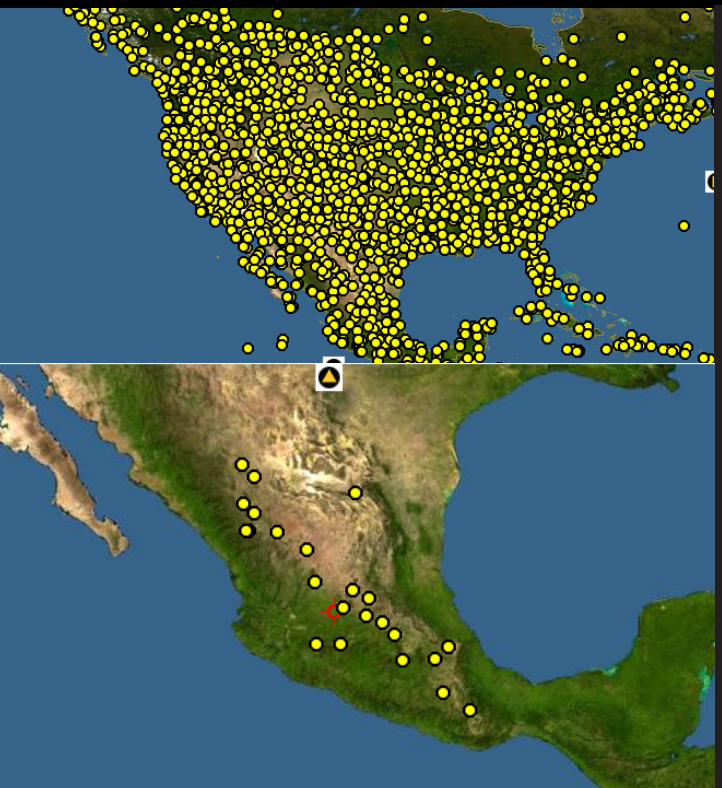
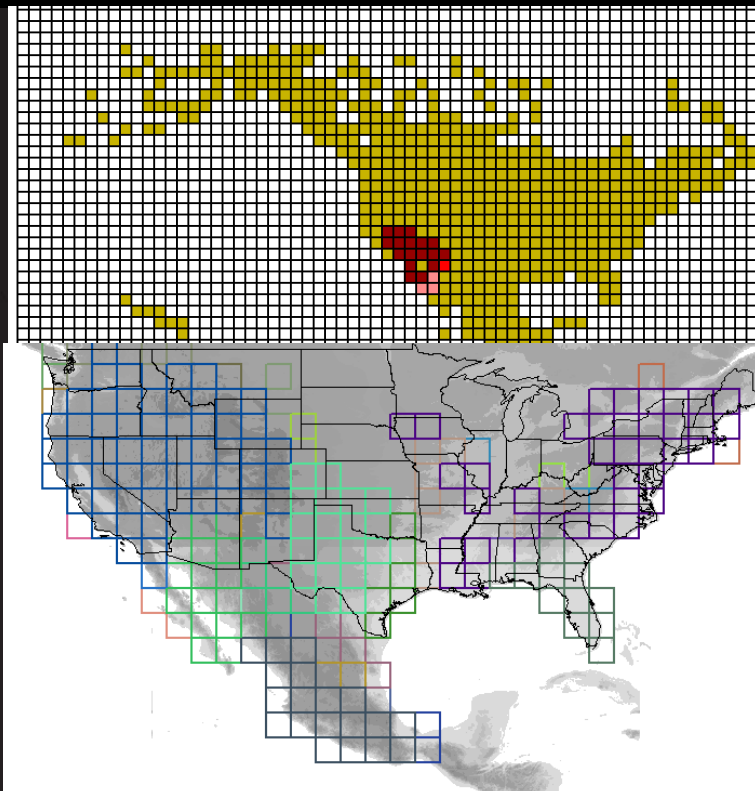
Areas of endemism in the Nearctic: a case study of 1,566 species of Miridae (Insecta: Hemiptera) and their plant hosts

C. Weirauch, R.T. Schuh, K. Seltmann, M.D. Schwartz, C. Johnson, M. A. Feist, P. Soltis





Advancing Digitization of Biodiversity Collections (ADBC)

PROGRAM SOLICITATION
NSF 15-576

REPLACES DOCUMENT(S):
NSF 13-569

National Science Foundation

Directorate for Biological Sciences
Division of Biological Infrastructure

Directorate for Geosciences
Division of Earth Sciences

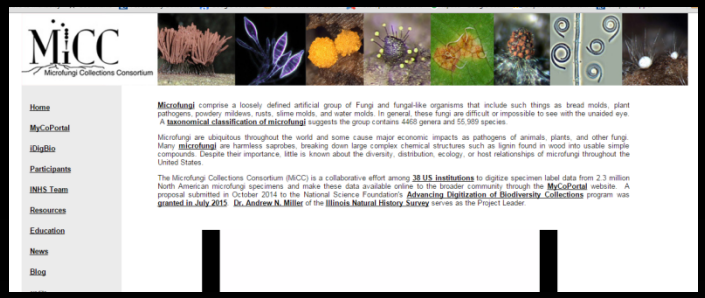
Full Proposal Deadline(s) (due by 5 p.m. proposer's local time):

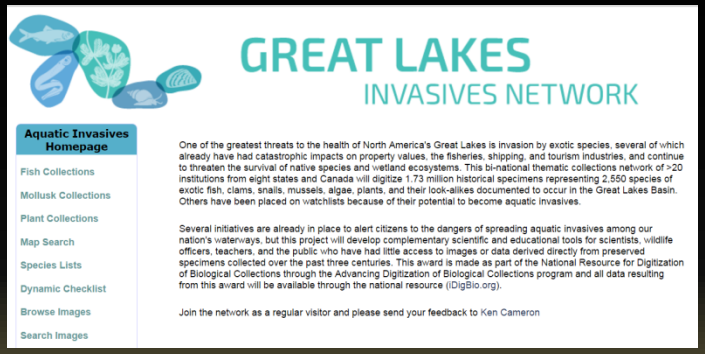
October 09, 2015

Second Friday in October, Annually Thereafter

- "National resource of digital data: documenting existing collections"
- "Baseline from which to further biodiversity research"

- 15 TCNs since 2011

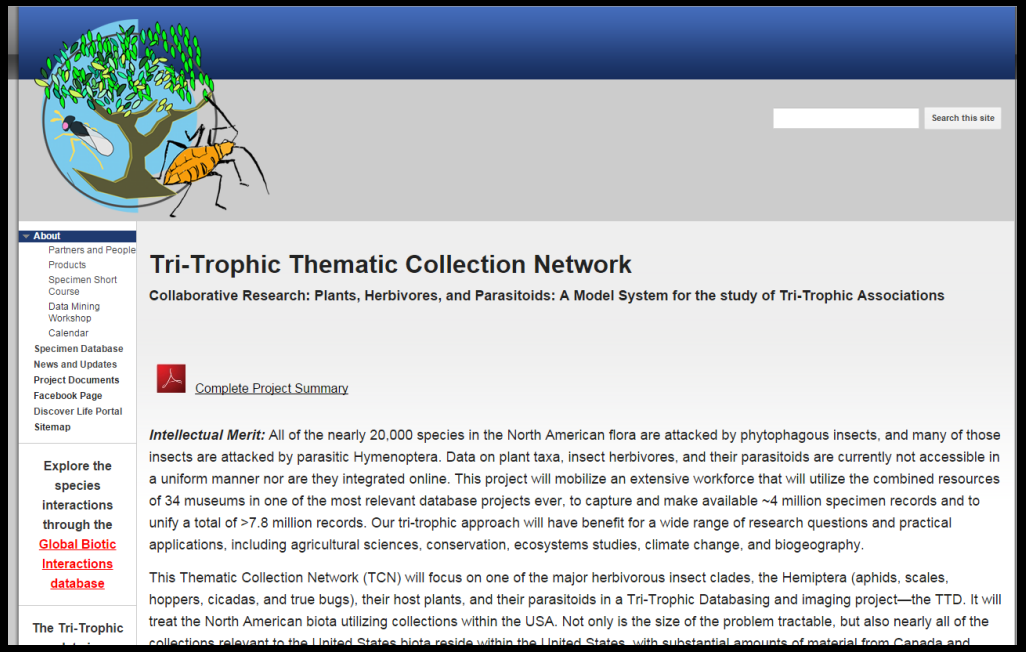




Synopsis of Program:

This program seeks to enhance and expand the national resource of digital data documenting existing vouchered biological and paleontological collections and to advance scientific knowledge by improving access to digitized information (including images) residing in vouchered scientific collections across the United States. The information associated with various collections of organisms, such as geographic, paleogeographic and stratigraphic distribution, environmental habitat data, phenology, information about associated organisms, collector field notes, and tissues and molecular data extracted from the specimens, is a rich resource providing the baseline from which to further biodiversity research and provide critical information about existing gaps in our knowledge of life on earth. The national resource is structured at three levels: a central coordinating organization, a series of thematic networks based on an important research theme, and the physical collections. The national resource builds upon a sizable existing national investment in curation of the physical objects in scientific collections and contributes vitally to scientific research and technology interests in the United States. It will become an invaluable tool in understanding contemporary biological issues and challenges.

- Most TCNs: explicit research questions



- Tri-trophic TCN: Plants, Herbivores, and Parasitoids: A Model System for the study of Tri-Trophic Associations
- North American Hemiptera, host plants, and chalcidoid parasitoids
  - Collaborative grant: 7 institutions
  - 34 natural history museums

BOTANISTS

- Robert Naczi, New York Botanical Garden
- Robert Magill, Missouri Botanical Garden
- Richard Rabeler, University of Michigan
- Melissa Tulig, New York Botanical Garden
- Kim Watson, New York Botanical Garden
- Mari Roberts, New York Botanical Garden
- Barbara Thiers, New York Botanical Garden
- Margaret Hanes, Eastern Michigan University
- Loy Phillippe, Illinois Natural History Survey
- Deborah Lewis, Iowa State University
- Michael Vincent, Miami University
- Timothy Hogan, University of Colorado
- Mary Ann Feist, University of Illinois
- Craig Freeman, University of Kansas
- Christopher Campbell, University of Maine
- Anita Cholewa, University of Minnesota
- Beryl Simpson, University of Texas
- Kenneth Cameron, University of Wisconsin

Data Contributors

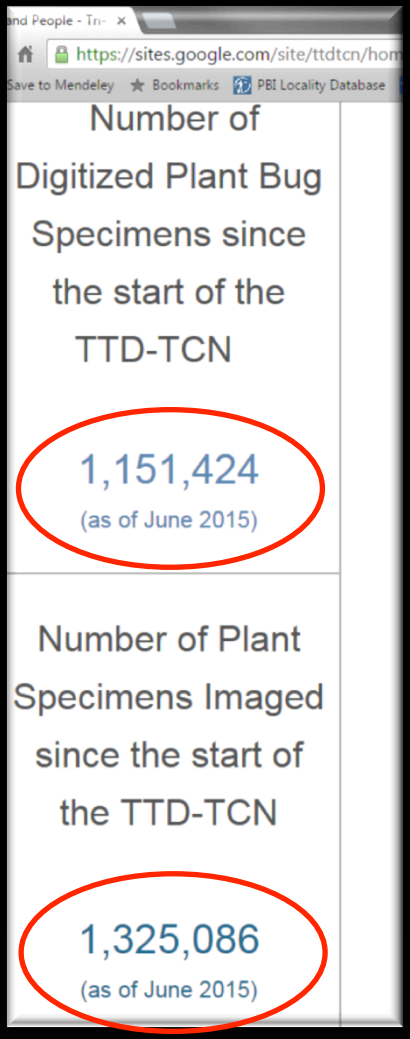
- Consortium of Pacific Northwest Herbaria
- Consortium of California Herbaria
- Southwest Biodiversity Consortium
- Canadian National Collection, Ottowa
- University of California, Davis
- Kansas State University

ENTOMOLOGISTS

- Randall Schuh, American Museum of Natural History
- Christine Johnson, American Museum of Natural History
- Katja Seltmann, American Museum of Natural History
- Matthew Wallace, East Stroudsburg University of Pennsylvania
- Michael Schwartz, Canadian National Collection
- Christiane Weirauch, University of California, Riverside
- John Heraty, University of California, Riverside
- Charles Bartlett, University of Delaware
- Benjamin Normark, University of Massachusetts, Amherst
- John Pickering, Discover Life
- Neal Evenhuis, BP Bishop Museum, Honolulu
- David Kavanaugh, California Academy of Sciences
- Stephen D. Gaimari, California Dept. Food and Agriculture
- Chen Young, Carnegie Museum, Pittsburgh
- Boris C. Kondratieff, Colorado State University
- James K. Liebherr, Cornell University
- Dmitry Dmitriev, Illinois Natural History Survey
- Richard Brown, Mississippi State University
- Bob Blinn, North Carolina State University
- David Maddison, Oregon State University
- Christopher Marshall, Oregon State University
- John Oswald, Texas A&M University
- Kipling Will, University of California, Berkeley
- Caroline Chaboo , University of Kansas
- Michael Sharkey , University of Kentucky

Tri-Trophic Database (TTD): main goals

1. **Database** >1.1 million Hemiptera specimens (PBI-AEC/other databases).
2. **Image and database** ~600,000 specimens in 20 host-plant families.
3. **Database** ~200,000 records for hymenopteran parasitoids.
4. Capture **images** for Hemiptera and parasitoid Hymenoptera.
5. **Integrate specimen data and digital images** for all taxa (together with already captured specimens)



"Datamining workshop"
June 2014
UC Riverside

About
- Partners and People
- Products
- Specimen Short Course
- Data Mining Workshop
- Calendar

Specimen Database
News and Updates
Project Documents
Facebook Page
Discover Life Portal
Sitemap

Explore the species interactions through the Global Biotic Interactions database

The Tri-Trophic

About >

Data Mining Workshop

ADBC TCN Tri-trophic Database: Hemiptera, their plant hosts and parasitoid Hymenoptera

Data mining and distribution modeling workshop (UCR)

Workshop Outline

Location: Department of Entomology, UC Riverside

Date: June 17-18, 2014 (Tuesday to Wednesday)

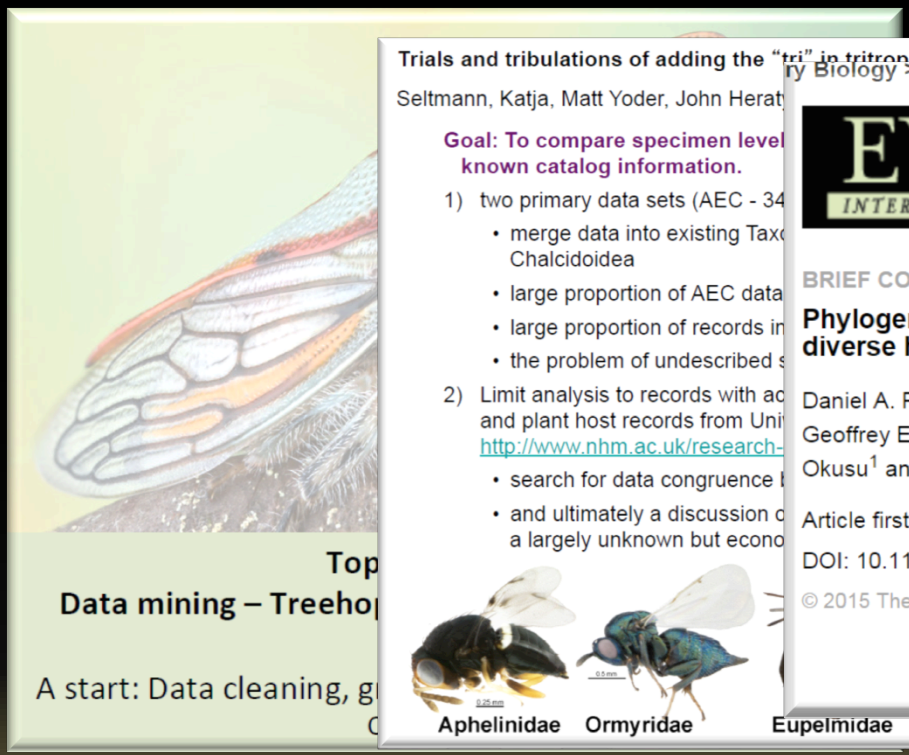
Objective: Bring together ADBC TTD TCN participants and external collaborators and experts to work on a series of research questions. The workshop will be to develop a set of draft papers. Group participation is oriented to working through problems and offering suggestions. The o to integrate collection data with higher level questions in science from biogeography to host associations, climate change and other major issu

Remote Participation: Remote viewing of the talks will be available through Adobe Connect (http://idigbio.adobeconnect.com/ttd-tcn). All pres will be recorded, and made available here.

Research projects:

Video of short explanations of the research projects (http://idigbio.adobeconnect.com/p4gz8umroyd/)

1. Evolution of host range in scale insects (lead: Normark)
2. Assessment of host-network associations found in natural history collection data (lead: Seltmann)
3. Areas of endemism in Western North America (lead: Schuh)
4. Data mining – treehoppers, oaks and climate change (lead: Bartlett)
5. Adding the "tri" in tri-trophic data: mining parasitoid information (lead: Heraty)



Trials and tribulations of adding the "tri" in tritrophic data: mining parasitoid information

Seltmann, Katja, Matt Yoder, John Herat

Goal: To compare specimen level known catalog information.

1) two primary data sets (AEC - 34
   - merge data into existing Taxo Chalcidoidea
   - large proportion of AEC data
   - large proportion of records in
   - the problem of undescribed s
2) Limit analysis to records with ac and plant host records from Uni http://www.nhm.ac.uk/research-
   - search for data congruence
   - and ultimately a discussion c a largely unknown but econo

Aphelinidae Ormyridae Eupelmidae Aphelinidae Eucharitidae

ry Biology > Evolution > Vol 69 Issue 10 > Abstract

EVOLUTION
INTERNATIONAL JOURNAL OF ORGANIC EVOLUTION

BRIEF COMMUNICATION

Phylogenetic analysis reveals positive correlations between adaptations to diverse hosts in a group of pathogen-like herbivores

Daniel A. Peterson[1], Nate B. Hardy[2], Geoffrey E. Morse[3], Ian C. Stocks[4], Akiko Okusu[1] and Benjamin B. Normark[1]

Article first published online: 28 SEP 2015

DOI: 10.1111/evo.12772

Issue

Evolution

Volume 69, Issue 10, October 2015

Areas of endemism in the Western Nearctic: a case study using 500(?) species of Miridae and host plants

Introduction

- Area of endemism (AOE): distribution congruence of at least 2 taxa
- Essential first step in investigating historical biogeography
- Different methods proposed to (objectively) determine AOEs: parsimony analysis of endemicity, biotic elements, and endemicity analysis (Szumik et al. 2002, Szumik & Goloboff, 2004)
- Compared to Central and South America, there is a surprising paucity of AOE hypotheses for the Western Nearctic region
- Investigation of AOE patterns for insects together with their host plants have not been attempted before (?)
- Mexico has a speciose fauna of Miridae, but species occurrence data for Miridae are rather scarce. Mexico straddles the boundaries between the Nearctic and Neotropical regions and is therefore of premier interest to biogeographic investigations. Ecological niche modelled distributions could shed light on the southernmost boundaries of mirid distribution ranges

Why Miridae?

- Cassis & Schuh (2012): "…hyperdiverse family containing more than 11,020 valid described species."
- North America: >2,000 species
- Small distribution ranges
- Many species are host plant specific

***Larinocerus balius* Froeschner, 1965**

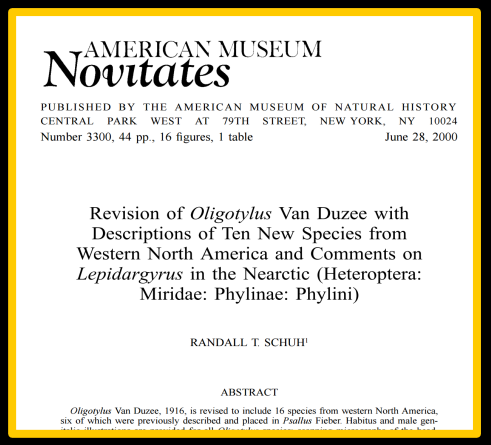
Salazaria mexicana

Why Miridae?

- Nearctic Miridae: pre-Plant Bug PBI, Plant Bug PBI, and ADBC : taxonomic revisions and electronic data capture

➢ Lots of data: > 295,723 specimen records

➢ Data "clean": IDs and localities (bugs and plants): 25 years of data collecting and cleaning


AMERICAN MUSEUM
Novitates

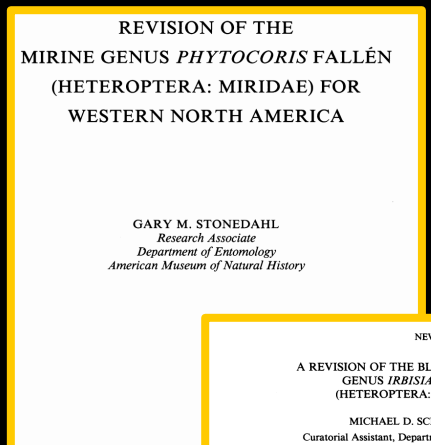
PUBLISHED BY THE AMERICAN MUSEUM OF NATURAL HISTORY
CENTRAL PARK WEST AT 79TH STREET, NEW YORK, NY 10024
Number 3300, 44 pp., 16 figures, 1 table June 28, 2000

Revision of *Oligotylus* Van Duzee with Descriptions of Ten New Species from Western North America and Comments on *Lepidargyrus* in the Nearctic (Heteroptera: Miridae: Phylinae: Phylini)

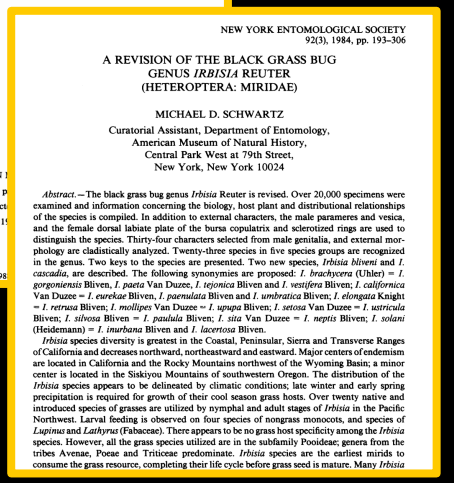
RANDALL T. SCHUH[1]

ABSTRACT

Oligotylus Van Duzee, 1916, is revised to include 16 species from western North America, six of which were previously described and placed in *Psallus* Fieber. Habitus and male gen-


REVISION OF THE MIRINE GENUS *PHYTOCORIS* FALLÉN (HETEROPTERA: MIRIDAE) FOR WESTERN NORTH AMERICA

GARY M. STONEDAHL
Research Associate
Department of Entomology
American Museum of Natural History


NEW YORK ENTOMOLOGICAL SOCIETY
92(3), 1984, pp. 193–306

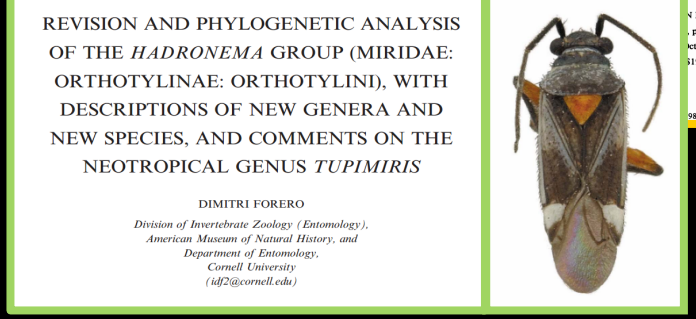
A REVISION OF THE BLACK GRASS BUG GENUS *IRBISIA* REUTER (HETEROPTERA: MIRIDAE)

MICHAEL D. SCHWARTZ

Curatorial Assistant, Department of Entomology, American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024

Abstract.—The black grass bug genus *Irbisia* Reuter is revised. Over 20,000 specimens were examined and information concerning the biology, host plant and distributional relationships of the species is compiled. In addition to external characters, the male parameres and vesica, and the female dorsal labiate plate of the bursa copulatrix and sclerotized rings are used to distinguish the species. Thirty-four characters selected from male genitalia, and external morphology are cladistically analyzed. Twenty-three species in five species groups are recognized in the genus. Two keys to the species are presented. Two new species, *Irbisia bliveni* and *I. cascadia*, are described. The following synonymies are proposed: *I. brachycera* (Uhler) = *I. gorgoniensis* Bliven, *I. paeta* Van Duzee, *I. tejonica* Bliven and *I. vestifera* Bliven; *I. californica* Van Duzee = *I. eurekae* Bliven, *I. paenulata* Bliven and *I. umbratica* Bliven; *I. elongata* Knight = *I. retrusa* Bliven; *I. mollipes* Van Duzee = *I. upupa* Bliven; *I. setosa* Van Duzee = *I. ustricula* Bliven; *I. silvosa* Bliven = *I. paulula* Bliven; *I. sita* Van Duzee = *I. neptis* Bliven; *I. solani* (Heidemann) = *I. inurbana* Bliven and *I. lacertosa* Bliven.

Irbisia species diversity is greatest in the Coastal, Peninsular, Sierra and Transverse Ranges of California and decreases northward, northeastward and eastward. Major centers of endemism are located in California and the Rocky Mountains northwest of the Wyoming Basin; a minor center is located in the Siskiyou Mountains of southwestern Oregon. The distribution of the *Irbisia* species appears to be delineated by climatic conditions; late winter and early spring precipitation is required for growth of their cool season grass hosts. Over twenty native and introduced species of grasses are utilized by nymphal and adult stages of *Irbisia* in the Pacific Northwest. Larval feeding is observed on four species of nongrass monocots, and species of *Lupinus* and *Lathyrus* (Fabaceae). There appears to be no grass host specificity among the *Irbisia* species. However, all the grass species utilized are in the subfamily Pooideae; genera from the tribes Avenae, Poeae and Triticeae predominate. *Irbisia* species are the earliest mirids to consume the grass resource, completing their life cycle before grass seed is mature. Many *Irbisia*


REVISION AND PHYLOGENETIC ANALYSIS OF THE *HADRONEMA* GROUP (MIRIDAE: ORTHOTYLINAE: ORTHOTYLINI), WITH DESCRIPTIONS OF NEW GENERA AND NEW SPECIES, AND COMMENTS ON THE NEOTROPICAL GENUS *TUPIMIRIS*

DIMITRI FORERO

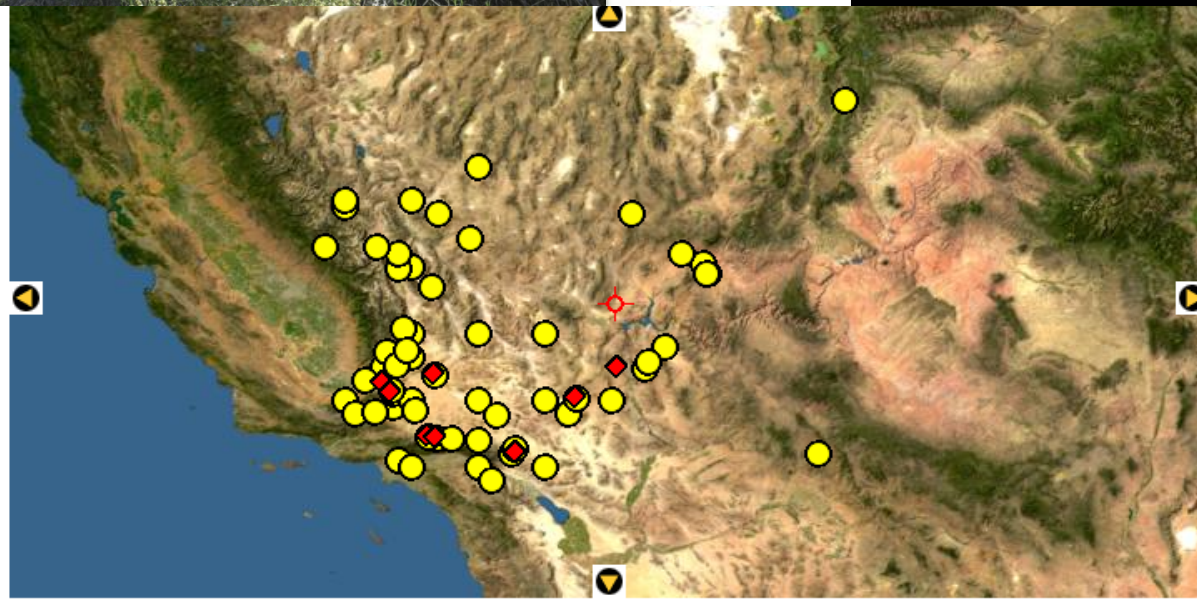
Division of Invertebrate Zoology (Entomology), American Museum of Natural History, and Department of Entomology, Cornell University (idf2@cornell.edu)

Plant Bug Planetary Biodiversity Inventory

Pls Toby Schuh and Gerry Cassis

Why Miridae?

- Dataset assembled during ADBC exceptional, because 43% of mirid records associated with host plant info
- Mirid species tend to have smaller distribution ranges than their host plant species
- Biogeography? Host association?



Zoom level: Globe sat s s **S** s s map m topo topo topo photo p
Map center: NAD83 **Lat-long** 36.5°N 115°W **UTM** 11 679121E 4041268N **Resolution** 0.025 degrees/pixel
Discover Life | Global Mapper
Help | About | Find place | Menu | Demo

Customize this map (add species, change resolution, filter points, etc. -- See all options).

© Designed by The Polistes Corporation

◆ Nevadocoris tetradymii @ Plant Bug (244)

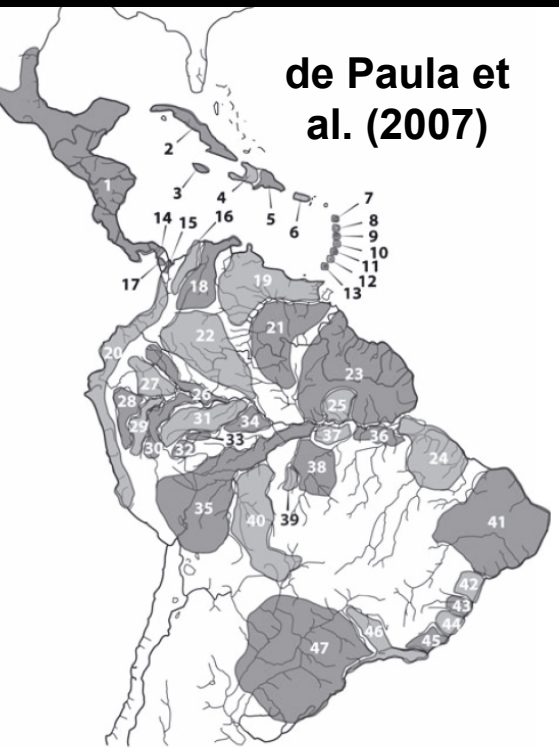
Hosts:

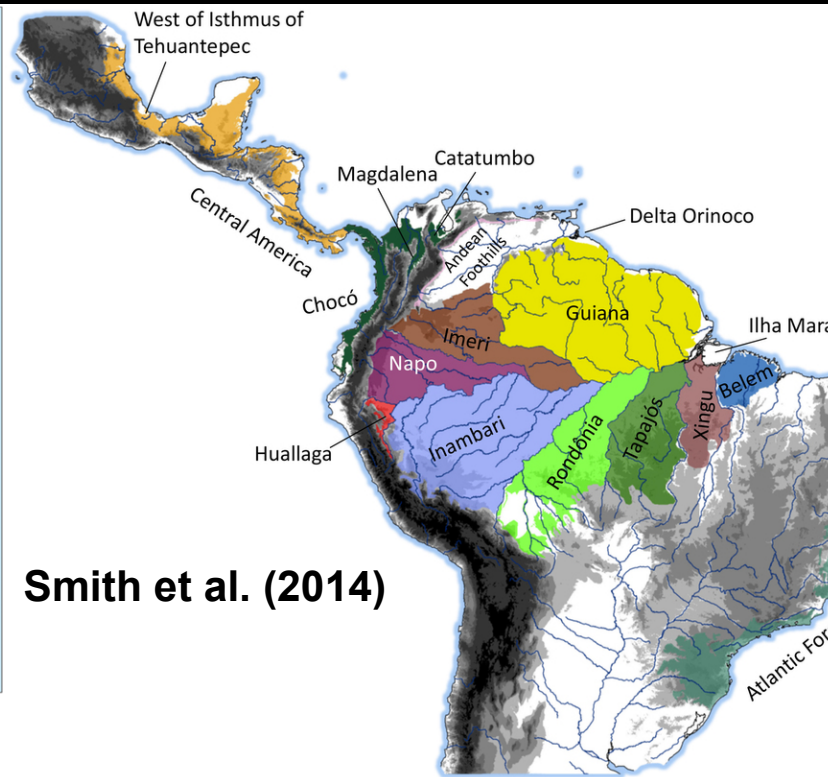
● Tetradymia stenolepis @ American Museum of Natural History Entomology (1); Plant Bug (160); Global Biodiversity Information Facility (182) [Consortium of California Herbaria (135); UCJEPS TAPIR Provider (38); Arizona State

Why areas of endemism?

- Historical biogeography: phylogenetic hypotheses required
- Phylogenetic hypotheses available only for some Nearctic taxa

➢ Contribute to essential first step in investigating historical biogeography: areas of endemism (AOE)





Syst. Biol. 43(3):438–441, 1994

Morrone (1994)

On the Identification of Areas of Endemism

JUAN J. MORRONE

Laboratorio de Sistemática y Biología Evolutiva (LASBE), Museo de La Plata, Paseo del Bosque, 1900 La Plata, Argentina[1]

What are the smallest areas of the world that house endemic species—how many are there, and where are they? We have only fragments of an answer, but it looks as though there are many local areas of endemism, each defined by the overlap of two or more species ranges.

—Platnick (1992:20)

Methodological developments in cladistic biogeography have mostly focused on converting taxon–area cladograms into area cladograms and on obtaining general area cladograms (Nelson and Platnick, 1981; Wiley, 1988; Page, 1990; Nelson and Ladiges, 1991). The problem of identifying areas of endemism, although fundamental for any cladistic biogeographic study, has been somewhat neglected.

An area of endemism is an area of nonrandom distributional congruence among different taxa. It is identified by the congruence of two or more species ranges. Müller (1973) suggested a protocol for determining areas of endemism by mapping species ranges where (1) species ranges are relatively small compared with the whole region itself, (2) their distributional limits are accurately known, and (3) the validity of the species is not in dispute. According to this approach, substantial overlap in ranges of two or more species determines an area of endemism. When dealing with a few species, Müller's approach may be easily applied by hand, but with a large number of species, difficulties arise. A way to choose which species to map so as to maximize the number of species contributing to each area of endemism would be useful.

The purpose of this paper is to explore the possibility of applying a parsimony

Areas of endemism

- "non-random distributional congruence among different taxa" identified by "congruent distributional boundaries of two or more species"
- Different methods proposed to (objectively) determine AOEs:
  - ❖ Parsimony analysis of endemicity (Morrone 1994)
  - ❖ Biotic elements analysis (Hausdorf and Hennig 2003)
  - ❖ Endemicity analysis (Szumik et al. 2002, Szumik & Goloboff, 2004)
- Endemicity analysis: more robust than other methods (Casagranda et al. 2012)

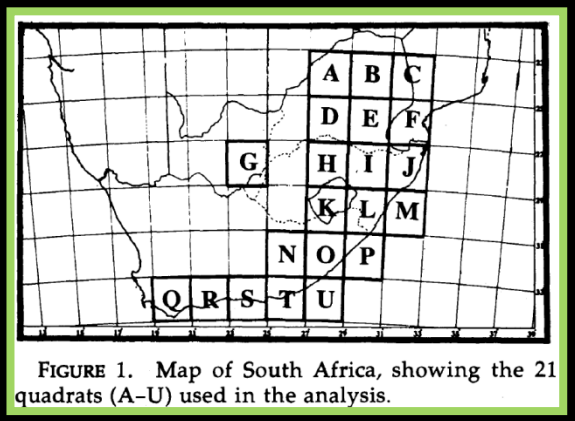


FIGURE 1. Map of South Africa, showing the 21 quadrats (A–U) used in the analysis.

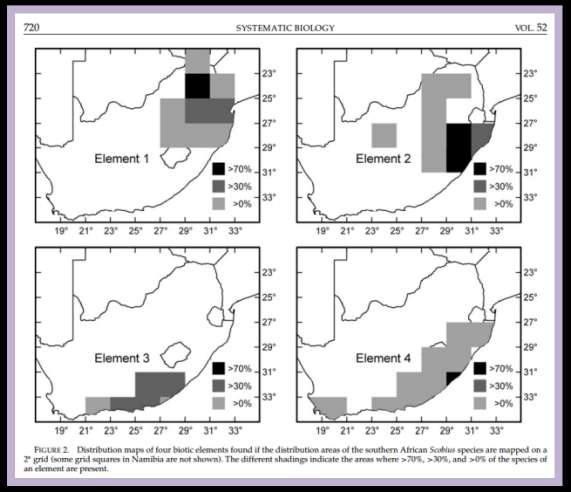
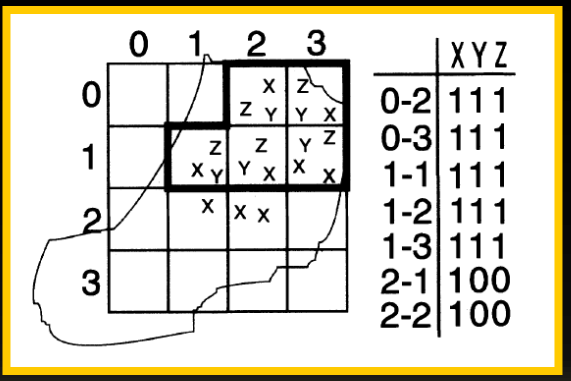


FIGURE 2. Distribution maps of four biotic elements found if the distribution areas of the southern African *Scobius* species are mapped on a 2° grid (some grid squares in Namibia are not shown). The different shadings indicate the areas where >70%, >30%, and >0% of the species of an element are present.



Endemicity Analysis: the concept

- AOE limits ideally inviolable
- In reality: limits diffuse
- Overlay records with grid cells
- Assign a value of endemicity (=score) to a given area
- Count species considered endemic, given the area: 4 endemicity criteria (different levels of strictness)
- Evaluate all possible sets of cells, select areas with highest scores

Syst. Biol. 51(5):806–816, 2002
DOI: 10.1080/10635150290102483

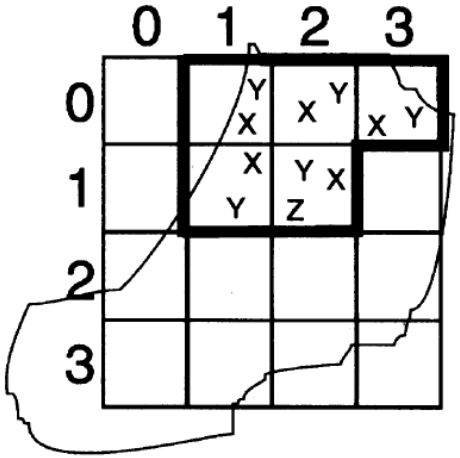
An Optimality Criterion to Determine Areas of Endemism

CLAUDIA A. SZUMIK,[1,2] FABIANA CUEZZO,[2] PABLO A. GOLOBOFF,[1,2] AND ADRIANA E. CHALUP[2]

[1]*Consejo Nacional de Investigaciones Científicas y Técnicas, Miguel Lillo 205, 4000 San Miguel de Tucumán, Tucumán, Argentina*
[2]*Instituto Superior de Entomología, Miguel Lillo 205, 4000 San Miguel de Tucumán, Tucumán, Argentina; E-mail: insue@infovia.com.ar*

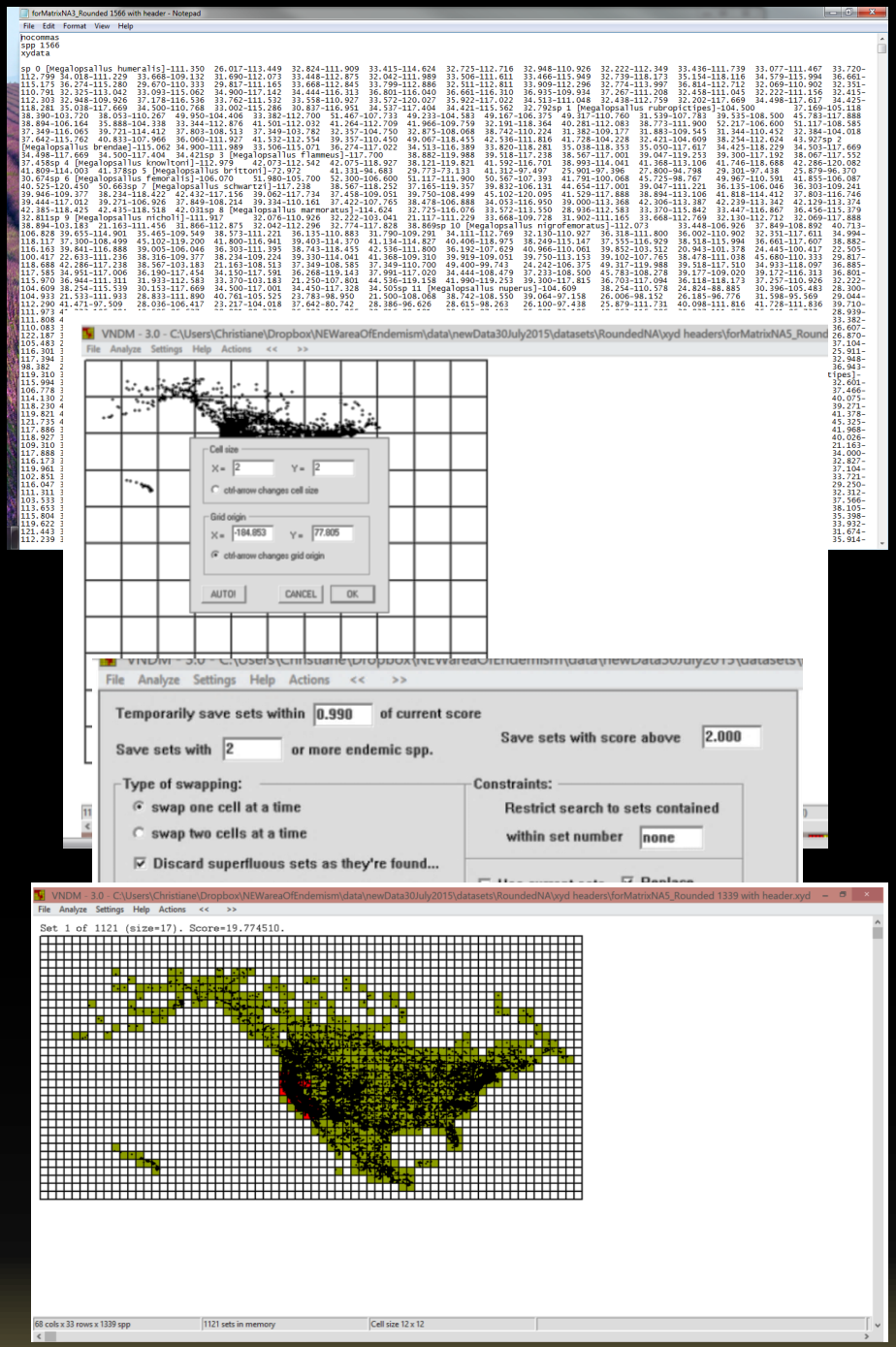
Abstract.—A formal method was developed to determine areas of endemism. The study region is divided into cells, and the number of species that can be considered as endemic is counted for a given set of cells (= area). Thus, the areas with the maximum number of species considered endemic are preferred. This is the first method for the identification of areas of endemism that implements an optimality criterion directly based on considering the aspects of species distribution that are relevant to endemism. The method is implemented in two computer programs, NDM and VNDM, available from the authors. [Biogeography; endemicity; optimality criterion.]

Under criteria 1 through 3, a species can contribute to the score only if it is present in each and every one of the cells of the area. A more realistic criterion, however, must take into account the fact that a species may be absent from a given cell because of poor collecting effort or partial extinction (as in urban



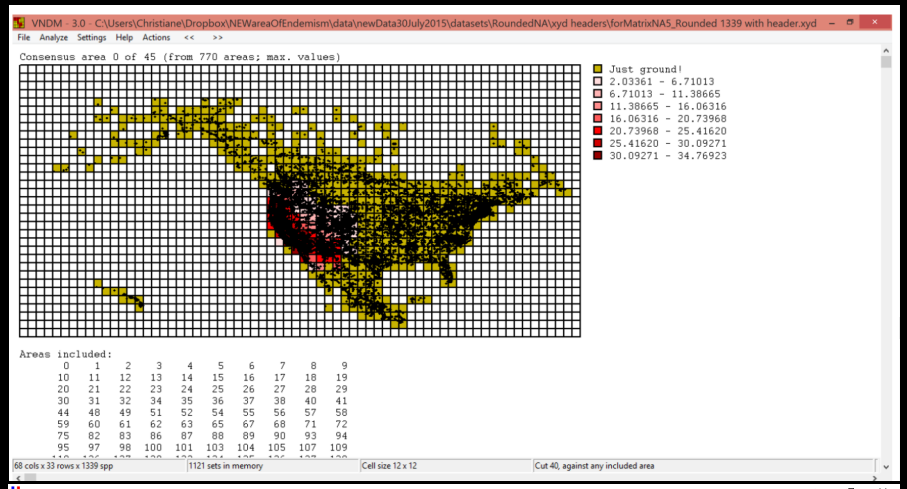
	XYZ
0-1	110
0-2	110
0-3	110
1-1	110
1-2	111

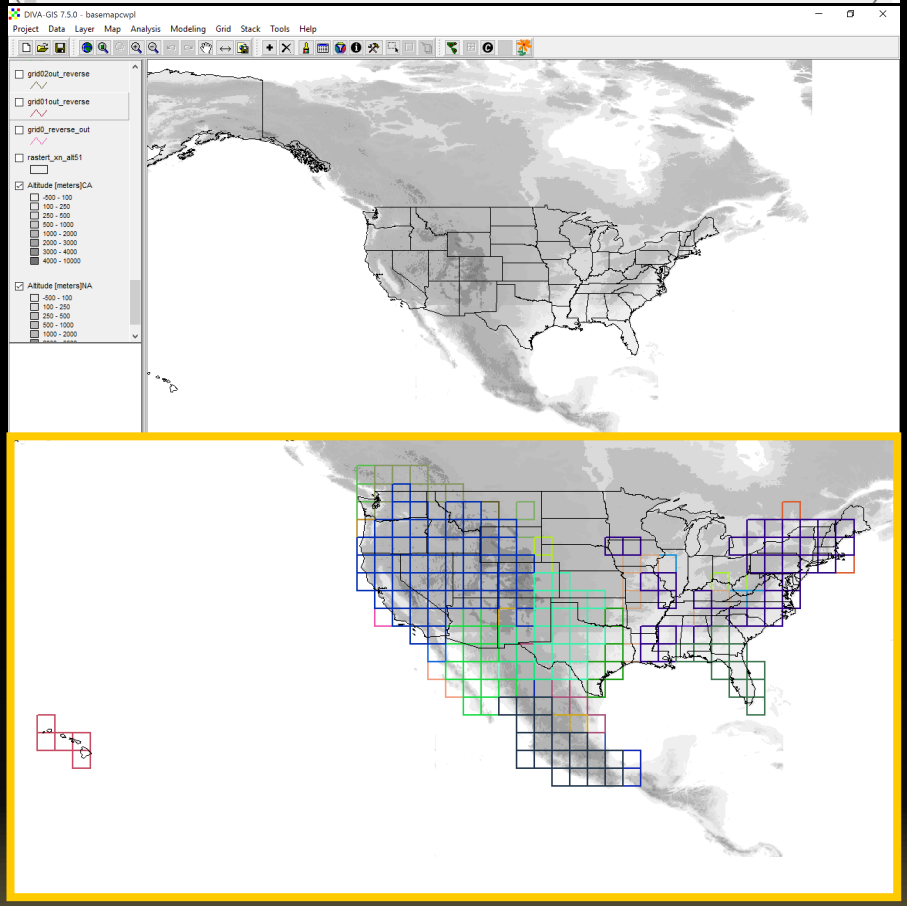
FIGURE 4. An area with score 2 under criterion 3. Not all cells in the area have identical species composition. Species X and Y contribute to the score; species Z does not because it is found in only some cells of the area.



….and this is how you do it…

- generate file with (cleaned!) georeferences and species names
- Upload into NDM/VNDM (two sister programs for analyzing areas of endemism; Szumik et al., 2002; Szumik & Goloboff, 2004)
- Select grid size
- Create matrix and select parameters
- Obtain candidate areas





….and this is how you do it…

- generate file with (cleaned!) georeferences and species names
- Upload into NDM/VNDM
- Select grid size
- Create matrix and select parameters
- Obtain candidate areas
- Consense candidate areas: consensus areas
- Import output files into DivaGIS
- Examine areas of endemism

AOE studies in the Neotropical and Nearctic regions

Journal of Biogeography (J. Biogeogr.) (2006)

ORIGINAL ARTICLE

Areas of endemism of the Patagonian steppe: an approach based on insect distributional patterns using endemicity

[1]Laboratorio de En
Argentino de Inves
Áridas (IADIZA),
Argentina and [2]Di
University of Nebr
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Detecting areas of endemism
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Claudia Szumik[a,*], Lone Aagesen
Diego Baldo[d], Lucía E. Claps
Adrián Di Giacomo[f], Alejandro
Cecilia Kopuchian[h], Sonia Kretzsc
Marcos Mollerach[i], Fernando N
Verónica V. Pereyra[a], María Sandov

[a]Instituto Superior de Entomología (INSUE-CONICET
(CONICET-ANCEFN), Labarden 200, CC22, San L
(CONICET-UNL), Ciudad Universitaria, El Pozo s/n,
4000 Tucumán, Argentina; [g]Instituto de Bio y Geociencias (IBI
de Ecología y Comportamiento Animal (FCEN-UBA), Ciuda
Miguel Lillo 251, 4000 Tucumán, Argentina; [h]División Ornitolo
de investigaciones en Biodiversidad Argen

Endemism analysis of Neotropical Pentatomidae (Hemiptera, Heteroptera)

Augusto Ferrari[1], Andressa Paladini[2], Cristiano Feldens Schwertner[3] & Jocelia Grazia[1]

1. Laboratório de Entomologia Sistemática, Departamento de Zoologia, Programa de Pós-Graduação em Biologia Animal, Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves, 9500, Bloco IV, prédio 43435, 91501-970 Porto Alegre, RS, Brazil. (ferrariaugusto@gmail.com; jocelia@ufrgs.br)
2. Departamento de Zoologia, Programa de Pós-Graduação em Entomologia, Universidade Federal do Paraná, Caixa Postal 19020, 81531-980 Curitiba, PR, Brazil. (andri_bio@yahoo.com.br)
3. Departamento de Ciências Biológicas, Universidade Federal de São Paulo, Campus Diadema, Rua Prof. Artur Riedel, 275, 09972-270, Diadema, SP, Brazil. (acrosternum@yahoo.com.br)

ABSTRACT. The definition of areas of endemism is central to studies of historical biogeography, and their interrelationships are fundamental questions. Consistent hypotheses for the evolution of Pentatomidae in the Neotropical region depend on the accuracy of the units employed in the analyses, which in the case of studies of historical biogeography, may be areas of endemism. In this study, the distribution patterns of 222 species, belonging to 14 Pentatomidae (Hemiptera) genera, predominantly neotropical, were studied with the Analysis of Endemicity (NDM) to identify possible areas of endemism and to correlate them to previously delimited areas. The search by areas of endemism was carried out using grid-cell units of 2.5° and 5° latitude-longitude. The analysis based on groupings of grid-cells of 2.5° of latitude-longitude allowed the identification of 51 areas of endemism, the consensus of these areas resulted in four clusters of

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Biogeographic regions of North American mammals based on endemism

TANIA ESCALANTE[1]*, JUAN J. MORRONE[1] and GERARDO RODRÍGUEZ-TAPIA[2]

[1]*Museo de Zoología 'Alfonso L. Herrera', Departamento de Biología Evolutiva, Facultad de Ciencias, Universidad Nacional Autónoma de México, Apartado Postal 70-399, 04510 Mexico, DF, Mexico*
[2]*Unidad de Geomática, Instituto de Ecología, Universidad Nacional Autónoma de México, Apartado Postal 70-275, 04510 Mexico, DF, Mexico*

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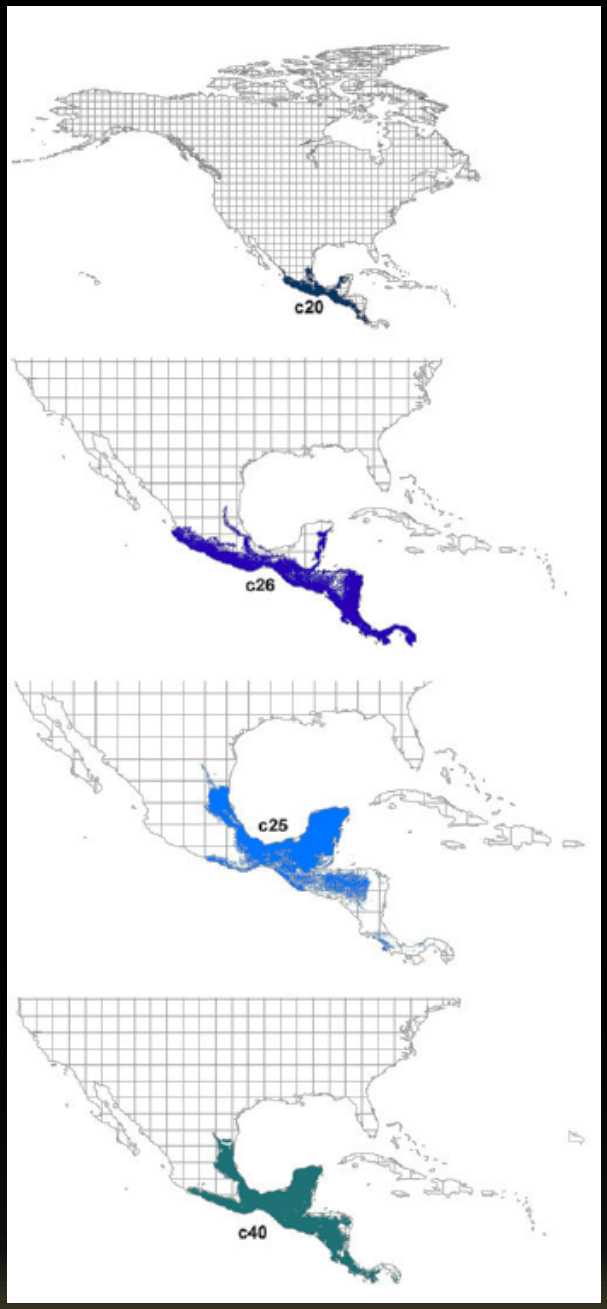
AOE in North America based on mammals (Escalante et al. 2013)

- Canada to Panama
- Data: GBIF; MaNIS; UNIBIO; Conabio, and Mammex, Mamíferos de México (T. Escalante, V. Sánchez-Cordero, M. Linaje & G. Rodríguez-Tapia, unpubl. data).
- 710 species; 245,818 records (unique combinations of name & georeference)
- 652 species selected: >5 records
- MAXENT model, then NDM/VNDM, version 3.0 (Goloboff, 2011)
- Resulting AOE classified into subregions and dominions using parsimony analysis of endemicity

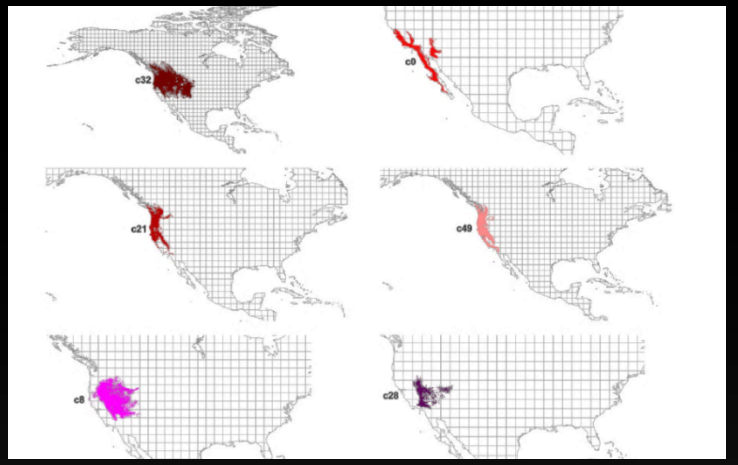


Escalante et al. 2013

- 329 candidate areas of endemism
- 76 consensus areas; **18 north of Mexico**
- **Areas in the US mostly large: e.g., "Western USA"**
- Max. endemicity scores: 3.25 to 17.49
- High-scoring areas (>7) mostly in Central America, also US West Coast (9.99) and California (10.79)
- Some AOEs in the Eastern and Central US: Florida (4.01) and Eastern USA (2.84)

Table 2. General patterns corresponding to regions, subregions, and dominions in North America

Clade	Consensus areas	Geographical location	Pattern
1	43, 65	Mexico and northern Central America	Mexican Transition Zone
2	40, 55	Gulf of Mexico coast, Yucatan peninsula, Isthmus of Tehuantepec, south of Mexican Pacific coast and Central America	Mexican Gulf-Central America subregion
3	26, 50	Gulf of Mexico coast, Yucatan peninsula, Isthmus of Tehuantepec, south of Mexican Pacific coast and Central America	Pacific Central America subregion
4	6, 32	Alopatric patterns of eastern and western USA	Alleghanian and Californian-Rocky Mountain subregions
5	0, 49	Pacific coast of Mexico and USA	Californian dominion
6	56, 68	Central Mexico	Mexican Transition Zone
7	70, 48, 58	Central America	Central America subregion
8	44, 52, 53	Northwestern Mexico	Rocky Mountain dominion
9	13, 27, 38	Allopatric patterns of eastern and western USA	Alleghanian and Californian-Rocky Mountain subregions
10	61, 16, 74	Mexican Pacific coast Yucatan peninsula, Isthmus of Tehuantepec, south of Gulf of Mexico coast, and Central America	Pacific Central America subregion
11	72, 73, 18, 57	Mexican Pacific coast Yucatan peninsula, Isthmus of Tehuantepec, Gulf of Mexico coast, and Central America	Neotropical region
12	41, 60, 24, 71	Chiapas, southern Yucatan peninsula, Central America	Central America subregion
13	46, 3, 2, 17	Southern Central America	Central America dominion
14	37, 12, 25, 7, 20, 51	Mexican Pacific coast Yucatan peninsula, Isthmus of Tehuantepec, Gulf of Mexico coast, and Central America	Mexican Gulf-Central America subregion
15	33, 45, 66, 62, 69, 22, 14, 19	Western USA, California, Nothern Mexico	Rocky Mountain dominion
16 (a)	54	Oaxaca	Mexican Transition Zone
16 (b)	11, 64	Western USA	Californian dominion
16 (c)	28, 15, 8, 21	Western USA	Californian dominion
16 (d)	1, 9, 63, 4, 31	Mexico	Mexican Transition Zone



Objectives

1. Generate AOE for Nearctic Miridae (parameters as Escalante et al. [2013])

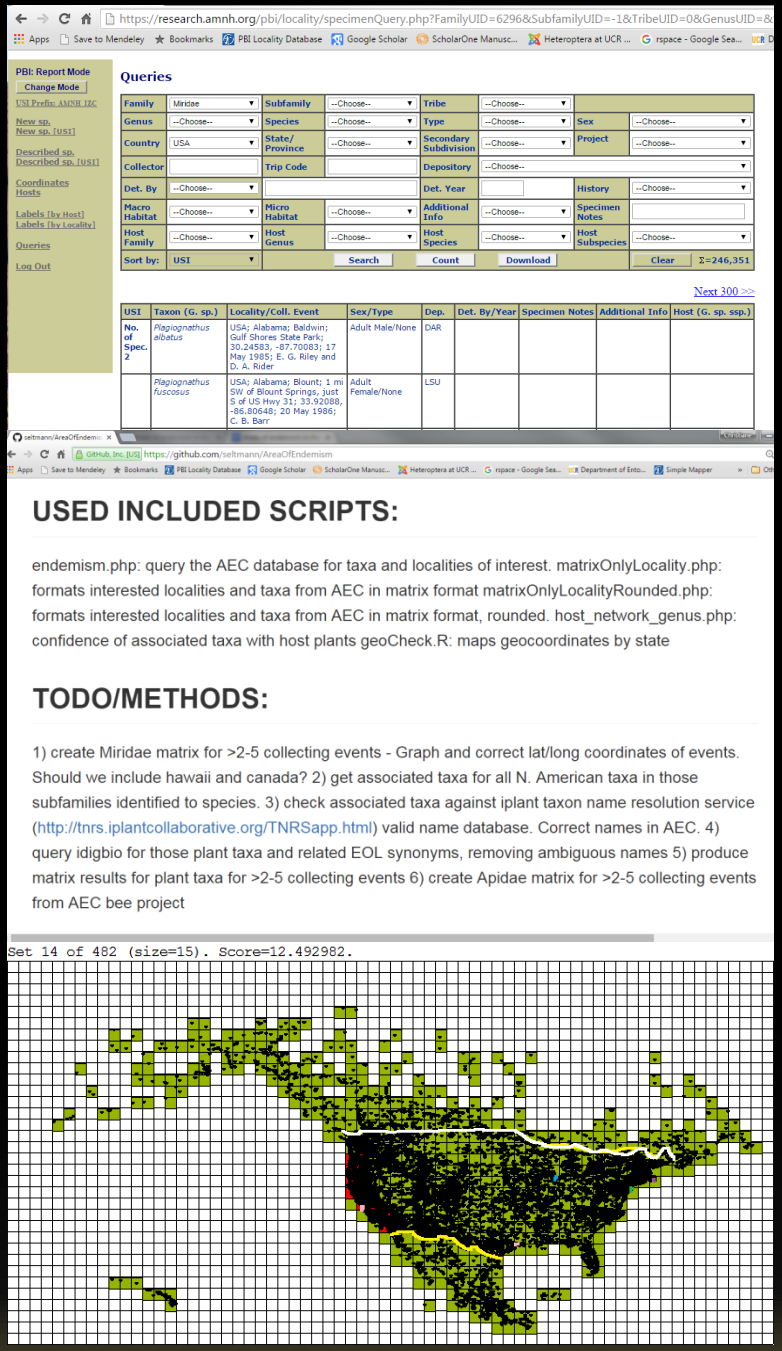
2. Compare results with Escalante et al. (2013): we predict that AOEs in North America are more numerous for Miridae

3. Investigate effects of number of locality records, grid size, consensus parameters, and varying levels of strictness in defining AOEs

4. Generate AOE for Nearctic host plants: Distribution ranges of Miridae are often smaller than those of their host plants and we predict that AOEs defined by Miridae will also be smaller than those defined by host plants

Miridae datasets

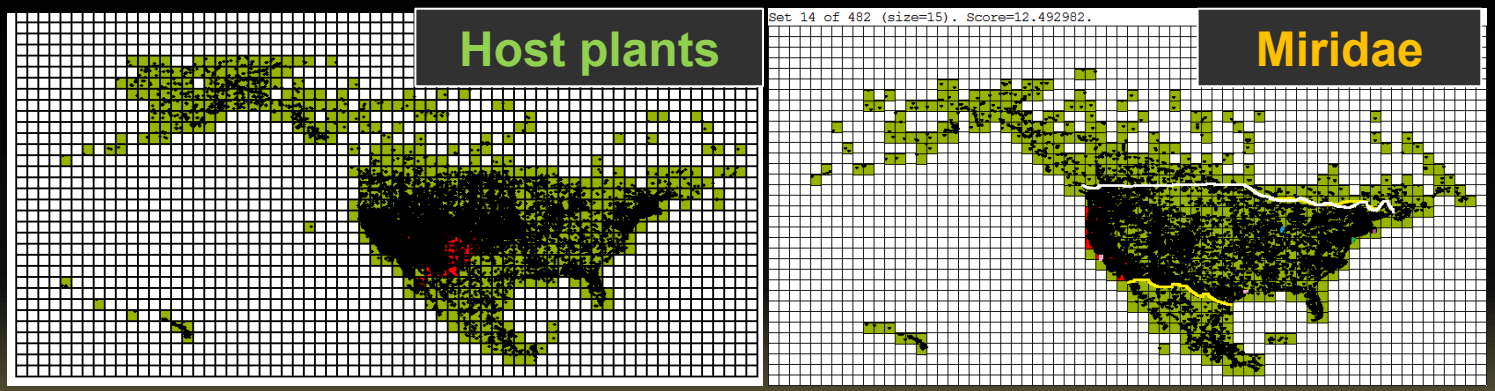
- Arthropod Easy Capture database: 4 largest subfamilies; Canada, US, and Mexico
- Datasets: 3, 5, and 10 or more (unique) georeferences:
  - 3: 1,566 spp.; 61,784 records
  - 5: 1,339 spp.; 61,016 records
  - 10: 1,004 spp.; 58,820 records
- R and PHP code for parsing and cleaning data available on GitHub. https://github.com/seltmann/AreaOfEndemism



Host plant dataset

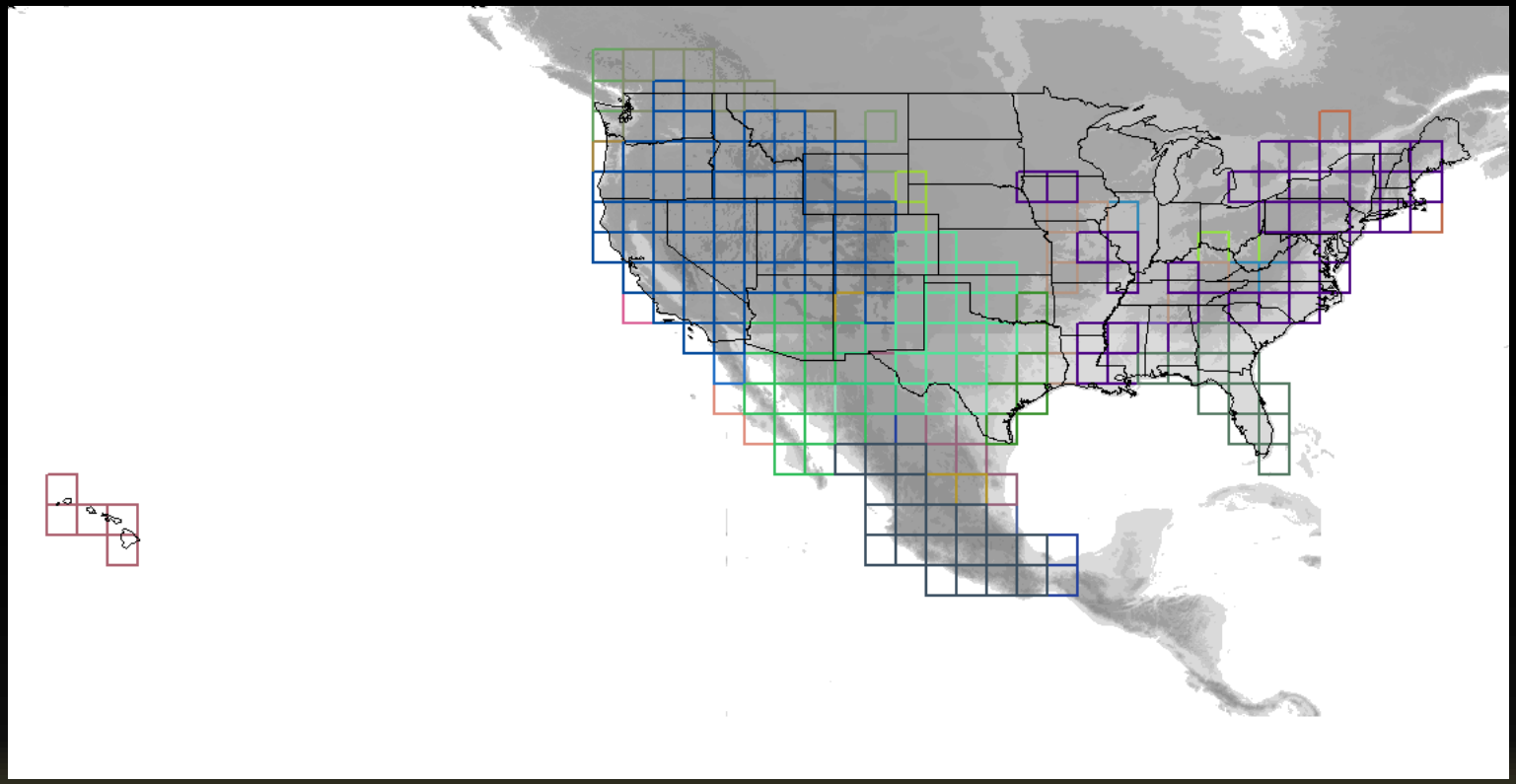
- Host plants for Miridae in the default dataset
- Downloaded from the ridigbio (extension of the idigbio api): https://github.com/iDigBio/ridigbio
- Names queried from the database and checked against the iplant taxon name resolution service (http://tnrs.iplantcollaborative.org/TNRSapp.html) for name status
- Lat Long checked (correct state?)
- Botanic Garden specimens removed (~1,200 records)

➢ 331 species of plants; 196,012 records (88 institutions)



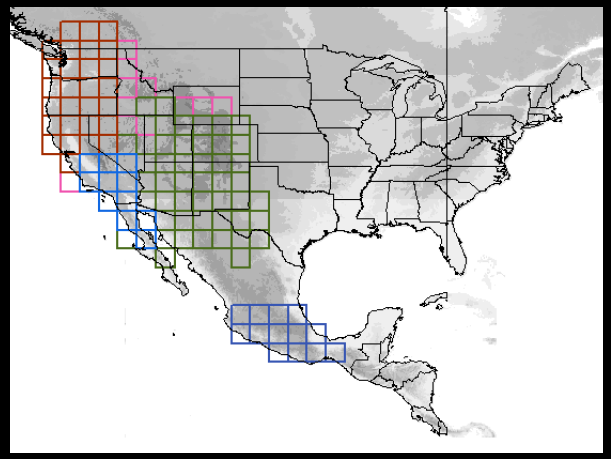
AOEs in the Nearctic based on Miridae

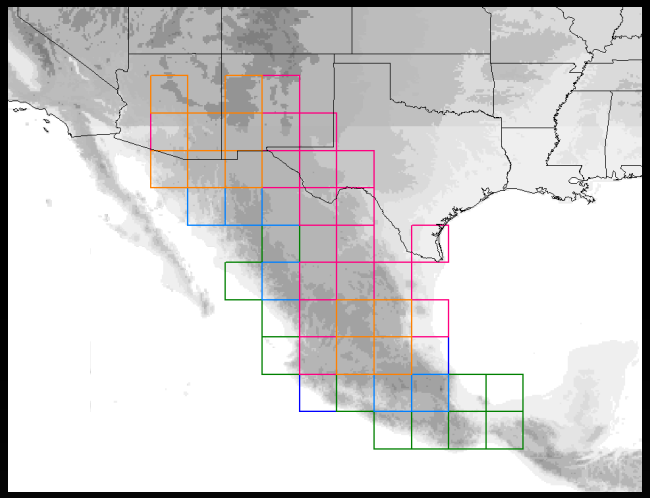
- 1121 candidate areas of endemism
- 45 consensus areas; **35 north of Mexico**
- Many overlapping AOEs in the Western Nearctic and in Mexico; 7 AOEs in the Eastern US

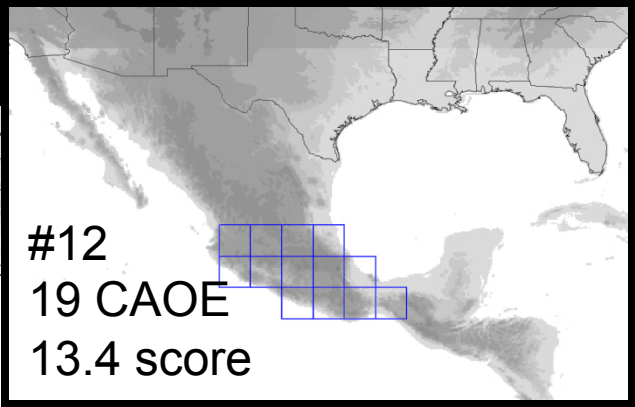


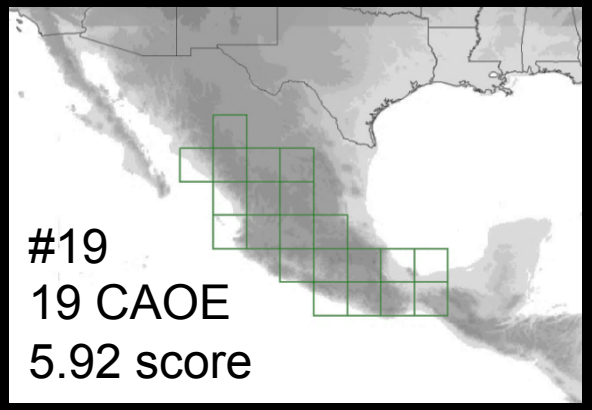
AOEs in the Nearctic based on Miridae

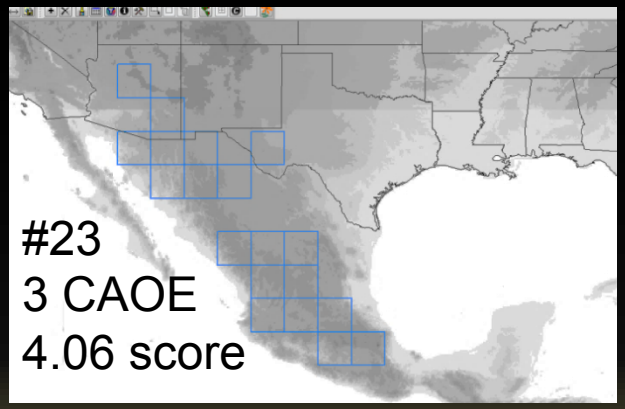
- Highest endemicity scores in the Western Nearctic and Mexico: 7.47 to 34.77
- Broadly overlapping areas:

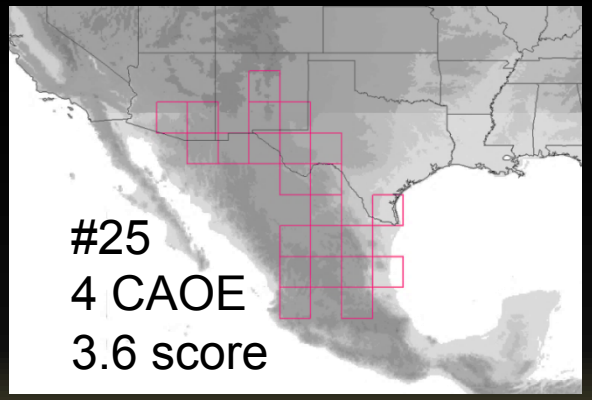






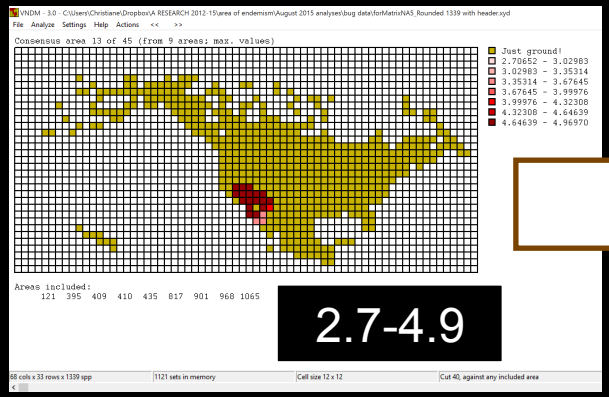






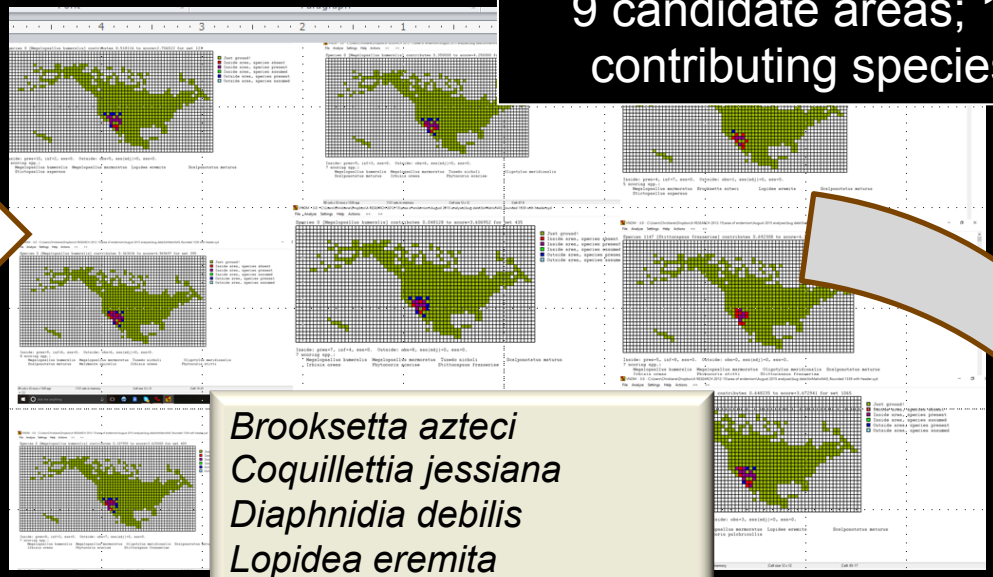
AOE in the Nearctic based on Miridae

- 442 of the 1,339 mirid species contribute to the 45 AOEs
- Western Nearctic: 184 scoring species



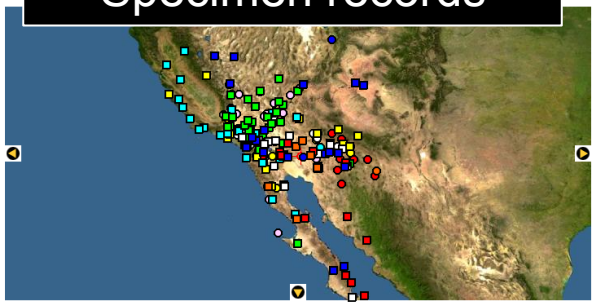
2.7-4.9

9 candidate areas; 15 contributing species



Brooksetta azteci
Coquillettia jessiana
Diaphnidia debilis
Lopidea eremita
Lopidea falcata
Lopidea falcicula
Lygidea rubecula
Megalopsallus humeralis
Megalopsallus marmoratus
Phytocoris kiowa
Phytocoris pulchricollis
Phytocoris stitti
Psallovius flaviclavus
Scalponotatus maturus
Stictopsallus aspersus

Specimen records



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Map center: NAD83 Lat-long 33°N 114°W UTM 12 219700E 3655286N Resolution 0.05 degrees/pixel
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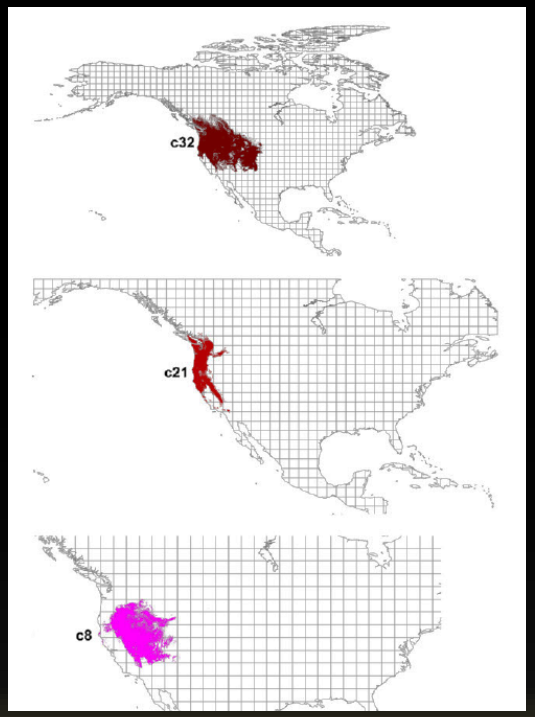
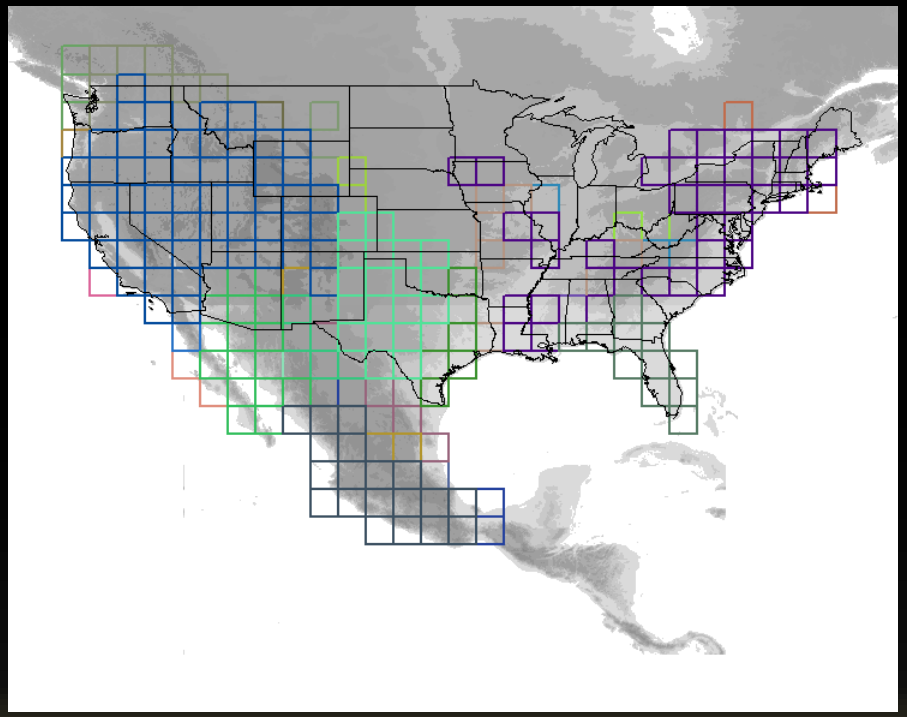
- Megalopsallus humeralis @ Plant Bug (25); University of California, Riverside, Entomology (34)
- Megalopsallus marmoratus @ Plant Bug (5)
- Tuxedo nicholi @ Plant Bug (1); University of California, Riverside, Entomology (2)
- Scalponotatus maturus @ American Museum of Natural History Entomology (263); Plant Bug (452); BOLD (3); University of California, Riverside, Entomology (36)
- Irbisia oreas @ American Museum of Natural History Department of Invertebrate Zoology (25); Plant Bug (14); University of California, Riverside, Entomology (178)
- Phytocoris acaciae @ American Museum of Natural History Entomology (37); Plant Bug (12); University of California, Riverside, Entomology (4)
- Stiltocapsus franseriae @ American Museum of Natural History Entomology (9); Plant Bug (4); University of California, Riverside, Entomology (5)

Are AOEs based on Miridae more numerous than those based on mammals?

- Mammals: 76 consensus areas; **18 north of Mexico**
- Miridae: 45 consensus areas; **35 north of Mexico**
- AOEs with high endemicity scores in the Western Nearctic





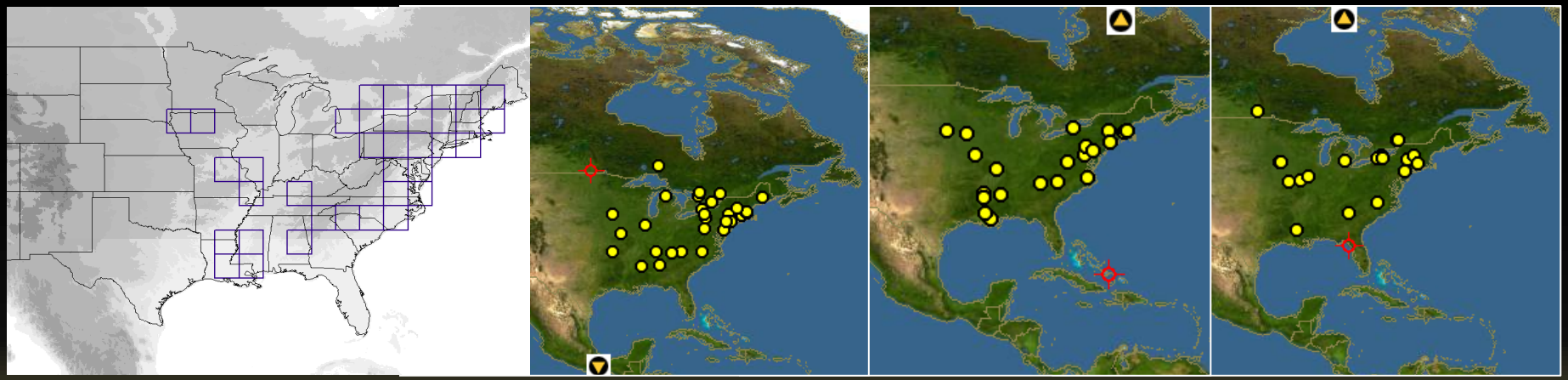
Miridae: effect of minimum # of records, definition of endemicity, grid sizes, and sampling

- Still in the process of evaluating effects….
- # records/species: default >5
  - >3 records (61,784 records; 1,566 spp.): 55 AOE
  - >10 records (58,820 records; 1,004 spp.): 33 AOE
- Endemicity defined by: default 2 or more spp.
  - 5 or more spp.: 21 AOE
  - 10 or more spp.: 12 AOE

- **Analyses that result in low numbers of AOEs: AOEs restricted to Western Nearctic**

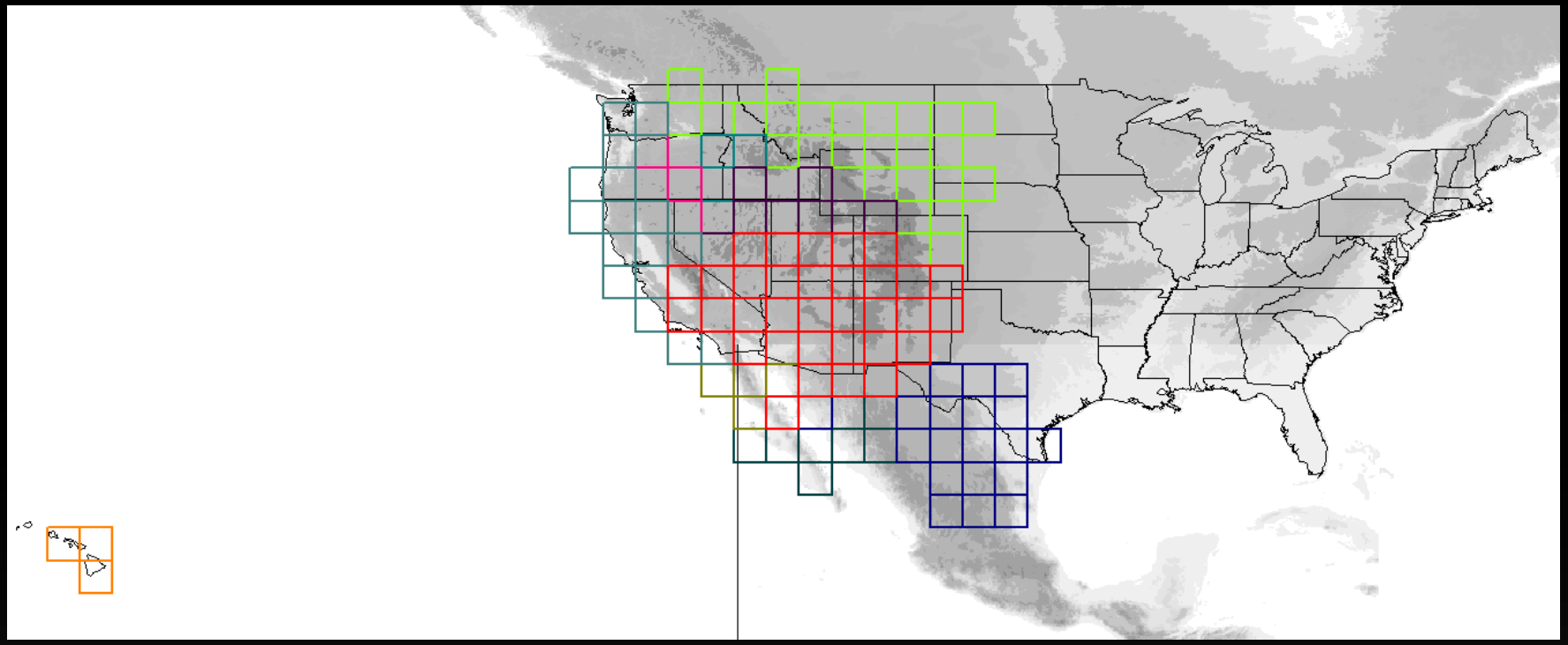
Miridae: effect of minimum # of records, definition of endemicity, grid sizes, and sampling

- Grid size: default 2 degrees: depends on questions
  - Smaller grid sizes (1; 0.5): few AOEs recovered: not enough records
  - Larger grid sizes (4; 10): only large AOEs recovered
- Sampling:
  - Disjunct AOEs in Eastern N America: lack of records



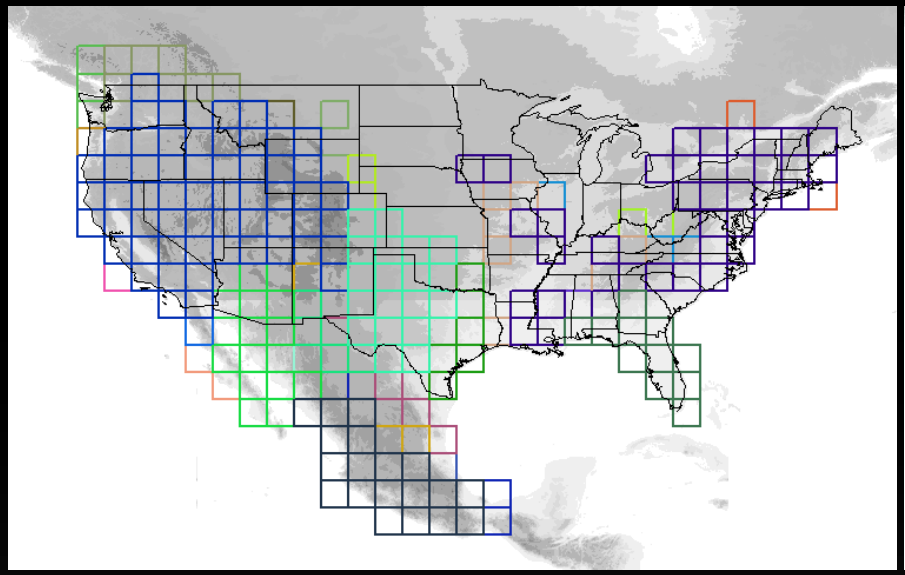
Host plant: results

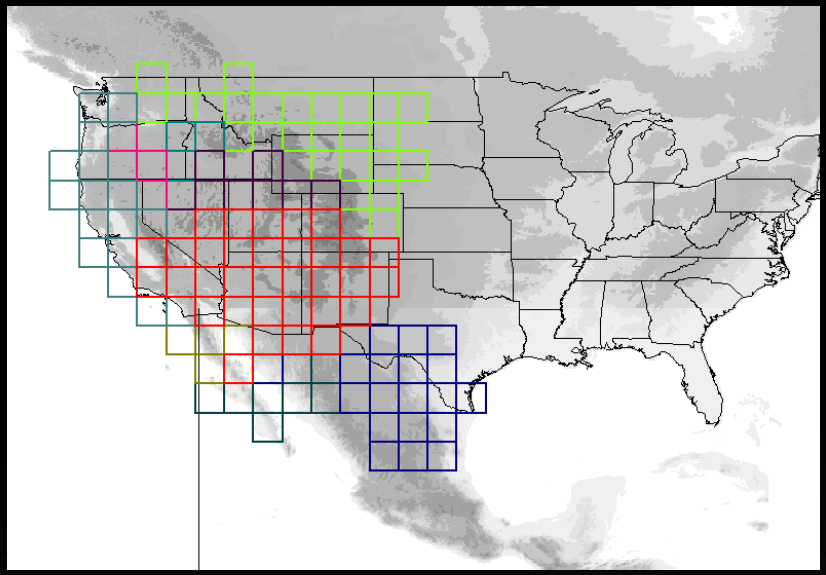
- 185 candidate areas; 10 AOE
- AOEs restricted to the Western Nearctic; mostly large
- Lack of AOEs in Mexico likely result of lack of data



Are AOE based on Miridae smaller than those based on their host plants?

- Sizes of smallest (2; 3 cells for mirids; plants) and largest (81; 87) AOE similar
- Mirid AOE smaller on average than plant (AOE): 22.8; 29.3





Conclusions and lessons learned

- Clean dataset imperative: species identification and name authority files, botanic garden records excluded, and well-excecuted georeferencing
- Selection of appropriate grid size essential for a given question
- Mirid dataset appears to be well suited to investigate areas of endemism in North America, especially in the Western Nearctic, but also the Central US, and to a lesser degree Eastern North America

Acknowledgements

- Participants of the TTD TCN project, especially all the undergrad students for databasing, imaging, and georeferencing
- Funding: NSF; AMNH, UCR, and some other institutions

- Questions?