

Occurrence and Phylogeny of EPN – *Paenibacillus* Associations

Enright, MR¹, El-Borai, FE², Duncan, LW² & Griffin, CT¹

¹ National University of Ireland, Maynooth. Co. Kildare, Ireland.

² University of Florida, IFAS, Citrus Research and Education Center, Lake Alfred, FL, USA.



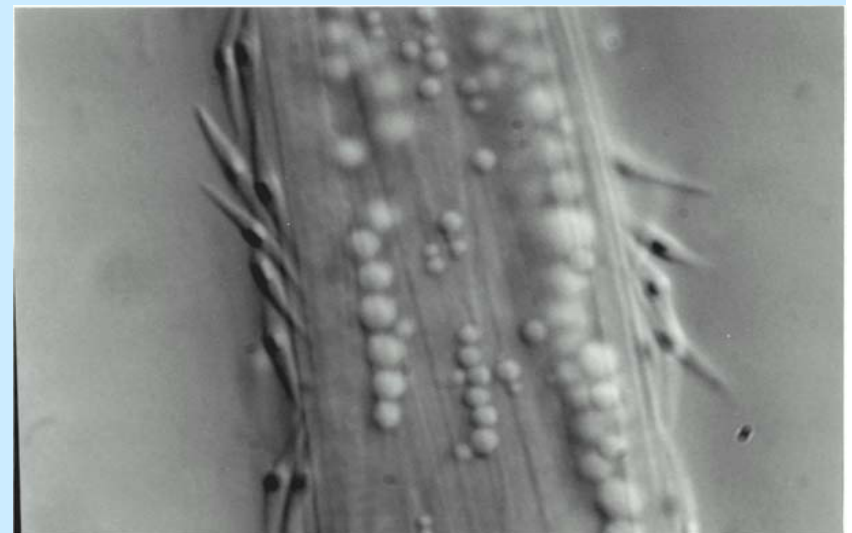
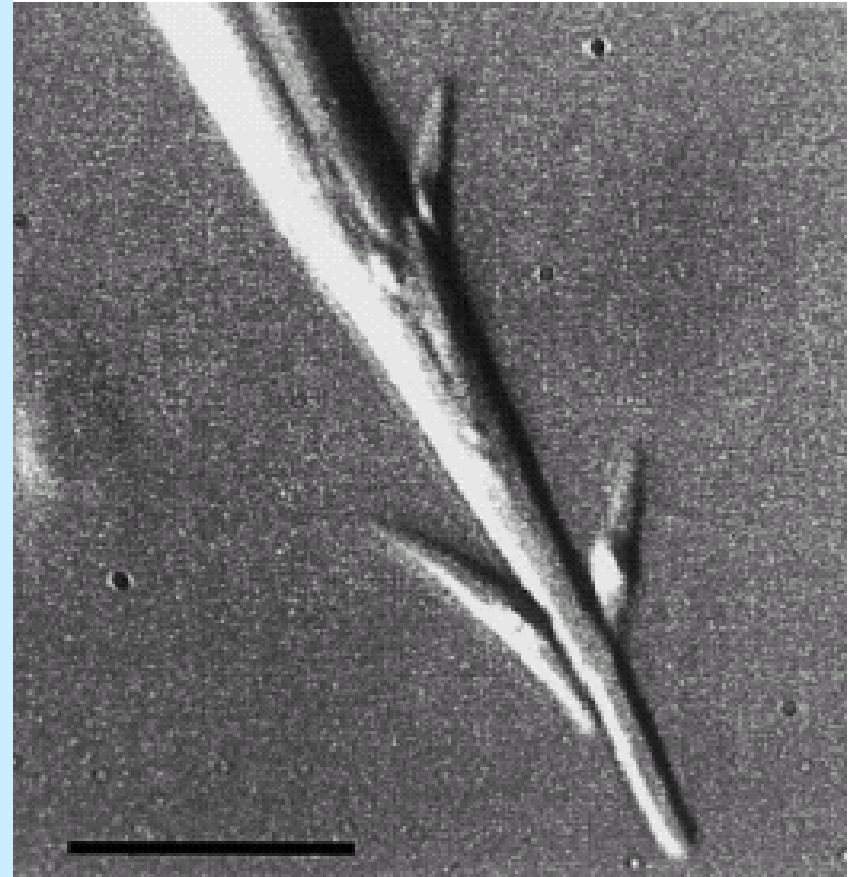
Background

H. megidis EU17 from Estonia:

IJs form clumps



- Sporangia cause clumping of IJs
- Phoretic relationship
- Reproduces within cadaver
- No effect on nematode reproduction/quality
- Movement inhibition
- Identified as a *Paenibacillus*



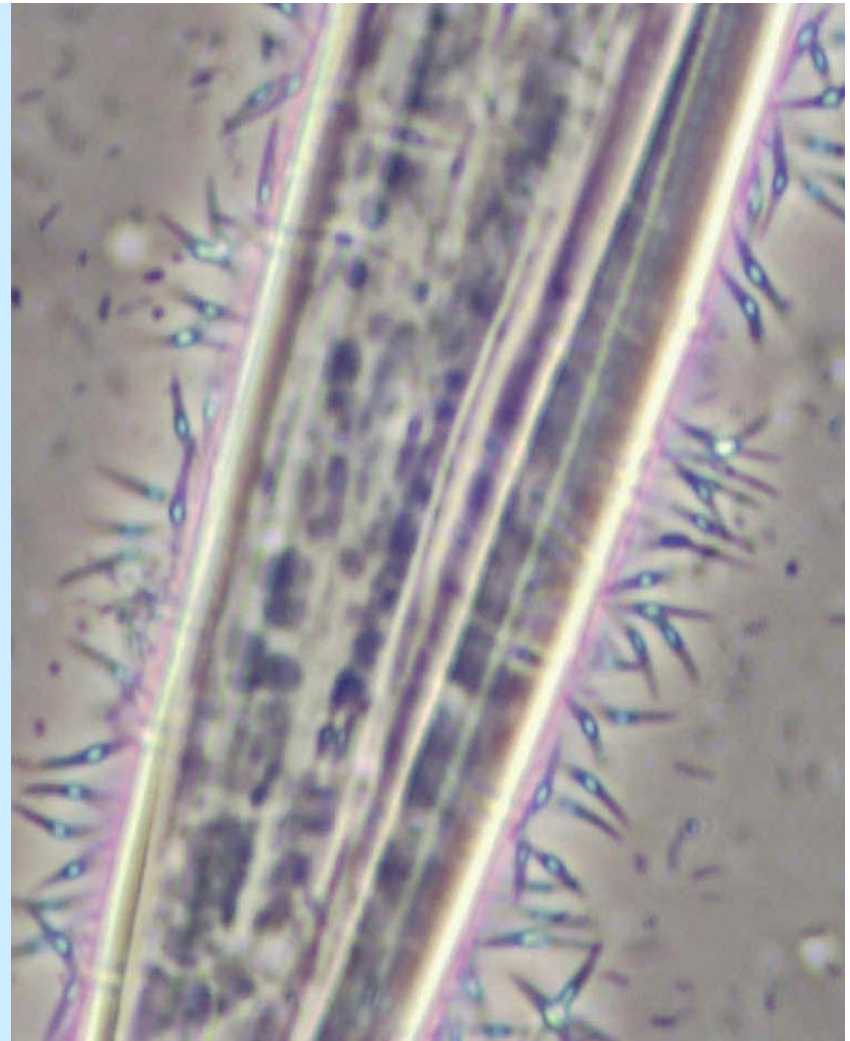
What are *Paenibacillus*?

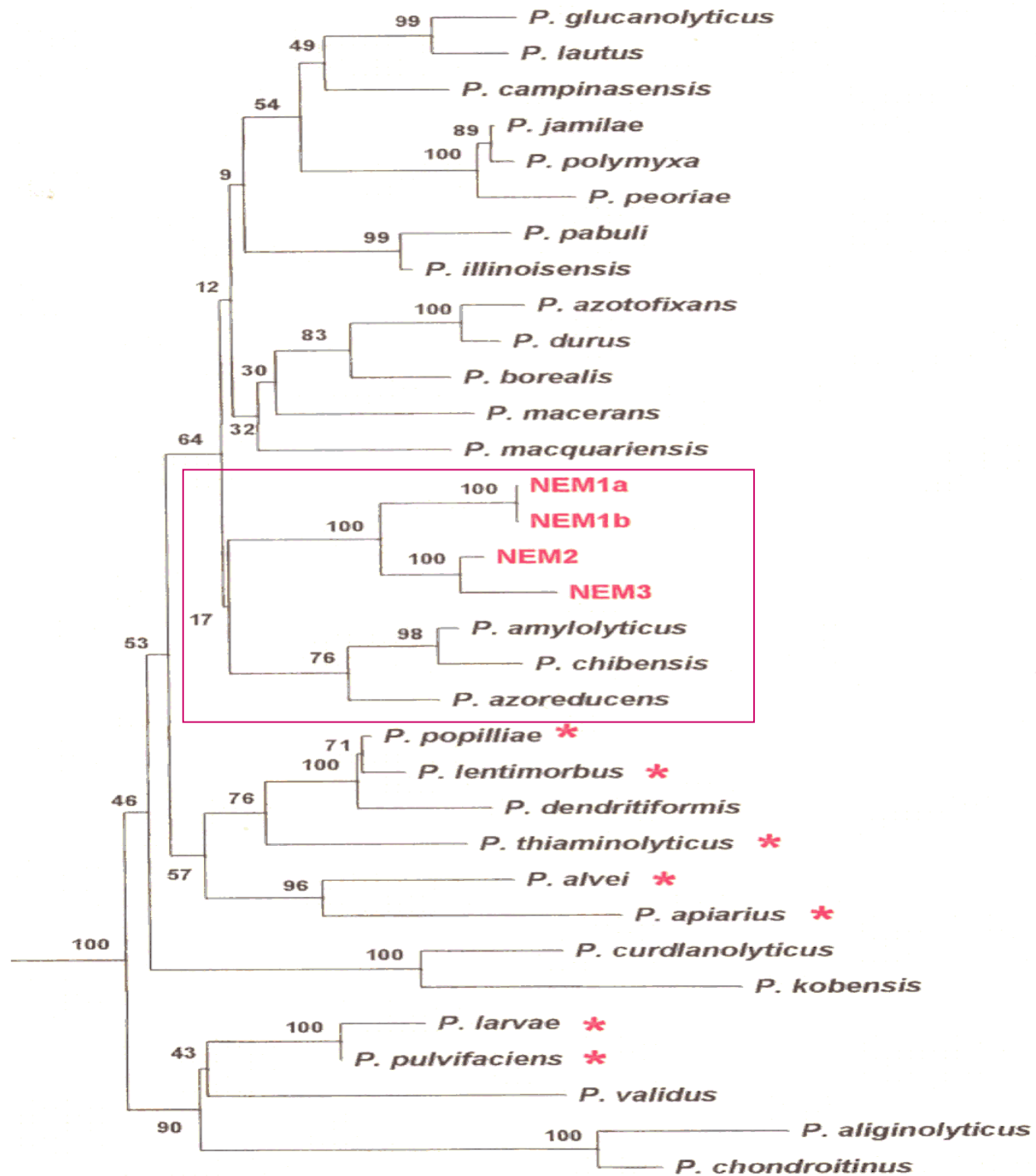
- Aerobic, Gram +, rod-shaped endospore-formers
- Described by Ash *et al.* (1993) following a taxonomic revision of genus *Bacillus*.
- Diverse and rapidly expanding genus
- Some species associated with insects
- Nothing known of ecology for majority of species

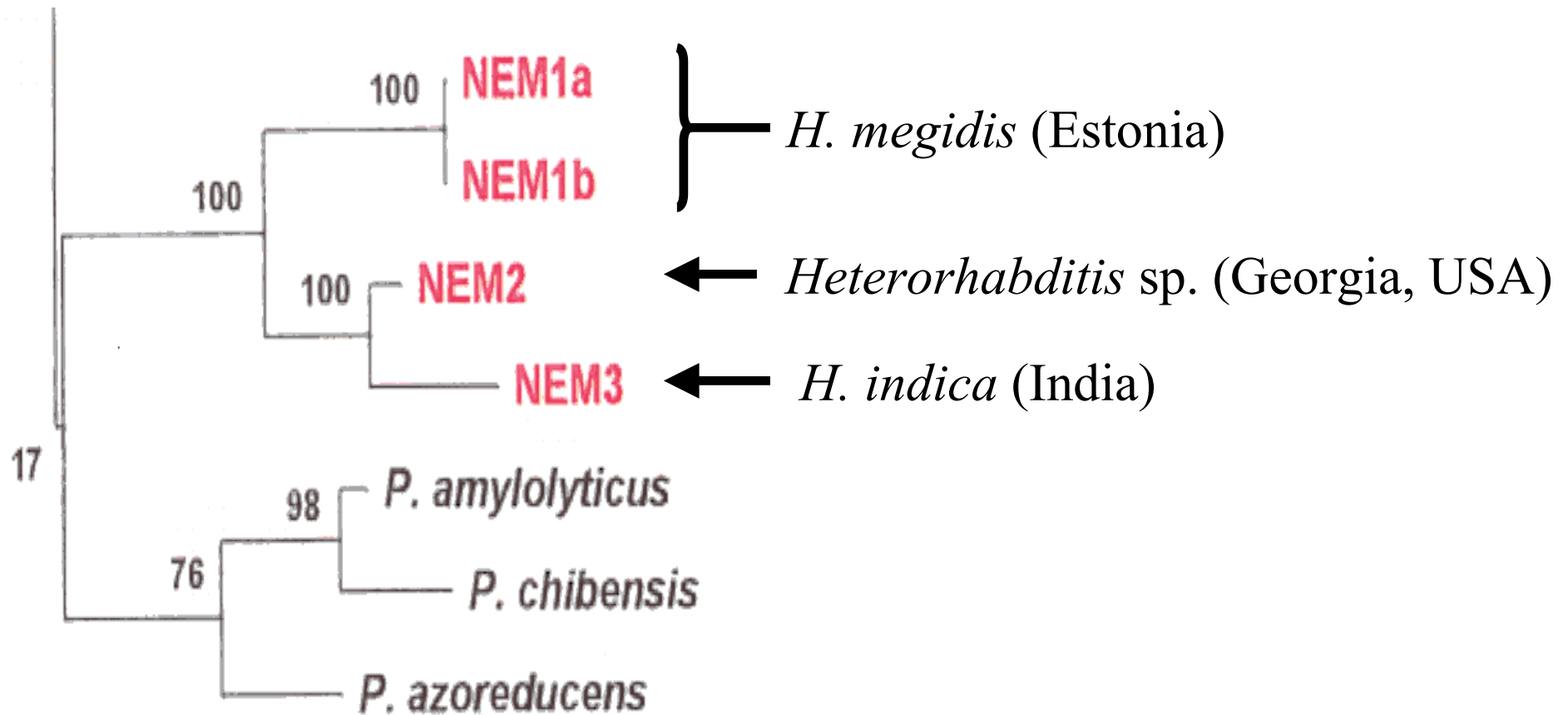
Associations with *Heterorhabditis*

Sporangia similar to those with *H. megidis* EU17 from Estonia also found with:

- *H. indica* from India
(*Enright et al., 2001*)
- *H. indica* and *H. zealandica* from Florida
(*El-Borai et al., in press*)
- *Heterorhabditis* sp. from Georgia, USA.
(*Marti & Timper, 1999*).



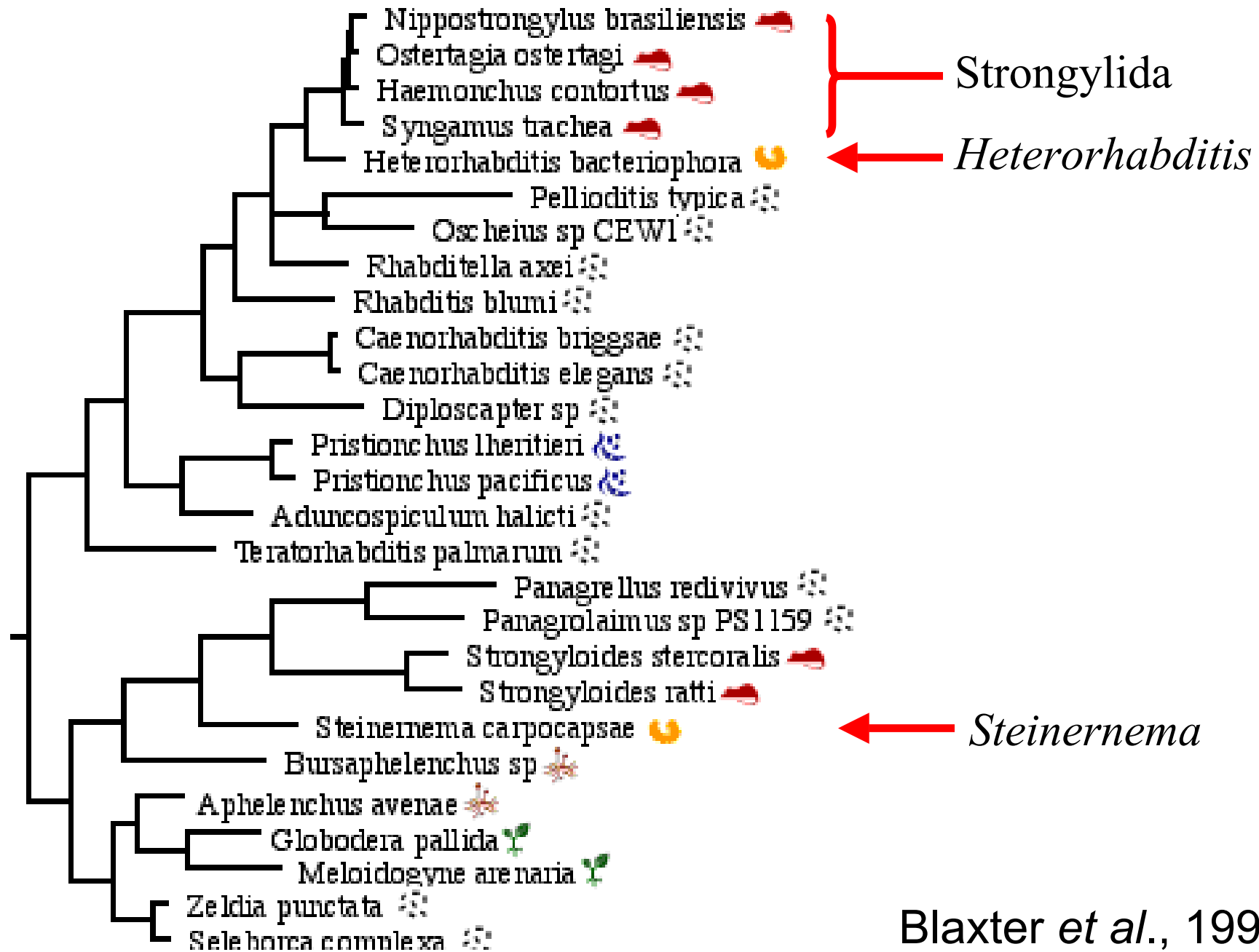




- Monophyletic group
- Phenotypically very similar
- A multi-species group
- *Paenibacillus nematophilus* described (Enright et al., 2003)

Paenibacillus* adhere to other *Heterorhabditis

- Adhere to all *Heterorhabditis* and Strongylida tested
- Do not adhere to *Steinernema* or a range of other nematodes



Blaxter *et al.*, 1998.

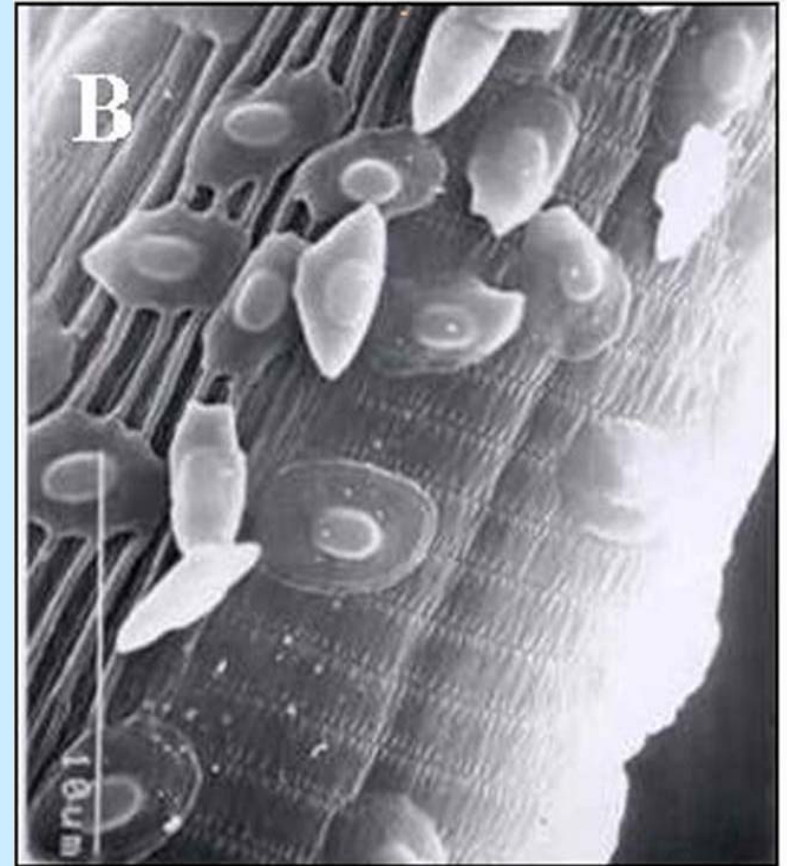
Specificity of *in vivo* reproduction

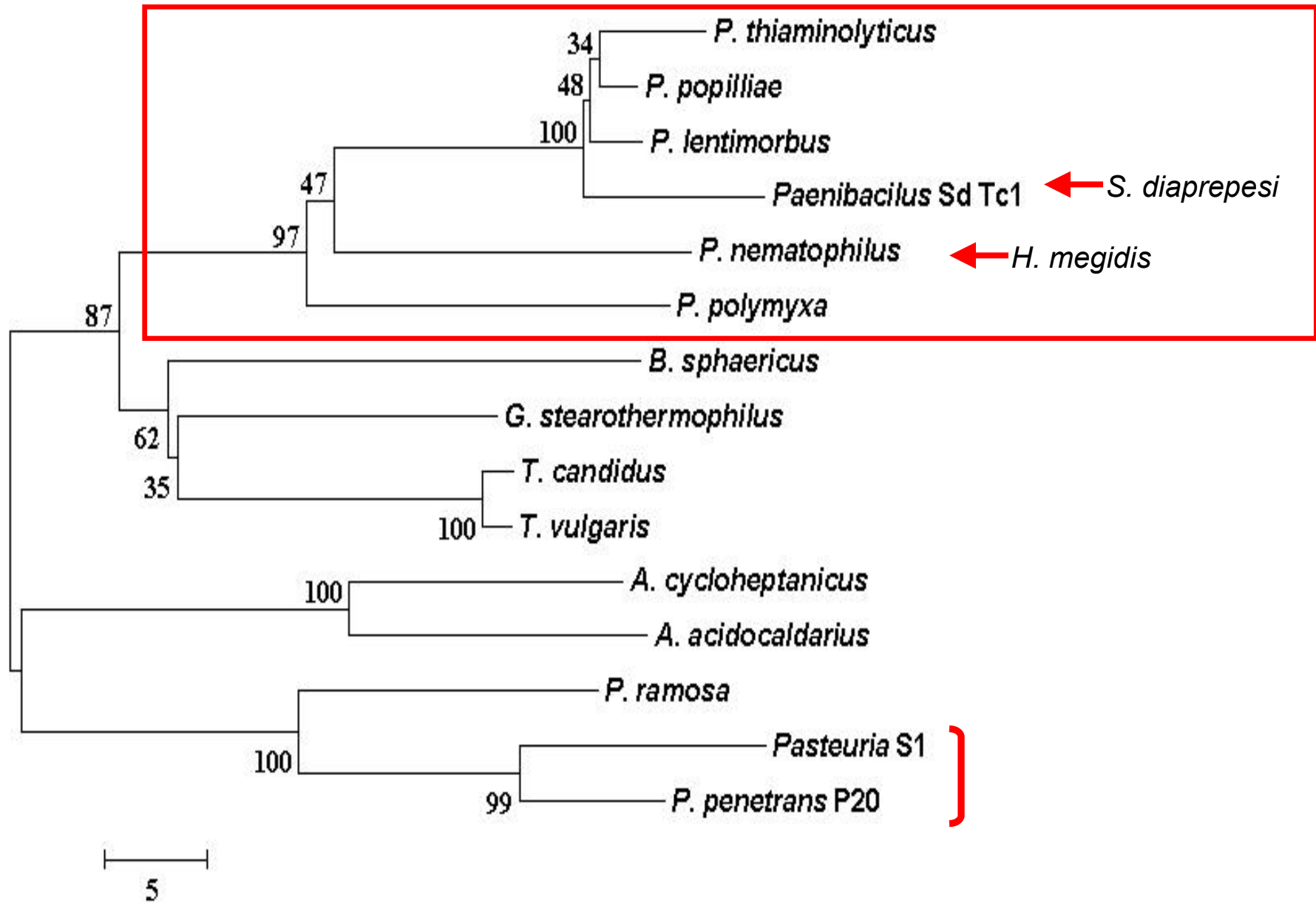
	NEM1a from <i>H. megidis</i> Estonia	NEM2 from <i>Heterorhabditis sp.</i> Georgia, USA	NEM3 from <i>H. indica</i> India
<i>H. megidis</i>	+	-	-
<i>H. downesi</i>	+	-	-
<i>H. bacteriophora</i>	W	W	W
<i>H. indica</i>	-	+	+
<i>Heterorhabditis sp.</i>	-	+	+

Associations with *Steinernema*

Sporangia with *Steinernema diaprepesi*

- Isolated from citrus-root weevil in Florida
- Frequent occurrence
- Phoretic relationship similar to those involving *Heterorhabditis*
- Different sporangial morphology

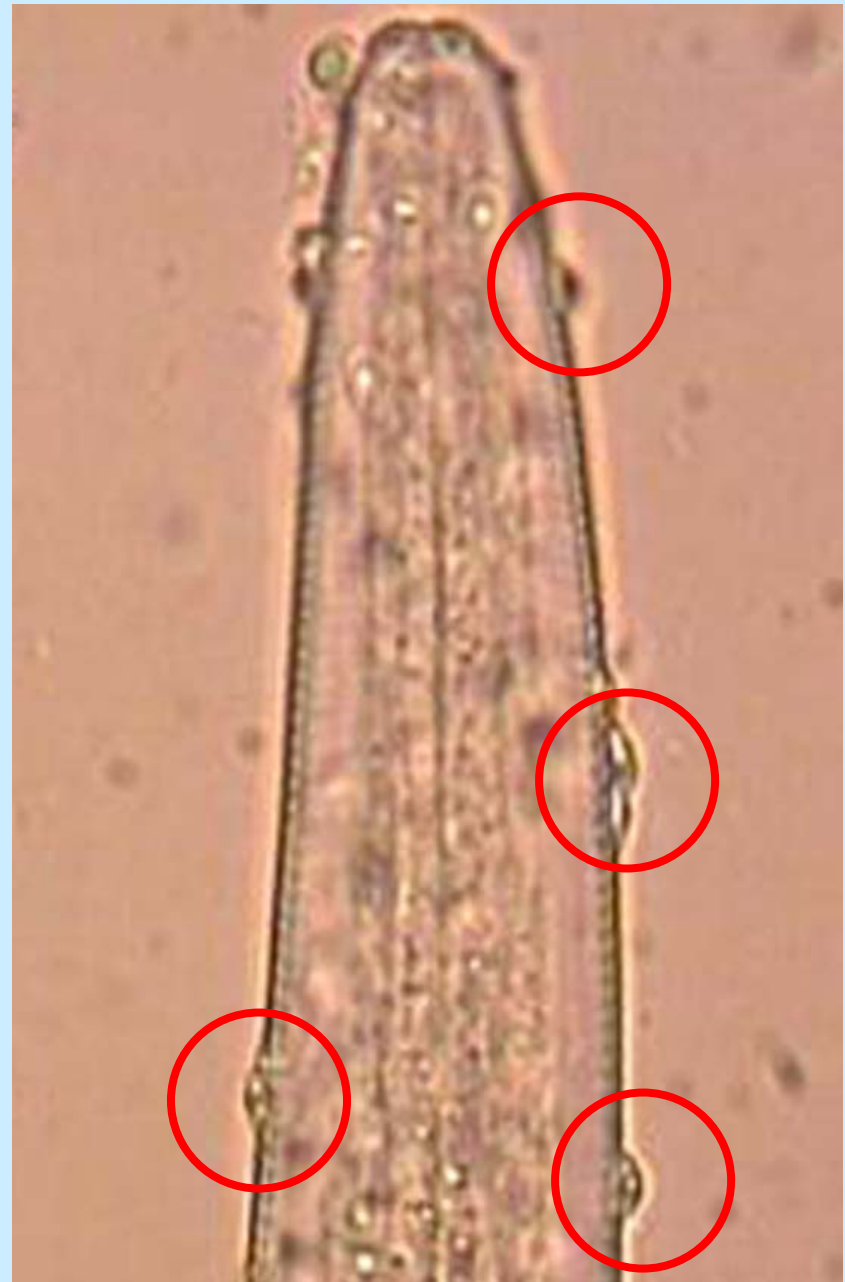




- *Paenibacillus* from *Steinernema diaprepesi* only adhere to that species. Does not adhere to other *Steinernema* species.

Associations with other *Steinernema* species

- Sporangia found with *S. glaseri* in Florida
- Unidentified bacterium



Adaptations to a phoretic life-style with EPN

- *Heterorhabditis* and *Steinernema* not closely related
- Association with each would require specific adaptations

Transport

- Retention of intact sporangium
- Adhesion to sheath (*Heterorhabditis*) or cuticle (*Steinernema*)

Survival & reproduction within cadaver

- Tolerance of symbiont's antimicrobials
- Tolerance of insect immune defense mechanisms

Conclusions

- At least two phylogenetically distinct nematode-associated *Paenibacillus* groups
- Possess adaptations to phoretic lifestyle
- Phoretic associations with EPN may be widespread
- Importance to EPN ecology?
- Movement inhibition – affects local populations?

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