How are invasive legumes so successful? A global meta-analysis

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What makes a species invasive?

Introduced Species: species that are non-native to a given area

Native Species: species that are ‘originally’ from a given area

Invasive Species: species that are non-native to a given area AND cause ecological and/or economical harm

Why are invasives so bad?

- Estimated 480,000 introduced species around the world
- Ecologically:
  - One of the greatest threats to biodiversity and stability of ecosystems
  - Threaten native species through competition, predation, or changes to the environment
  - A single invasive species can cause up to a 16.6% reduction in species richness
  - Deemed responsible for 124 out of 215 extinct species in the IUCN Red List of Threatened Species
- Economically:
  - Invasives cost > US$314 billion per year in damages in six nations

Table 2
Economic losses to introduced pests in crops, pastures, and forests in the United States, United Kingdom, Australia, South Africa, India, and Brazil (billion dollars per year)

Introduced pest	United States	United Kingdom	Australia	South Africa	India	Brazil	Total
Weeds							
Crops	27.9	1.4	1.8	1.5	37.8	17.0[a]	87.4
Pastures	6.0	–	0.6	–	0.92	–	7.52
Vertebrates							
Crops	1.0[b]	1.2[c]	0.2[d]	–[e]	–	–	2.4
Arthropods							
Crops	15.9	0.96	0.94	1.0	16.8	8.5	44.1
Forests	2.1	–	–	–	–	–	2.1
Plant path							
Crops	23.5	2.0	2.7	1.8	35.5	17.1	82.6
Forests	2.1	–	–	–	–	–	2.1
Total	78.5	5.56	6.24	4.3	91.02	42.6	28.72

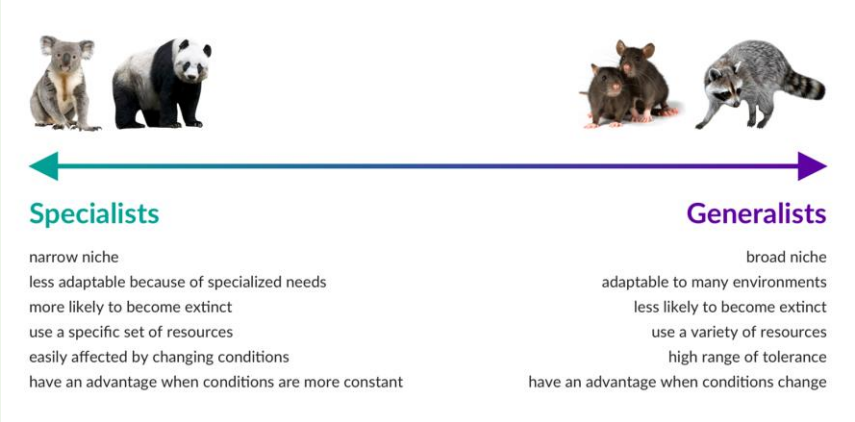
[a] Pasture losses included in crop losses.
[b] Losses due to English starlings and English sparrows (Pimentel et al., 2000).
[c] Calculated damage losses from the European rabbit (see text).
[d] Emmerson and McCulloch, 1994.
[e] –: data not available.

(Pimentel, *et al*. 2016))

How are invasives so successful?

Common thought: Generalist species are more successful invaders than specialist species

- Does not account for all instances of invasion



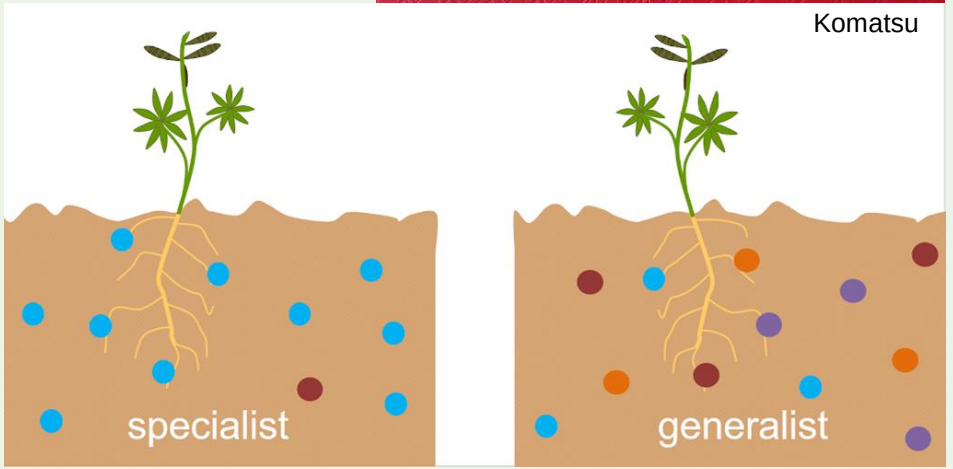
(relatively) New Hypothesis: microbial symbiosis increases competitive success of invasives

- Success (health, productivity, adaptive capacities) of all organisms can be attributed in various ways to microbial communities

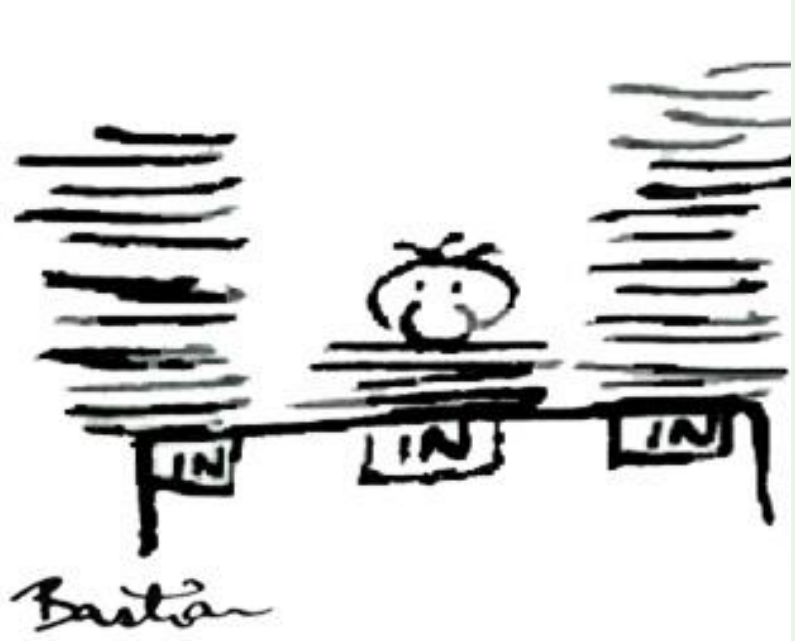
Legumes are the perfect model to test this hypothesis!

Legumes

- Third largest family of angiosperms
- Widely cultivated BUT there are ~20,000 species legumes
- Form symbiotic relationships with nitrogen-fixing bacteria (rhizobia)
- Rhizobia are infectiously transferred
- Prolific invaders - consists of some of the most invasive species world-wide
- **Model family for invasive species success in relation to microbial symbionts and generalist vs. specialist species**



A Global Meta-Analysis

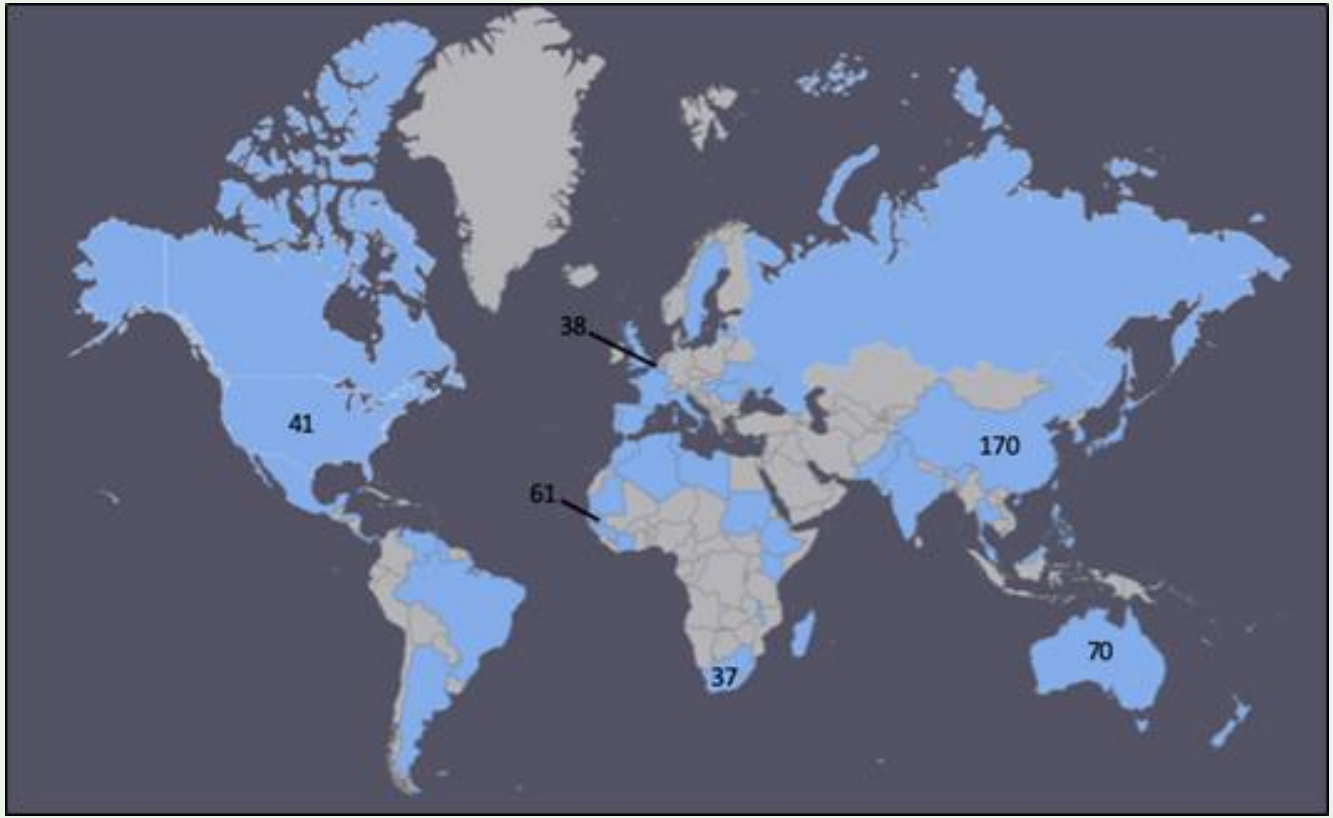


- Analyzed 211 experiments
  - Published between 1984 - 2014
  - Compiled using Web of Science and Google Scholar (92 search terms)
  - Removed experiments regarding widely cultivated legumes
  - Manually extracted data about rhizobial associates, study site, legume species
- Identified legumes as native, invasive, or introduced

Hypothesis:
Invasive legumes will associate with more rhizobial symbionts on average than native legumes

Important Note:
These results are incomplete!!

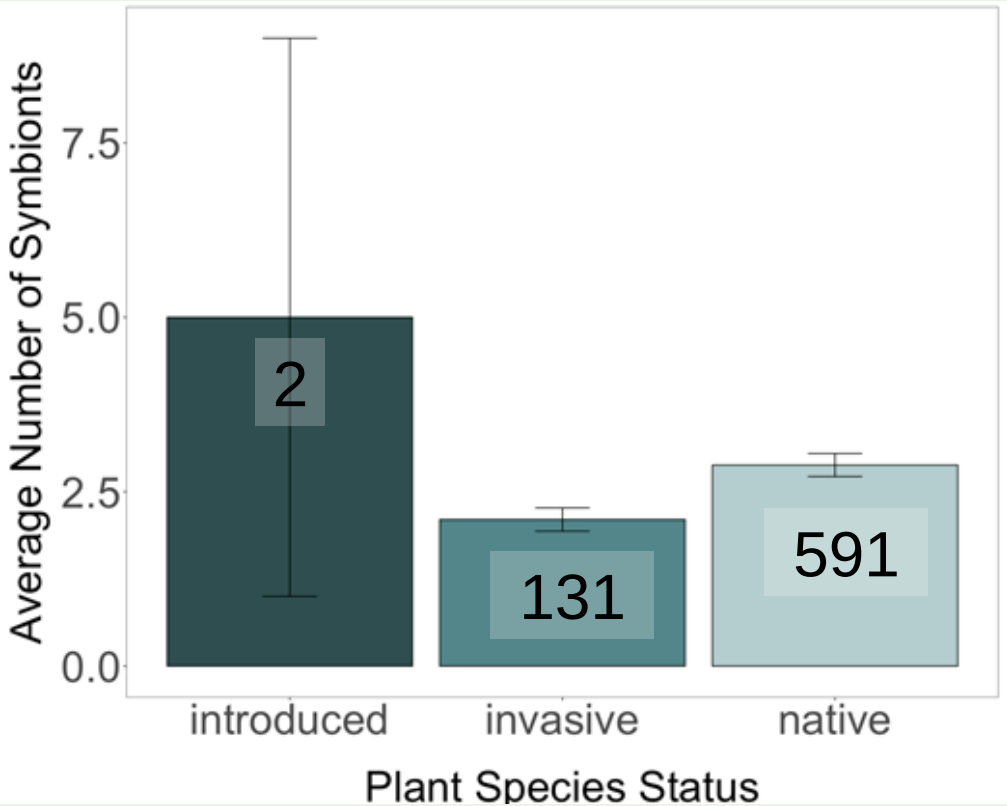
515 leguminous species from 9 continents and 69 countries



Out of 724 total legumes over 80% were studied in their native range

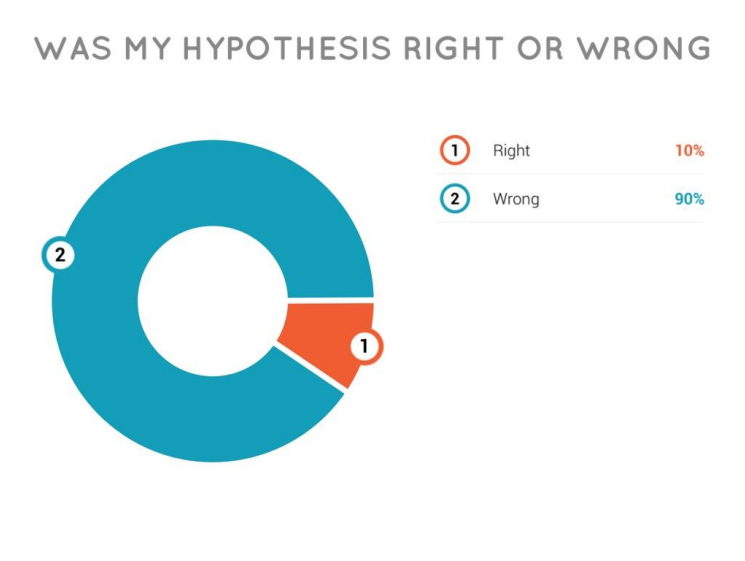
Invasive species aren’t generalists?

- Native Species: associated on average with ~ 3 species
- Invasive Species: associated on average with ~ 2 species
- Appears to be significant (although not determined yet)



General Findings:

- Native species appear to more commonly associate with more rhizobial species than invasives

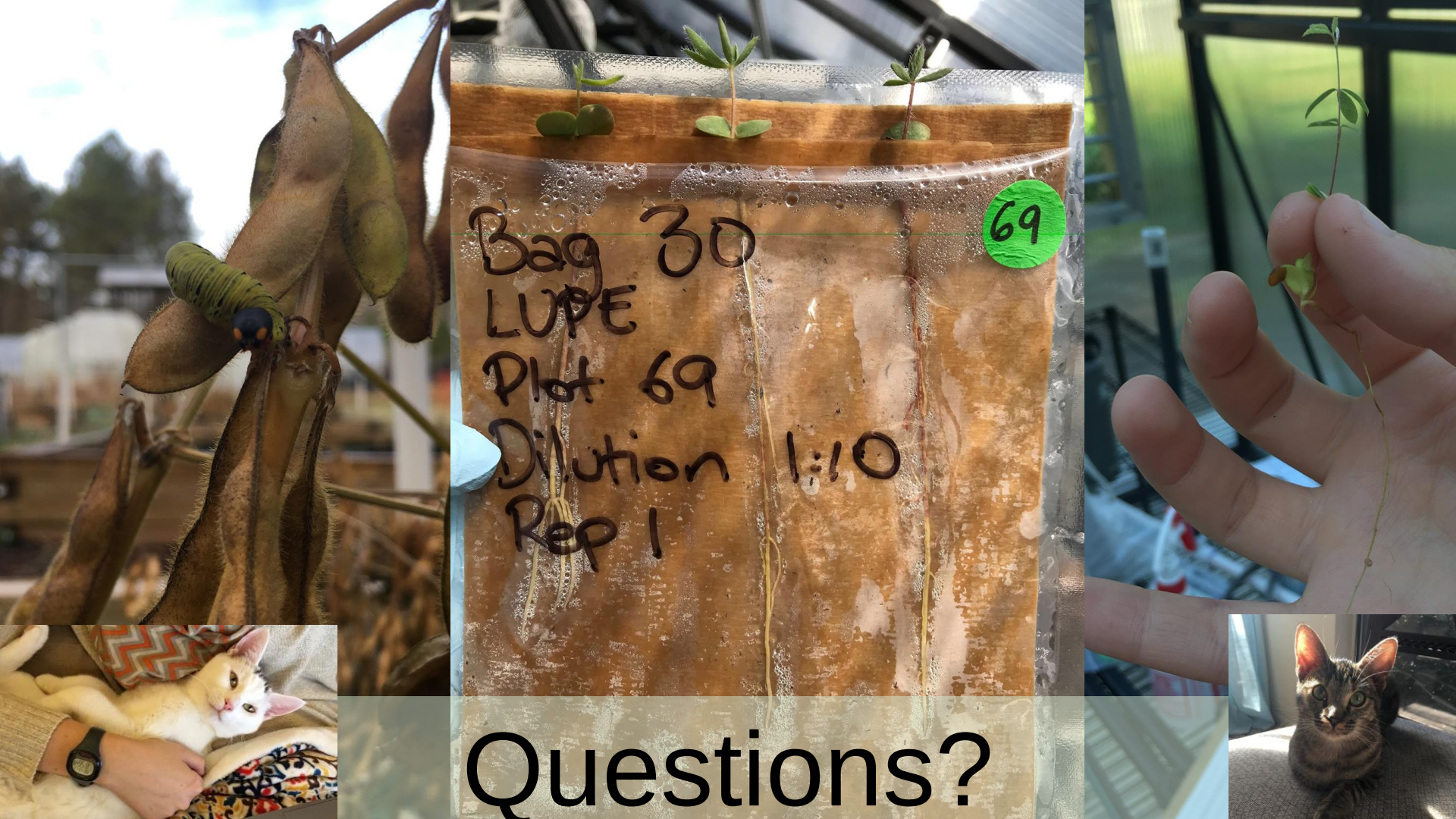


Considerations:

- Still 120 papers to analyze
- >80% of species assessed were native
- >30% of all experiments occurred in China

If these patterns stay consistent...

- It will be very unexpected (and therefore exciting!!)
- It will lead to more questions about how invaders are actually so successful
- Legumes may be bringing rhizobia along with them on their seed coats when they invade
- It might support the “everything is everywhere but the environment selects” hypothesis
    - All microbial species are present at low levels everywhere
    - When legumes occur in non-native areas they could associate with their preferred symbiont that is found in the soil (and increase the levels of this symbiont over time?)



Questions?