Interaction of generalist grasshoppers with native and exotic grasses: behavioral and molecular approaches

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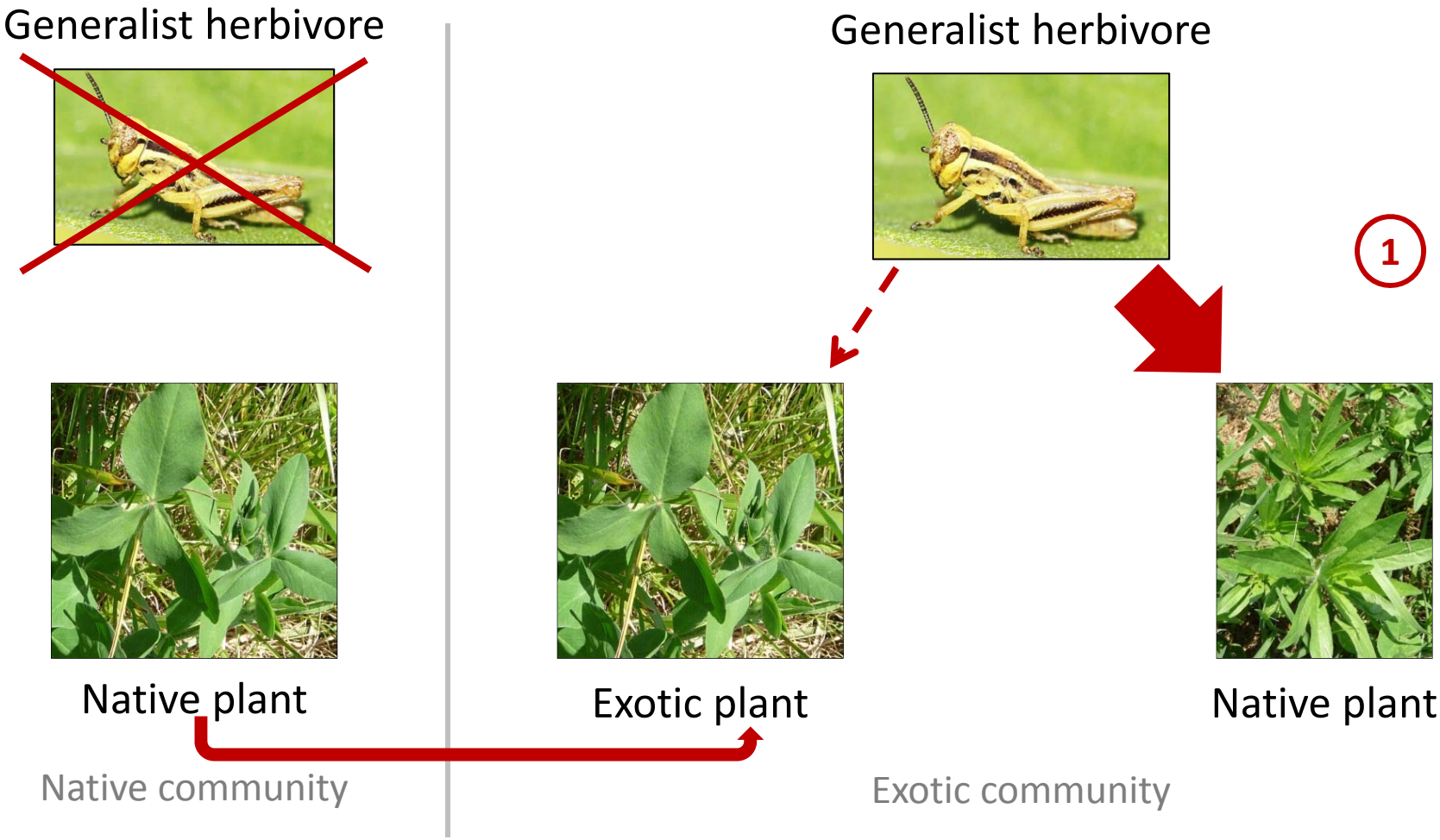
Entomology 2014

Feeding Preferences of Generalist Insects on Native and Exotic Plants



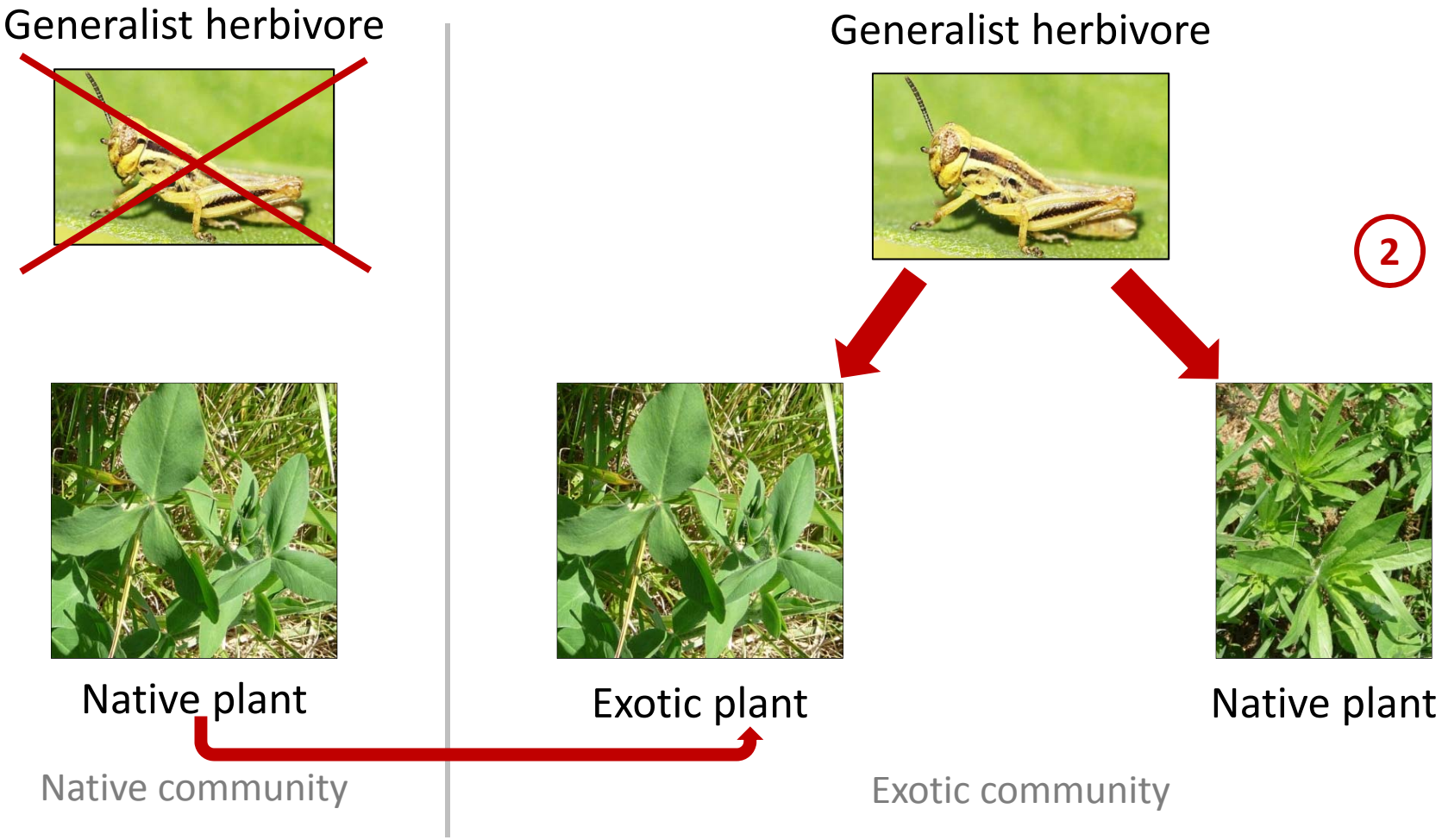
- Less explored than specialists [Ali & Agrawal , 2012]
- Difficult to predict their feeding preferences [Tallamy et al., 2010]
- Can have an impact on the success of invasive plant species [Bossdorf et al. 2004; Joshi & Vrieling 2005; Tallamy et al. 2010; Schaffner et al. 2011]

How can the interaction between generalist insect herbivores and exotic plants affect plant invasion?



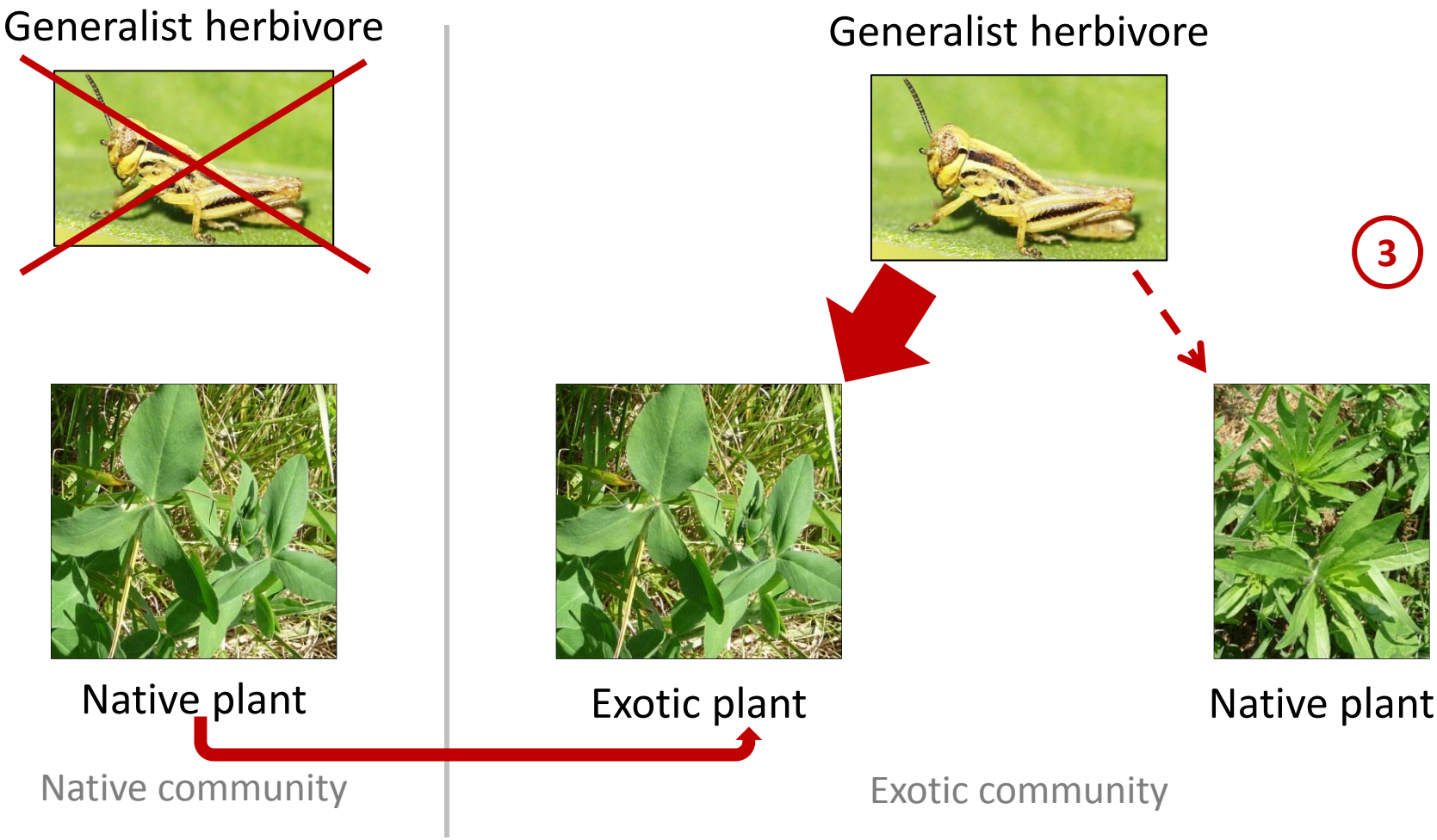
(The Enemy Release Hypothesis; modified from Keane & Crawley, 2002)

How can the interaction between generalist insect herbivores and exotic plants affect plant invasion?



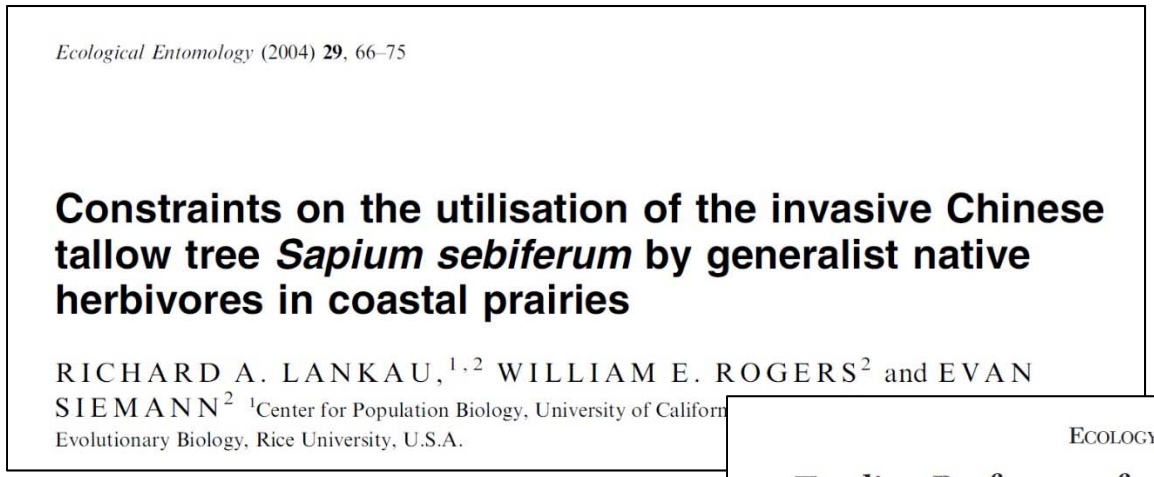
(The Biotic Resistance Hypothesis; Parker et al. 2006)

How can the interaction between generalist insect herbivores and exotic plants affect plant invasion?



(The Biotic Resistance Hypothesis; Parker et al. 2006)

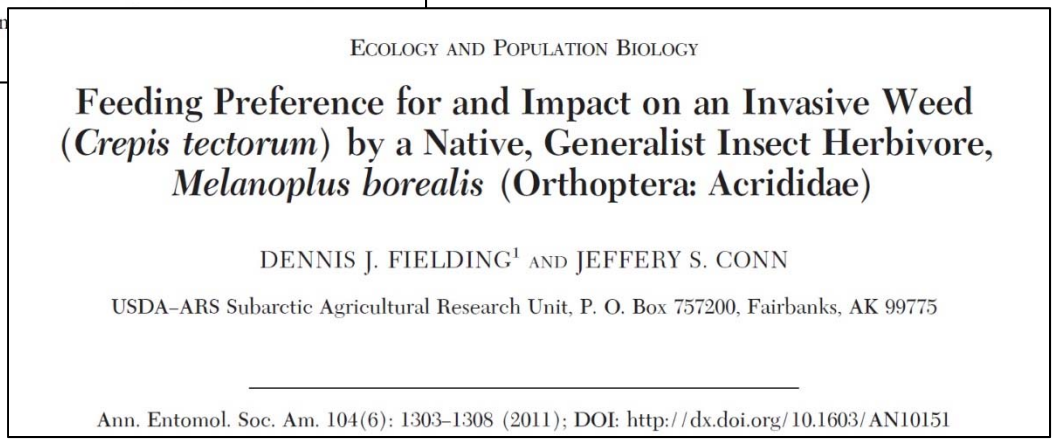
Inconsistency of Experimental Results



Ecological Entomology (2004) **29**, 66–75

Constraints on the utilisation of the invasive Chinese tallow tree *Sapium sebiferum* by generalist native herbivores in coastal prairies

RICHARD A. LANKAU,[1,2] WILLIAM E. ROGERS[2] and EVAN SIEMANN[2] [1]Center for Population Biology, University of Californ
Evolutionary Biology, Rice University, U.S.A.



ECOLOGY AND POPULATION BIOLOGY

Feeding Preference for and Impact on an Invasive Weed (*Crepis tectorum*) by a Native, Generalist Insect Herbivore, *Melanoplus borealis* (Orthoptera: Acrididae)

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Ann. Entomol. Soc. Am. 104(6): 1303–1308 (2011); DOI: http://dx.doi.org/10.1603/AN10151

- Different experimental conditions (field, greenhouse, intact plants, clipped leaves etc.) [Motheral & Orrock, 2010; Atwood & Meyerson, 2011]
- Different non-standard measurements [e.g. Atwood & Meyerson, 2011]

Experimental Design

Feeding Behavior

- Intact Plants
  - Field

  - Greenhouse

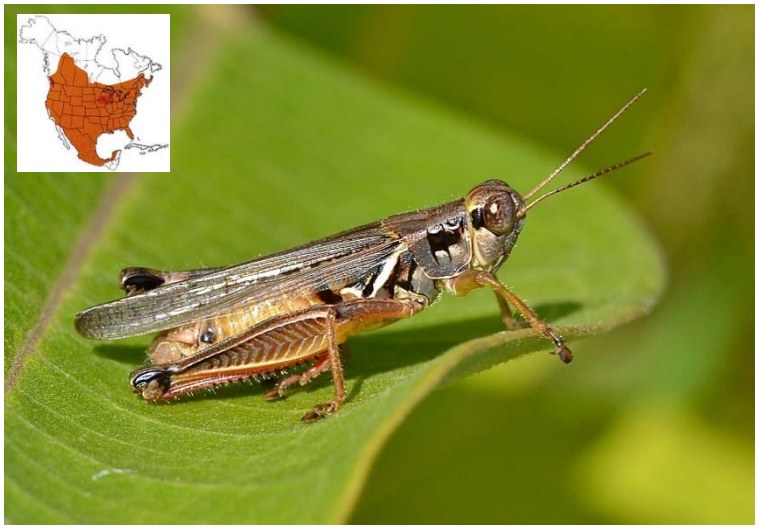
- Leaf Segments

Molecular Confirmation of Diet

- Protocol

- Ingested plants

Study Organisms



Melanoplus femurrubrum
Red-legged grasshopper

Andropogon gerardii
Big Bluestem

Bouteloua curtipendula
Side oats Grama

Native grasses

Miscanthus sinensis
Chinese Silver Grass

Bothriochloa ischaemum
Yellow Bluestem

Exotic grasses

http://plants.usda.gov/

Research Questions

RQ 1. Do *Melanoplus femurrubrum* grasshoppers incorporate exotic plants in their diet?

RQ 2. If yes, do they prefer to feed more on exotic than on native plants?

RQ 3. Are the results consistent across behavioral experiments and molecular confirmation of diet?

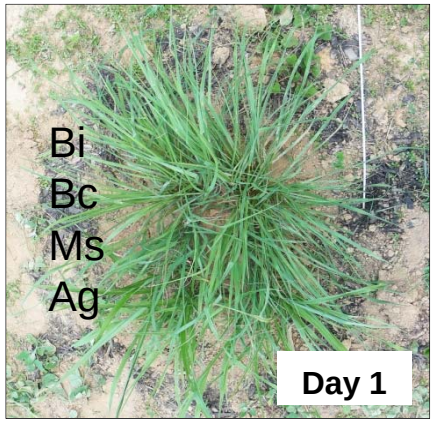
Field Experiments

Study Sites

University of Cincinnati
Center for Field Studies
(Hamilton, OH)

Western Maryland
Research and Education Center
(Keedysville, MD)

Grasshopper Herbivory Assays



April – August 2013

Measurements

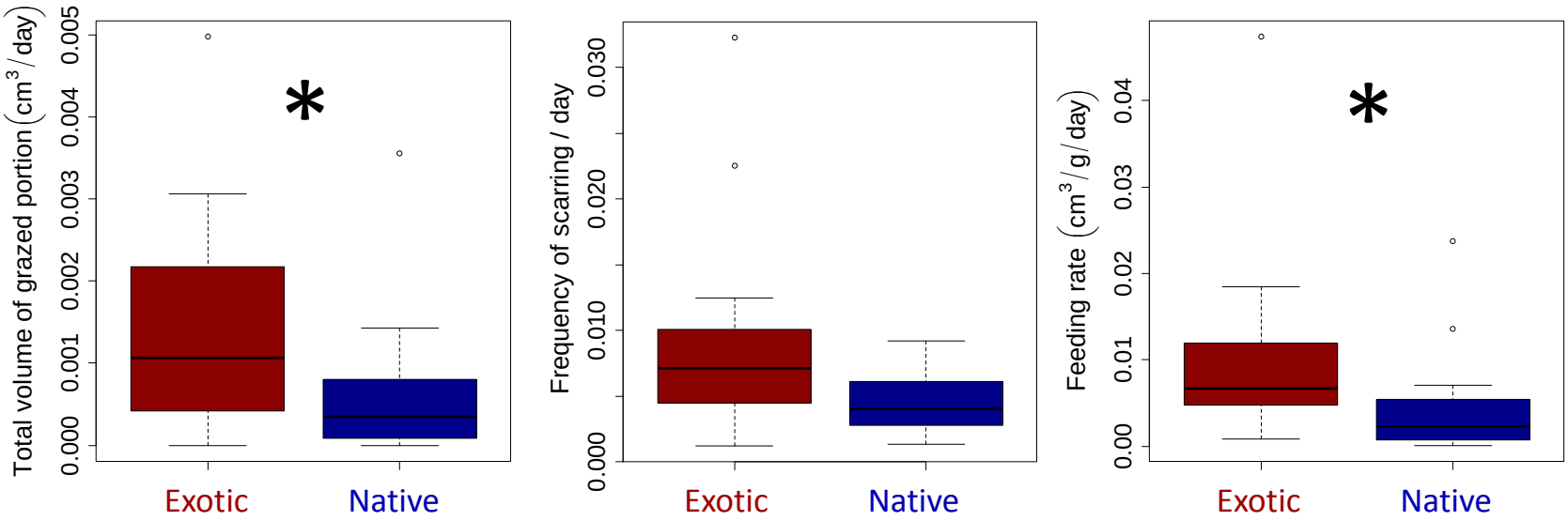
Food consumption:

- Total volume of the grazed portion [length × width × depth of "scars", cm^3]

Feeding activity:

- Frequency of "scarring" [number of scars/number of leaves]
- Feeding rate [Total volume of the grazed portion/grasshopper weight/day, cm^3 /g/d]

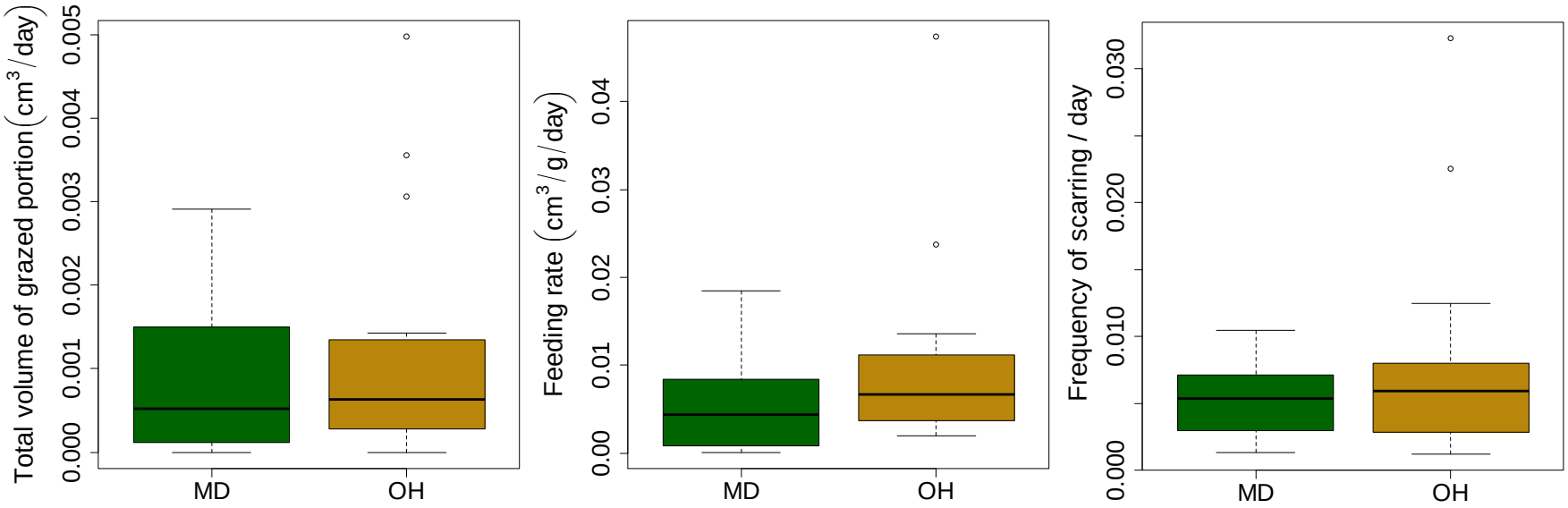
Grasshopper Feeding in the Field



- Grasshopper food consumption and feeding activity were greater on exotic grasses; * $p < 0.05$

(Avanesyan & Culley, *in review*)

Grasshopper Feeding at Different Field Sites

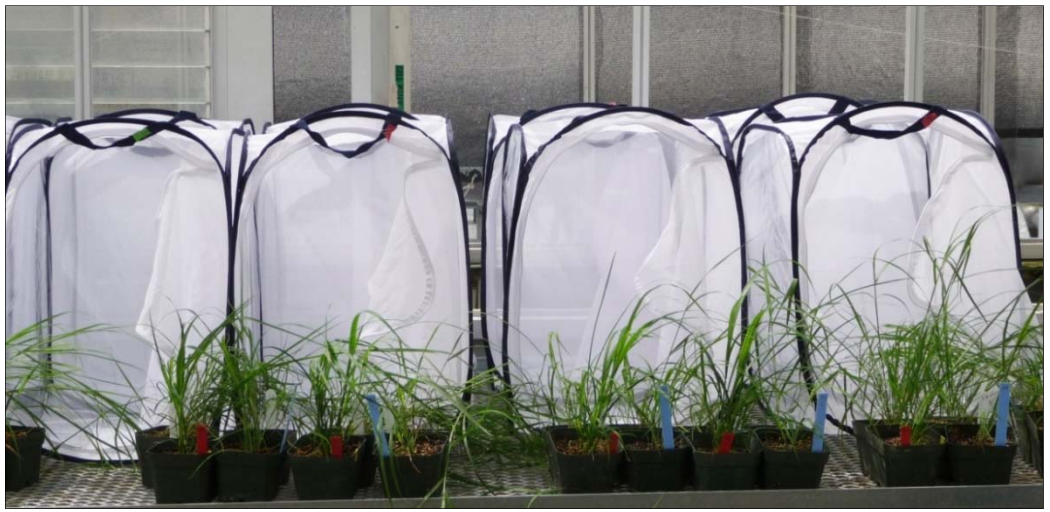


- Grasshopper food consumption and feeding activity did not differ between field sites; $p > 0.05$

(Avanesyan & Culley, *in review*)

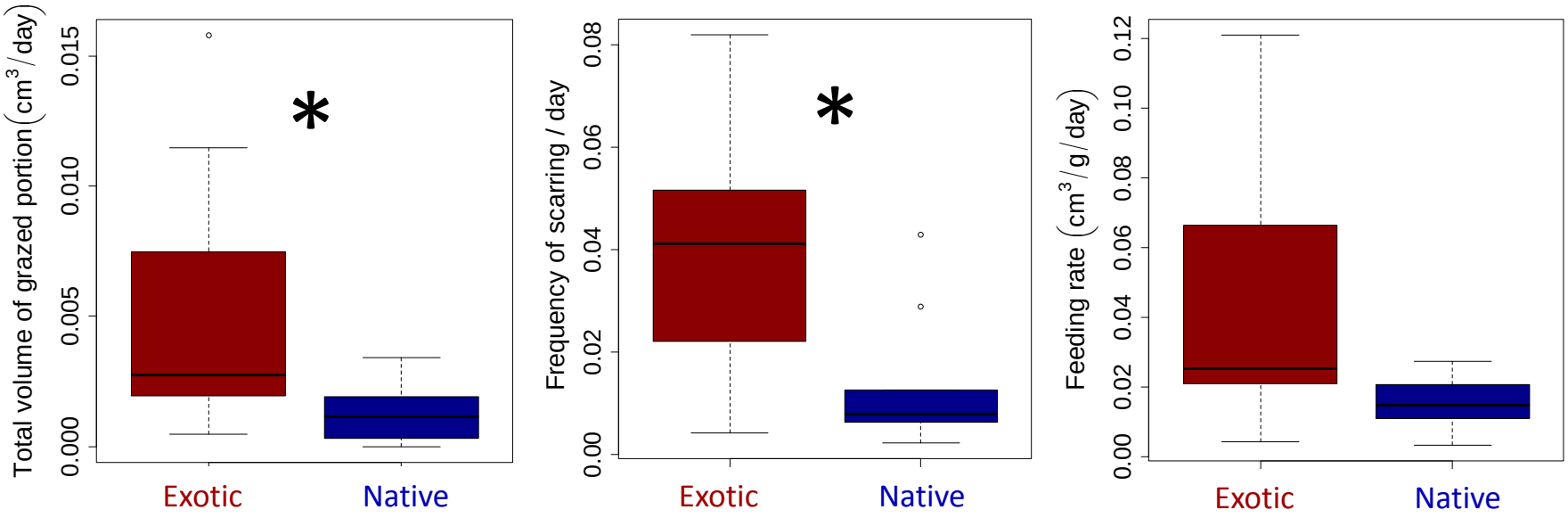
Greenhouse Experiments

University of Cincinnati Greenhouse



April – August 2013

Grasshopper Feeding in the Greenhouse



- Grasshopper food consumption and feeding activity were greater on exotic grasses; * $p < 0.05$

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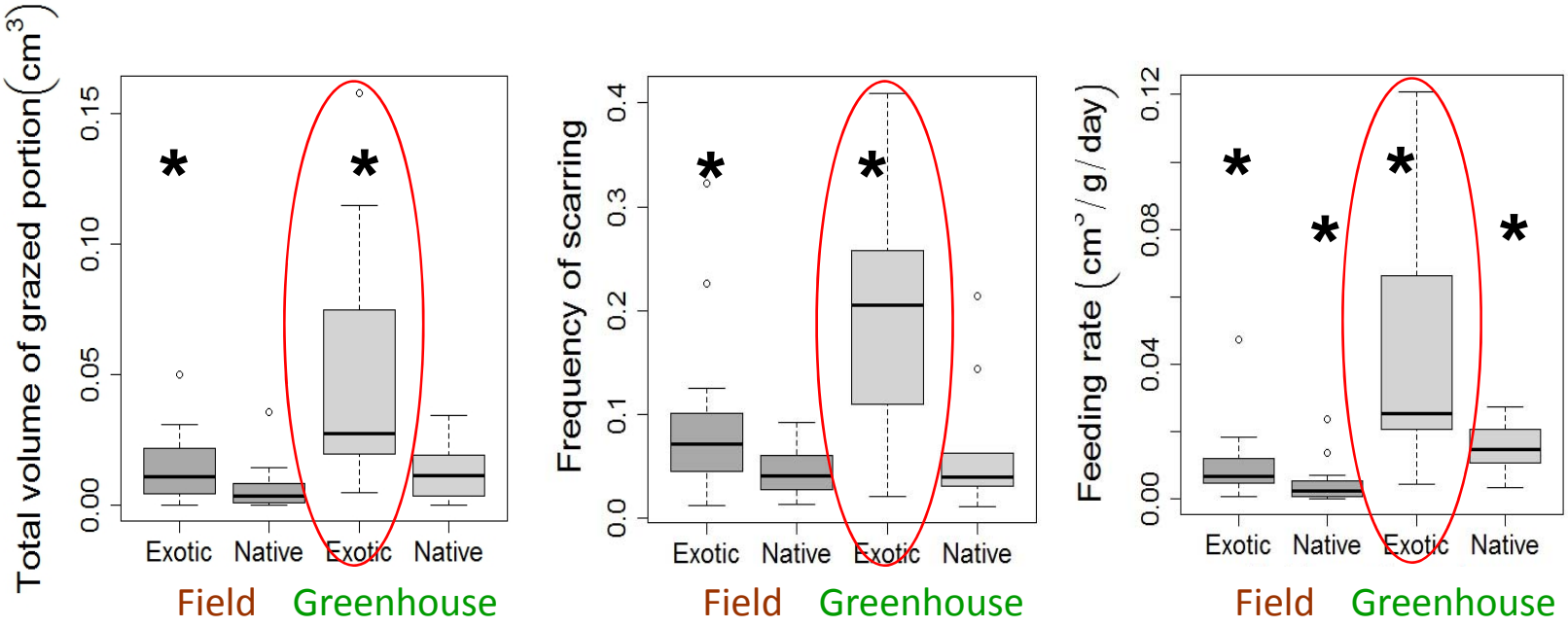
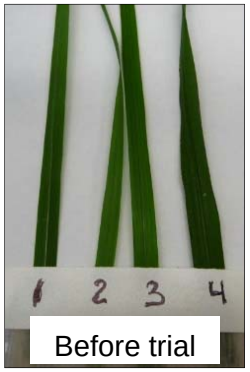
Grasshopper Feeding under Field and Greenhouse Conditions

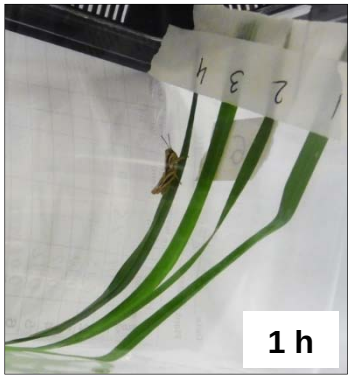


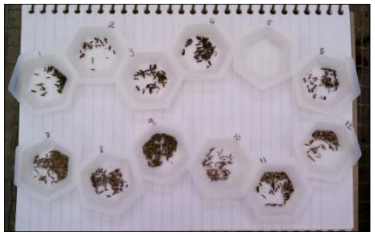
- Grasshoppers consumed more exotic plants in the greenhouse than in the field; * $p < 0.05$

(Avanesyan & Culley, *in review*)

Experiments with Clipped Leaf Segments







After trial

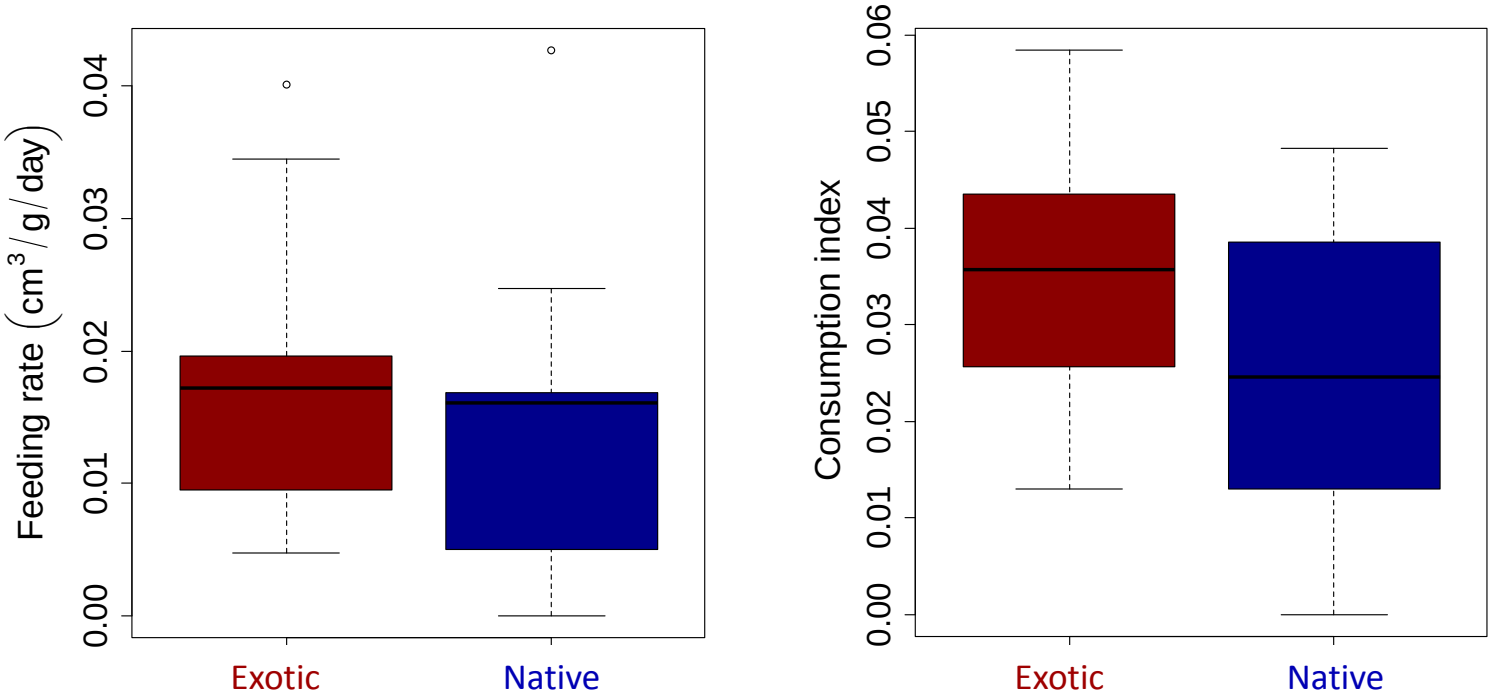
Food consumption:

- Feeding rate
  [food intake (Waldbauer, 1968) /grasshopper weight, g/g/h]
- Consumption index [Waldbauer, 1968]

Food assimilation:

- Assimilation rate
  [food assimilated/grasshopper weight, g/g/h]
- Approximate digestibility
  [food assimilated/food ingested]

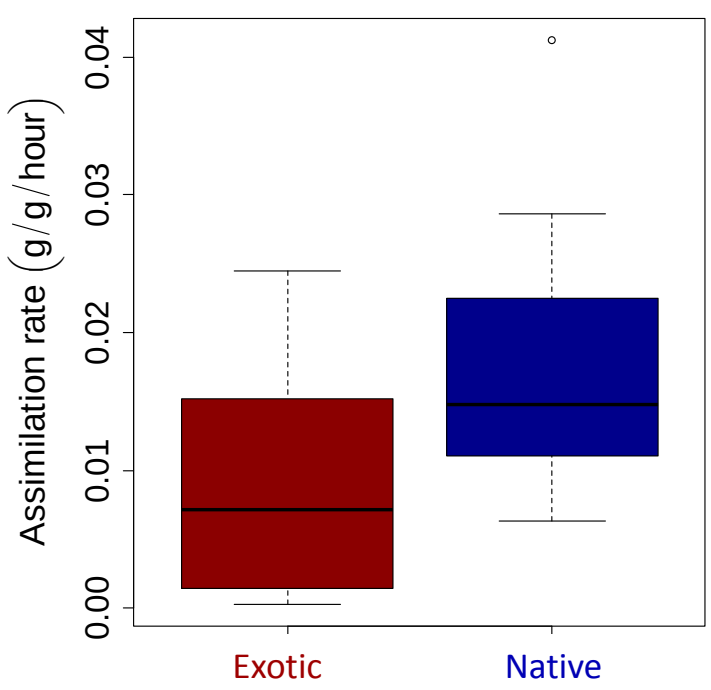
Grasshopper Feeding on Leaf Segments: Food Consumption

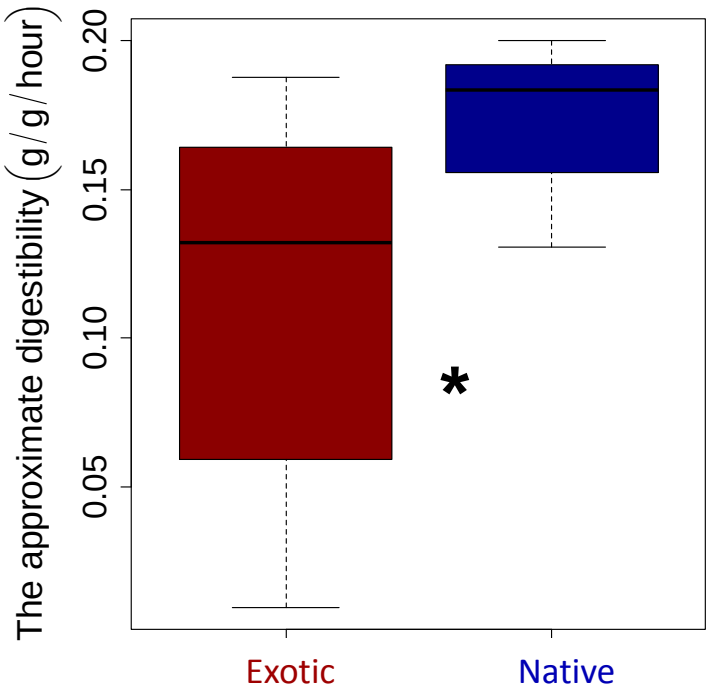


- Grasshopper food consumption did not differ on the leaves clipped from native and exotic grasses ($p > 0.05$)

(Avanesyan & Culley, *in review*)

Grasshopper Feeding on Leaf Segments: Food Assimilation





- Grasshopper assimilation rate did not differ on the leaves clipped from native and exotic grasses ($p > 0.05$), but the approximate digestibility was greater on native plants than on exotics; * $p < 0.05$

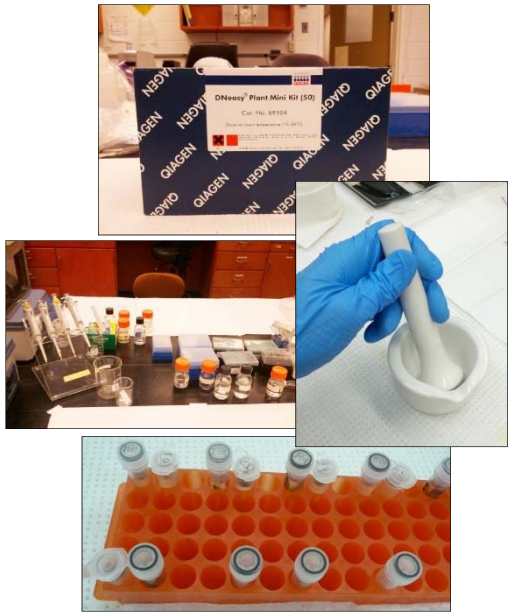
(Avanesyan & Culley, *in review*)

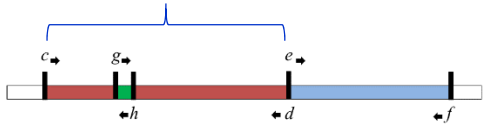
Creating the Protocol

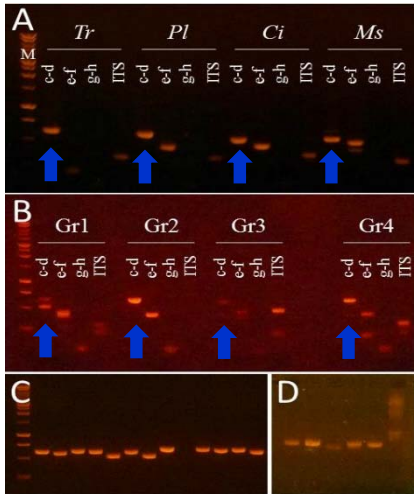
Melanoplus sp.

Plantago *Cichorium* *Trifolium* *Miscanthus*

Chloroplast *trn*L (UAA) intron
~ 550 bp







(Avanesyan 2014, Appl Plant Sci)

Testing the Protocol

Grasshoppers of different sizes

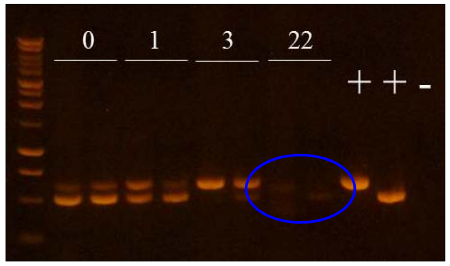
Melanoplus spp. nymph

12 h PI: choice, two plants

M. femurrubrum

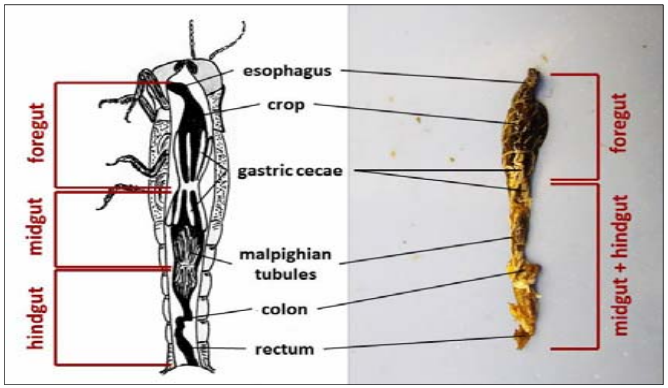
12 h PI: no choice, single plant

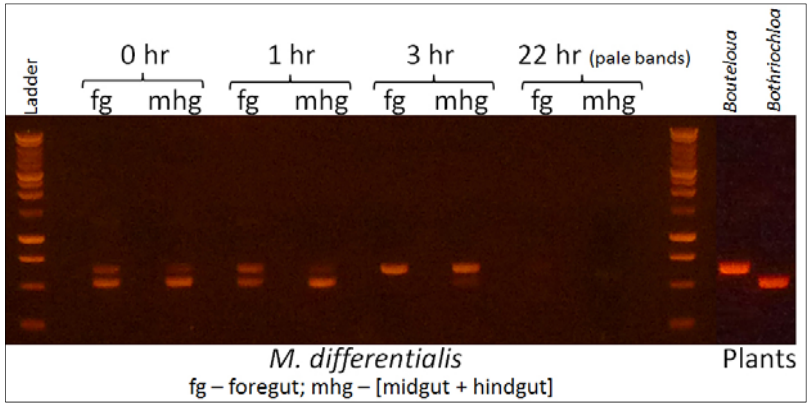
M. differentialis



22 h PI: choice, two plants

Different parts of grasshopper digestive system



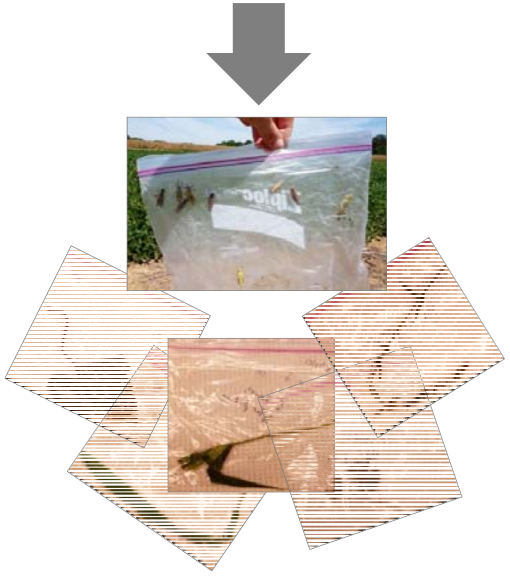


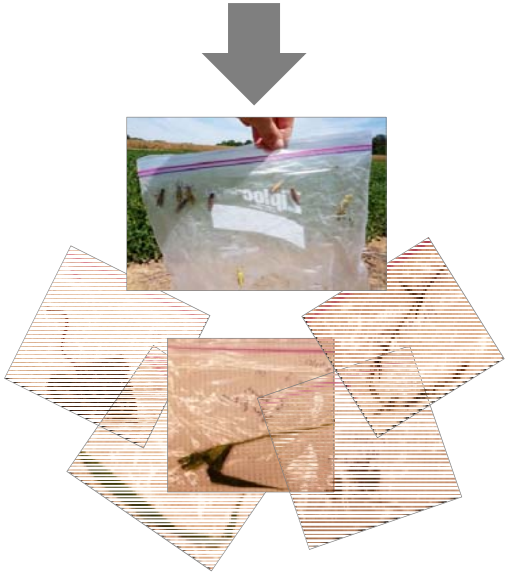
(Avanesyan 2014, Appl Plant Sci)

Collecting Plants and Grasshoppers

University of Cincinnati Center for Field Studies (OH)

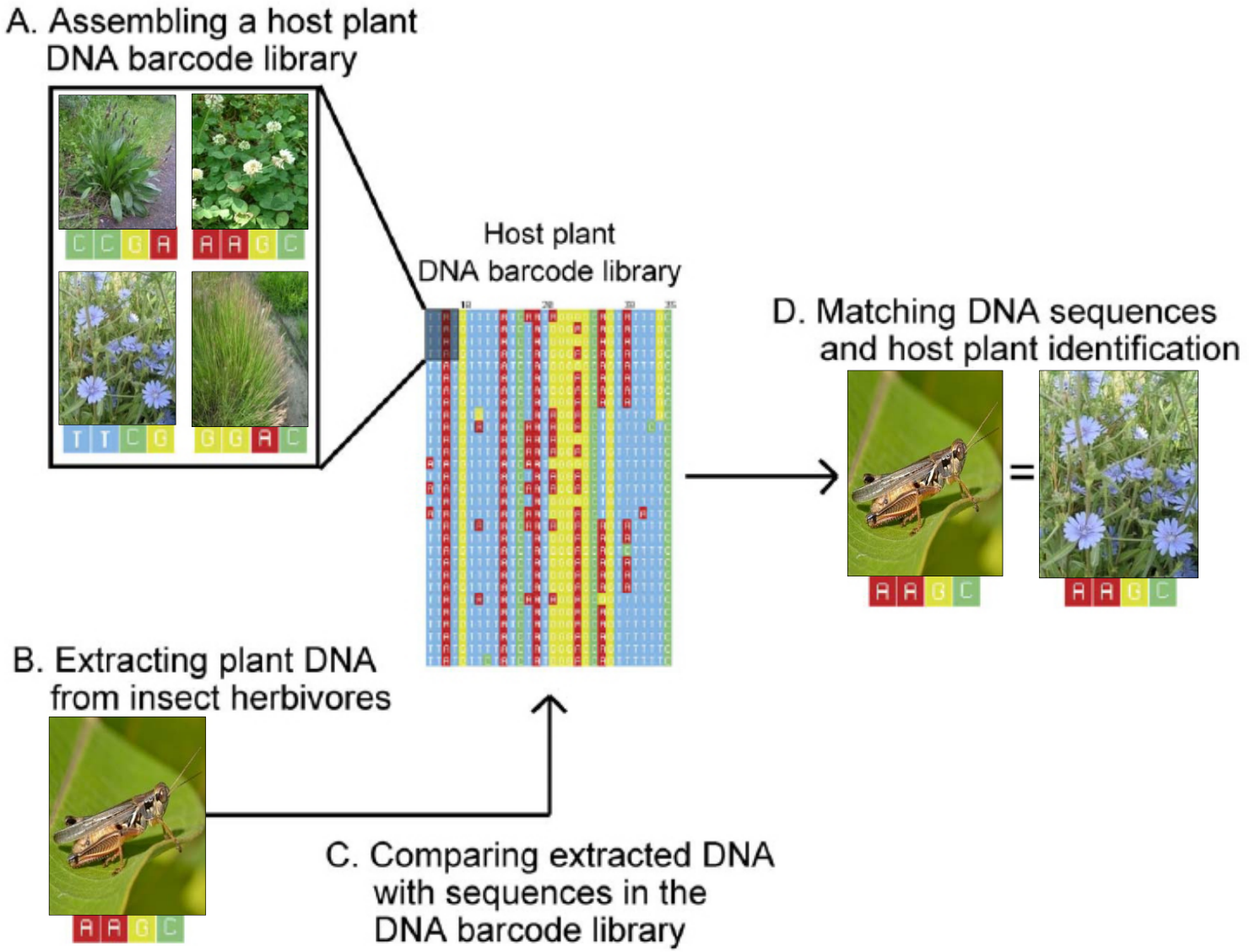
Western Maryland Research and Education Center (MD)





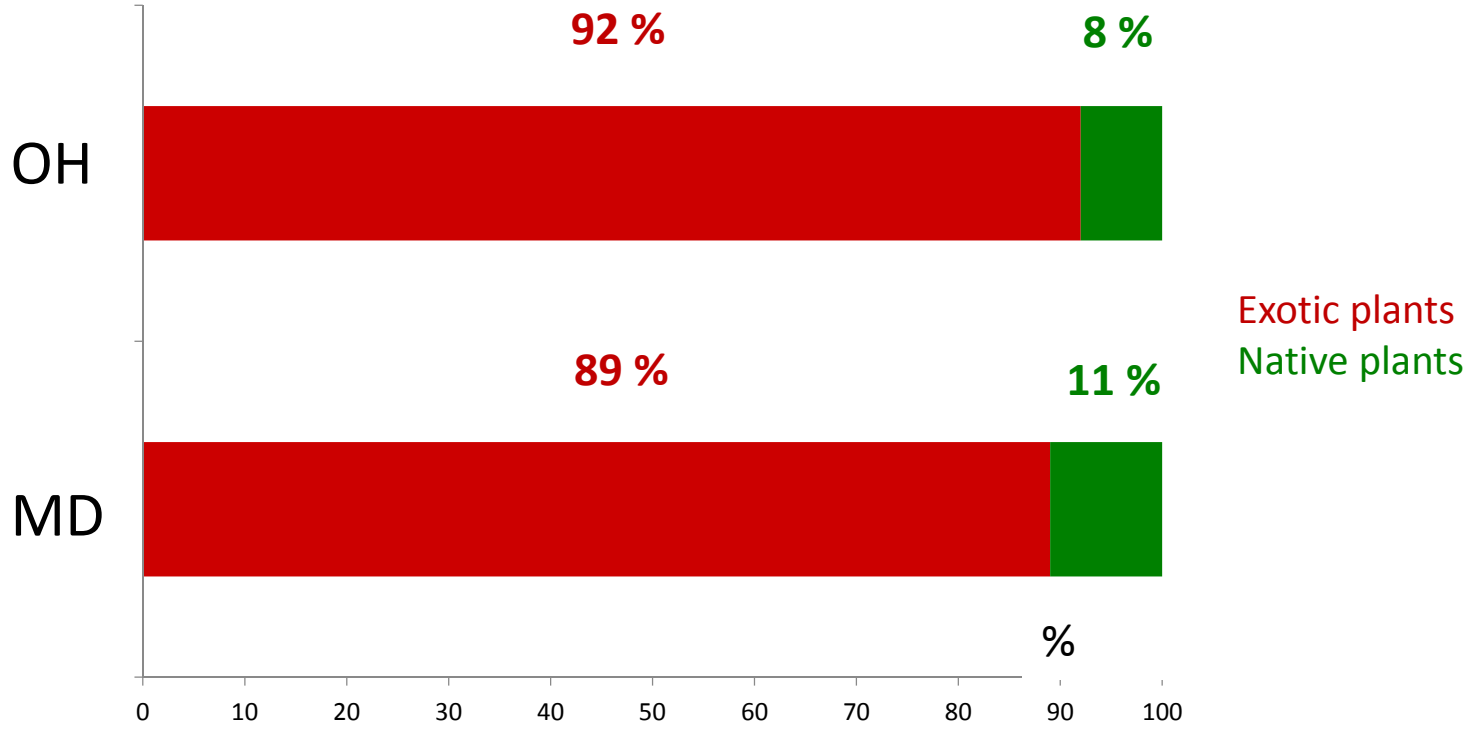
August 2013

Host Plant Identification



Modified from García-Robledo et al. (2013)

Proportions of Ingested Plants



- Grasshopper gut contents contained greater numbers of exotic plant species at both field sites ($p < 0.0001$, Binomial test)

(Avanesyan & Culley, *in review*)

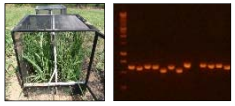
Summary

Melanoplus femurrubrum grasshoppers did not avoid feeding on exotic plants and even preferred them to native plants in most experiments

Feeding preferences: behavioral approach — E ≥ N

Feeding preferences: molecular approach — E > N

- If exotic grasses invade natural areas, *M. femurrubrum* grasshoppers may pose the biotic resistance to exotic grasses
- a lower level of defenses of exotic grasses (lack of coevolutionary history with *M. femurrubrum*) – *needs to be further examined*



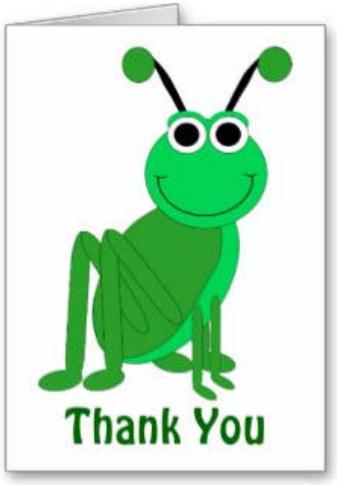
- this combined approach can be applied to other plant-insect systems, especially which involve highly invasive species

Future Directions

- Does the plant coverage (for both native and exotic plants) affect grasshopper feeding choice?

- Does the taxonomic relatedness of plants affects grasshopper feeding choice?

Native vs. exotic plants?



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Credits:
wallpho.com, news.science360.gov, fxdirectory.info, thesun.co.uk, en.wikipedia.org, nps.gov/long/naturescience/insects.htm, pbase.com, commons.wikimedia.org, nwiassoc.com, per.ornl.gov, scenicreflections.com, theg2gallery.com, redorbit.com, miriadna.com, cleancutproperty.com, 123rf.com, dev.keepbritaintidy.org, en.wikipedia.org, two.ucdavis.edu, vector.me, sweetclipart.com, astrophotophils.com, bugphoto.net, mrgoutham.blogspot.com, naturalalternativeremedy.com, prepare-and-protect.net, ivingafield.com, weeds.cropsci.illinois.edu, ariseandshineblog.com