Population biology of wild sunflowers and studies of rust incidence using herbarium data

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Population biology

- how does the *numbers of individuals* and/or the *genetic composition* of a population change over time or over space?
- what processes are important?

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Plan for today:

1) brief overview of past sunflower research
2) present early results: herbarium study on rust incidence in eight *Helianthus* species

Overview of past research on Helianthus

Wild *H. annuus* life cycle and dynamics of small populations

1. Seed dormancy:
   - Effect of dormant seed on numbers of plants in populations
   - Effect of soil disturbance on persistence of seeds in the soil

   J Ecol 91:987-998; *J Ecol.* 95:851-864

2. Seed predation and plant density affecting local patch growth
   Oecologia 130:274-280

Patterns of regional distribution of wild *H. annuus* and local extinctions and colonizations (*Ecography (accepted with revision)*

Overview of past research on Helianthus

Biology of crop-wild hybridization (*H. annuus*)

1. Differential seed size and seed predation of hybrids and wilds *American Journal of Botany* 88:623-627, *Oecologia* 121:330-338
2. Experimental populations: persistence of crop alleles *Ecological Applications* 12:1661-1671
3. Current collaboration with Mercer and Snow: experimental populations: importance of seed and seedling biology

Plant-pathogen interactions

1. Ecological study of rust infection *Oecologia* 86:125-131

Sunflower and sunflower rust (*Puccinia helianthi)*

Helianthus sp. - diverse species (life cycle, habitat, morphology, distribution)

Puccinia helianthi - on 22 species (Farr et al. 1989)
- commonly found, but widely varying incidence and disease severity
- when disease is severe, reduces survival and reproduction of plant

Potential for pathogen to affect the ecology and evolution of the plant and *vice versa*

http://www.growinglifestyle.com/article/s0/a96540.html

Long term goal: explore interactions between *Helianthus – Puccinia*

Short term goals:

1. Understand past and current research by others

2. Patterns of infection
   a) Within a plant species:
   - variation in disease incidence: across major geographic regions?
     across large time periods?

   b) Among *Helianthus* species:
   - variation in incidence of disease among species?
   - any patterns in disease incidence in terms of species'
     habitat, phylogeny, or morphology?

8 species of *Helianthus* occurring commonly in Kansas and Missouri

H. maximiliani

H. hirsutus

H. grosseserratus

H. pauciflorus

6 perennials

H. tuberosus

H. mollis

2 annuals

H. annuus

H. petiolaris

http://plants.usda.gov/java/profile?symbol=HELIA3

http://www.carsoncity.k12.mi.us/~hsstudent/wildflowers00/compositae/prairiesunflower.html

Habitat:

Open habitats:
H. annuus
H. grosseserratus
H. maximiliani
H. mollis
H. pauciflorus
H. petiolaris
H. tuberosus

Open habitats and woodland edges:
H. hirsutus

Soil moisture characteristics:

Dry soil:
H. hirsutus
H. mollis
H. pauciflorus
H. petiolaris

Moist soil:
H. grosseserratus
H. tuberosus

Broad tolerance:
H. annuus
H. maximiliani

Geographical distribution:

Great Plains and eastward:
H. grosseserratus
H. hirsutus
H. mollis
H. pauciflorus

Great Plains and eastward with scattered western populations
H. maximiliani
H. tuberosus

Great Plains and westward with scattered eastern populations:
H. petiolaris

N. America and worldwide
H. annuus

Species also differ in leaf surface traits and in phylogenetic relationships

Challenges: - rust incidence highly variable

- hard to study over large geographic regions/times

Partial solution: herbarium collections

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Increased use of herbaria collections in studies of disease:

Patterns of smut infection within and among species
Antonovics et al. *A. J. Bot.* 90:1522-1531.
Alexander et al. *J. Ecol.* 95:446-457.

Advantages for *Helianthus – Puccinia*:

1. Large collections (for ex., 1429 specimens of *Helianthus* from Kansas at KU herbarium)

2. Plants collected in fall; peak rust infection

3. Rust pustules easily recognized on dried specimens

4. Rust often inconspicuous – unlikely to have major bias on collectors

Pilot study:

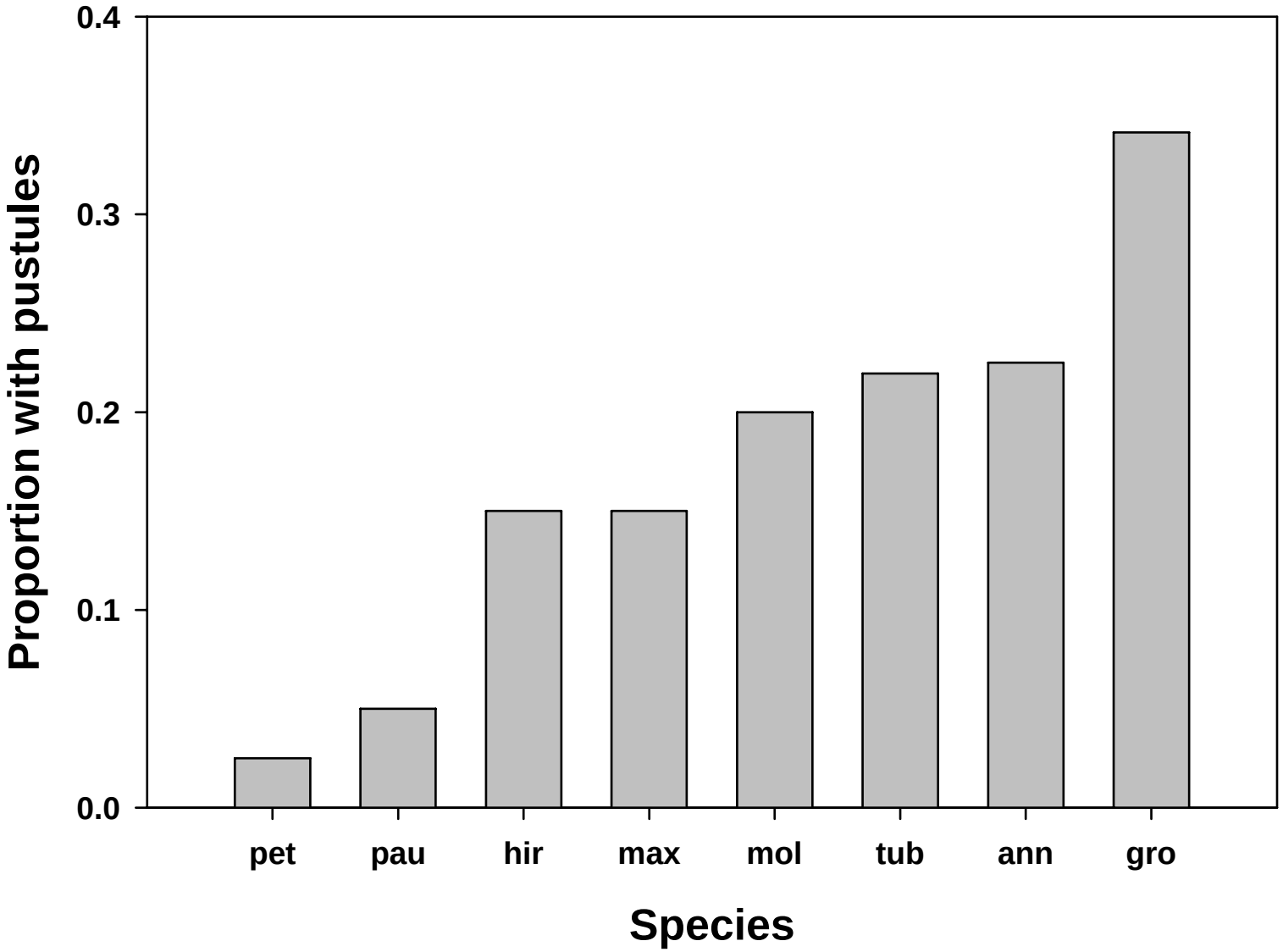
- Examined 40 specimens of each of eight sunflower species from KS or MO
- Recorded:

  a) presence of rust on specimens on log scale
  (0, 1-10, 11-100, > 100 pustules)

  b) collection date, approximate leaf area (upper and lower surface), and location

Initial data insufficient to look at within-species patterns; focus today on among-species patterns

Variation among species (p = 0.017)



pet = petiolaris, pau = pauciflorus, hir = hirsutus, max = maximiliani, mol = mollis, tub = tuberosus, ann = annuus, gro = grosseserratus

Potential explanations:

Hypothesis: greater chance of specimen having pustules if collection date is late in the season

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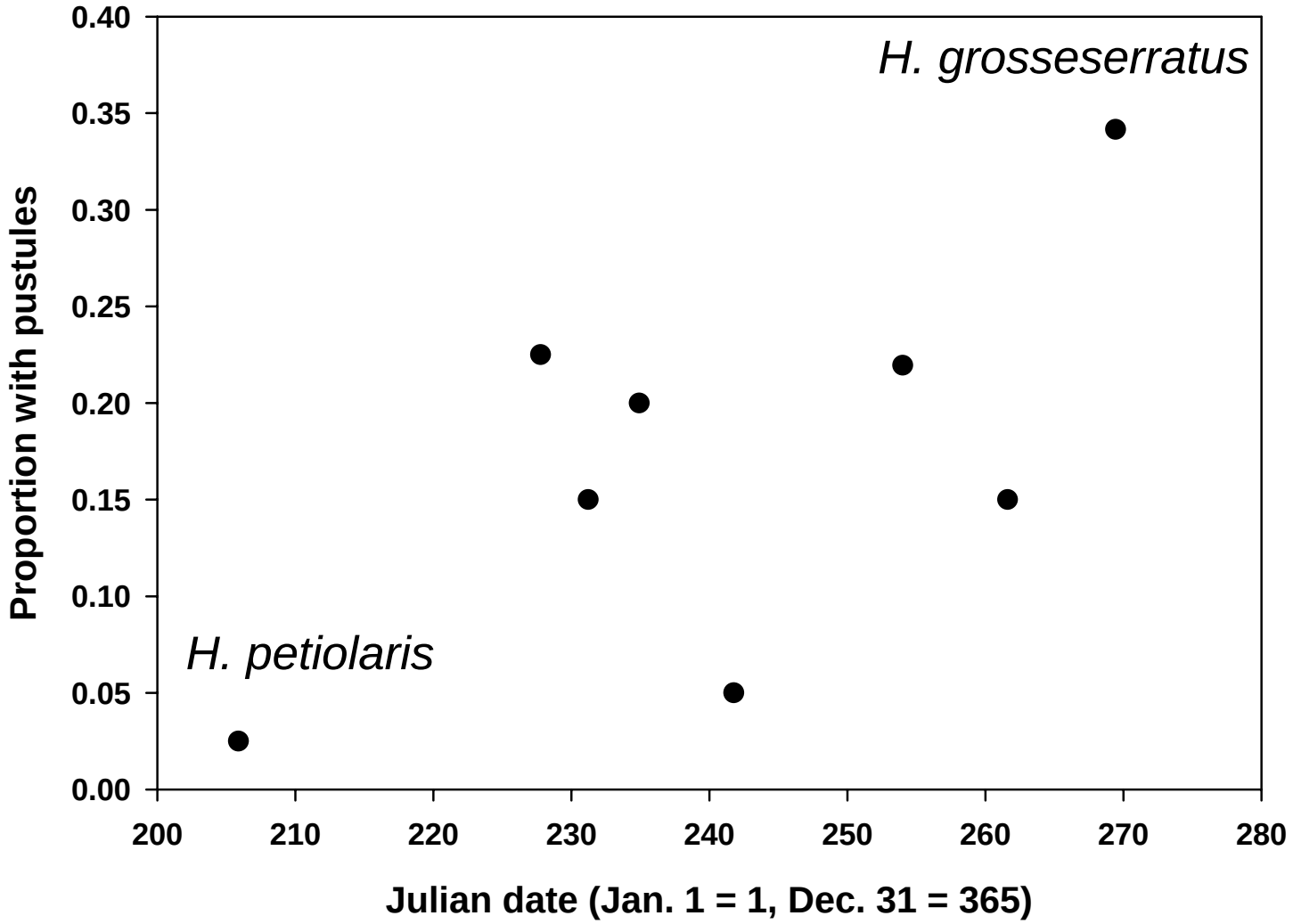
Data are consistent: late flowering species more likely to have rust



Hypothesis: greater chance of specimen having pustules if greater leaf area (lower surface)

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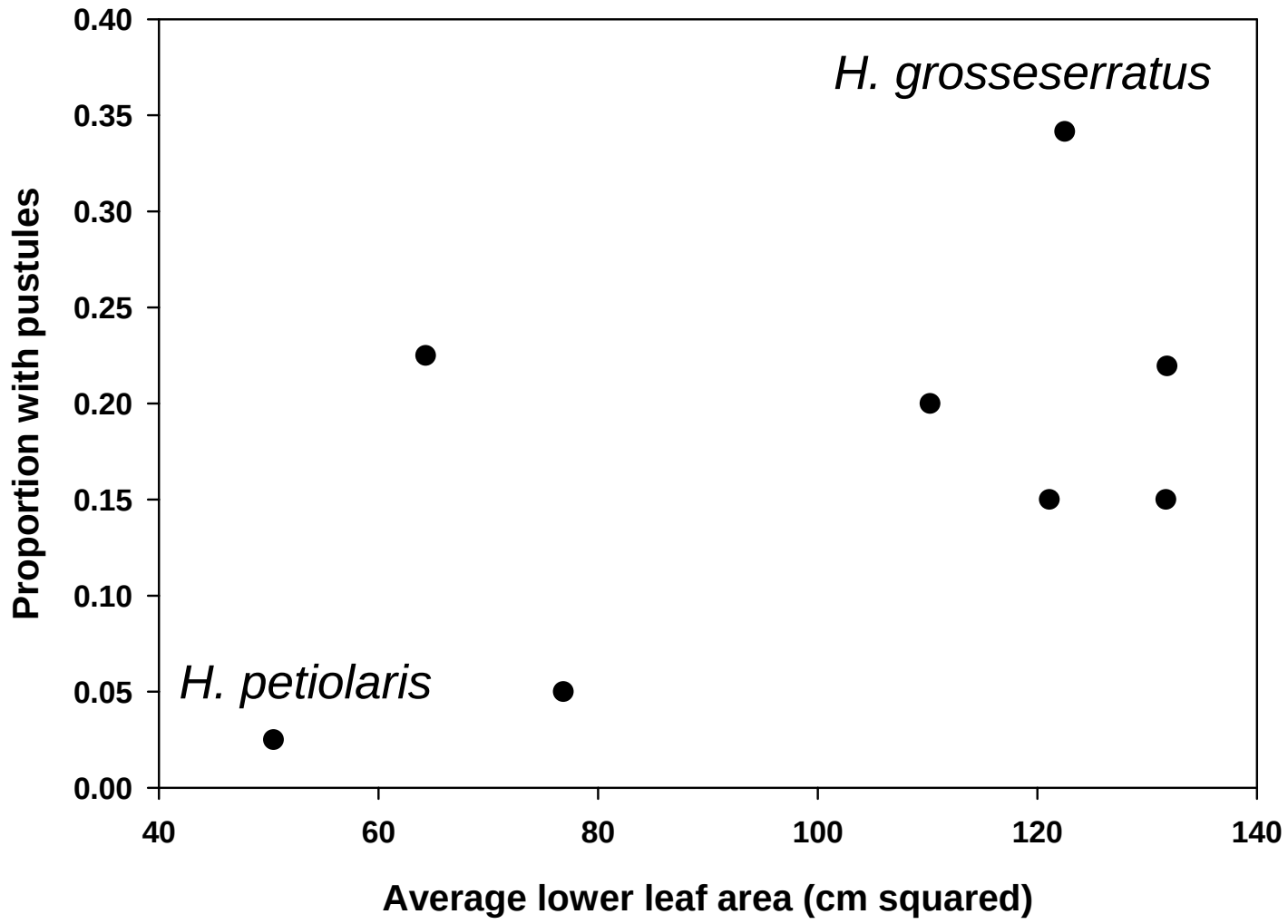
Data are consistent: species with more leaf area more likely to have rust



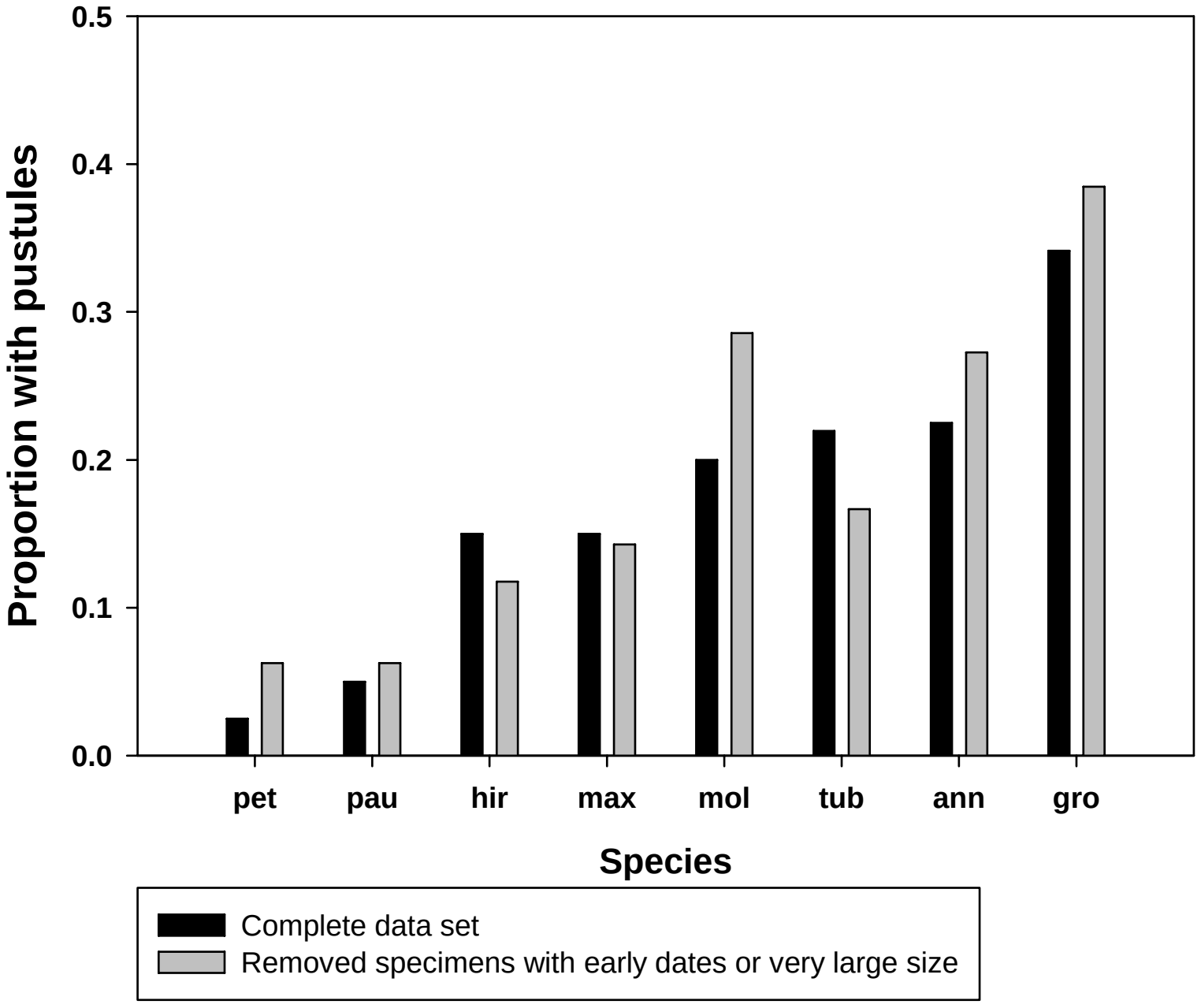
Preliminary results could be biologically interesting:

– does *H. petiolaris* “escape” disease in nature by being a smaller plant, or by producing seed earlier in the fall?

Are there differences among species when one removes variation in date and size?

- Date and size data were skewed; removed all specimens that were in lowest quartile for date and highest quartile for size

Still see variation among species



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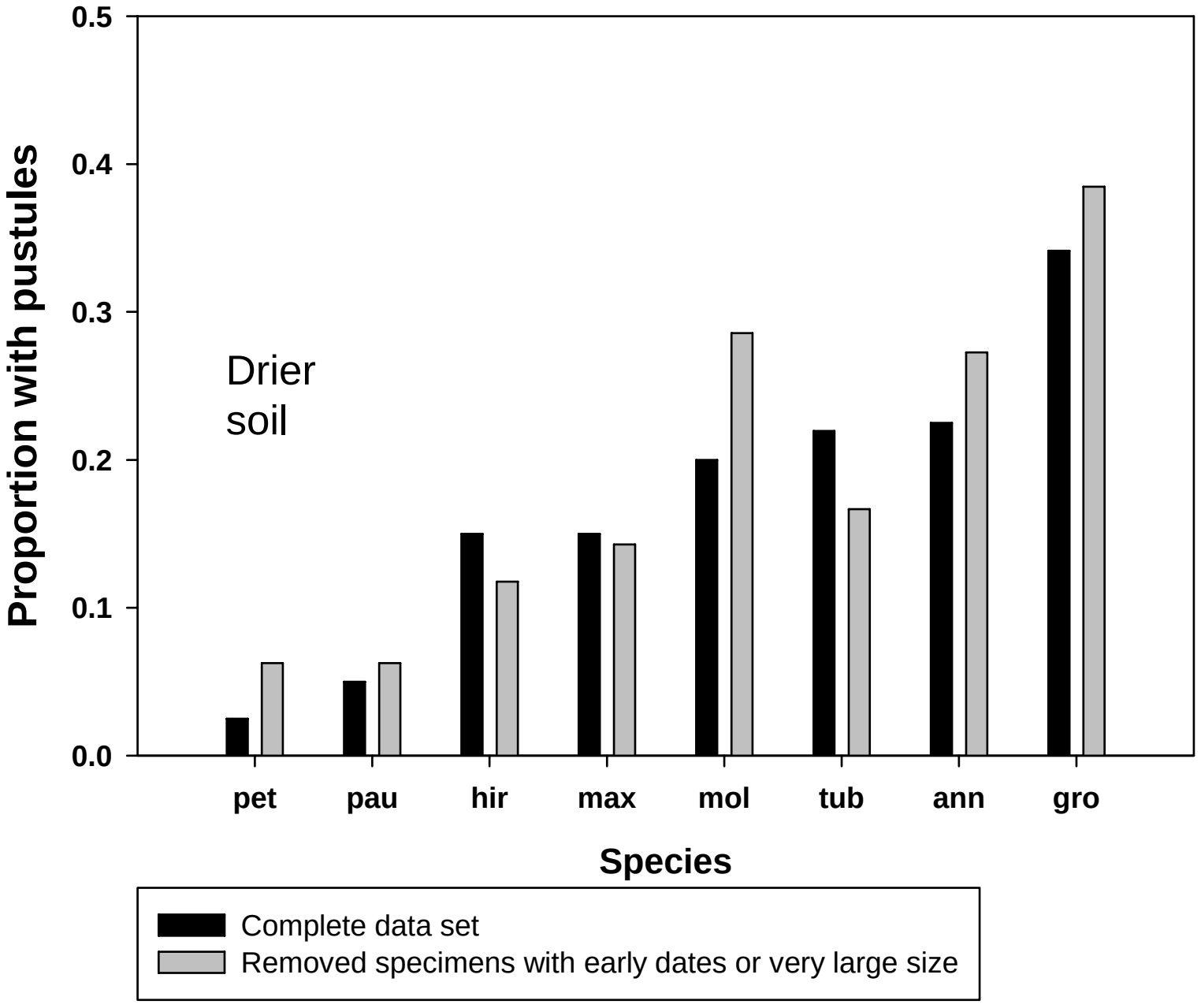

Future work:

1) Herbarium study: Greatly increase numbers of specimens to allow examination of among- and within-species patterns
   a) over 100 year collection history
   b) over geographic region (east – west gradient through KS and MO)

2) Inoculation studies within and across sunflower species

Source of rust

Rust inoculated on these species

	ann	*gro*	*hir*	*max*	*mol*	*pet*	*pau*	*tub*
ann	2	2		2,0	2	2,0		2,0
gro	2	2			0			
hir		0			1			
max		2,0			0			
mol		0			2,0			
pet	2			0		2		0
pau					0			
tub	2	0		0	0	0		2

0 = no infection
1 = slight infection/ slow growth
2 = successful infection

Based on Arthur (1903,1905), Browth (1936), and current work by Gulya