Ascomycete insect & nematode symbionts and parasites

Sordariomycetes

Insect parasites/pathogens

Hypocreales, Clavicipitaceae

Cordyceps

Torrubiella, Beauveria (anamorphs)

also nematode parasite *Drechmeria* (anamorph)

Metarrhizium (anamorph)

Insect symbionts

Ophiostomatales insect associates (bark beetles)

Ophiostoma, Leptographium (anamorph)

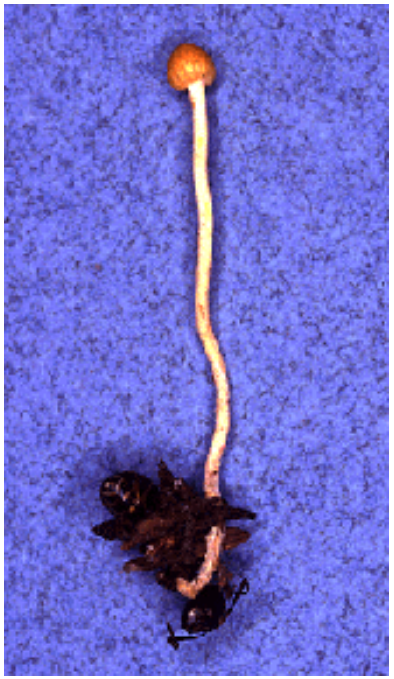
Ambrosia beetles and ambrosia fungi (several genera)

Laboulbeniales host specific insect ectoparasites

Orbiliomycetes

Nematode trapping fungi

Cordyceps

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1 cm


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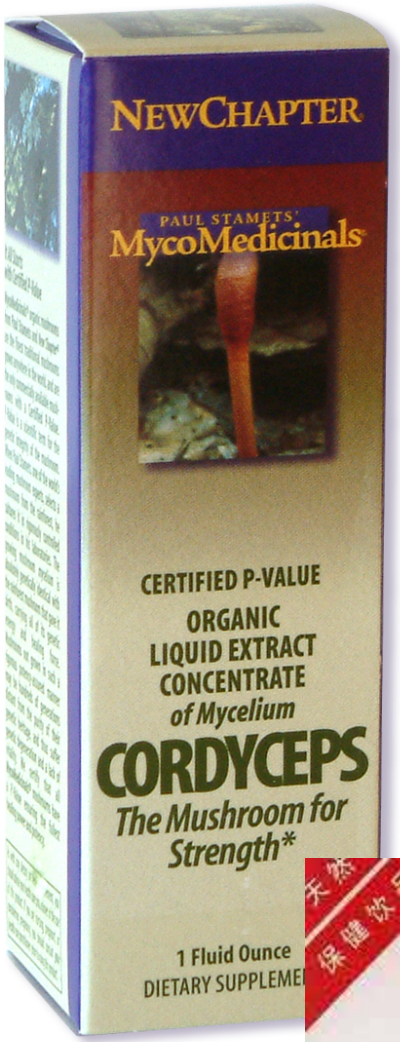
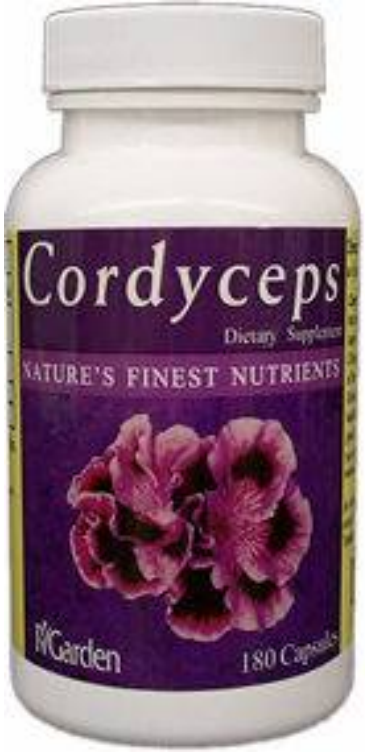
University of Nebraska
Department of Entomology

Yartsa gunbu, “summer-grass, winter-worm”

40% of the rural cash income in the Tibet Autonomous Region is derived from its collection, figured at 50,000 kg in 2004, contributing at least CNY (Chinese yuan) $1.8 billion (=USD 225 million) to the Tibet Autonomous Region’s GDP. A dramatic fungal commodification of the rural Tibetan economy is occurring, as the income from sale of Cordyceps often accounts for 70%–90% of a family’s annual cash income in areas where it grows.


NEWCHAPTER
PAUL STAMETS'
MycoMedicinals
CERTIFIED P-VALUE
ORGANIC
LIQUID EXTRACT
CONCENTRATE
of Mycelium
CORDYCEPS
The Mushroom for
Strength*
1 Fluid Ounce
DIETARY SUPPLEME


Cordyceps
Dietary Supplement
NATURE'S FINEST NUTRIENTS
Garden
180 Capsules


蟲草


保健饮品
MING SAO TRADE MARK


Cordyceps
Energy


Cordyceps

Sordariomycetes--Cordyceps

Cordyceps and anamorphs *Isaria, Hirsutella, Akanthomyces*

Ascocarps organized on complex stromata

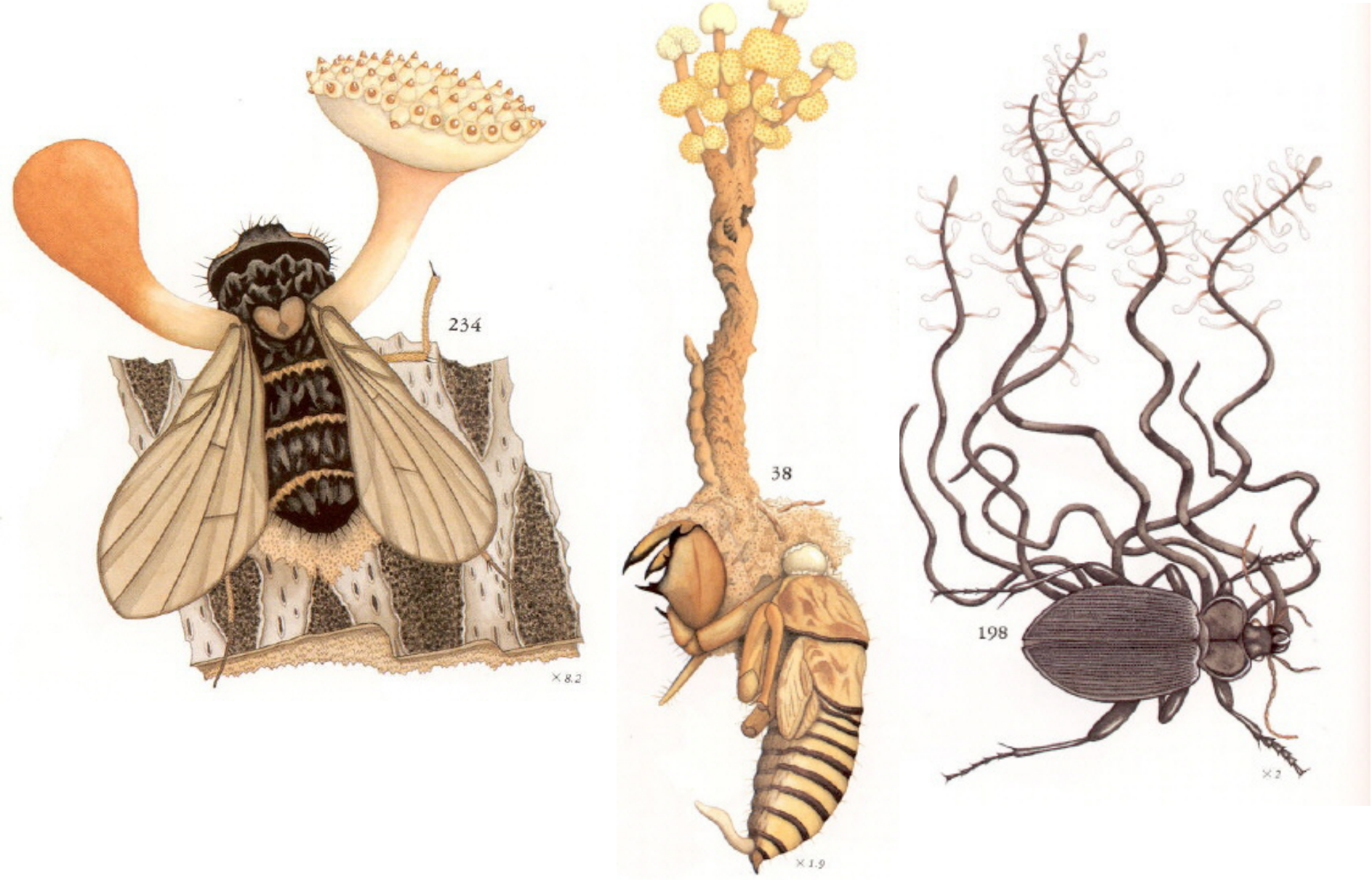
parasites of insects

about 100 spp. on various insects

known especially from Lepidoptera
(vegetable caterpillars)

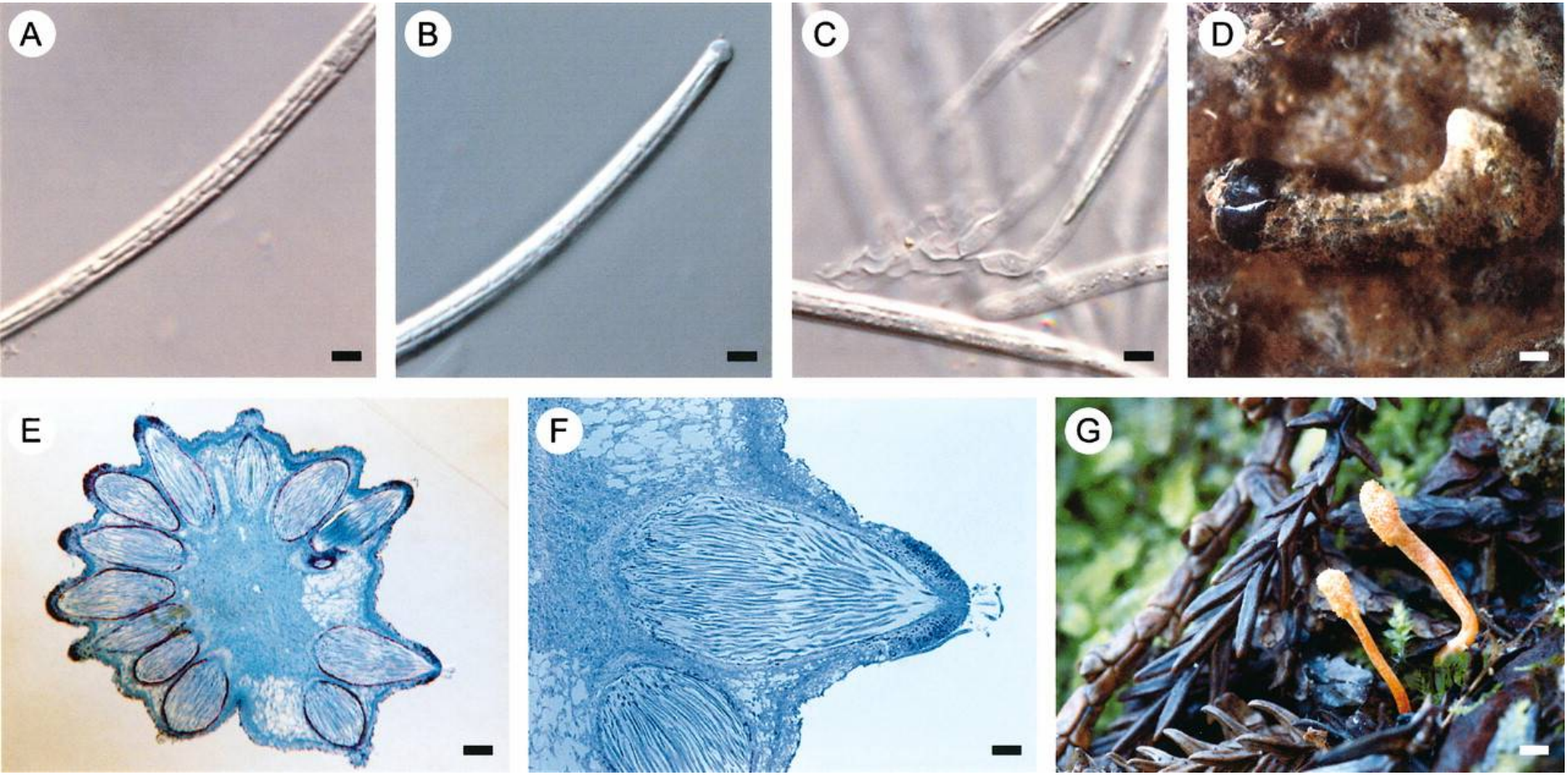
also species occur on *Elaphomyces* (Elaphocordyceps), ectomycorrhizal, hypogeous (truffle) ascomycete

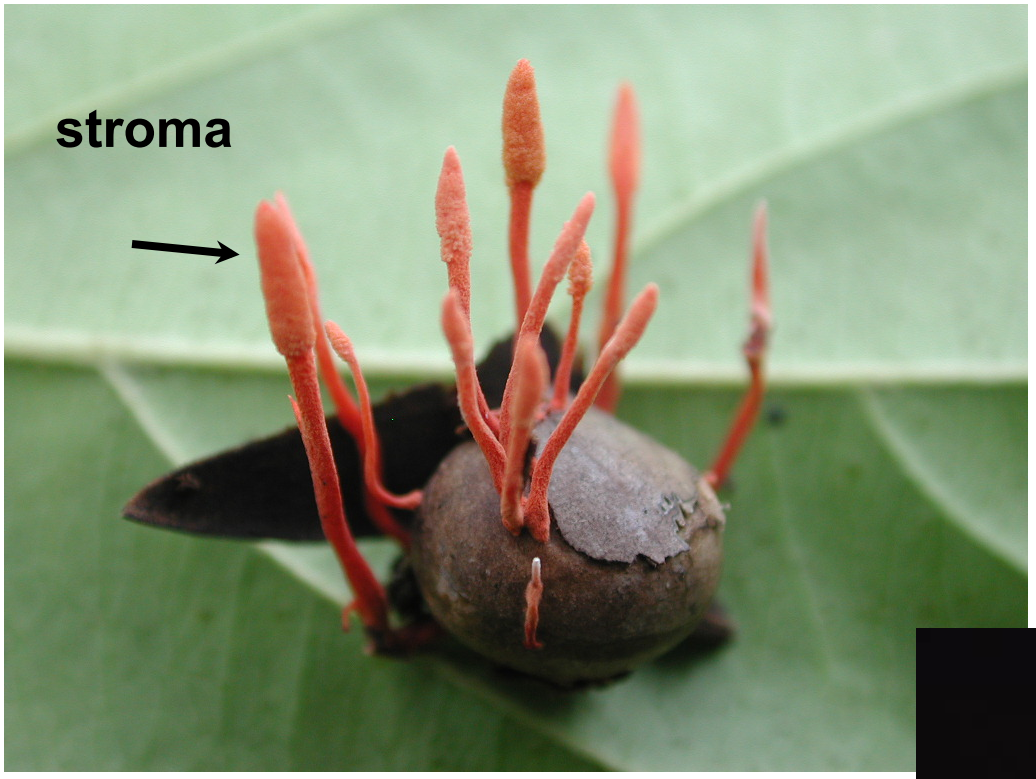
Closely related to *Claviceps*--remember? cause of ergot of cereal grains, but most spp. are insect parasites



D. Shimizu and K. Kobayasi Illustrated Vegetable Wasps and Plant Worms in Colour (1997)

Ophiocordyceps cardinalis from Lepidoptera larvae




stroma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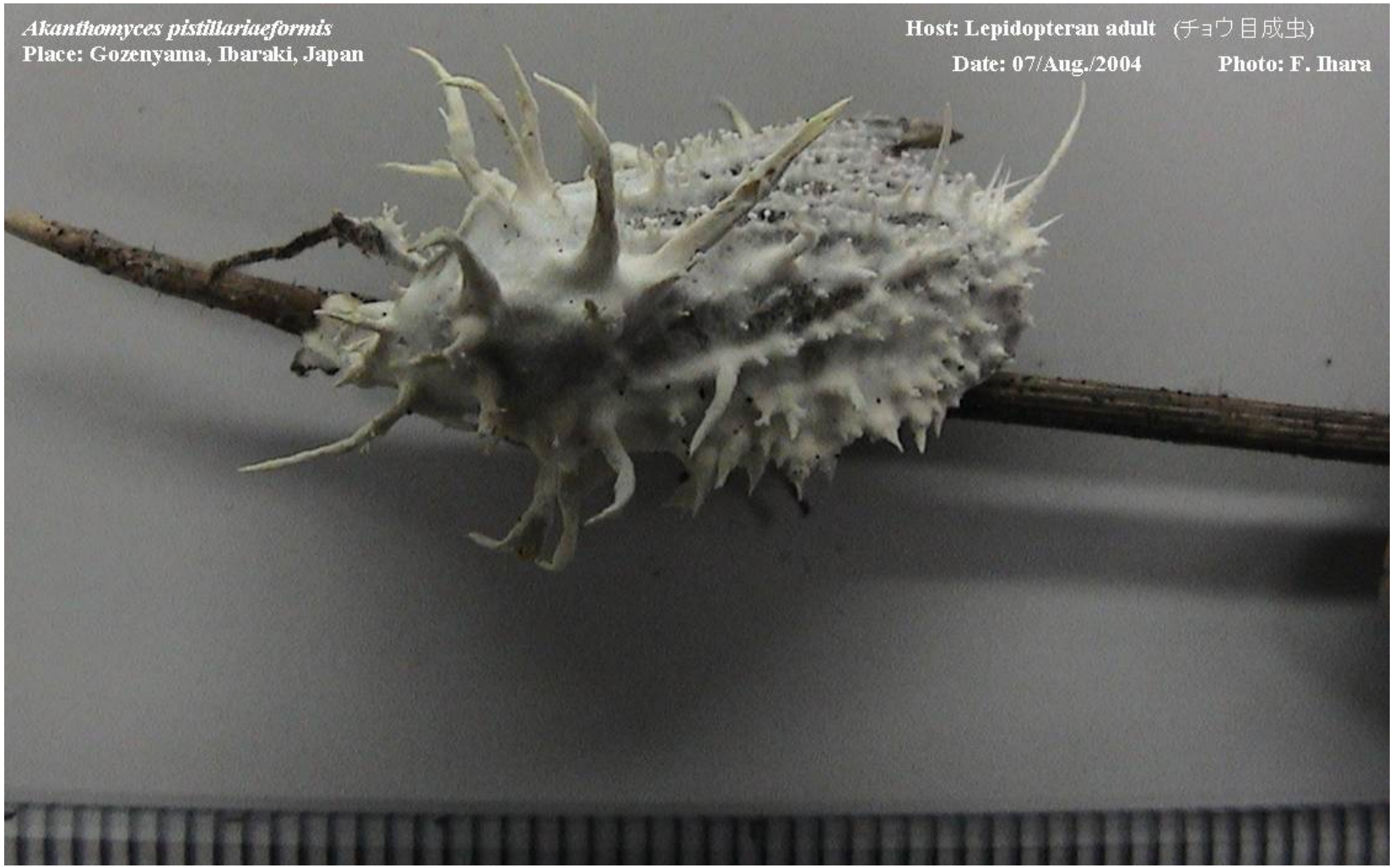
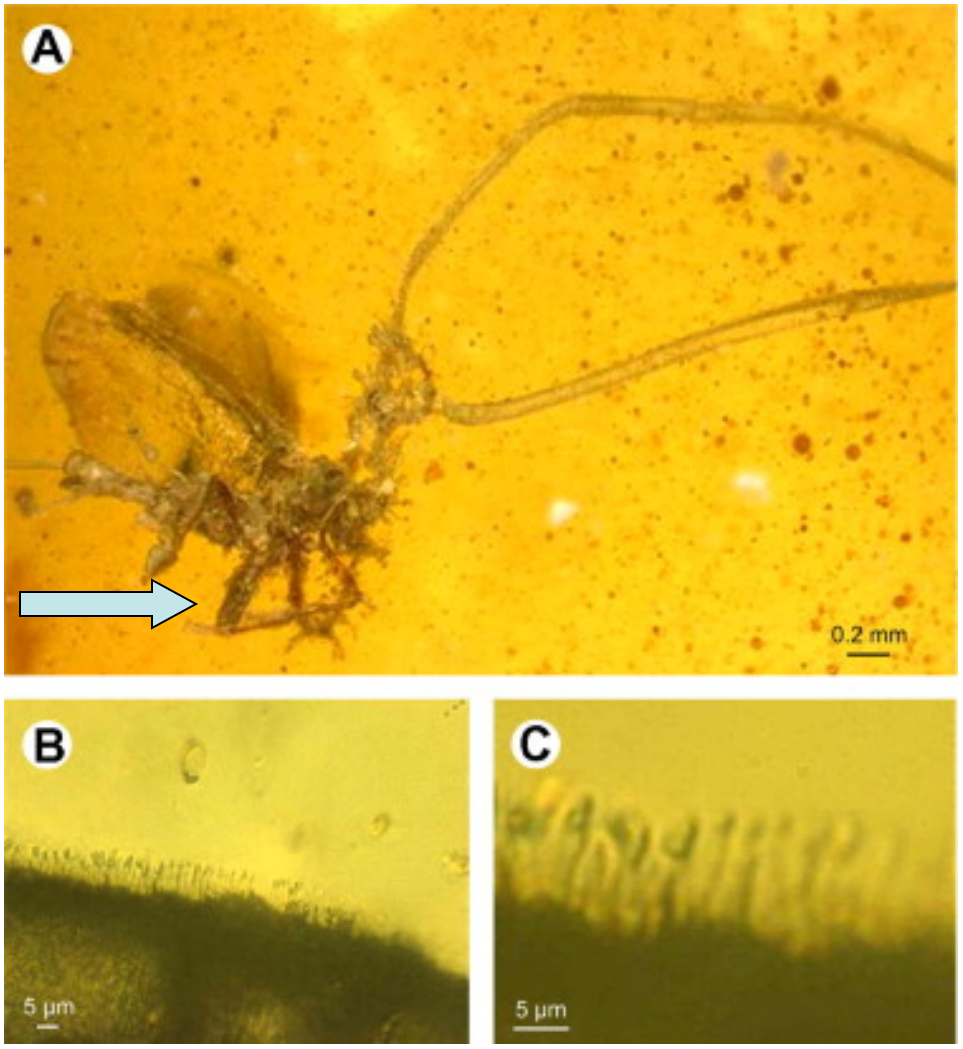
Elaphocordyceps species parasitize the hypogeous (truffle) ectomycorrizal ascomycete Elaphomyces

An evolutionary host switch from insects to fungi? or fungi to insects?

Akanthomyces, Hirsutella anamorphs of Cordyceps





Paleoophiocordyceps coccophagus

Oldest fossil evidence of insect parasitism by fungi

On a scale insect in Burmese amber dated to the upper Cretaceous, 100 - 110 MYA

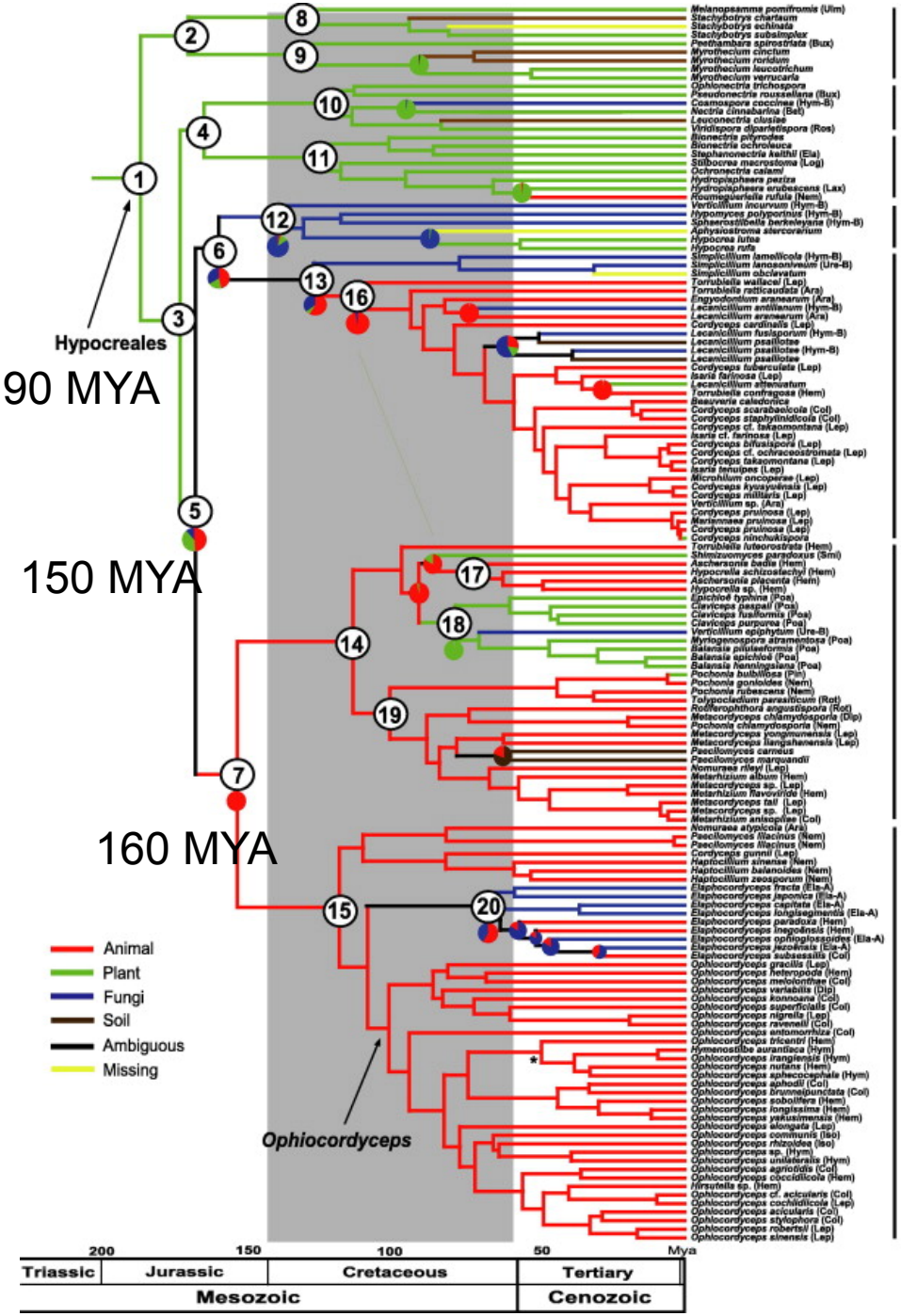
Arthropods and Angiosperms both radiated during the Cretaceous, 90 - 110 MYA

fossil used to calibrate dates of divergence and reconstruct ancestral states

Hypocrealean fungi also diversified during the Cretaceous

G.-H. Sung, G. O. Poinar Jr. and J. W. Spatafora 2008. The oldest fossil evidence of animal parasitism by fungi supports a Cretaceous diversification of fungal–arthropod symbioses. Molecular Phylogenetics and Evolution 49:495-502.

Contemporary Hirsutella on a scale insect



Cordycipitaceae, insect & fungal parasites

Clavicipitaceae, insect & plant parasites

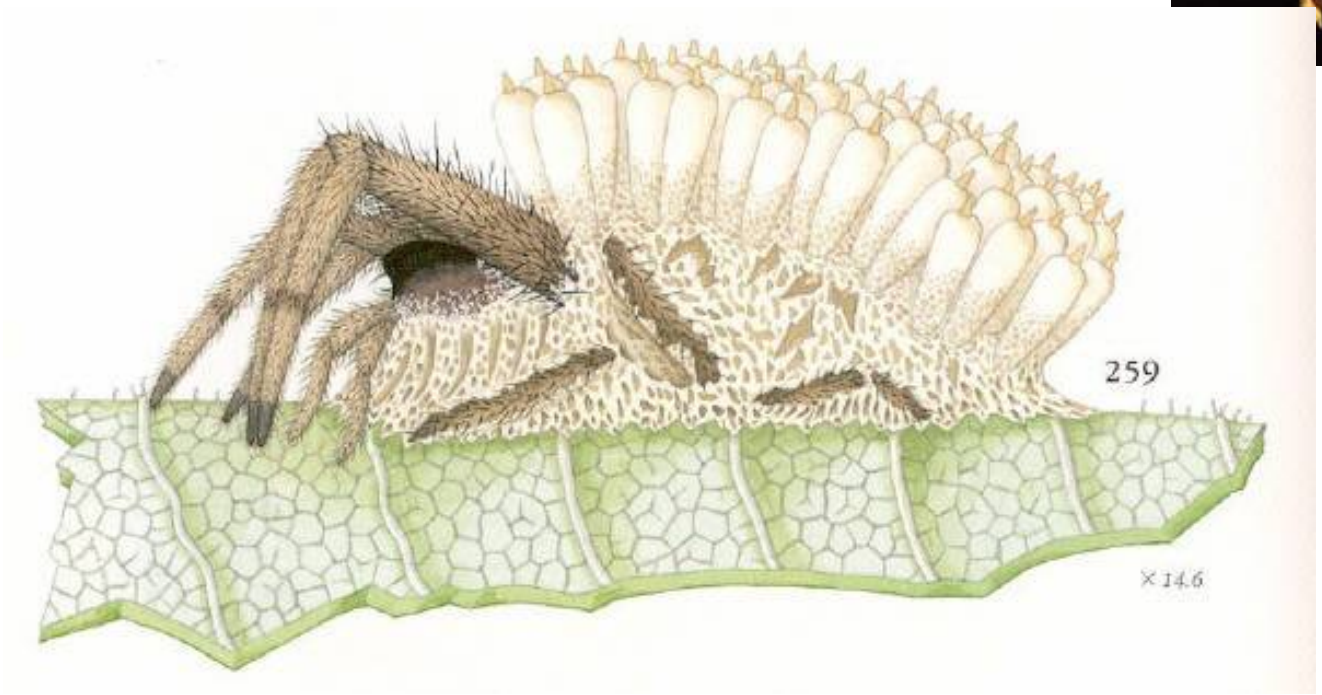
common ancestor was an insect parasite

Ophiocordycipitaceae, insect parasites


Akanthomyces aranearum
Date: 06/Nov./2003
Place: Gozenyama, Ibaraki, Japan
Photo: F. Ihara
Host: Spider (クモ)

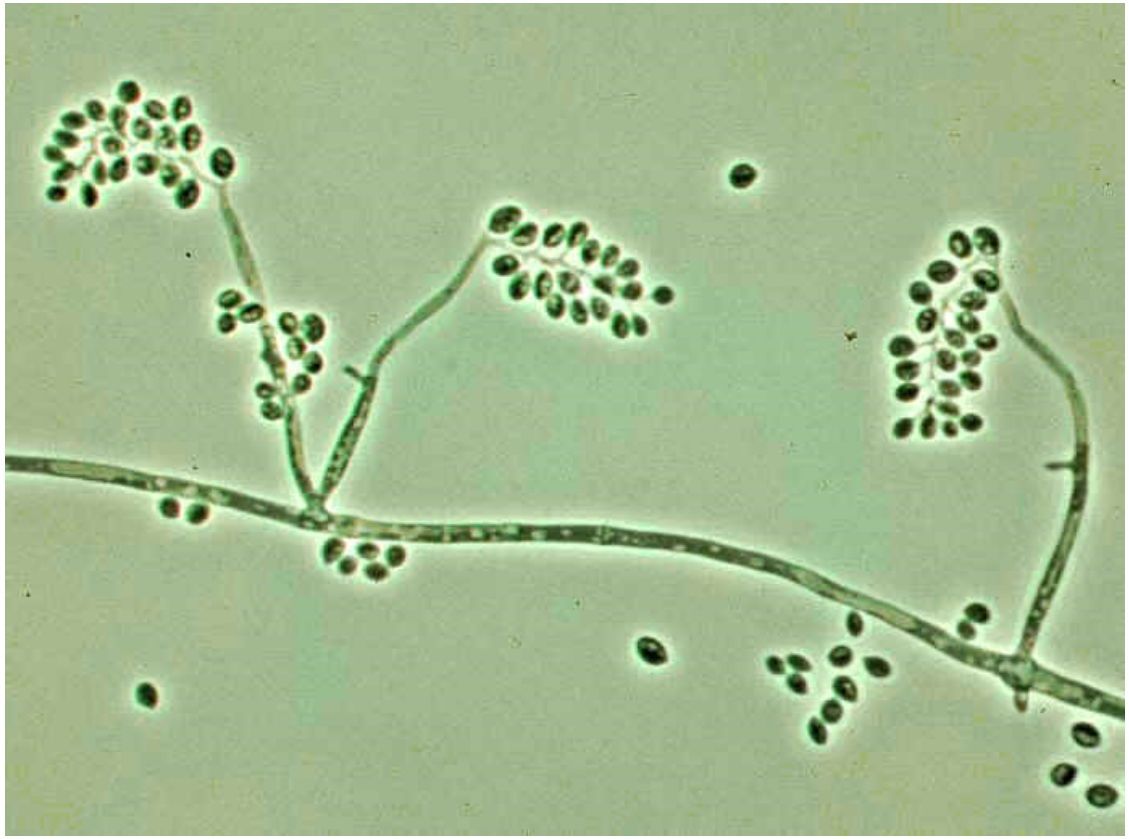
Torrubiella/Gibellula

parasites of
Arachnids (spiders)



Clavicipitaceae *Beauveria bassiana*
Demonstrated to be an infectious agent by Bassi, 1835, the first infectious agent described, germ theory of disease based on Bassi's experiments on muscardine disease of silkworms

Parasitic on insects, mainly Lepidoptera but also aphids, whiteflies, beetles, grasshoppers, termites



Beauveria produces an insect toxin, Beauvericin (also produced by several Fusarium spp.) and an antibacterial compound oosporein

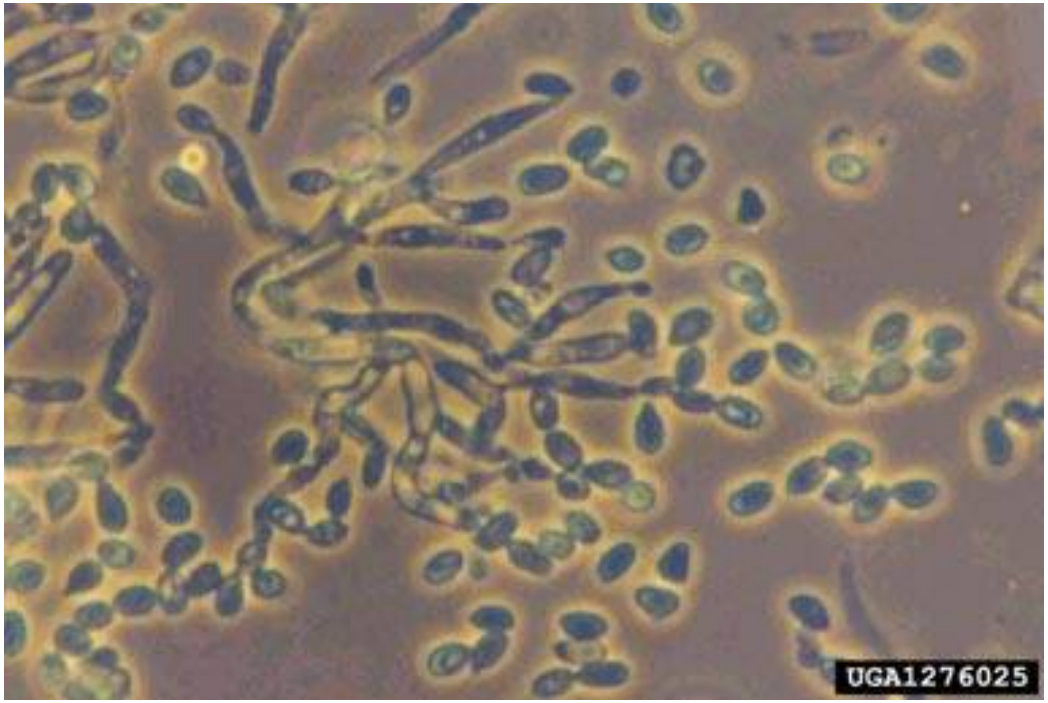
Beauveria can attack various insects

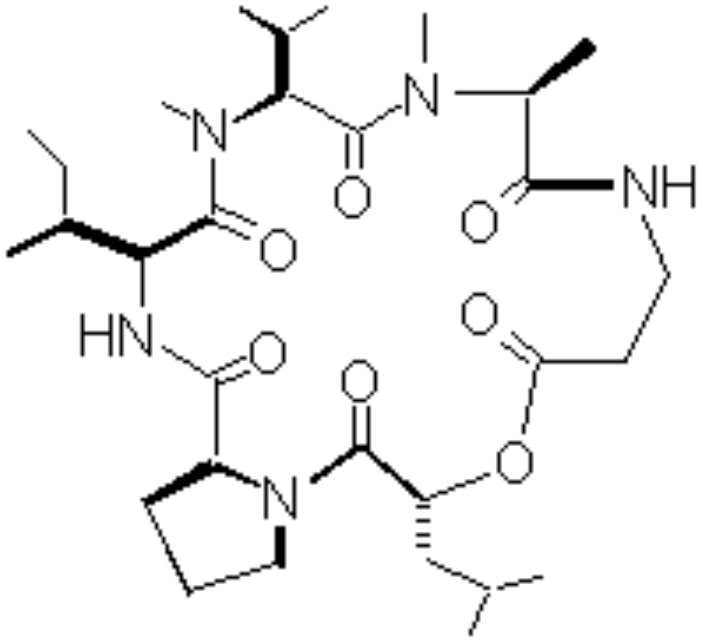
Metarhizium anisopleae
anamorphic Cordycipitaceae

Another common soil fungus, parasitizes a various insects
Used for biocontrol

Metarhizium anisopliae (artificially inoculated、菌を接種後飼育) Photo: F. Ihara
Host: Longhorn beetle (*Massicus raddei*, ミヤマカミキリ)

Metarhizium produces a novel type of cyclic peptide toxins, destruxins



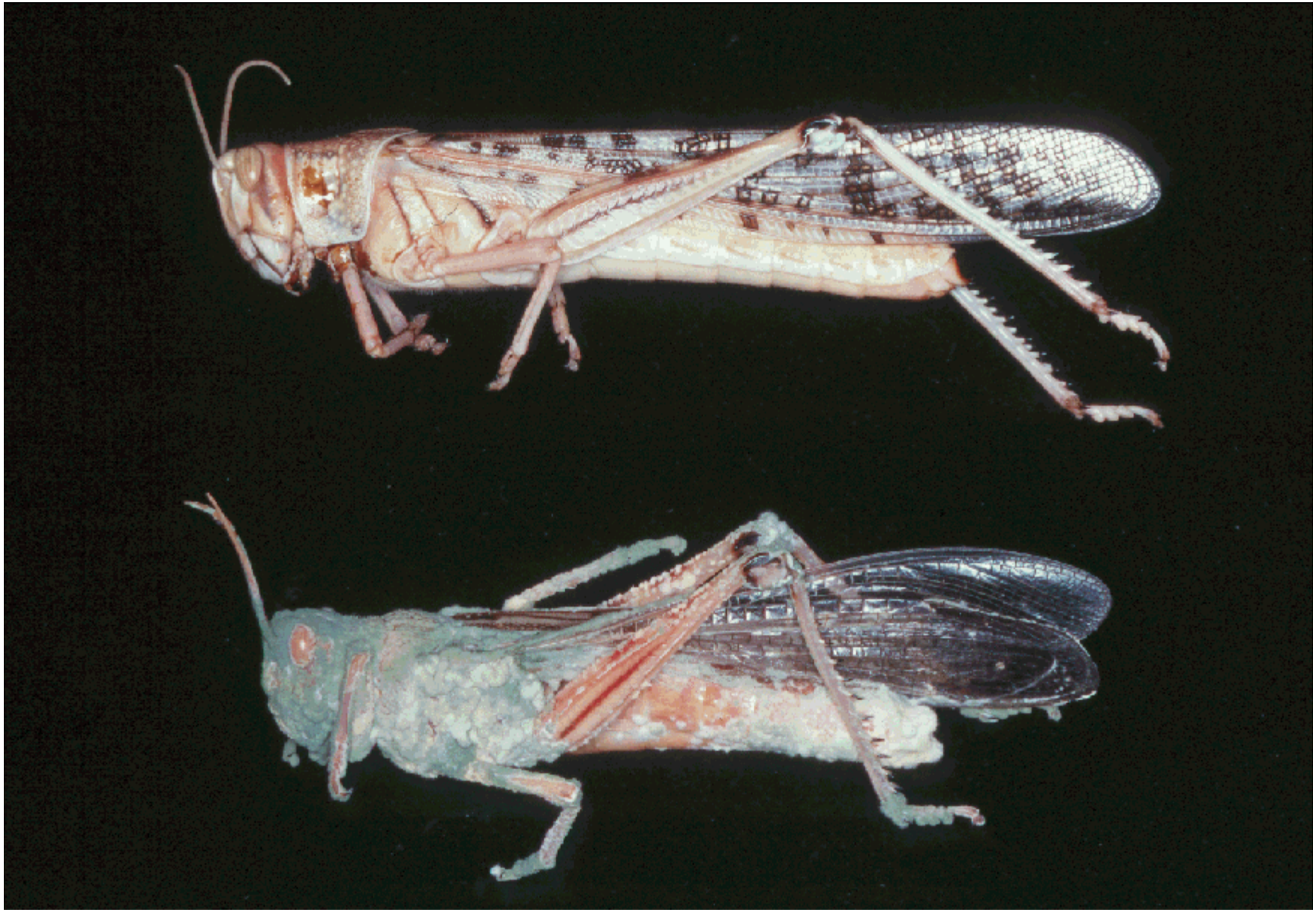


Destruxins are nerve poisons, cytotoxins

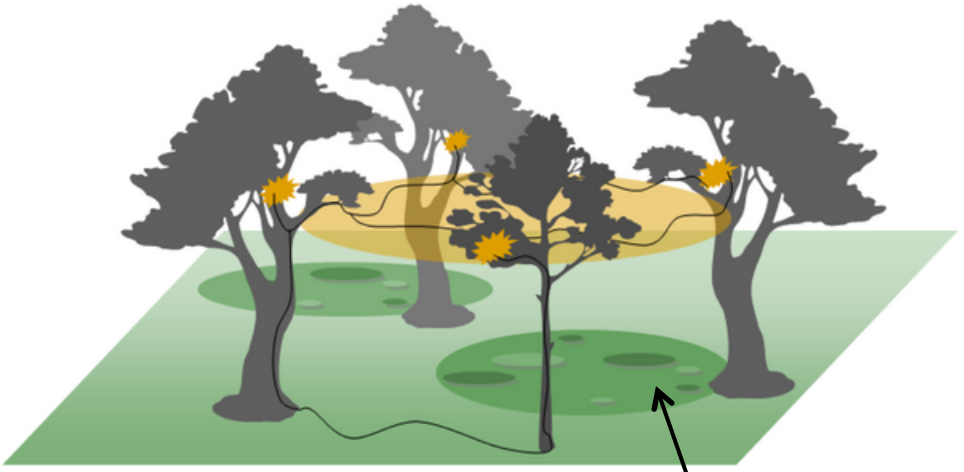
hexapeptides

potential for insecticides, pharmaceuticals

Metarhizium anisopliae Photo: F. Ihara



Infected insects display ‘summitting behvior’



Distribution of dead ants is patchy, ‘graveyards’ that are avoided by foraging ants

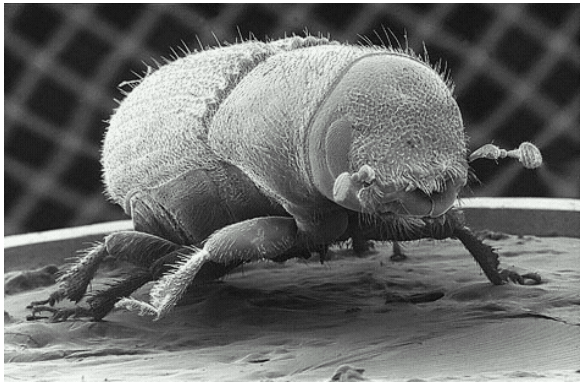
graveyard

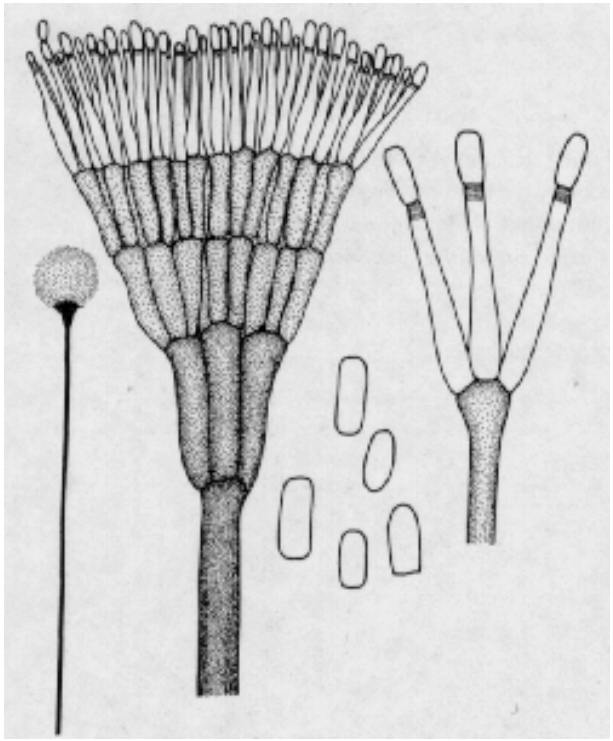
M-B Pontoppidan, W Himaman, N. L. Hywel-Jones, J. J. Boomsma, D. P. Hughes 2009. Graveyards on the Move: The Spatio-Temporal Distribution of Dead Ophiocordyceps-Infected Ants. Plos1 4:4835

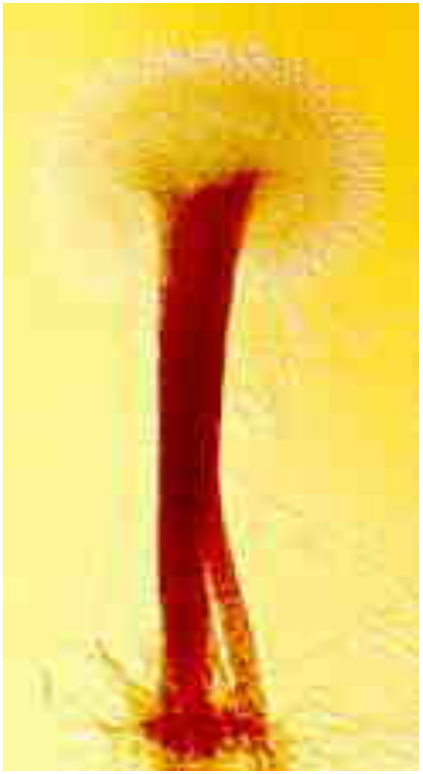
Ophiostoma and Ceratocystis

Associated with bark beetles

Both anamorph and teleomorph are adapted to elevating the spore mass above the substrate







Insect dispersal

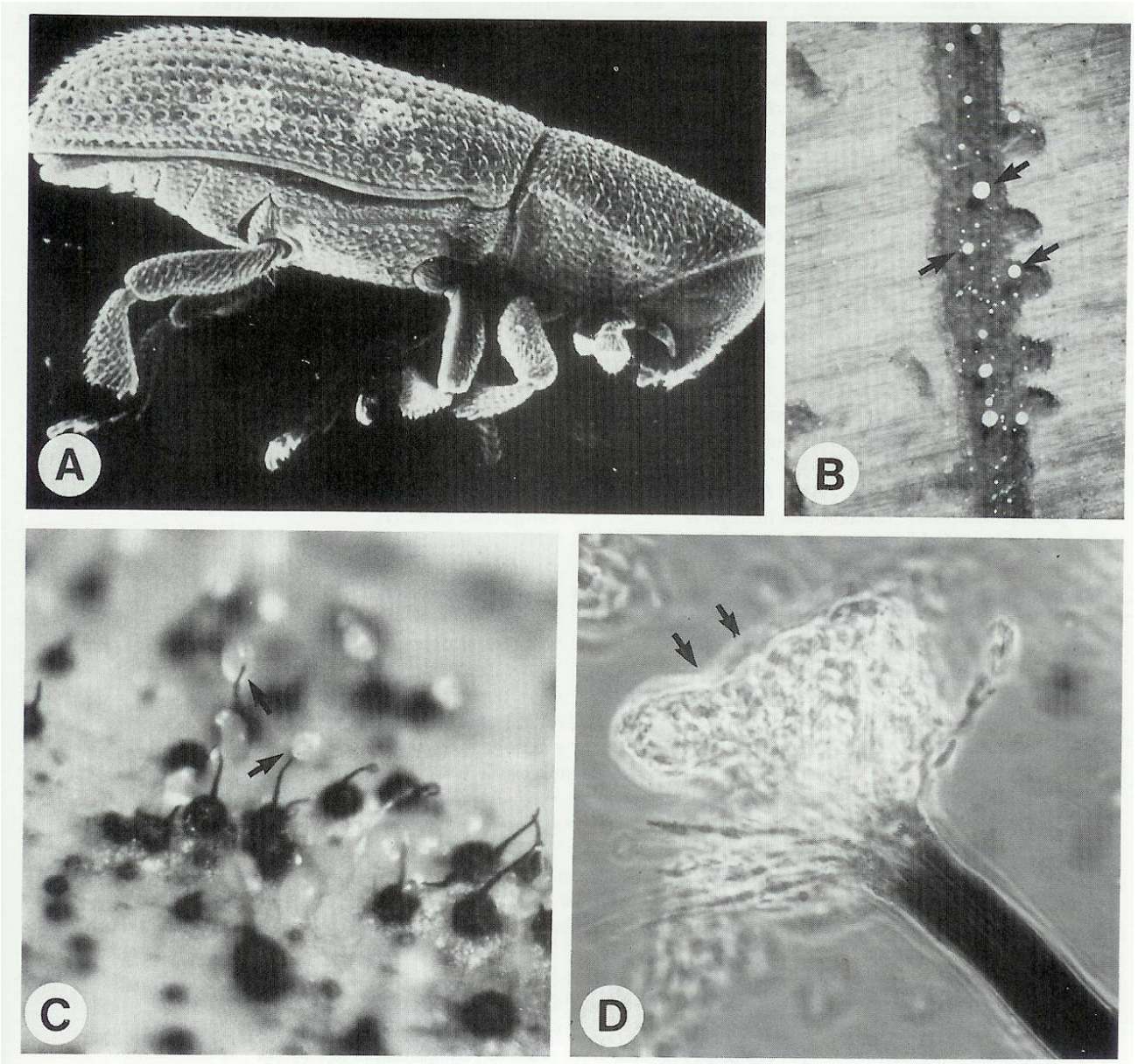
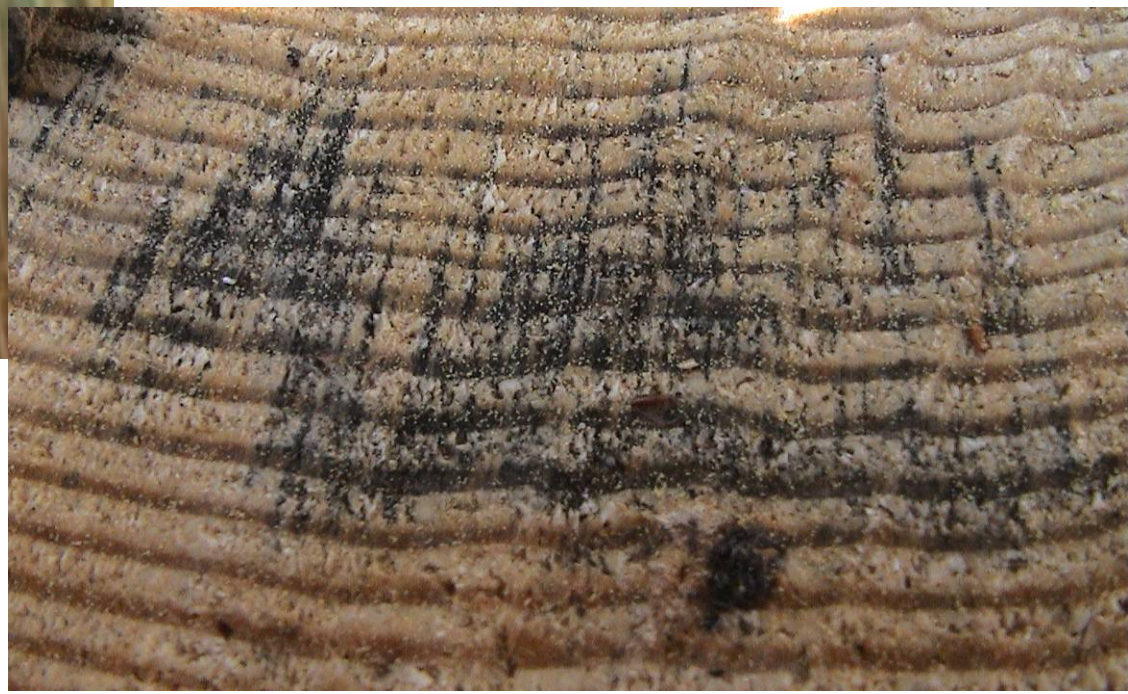


Fig. 11. Most *Leptographium* spp. are vectored by bark beetles such as the root-feeding beetle *Hylastes angustatus* (A). Fungal structures are adapted to insect dispersal with conidiophores (B) and perithecia (C, D) produced in galleries with spores in slimy masses (arrows) at their apices.

Ophiostoma/Leptographium grow in vascular tissues, sometimes causing vascular wilt diseases or “blue stain” in wood



Massive outbreak of mountain pine beetle in Northern BC has porvided a marketing opportunity:

“Denim Pine”

Black stain root disease symptoms in roadside Douglas-fir

Hylastes, Steremnius attracted to stressed trees, roots killed by BSRD