



Systematics and Evolution of
Heterodanophthalmus cave
beetles

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Pseudanophthalmus cave beetles

- Carabid ground beetle tribe **Trechini**
 - Many troglobiont lineages in Trechini
 - Eastern US
 - Europe: Spain, France, Italy, etc.
 - East Asia
 - New Zealand
 - Northeast Mexico
 - Trechines may be predisposed to subterranean life

Pseudanophthalmus cave beetles

- Carabid ground beetle tribe **Trechini**
 - Other eastern US cave trechines are closely related to *Pseudanophthalmus*
 - Only *Pseudanophthalmus* spp. occur in Appalachia Ridge and Valley region (Virginia)
 - Eurasian *Trechoblemus* may be the closest relative with wings and eyes
 - No surface-dwelling close relative exists in North America



Neaphaenops tellkampfi

Trechoblemus



Pseudanophthalmus cave beetles

- Ground beetle genus *Pseudanophthalmus*
 - All obligate cave species
 - Tiny in size: 3 - 7mm
 - Blind, de-pigmented, flightless, elongate body, sensory setae, and appendages



Pseudanophthalmus cave beetles

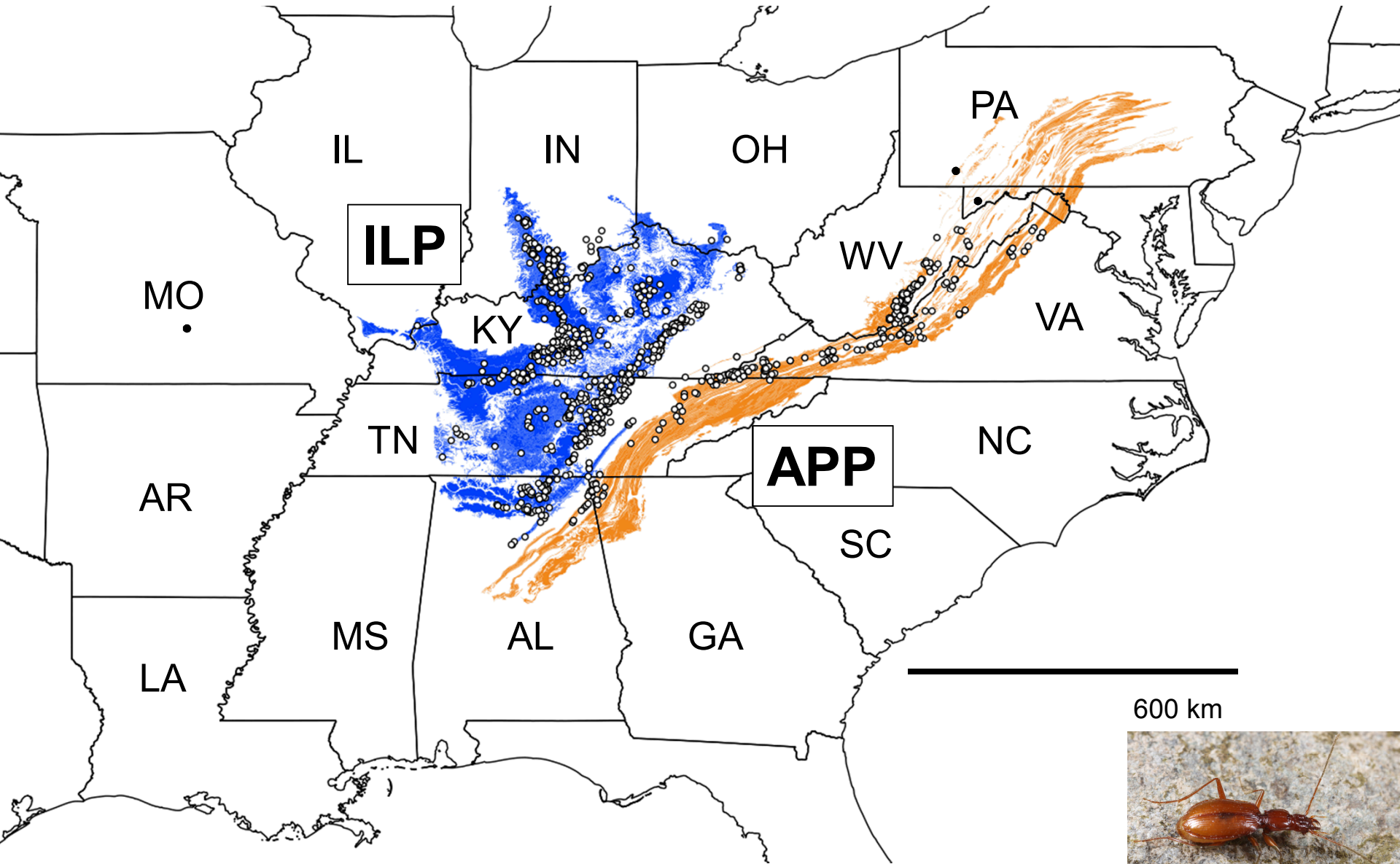
- Ground beetle genus *Pseudanophthalmus*
 - Predators as adults and larvae
 - Important terrestrial troglobiont predator in caves in eastern US
 - Probably prey on insect eggs, small mites, collembola, or small worms in soil or silt
 - Females lay eggs in soil or silt
 - Life history unknown
 - Surface-dwelling trechine ground beetles live ~1 year and have 3 larval instars
 - Probably relatively small population sizes



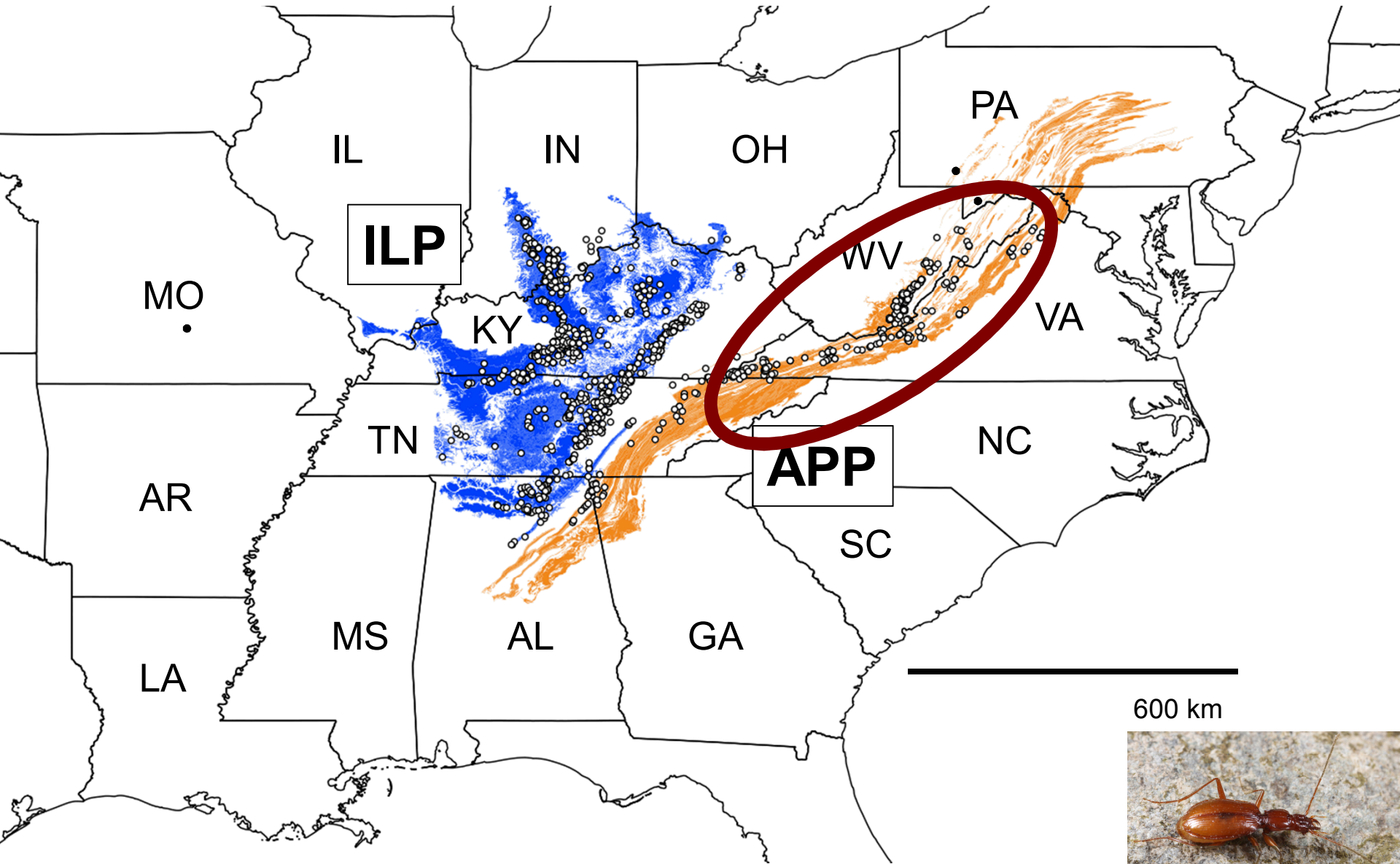
Pseudanophthalmus cave beetles

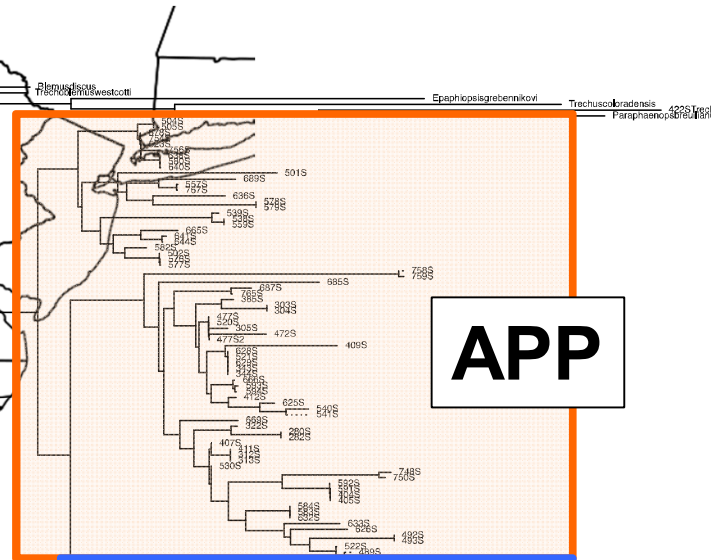
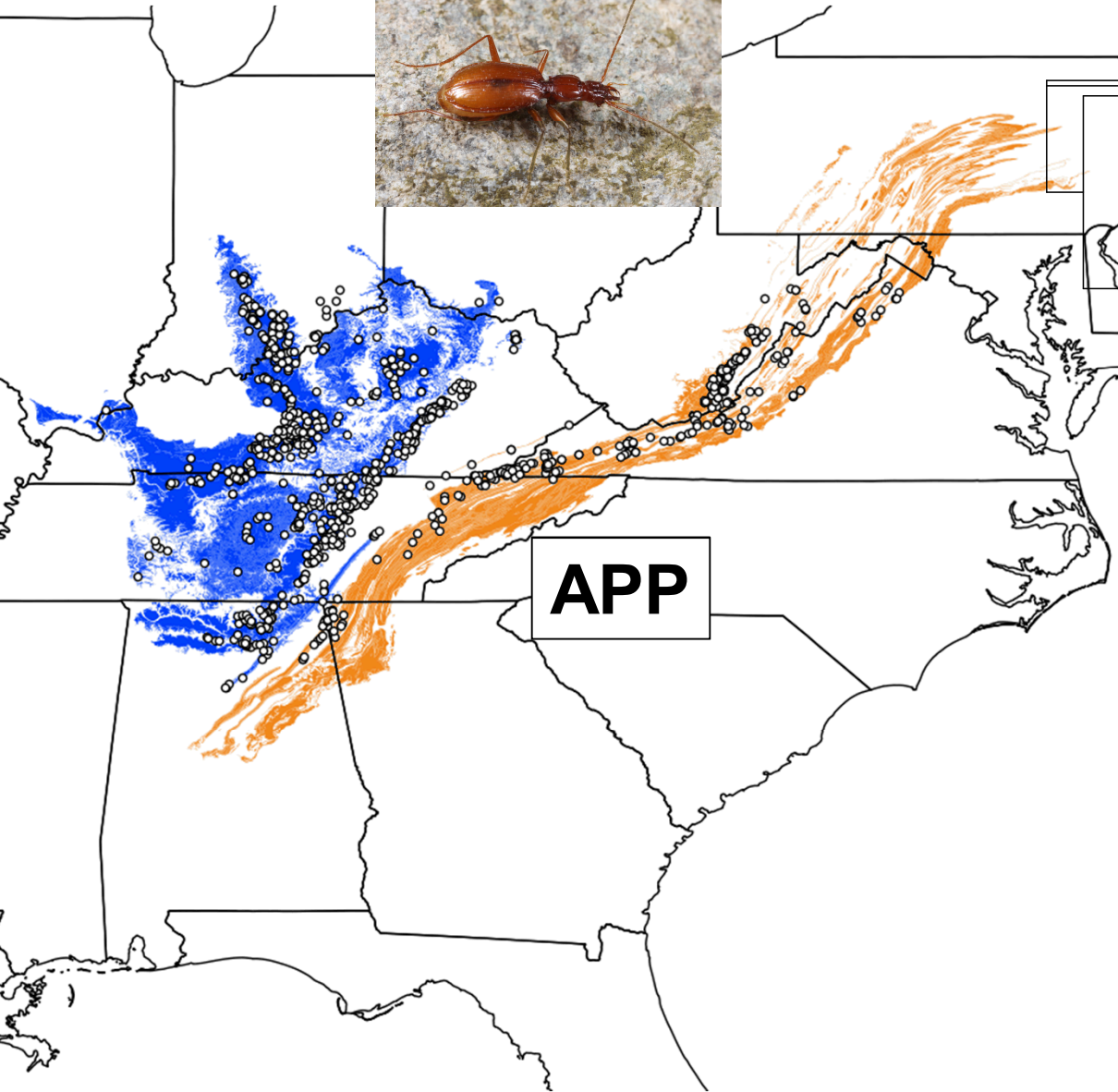
- Ground beetle genus *Pseudanophthalmus*
 - Endemic to southern Appalachia region
 - 145+ described species with ~80 undescribed species
 - Most species restricted to a single cave or cave system
 - Karst islands

Range of *Pseudanophthalmus*

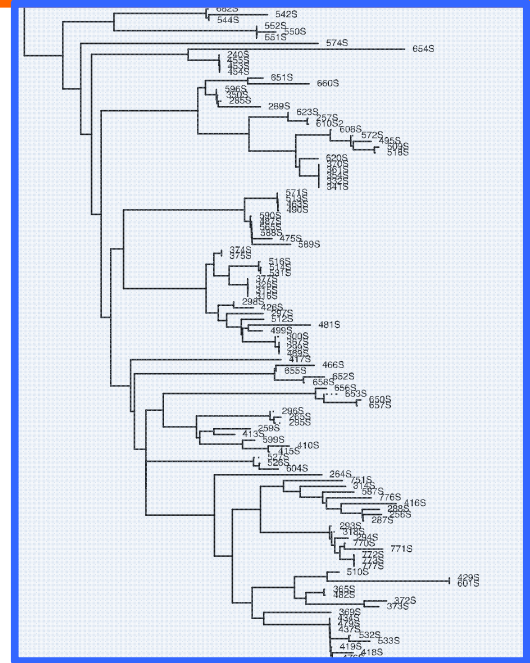


Range of *Pseudanophthalmus*





APP



APP

Systematics and Evolution of *Pseudanophthalmus*

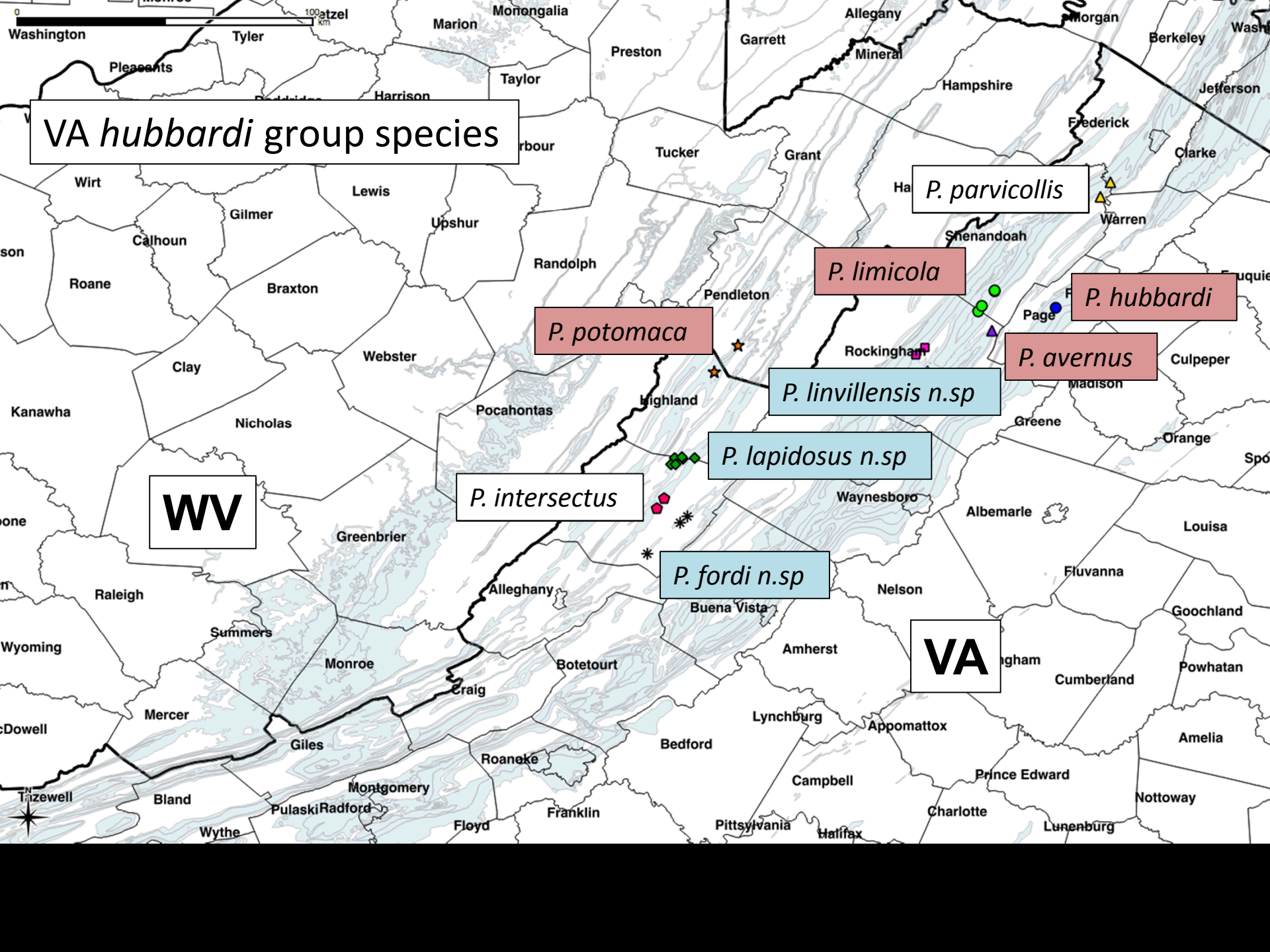
- Many Appalachian Ridge and Valley (APP) species are restricted to a single cave
 - 22 of the 64 described APP species are endemic to a single cave in a narrow band of karst, separate from other caves
- Sympatry is rare
 - Exception = Blair-Collins Cave system: *P. thomasi* & *P. sericus*;
 - Exception = Hugh-Young Cave: *P. virginicus* & *P. vicarius*
- APP has ~ 2x as many described species per km² of karst versus other regions of US
- Significantly smaller species ranges (if found in more than one cave) in APP versus other regions of US
 - 159.43 km² (APP) vs 629.12km² (ILP)

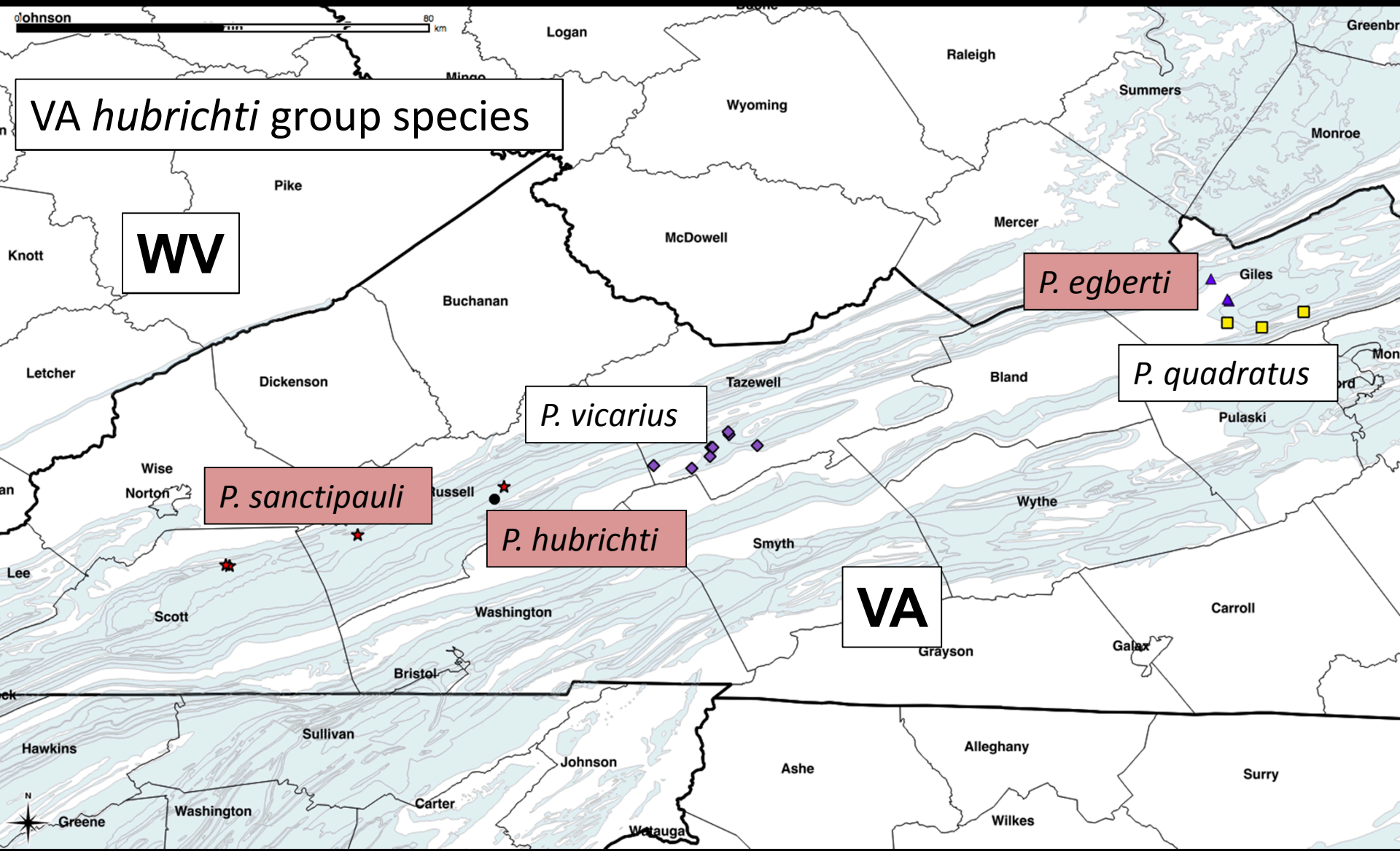
Systematics and Evolution of *Pseudanophthalmus*

- Morphologically related species taxa occur in adjacent limestone valleys
- APP has ~ 2x as many described species per km² of karst versus other regions of US
- Significantly smaller species ranges (if found in more than one cave) in APP versus other regions of US
 - 159.43 km² (APP) vs 629.12km² (ILP)

Virginia *Pseudanophthalmus* SSA

- *hubbardi* species group
 - *P. avernus*
 - *P. limicola*
 - *P. hubbardi*
 - *P. potomaca*
 - *P. parvicollis*
- *hubrichti* species group
 - *P. hubrichti*
 - *P. egberti*
 - *P. sanctipauli*
- *jonesi* species group
 - *P. thomasi*
 - *P. cordicollis*
- *hirsutus* species group
 - *P. sericus*
- *P. hirsutus*
- *hypolithos* species group
 - *P. praetermissus*
- *engelhardti* group
 - *P. holsingeri*
- *pusio* group
 - *P. pusio*
- *grandis* group
 - *P. virginicus*





VA *hubrichti* group species

WV

P. sanctipauli

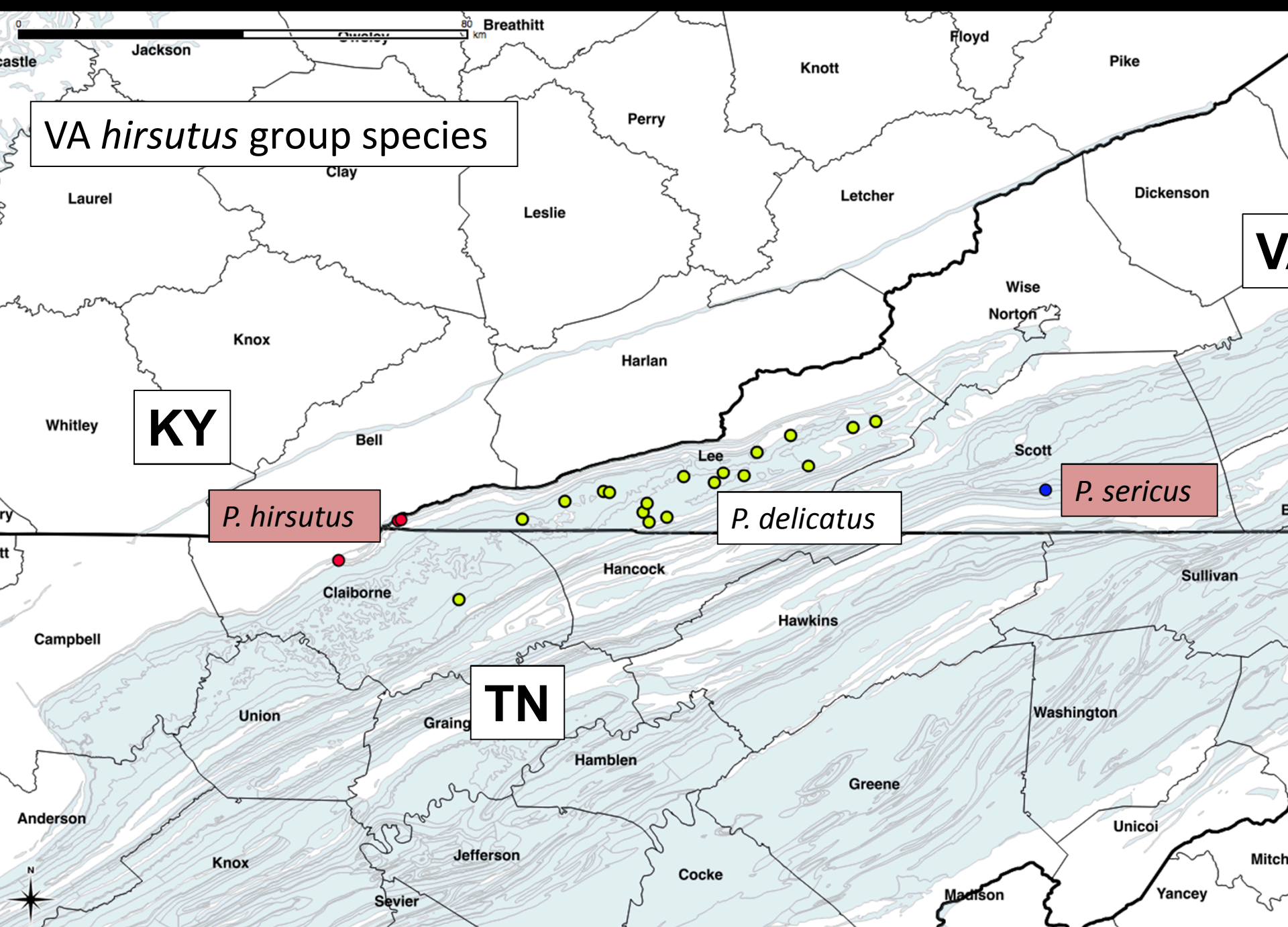
P. vicarius

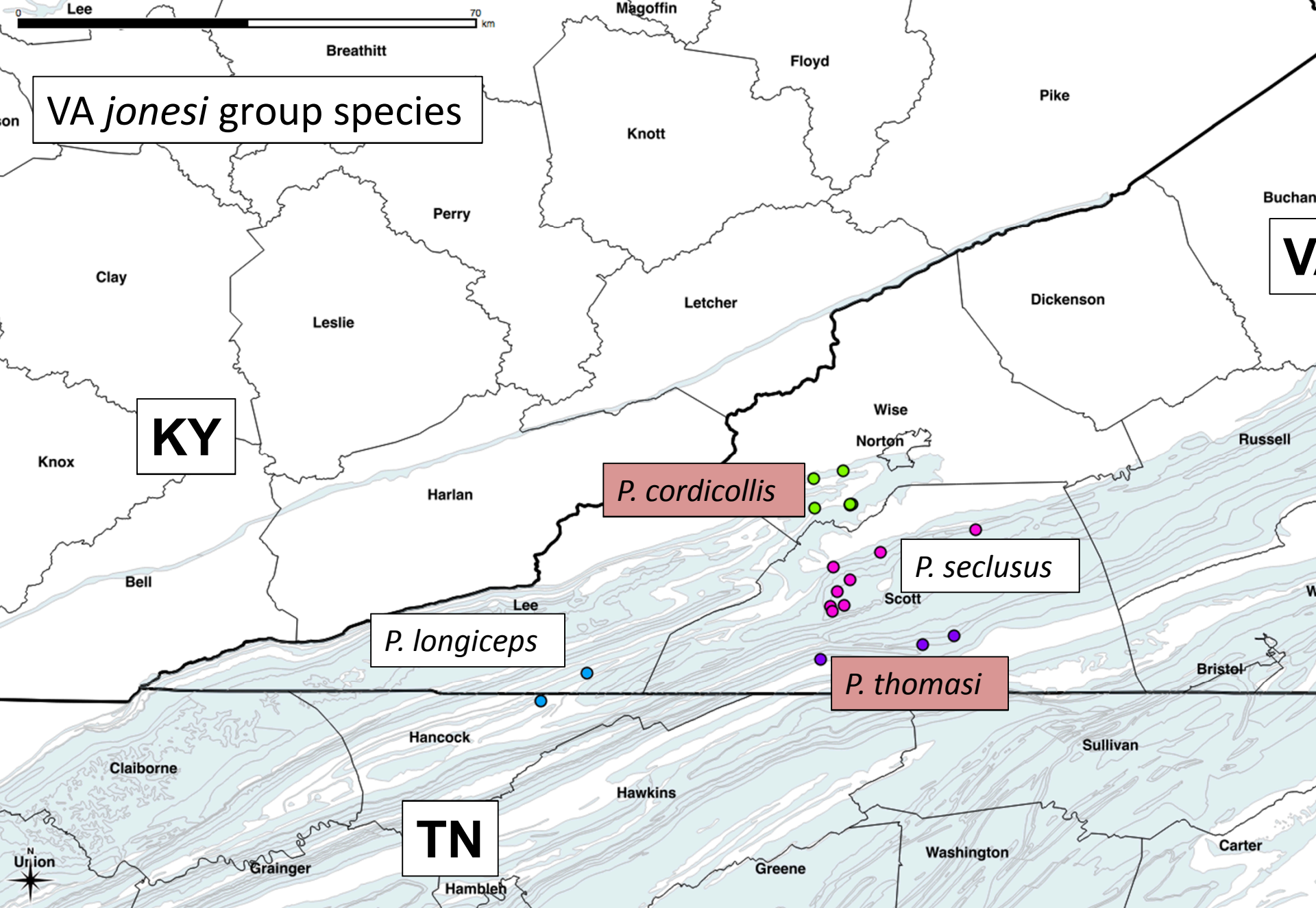
P. hubrichti

P. egberti

P. quadratus

VA





VA *jonesi* group species

KY

P. longiceps

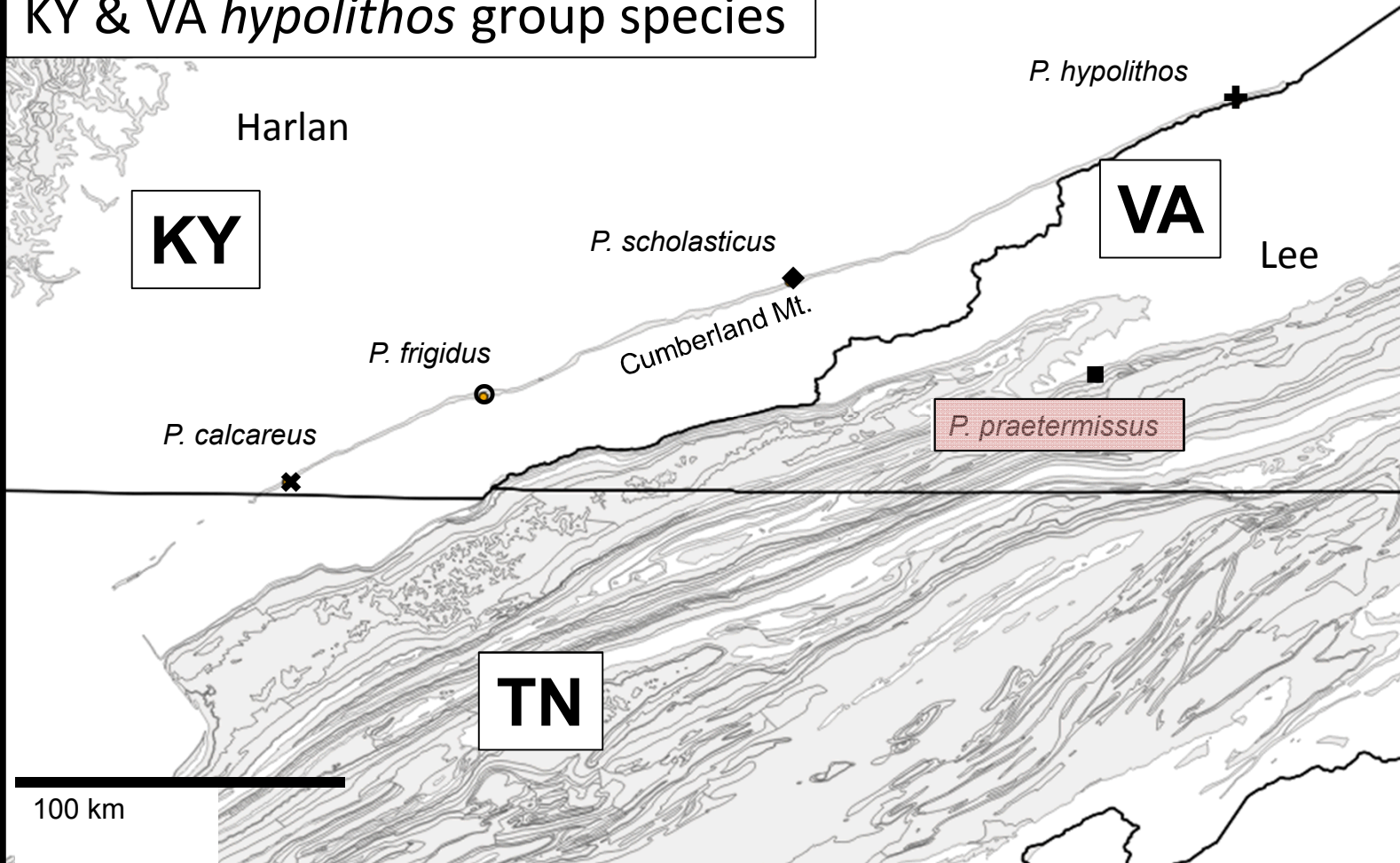
P. cordicollis

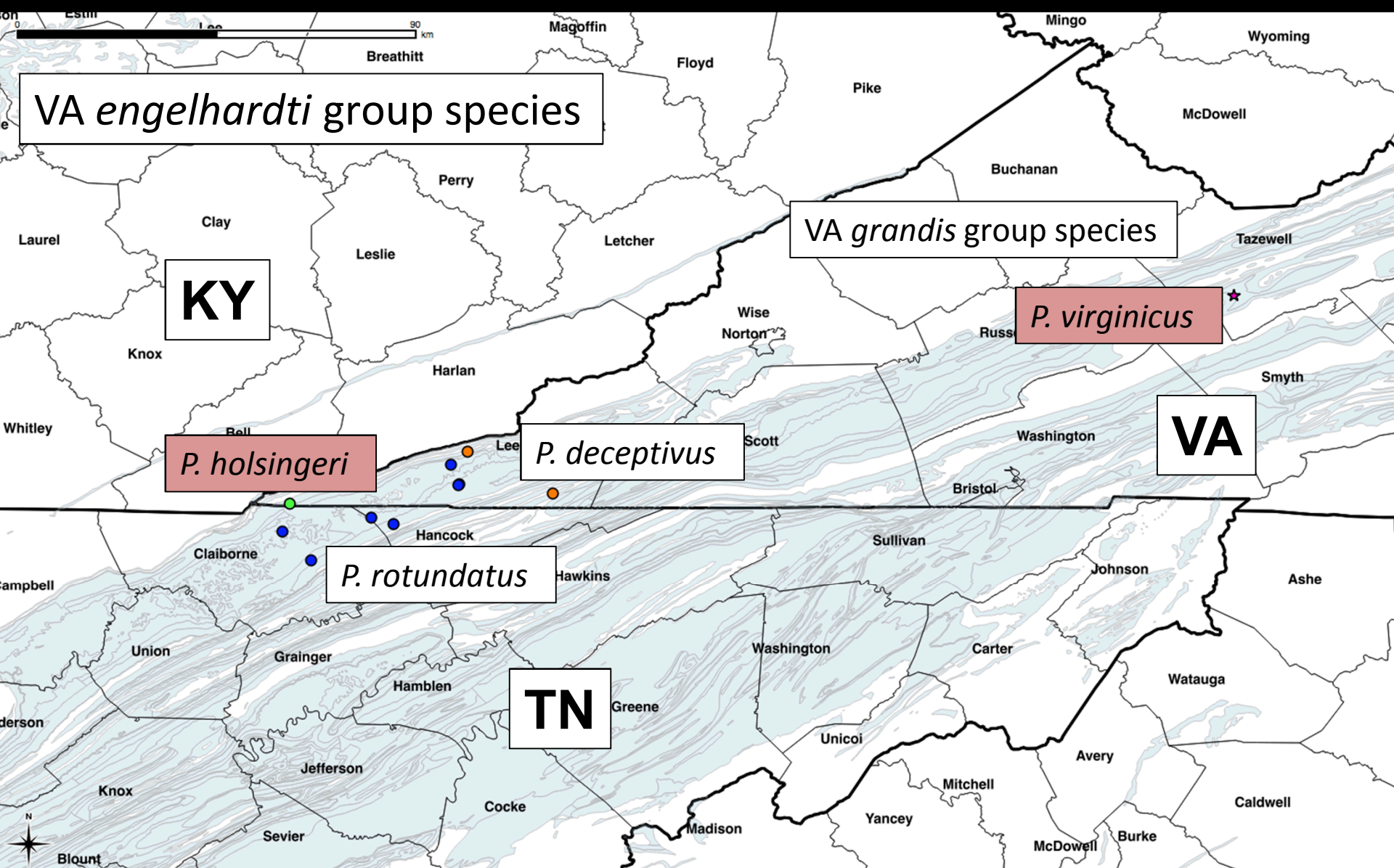
P. seclusus

P. thomasi

TN

KY & VA *hypolithos* group species





VA *engelhardti* group species

VA *grandis* group species

KY

P. virginicus

VA

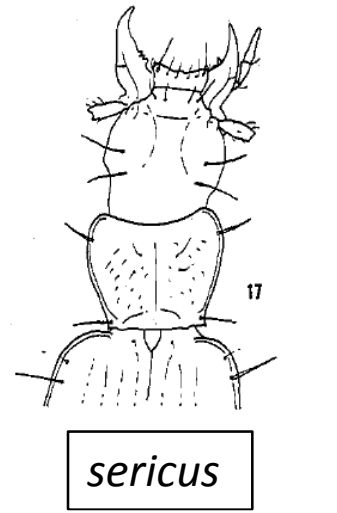
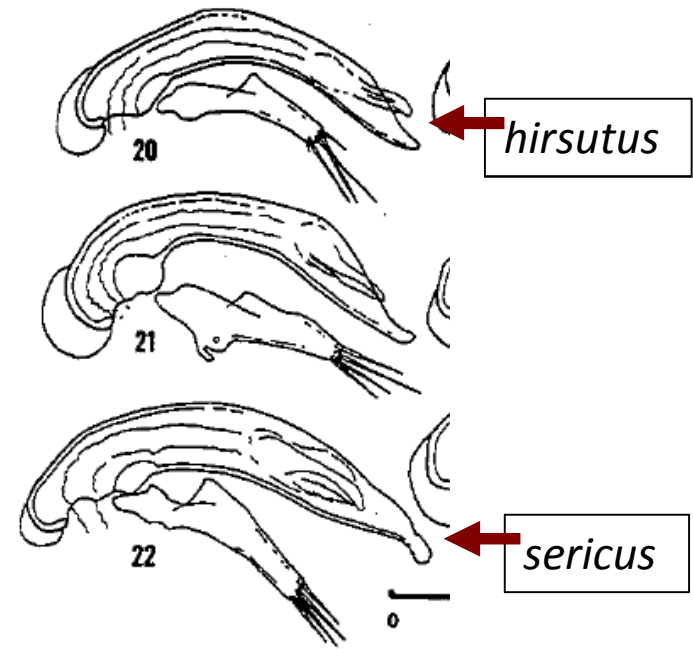
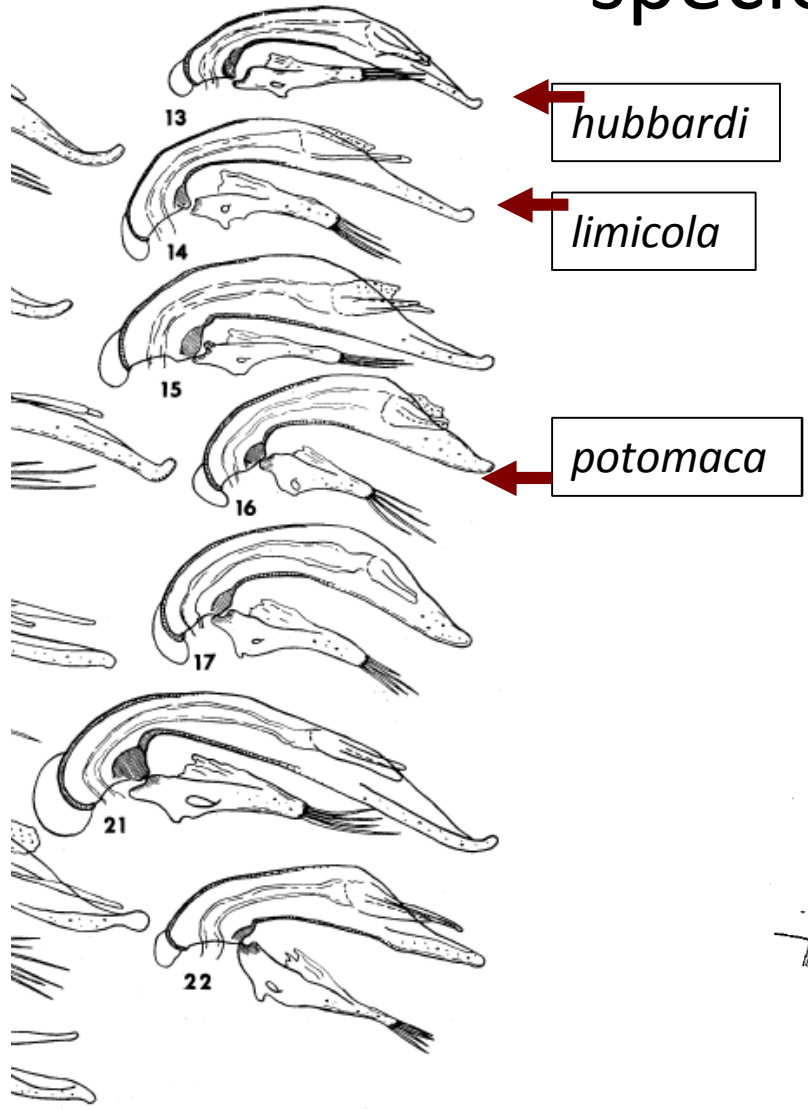
P. holsingeri

P. deceptiveus

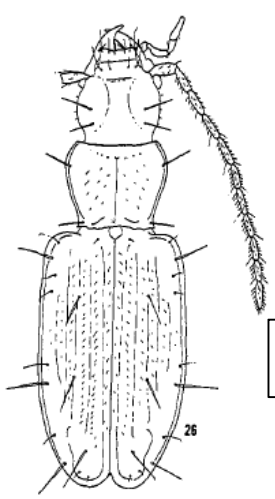
P. rotundatus

TN

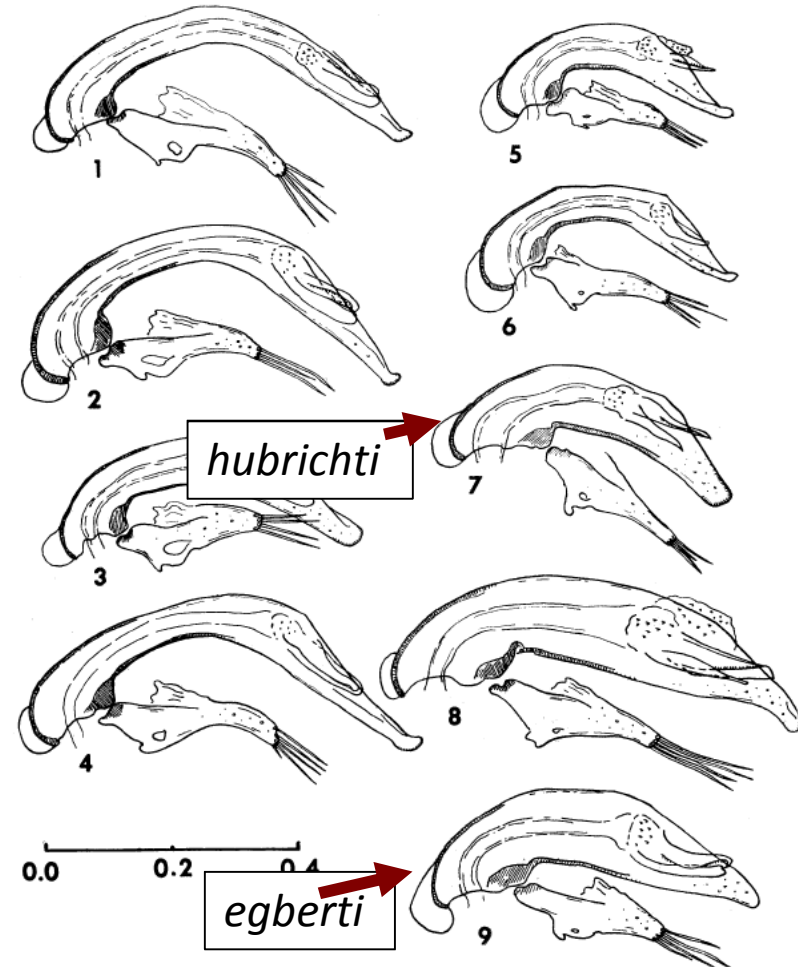
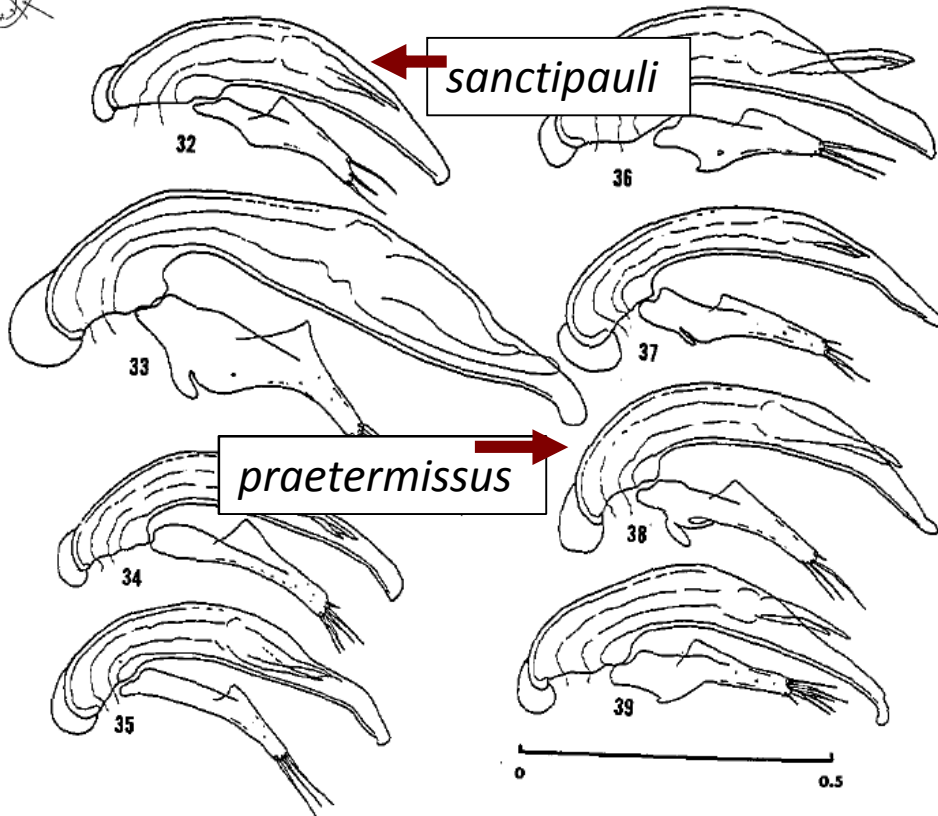
Male genitalia of *hubbardi* and *hirsutus* species groups



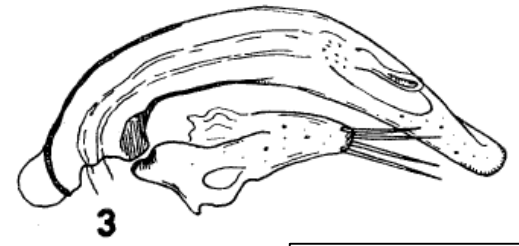
Male genitalia of *hubrichti* species group



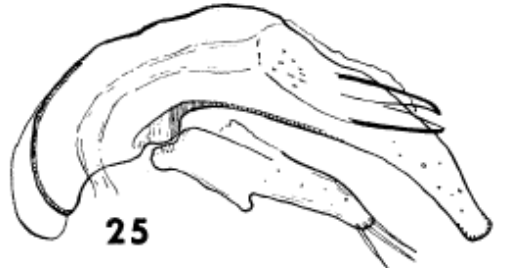
sanctipauli



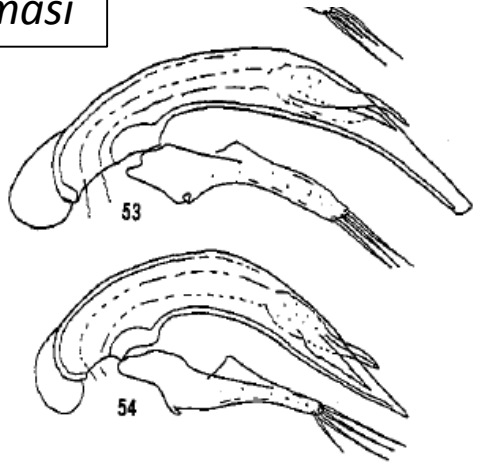
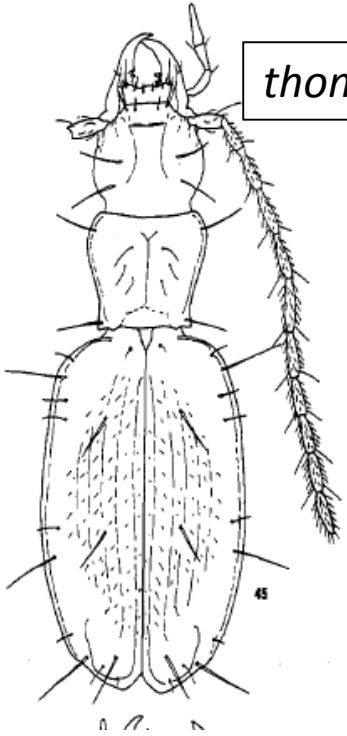
pontis



holsingeri



thomasi



cordicollis

FIGS. 44-47. *Pseudomeloe* sp. nov.



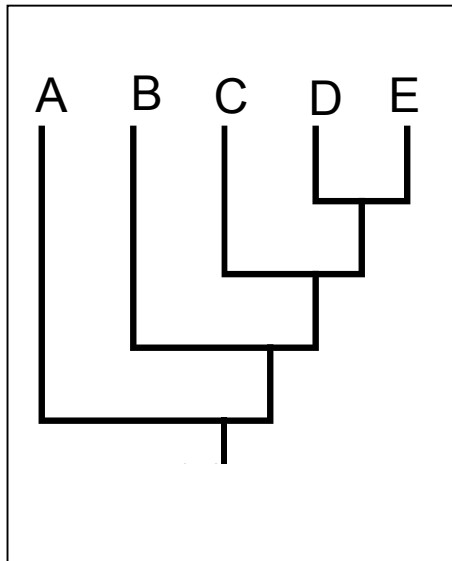
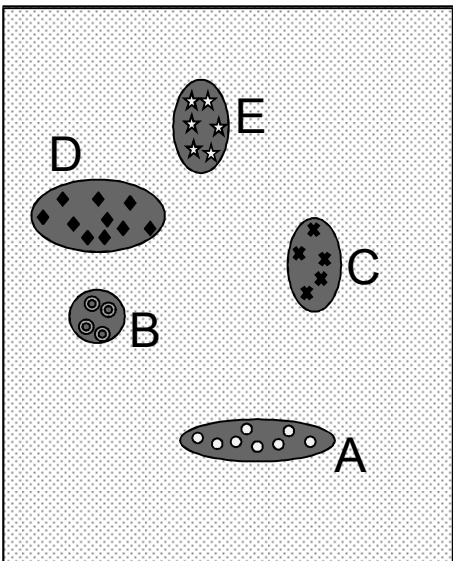
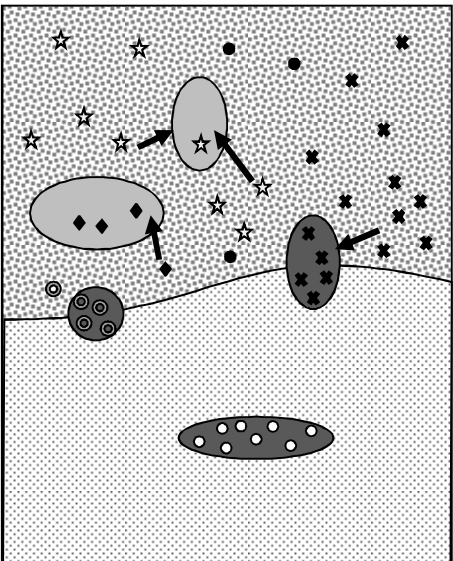
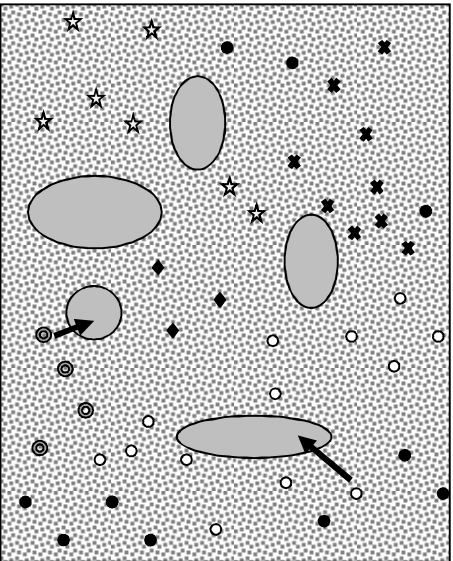
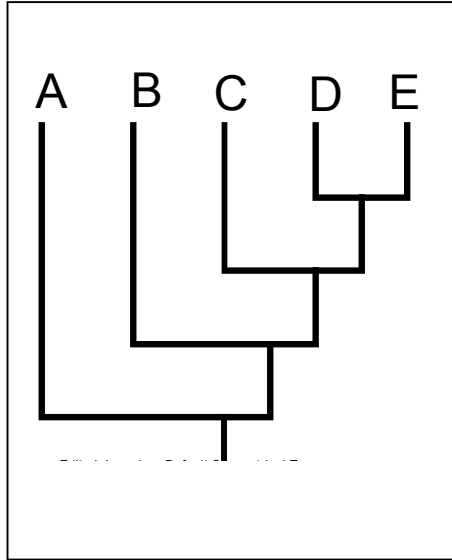
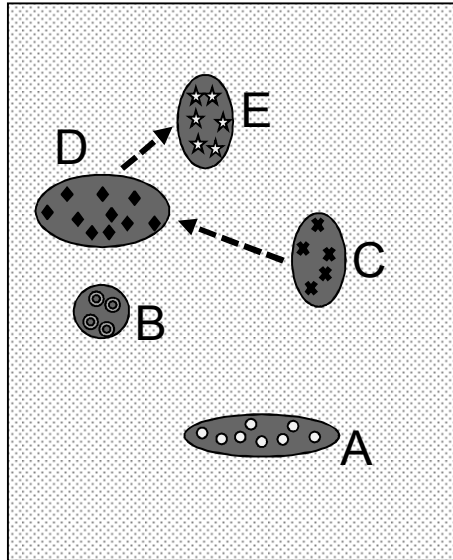
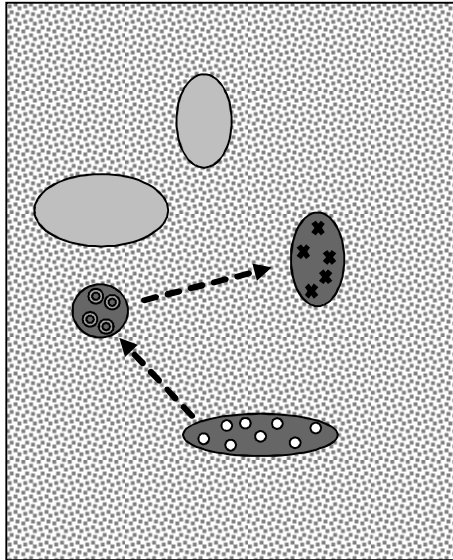
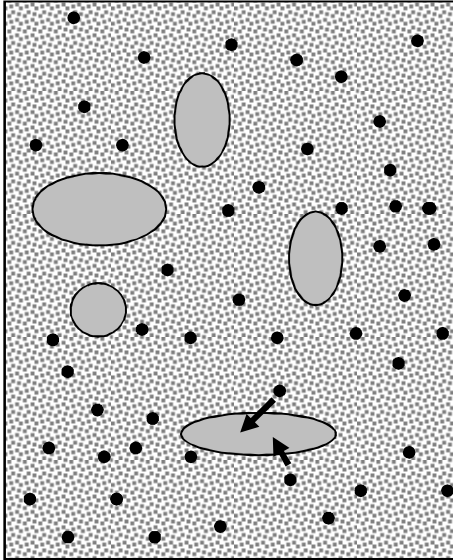
holsingeri

Virginia *Pseudanophthalmus* SSA

- These *Pseudanophthalmus* species have very specific habitat requirements
 - Low temperature, high moisture, constant barometric pressure
- They are highly endemic and have very small restricted ranges
- They cannot live outside caves

Virginia *Pseudanophthalmus* SSA

- They cannot migrate/disperse to utilize other unconnected caves
 - Karst islands
 - Small, isolated pockets of karst separated by shale and sandstone
- Species are distinguished by differences in male genitalia which may reproductively isolate species if sympatry with other species
- Population size and genetic variation are unknown for these specie
 - Presumably small populations (limited habitat and small ranges) and therefore low genetic variation



Vicariance

Invasion:



S_A

S_B

S_C



Extinction of surface populations:



C_A

C_B

C_C



Dispersal

Invasion:



$S_{B'}$



Extinction of surface populations:



C_B



Subsurface migration and speciation:

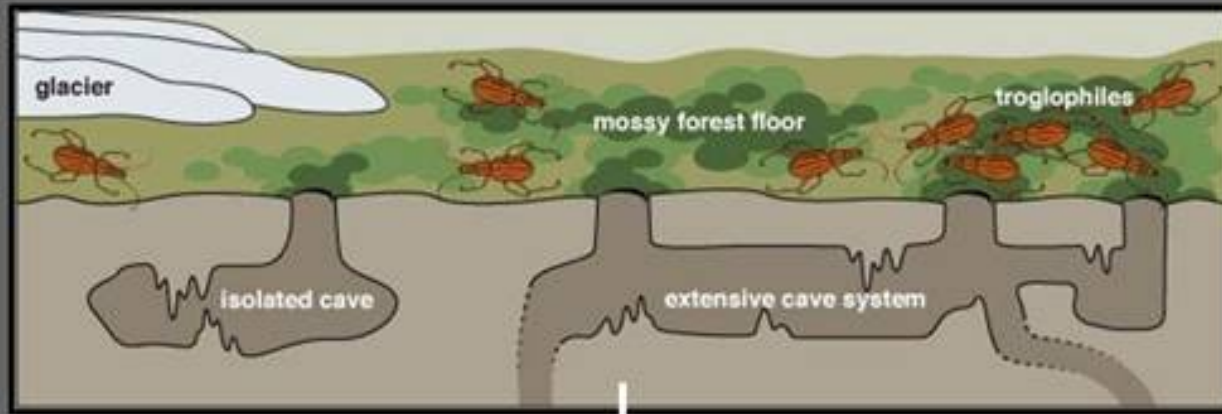


$C_{A'}$

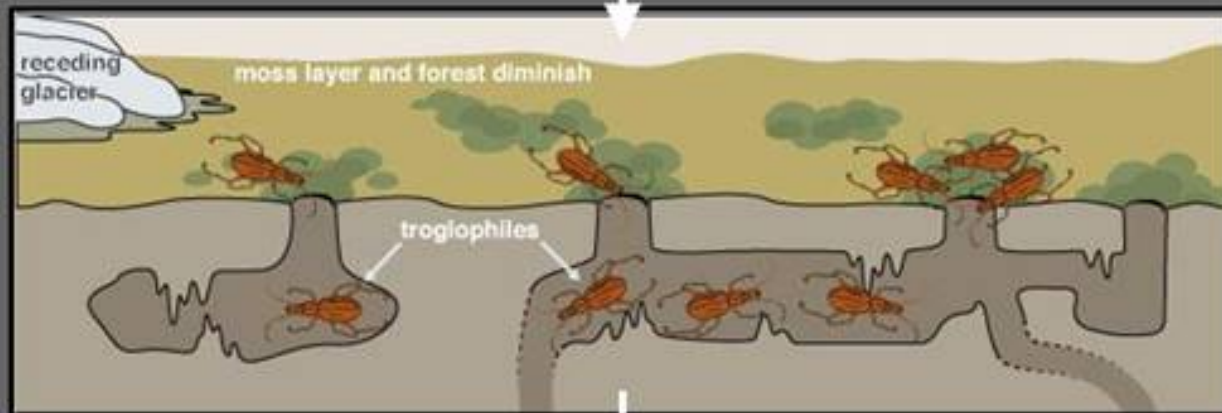


$C_{C'}$

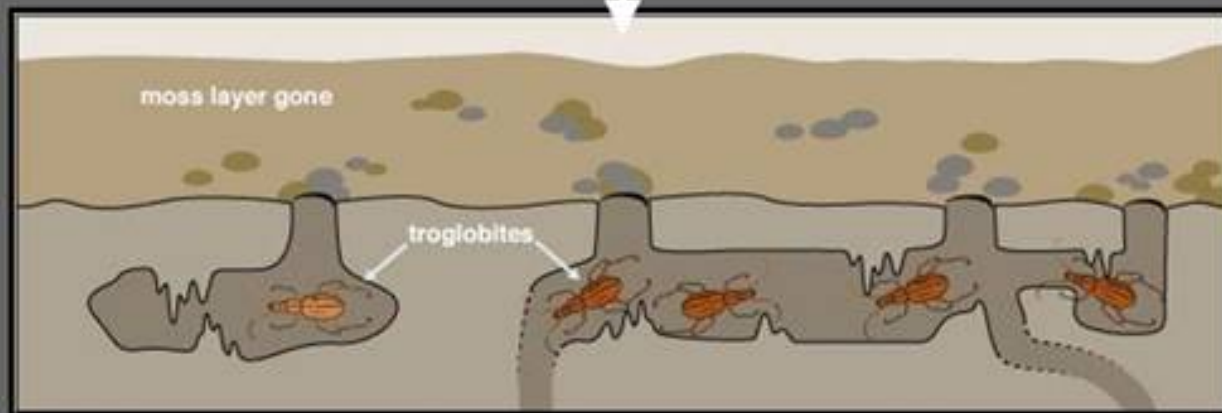




Pleistocene
glacial period



Pleistocene
interglacial



Postglacial