

## HYBRIDIZATION AND GENETIC DISTANCES SUGGEST ONE LARGE MONOBARAMIN IN THE GOURD FAMILY (CUCURBITALES: CUCURBITACEAE)

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### ABSTRACT

The gourds form a primarily tropical and subtropical family (Cucurbitales: Cucurbitaceae) of herbaceous climbers and woody lianas composed of approximately 960 species in 95 genera and 15 tribes. Many of these are globally important food crops and ornamentals including cucumbers, gourds, squashes, melons, pumpkins, and luffas. Utilizing published literature, there is evidence of interspecific hybridization (natural, experimental cross-pollination, and embryo/ovule culture) in five of the 15 tribes. These consist of successful crosses between 131 unique species pairs, including two intergeneric and one intertribal cross, forming eight monobaramins. In addition, species that do not hybridize directly, but hybridize with the same third species are added to the various monobaramins. This results in an additional 227 species pairs, including two intergeneric and two intertribal. A hybridogram, constructed from these direct and indirect hybridization results, reveals the following monobaramins: 1) 23 species from genus Cucumis; 2) 18 species from genus Cucurbita; 3) nine species from genus Luffa; 4) four species from genera Trichosanthes and Momordica (includes intertribal crosses); 5) three species from genus Citrullus; 6) two species from genus Lagenaria; 7) two species from genus Bryonia; and 8) two species from genera Coccinia and Diplocyclos. Next, using genetic distances (ITS regions of nuclear ribosomal RNA genes) from 26 cucurbit species, several monobaramins are enlarged and some are even connected by adding an additional 113 species pairs, including 82 intergeneric and 58 intertribal. A revised hybridogram, utilizing all of the above methods, reveals the following: 1) the original [Trichosanthes + Momordica] monobaramin connects to the original Luffa and Bryonia monobaramins as well as a new monobaramin, composed of the genera [Echinopepon + Cyclanthera + Sicyos + Ecballium], to form one large monobaramin consisting of 20 species from eight genera and three tribes (Sicyoeae, Bryonieae, and Momordiceae); 2) the original Citrullus monobaramin connects to a member of the genus Lagenaria and the resulting monobaramin is slightly larger with six species; 3) the original Cucumis monobaramin has additional internal continuity and may connect to the contribal [Coccinia + Diplocyclos] and [Citrullus + Lagenaria] monobaramins to form one large monobaramin consisting of 31 species from five genera in Tribe Benincaseae; 4) the original Cucurbita monobaramin connects to one additional species and has 19 species overall, all from genus Cucurbita and Tribe Cucurbitae. Finally, the [Sicyoeae + Bryonieae + Momordiceae] monobaramin connects directly to both the Cucurbitae and Benincaseae monobaramins. Connections between these last two tribes are also suggested by grafting and somatic hybridization experiments which are generally most successful between closely related species. In conclusion, these data suggest that members of all five tribes (70 species and 14 genera) may form one large monobaramin in the Family Cucurbitaceae. Additional research is required (hybridization, molecular, morphological) to determine the baraminological status of the family as a whole.

### KEYWORDS

Gourd family, cucurbitaceae, hybridization, genetic distance, monobaramin

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## Abstract

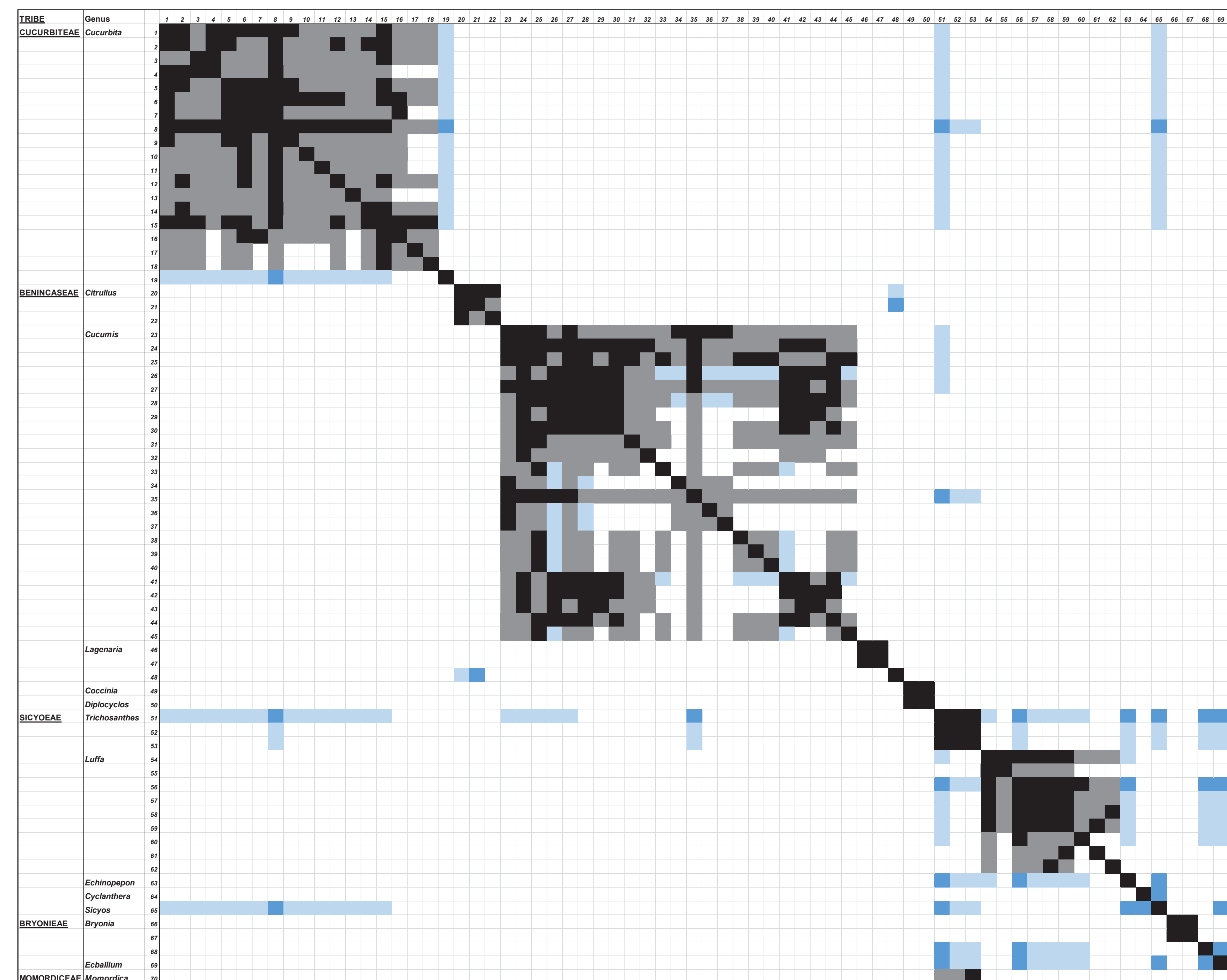
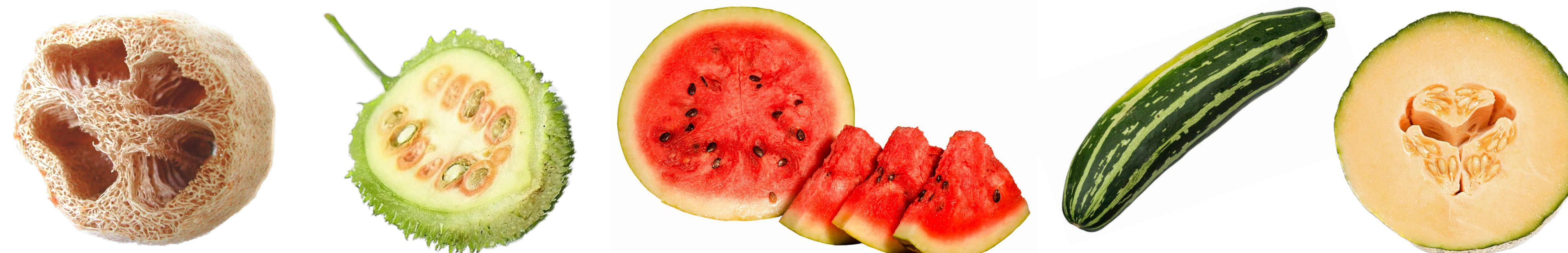
The gourds form a primarily tropical and subtropical family (Cucurbitales: Cucurbitaceae) of herbaceous climbers and woody lianas composed of approximately 960 species in 95 genera and 15 tribes. Many of these are globally important food crops and ornamentals including cucumbers, gourds, squashes, melons, pumpkins, and luffas. Utilizing published literature, there is evidence of interspecific hybridization (natural, experimental cross-pollination, and embryo/ovule culture) in five of the 15 tribes. These consist of successful crosses between 131 unique species pairs, including two intergeneric and one intertribal cross, forming eight monobaramins. In addition, species that do not hybridize directly, but hybridize with the same third species are added to the various monobaramins. This results in an additional 227 species pairs, including two intergeneric and two intertribal. A hybridogram, constructed from these direct and indirect hybridization results, reveals the following monobaramins: 1) 23 species from genus *Cucumis*; 2) 18 species from genus *Cucurbita*; 3) nine species from genus *Luffa*; 4) four species from genera *Trichosanthes* and *Momordica* (includes intertribal crosses); 5) three species from genus *Citrullus*; 6) two species from genus *Lagenaria*; 7) two species from genus *Bryonia*; and 8) two species from genera *Coccinia* and *Diplocyclos*. Next, using genetic distances (ITS regions of nuclear ribosomal RNA genes) from 26 cucurbit species, several monobaramins are enlarged and some are even connected by adding an additional 113 species pairs, including 82 intergeneric and 58 intertribal. A revised hybridogram, utilizing all of the above methods, reveals the following: 1) the original [*Trichosanthes* + *Momordica*] monobaramin connects to the original *Luffa* and *Bryonia* monobaramins as well as a new monobaramin, composed of the genera [*Echinopepon* + *Cyclanthera* + *Sicyos* + *Ecballium*], to form one large monobaramin consisting of 20 species from eight genera and three tribes (Sicyoeae, Bryonieae, and Momordiceae); 2) the original *Citrullus* monobaramin connects to a member of the genus *Lagenaria* and the resulting monobaramin is slightly larger with six species; 3) the original *Cucumis* monobaramin has additional internal continuity and may connect to the contribal [*Coccinia* + *Diplocyclos*] and [*Citrullus* + *Lagenaria*] monobaramins to form one large monobaramin consisting of 31 species from five genera in Tribe Benincaseae; 4) the original *Cucurbita* monobaramin connects to one additional species and has 19 species overall, all from genus *Cucurbita* and Tribe Cucurbitae. Finally, the [Sicyoeae + Bryonieae + Momordiceae] monobaramin connects directly to both the Cucurbitae and Benincaseae monobaramins. Connections between these last two tribes are also suggested by grafting and somatic hybridization experiments which are generally most successful between closely related species. In conclusion, these data suggest that members of all five tribes (70 species and 14 genera) may form one large monobaramin in the Family Cucurbitaceae. Additional research is required (hybridization, molecular, morphological) to determine the baraminological status of the family as a whole.

## Methods & Materials

- Published literature (see References) surveyed for evidence of interspecific hybridization in gourd family:
  - Successful natural hybridization
  - Successful experimental cross-pollination
  - Successful embryo and/or ovule culture
  - Results of protoplast fusion (i.e. somatic hybridization) experiments not considered as evidence of interspecific hybridization
- Genetic distances calculated for 21 of the 26 gourd/cucurbit species analyzed by Jobst et al. (1998):
  - ITS regions of nuclear ribosomal RNA genes
  - Gaps and missing information, including insertion/deletion sites, removed from sequences prior to distance calculations
- Hybridogram constructed based on direct and indirect hybridization and genetic distance data
- Two species considered part of same monobaramin if:
  - Hybridize directly
  - Hybridize with same 3rd species
  - Fall within range of genetic distances of hybridizing species
  - One hybridizes with and other is genetically similar to same 3rd species

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. <i>Cucurbita pepo</i>																				
2. <i>Cucurbita pedatifolia</i>	0.0926																			
3. <i>Ecballium elaterium</i>	0.1532	0.1665																		
4. <i>Echinopepon wrightii</i>	0.1626	0.2010	0.1451																	
5. <i>Cyclanthera brachystachia</i>	0.1654	0.1701	0.1578	0.1722																
6. <i>Sicyos angulatus</i>	0.1398	0.1567	0.1400	0.1265	0.1212															
7. <i>Bryonia cretica</i>	0.1665	0.1850	0.1097	0.1528	0.1999	0.1571														
8. <i>Trichosanthes cucumerina</i>	0.1355	0.1485	0.1138	0.1179	0.1713	0.1309	0.0836													
9. <i>Momordica charantia</i>	0.2119	0.2212	0.1793	0.1698	0.2593	0.1954	0.1551	0.1419												
10. <i>Luffa cylindrica</i>	0.1701	0.1790	0.1250	0.1382	0.1742	0.1567	0.1291	0.0833	0.1686											
11. <i>Citrullus lanatus</i>	0.2045	0.2045	0.1949	0.2153	0.1944	0.1854	0.1890	0.1753	0.2293	0.2026										
12. <i>Lagenaria vulgaris</i>	0.2123	0.2225	0.1838	0.1944	0.1618	0.1478	0.1922	0.1742	0.2267	0.2065	0.1298									
13. <i>Cucumis sativus</i>	0.2483	0.2735	0.2225	0.2362	0.2614	0.2367	0.2016	0.1871	0.2472	0.2155	0.2209	0.2497								
14. <i>Cucumis melo</i>	0.1875	0.2319	0.1587	0.1713	0.2190	0.1904	0.1771	0.1674	0.2272	0.1749	0.1742	0.2165	0.1380							
15. <i>Cucumis metuliferus</i>	0.1820	0.2153	0.1583	0.1757	0.2031	0.1761	0.1528	0.1300	0.2040	0.1651	0.1518	0.1879	0.1291	0.0638						
16. <i>Cucumis anguria</i>	0.2107	0.2565	0.1870	0.1989	0.2430	0.2136	0.1810	0.1753	0.2334	0.1977	0.1690	0.2158	0.1421	0.0795	0.0405					
17. <i>Cucumis myriocarpus</i>	0.2010	0.2572	0.1864	0.1895	0.2393	0.2101	0.1717	0.1661	0.2287	0.1883	0.1605	0.2119	0.1291	0.0756	0.0405	0.0181				
18. <i>Cucumis dipsaceus</i>	0.2246	0.2712	0.1954	0.2127	0.2630	0.2382	0.2045	0.1985	0.2489	0.2072	0.1925	0.2403	0.1596	0.1081	0.0715	0.0407	0.0521			
19. <i>Cucumis zeyherii</i>	0.2246	0.2826	0.2096	0.2127	0.2642	0.2340	0.1944	0.1886	0.2489	0.2115	0.1739	0.2358	0.1417	0.0956	0.0597	0.0330	0.0218	0.0597		
20. <i>Cucumis africanus</i>	0.2305	0.2893	0.2153	0.2132	0.2648	0.2293	0.1850	0.1753	0.2472	0.2169	0.1736	0.2310	0.1373	0.0999	0.0638	0.0481	0.0367	0.0793	0.0218	
21. <i>Zanonia indica</i>	0.1777	0.2259	0.2162	0.2212	0.2468	0.2016	0.1916	0.1686	0.2103	0.2099	0.2371	0.2507	0.2497	0.2208	0.1916	0.2059	0.1873	0.2455	0.2106	0.2152

**Figure 1.** Genetic distance matrix, using ITS regions of nuclear ribosomal RNA genes, for 21 of 26 cucurbit species analyzed by Jobst et al. (1998). Gaps and missing information, including insertion/deletion sites, were removed from sequences prior to distance calculations.



**Figure 2.** Hybridogram based on direct and indirect hybridization and genetic distance data. Black = two species hybridize directly; Gray = two species hybridize with same 3rd species; Dark Blue = two species fall within range of genetic distances of hybridizing species; Light Blue = one species hybridizes with and the other is genetically similar to same 3rd species.

## Results & Discussion

- Evidence of direct and indirect hybridization in five of the 15 gourd/cucurbit tribes (Fig. 2–Black & Gray)
  - Successful crosses between 131 unique species pairs, including two intergeneric and one intertribal cross
  - Species that hybridize with same third species result in an additional 227 species pairs, including two intergeneric and two intertribal
- Genetic distances for hybridizing species range from 0.0181–0.1421 (Fig. 1–Black)
  - Using direct and indirect genetic distance data adds an additional 113 species pairs, including 82 intergeneric and 58 intertribal (Fig. 2–Dark & Light Blue)
- Hybridogram, utilizing all the above methods, reveals the following (Fig. 2–all colors):
  - One large monobaramin consisting of 20 species from eight genera in three tribes (Sicyoeae, Bryonieae, and Momordiceae) – *Luffa*, *Bryonia*, [*Trichosanthes* + *Momordica*], and [*Echinopepon* + *Cyclanthera* + *Sicyos* + *Ecballium*] monobaramins
  - One large monobaramin consisting of 31 species from five genera in Tribe Benincaseae – *Cucumis* monobaramin may connect with contribal [*Coccinia* + *Diplocyclos*] and [*Citrullus* + *Lagenaria*] monobaramins
  - One large monobaramin consisting of 19 species from genus *Cucurbita* in Tribe Cucurbitae
  - [Sicyoeae + Bryonieae + Momordiceae] monobaramin connects directly to both Cucurbitae and Benincaseae monobaramins via genetic distance data
  - Connections exist between Cucurbitae and Benincaseae via grafting and somatic hybridization which are generally most successful between closely related species

## Conclusions

- These data suggest that members of all five tribes (70 species and 14 genera) may form one large monobaramin in the Family Cucurbitaceae
- Additional research is required (hybridization, molecular, morphological) to determine the baraminological status of the family as a whole

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