

# Insects in Urban & Agricultural Waste Management

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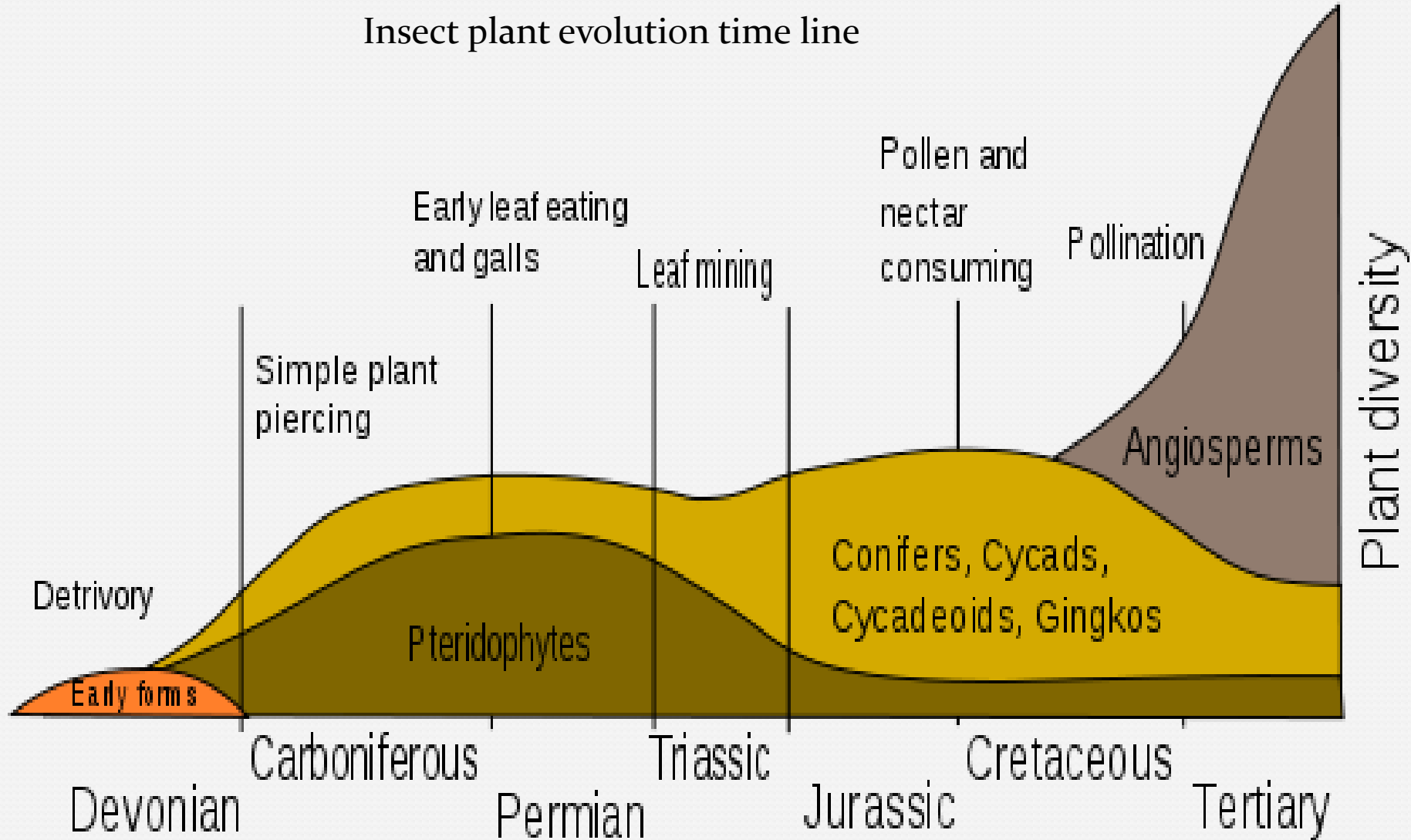
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# PLANTS AND THEIR PREDATORS THROUGH TIME

by Bruce H. Tiffney, Berkley University

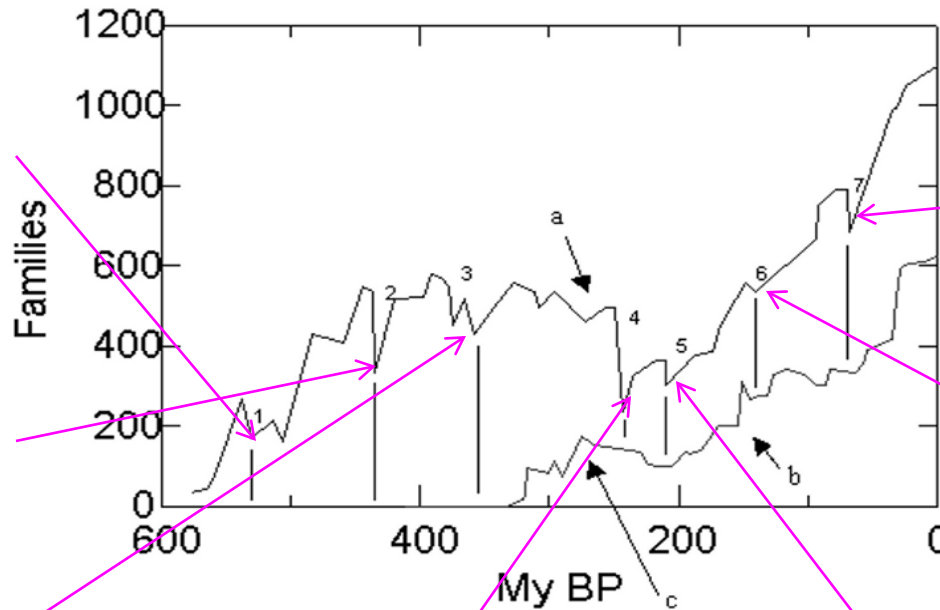
## Insect plant evolution time line



early Cambrian

end Ordovician

end Devonian



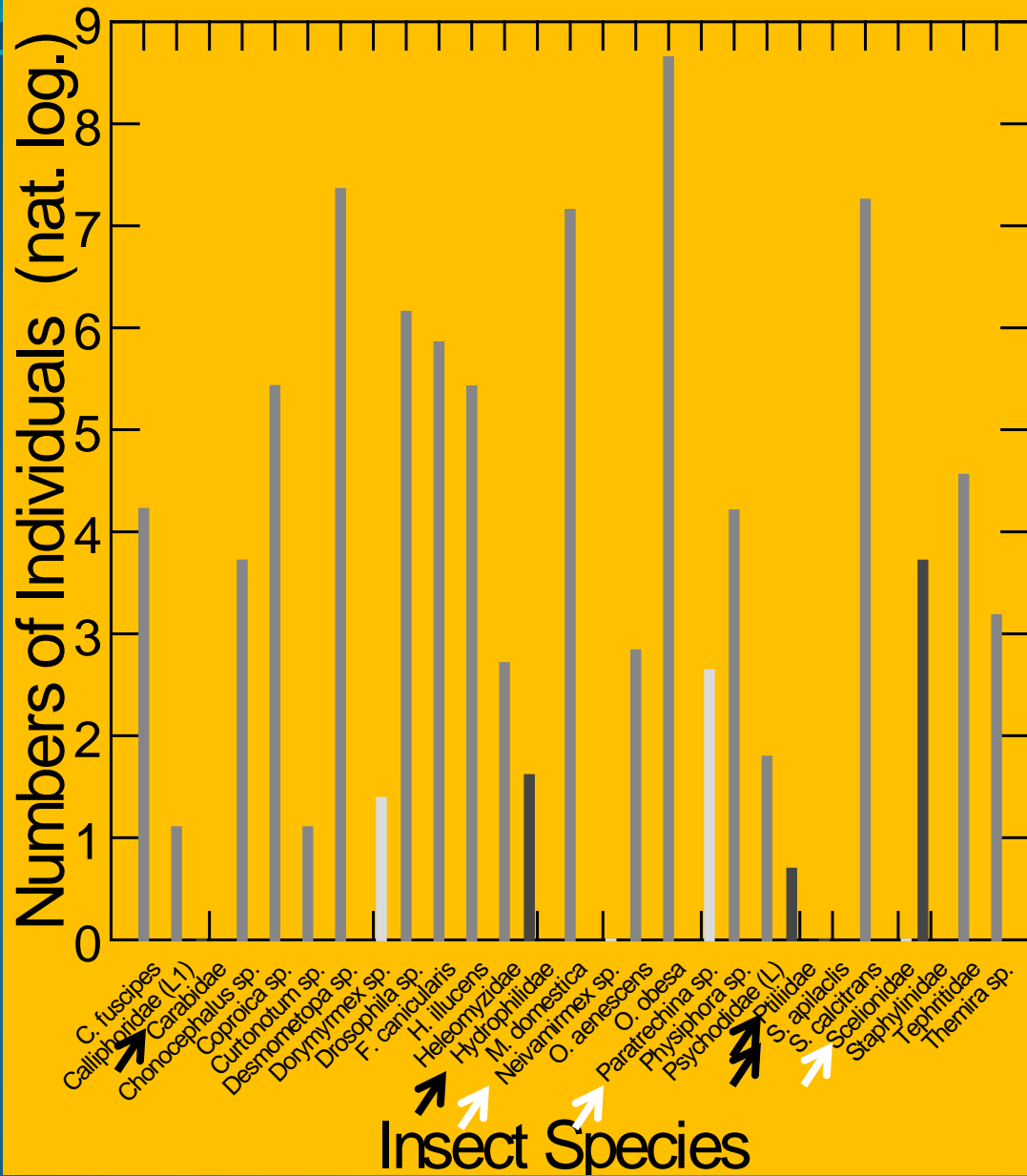
K-T extinction

mid Cretaceous

mid Triassic

end Permian P-T

- (a) is the middle Pennsylvanian extinction,
- (b) is the late Jurassic extinction, and
- (c) the extinction indicated by arrow a is not followed by origination



Insects associated with composting of solid waste management

Taxonomic order

- Coleoptera
- Diptera
- Hymenoptera

Insect Species

# The role of insects in the decomposition process of ecosystems

- Decomposers of plant remains
- Leaf-shredding insects
  - Trichoptera [caddishflies],
  - Plecoptera [stoneflies]
  - Diptera [true flies]
- Decomposers of corpses
  - 1<sup>st</sup> wave of colonization
    - Diptera: Calliphoridae, Muscidae, Sarcophagidae
    - Hymenoptera (ants)
  - 2<sup>nd</sup> wave of colonization
    - Diptera: Sarcophagidae
    - Coleoptera: Staphylinidae, Histeridae, Silphidae [they are also predators of Diptera]
  - 3<sup>rd</sup> wave of colonization
    - Diptera: Phoridae, Drosophilidae, Syrphidae: Eristalinae



*Plectrocnemia kydon*



*Agapatiana* sp.



*Musca domestica*



Staphylinidae: *Dinothenarus flavocephalus*



Silphidae species



Histeridae species

# The role of insects in the decomposition process of ecosystems

- 4<sup>th</sup> wave of colonization
  - Diptera: Piophilidae [cheese skipper flies] *et cetera*
- 5<sup>th</sup> wave of colonization
  - Coleoptera: Dermestidae, Scarabaeoidea: Trogidae, Cleridae
  - Lepidoptera: Tineidae [that eat keratin and feed on the remaining hair and feathers]



*Scarabaeus typhon*



Geotrupidae: *Typhaeus fossor*



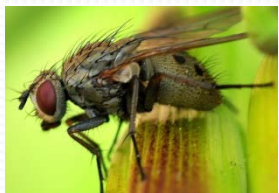
*Tinea pellionella*

## Decomposers of animal excrement

- Diptera: Muscidae, Scatophagidae, Fanniidae, Stratiomyidae, Calliphoridae
- Coleoptera: Scarabaeidae: Scarabaeinae, Geotrupinae, Aphodiinae



*Trogoderma glabrum*



*Scatophaga stercoraria*



*Fannia armata*



*Prochyliza nigrimana*

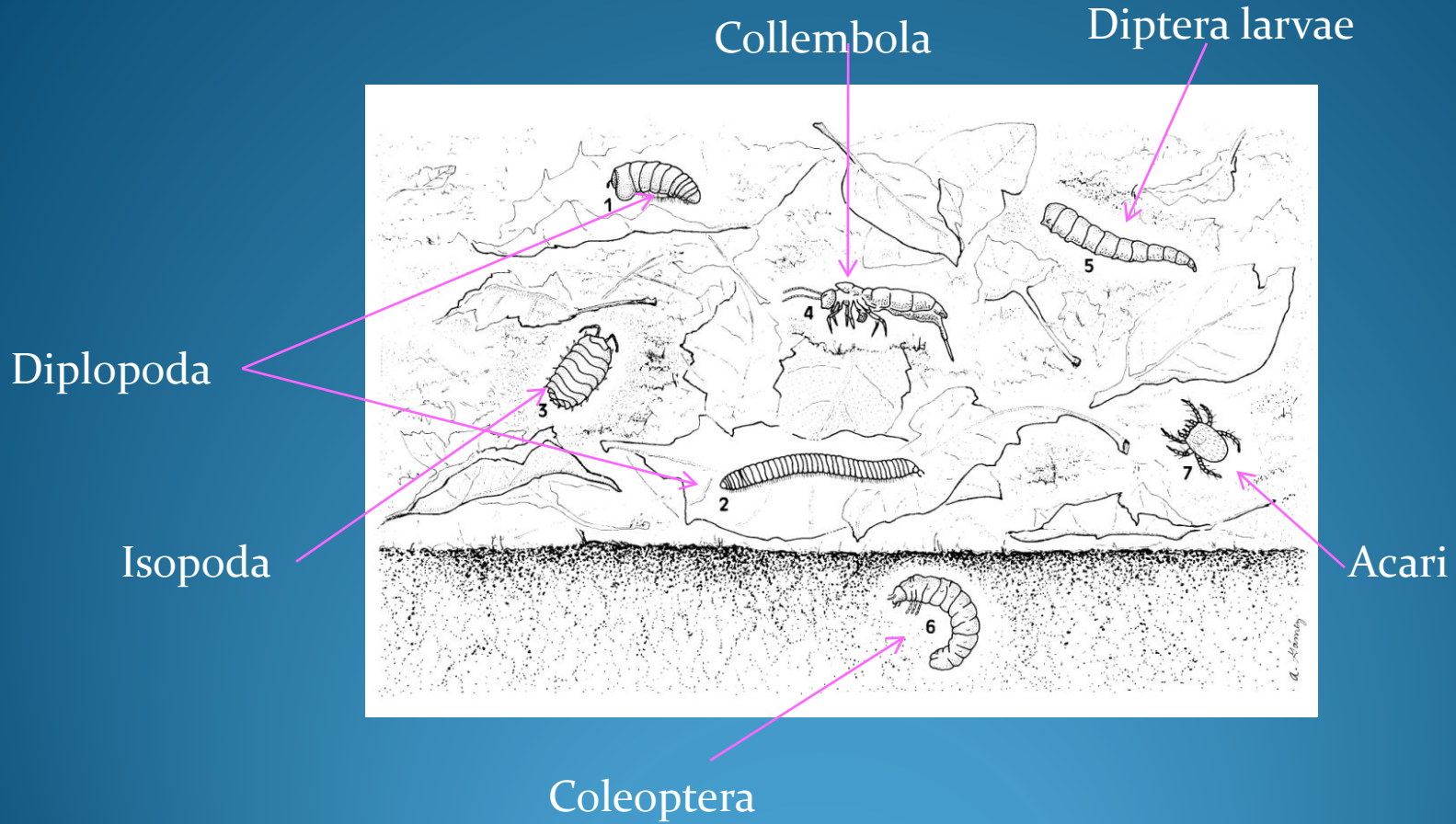


*Hermetia illucens*

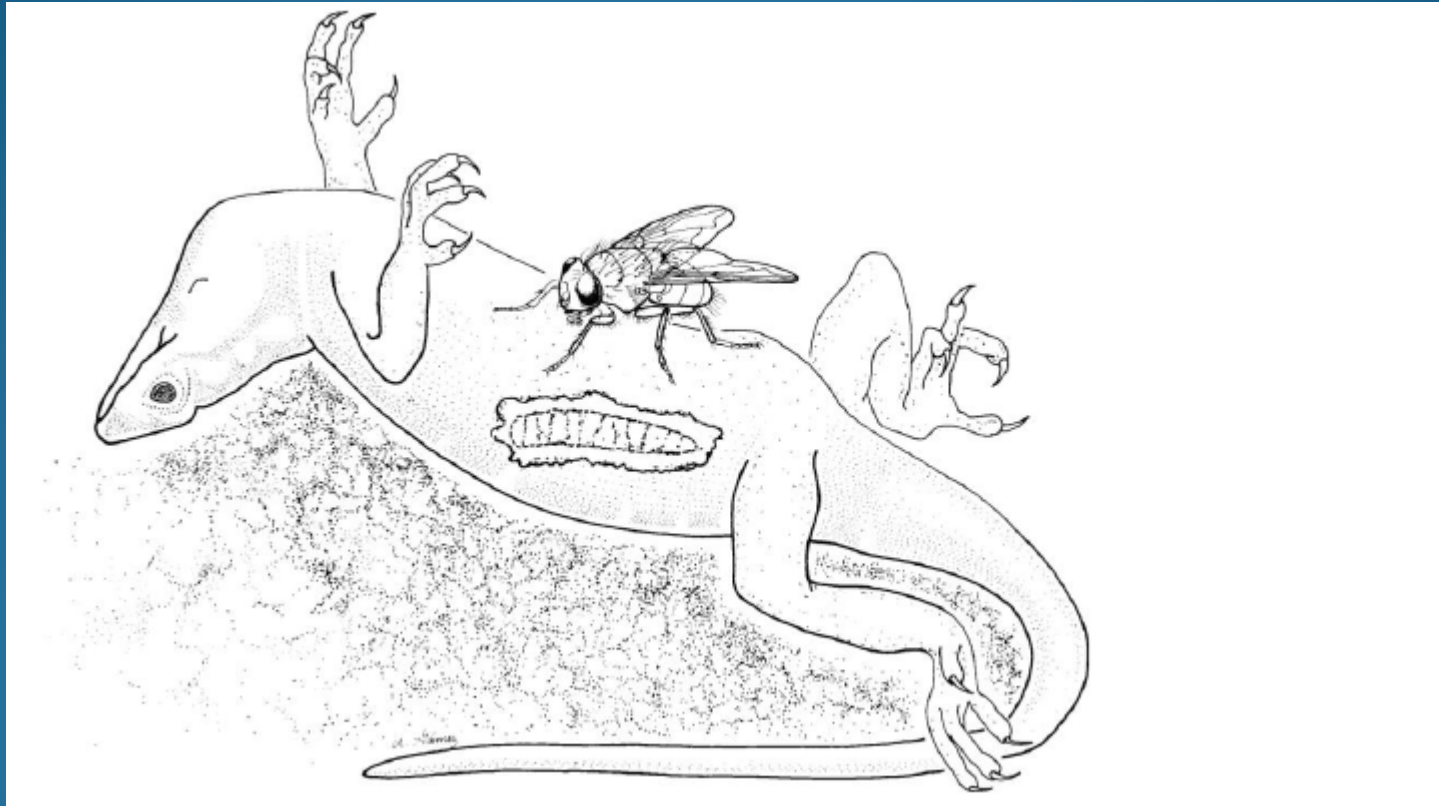


Trogidae: *Trox niger*

# Arthropods involved in the process of decomposition of animal and plant remains

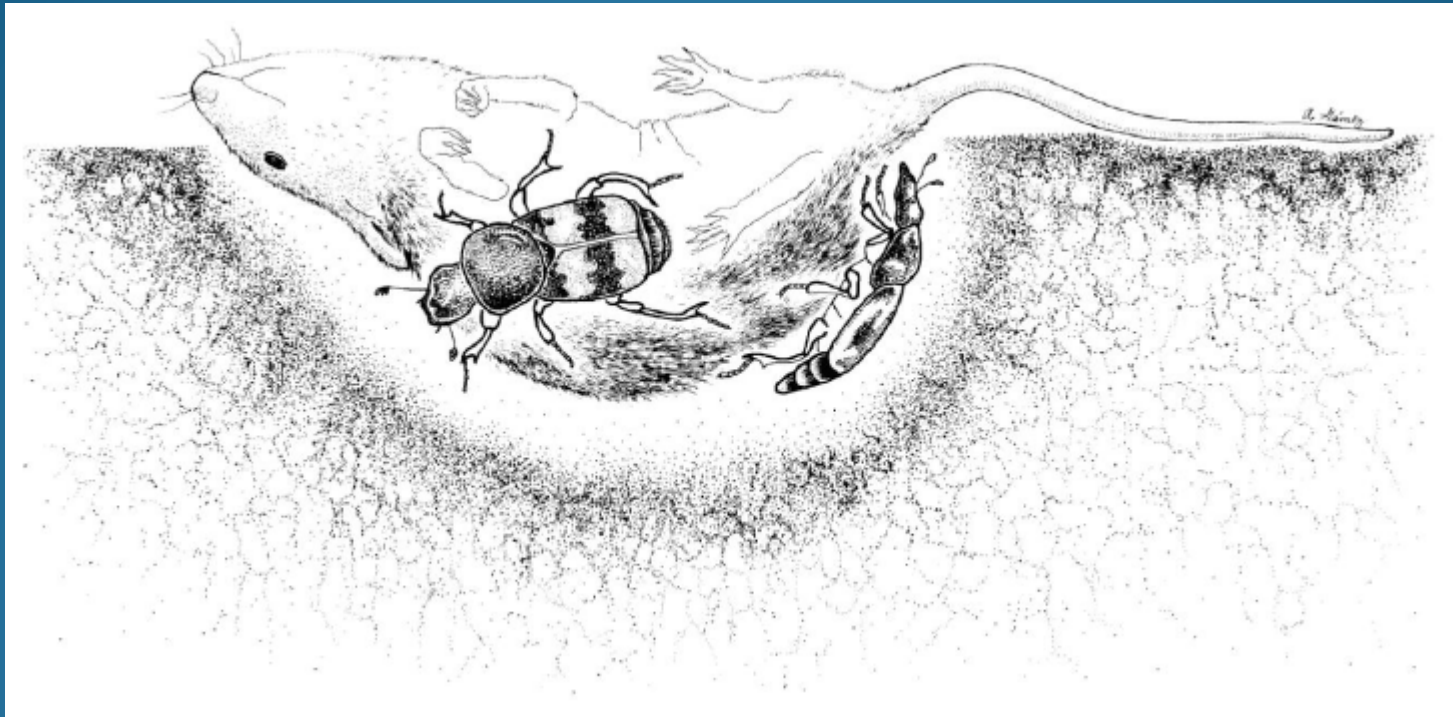


Adult and larva of a blow fly (Diptera: Calliphoridae) on a lizard cadaver





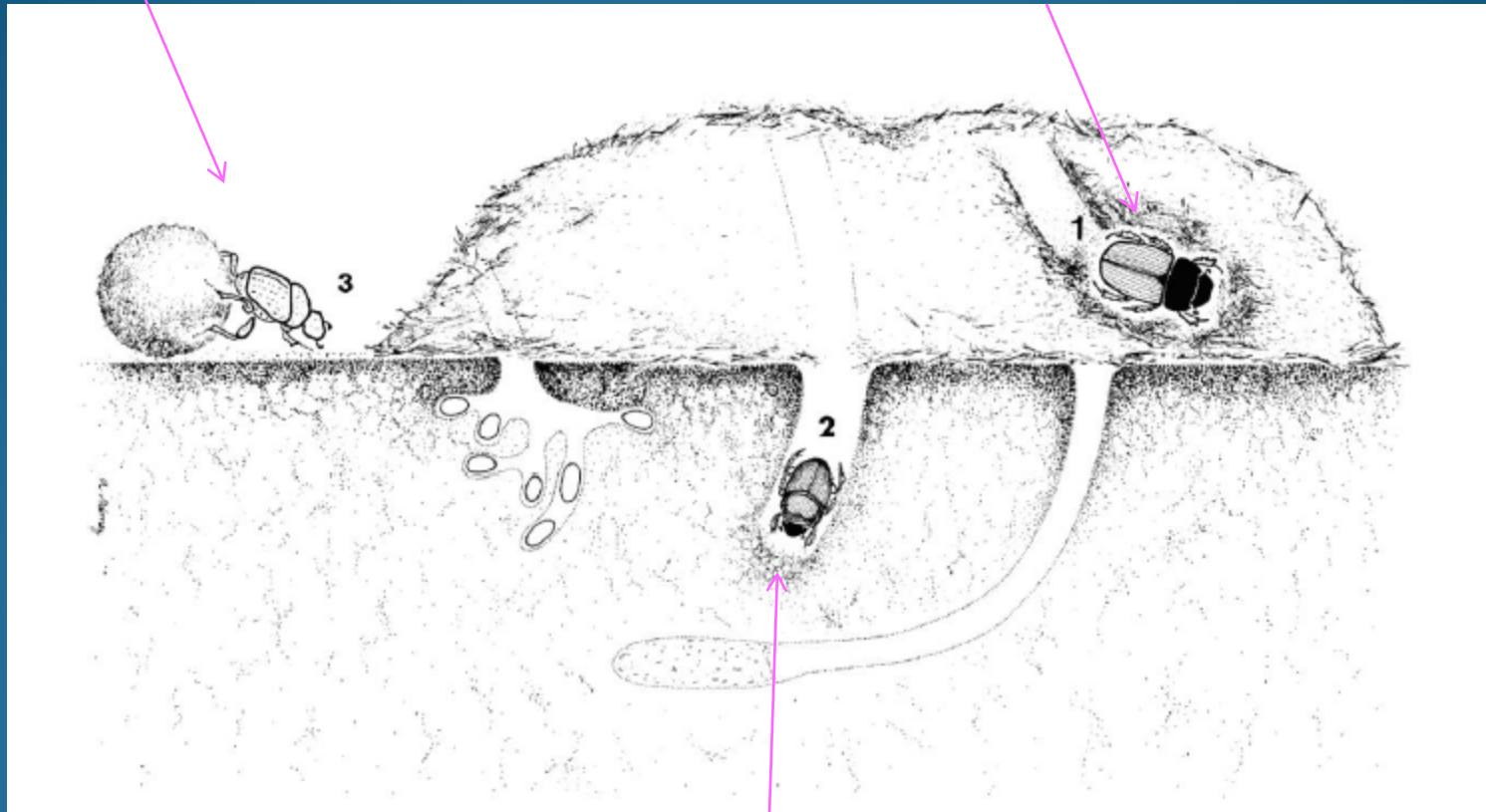
Male and female *Nicrophorus* (Coleoptera: Silphidae) burying a mouse corpse underground



# Behavior of dung beetles (Coleoptera: Scarabaeidae)

Scarabaeinae

Aphodiinae



Geotrupinae

The marsh at Schinias Marathon, Attica, is a breeding place for migrant and resident bird species and harbors many amphibians, reptiles, and mammals





*Himantopus himantopus* (Least Concerned, pied stilt,)



*Egretta garzetta* (Least Concerned, little egret )



*Eurystylus bellevoeyi* new for Greece

more than . . . 1000 vascular plant species  
3000 insect species of all orders  
50 threatened bird, mammal, freshwater fish, amphibians and reptiles



The core of the national park, the wetland between the pinewood and the surrounding hills is regularly and interchangeably cleaned

and used as a disposal area of various kinds of debris



Solid waste disposal is problematic and needs coordinated actions from tavern owners (e.g. at Schnias the garbage collection service of Marathon municipality)



## Sawmill dust





Plant debris (yard and farms)



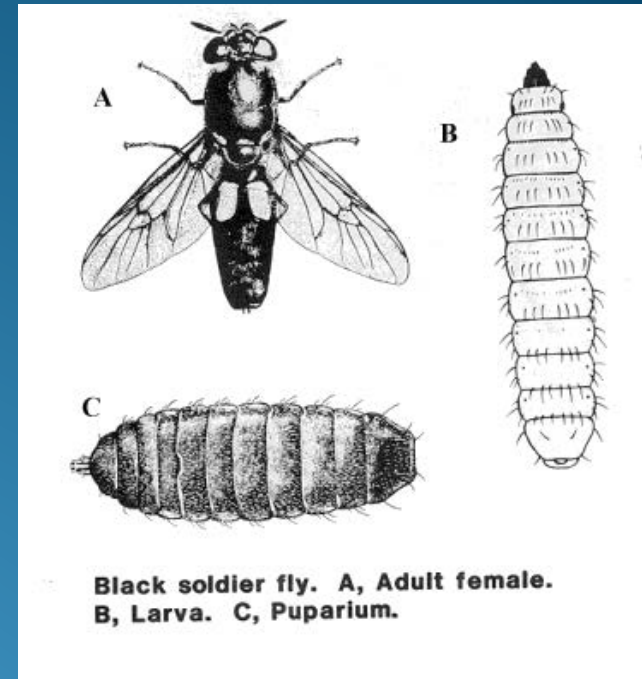


European distribution of  
*Hermetia illucens* (Diptera,  
Stratiomyidae)



# Black Soldier Fly (BSF)

- *Hermetia Illucens*
- Naturally occurring in all warm regions of the world
- Considered non-pest since ...
- Larvae are voracious organic matter eaters
- As adults they have no working mouth parts





adult

*Hermetia illucens*

larva

mating pair



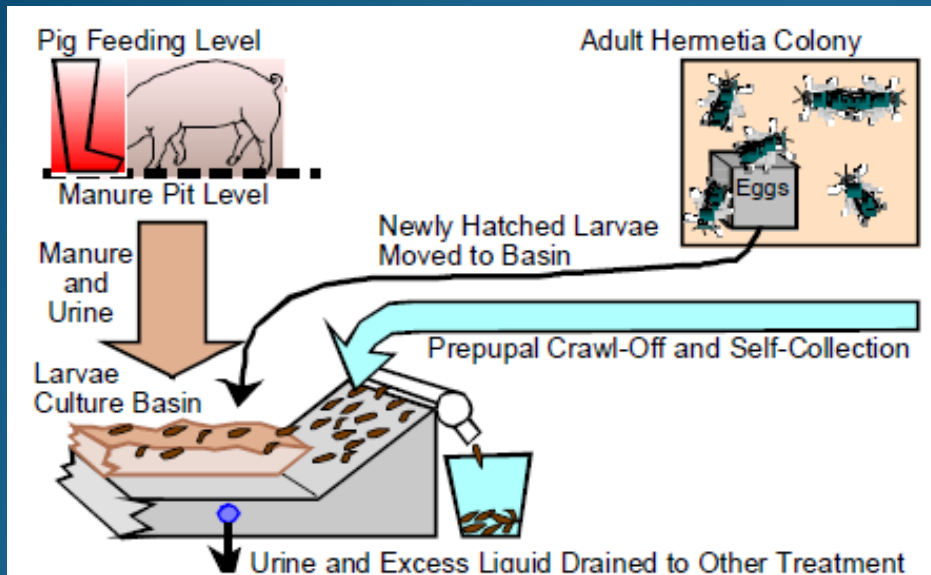
## BSF larvae grow in a variety of decaying plant and animal matter such as

- ❑ Manure of (swine, poultry and cattle)
- ❑ Waste material from poultry / fish / bovine / pig rearing and processing units
- ❑ Municipal garbage
- ❑ Food scraps
- ❑ Rotting plant material
- ❑ Sawmill dust and other debris

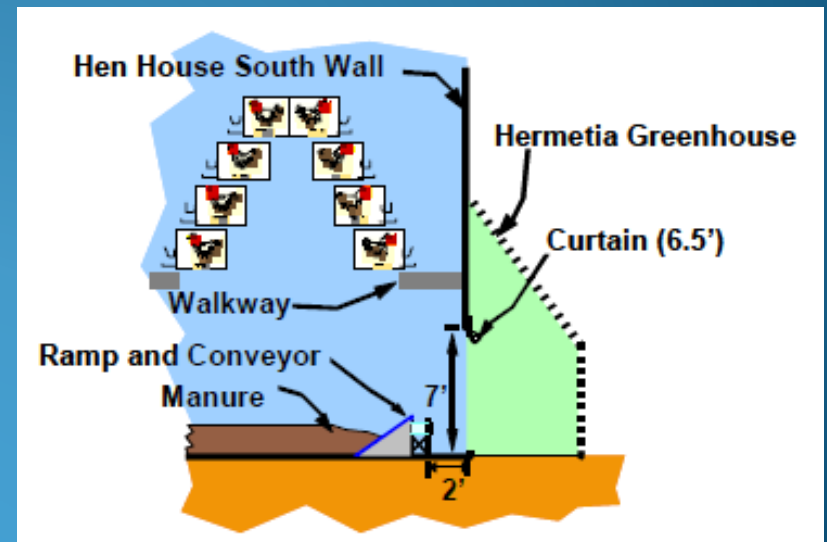


Larvae of *Hermetia illucens* (Linnaeus), in compost. Credit: Lyle J. Buss.

# Swine manure treatment system with BSF

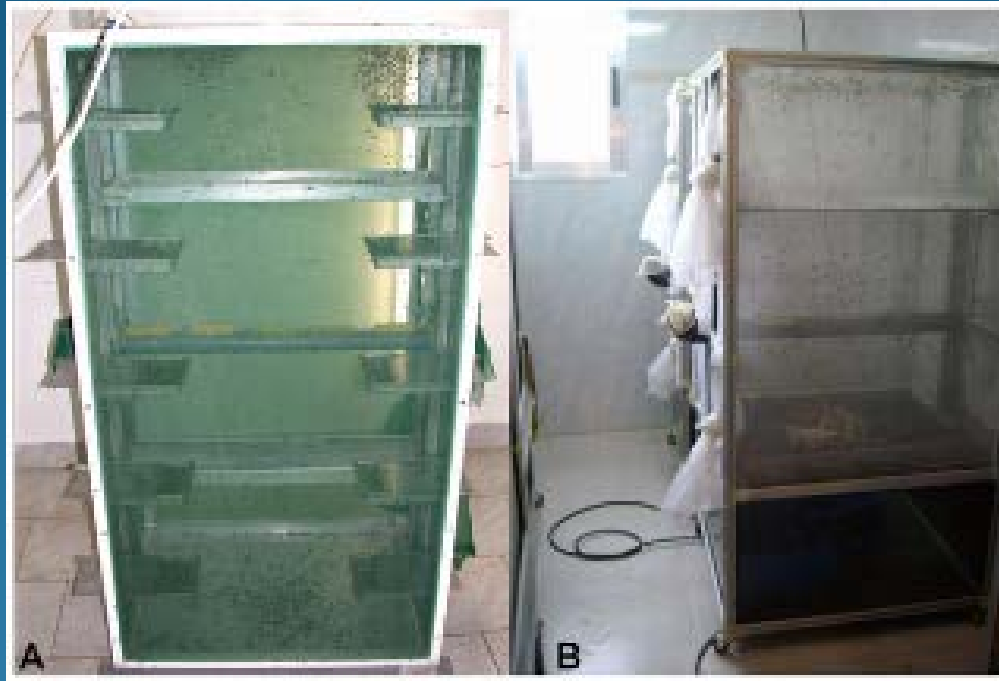


# Hen droppings treatment system with BSF



*Hermetia illucens*

rearing and experimental facilities



# Isolated bacteria from eggs of *Hermetia illucens*

Accession Number	Length in base pairs	RPD ID ‡	Bootstrap value (%)
JQ979475	688	<i>Bacillus</i> sp.	100
JQ979469	682	<i>Cellulomonas</i> sp	100
JQ979474	615	<i>Empedobacter</i> sp.	71
JQ979482	663	<i>Enterobacter</i> sp.	97
JQ979470	718	<i>Gordonia</i> sp.	100
JQ979476	691	<i>Kurthia</i> sp.	99
JQ979471	666	<i>Microbacterium</i> sp.	100
JQ979472	664	<i>Micrococcus</i> sp.	100
JQ979473	666	<i>Micrococcus</i> sp.	100

‡ *Ribosomal Database Project*

Taxonomic identification y means of the naive Bayesian classifier

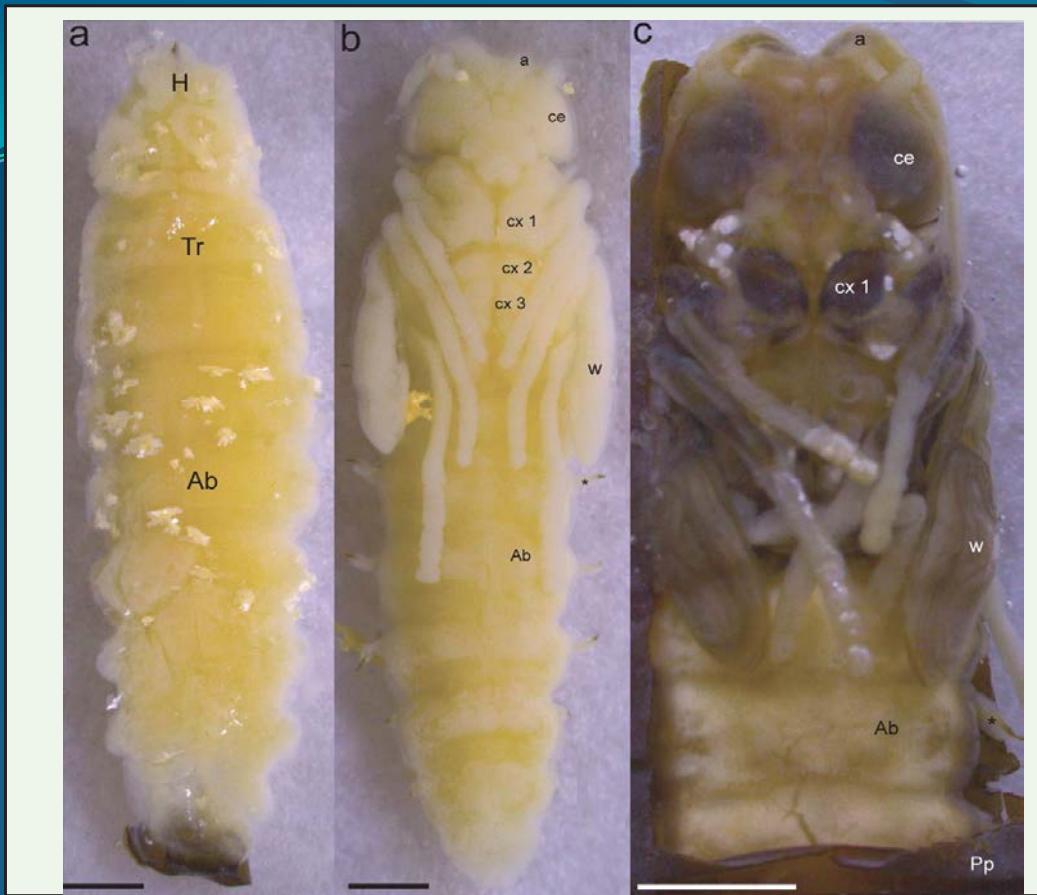
$10^8$  cfu/ml  
of the  
bacterial  
mix is



control  
(agar only)







a. Cryptocephalic pupa    b. Pharate adult    c. imago



d. Pupae    e. detail of the head



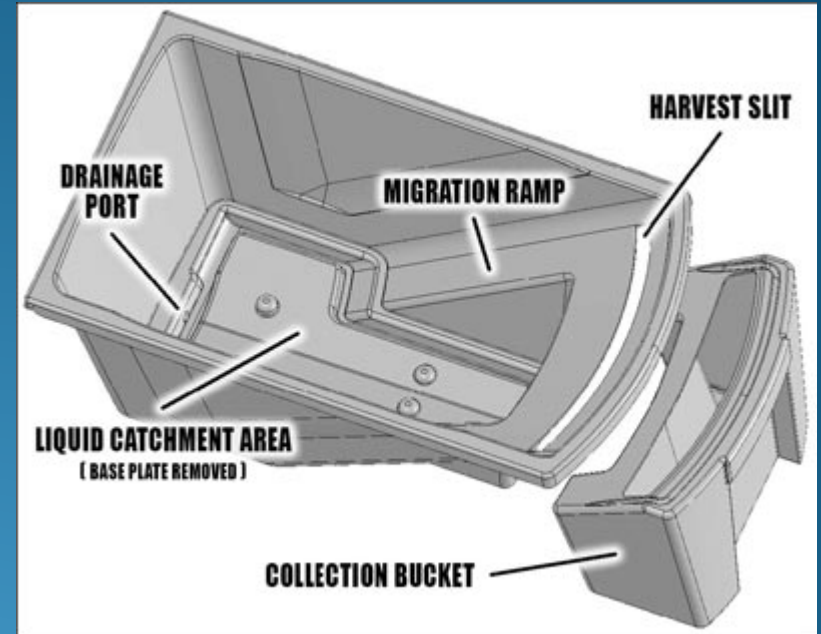
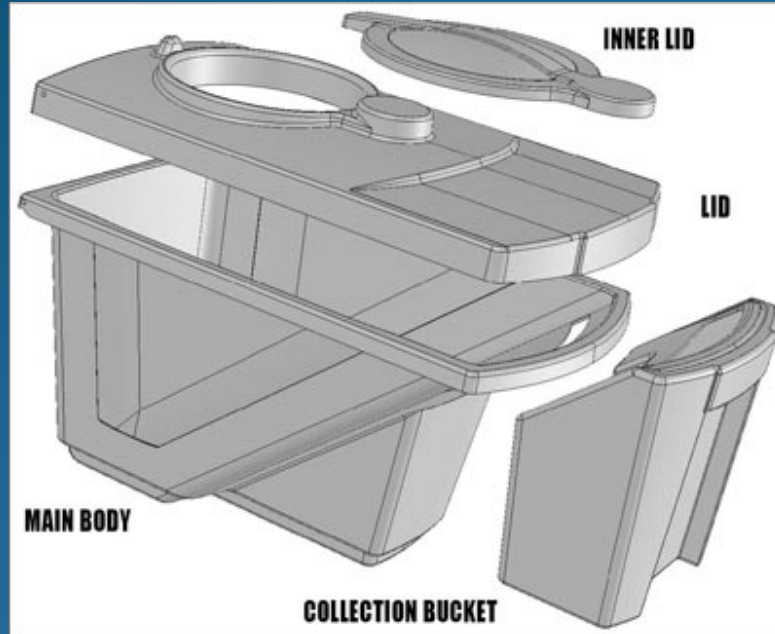
Abbreviations: Ab, abdomen; a, antenna; ce, compound eyes; cx, coxa; H, head; Pp, puparium; Tr, thorax; w, wing; wy, white-eyes; \* respiratory tubes.

Scale bars: 1.6 mm (a,b), 2.5 mm (c) 1.2 mm (d), and 0.7 mm (e).



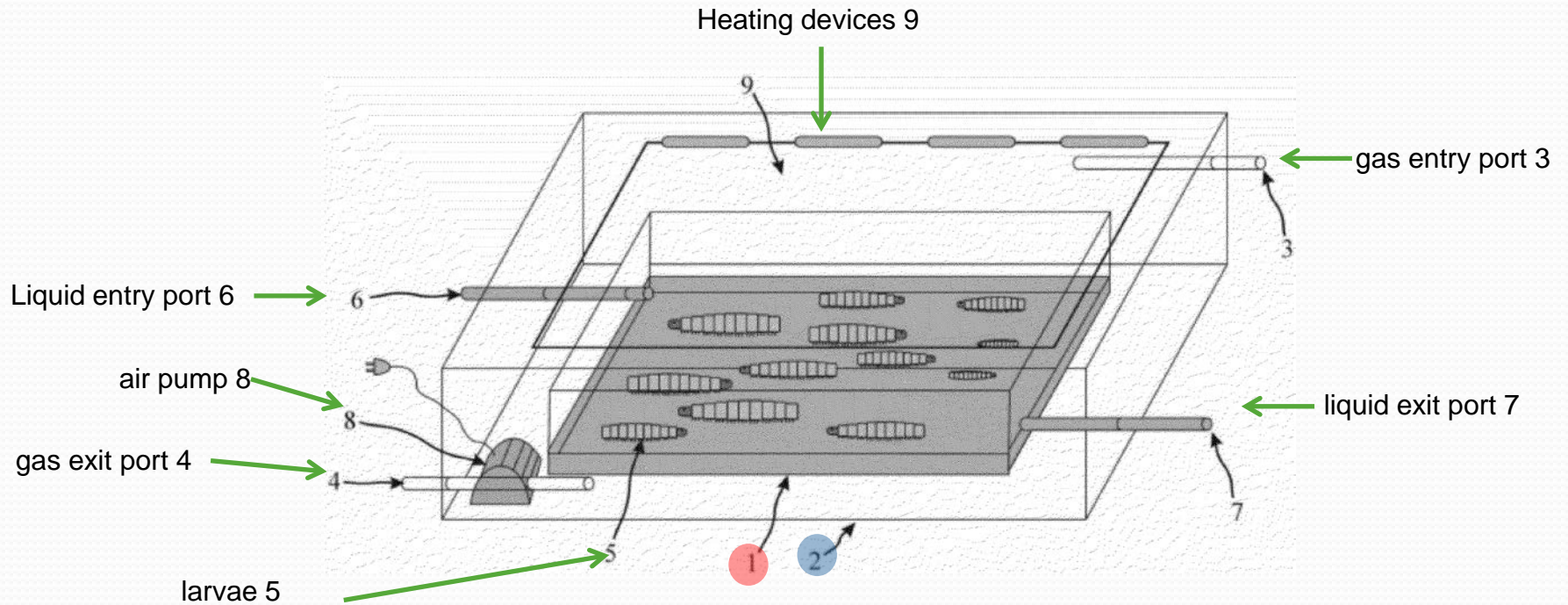


# Embodiment of a BSF plastic bucket composter (BioPod™ Plus)



# INSECT-BASED REMOVAL OF ORGANIC SOLUTES FROM LIQUID

Patent Application Publication Jul. 26, 2012 Sheet 1 of 9 US 2012/0187041 A1 (Popa & Green, 2012)



open inner reservoir 1 for processing a liquid nutrient source enclosed inside enclosed tank 2

Comparison of enzyme activity in salivary gland and gut extracts from *Hermetia illucens* and *Musca domestica* using Api-ZYM kit.

Enzymes	<i>Hermetia illucens</i>		<i>Musca domestica</i>	
	Salivary	Gut	Salivary	Gut
Control	0	0	0	0
Alkaline phosphatase	1	5	1	5
Esterase (C <sub>4</sub> )	3	3	3	3
Esterase lipase	3	5	3	5
Lipase	1	5	0	5
Leucine arylamidase	5	5	2	5
Valine arylamidase	0	5	0	5
Cystine arylamidase	0	5	0	5
Trypsin	0	4	1	4
α-Chymotrypsin	0	1	0	1
Acid phosphatase	4	5	3	5
α-Galactosidase	0	4	0	1
β-Galactosidase	3	5	0	5
β-Glucuronidase	0	1	0	1
α-Glucosidase	3	5	2	5
β-Glucosidase	0	1	1	1
N-Acetyl-β-glucoaminidase	2	5	2	5
α-Mannosidase	0	4	0	1
α-Fucosidase	3	3	0	1

Comparison of enzyme activity in the gut extracts from *Hermetia illucens* and *Musca domestica* using 4 specific substrates of  $\alpha$ -amylase, lipase, protease and trypsin-like protease. All experiments replicated three times. Enzymes activity (Mean $\pm$  SE)

	<i>Hermetia illucens</i>	<i>Musca domestica</i>
$\alpha$ -amylase (U/g)	3.85 $\pm$ 0.014 (p<0.01)	1.27 $\pm$ 0.008
Lipase (U/g)	7.75 $\pm$ 0.519 (p<0.01)	3.30 $\pm$ 0.110
Protease (OD/h/ $\mu$ g)	3.33 $\pm$ 0.131 (p<0.01)	2.13 $\pm$ 0.018
Trypsin-like protease (OD/min/ $\mu$ g)	0.13 $\pm$ 0.008 (p<0.01)	0.06 $\pm$ 0.003





*Thank you for your attendance . . .*