



A morphological phylogeny of the genus, *Hemichaena*

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Abstract

The genus *Hemichaena* encompasses five species of woody shrubs found in central America and Northern Mexico. Within the genus are species adapted to insect and hummingbird pollination as well as high and low elevations. *Hemichaena* has historically been associated with the genus *Mimulus*, *Erythranthe*, and *Diplacus* collectively known as monkeyflowers, which have species that have become model organisms in the field of evolutionary genetics can ecological genetics. Phylogenetic analyses using molecular data confirm that the genus is closely related to monkeyflowers and that wood and hummingbird pollination have evolved separately in *Hemichaena*. While the placement of the genus is well understood, the relationships among the five species in the genus has not been studied. The purpose of this study is to collect morphological data on multiple individuals within each species to generate a morphological dataset for phylogeny estimation. We collected 74 digital herbarium specimens on which we are scoring 21 characters. The scoring of characters is underway and will lead to phylogenetic hypotheses.

Methods

The specimens were acquired via online herbaria databases. Prior to selecting characters for sampling, sufficient specimens for each species had to be collected. A total of 90 specimens were downloaded, with a total of 16 that were discarded due to being duplicate specimens. Once downloaded, the herbaria specimens were measured using the application ImageJ. Utilizing the 10 centimeter ruler provided for scale on each herbarium specimen, the scale could be set in ImageJ for collecting quantitative measurements of characters. The characters sampled were determined by observing the available specimens and assessing which traits were quantifiable. For traits that were relative (e.g. degree of hairiness of leaves), the individual degrees of density were noted and used as a reference across all species. To ensure uniformity in data collection, the characters were sampled from the 7th to 8th node of each specimen.

Characters Sampled

altitude (m)	claspings	leaf area (cm ²)
exserted stamen	leaf margin	length of petiole (cm)
hair on stem	leaf shape	length of pedicel (cm)
color (yellow)	number of flowers in peduncle	length of calyx (cm)
color (red)	leaf length (cm)	length of tooth (cm)
color (orange)	leaf width (cm)	length of calyx tooth (cm)
length of corolla (cm)	length of stamen (cm)	hair on leaf

Example of Morphological Characters



Figure 1a. Figure 1b. Figure 1c. Figure 1d.

Figure 1. a. exserted stamen, b. hair on leaf, c. number of flowers in peduncle, d. color (yellow)

Distribution Map of the Five Species



Figure 2. Documented distribution of *Hemichaena rugosa* (orange), *Hemichaena spinulosa* (yellow), *Hemichaena coulteri* (green), *Hemichaena levigata* (blue), *Hemichaena fruticosa* (red) in Mexico and Central America

Current Developing Data

species (file name)	altitude (m)	exserted stamen	hair on stem	color (yellow)	color (red)	color (orange)	claspings	leaf margin	leaf shape	# of flowers in peduncle	leaf length (cm)	leaf width (cm)	leaf area (cm ²)	length of petiole (cm)	length of pedicel (cm)	length of calyx (cm)	length of tooth (cm)	length of calyx tooth (cm)	length of corolla (cm)	length of stamen (cm)	hair on leaf
01 spinulosa	n/a	1	2	1	0	0	1	dentate	elliptical	1	1.43	0.45	0.47	0.2	0.59	0.48	0.05	0.08	1.42	1.05	1
02 spinulosa	n/a	1	2	1	0	0	1	dentate/entire	elliptical/oblongate	1	1.69	0.62	0.6	0.29	0.48	0.54	0.4	0.11	1.48	0.75	1
03 spinulosa	n/a	1	2	1	0	0	1	entire	elliptical/oblongate	1	1.49	0.31	0.31	0.127	0.57	0.61	n/a	0.13	1.8	0.73	1
04 spinulosa	n/a	1	1	1	0	0	1	dentate/entire	elliptical/oblongate/ovate	1	1.3	0.49	0.41	0.2	0.21	0.53	0.07	0.1	1.42	0.96	1
05 spinulosa	n/a	1	1	1	0	0	1	dentate/entire	elliptical/oblongate	1	1.11	0.35	0.43	0.17	0.37	0.51	0.04	0.08	1.75	n/a	1
06 spinulosa	1120	1	1	1	0	0	1	dentate	elliptical/oblongate	1	1	0.64	0.36	0.11	0.53	0.54	0.09	0.08	1.1	0.93	1
07 spinulosa	1525	1	2	1	0	0	1	entire	elliptical/oblongate	1	0.97	0.4	0.25	0.12	0.36	0.56	n/a	0.1	1.3	0.98	2
08 spinulosa	1204	1	1	1	0	0	1	entire/dentate	elliptical/oblongate/ovate	1	0.82	0.34	0.2	0.11	0.48	0.64	0.05	0.13	1.4	0.52	2
09 spinulosa	914	1	2	1	0	0	1	entire/dentate	elliptical	1	0.79	0.32	0.17	0.15	0.33	0.56	0.04	0.1	1.64	0.95	2
01 coulteri (holotype)	n/a	1	1	1	0	0	0	undulate	elliptic	2-3	3.47	1.63	2.11	0.19	0.56	0.65	n/a	0.22	0.81	1.16	1
02 coulteri	n/a	1	0	n/a	0	0	0	undulate	elliptic	2	4.16	2.21	3.88	0.17	0.7	0.7	n/a	0.18	n/a	1.19	0
03 coulteri	n/a	1	0	1	0	0	0	undulate	elliptic	2-3	3.59	1.98	3.64	0.21	0.62	0.68	n/a	0.19	1.22	1.08	1
04 coulteri	n/a	1	1	1	0	0	0	undulate	elliptic	2-3	2.85	1.34	2.17	0.15	0.58	0.66	n/a	0.2	1.58	1.14	1
05 coulteri	1850	1	1	1	0	0	0	smooth	elliptic	2-3	2.8	1.2	2.27	0.37	0.41	0.74	n/a	0.16	1.38	0.73	1
06 coulteri	1800	1	1	1	0	0	0	undulate	elliptic	1-2	3.98	2.5	6.9	0.31	0.84	0.8	n/a	0.17	1.65	1.28	1
01 levigata	1676	0	0	0	1	1	1	serrate	ovate	1	3.36	1.15	2.15	0.5	0.73	0.68	0.05	0.18	1.33	1.05	0

Figure 4. Current spreadsheet of character data in progress

Five Species of *Hemichaena*

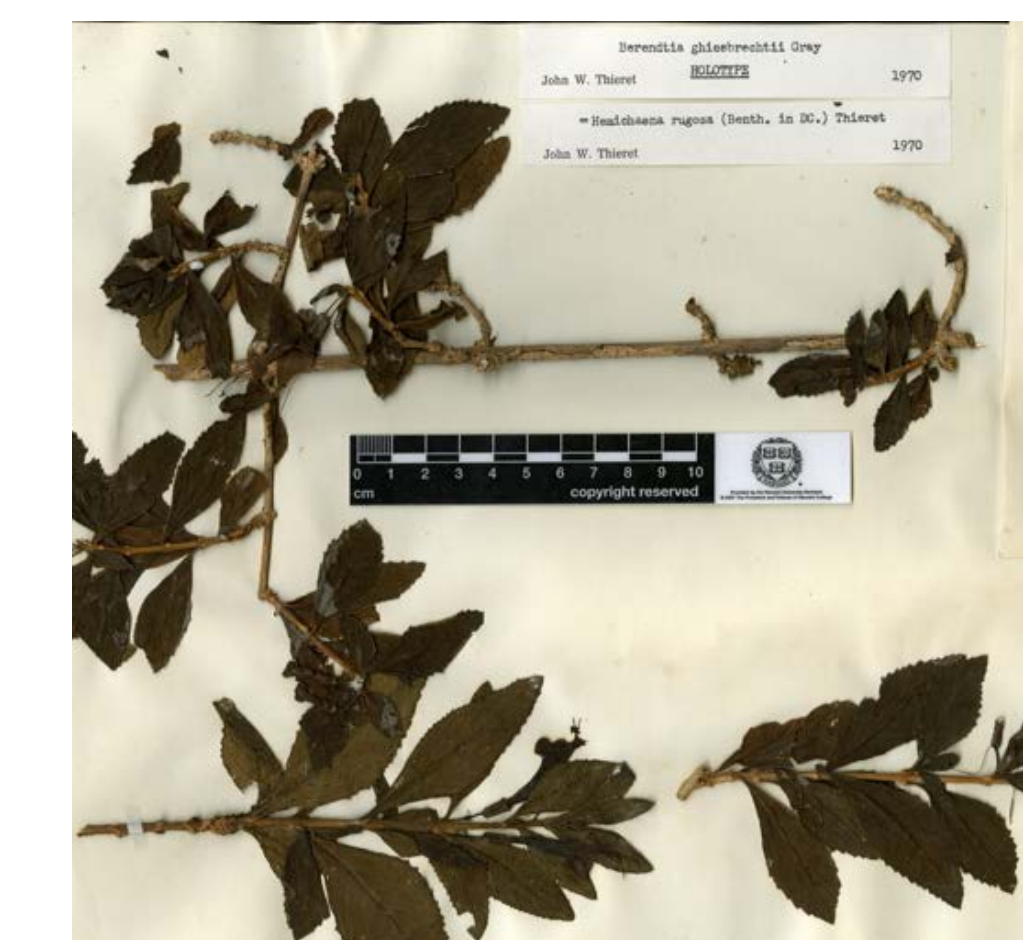


Figure 3a.



Figure 3b.



Figure 3c.



Figure 3d.

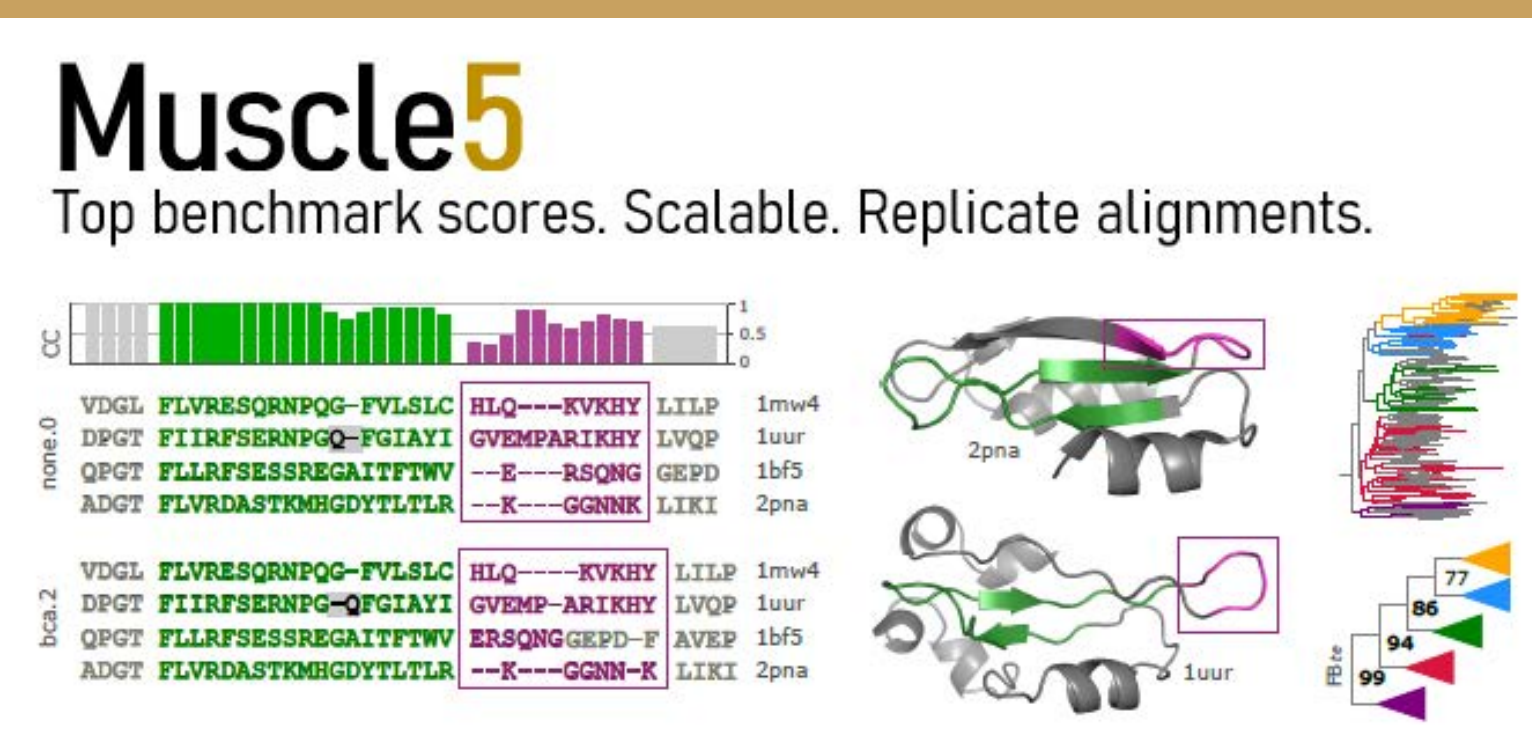


Figure 3e.

Figure 3. a. *Hemichaena rugosa*, b. *Hemichaena spinulosa*, c. *Hemichaena coulteri*, d. *Hemichaena fruticosa*, e. *Hemichaena levigata*

Next Steps

So far we identified 21 morphological characters that could be reliably scored on digital herbarium specimens. To date, we have scored 336 characters in 16 specimens. Once the data matrix is complete, we will estimate a phylogeny using simple models such as UPGMA and more complex models such as Bayesian inference using Muscle5 software.



Acknowledgments

Thank you to the multiple herbaria that have online specimens available to the scientific community. This project wouldn't not have been possible without them.



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Affiliations

Thank you to Dr. Paul Beardsley for mentoring me throughout the research process. Thank you to the Kellogg Honors College for providing the opportunity for me to develop a research capstone project. Thank you to the CSU-LSAMP program for their development of the NSF SPIRES Fellowship at Cal Poly Pomona.



Kellogg Honors College



CSU-LSAMP