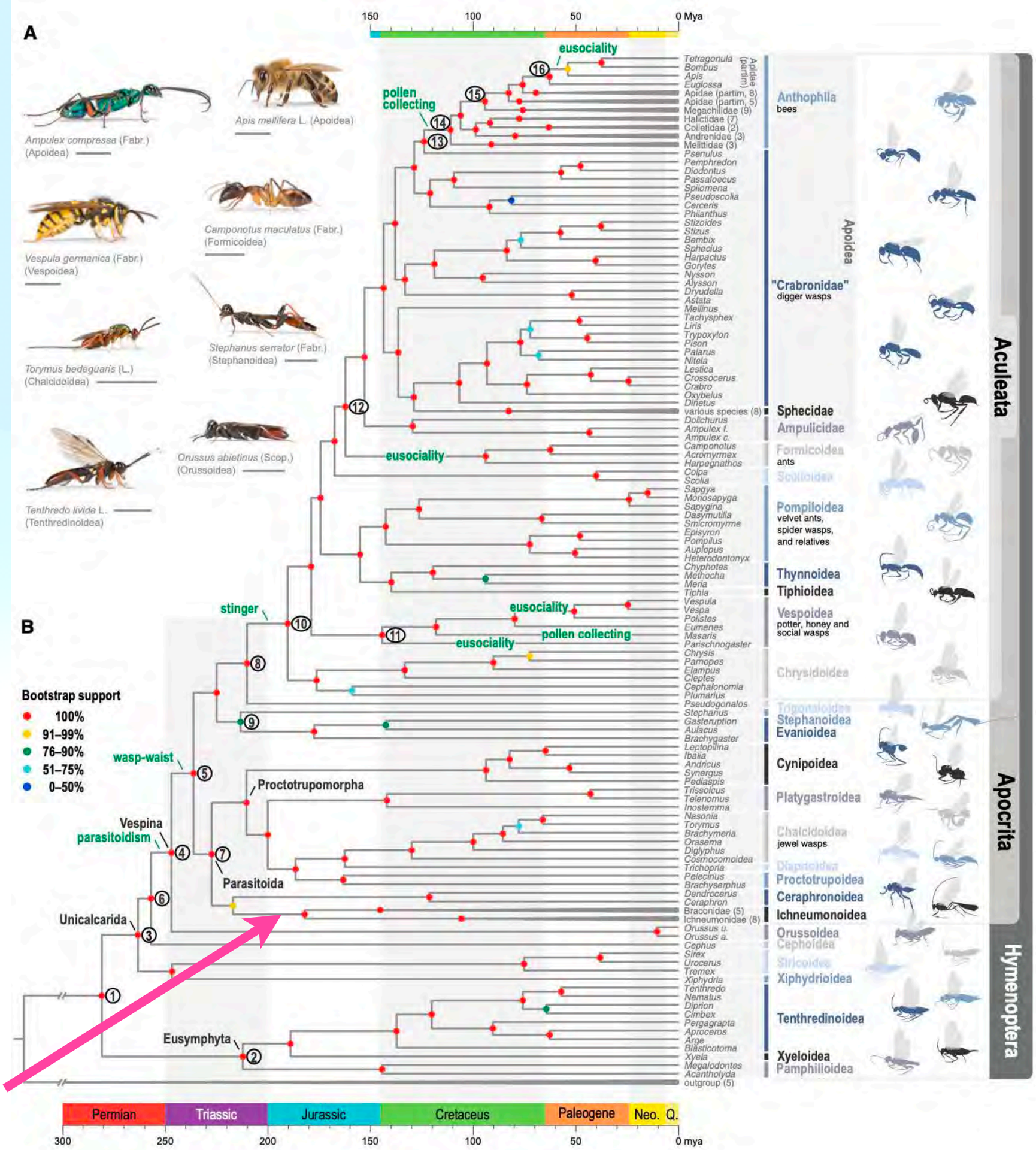
- Braconidae + Ichneumonidae = Ichneumonoidea
- The most diverse families within Hymenoptera
- Braconidae - 1,100 genera in 42 subfamilies; ~22,000 species

Phylogeny

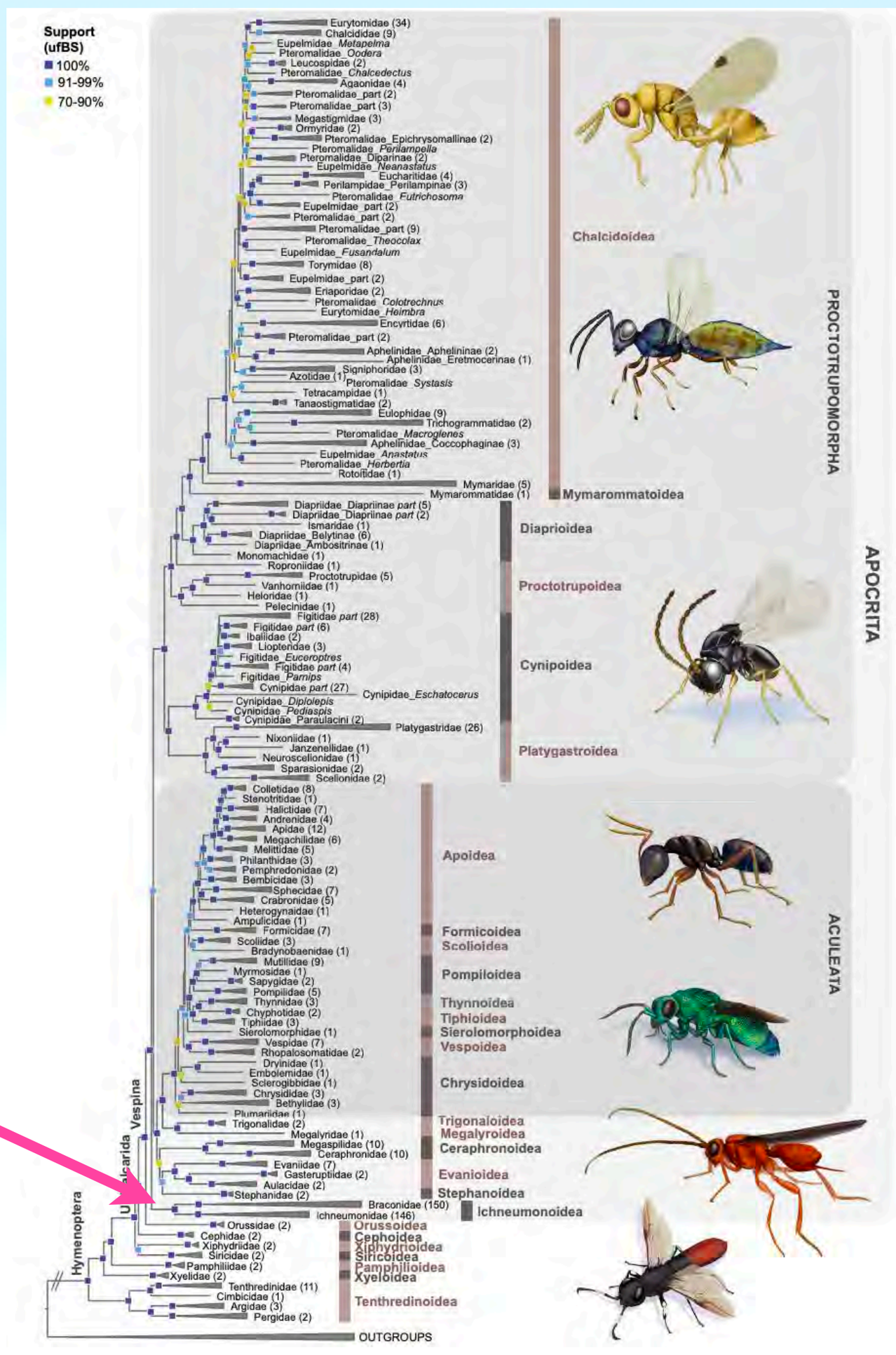




Peters et al. 2017



Phylogeny



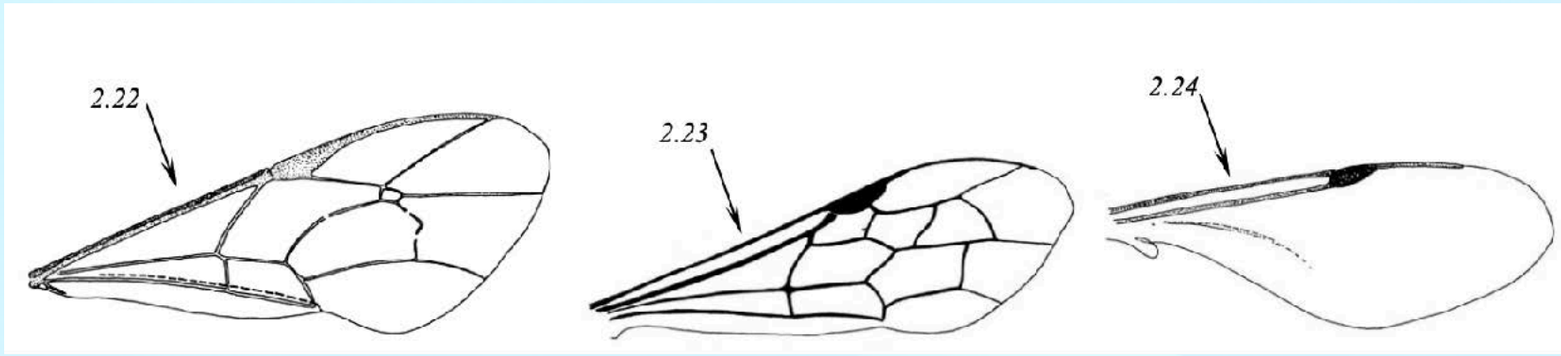
Blaimer et al. 2023

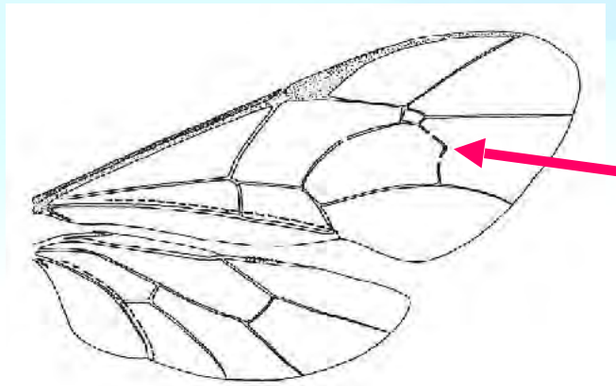
2. Braconidae

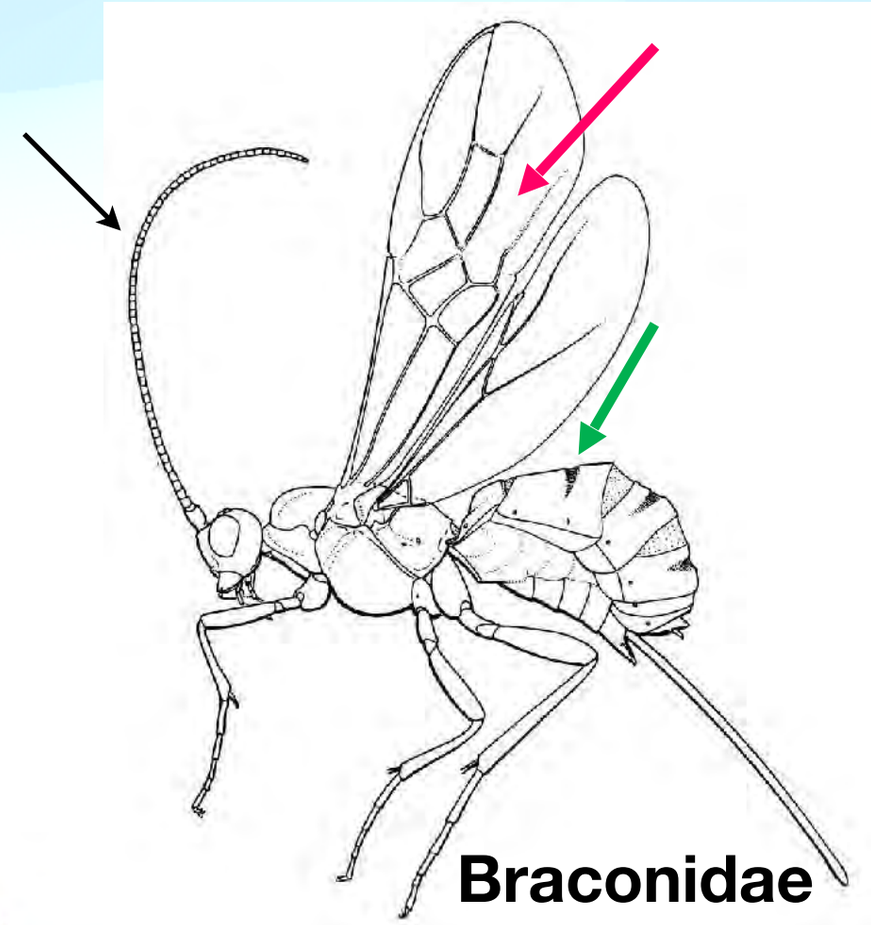
Morphology

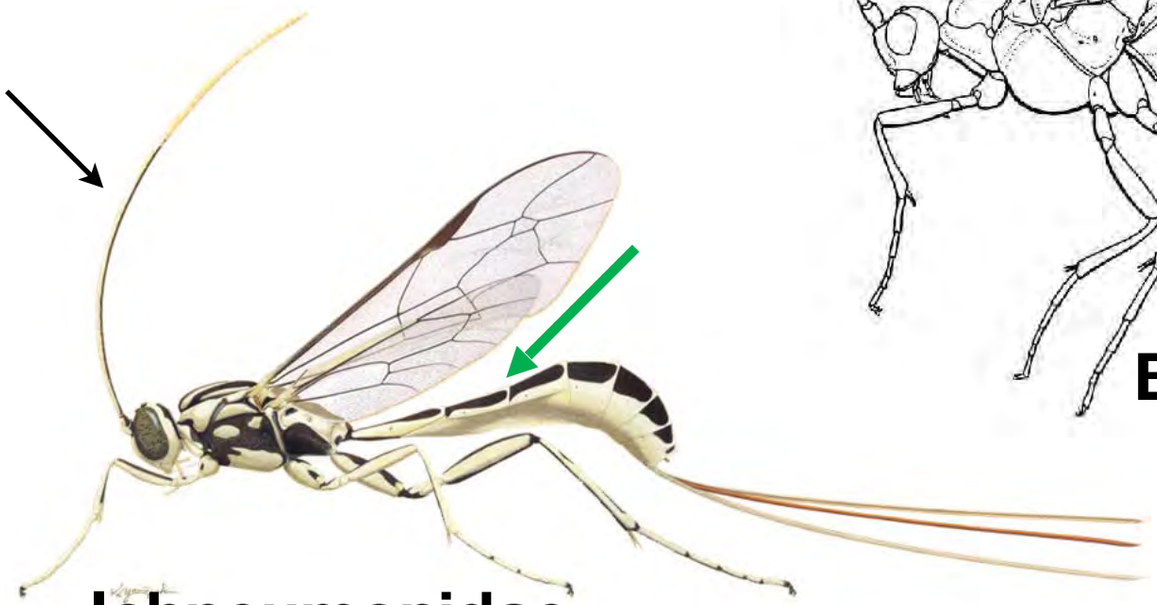
- Ichneumonoidea: wing venation (costal cell absent -2.22) and antenna filiform.

- Braconidae vs Ichneumonidae: T2+3 (and absence of vein 2m-cu - the second recurrent vein)









2. Braconidae

Biology

- Most Braconidae are larval parasitoids of holometabolous insects (Lepidoptera, Coleoptera and Diptera)

2. Braconidae

Biology

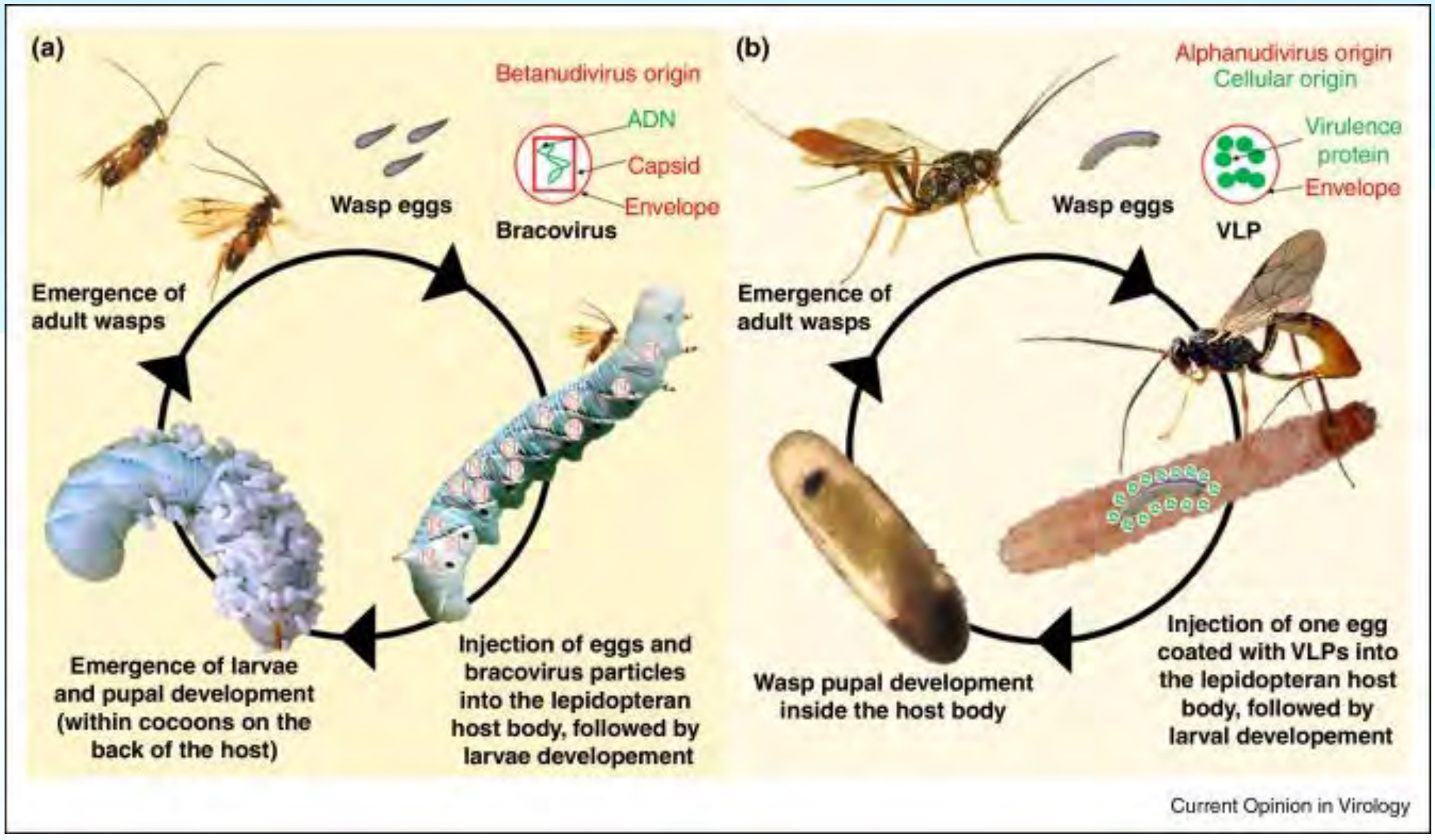
- Exceptions: aphids, adults, phytophagous

Euphorinae

Aphidiinae

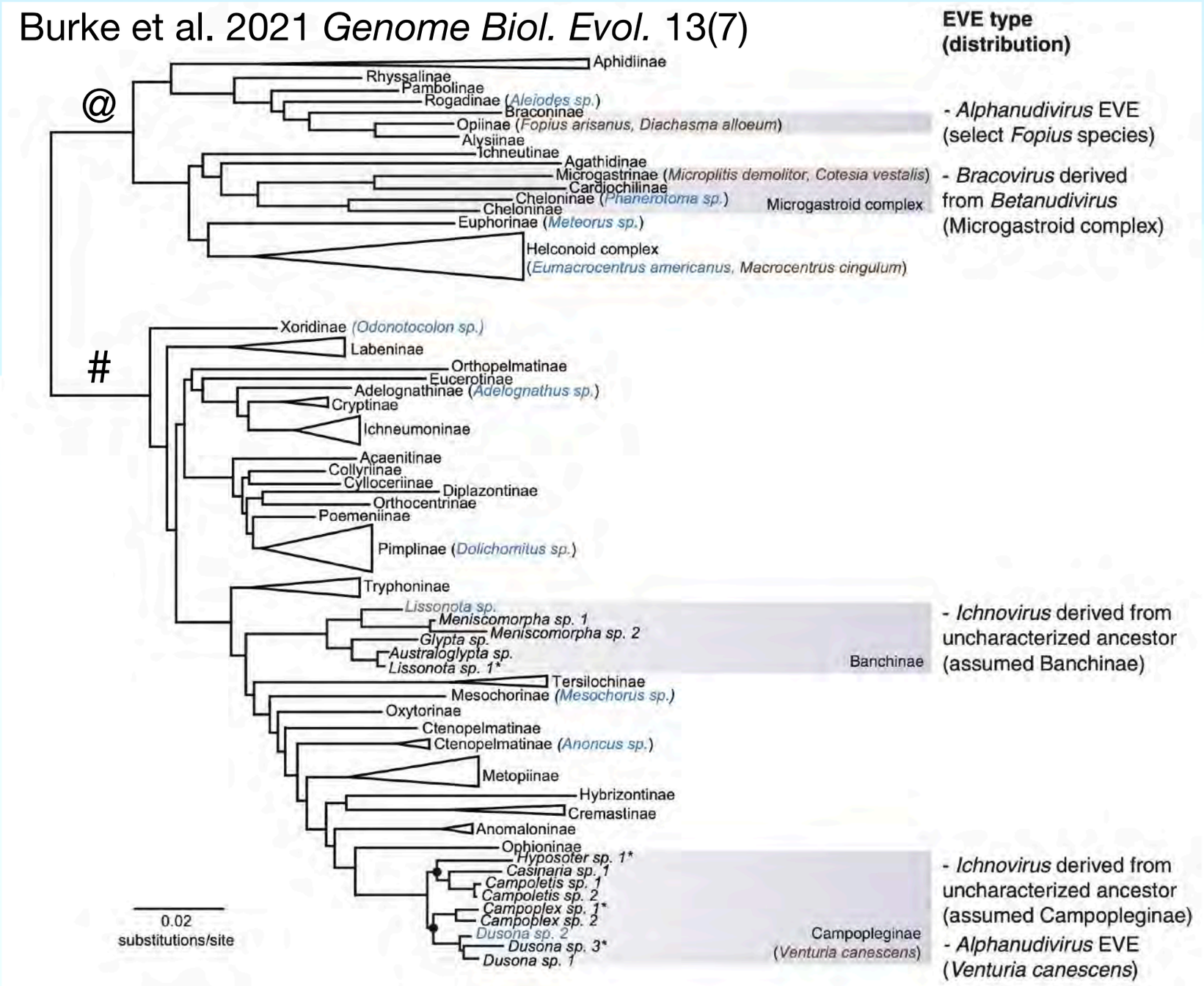
2. Braconidae

Polidnavirus



2. Braconidae

Polidnavirus



- Polidnavirus are well known from Braco (@) and Ich (#)
- Domestication is widespread (diverse origins) and related to endoparasitism

3. The taxonomic gap

and the taxonomic impediment

- Most of the **biodiversity remains unknown** (concentrated in the **dark taxa**)
- The biodiversity **crisis is intensifying** - loss of species, habitats and interactions (taxonomic urgency)
- The **arthropods** are essential (ecological roles)
- Biodiversity-based sciences depend on taxonomy
- The **taxonomic impediment**: lack of resources, mainly of taxonomists
- The problem is deeper in the **tropics**: fewer studies, more species
- **How do we quantify (grossly) the gap?**
- **How do we deal with this problem?**


Zoological Journal of the Linnean Society, 2021, 193, 381–387.

EDITORIAL

The taxonomic impediment: a shortage of taxonomists, not the lack of technical approaches

MICHAEL S. ENGEL[1,*], LUIS M. P. CERÍACO[2,*], GIMO M. DANIEL[3,*],

et al.

?

4. How deep is the gap?

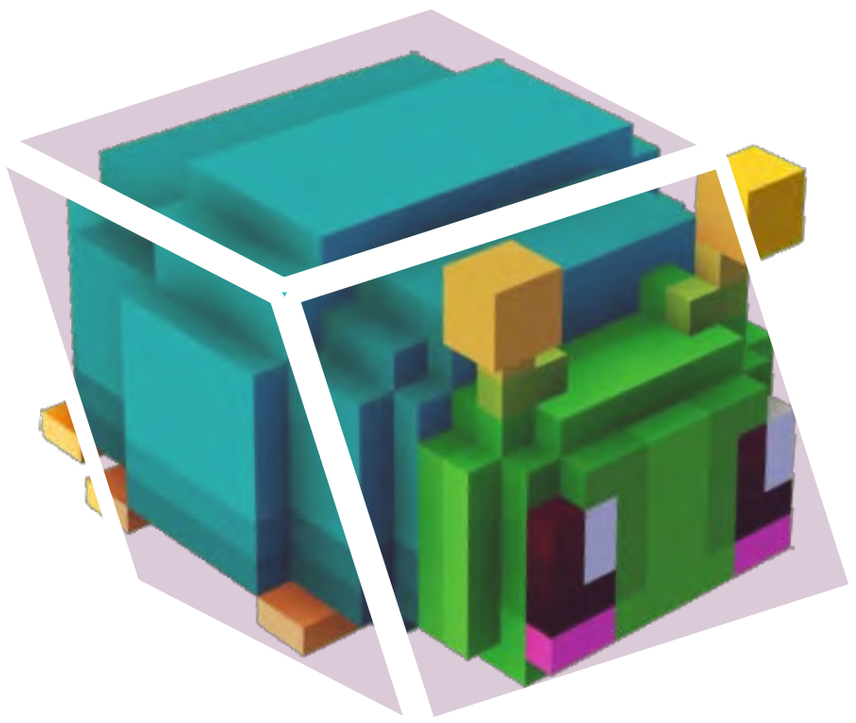
Estimations - described VS undescribed

Species diversity may be explained in terms of niche availability/creation/differentiation.

Most of a parasitoid species niche is determined by its hosts, as they spend virtually their entire life in it or searching for it.

1:1 proportion — Parasitoid : Host (P:H)

But, of course, things are not so simple



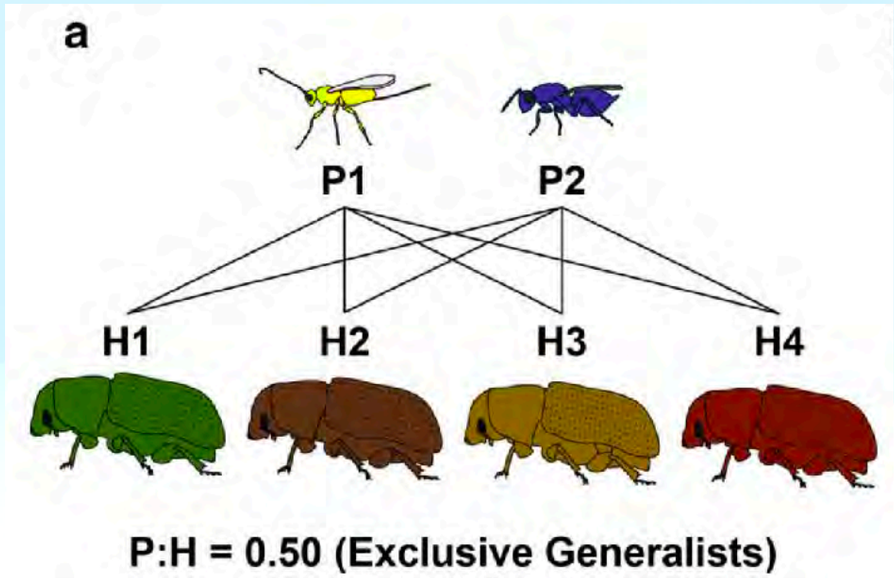
4. How deep is the gap?

Estimations - described VS undescribed

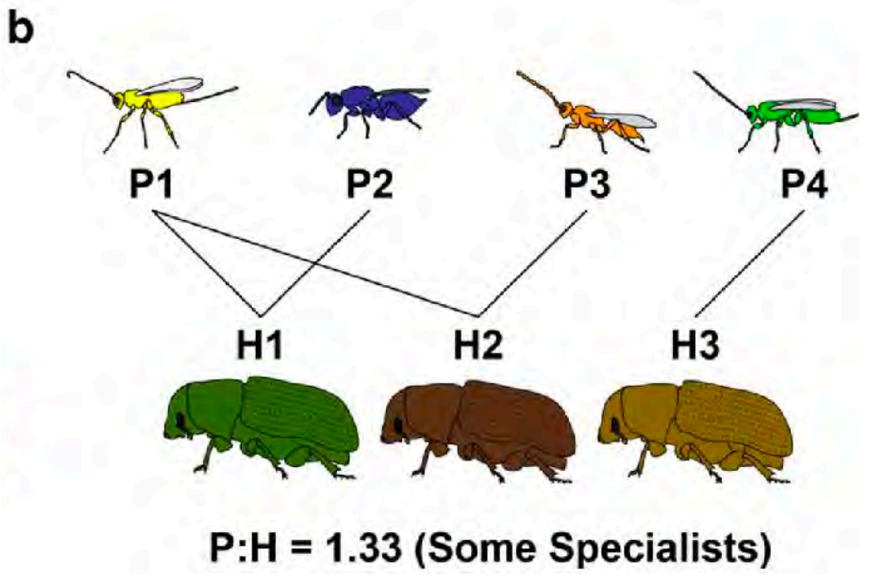
Forbes et al. (2018)

Hymenoptera is larger than Coleoptera

P : H based on 4 well-known genera and their parasitoids = 0.95 – 1.83



Unrealistic? - ignores the complexity of food webs



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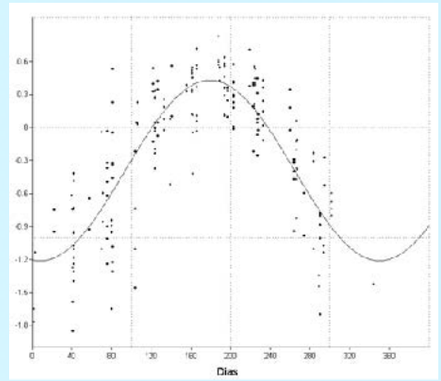
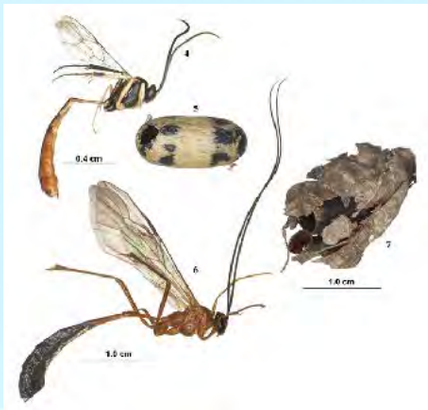
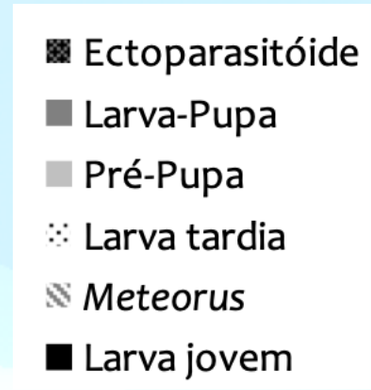


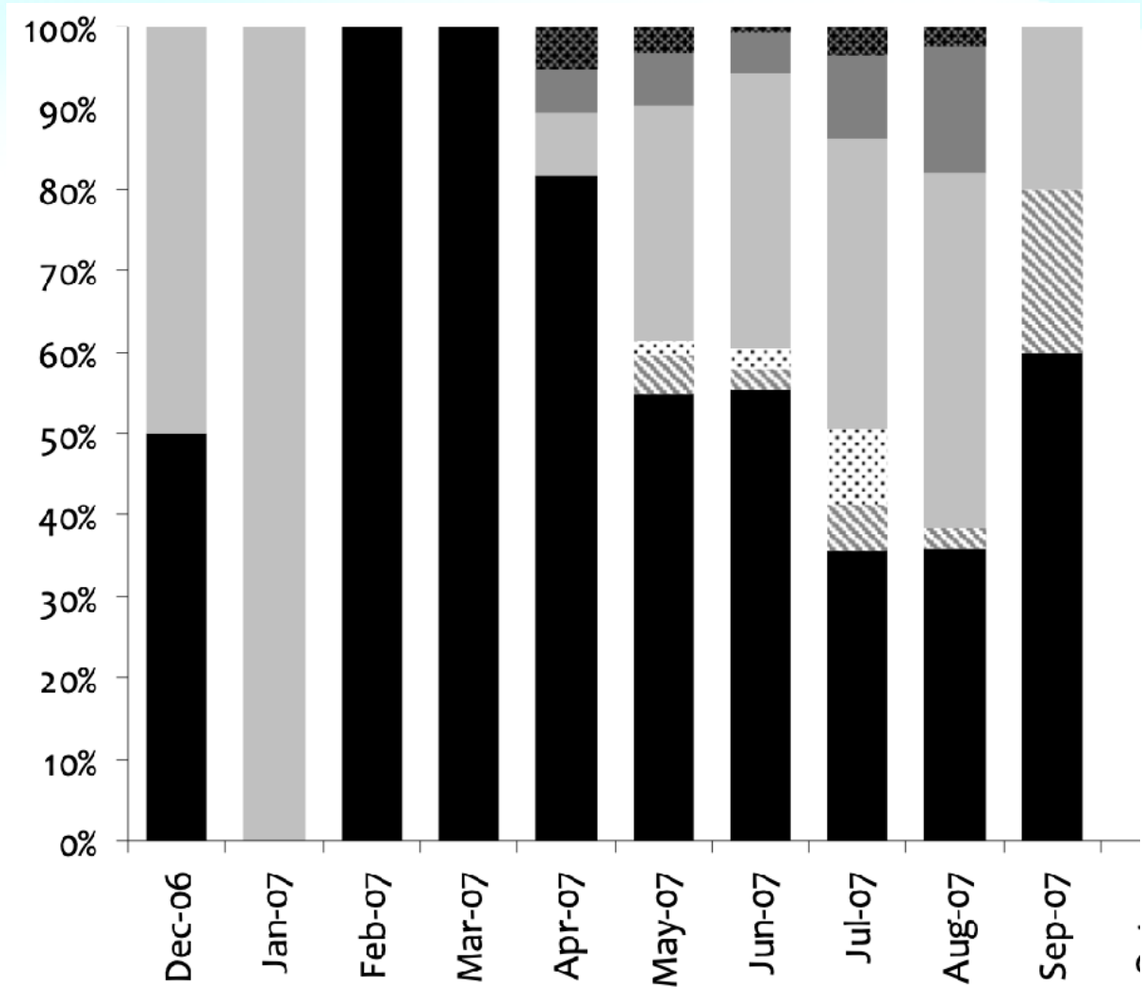




Real tropical system

1. Based on 2 plant spp.
2. Dominated by 1 herbivore:
   a. Niche segregation: 21 species in 6 guilds
3. 105 potential hosts (41 actual hosts), 102 primary parasitoids and 21 hyperparasitoids:

   P : H = 1.15 (= Forbes et al. 2018 low estimates)



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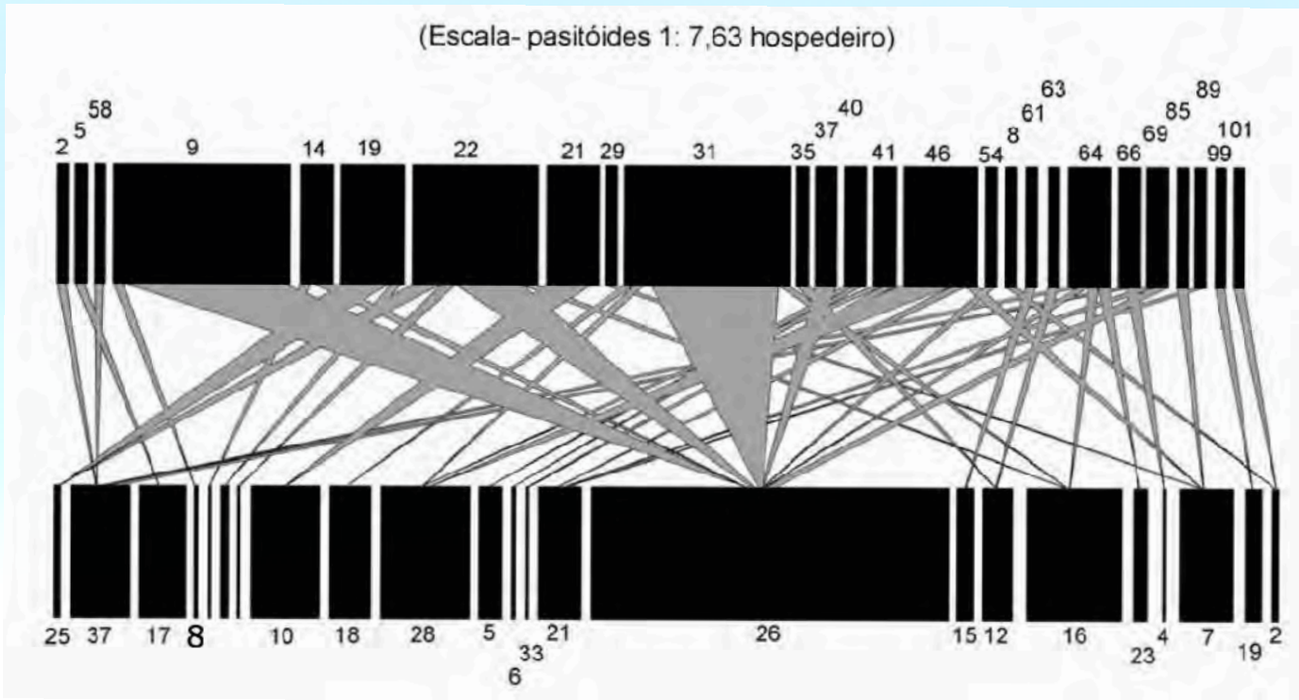
Estimations - described VS undescribed



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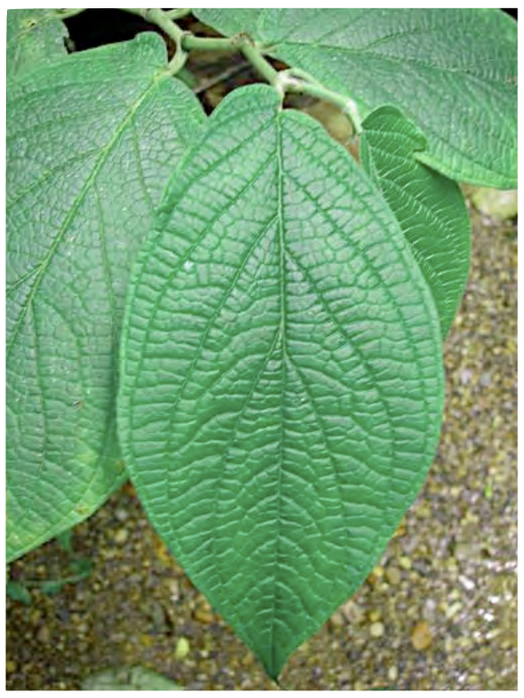
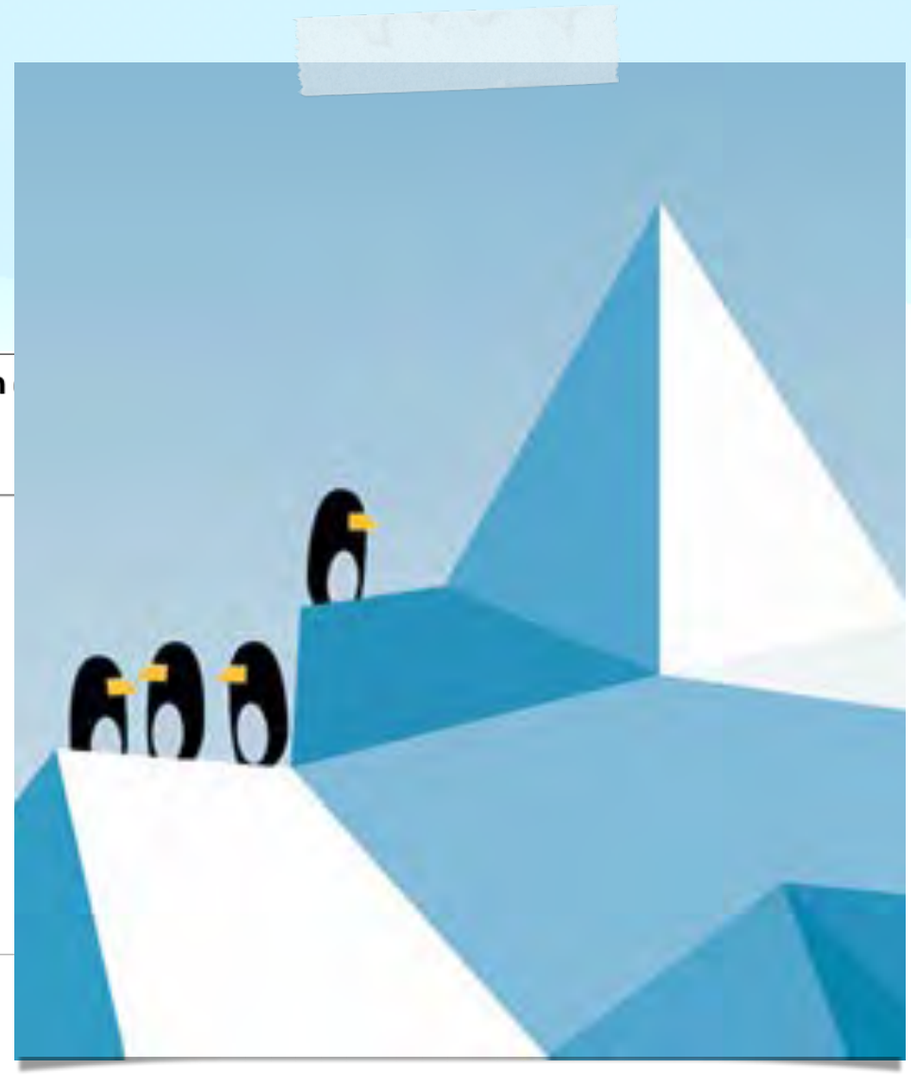


4. How deep is the gap?

Estimations - described VS undescribed

740 thousand to 1 million species of undescribed Hym. parasitoids

Described species ~154,000	High P:H estimates from case studies	Low P:H estimates from studies
Diptera (152,244)	228,366	199,440
Lepidoptera (156,793)	286,931	156,793
Coleoptera (359,891)	494,850	406,677
Non-parasitoid Hymenoptera (~62,000)	79,980	58,900
All other insect orders (335,970)	0[a]	0[a]
Total parasitoid Hymenoptera	1,107,487	833,590
Non-parasitoid Hymenoptera (to add to calculated parasitoid numbers)	62,000	62,000
Total Hymenoptera	1,152,127	883,810



Estimates for Microgastrinae: 0.1 P : H
(Rodriguez et al. 2013) = Brazil = 1-2% spp.

90-92%

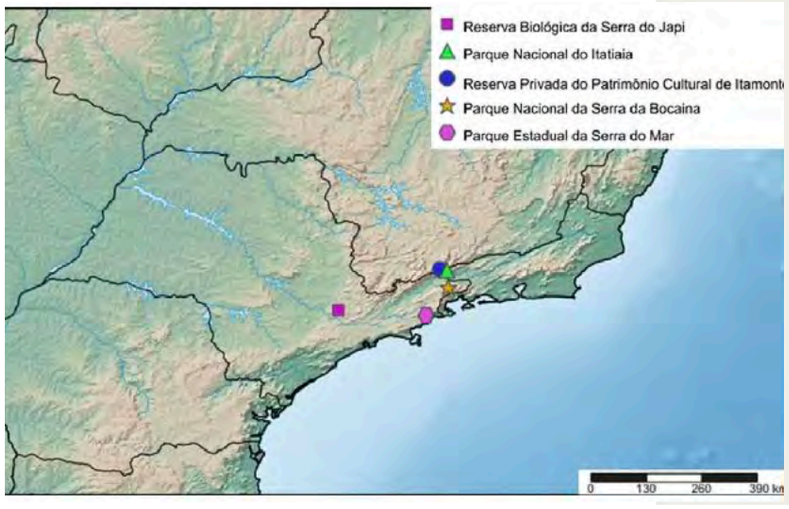
4. How deep is the gap?

Estimations - described VS undescribed

Examples from intensive surveys

Microgastrinae: 24 genera, 434 morphospecies (1 yr) — Brazil: 23 genera, 126 species. (Gomes 2023)

Orthocentrinae: 13 genera, 127 MOTUS (1 yr) — Brazil - 4 genera, 7 species. (Camargo et al 2021)



5. Bridging the taxonomic gap

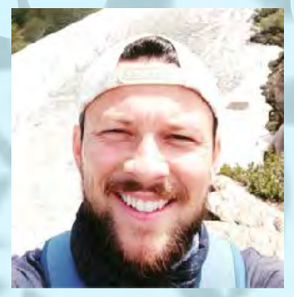
and reducing the taxonomic impediment?

- How do we deal with this problem?

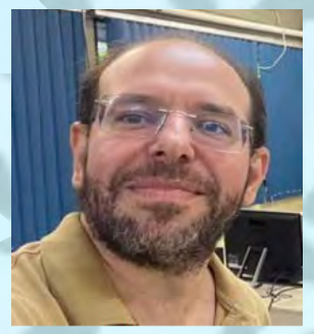
5. Bridging the taxonomic gap

and reducing the taxonomic impediment?

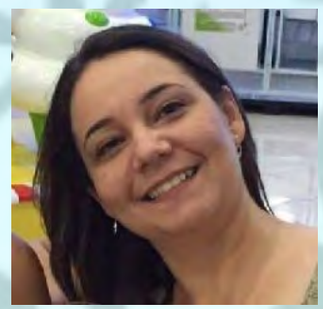
- How do we deal with this problem?
  - Training/Education in Universities and Collections (1/2)



Diego Pádua
Ichneumonidae/UCM-Chile



Daniell Fernandes
Ichneumonidae/INPA



Helena Onody
Ichneumonidae/UEPI

Juliano Nunes
Braconidae/UEMG

Eduardo Shimbori
Braconidae/UNAM

Wesley Colombo
Bethylidae/UFES

Cecília Waichert
Pompilidae/UnB

Nelson Perioto
Eurytomidae/IB

Angelica Penteado-Dias
Braconidae/UFSCar

Marcelo Tavares
Chalcididae/UFES

Celso Azevedo
Bethylidae/UFES

Training-Education
University-Collection

5. Bridging the taxonomic gap

and reducing the taxonomic impediment?


Allobracon - 12 /24

Aleiodes 39 new

Monitoriella - 3/9


Pedinotus - 24/37

Adelius - 16/19


Andesipolis - 22/25

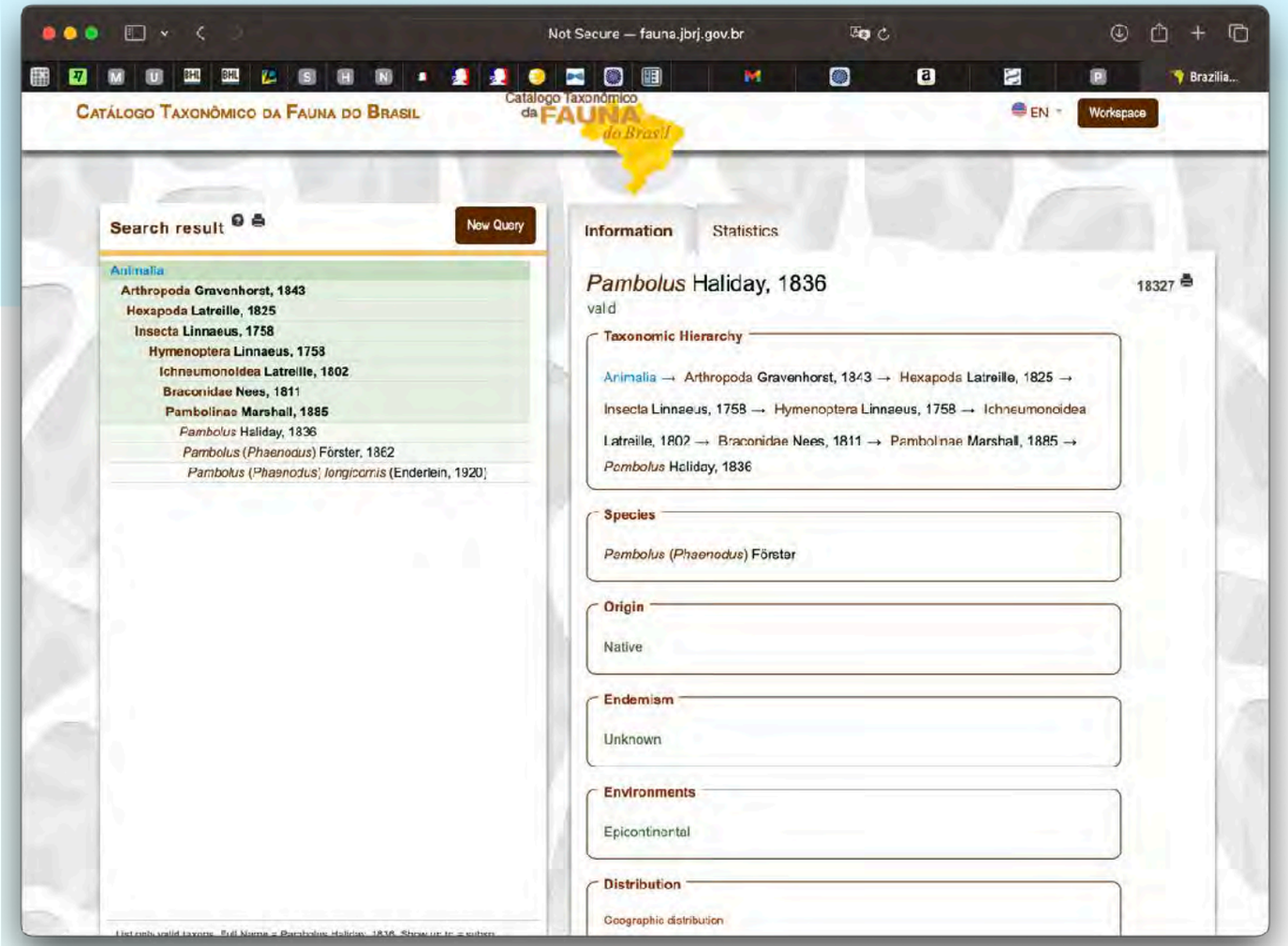

Alphomelon 30 new

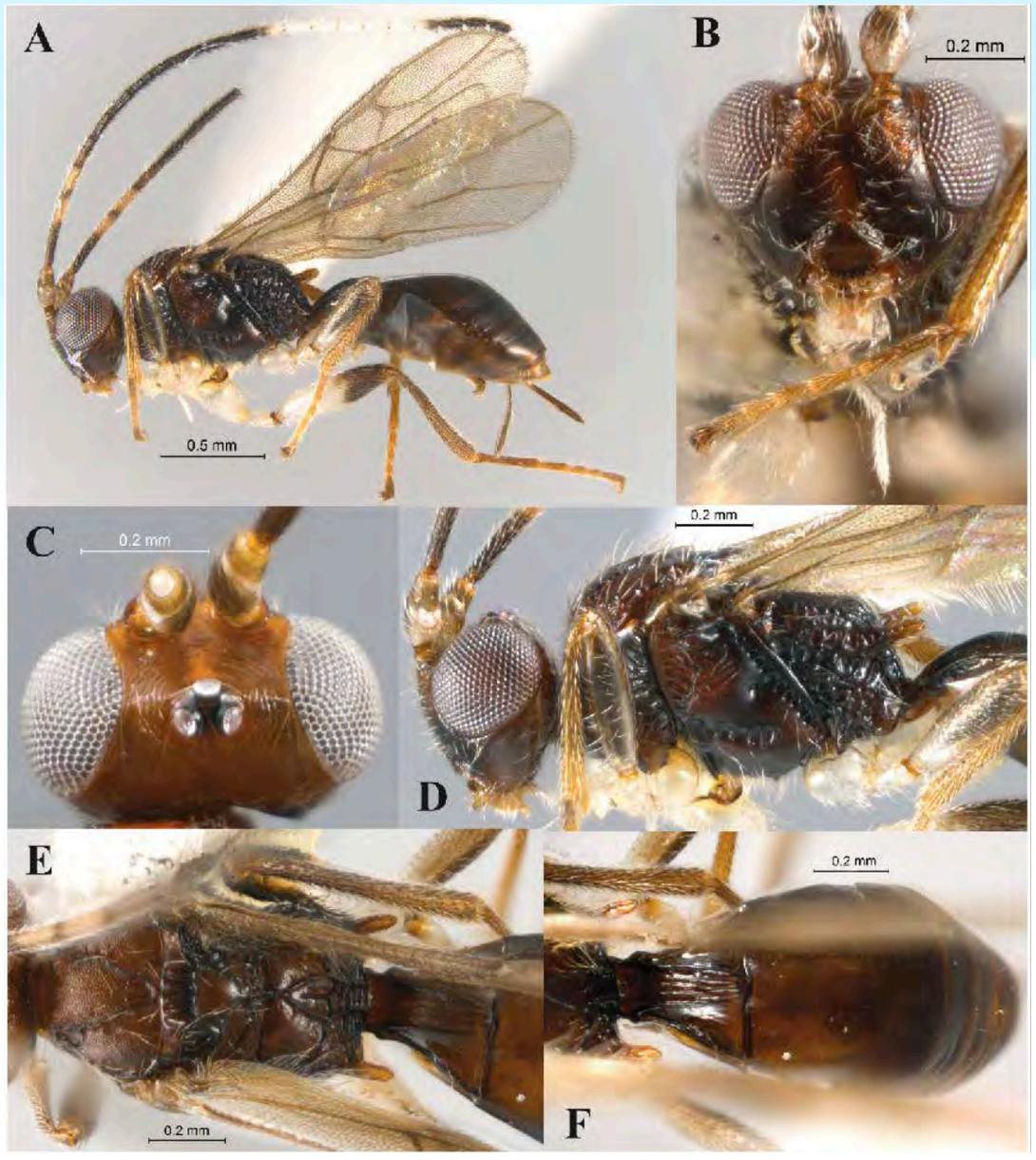

Athacryvac - 11/13

5. Bridging the taxonomic gap

and reducing the taxonomic impediment?

- *Pambolus*





5. Bridging the taxonomic gap

and reducing the taxonomic impediment?

Superficial impediment* in the tropics:

Naturalists expeditions

Many groups have very old treatments only

Superficial descriptions

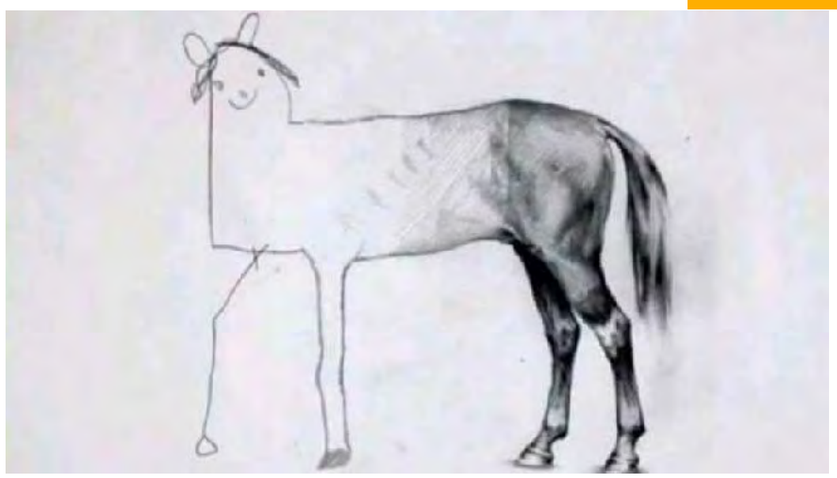
Very high diversity

Types unavailable

Information access: interest and work

Morphology: good images, 3D models and modern descriptions

Barcoding: museomics in old specimens



*R. Meier et al. / Cladistics 0 (2021) 1–12

5. Bridging the taxonomic gap

and reducing the taxonomic impediment?

Butcher et al. 2012: 1/4 of all names for *Aleiodes* (179 of 698) Thailand

A turbo-taxonomic study of Thai *Aleiodes (Aleiodes)* and *Aleiodes (Arcaleiodes)* (Hymenoptera: Braconidae: Rogadinae) based largely on COI barcoded specimens, with rapid descriptions of 179 new species

Costa Rica:

Marsh 2013: *2/3* all *Heterospilus* names (277 of 416);

Fernandez-Triana et al. 2014: 186 of 997 *Apanteles*;

Arias-Penna et al. 2019: 136 of 213 *Glyptapanteles*

The Doryctinae (Braconidae) of Costa Rica: genera and species of the tribe Heterospilini

Review of *Apanteles sensu stricto* (Hymenoptera, Braconidae, Microgastrinae) from Area de Conservación Guanacaste, northwestern Costa Rica, with keys to all described species from Mesoamerica

A species-level taxonomic review and host associations of *Glyptapanteles* (Hymenoptera, Braconidae, Microgastrinae) with an emphasis on 136 new reared species from Costa Rica and Ecuador

6. Biological control - taxonomy

Integration

- Integrating taxonomy with applied fields, and collaborative work in general, is a good way to reduce the taxonomic impediment

- Search for common goals: results improve, appreciation improves, access to wider funding

- One may think that natural enemies are pretty much known for biological control already, but

Neotropical Entomology
https://doi.org/10.1007/s13744-023-01025-5

INSECT TAXONOMY AND BIODIVERSITY

Taxonomy and Biological Control: New Challenges in an Old Relationship

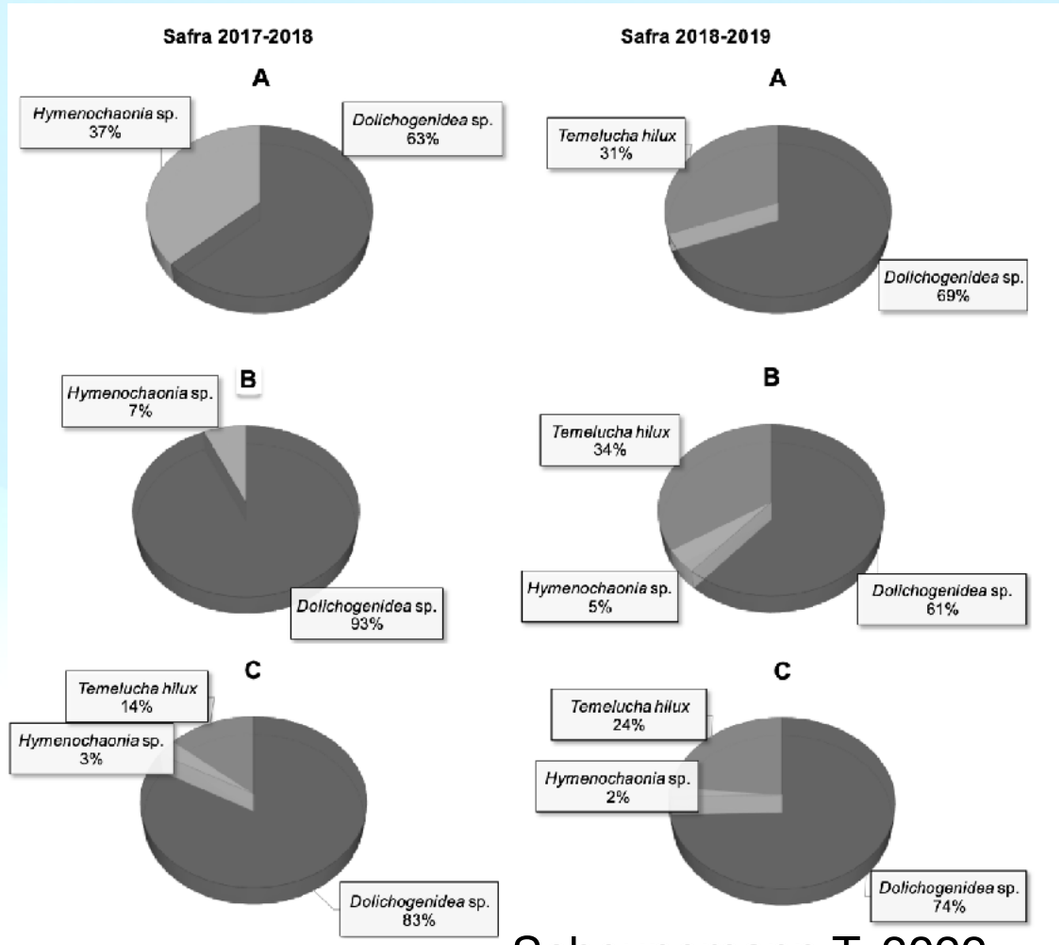
Eduardo Mitio Shimbori[1] · Ranyse Barbosa Querino[2] · Valmir Antonio Costa[3] · Roberto Antonio Zucchi[1]

Received: 1 July 2022 / Accepted: 3 January 2023

6. Biological control - taxonomy

Integration

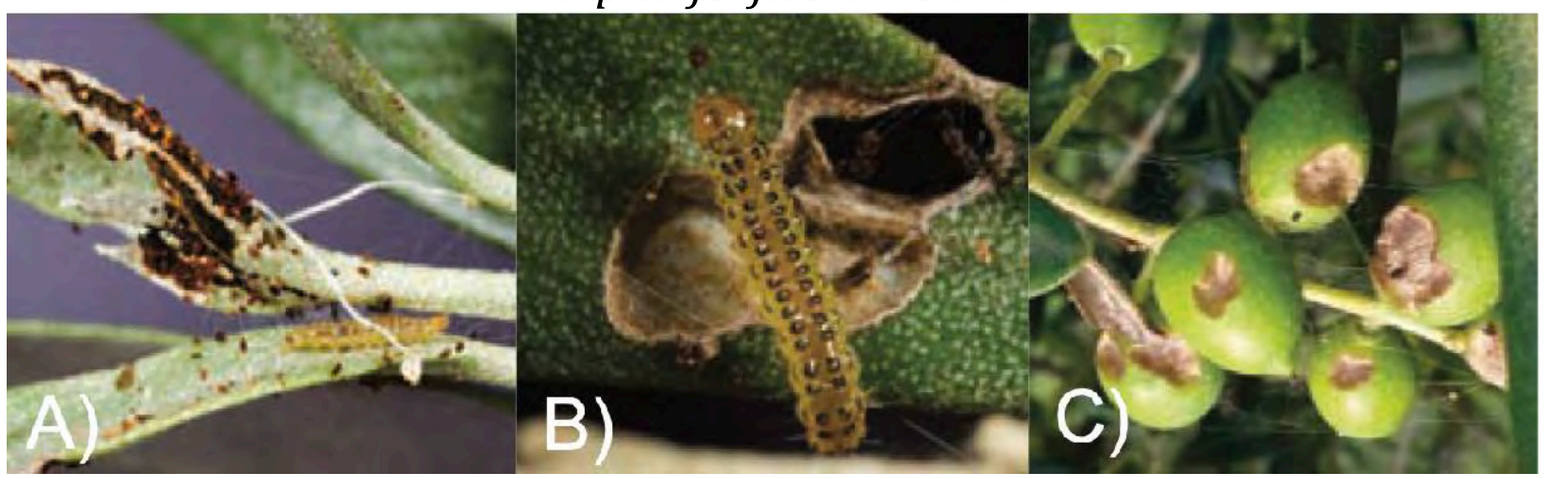
Gymnandrosoma aurantianum - citrus



Scheunemann T, 2022

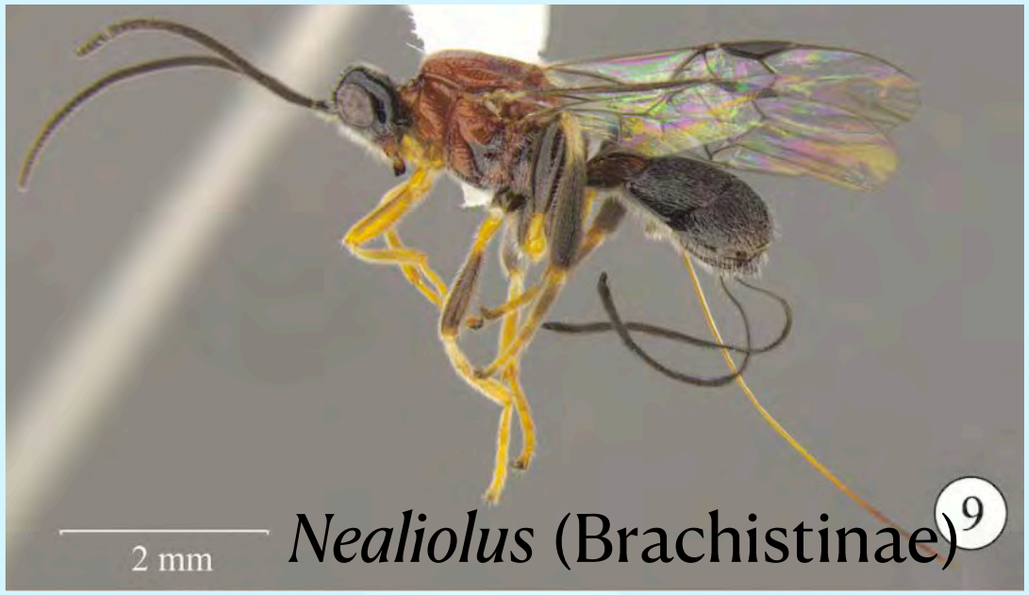
Dolichogenidea sp.

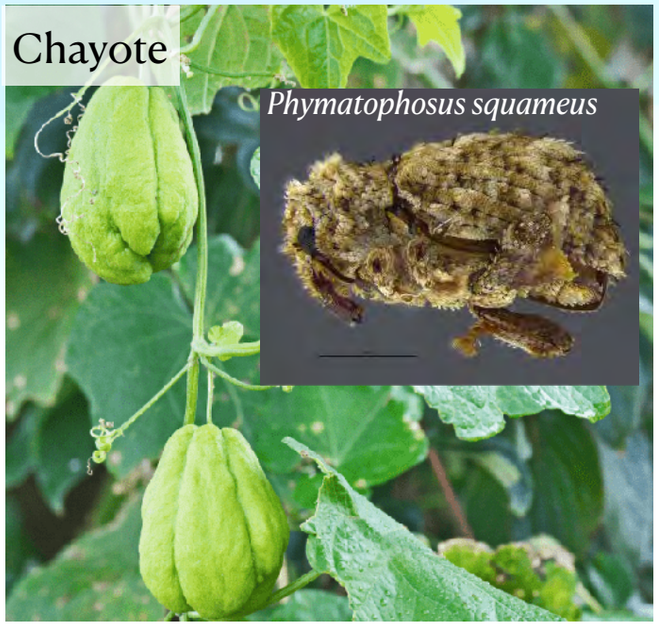
Palpita forficera - olive

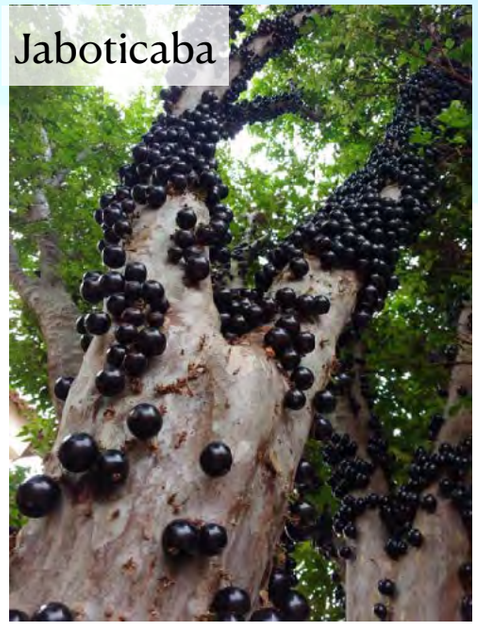


6. Biological control

Integration







Plinia cauliflora (Myrtaceae)

Apanteles (Microgastrinae)

6. Biological control - taxonomy

Integration

- cryptic species complexes and gamma-level taxonomy

Revista Brasileira de Entomologia 63 (2019) 238–241

REVISTA BRASILEIRA DE
Entomologia
A Journal on Insect Diversity and Evolution
www.rbentomologia.com

Systematics, Morphology and Biogeography

First record of *Cotesia scotti* (Valerio and Whitfield, 2009) (Hymenoptera: Braconidae: Microgastrinae) comb. nov. parasitising *Spodoptera cosmioides* (Walk, 1858) and *Spodoptera eridania* (Stoll, 1782) (Lepidoptera: Noctuidae) in Brazil

Josiane Garcia de Freitas[a], Tamara Akemi Takahashi[b], Lara L. Figueiredo[a], Paulo M. Fernandes[a], Luiza Figueiredo Camargo[c], Isabela Midori Watanabe[d], Luís Amilton Foerster[e], José Fernandez-Triana[f], Eduardo Mitio Shimbori[a,*]

Neotropical Entomology
https://doi.org/10.1007/s13744-023-01076-8

SYSTEMATICS, MORPHOLOGY AND PHYSIOLOGY

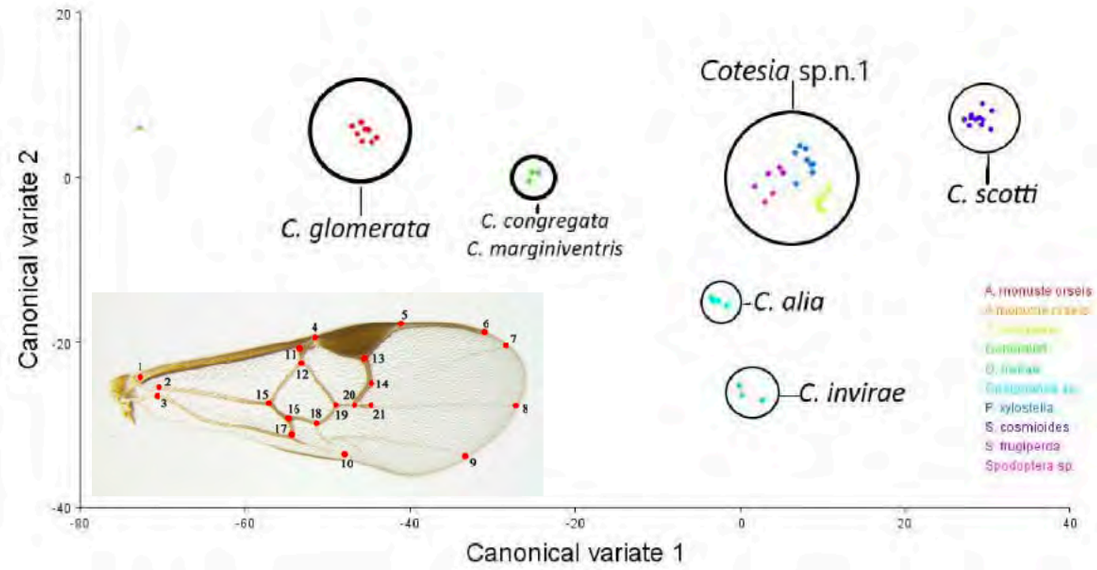
A New Species of *Aleiodes* Wesmael (Braconidae, Rogadinae) with Potential for Biological Control of *Spodoptera* spp. (Lepidoptera, Noctuidae), and Notes on the Definition of the *gastritor, circumscriptus,* and Related Species-Groups

Eduardo Mitio Shimbori[1,2] · Tamara Akemi Takahashi[1] · Isabela Midori Watanabe[3] · Angélica Maria Penteado-Dias[3] · Luís Amilton Foerster[4] · Scott Richard Shaw[5] · José Roberto Postali Parra[1]

Programa de Pós-Graduação em Entomologia USP/ESALQ

Sarah Garcia

Integrative taxonomy of ***Cotesia*** Cameron (Hymenoptera: Braconidae) and its potential for biological control in the Neotropical region (2022)



6. Biological control - taxonomy

Integration

- cryptic species complexes and gamma level taxonomy

NOTES ON THE VARIABILITY OF *MICROCTONUS AETHIOPOIDES* LOAN
(HYMENOPTERA : BRACONIDAE : EUPHORINAE)

Jean-Paul Aeschlimann
335 avenue Paul Parguel, 34100 Montpellier, France

Moroccan strain

Sitona discoideus
(lucerne weevil)

X

Irish strain

Sitona obsoletus
(clover root weevil)

intraspecific variation

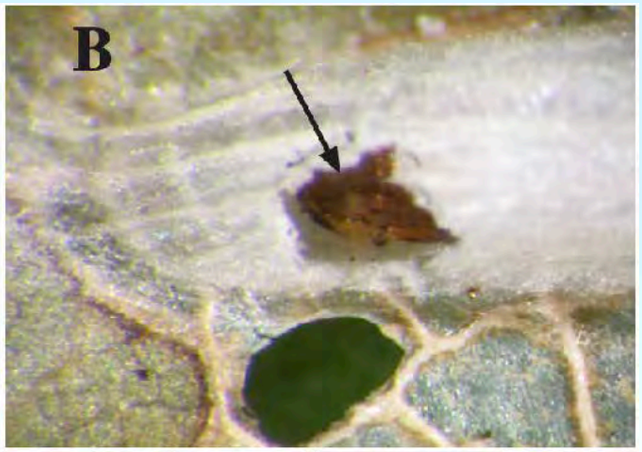
hybridization/ speciation

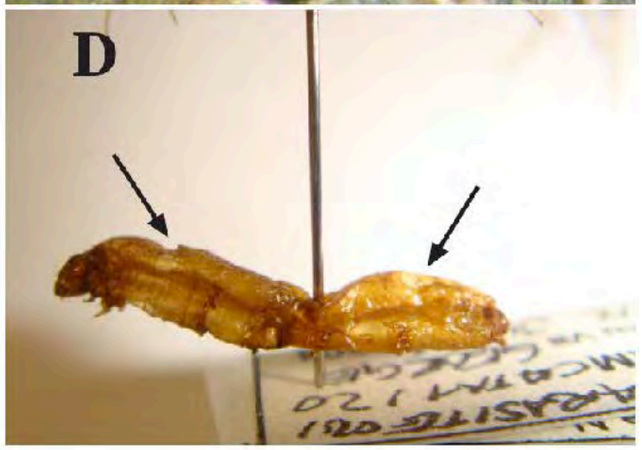
endosymbionts and viral endogenization

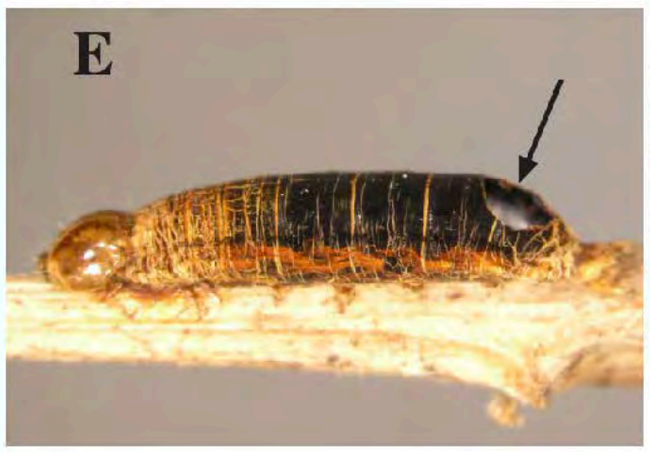
non-target impacts

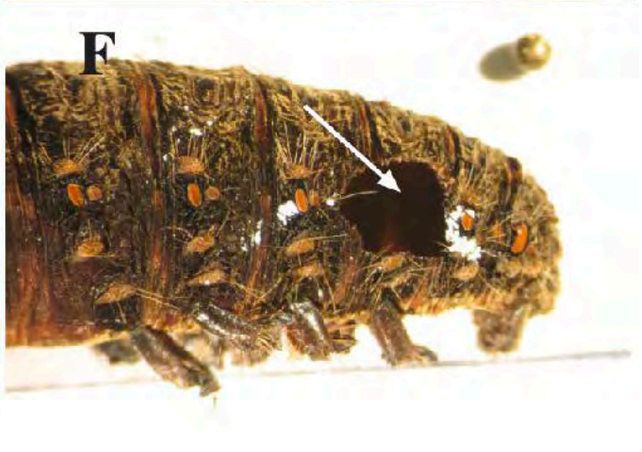
7. Current projects

Genomics tools - Rogadinae









7. Current projects

Genomics tools - Rogadinae

Universidade Federal de São Carlos

Universidad Nacional Autónoma de México

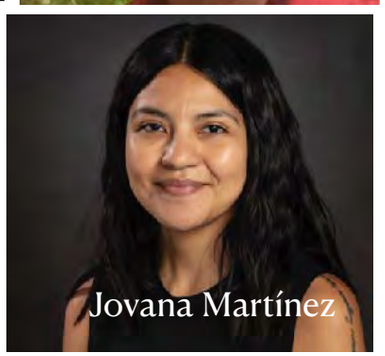

Alejandro Zaldivar


Angélica Penteado-Dias


Donald Quicke


Scott Shaw


Kees van Achterberg


Jovana Martínez


Bob Kula


Gavin Broad

Phylogenetic systematics and evolution of *Aleiodes* (Braconidae) based on UCEs

Worldwide sampling (~300 spp)

Whole-genome shotgun sequencing - UCEs

Hypothesis: subgenera and species group (>30)

Revise systematics at subgeneric level

Origin and diversification times and ancestral states

Bulborogas_sp_CNIN4829
Yelicones_delicatus_USNMENT01322497
Yelicones_sp_CNIN3896
Yelicones_sp_CNIN4828
Yelicones_sp_CNIN4845
Aleiodes_chileverde_USNMENT_1322939
Heterogamus_sp_CNIN4830
Heterogamus_dispar_CNIN5048
Aleiodes_Heterogamus_sp_CNIN4017
Aleiodes_nr_withknob_CNIN4885
Heterogamus
Aleiodes_withbump_Dominica_USNMENT_1322944
Aleiodes_withknob_1_CNIN4790
Aleiodes_withknob_CNIN4807
new subgenus
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Aleiodes_Eucystomastax_sp_PNG_USNMENT_1322982
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Aleiodes_cameronii_CNIN3898
Aleiodes_mayrabenillae_USNMENT_1322926
Arcaleiodes etc
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Aleiodes_amazoniensis_CNIN4865
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Athacryvac_sp_CNIN4785
Athacryvac_2_CNIN4786
Athacryvac
Xenolobus_sp_CNIN4170
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bakeri
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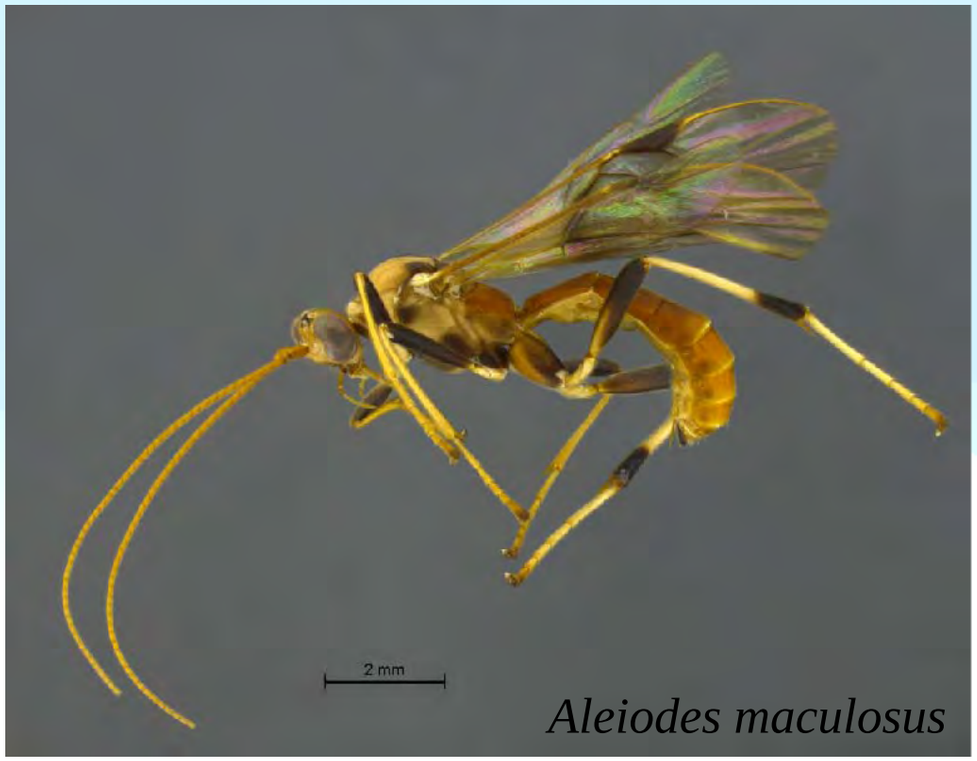
gastritor

Geometridae

Noctuidae



Aleiodes maculosus

Erebidae

Sphingidae

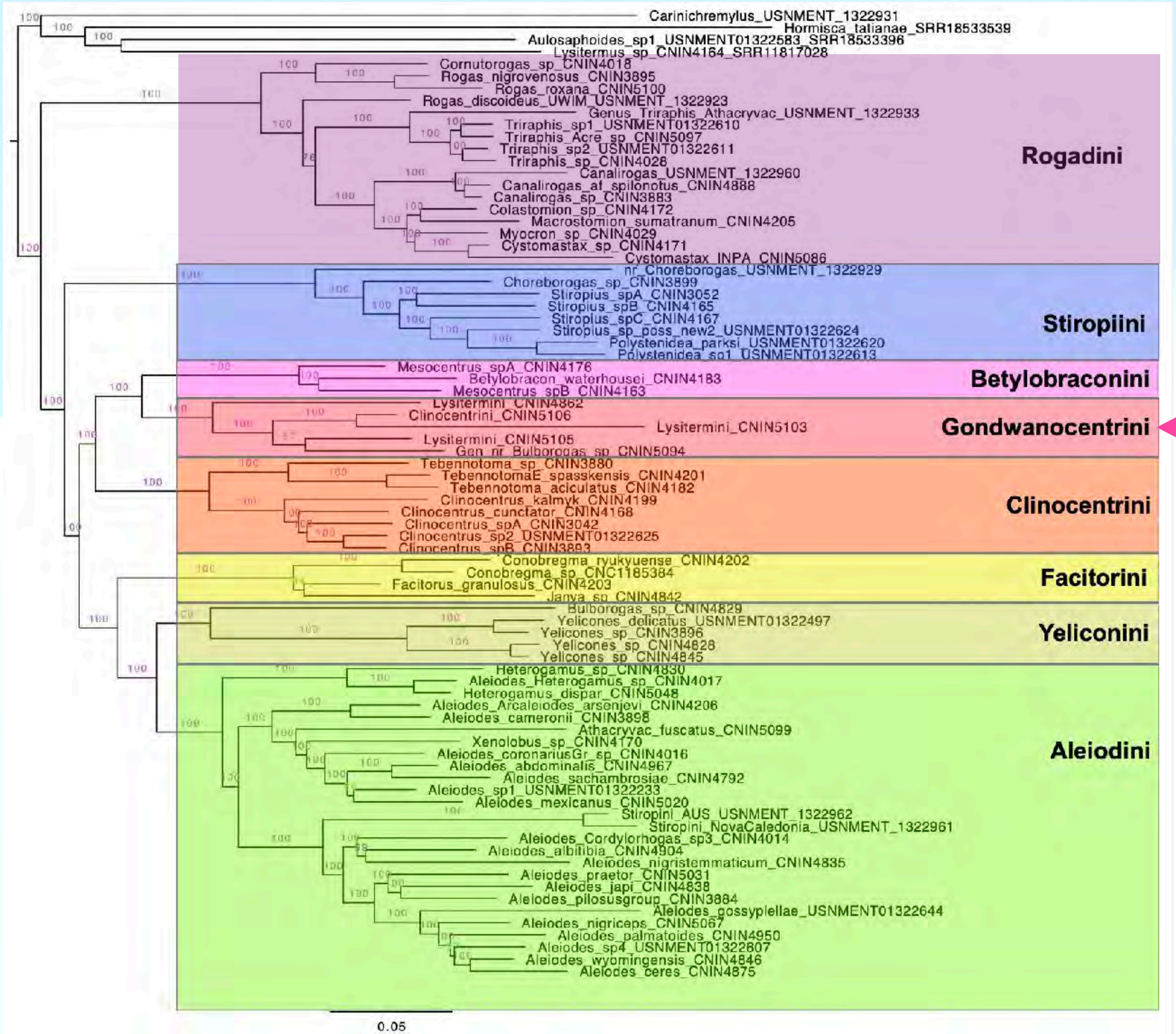
Geometridae

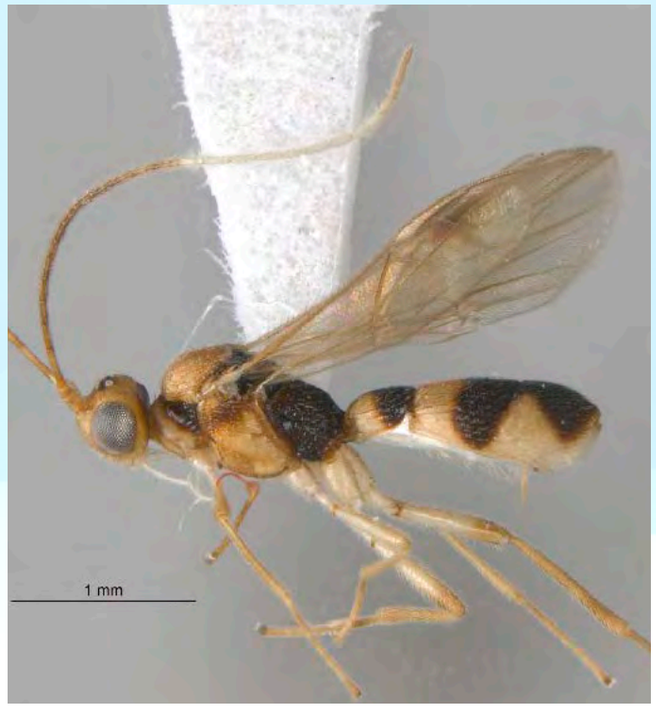
Noctuidae

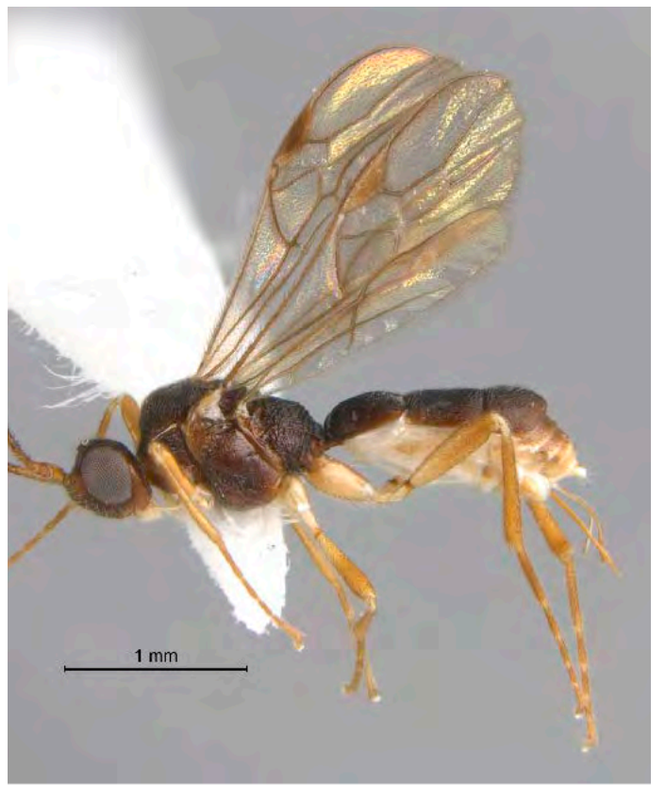
How to taxonomically treat a genus with worldwide distribution and probably thousands of species?

7. Current projects

Genomics tools - Rogadinae



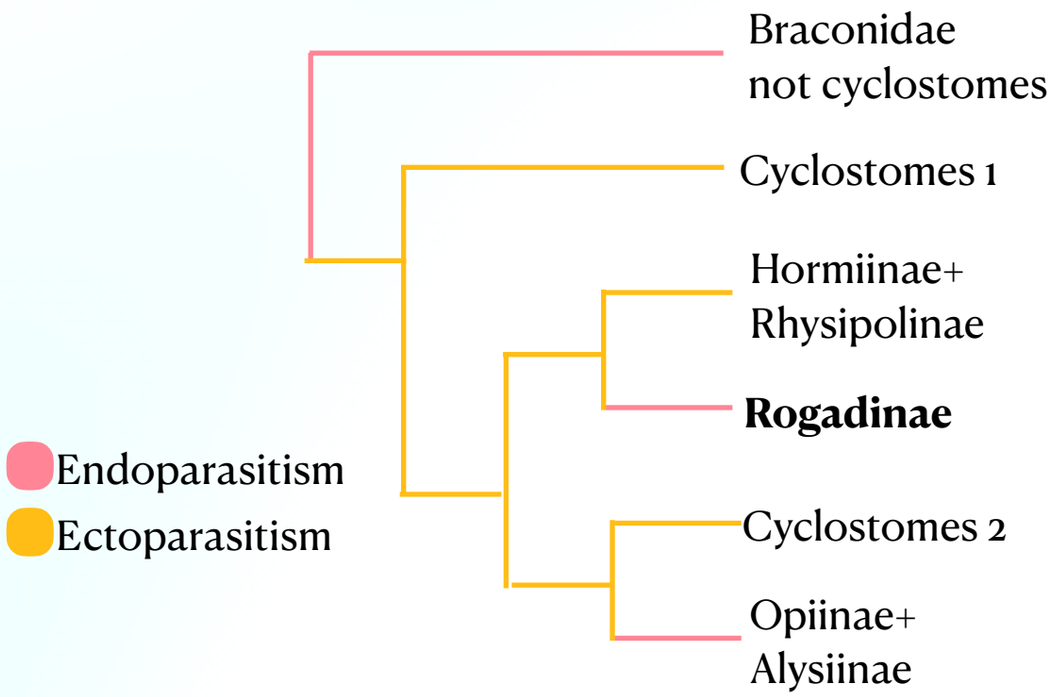


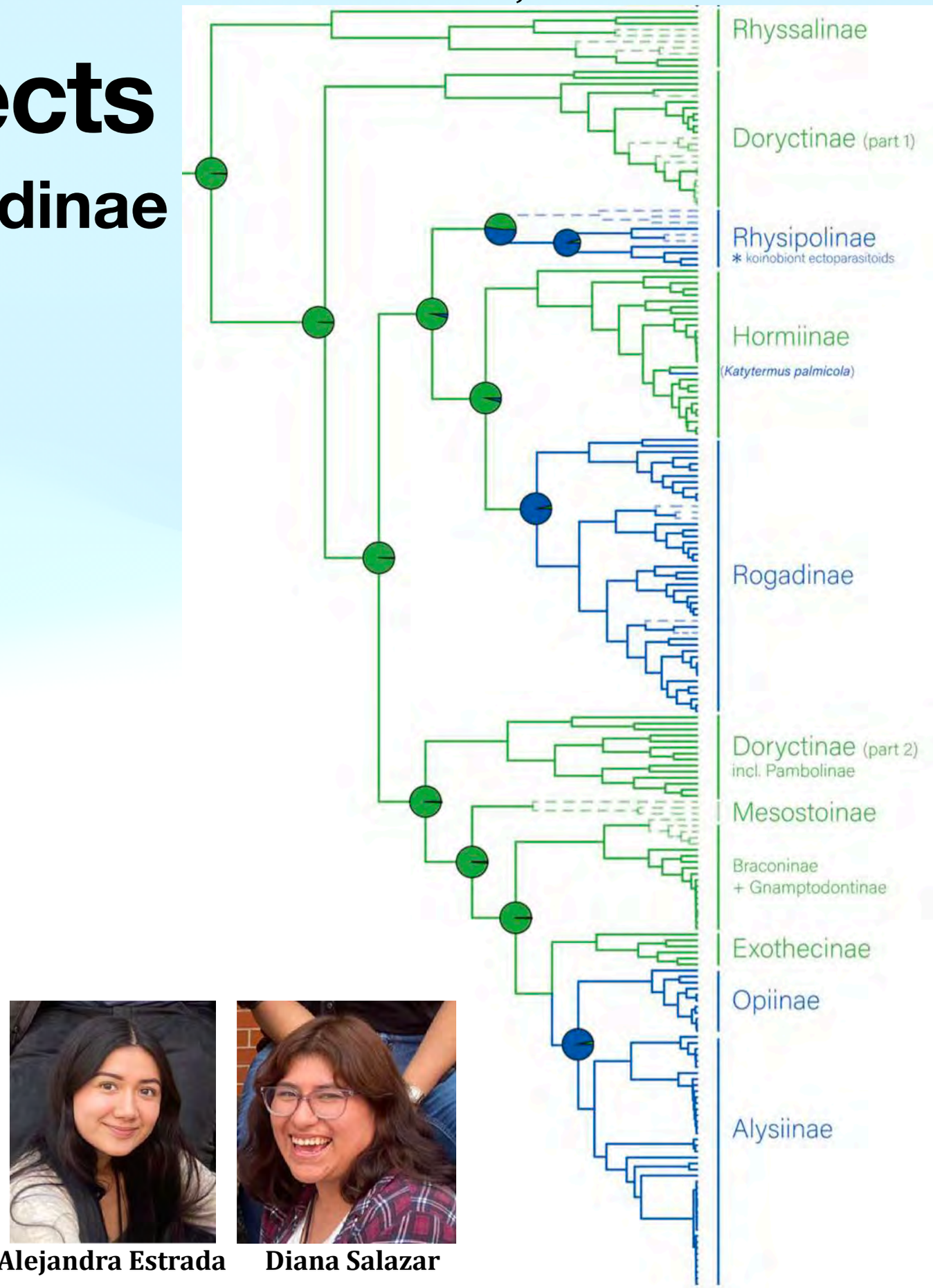


7. Current projects

Genomics tools - Rogadinae

Evolution of Rogadinae using genomic tools: role of endogenized viral elements and toxin-resistance genes in the transition of life modes and host exploitation.





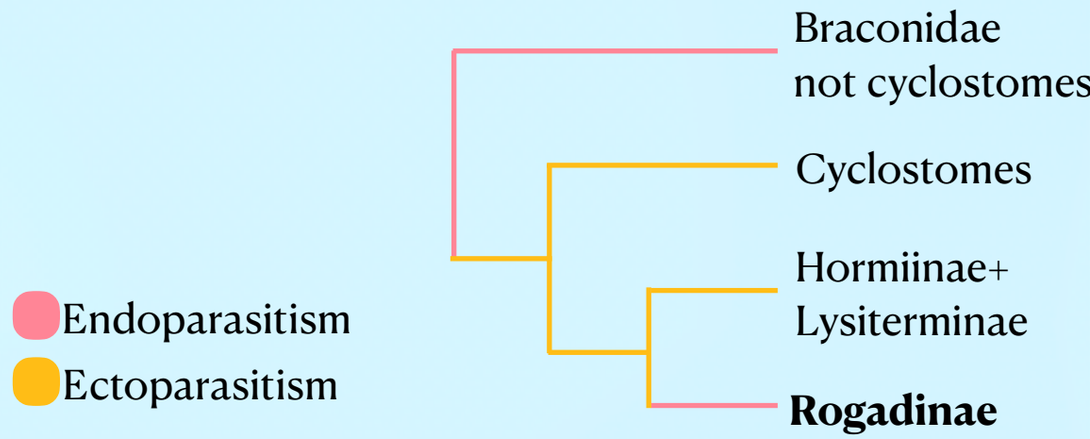
Alejandra Estrada

Diana Salazar

7. Current projects

Genomics tools - Rogadinae

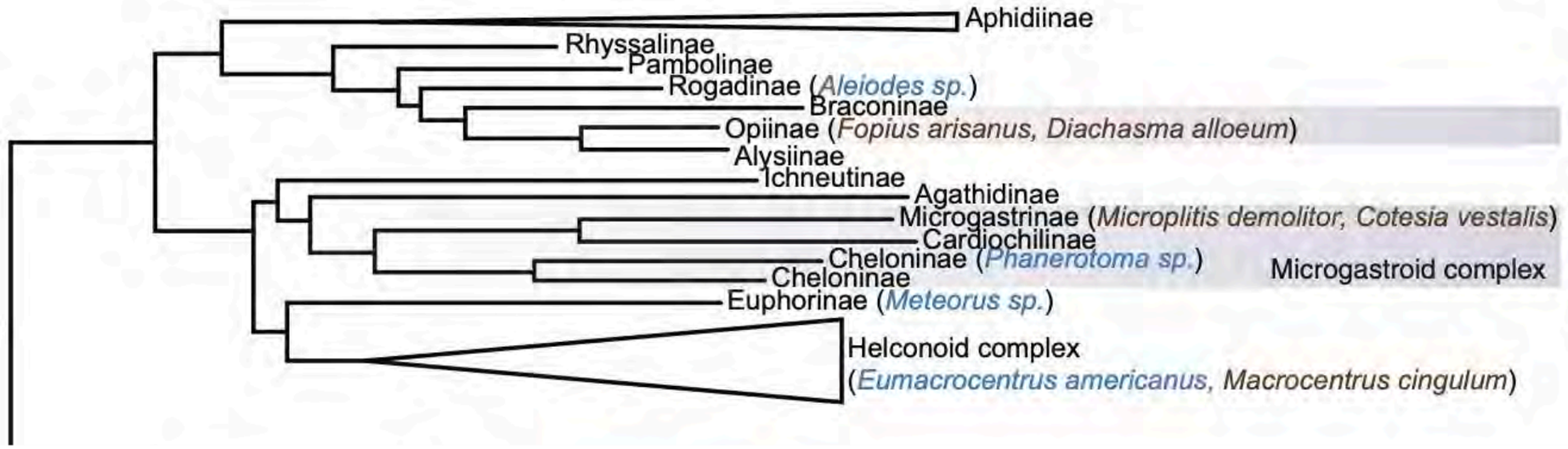
Evolution of Rogadinae using genomic tools: role of endogenized viral elements and toxin-resistance genes in the transition of life modes and host exploitation.



Endoparasitoid lifestyle promotes endogenization and domestication of dsDNA viruses

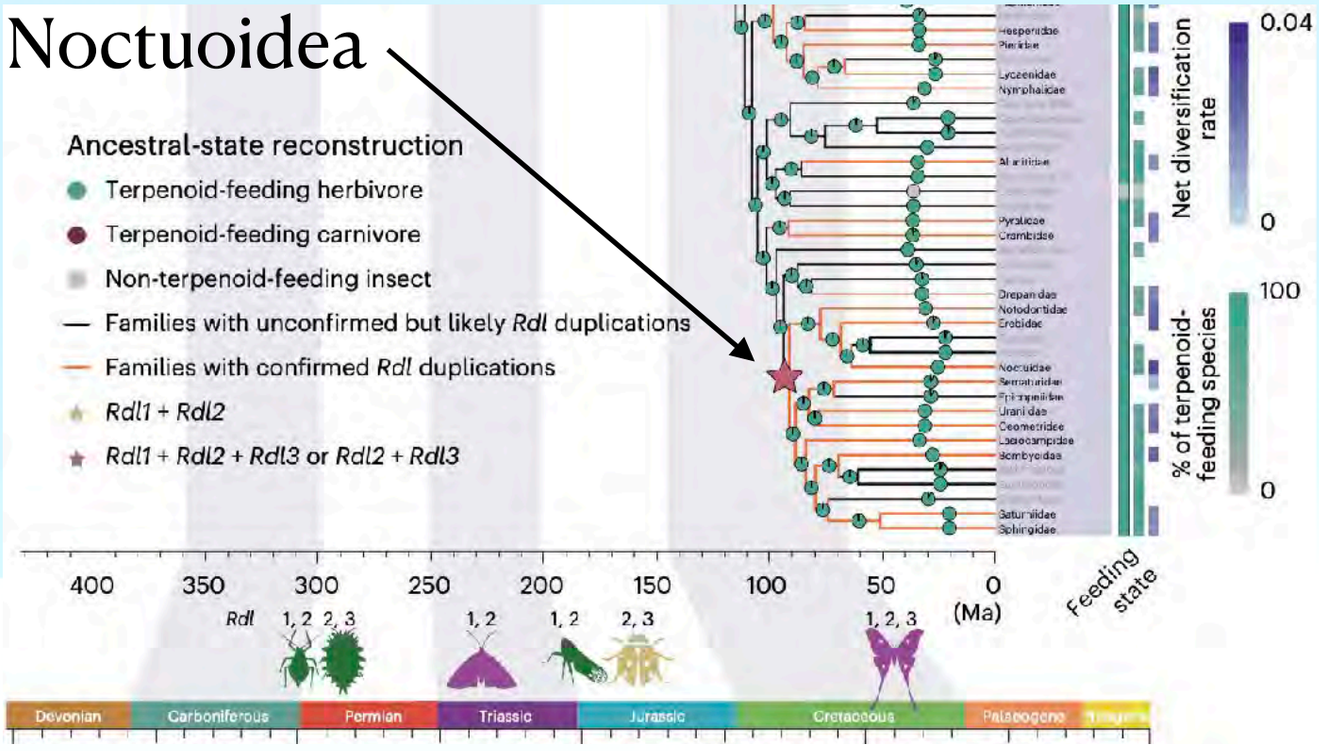
Benjamin Guinet[1]*, David Lepetit[1], Sylvain Charlat[1], Peter N Buhl[2], David G Notton[3], Astrid Cruaud[4], Jean-Yves Rasplus[4], Julia Stigenberg[5], Damien M de Vienne[1], Bastien Boussau[1], Julien Varaldi[1]*

Burke et al. 2021 *Genome Biol. Evol.* 13(7)



7. Current projects

Genomics tools - Rogadinae



nature ecology & evolution

Article

https://doi.org/10.1038/s41559-023-02127-4

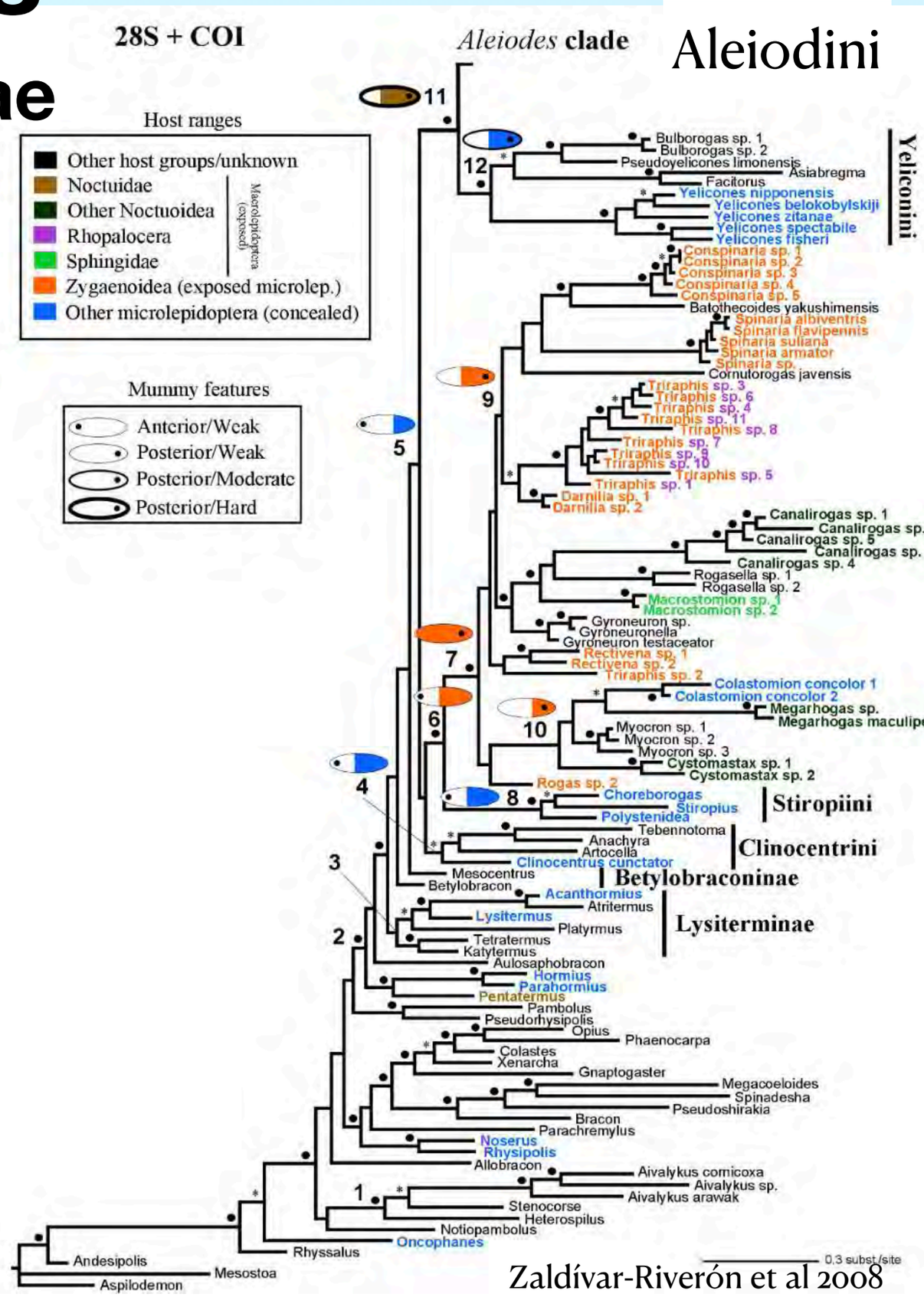
Convergent resistance to GABA receptor neurotoxins through plant–insect coevolution

Received: 7 February 2023

Accepted: 22 June 2023

Published online: 17 July 2023

Lei Guo[1,5], Xiaomu Qiao[2,5], Diler Haji[3], Tianhao Zhou[1], Zhihan Liu[1], Noah K. Whiteman[3,4] & Jia Huang[1]



Zaldívar-Riverón et al 2008

7. Current projects

Genomics tools - Rogadinae

- IPM context:
    - Resistance to toxins = resistance to pesticides?
    - Endogenous viral elements and virus biocontrol — interactions in Lepidoptera as preferred targets?

7. Current projects

Genomics tools and barcoding

- **Essential tools for bridging gaps**
- DNA from museum specimens
- Generating barcodes (legacy genes)
- micro -> macroevolutionary
- Host-parasitoid associations

JHR 97: 29–42 (2024)
doi: 10.3897/jhr.97.113231
https://jhr.pensoft.net

RESEARCH ARTICLE

JOURNAL OF Hymenoptera RESEARCH

High hymenopteran parasitoid infestation rates in Czech populations of the *Euphydryas aurinia* butterfly inferred using a new molecular marker

Hana Konvičková[1,2], Václav John[1,2,3], Martin Konvička[1,2], Michal Rindoš[1,2], Jan Hrček[1,2]

Species discovery/
identification

Host-Parasitoid
associations

Insect monitoring

Barcode
Reference databases

Taxonomic Impediment

Legacy descriptions

Merci beaucoup !

SHIMBORI@GMAIL.COM