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MISSOURI BOTANICAL GARDEN

Evolutionary insights from fruit and seed morphology in *Ludwigia* (Onagraceae)

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Friday, July 31st, 2015



Introduction



- ▶ The plant family Onagraceae is divided into two subfamilies, Ludwigioideae, with only genus *Ludwigia* of 82 species and 22 sections, and Onagroideae, which consists of six tribes and 21 genera.
- ▶ This research is taking a closer look at fruit and seed morphology in 35 species representing all sections chosen to fill gaps in the previous studies (Edge, 1978).

Introduction

- The objective is to discover how fruit and seed morphology can advance knowledge of the relationships among and within the sections of *Ludwigia*.

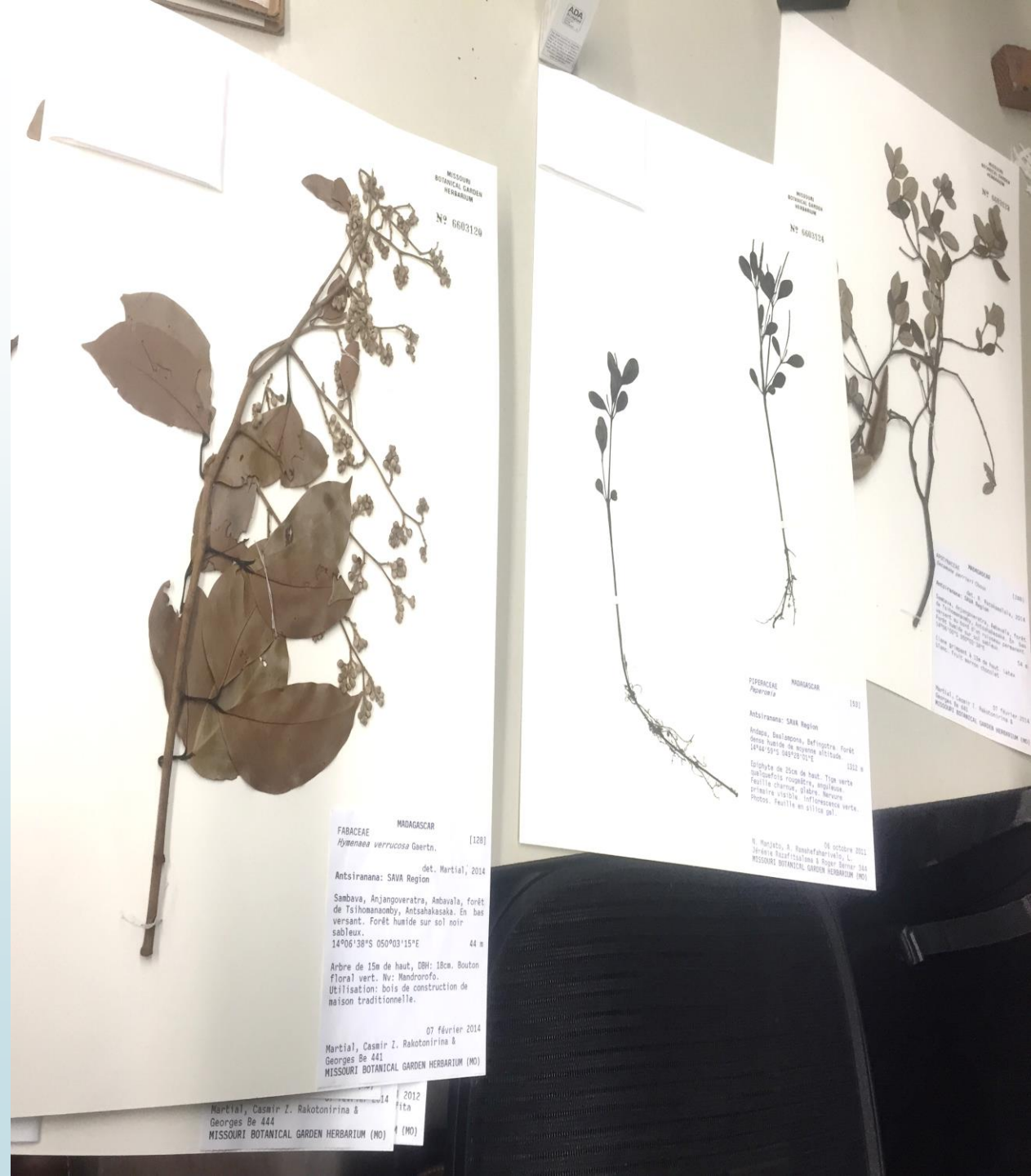


Ludwigia sedoides

- Why: Our understanding of the phylogenetics of *Ludwigia* is advancing and within this context there is a need for more morphological work to be done, to complement and focus molecular phylogenetic studies.

Materials & Methods

- ▶ Samples
- ▶ Literature
- ▶ R Program
- ▶ Light Microscope
- ▶ Sputter Coater
- ▶ Scanning Electron Microscope (SEM)



Materials & Methods



- ▶ **35 species & 10 specimens per species**
- ▶ **3 fruits and seeds were measured per specimen**
- ▶ **Measured under Light Microscope and photographed**
- ▶ **SEM images of seeds at several magnifications were taken for species not already imaged**

Examples of morphological characters

Winged Raphe

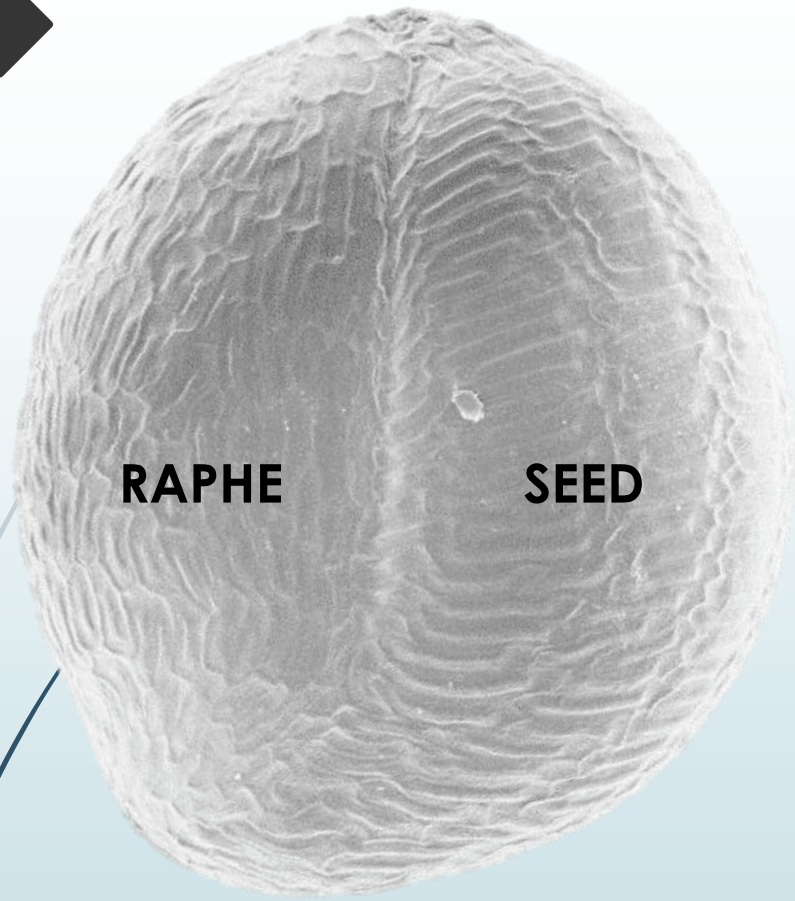


Ludwigia ovalis Boufford & Mitsuta
19985, MO

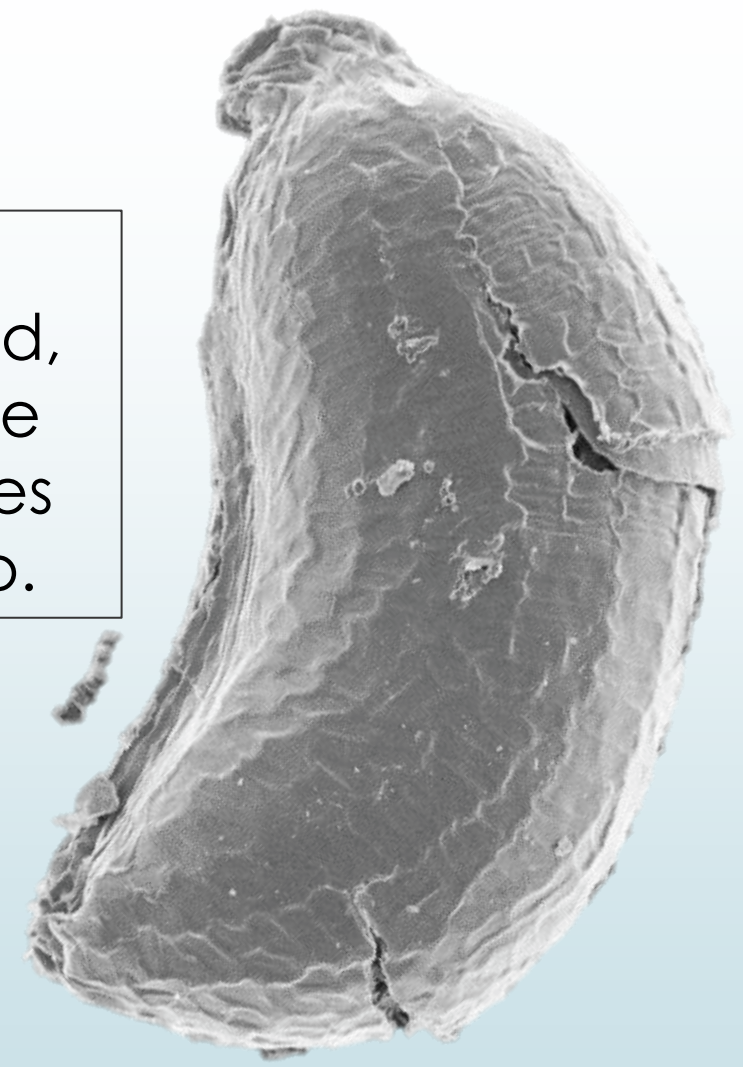
Capsule Shape



Ludwigia abyssinica Richards 22515,
MO



Raphe is a groove attached to the seed, typically marking the line where two halves fused in the embryo.

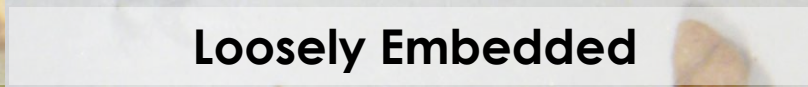


200 μm

Ludwigia hyssopifolia Hooper & Gaudhi 2491, MO



Free



Loosely Embedded



Firmly Embedded



Ludwigia hirtella Boufford, Wood, & Peng 21433, MO



Ludwigia hexapetala Raven 16563, MO

Ludwigia linearis
Henderson 93300, MO

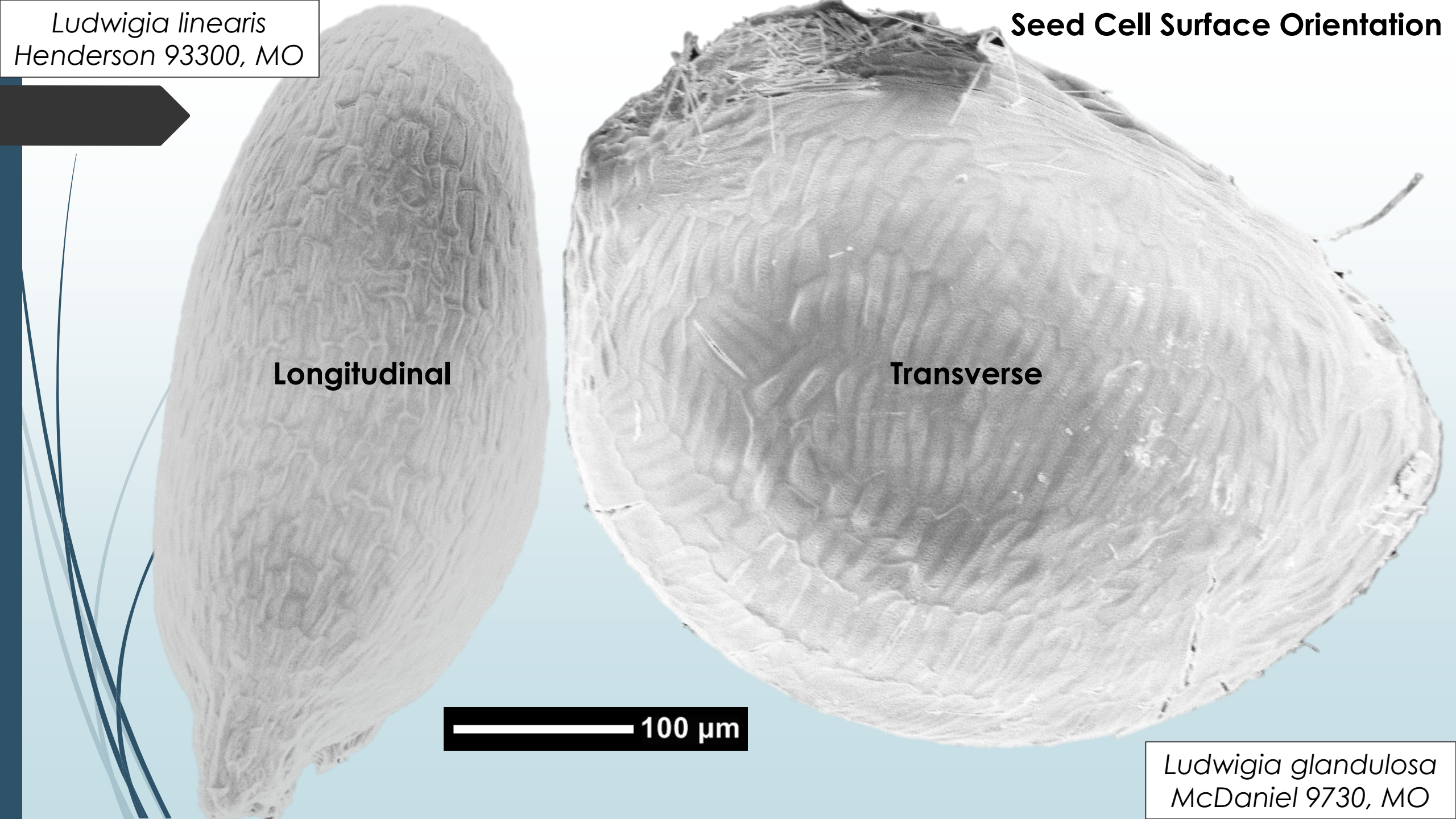
Seed Cell Surface Orientation

Longitudinal

Transverse

100 μ m

Ludwigia glandulosa
McDaniel 9730, MO



Results & Discussion

Table Summary of the morphological characters

- ▶ 3 sections characterized by expanded raphe
- ▶ Seed cell surface orientation only groups 4 of the 35 species together
- ▶ Five types of capsule shapes and seed arrangements.

Analysis of variance and means

- ▶ In searching for differences the trend was that within sections the means were significantly the same
 - ▶ Exception: *Myrtocarpus*
- ▶ Within the genus there are fewer sections that are consistently significantly the same
 - ▶ i.e., *Isnardia* and *Miquelia*

“R” Analysis Results

- Two tables of discrete and continuous character were created. For Anova and Tukey t-test results in the table are created from the continuous character means.
- Two trees were constructed. The discrete and continuous characters were used to derive two parsimony tree.

The screenshot displays the RGui (64-bit) interface. The top menu bar includes File, Edit, Packages, Windows, and Help. The R Console window is empty. The R Graphics window shows the message "figure margins too large". The R Editor window, titled "Untitled - R Editor", contains the following text:

```
#####  
#  
#  
#           R analysis results  
#  
#####  
  
# Two tables of discrete and continous character were created.  
# Anova and Tukey test results were create from the continuous character means.  
# Two trees were conncstruced.  
# The discrete and continuous characters were used to derive two parsimony tree.
```

Figure 1: Strict consensus from parsimony of discrete morphological characters (R program)

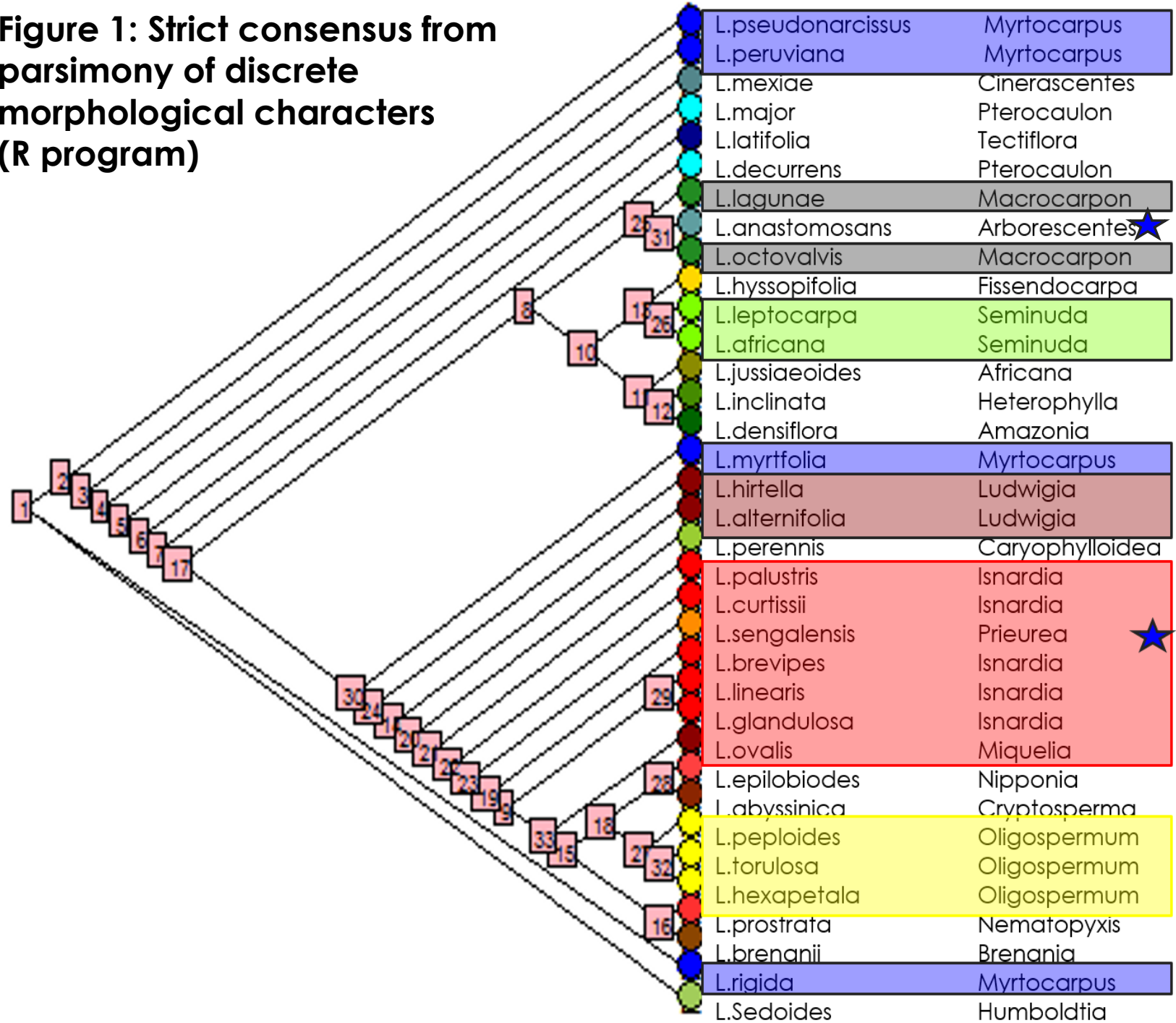
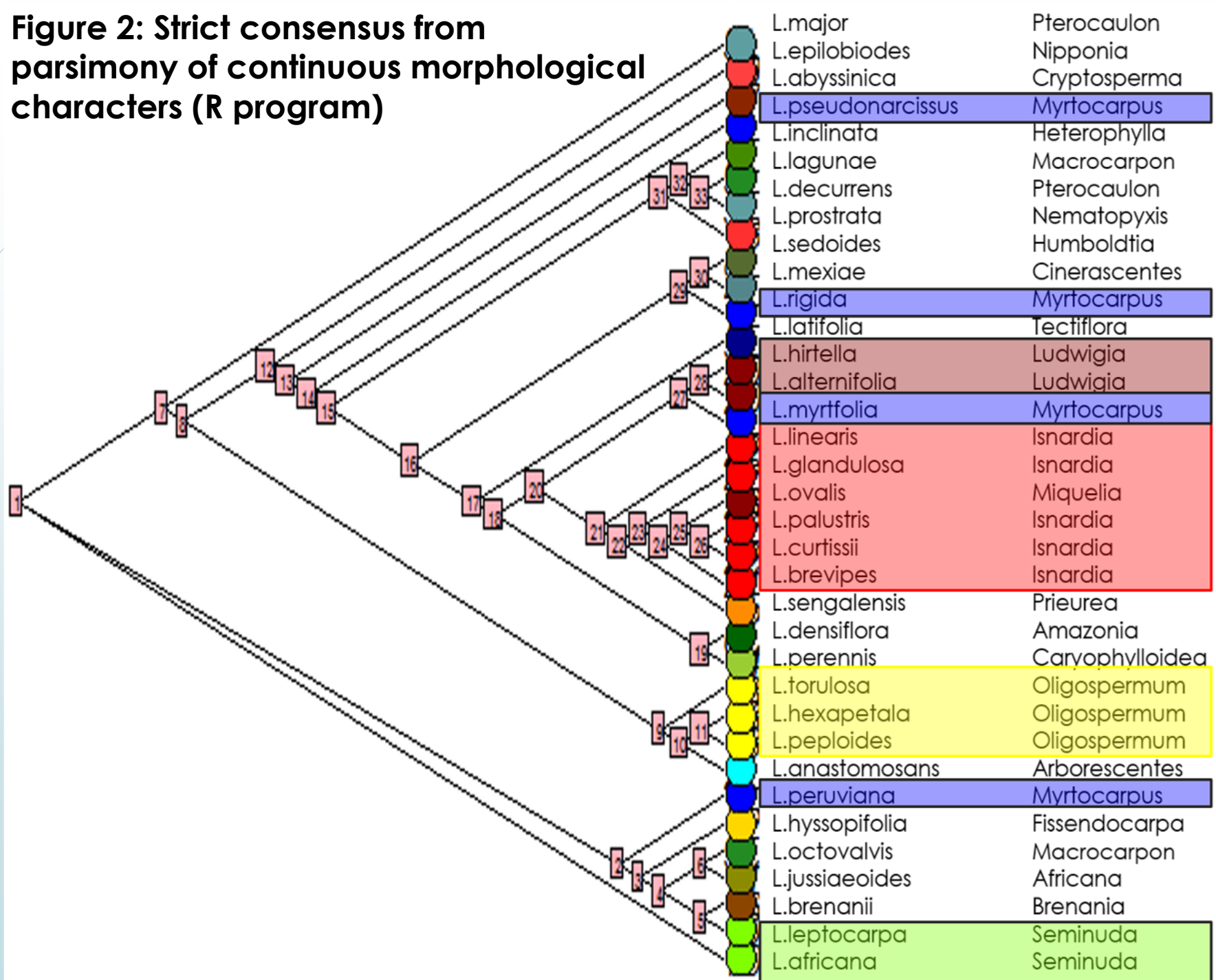


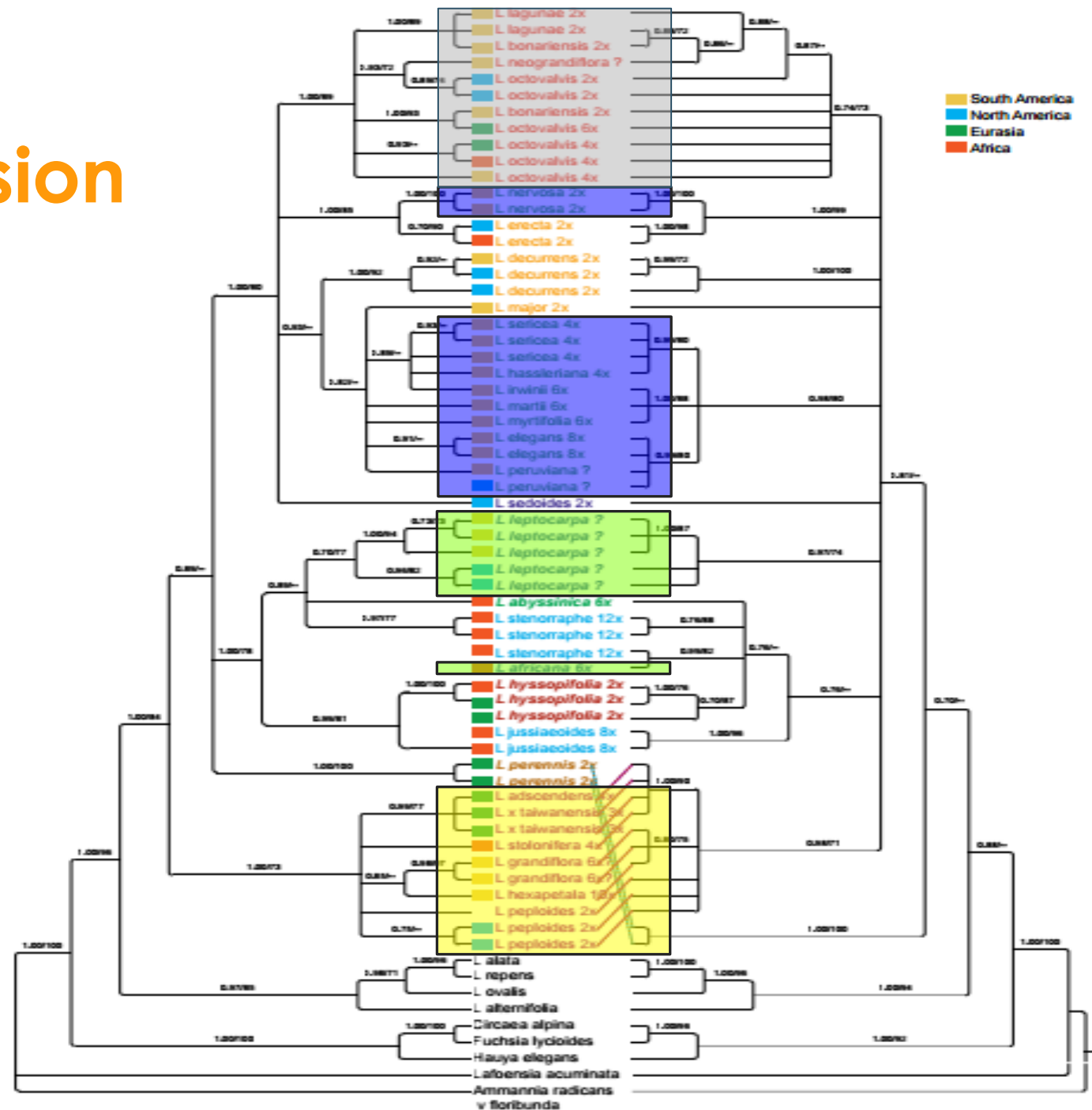
Figure 2: Strict consensus from parsimony of continuous morphological characters (R program)



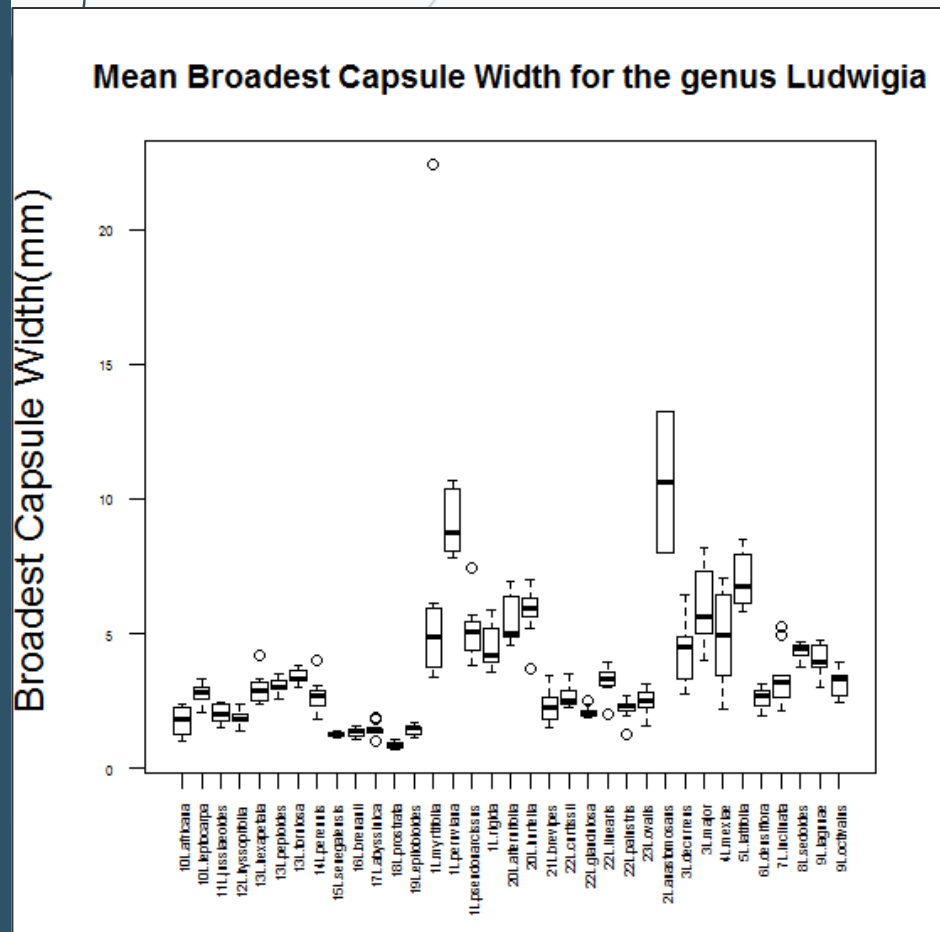
Results & Discussion

Molecular Phylogeny

- ➔ The morphological data provide some support for the new molecular phylogeny (S. Liou et al., unpubl.), but it is still unclear the degree to which either or both datasets support the traditional sectional classification



Future Research



- *Ludwigia* is very diverse morphologically, and a thorough analysis will require morphological data from all or most species, and from additional characters.
- Combining morphological and molecular data is essential for a complete understanding of the phylogeny and evolutionary history of *Ludwigia*.
- Continued analysis of fruit and seed characters in *Ludwigia* will provide insight into ecological adaptations that have facilitated the evolutionary success of the genus.

A dark grey arrow points to the right from the left edge of the slide. Below it, several thin, curved lines in shades of blue and grey sweep across the left side of the slide.

Conclusion

- **Fruit and Seed morphology provides limited support for some sections and the North Temperate haplostemonous group (sections *Ludwigia*, *Isnardia*, and *Miquelia*)**
- **Recent molecular phylogenetic analysis also provides only limited support for some parts of the traditional sectional classification.**
- **Several fruit and seed morphological character appear to be associated with the evolutionary radiation of some taxa or groups of *Ludwigia***

Thank You!

- National Science Foundation Research Experience for Undergraduates
- Missouri Botanical Garden
- Program Mentors
 - Peter Hoch
 - Iván Jiménez
 - George Yatskievych
 - David Bogler
- Columbia College



Ludwigia hexapetala,
Peter Hoch



Questions?

Thank you for listening!