Les Insectes

(avec un focus sur les Formicidae)

Thibaut DELSINNE, IRSNB

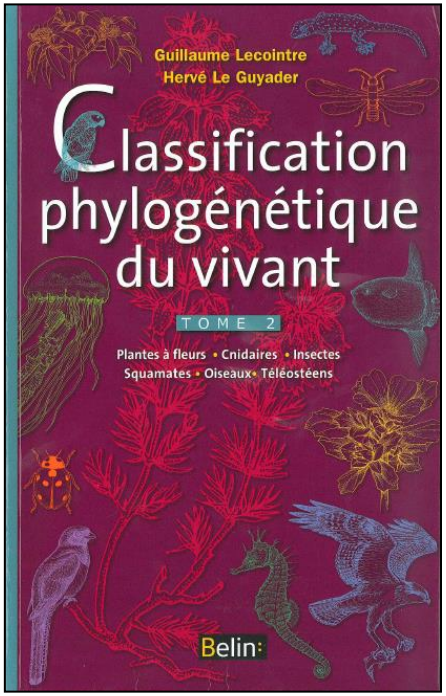
LAMTO 2016

Plan de l'exposé

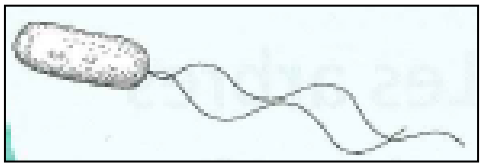
1. **Classification et évolution des insectes**
2. **Diversité des insectes**
3. **Caractéristiques des Formicidae**
4. **Biologie des Formicidae**

1. Classification et évolution des insectes

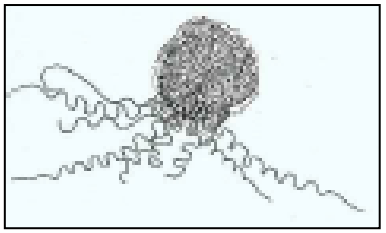
Le Vivant



Eubactéries

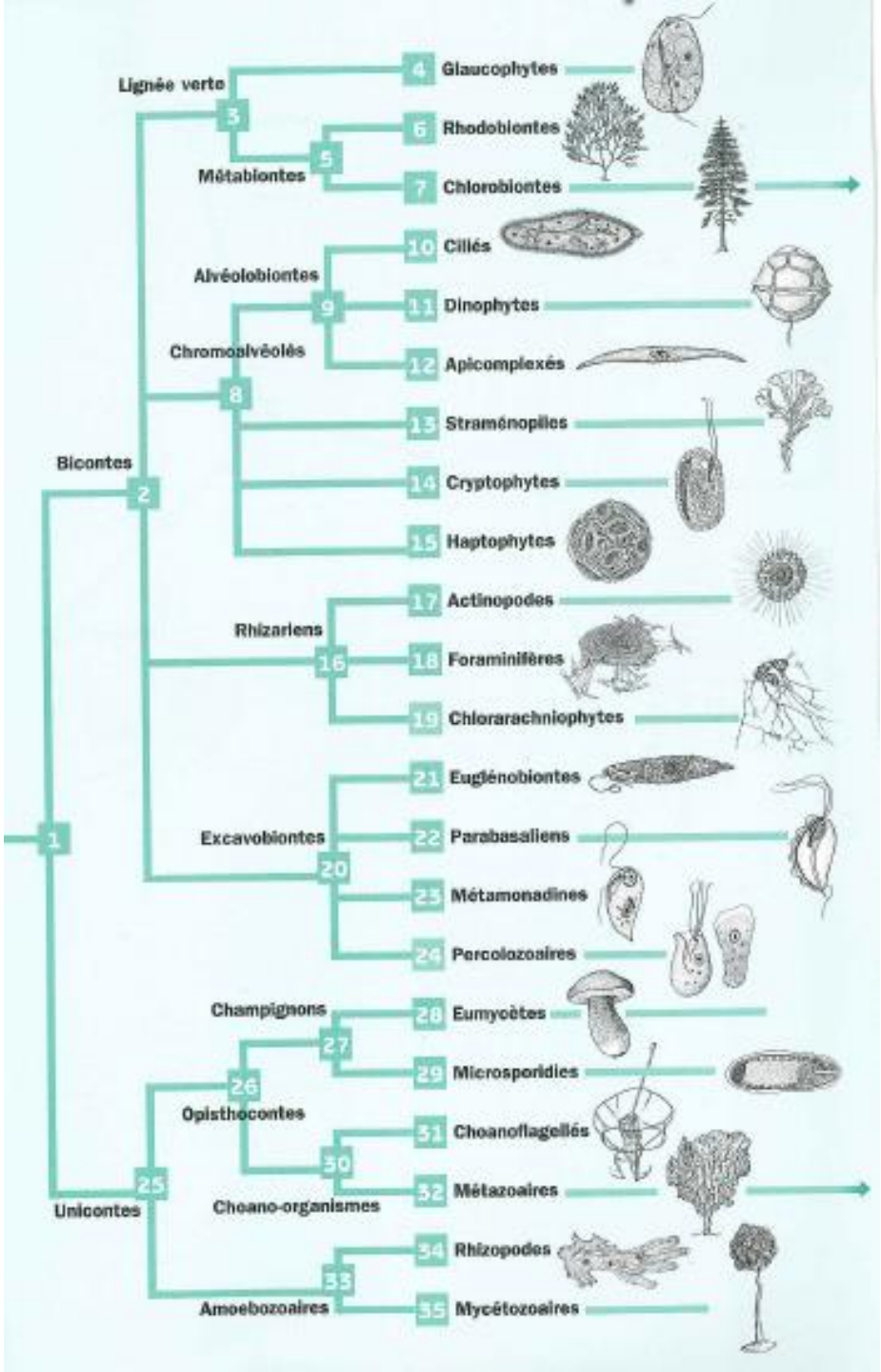


Archées



Eucaryotes

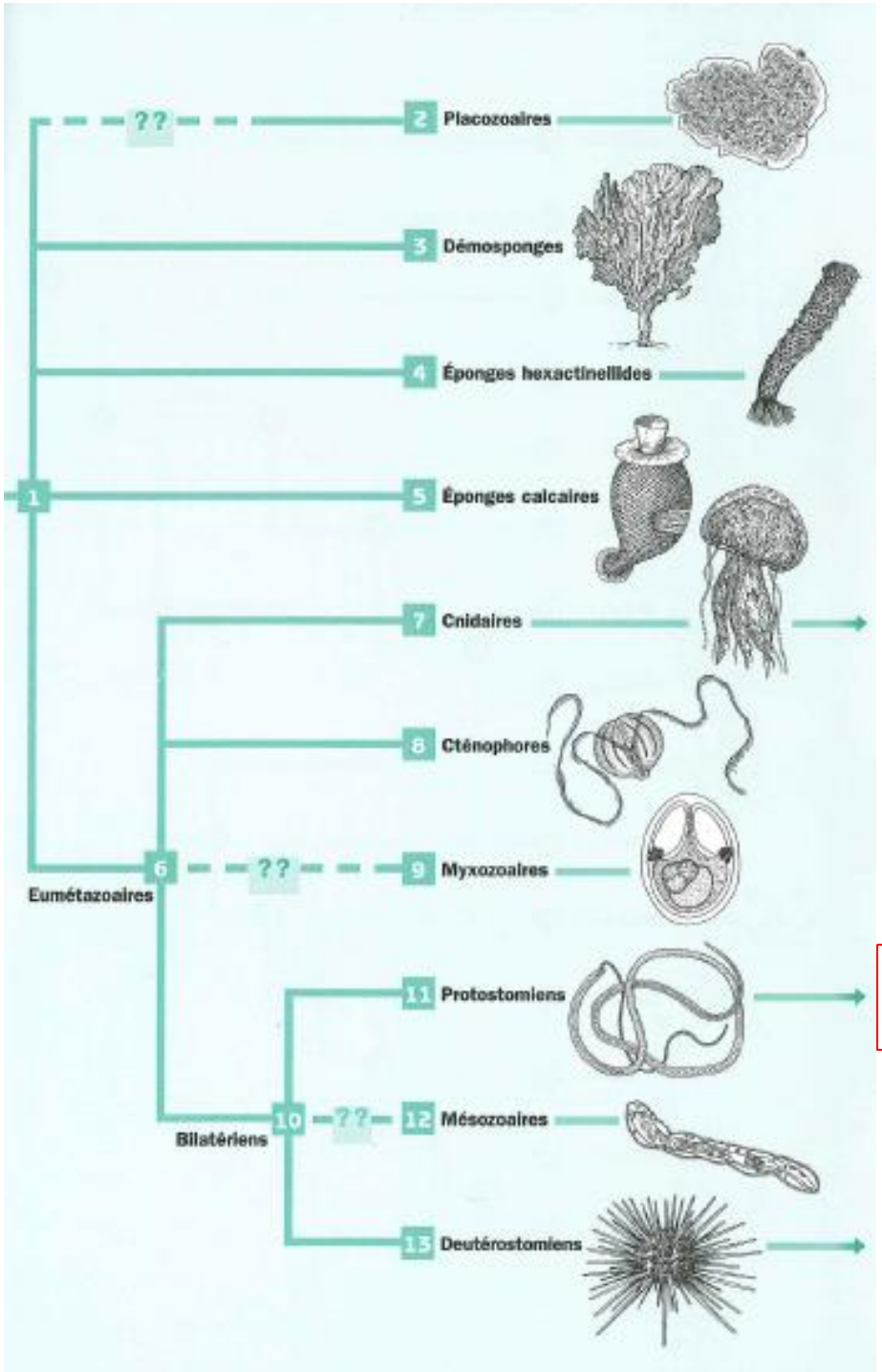
Eucaryotes



Plantes

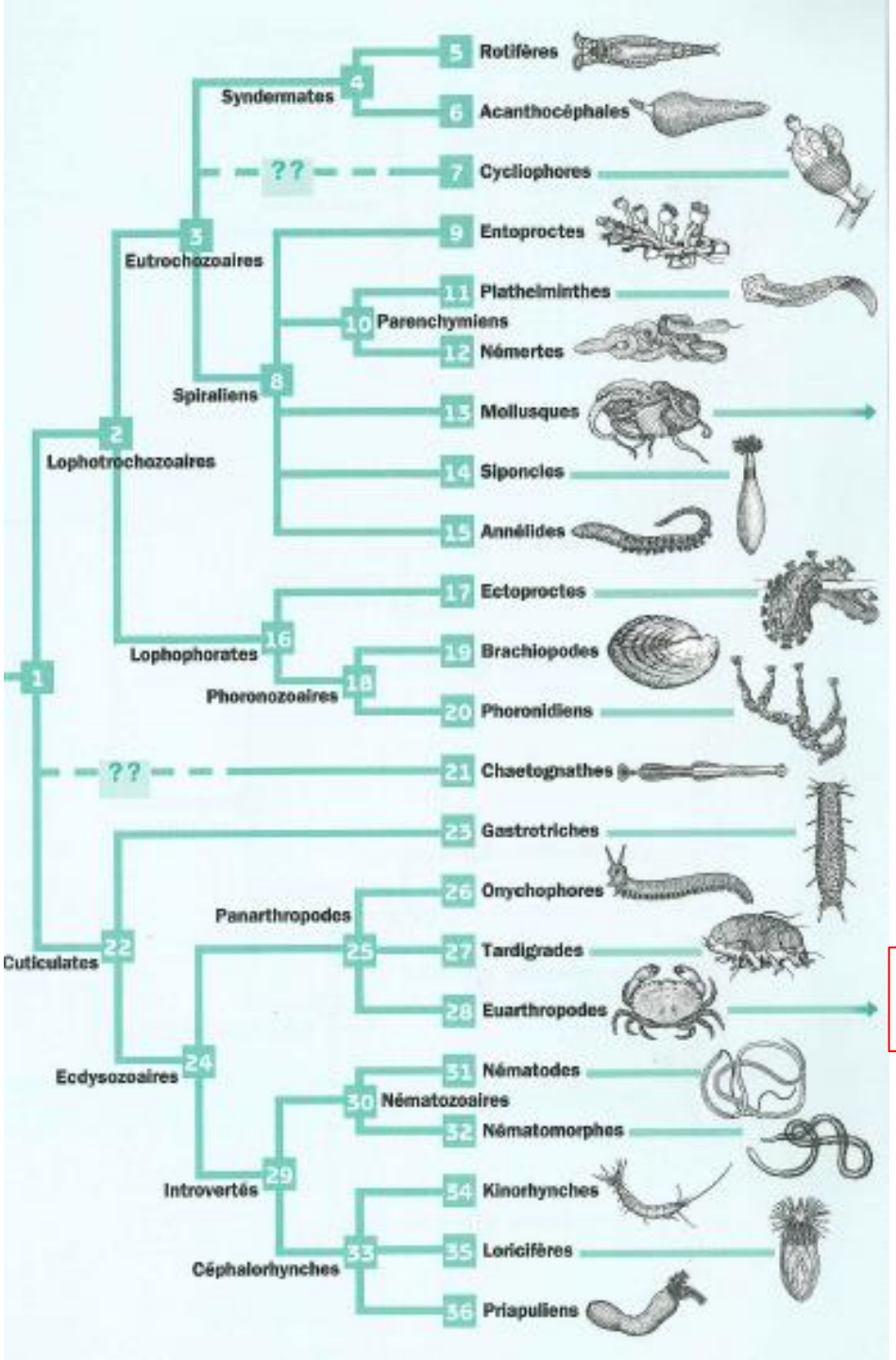
Métazoaires

Métazoaires



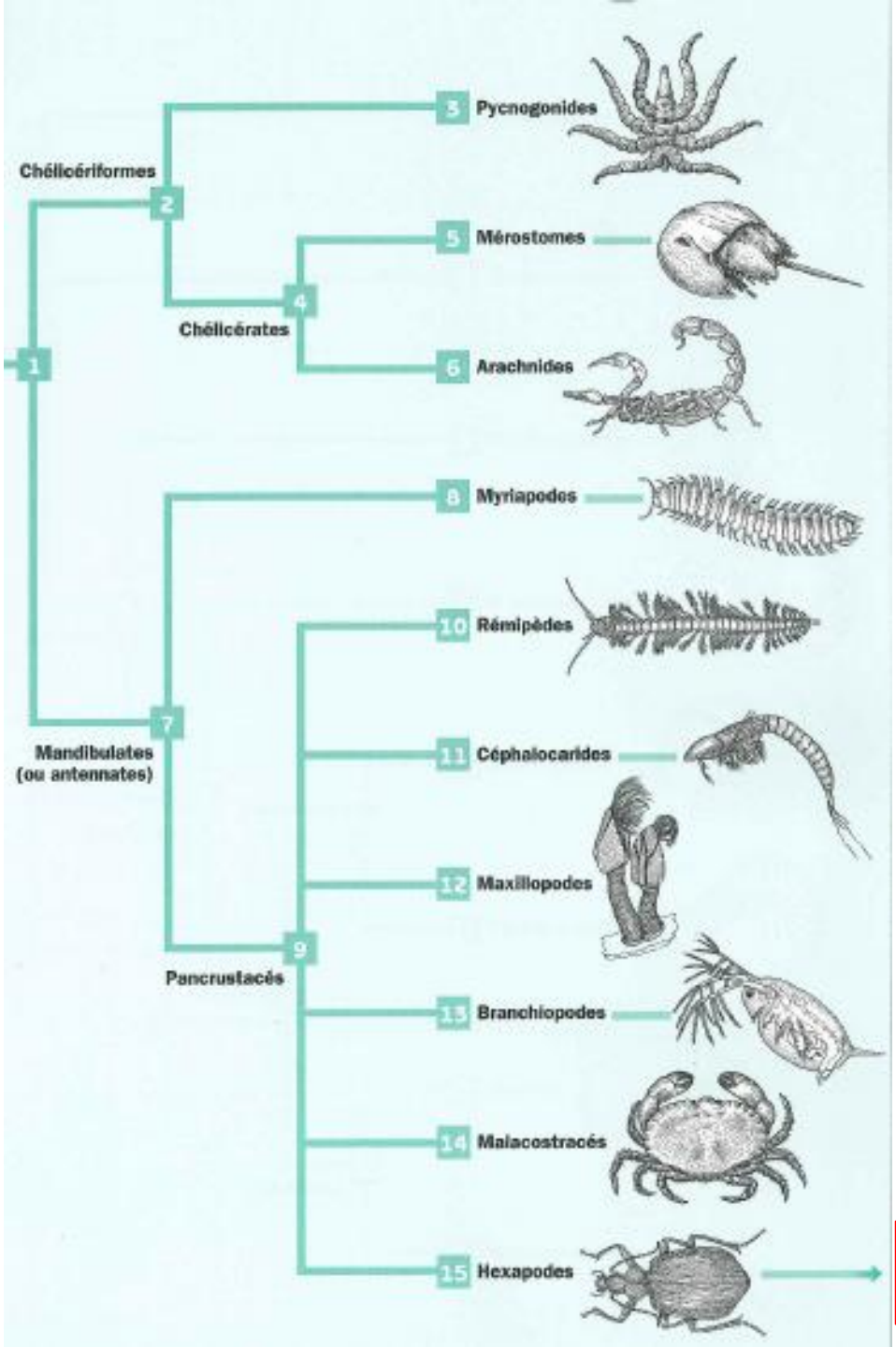
Protostomiens

Protostomiens



Euarthropodes

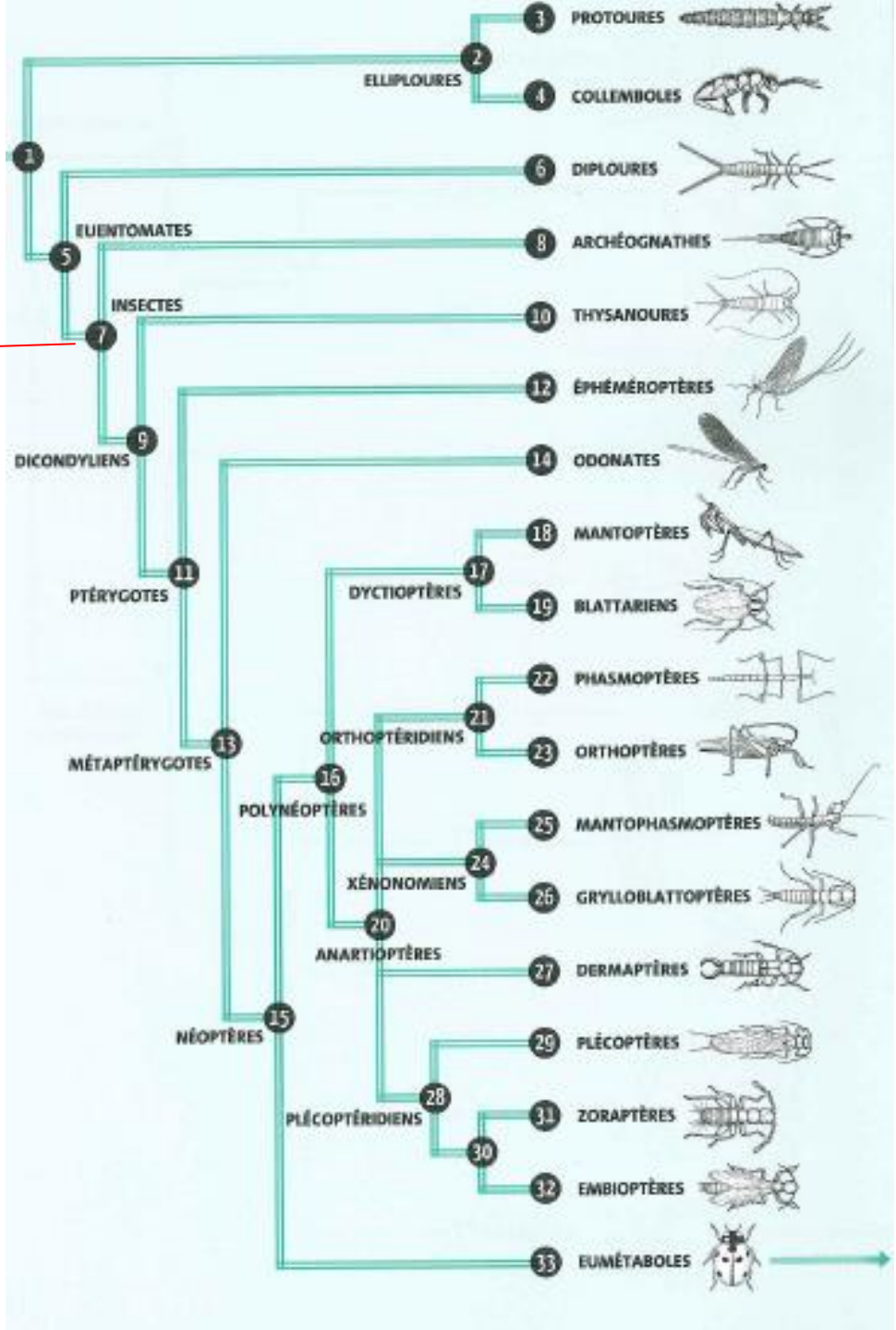
Euarthropodes



Hexapodes

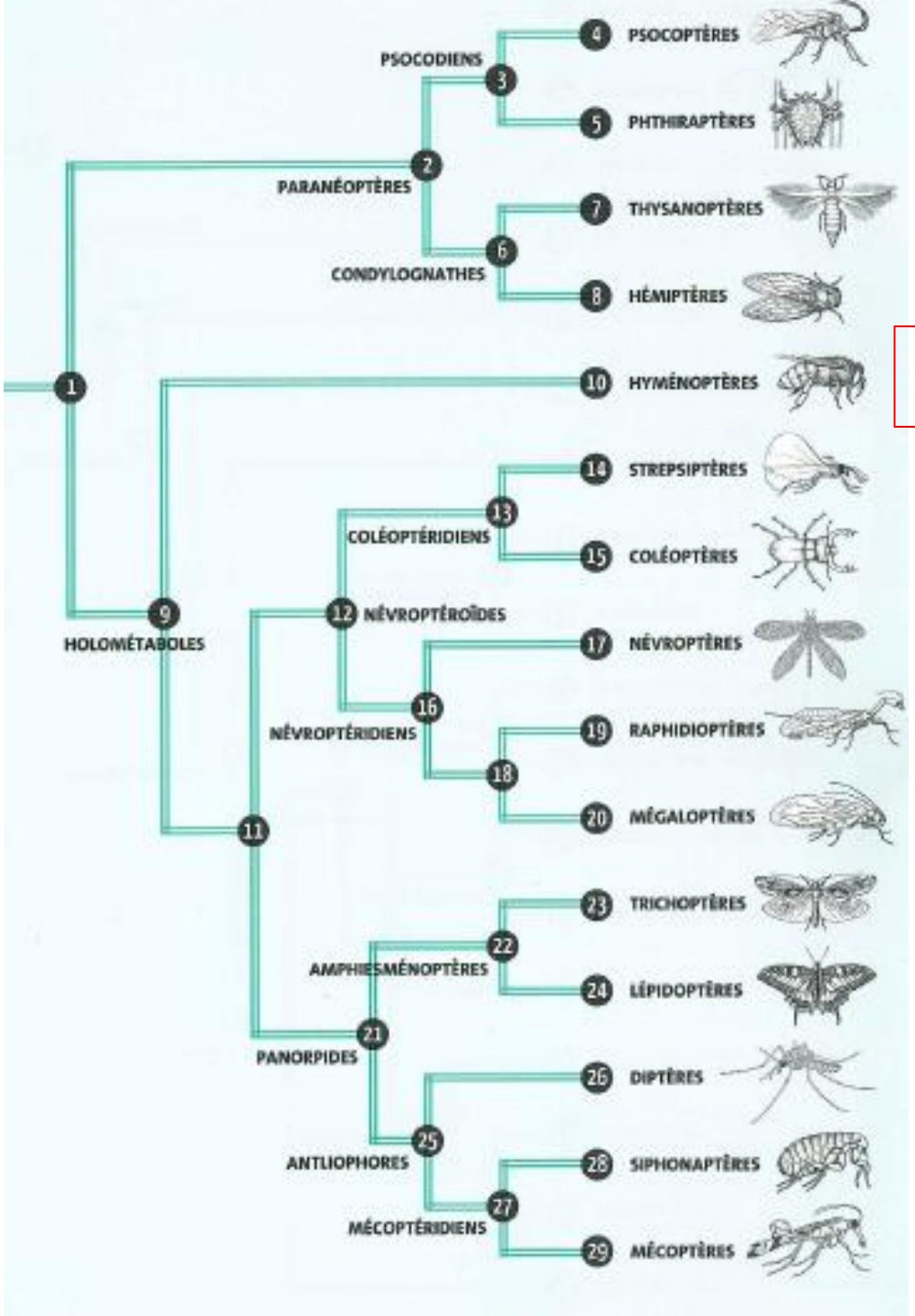
Hexapodes

Insectes



Eumétaboles

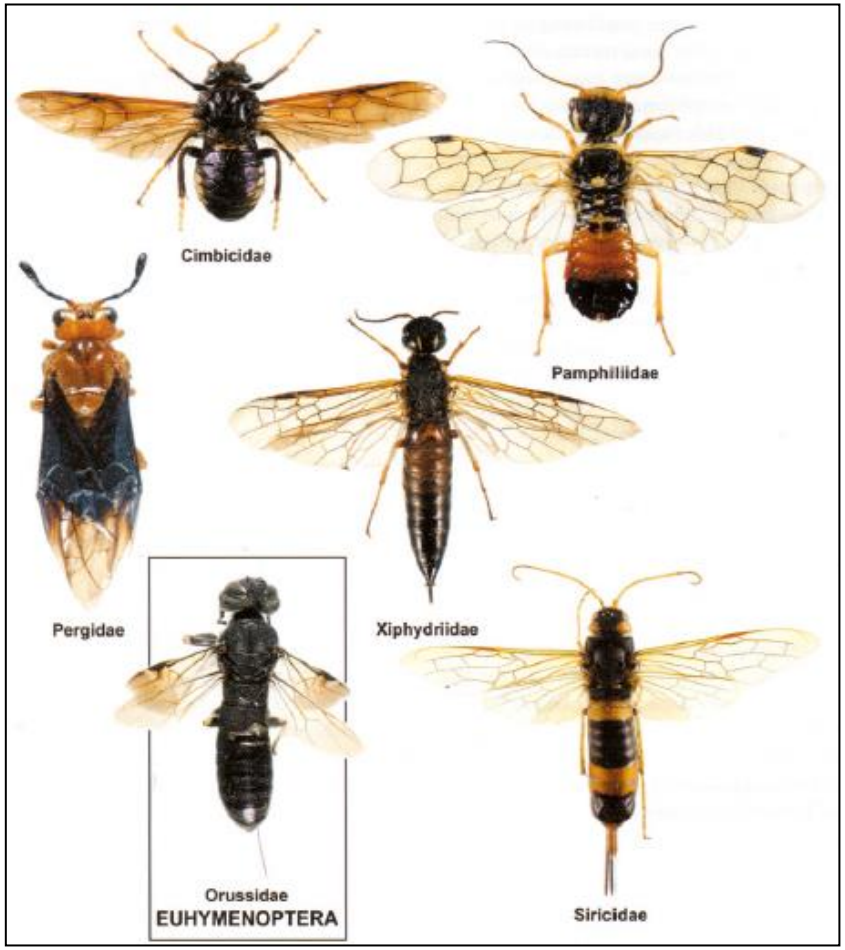
Eumétaboles



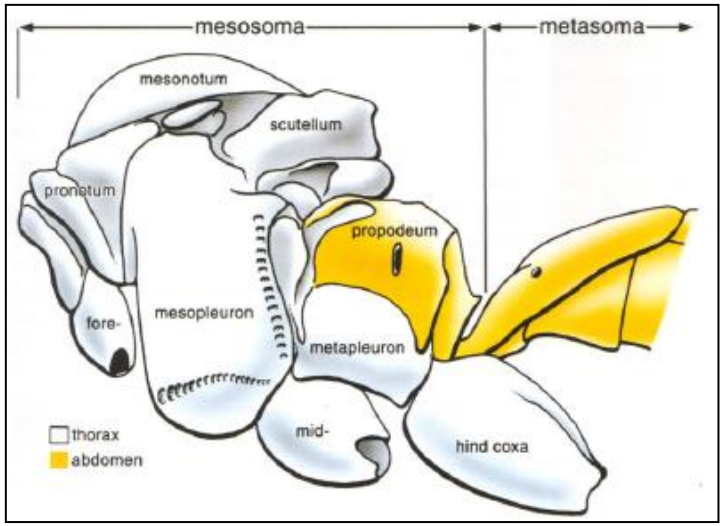
Hyménoptères

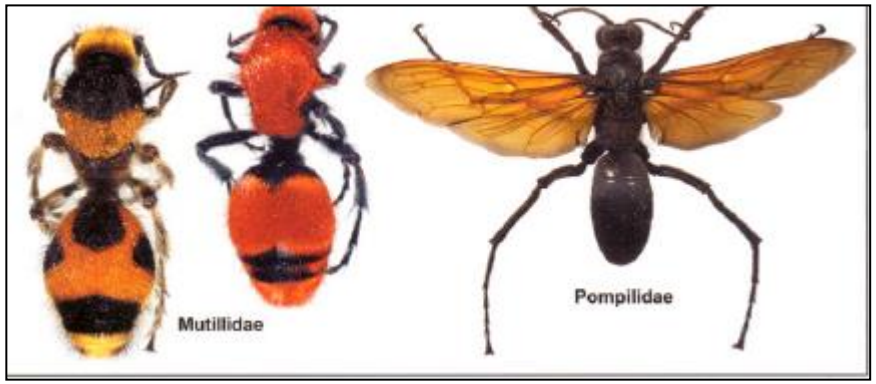
Hyménoptères

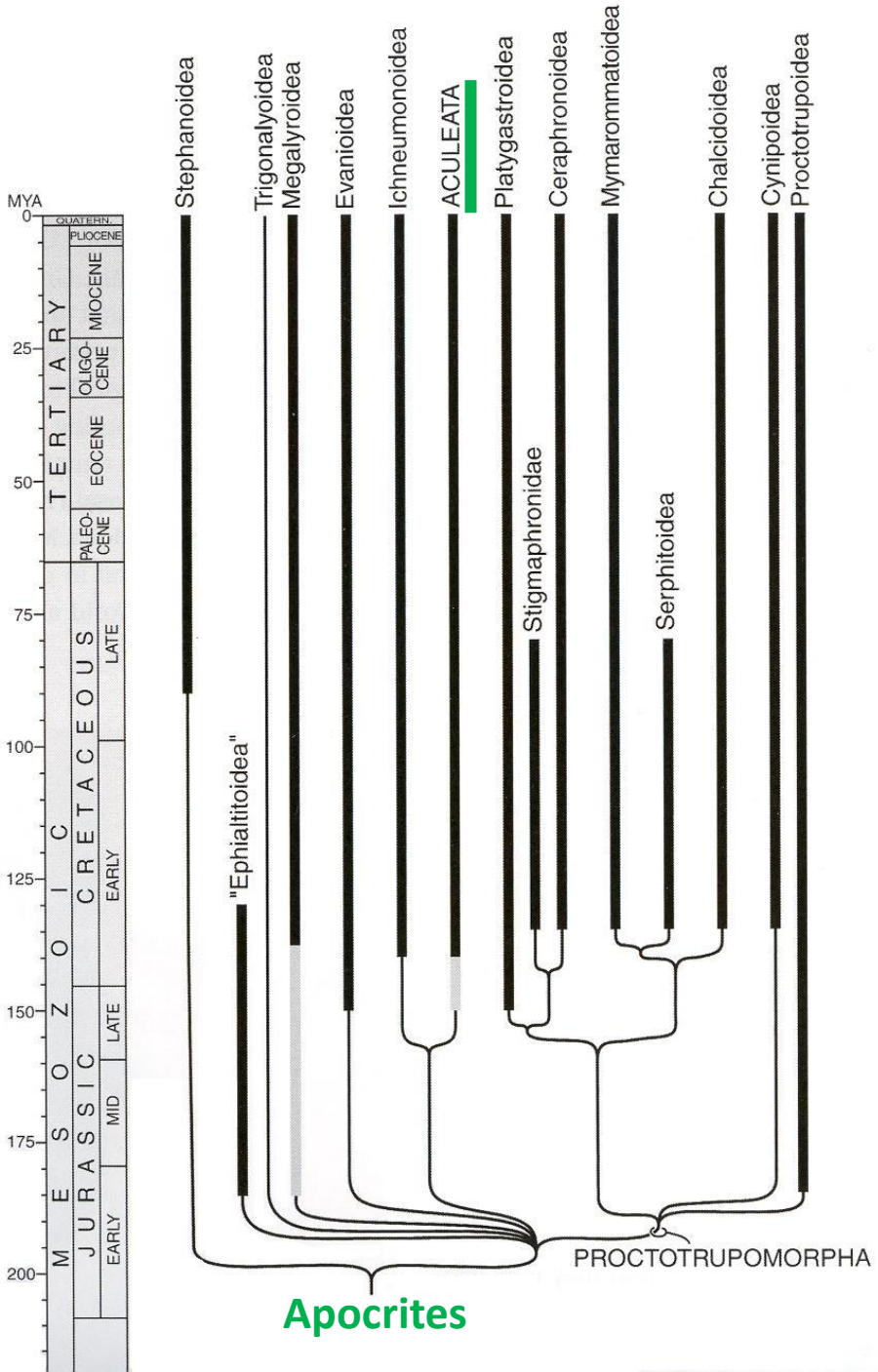
Symphyta (25 familles)

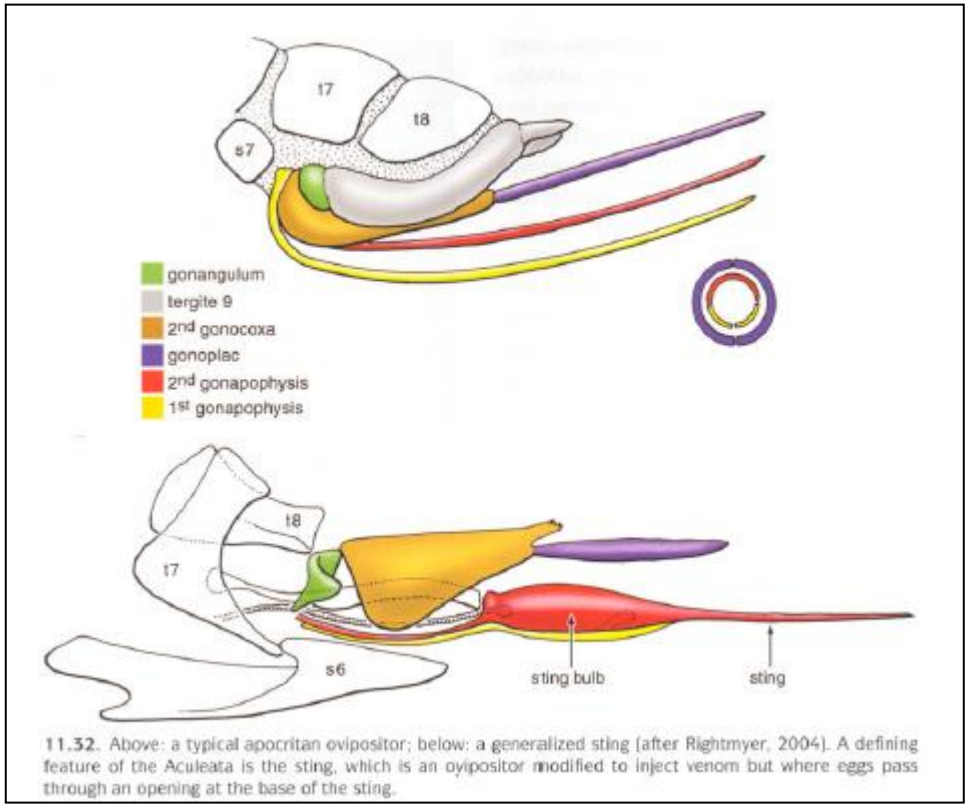


Apocrites
(105 familles dont Formicidae)

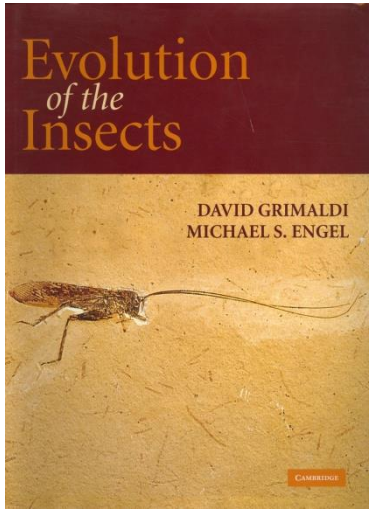


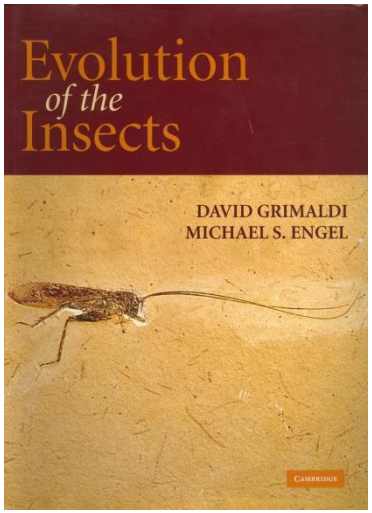


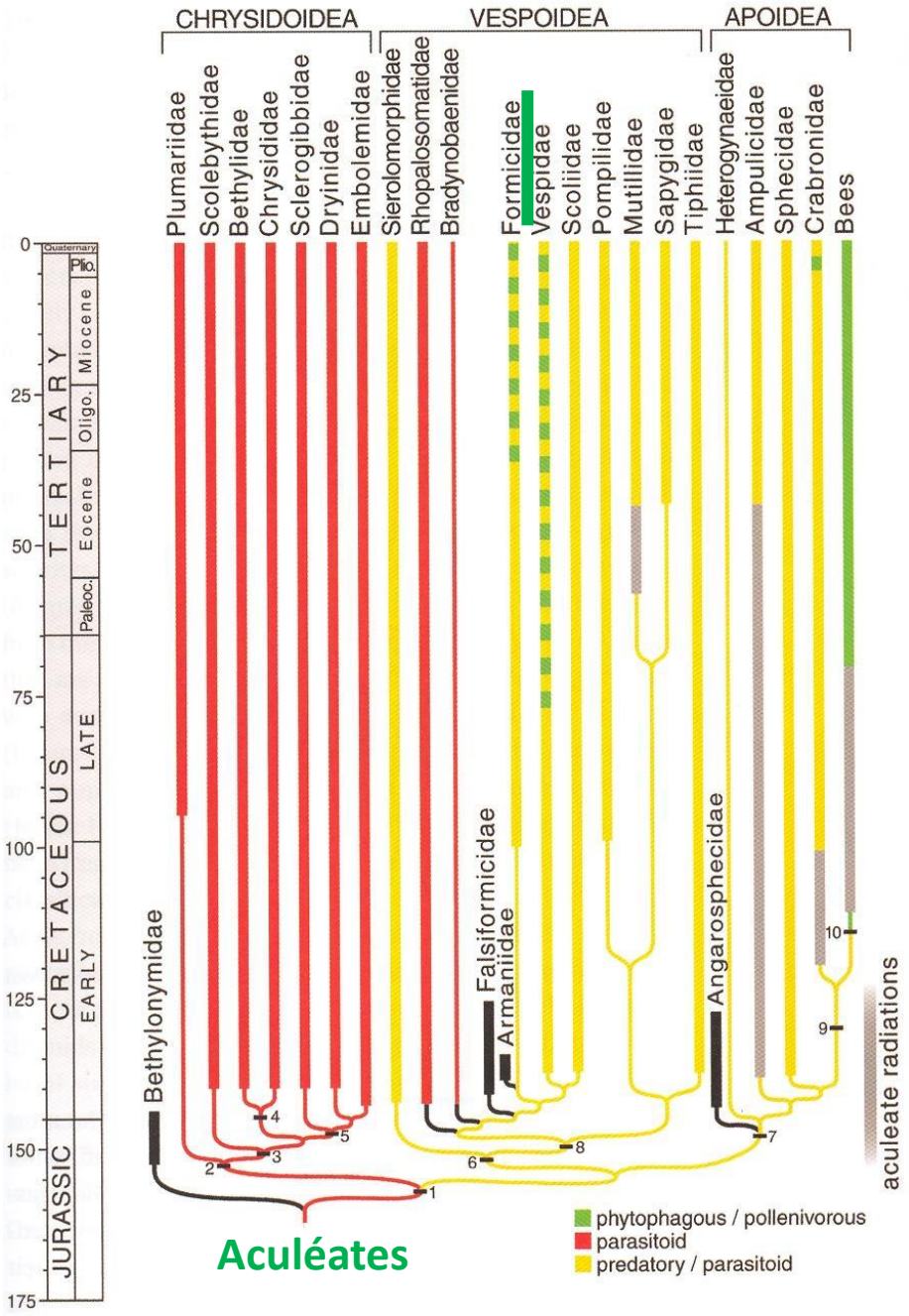




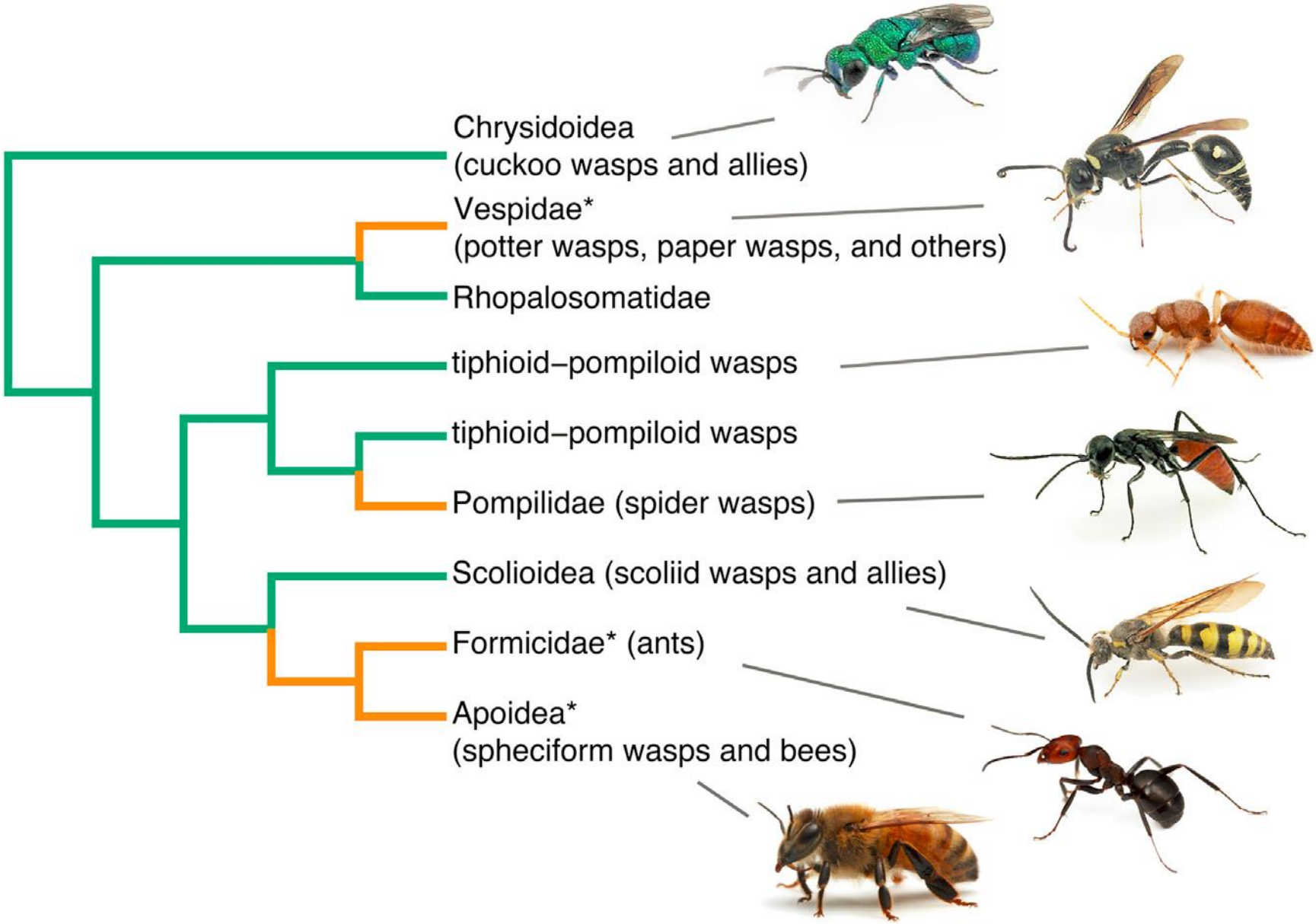
11.32. Above: a typical apocritan ovipositor; below: a generalized sting (after Rightmyer, 2004). A defining feature of the Aculeata is the sting, which is an ovipositor modified to inject venom but where eggs pass through an opening at the base of the sting.







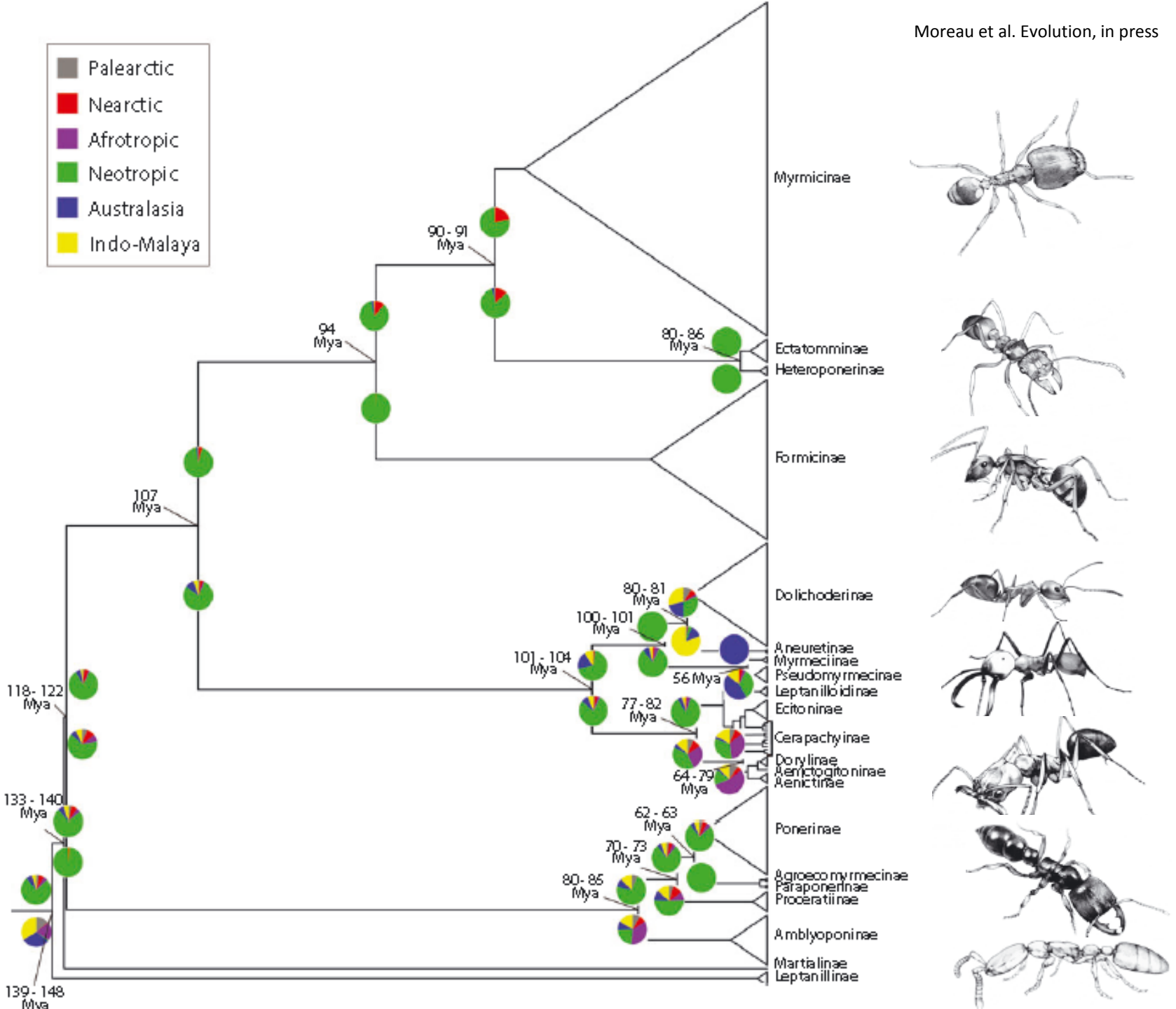
Phylogeny of the Aculeata with significant characters indicated. Thick lines indicate the known extent of fossils. Relationships based on Brothers and Carpenter (1993), with fossils added.



Johnson et al. (2013).

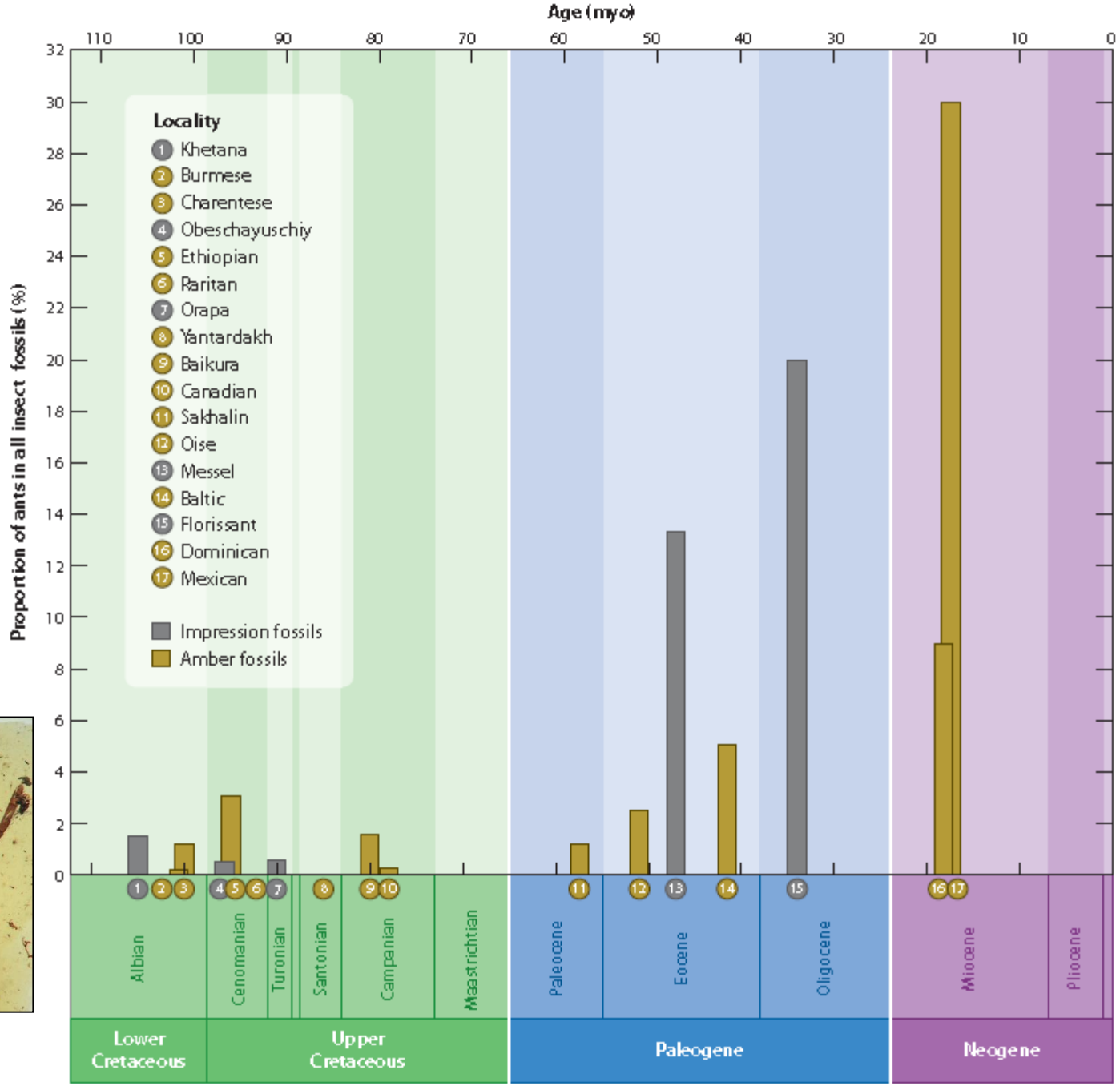
Evolution of the Aculeate Hymenoptera. Blue-green branches represent parasitoidism; orange branches represent nest construction and predation (with pollenivory and omnivory as derivative states thereof). Asterisks designate lineages containing eusocial species. Ants are entirely eusocial, but this is not true of all species of Vespidae and Apoidea. Images courtesy of Alexander Wild and Kurt Schaefer.

Moreau et al. Evolution, in press



LaPolla et al. 2013.Annu. Rev. Entomol. 58: 609-630

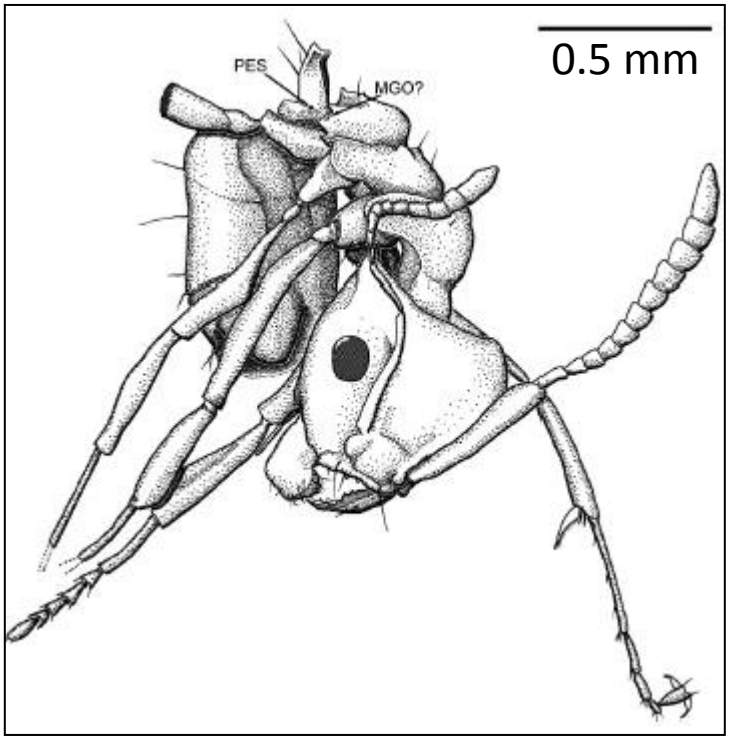
Formicidae



Haydomyrmex sp.
99 millions d'années

New ants (Hymenoptera: Formicidae: Dolichoderinae) from Canadian Late Cretaceous amber

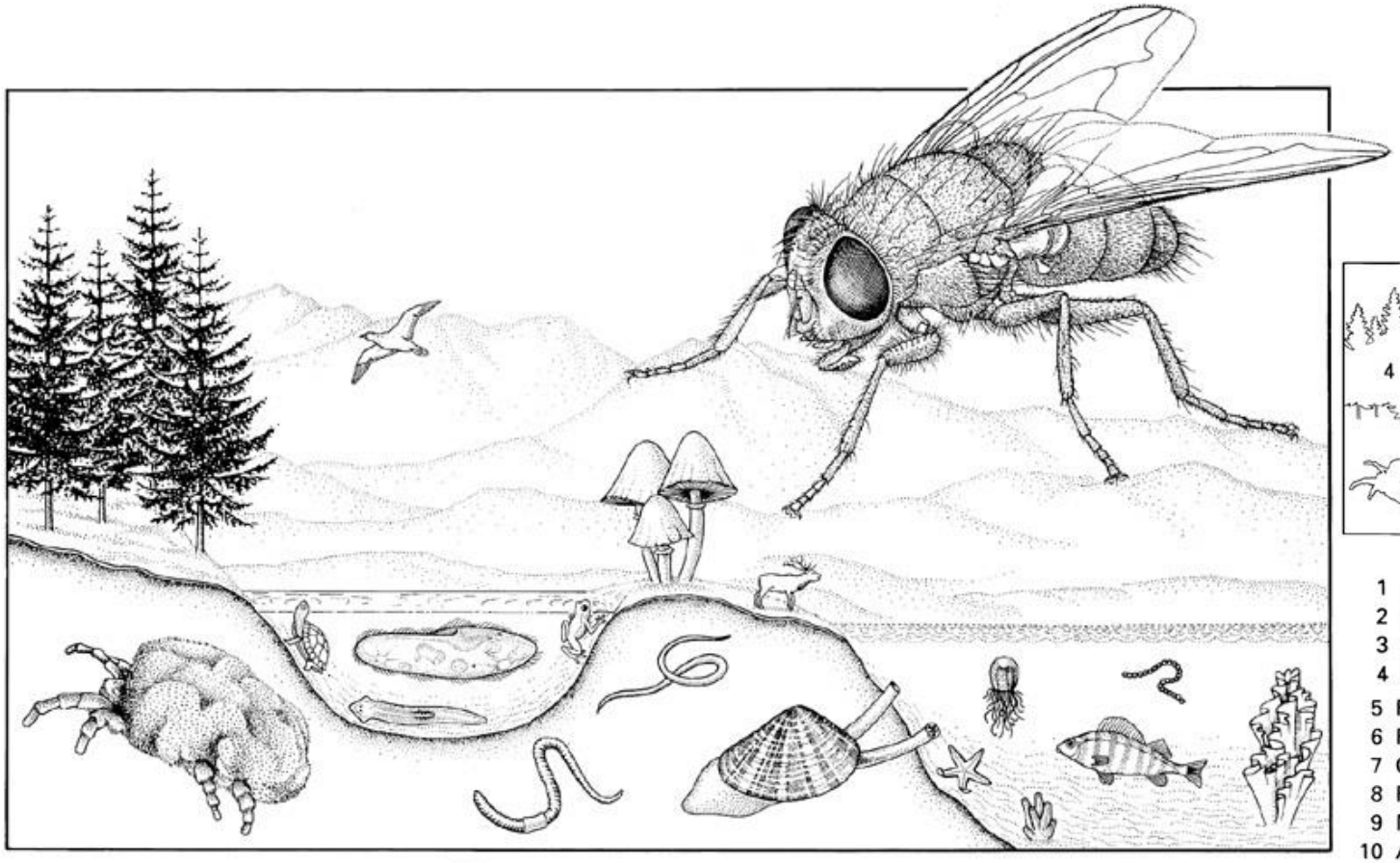
McKellar, R.C., Glasier, J.R.N. & Engel, M.S. 2013. New ants (Hymenoptera: Formicidae: Dolichoderinae) from Canadian Late Cretaceous amber. *Bulletin of Geosciences 88(3)*, 583–594 (4 figures). Czech Geological Survey, Prague. ISSN 1214-1119. Manuscript received February 28, 2013; accepted in revised form May 10, 2013; published online June 10, 2013; issued July 3, 2013.

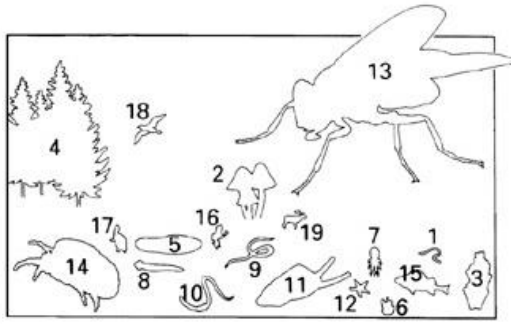


2. Diversité des insectes

LES INSECTES

LES INSECTES





1 Prokaryotes
2 Fungi
3 Algae
4 Plantae (multicellular plants)
5 Protozoa
6 Porifera (sponges)
7 Cnidaria (jellyfish, corals, etc.)
8 Platyhelminthes (flatworms)
9 Nematoda (roundworms)
10 Annelida (earthworms, leeches, etc.)
11 Mollusca (snails, bivalves, octopus, etc.)
12 Echinodermata (starfish, sea urchins, etc.
13 Insecta
14 Non-insect Arthropoda
15 Pisces (fish)
16 Amphibia (frogs, salamanders, etc.)
17 Reptilia (snakes, lizards, turtles)
18 Aves (birds)
19 Mammalia (mammals)

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Phylum Arthropoda*

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* *In*: Zhang, Z.-Q. (Ed.) Animal Biodiversity: An Outline of Higher-level Classification and Survey of Taxonomic Richness (Addenda 2013). *Zootaxa*, 3703, 1–82.

Abstract

Arthropodes: 1 257 040 espèces vivantes

The Arthropoda is here estimated to have 1,302,809 described species, including 45,769 fossil species (the diversity of fossil taxa is here underestimated for many taxa of the Arthropoda). The Insecta (1,070,781 species) is the most successful group, and it alone accounts for over 80% of all arthropods. The most successful insect order, Coleoptera (392,415 species), represents over one-third of all species in 39 insect orders. Another major group in Arthropoda is the class Arachnida (114,275 species), which is dominated by the Acari (55,214 mite and tick species) and Araneae (44,863 spider species). Other diverse arthropod groups include Crustacea (73,141 species), Trilobitomorpha (20,906 species) and Myriapoda (12,010 species).

Published: 30 Aug. 2013

Key words: Classification, diversity, Arthropoda

LES INSECTES

Subphylum 2.2.2 **Hexapoda** (1,080,760 species, including †17,227 species)[37]
Class 1.1 **Collembola** (8,187 species, including †24 species)[38]
Class 1.2.1 **Protura** (816 species, including †0 species)[39]
Class 1.2.2 **Diplura** (976 species, including †1 species)[40]
Class 2 **Insecta** (1,070,781 species, including †17,203 species)[41]
Order 1 **Archaeognatha** (514 species, including †8 species)[42]
Order 2.1 **Zygentoma** (574 species, including †20 species)[43]
Order 2.2.1.1 **Ephemeroptera** (3,281 species, including †157 species)[44]
Order 2.2.1.2.1.2.2 **Odonata** (6,650 species, including †608 species)[47]
Order 2.2.2.2.3 **Orthoptera** (24,481 species, including †651 species)[54]
Order 2.2.2.3.1 **Phasmida** (3,100 species, including †54 species)[55]
Order 2.2.2.3.2 **Embioptera** (464 species[56], including †7 species)
Order 2.2.2.4.1 **Grylloblattodea** (542 species, including †510 species)[57]
Order 2.2.2.4.2 **Mantophasmatodea** (23 species, including †6 species)[58]
Order 2.2.2.5.1 **Plecoptera** (3,833 species[59], including †120 species[60])
Order 2.2.2.5.2 **Dermaptera** (1,982 species, including †49 species)[61]
Order 2.2.2.6.1 **Zoraptera** (45 species, including †9 species)[62]
Order 2.2.2.6.2.1 **Mantodea** (2,447 species, including †22 species)[63]
Order 2.2.2.6.2.2 **Blattodea** (8,643 species, including †1073 species)[64]
Order 2.2.3.1 †**Miomoptera** (89 species, including †89 species)[65]
Order 2.2.3.2.1 **Psocoptera** (5,732 species, including †121 species)[66]
Order 2.2.3.2.2 **Phthiraptera** (5,136 species, including †1 species)[67]
Order 2.2.3.3.1 **Thysanoptera** (6,091 species, including †153 species)[68]
Order 2.2.3.3.2 **Hemiptera** (104,165, including †1,982 species)[69]

Hexapodes: 1 063 533 espèces vivantes

Insectes: 1 053 578 espèces vivantes

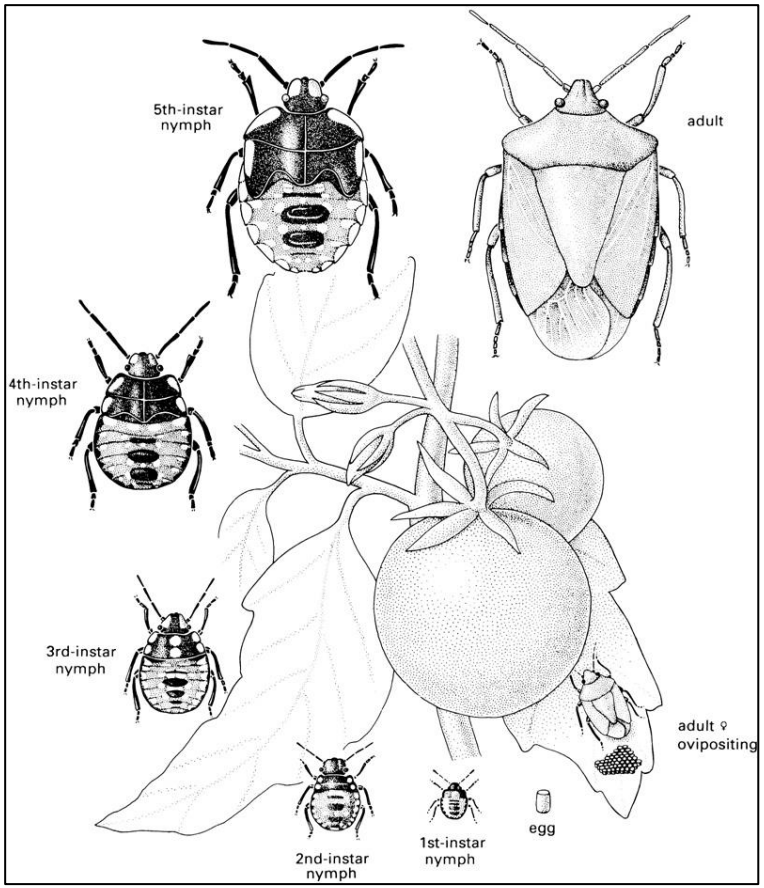
Hyménoptères: 1 53 088 spp. vivantes soit 14% des Insectes

Hymenoptera[71] (155,517 species, including †2,429 species)[72]
.1.1.1 **Strepsiptera** (624 species, including †11 species)[73]
.1.1.2 **Coleoptera** (392,415 species, including †2,928 species)[74]
.1.2.1 **Neuroptera** (5,937 species, including †469 species)[75]
.1.2.2.1 **Megaloptera** (380 species, including †21 species)[76]
.1.2.2.2 **Raphidioptera** (271 species, including †87 species)[77]
.2.1.1 **Trichoptera** (15,233 species, including †685 species)[78]
.2.1.2 **Lepidoptera** (158,570 species, including †147 species)[79]
.2.2.1 **Diptera** (160,591 species, including †3,817 species)[80]
.2.2.2.1 **Siphonaptera** (2,086 species, including †4 species)[81]
.2.2.2.2 **Mecoptera** (769 species, including †369 species)[82]

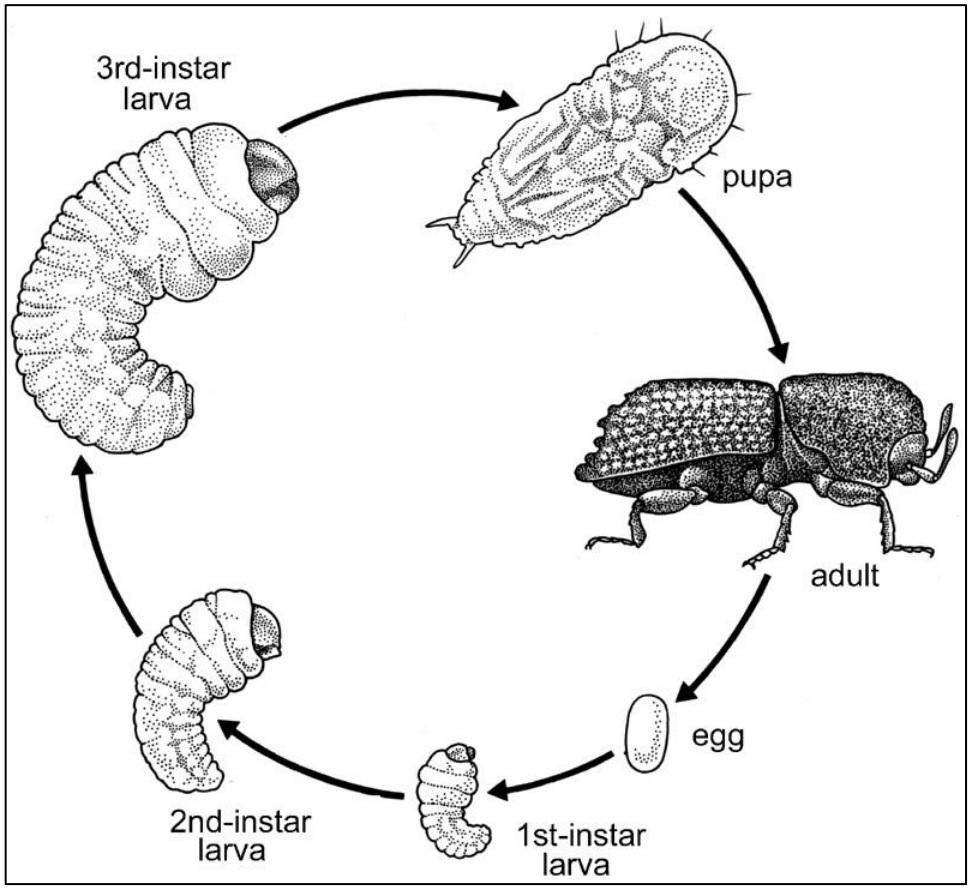
Les raisons du succès ?

- Petite taille
- Multigénérationnel
- Vol
- Métamorphose
- Large gamme de régime alimentaire
- Large variété de (micro)habitats utilisés

Métamorphose

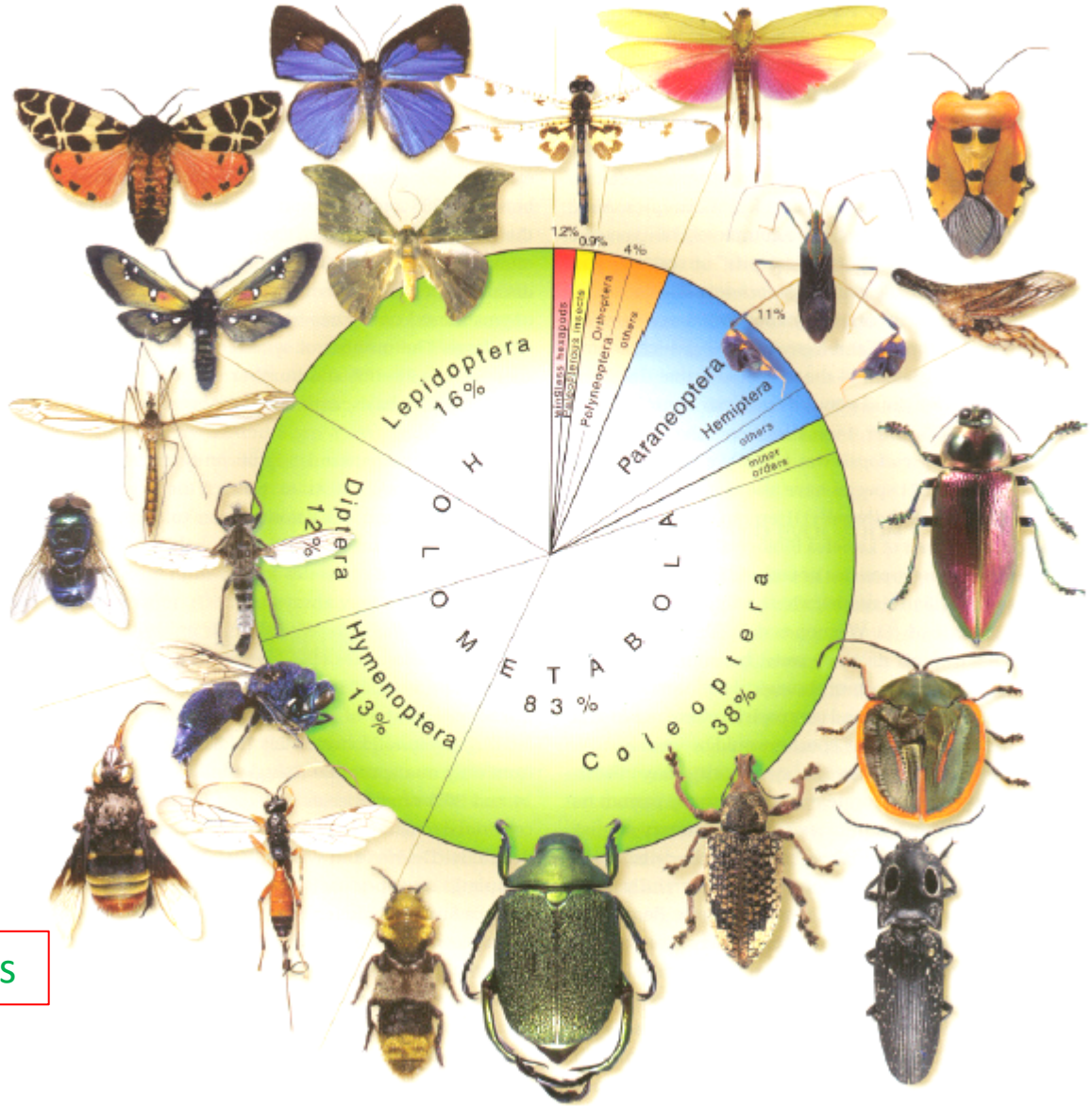


Incomplète
(Hémimétaboles)



Complète
(Holométaboles)

HYMENOPTERA



1.6. The diversity of Recent hexapods as proportions of named species.

Hyménoptères

LES HYMENOPTERES

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Order Hymenoptera*

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Abstract

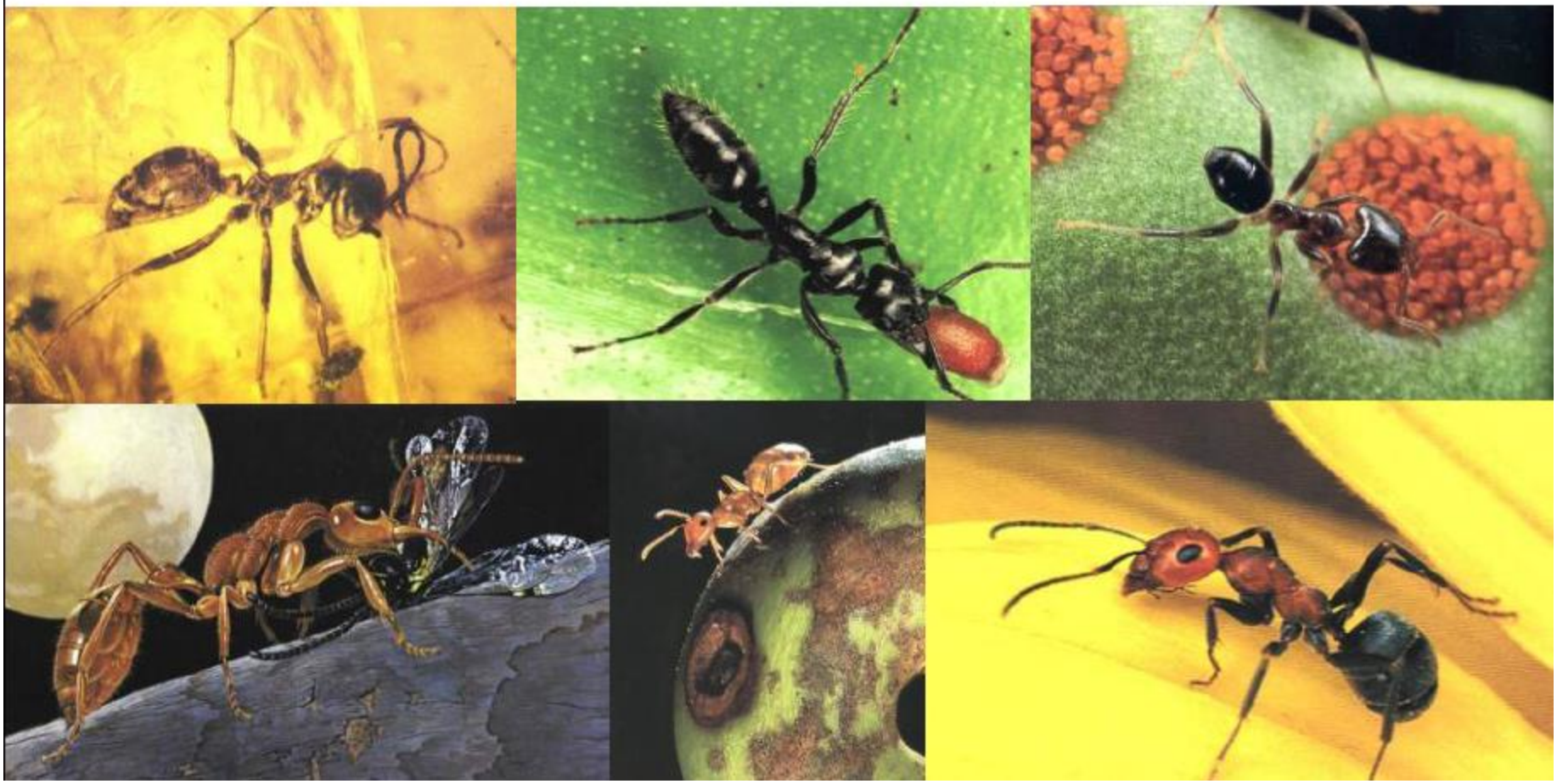
An updated classification of the order Hymenoptera is provided with the current numbers of genera and species described so far specified. The order is composed of 2 suborders, 27 superfamilies, 132 families, 8423 extant genera with an additional 685 extinct genera. Considered one of the most species-rich insects orders a total of 153088 extant species have been described, in addition to 2429 extinct species.

Key words: Hymenoptera, wasps, bees, ants, classification, diversity

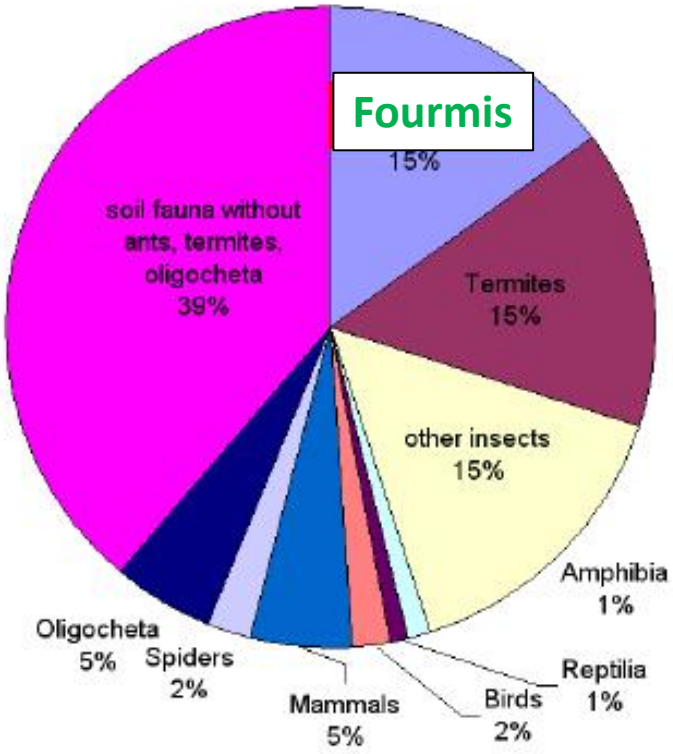
Published: 30 Aug. 2013

Family **Formicidae**[38] Latreille, 1802 (299 (and †132) genera, 12199 (and †620) species)

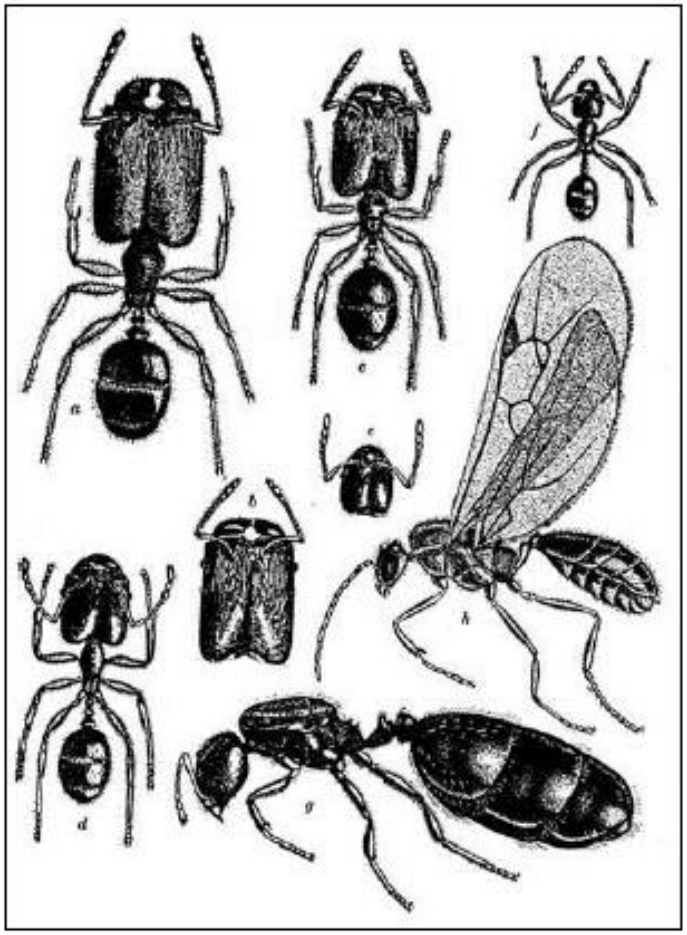
Fourmis: Au moins 100 millions d’années et autour de 25 000-30 000 espèces estimées



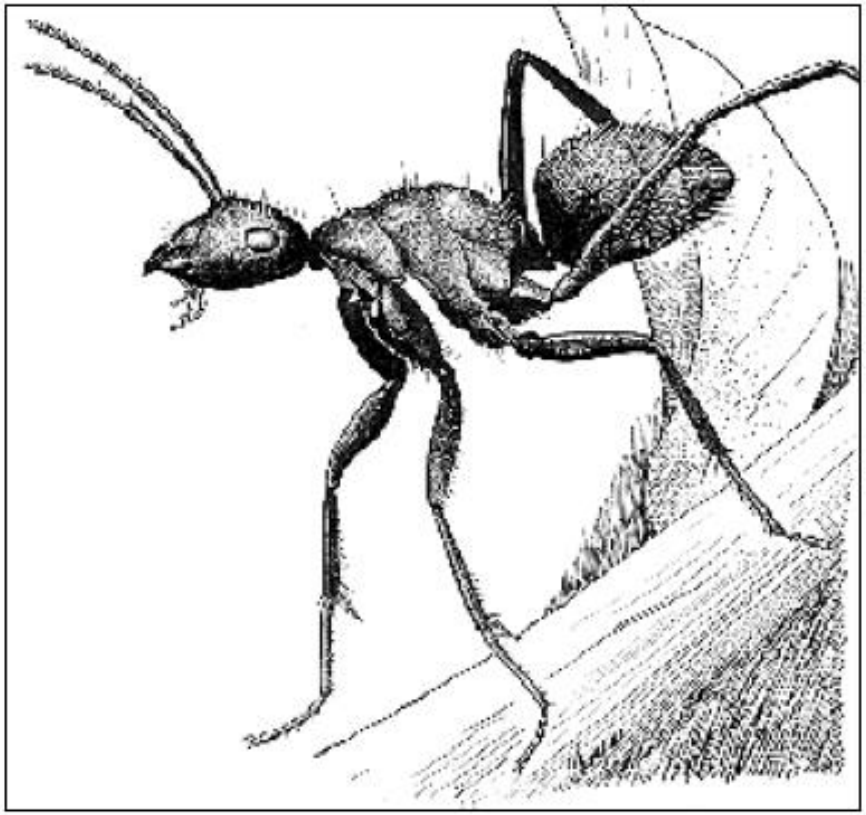
Pourquoi s'intéresser aux fourmis?



3. Caractéristiques des Formicidae

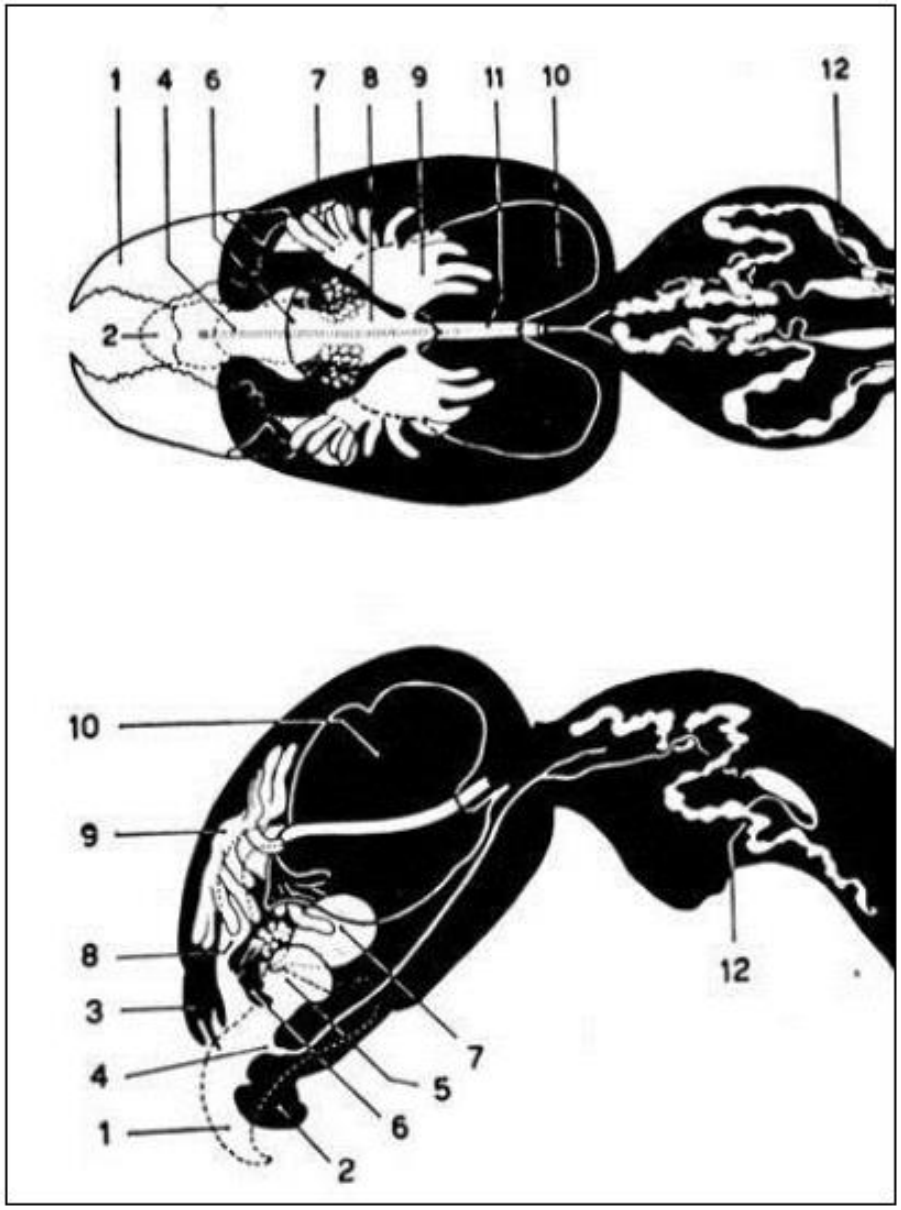


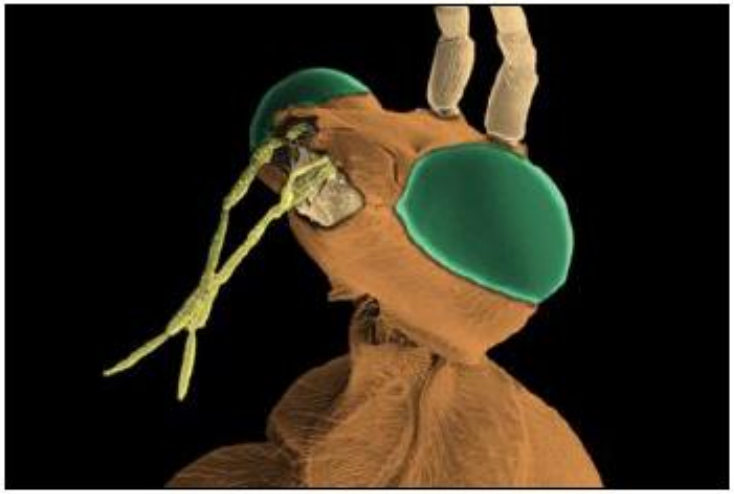
Les fourmis sont **eusociales**, avec une **caste** ouvrière aptère.



Tête prognathe

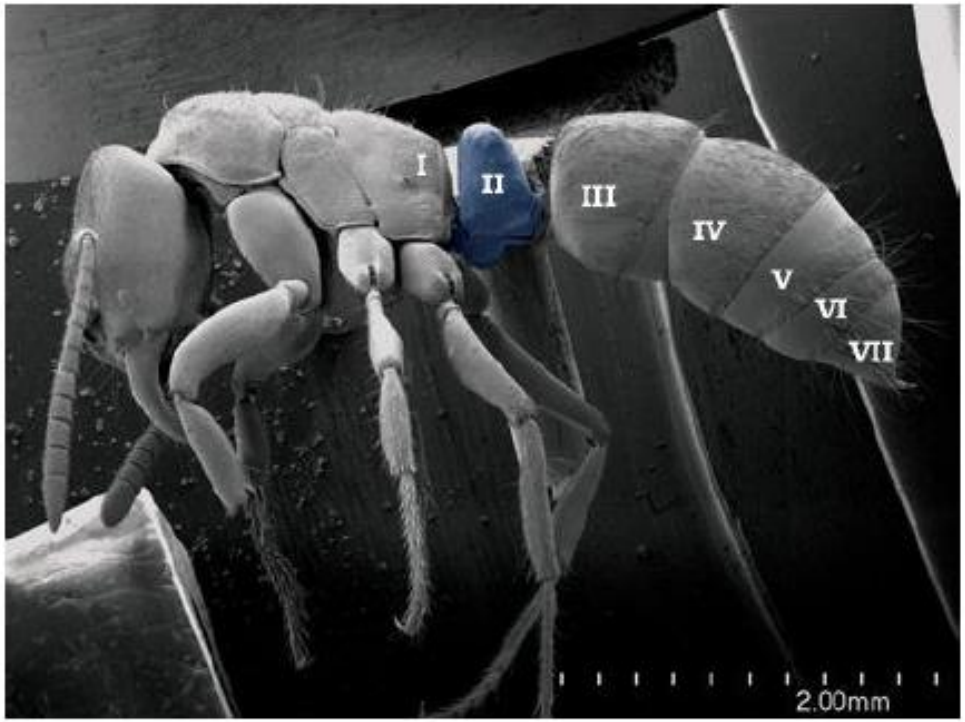
Présence d'une **cavité infrabuccale**



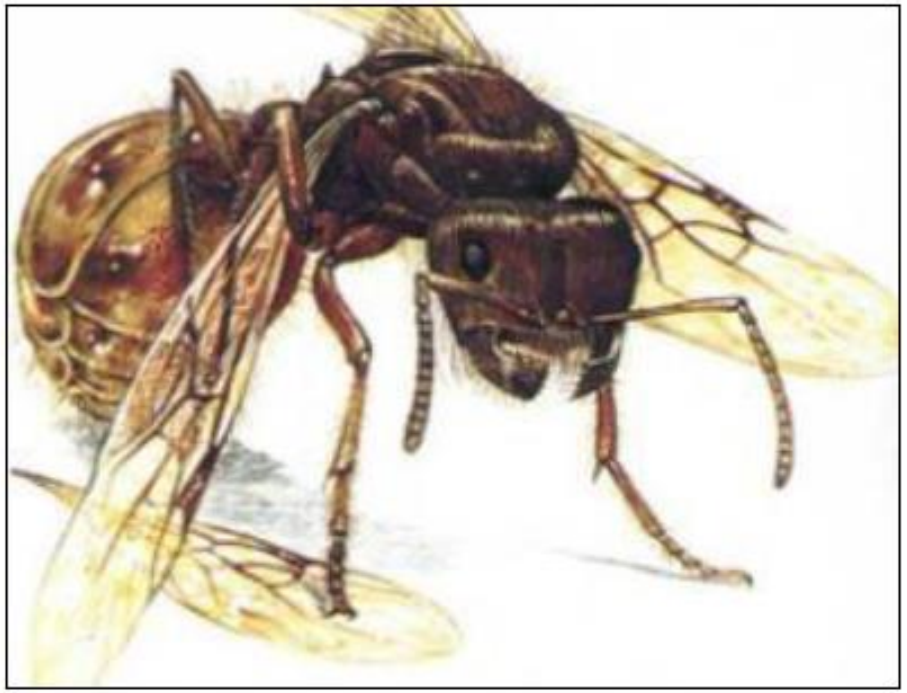


Antennes coudées (scape)

Glande métapleurale

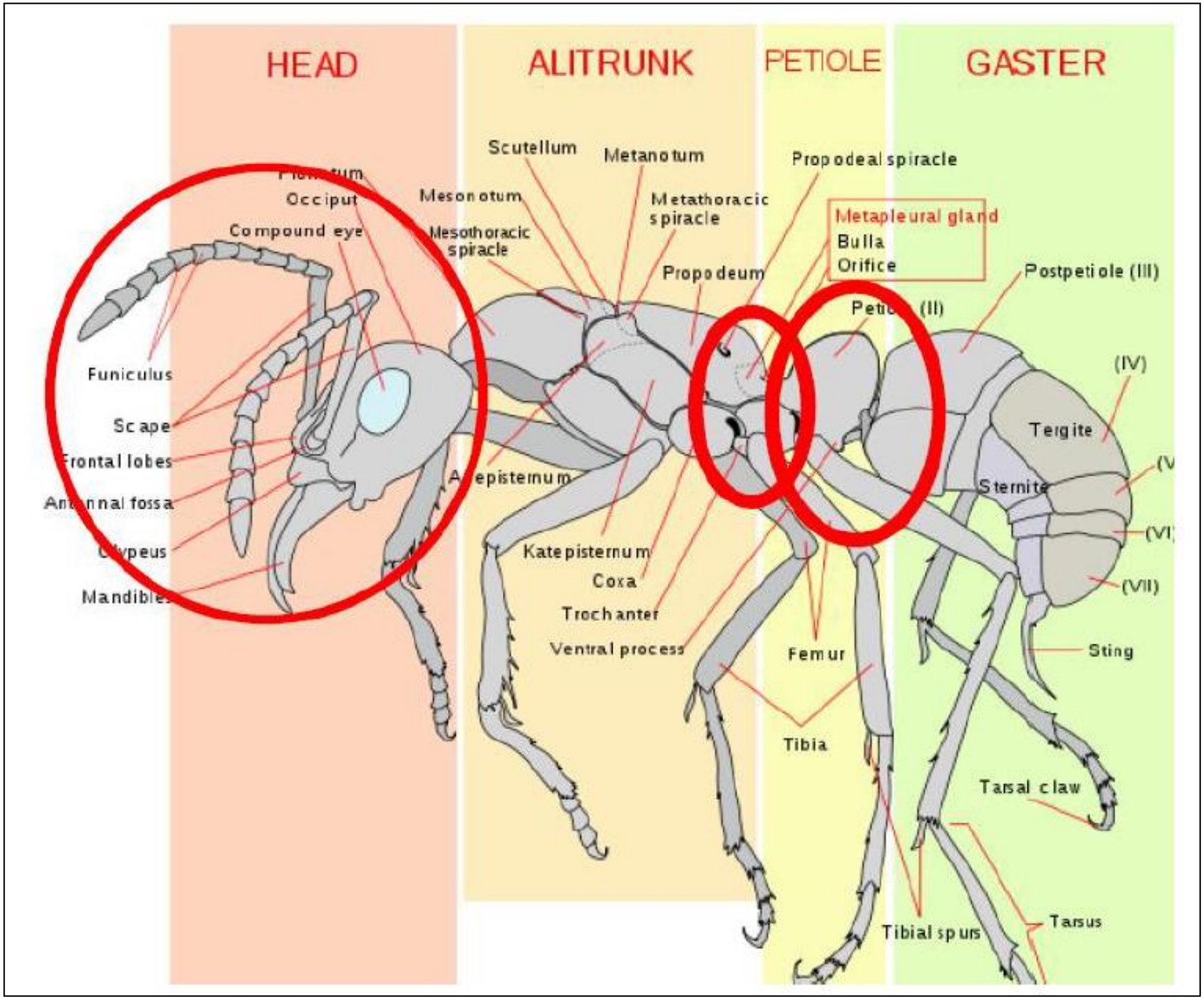


Pétiole (et postpétiole)



Ailes temporaires

Vols nuptiaux
souvent en masse
(Essaimage)


HEAD
ALITRUNK
PETIOLE
GASTER
Scutellum
Metanotum
Propodeal spiracle
Occiput
Mesonotum
Metathoracic spiracle
Metapleural gland
Bulla
Orifice
Compound eye
Mesothoracic spiracle
Propodeum
Postpetiole (III)
(II)
(IV)
Funiculus
Scape
Frontal lobes
Antennal fossa
Clypeus
Mandibles
Tergite
Sternite
Katepisternum
Coxa
Trochanter
Ventral process
Femur
Sting
Tibia
Tarsal claw
Tibial spurs
Tarsus

Attention aux myrmécomorphes!

4. Biologie des Formicidae

Queen

Male

Normal-sized worker Soldier

Les colonies sont les unités de cohésion chez les fourmis. Elles occupent généralement un nid composé d'une ou plusieurs reines, d'ouvrières, d'immatures, et parfois de mâles.

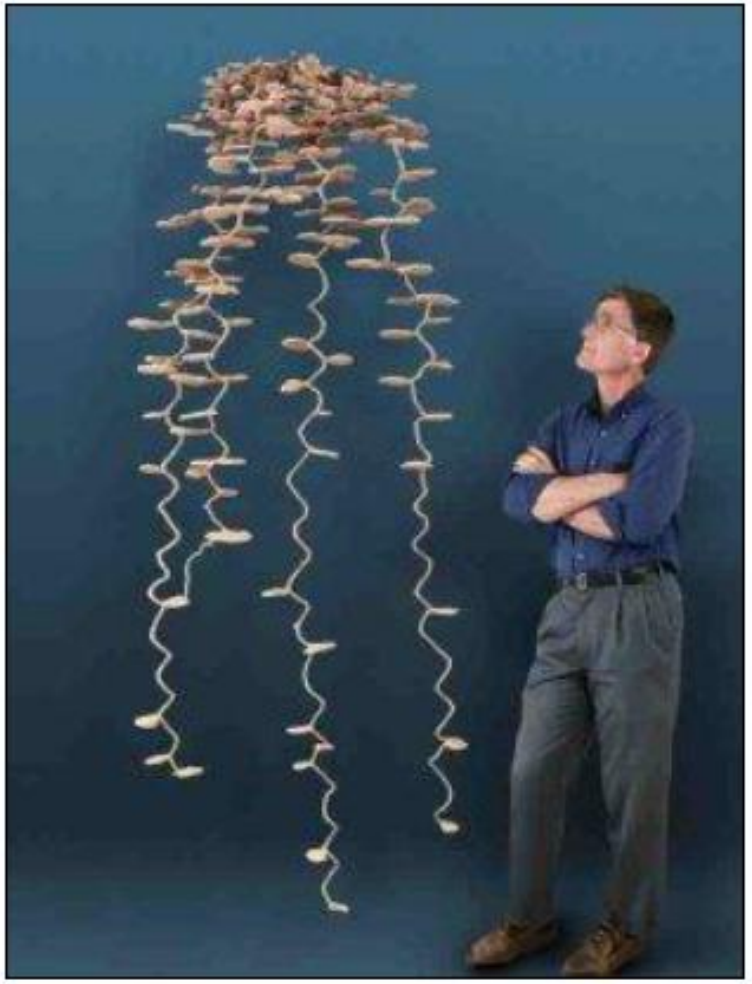
Dinoponera

Paraponera

Dorylus

Dorylus

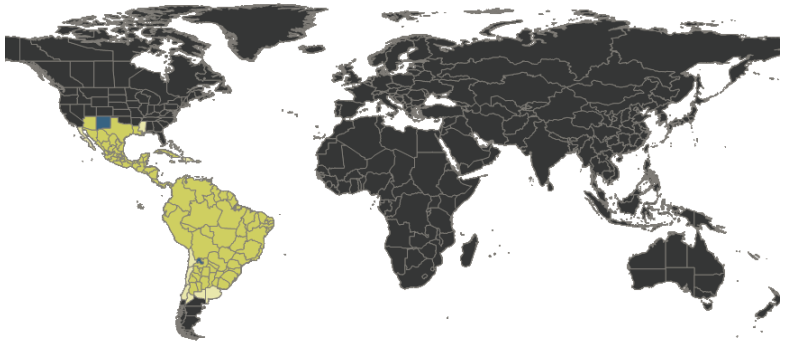
The size of ants and the colonies they form—the superorganisms—vary enormously. An entire colony of *Brachymyrmex* from South America (a worker of which is shown peeking from behind the antenna of a Bornean carpenter ant *Camponotus gigas*) would fit into the head of the larger ant. (Scanning electron micrograph by Ed Seling.)



Les nids des fourmis sont simples et peuvent être trouvés du sol à la canopée.

La majorité sont **multicoloniales** (colonies dans des nids séparés), d'autres sont **polydomiques** (colonie occupe plusieurs nids), certaines sont **unicoloniales** (limite entre colonies différentes sont floues).

Atta sp.

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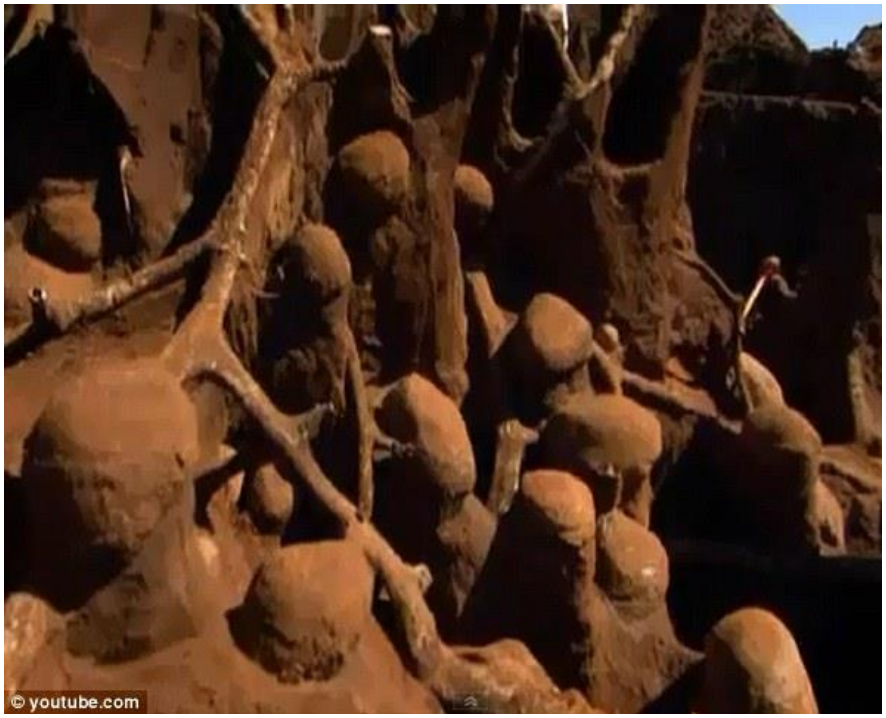
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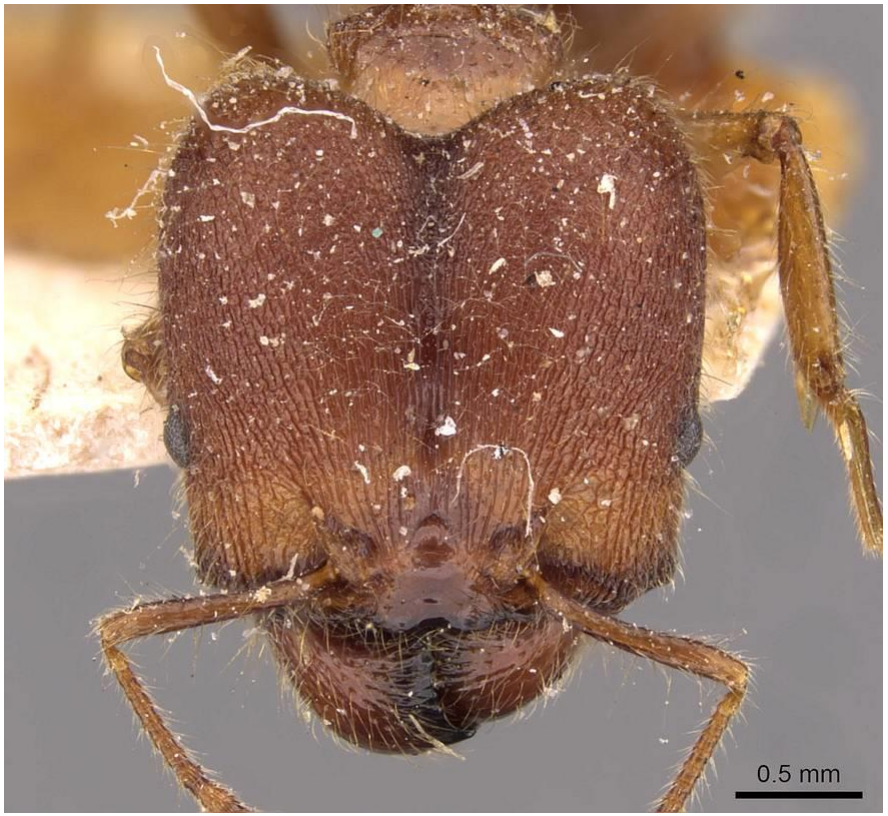
A.


B.


C.


D.
Delsinne (2007)

Pheidole sykesii



Formica rufa

Richard Bartz

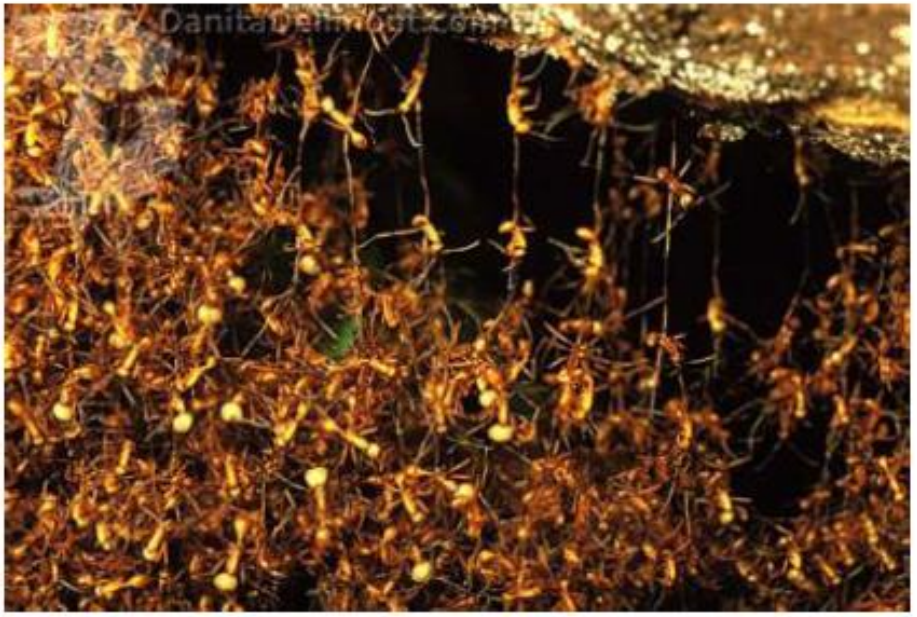
Thue

Une fraction importante des fourmis nidifient à la surface du sol (litière forestière, cavités naturelles, bois mort).

Divers groupes de fourmis vivent dans la canopée, où certaines construisent des nids relativement complexes (Ex: *Crematogaster*).

D'autres fourmis, souvent plus petites, peuvent vivre dans la litière suspendue, dans de petites branches ou en association avec des plantes (myrmécophytes).

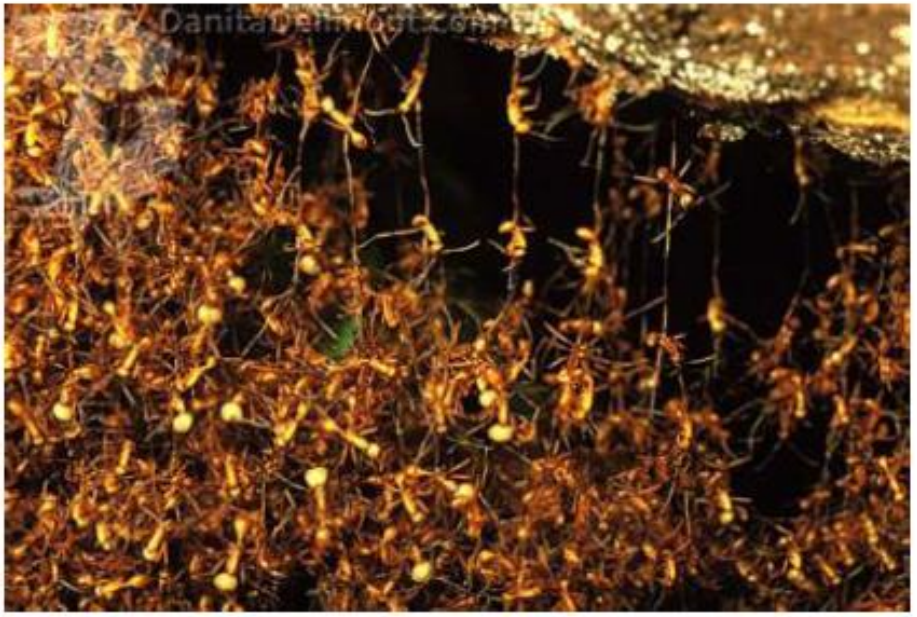
Nylanderia



Eciton spp.

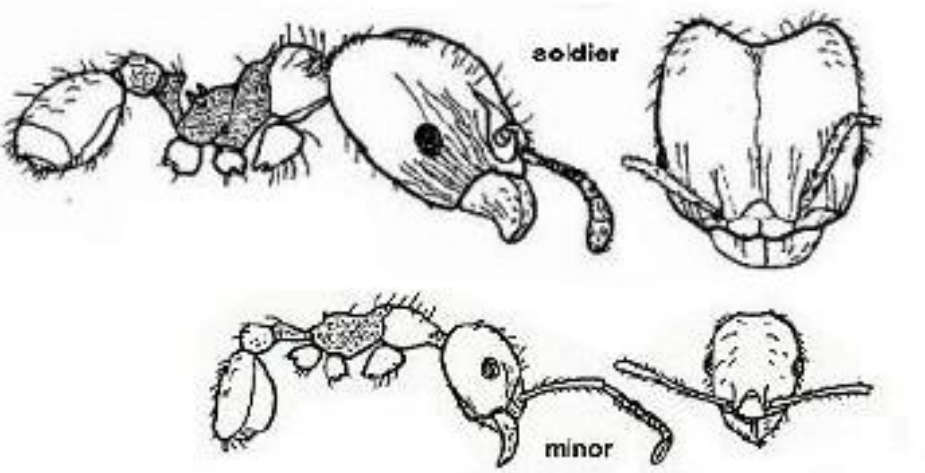
http://www.powell-lab.net/ants/

http://www.powell-lab.net/ants/



Monomorphisme

La grande majorité des fourmis sont monomorphiques (pas de différence de taille entre ouvrières). Certaines espèces peuvent présenter de petites variations allométriques.



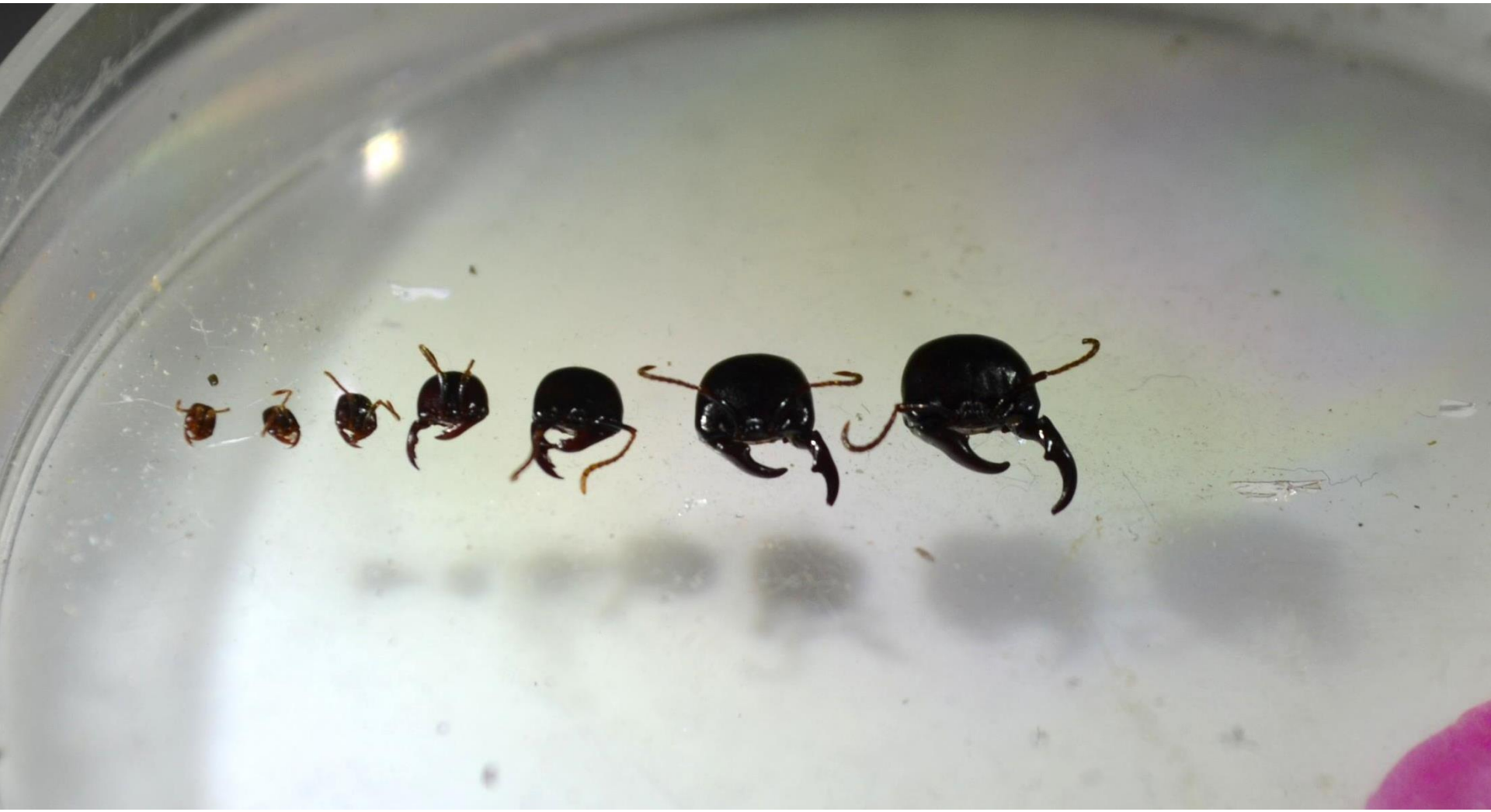
Dimorphisme

Ecitoninae (sauf *Eciton*). Myrmicinae: *Carebara, Monomorium, Crematogaster, Pheidole, Solenopsis*. Formicinae: *Camponotus*. Dolichoderinae: *Azteca*.

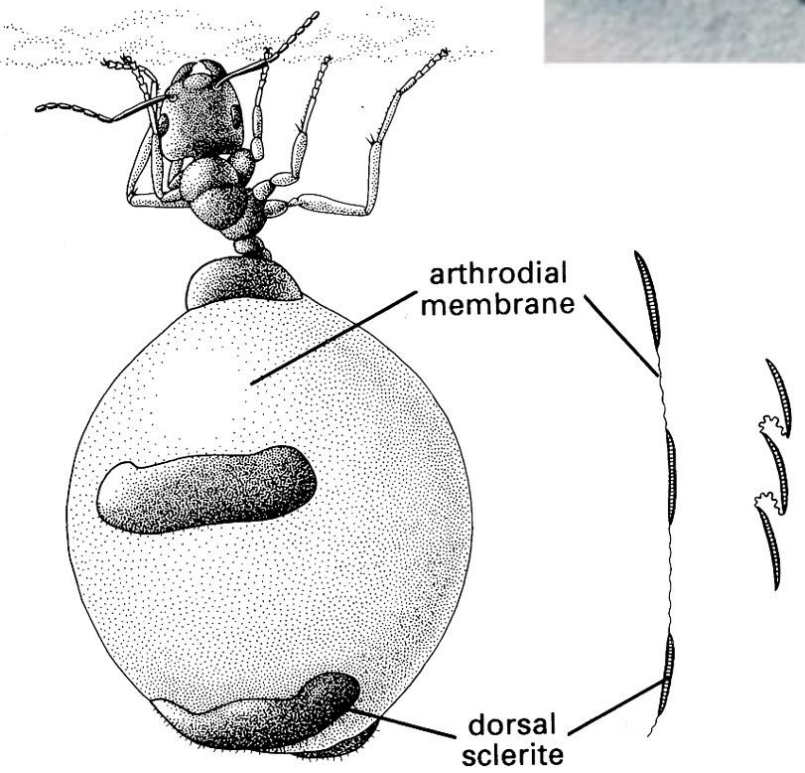
Polymorphisme

Ecitoninae: *Eciton*. Dorylinae: *Dorylus.* Myrmicinae: *Crematogaster, Solenopsis, Pheidolegeton*. Formicinae: *Camponotus*.

Dorylus



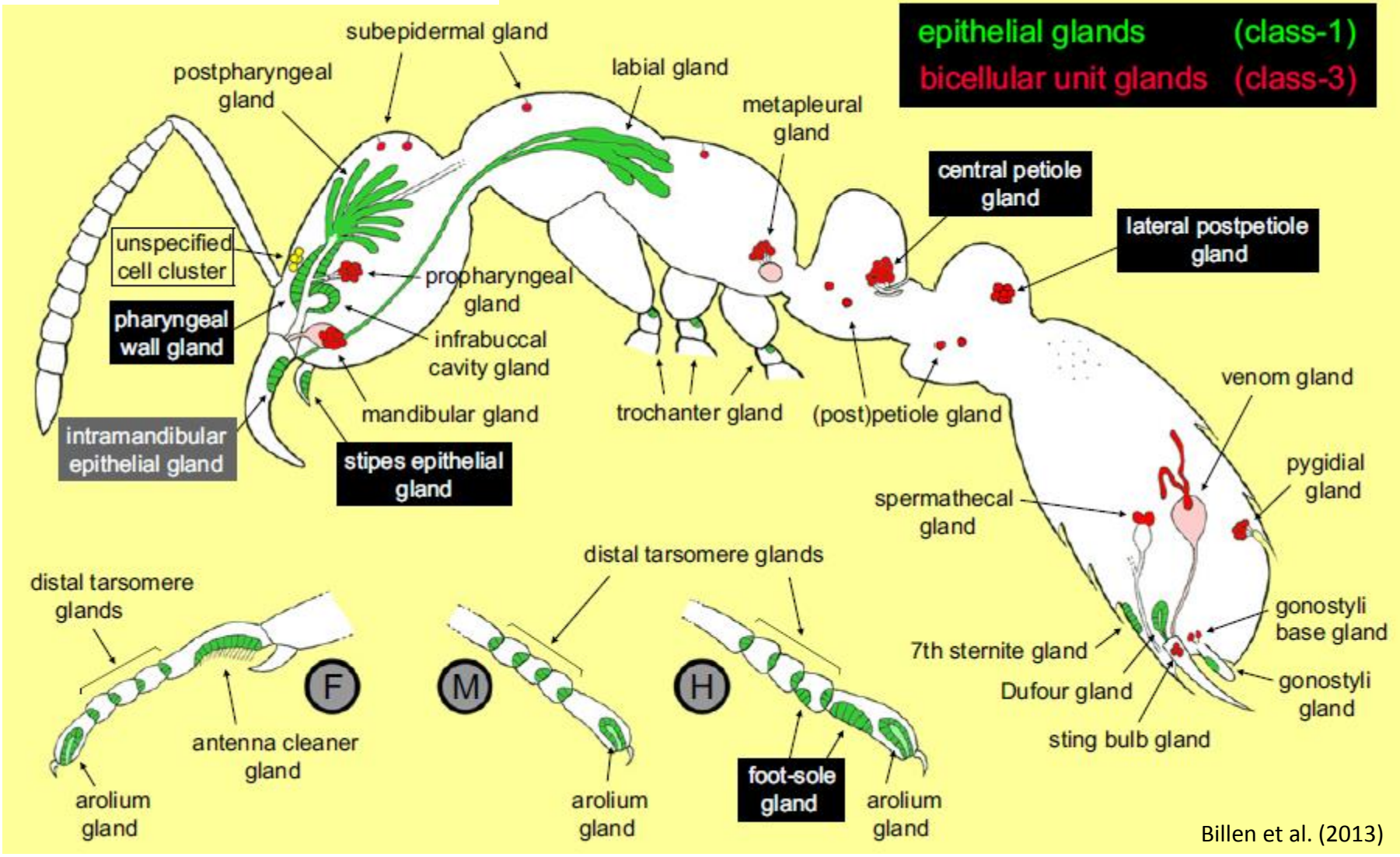
Spécialisation des castes



Fourragement

Les fourmis cherchent leur nourriture de façon **solitaire** ou en **groupes** de tailles variables. Certaines utilisent des **phéromones** de recrutement pour exploiter les sources alimentaires.

Communication



Billen et al. (2013)

La communication entre fourmis est vitale. Elle s'effectue principalement via des **phéromones** produites par une large gamme de **glandes** réparties sur tout le corps (84 connues).

Alimentation

Les fourmis utilisent de nombreuses sources alimentaires, très variées. Certaines sont des prédatrices généralistes, d'autres sont spécialistes de certaines proies.

Thaumatomyrmex

1000 µm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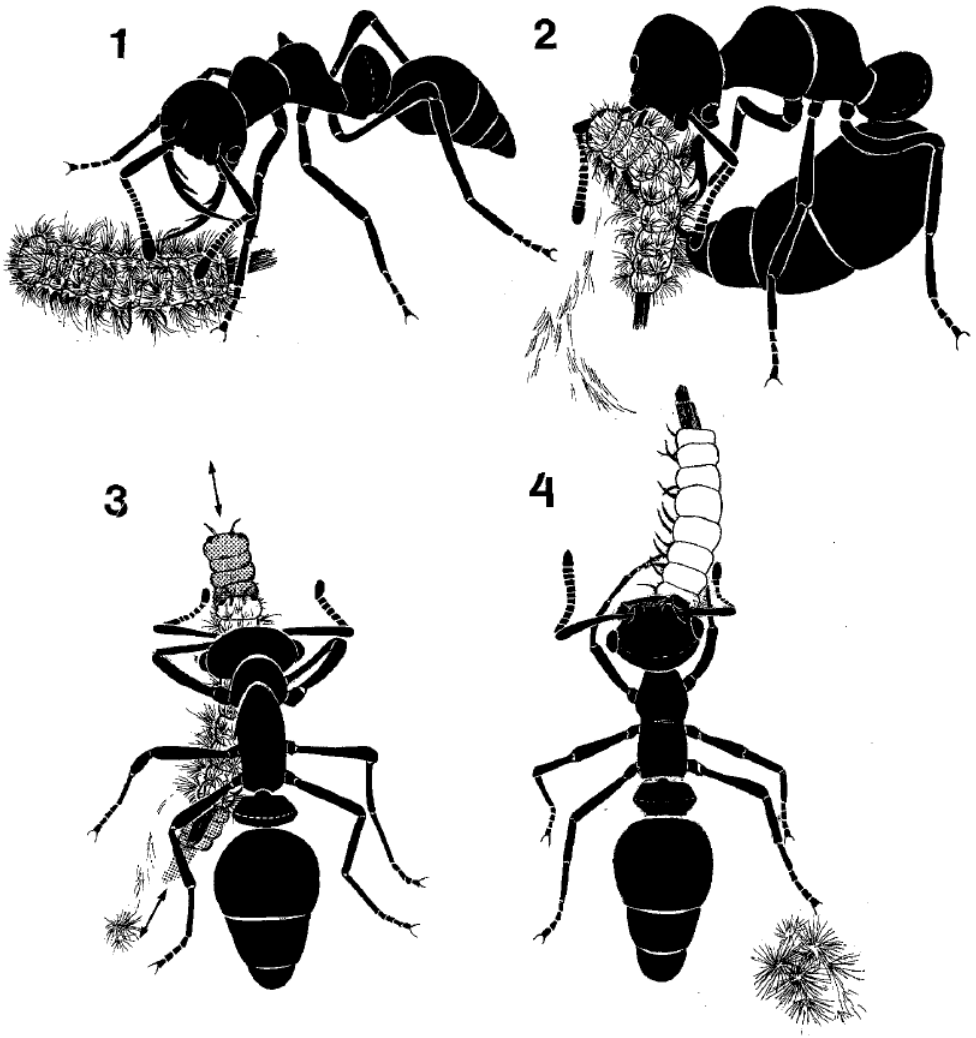
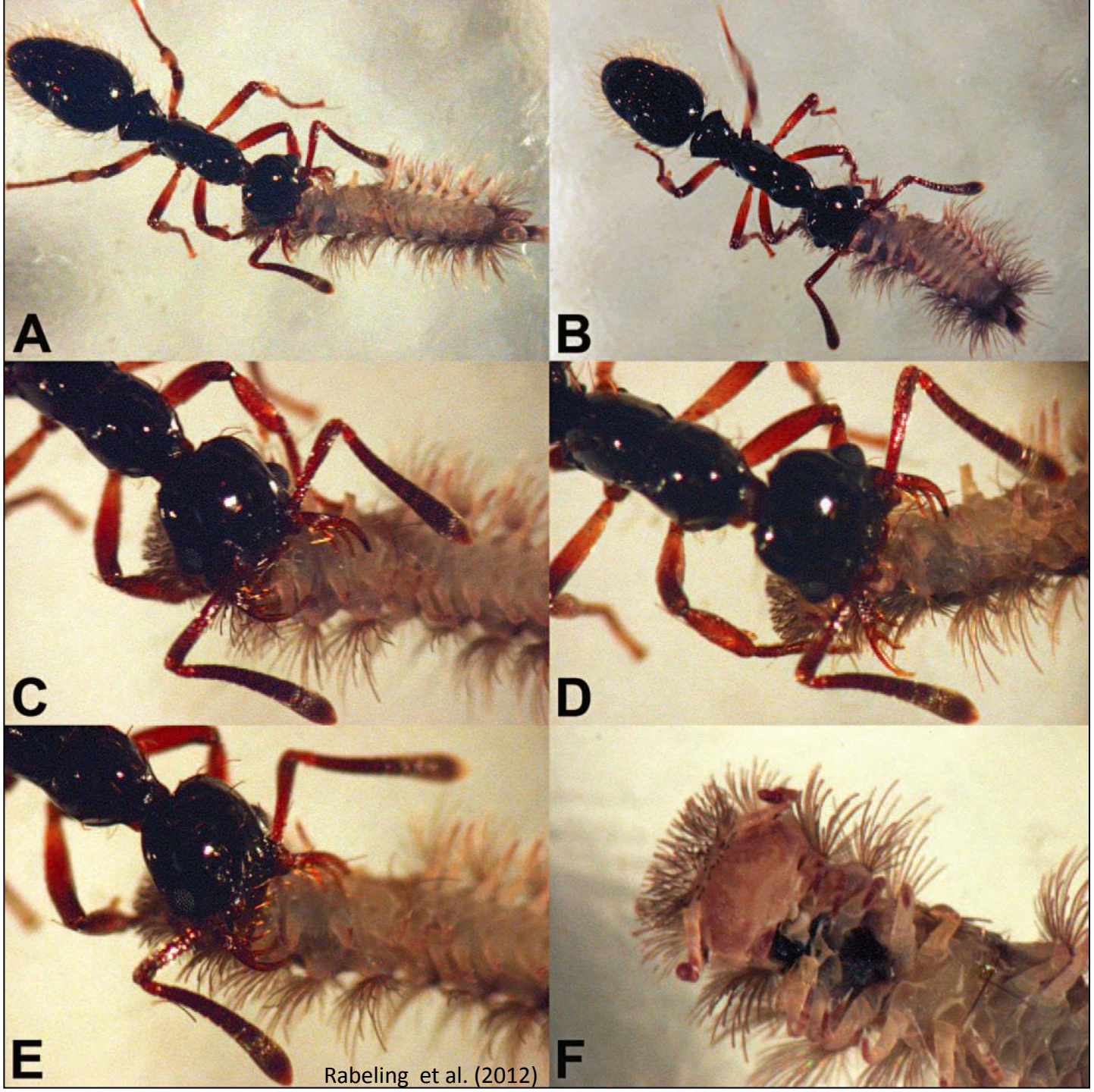


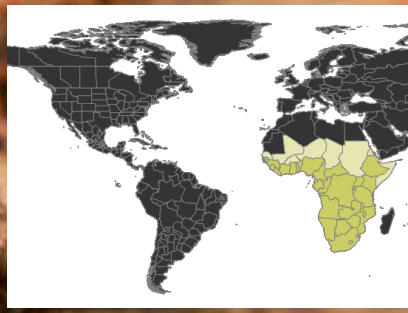

Myriapoda: Polyxenida


© Mark W. Moffett/Minden Pictures



Rabeling et al. (2012)

Plectroctena



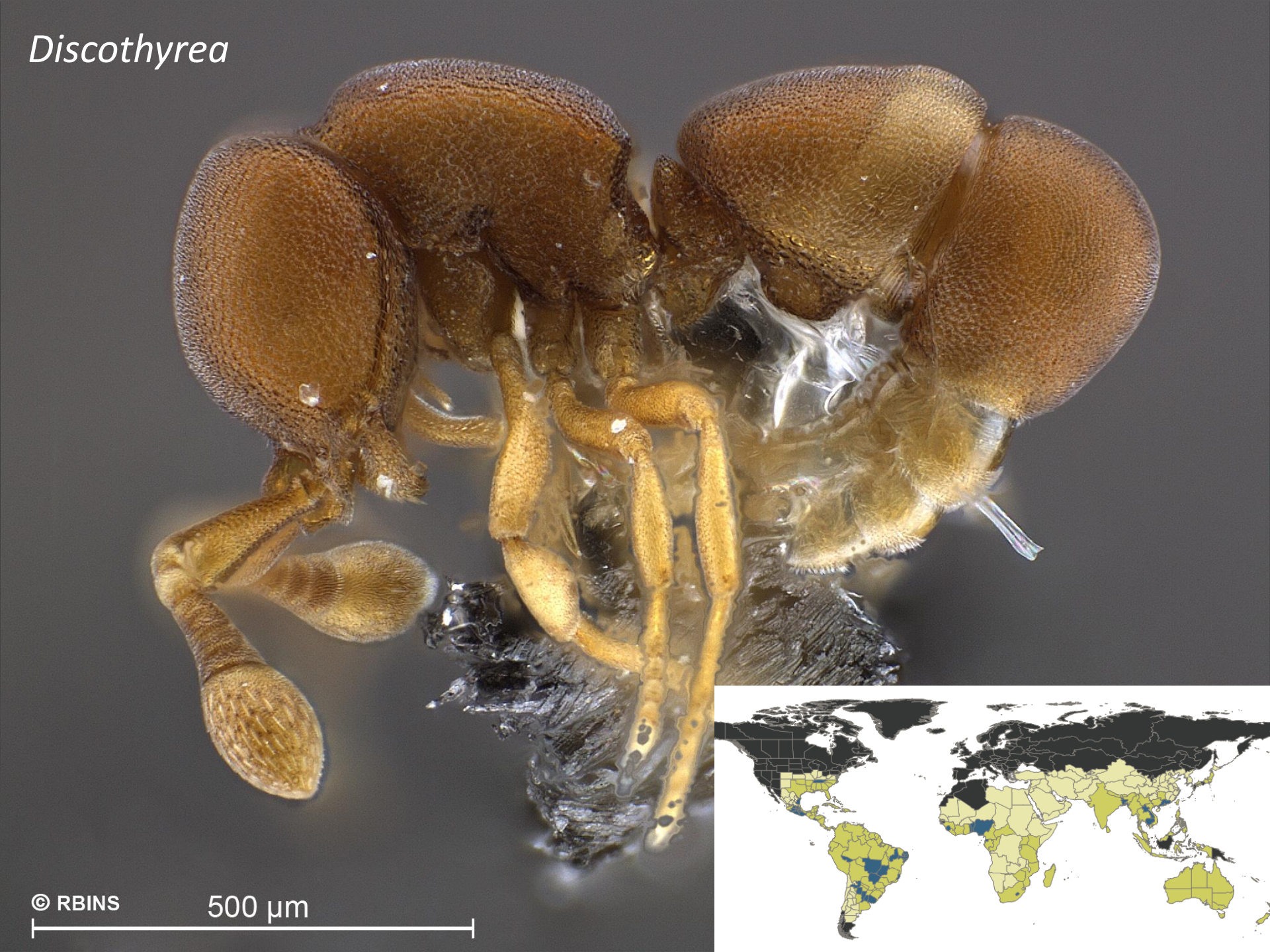
Paul Bertner


Paul Bertner

Paul Bertner

Leptogenys

Discothyrea



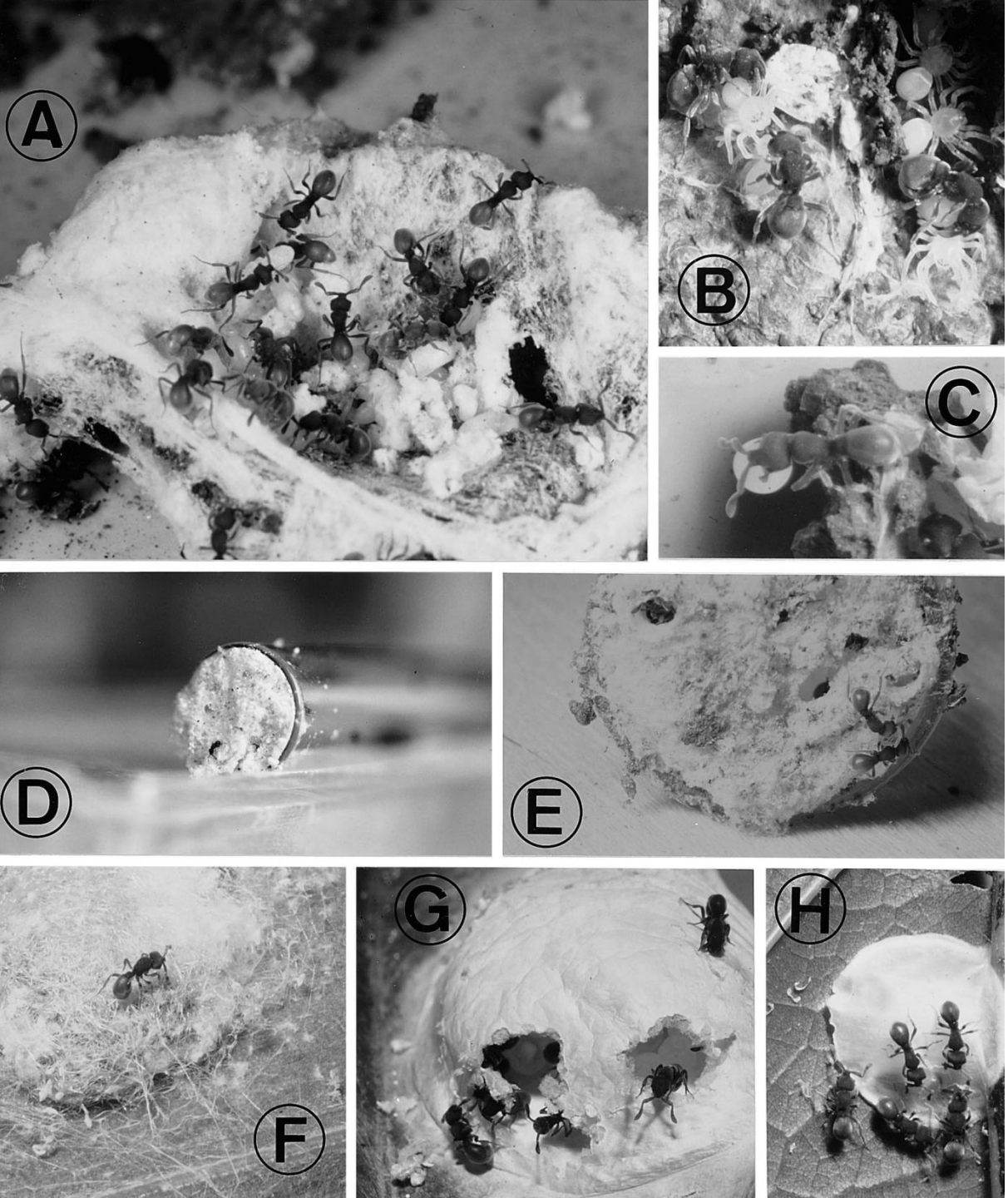
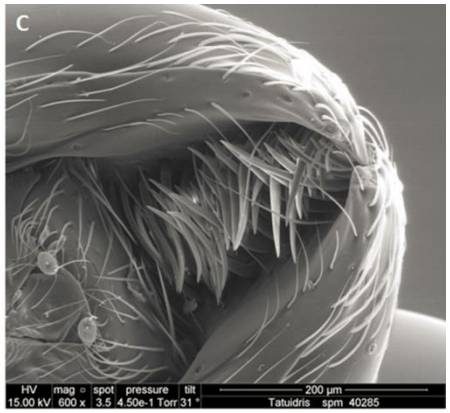
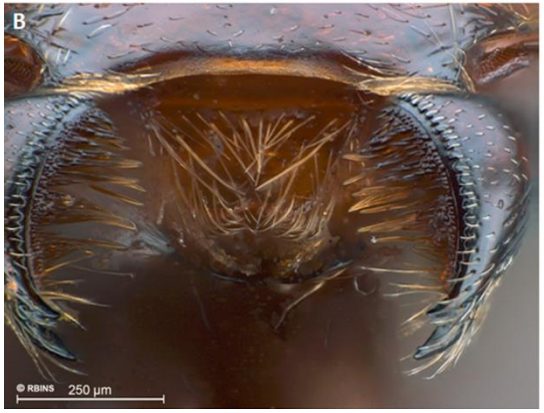


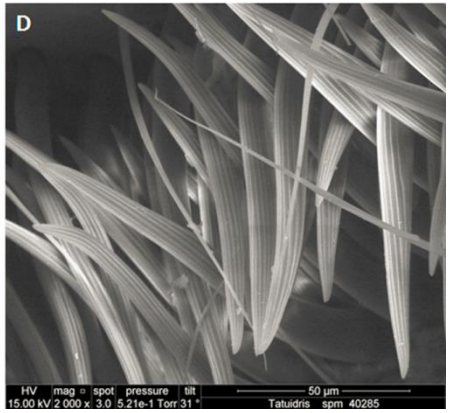
Fig. 1. A) Opened nest of D. oculata discovered in a cavity of a Crenetermes albotarsalis mound. In reality this ant colony had moved into a nest of Raecius sp., a cribellatid spider, thus the crimped appearance of the thick coat of silk lining the cavity. Note the presence of both white and pigmented naked nymphs and of spherical spider eggs. B) Workers attacking and stinging spiderlings that tried to escape. C) A worker retrieving a spider egg to her nest. D) In the laboratory, workers operculate the test tubes used as artificial nests with the silk of the spider oothecas that they retrieved and manipulated with their mandibles and forelegs. E) Detailed view showing the orifices by which the workers go in and out. F) Spider ootheca with strands of silk that remain separated; a worker antennates the silk before opening an entrance. G) Spider ootheca with strands of silk welded together, forming a protective film around the eggs; recruited workers are opening entrances with their mandibles. H) Recruited workers arriving on a spider ootheca not previously opened by the scouting worker who discovered it

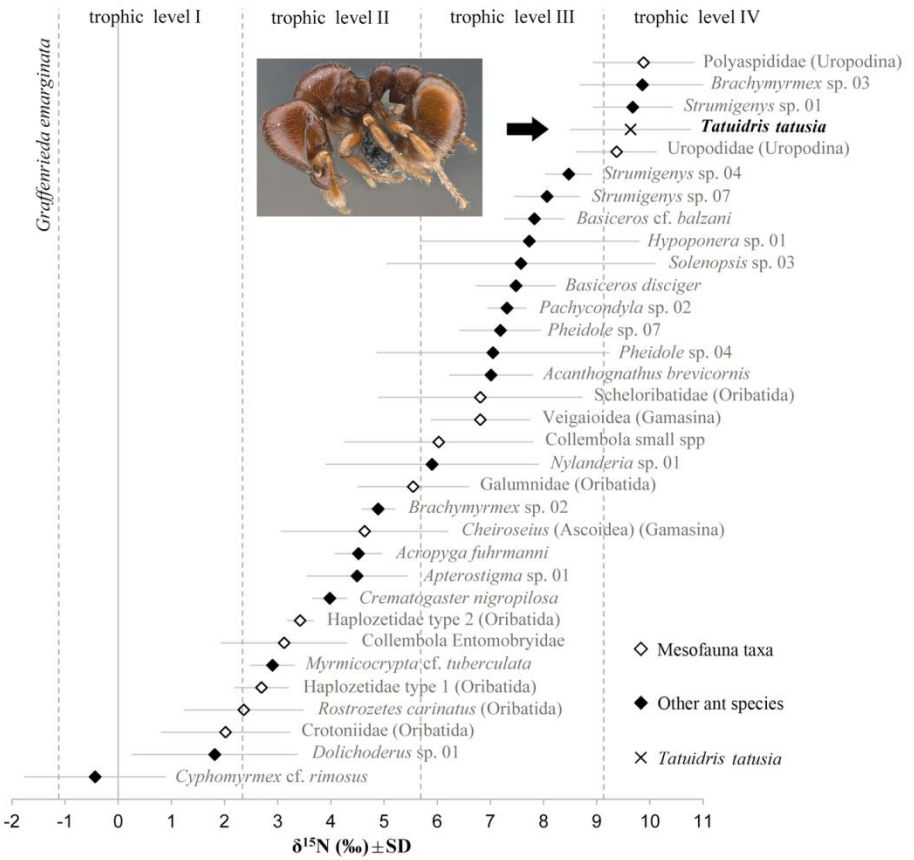
Dejean et al. (1999)

Tatuidris tatusia

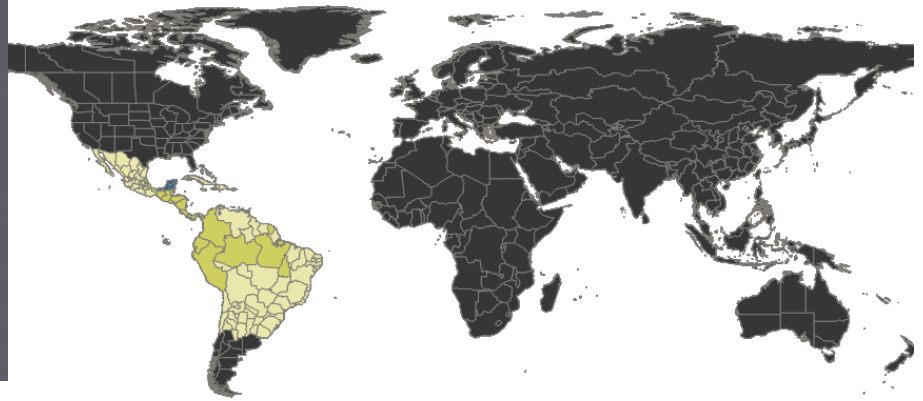








Jacquemin et al (2014)



Lenomyrmex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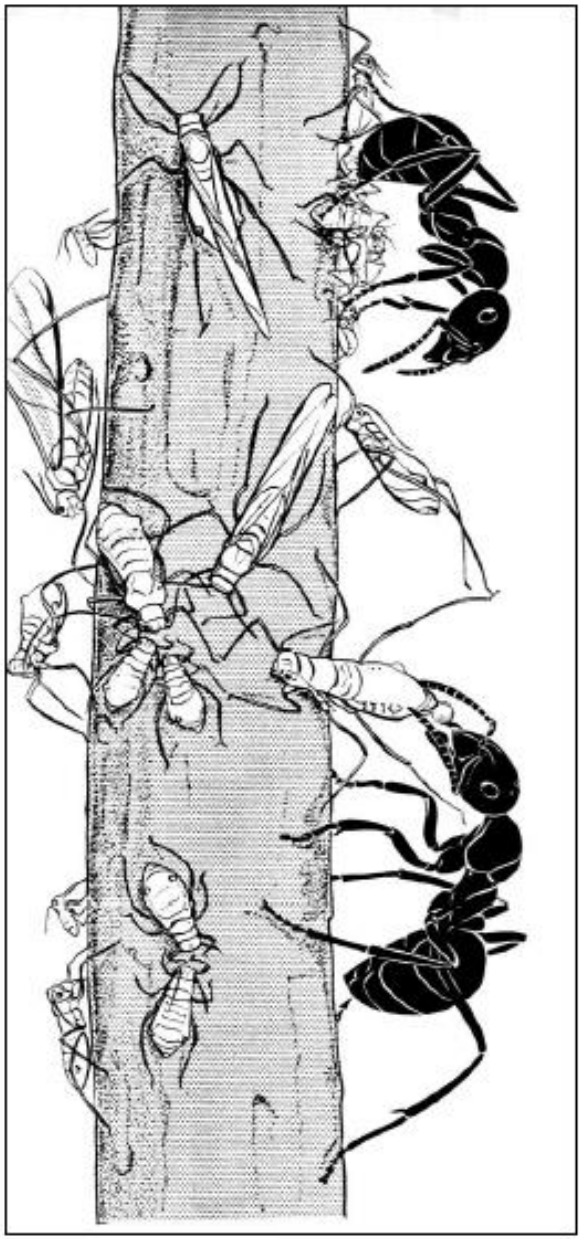
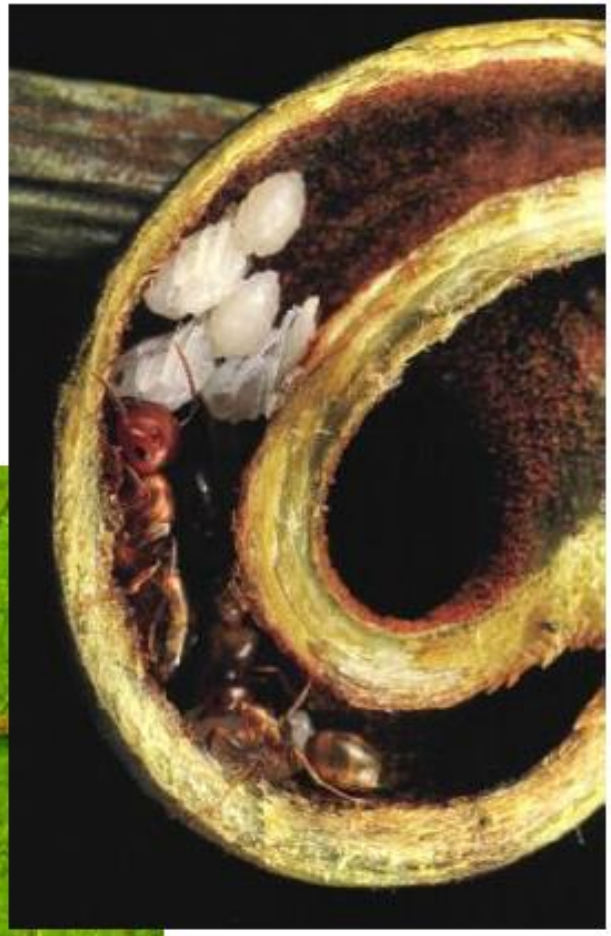


Miellat
d'hémiptères
(*honeydew*)

Acropyga - Hemiptera: Pseudococcidae



Myrmécophytes

Certaines plantes possèdent une ou plusieurs structures pour attirer les fourmis: nectaires extrafloraux, corps de Belt ou de Müller, domaties.

Cordia nodosa
(Boraginaceae)

« Jardines del Diablo »

Clidemia - Myrmelachista

Caularthron bilamellatum
(Orchidaceae)

Dischidia (Apocynaceae)-*Philidris* (Dolichoderinae)

Peeters & Wiwatwittaya (2014)

Nepenthes bicalcarata (Nepenthaceae) - *Camponotus schmitzi* (Formicinae)


Jeremiah Harris


Vincent Bazile


Christian Ziegler


Christian Ziegler

Barteria (Passifloraceae) – *Tetraponera* (Pseudomyrmecinae)

Arbre de l'adultère

THE ROYAL SOCIETY

Received 4 April 2002
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Tetraponera ants have gut symbionts related to nitrogen-fixing root-nodule bacteria

Steven van Borm[1], Alfred Buschinger[2], Jacobus J. Boomsma[3] and Johan Billen[1*]

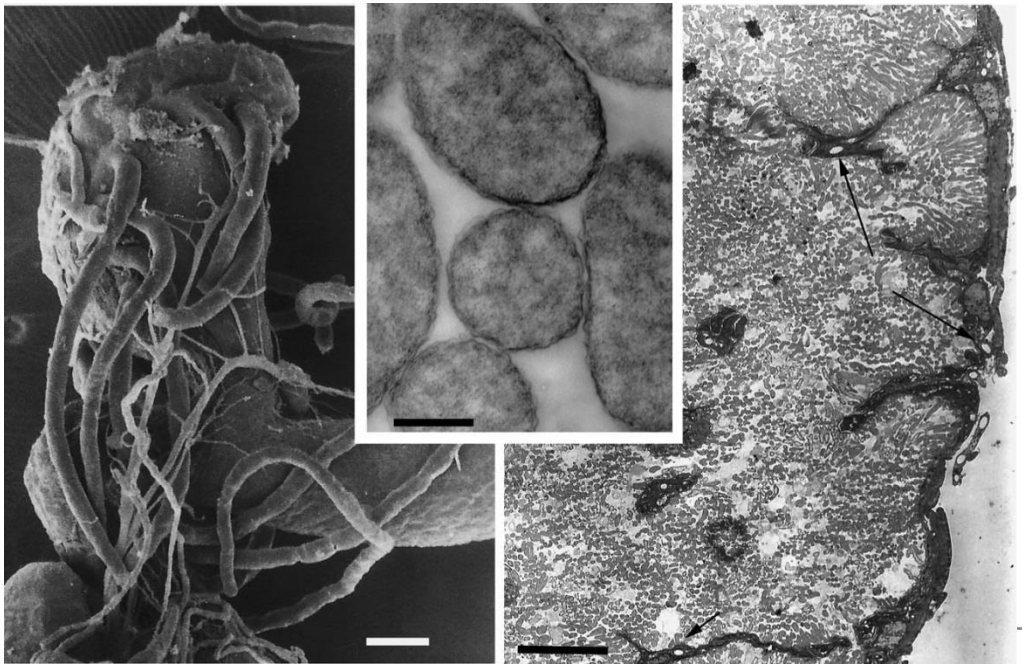


Figure 1. Electron micrographs of the bacterial symbionts and the gut pouch of a worker of the *ant Tetraponera binghami*. (a) Scanning electron micrograph showing the bacterial pouch (BP), Malpighian tubules (mt) and tracheal air supply. The intestine (INT) and midgut (MG) are also visible (scale bar, 100 µm). Reprinted from J. Billen & A. Buschinger 2001, with permission. (b) Detail (transmission electron micrograph (TEM)) of the bacterial contents of the pouch lumen (scale bar, 0.5 µm). (c) Overview (TEM) showing typical bacterial aggregations associated with the inner epithelium (right hand side of the figure) at the tip of the pouch. Cross-sections through tracheae (tr) are also indicated (scale bar, 10 µm).

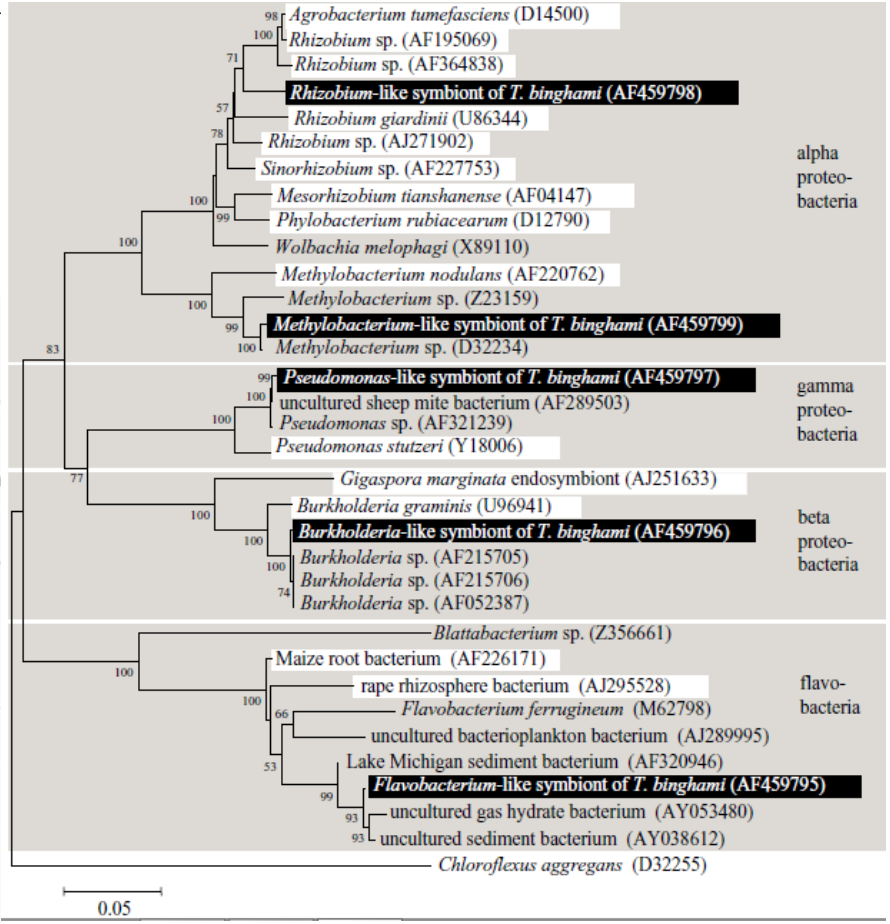


Figure 2. Rooted neighbour-joining tree showing the symbionts of *Tetraponera binghami*, their closest relatives and reference strains, based on aligned partial 16S rRNA-encoding sequences. Distances were calculated using the Kimura 2-parameter model in Mega 2.0 (the scale bar represents a distance of 5%). Bootstrap support values (1000 pseudoreplicates) above 50% are given next to the branches. Sequences generated in this study are indicated in white on a black background. Names of strains are followed by their GenBank accession numbers. Plant-associated symbiotic bacteria are indicated by a white background. Note *that Wolbachia melophagi*, a gut symbiont of *Melophagus* sheep keds (wingless bloodsucking flies), is unrelated to intracellular *Wolbachia pipientis* symbionts of arthropods (Birtles 1994).

Certaines fourmis construisent des nids pouvant former des **jardins de fourmis** dans lesquels poussent certaines plantes épiphytes plus ou moins spécialisées. Dans certains cas, plusieurs espèces de fourmis se partagent le jardin (**parabiosis**).

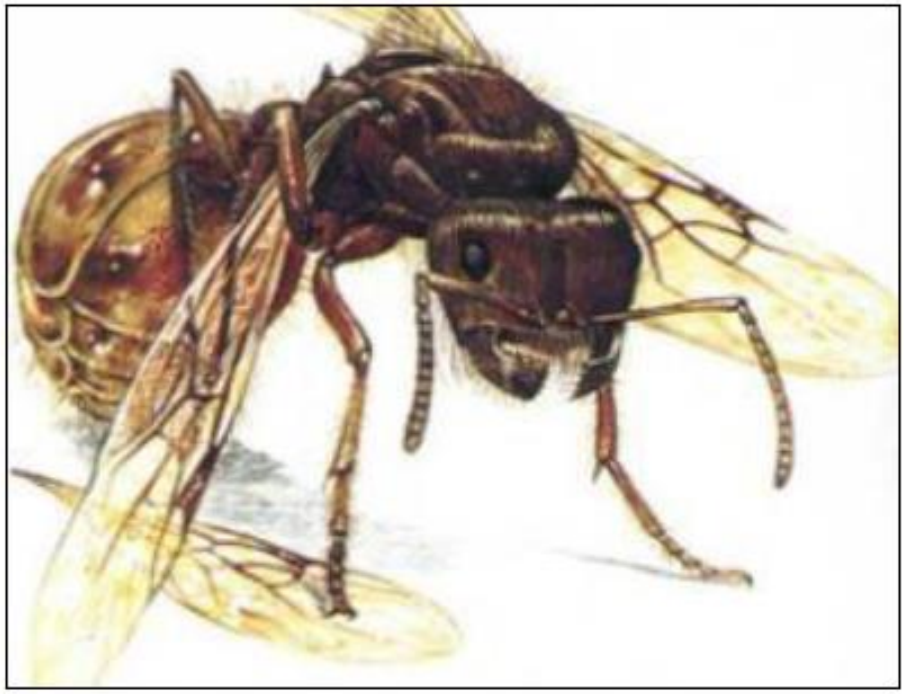
Fourmis tisserandes (*Oecophylla*)

Fig. 5 An *Oecophylla longinoda* worker is able to hold onto a small bird alone while its nestmates recruit other workers at long range, illustrating the power of the worker's claws and adhesive pads.

Dejean et al. 2007

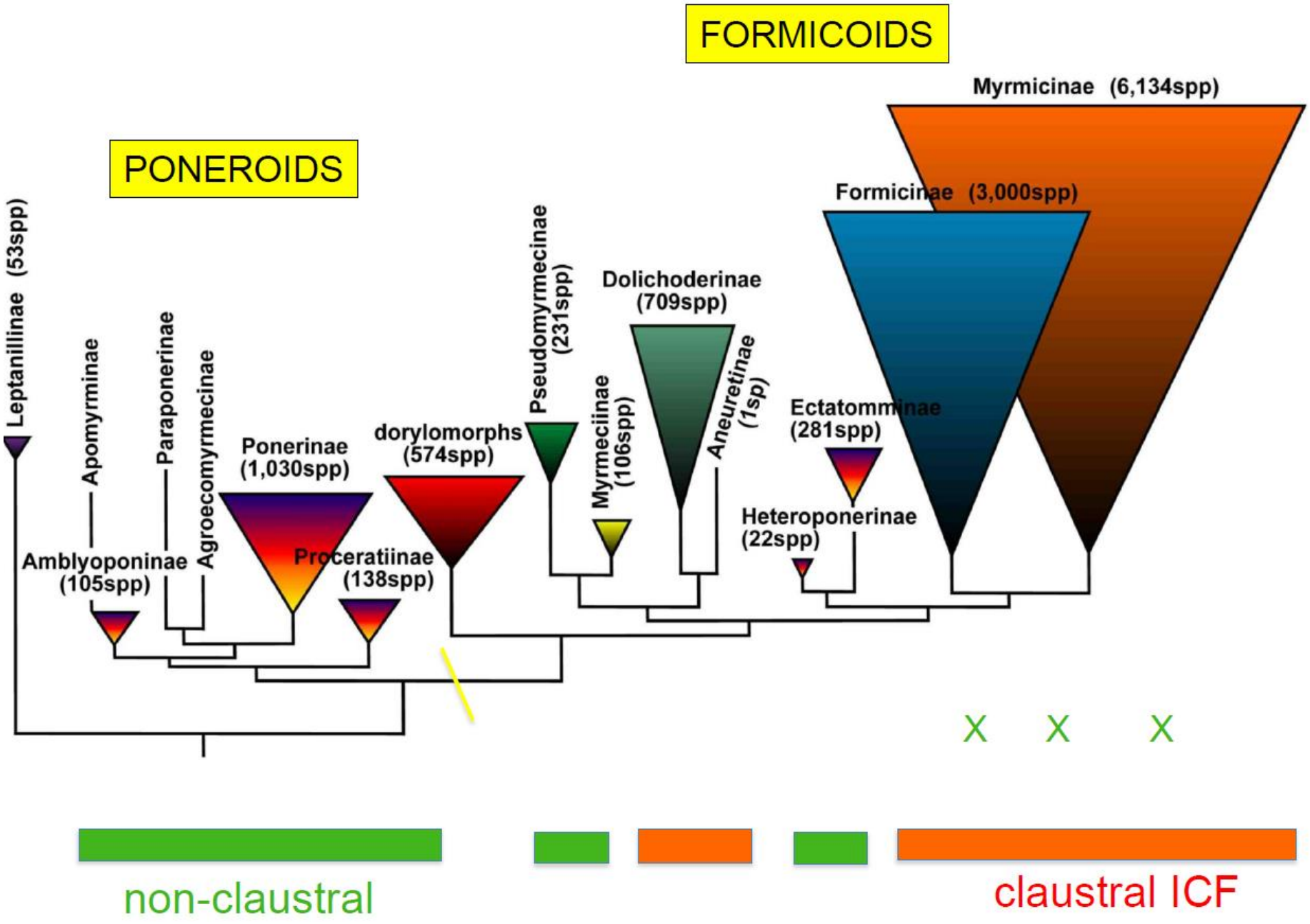
Impact des fourmis peut aussi être négatif pour la plante (via des associations avec des hémiptères pouvant fatiguer la plante ou transmettre des maladies).

Reproduction



Vols nuptiaux souvent en masse (**essaimage**) puis fondation de la colonie (nombreuses catégories: fondation dépendante, indépendante [= fission ou « budding »], male-aggregation, female calling, claustrale ou non, pléométrose, etc.)


1 cm


FORMICOIDS
PONEROIDS
Myrmicinae (6,134spp)
Formicinae (3,000spp)
Leptanillinae (53spp)
Apomyrminae
Paraponerinae
Agroecomyrmecinae
Ponerinae (1,030spp)
dorylomorphs (574spp)
Pseudomyrmecinae (231spp)
Myrmeciinae (106spp)
Dolichoderinae (709spp)
Aneuretinae (1sp)
Ectatomminae (281spp)
Heteroponerinae (22spp)
Amblyoponinae (105spp)
Proceratiinae (138spp)
X X X
non-claustral
claustral ICF

Stratégies de reproduction parfois fort complexes (**parasitisme social, esclavagisme**).

Parasitisme: *Ophiocordyceps*

Parasitisme: Nematoda, Mermithidae

Borowiec & Salata (2015)


Merci pour votre attention