Phytotaxa 205 (3): 129–144
www.mapress.com/phytotaxa/

Article

ISSN 1179-3155 (print edition)
PHYTOTAXA
ISSN 1179-3163 (online edition)

http://dx.doi.org/10.11646/phytotaxa.205.3.1

A revision of generic boundaries and nomenclature in the North American cleomoid clade (Cleomaceae)

ERIC H. ROALSON[1, *], JOCELYN C. HALL[2, *], JAMES P. RISER II[1], WARREN M. CARDINAL-MCTEAGUE[3], THEODORE S. COCHRANE[4] & KENNETH J. SYTSMA[4]

[1] *School of Biological Sciences, Washington State University, Pullman, Washington 99164-4236 USA*
[2] *Department of Biological Sciences, University of Alberta, Edmonton, Alberta, T6G 2E9 Canada*
[3] *Department of Biology, University of Ottawa, Ottawa, Ontario, K1N 6N5, Canada; Research & Collections Division, Canadian Museum of Nature, Ottawa, Ontario, K1P 6P4, Canada*
[4] *Department of Botany, University of Wisconsin, Madison, Wisconsin 53706 USA*
** Authors for correspondence: eric_roalson@wsu.edu; jocelyn.hall@ualberta.ca*

Abstract

The family Cleomaceae is in need of taxonomic revision, which begins here with a set of taxa informally recognized as the North American cleomoid clade. This group is evaluated first because molecular-based analyses almost comprehensively sample this lineage. These investigations revealed that the two largest genera, *Cleomella* and *Peritoma*, are para- or polyphyletic. Strong support from molecular data necessitates name changes for these taxa. Furthermore, controversy exists on the recognition of the remaining genera, owing to morphological variation and specialization. Three possible classification scenarios are described to accommodate monophyletic lineages based on previously-published evidence. The option to create the single large genus *Cleomella* is proposed, and as a result one new name, ***Cleomella oxystyloides***, is provided, and 12 new combinations are made: ***C. arborea***, ***C. arborea*** var. ***angustata***, ***C. arborea*** var. ***globosa***, ***C. californica***, ***C. jonesii***, ***C. lutea***, ***C. multicaulis***, ***C. palmeri***, ***C. platycarpa***, ***C. refracta***, ***C. serrulata***, and ***C. sparsifolia***. Two lectotypes and one isolectotype are designated, and another lectotype is confirmed.

Key words—*Carsonia*, *Cleome*, *Cleomella*, *Oxystylis*, *Peritoma*, *Wislizenia*

It has long been evident from fluctuating trends of "lumping" and "splitting," whether based primarily on morphology or molecular data, that the specialized genera of the Cleomaceae (Iltis 1950, Angiosperm Phylogeny Group 2009, Iltis *et al*. 2011) are derived from within a broadly circumscribed *Cleome* (Fig. 1; Hall *et al*. 2002, Sánchez-Acebo 2005, Hall 2008, Inda *et al*. 2008, Feodorova *et al*. 2010, Riser *et al*. 2013, Patchell *et al.* 2014). This broad paraphyly of *Cleome* has been recognized for some time, but little was done to rectify the taxonomy until somewhat recently, when some workers, particularly Iltis and Cochrane (Iltis & Cochrane 2007, 2014, Cochrane & Iltis 2014), have begun to dismantle, piecemeal, *Cleome* s.l. This deconstruction of *Cleome* has been approached from a regional floristic perspective, with transfers of species to new genera as necessary for floristic treatments (e.g., Flora of North America: Iltis & Cochrane 2007, Tucker & Vanderpool 2010). Because the family Cleomaceae lacks a modern systematic treatment, we are undertaking the work of addressing generic circumscription in the family clade by clade, integrating morphological definitions of genera with the desire that genera be monophyletic. We start here by revising a group informally recognized as the North American cleomoids, hereafter "NA cleomoids" (Hall 2008, Feodorova *et al*. 2010, Riser *et al*. 2013, Patchell *et al*. 2014). The monophyly of this clade and its principal subclades is strongly supported in the recent investigation by Riser *et al*. (2013), which, taking advantage of nearly exhaustive taxon sampling, provides the best resolved phylogeny thus far obtained for this group. This study indicates the lack of reliability of some of the morphological characters traditionally used in defining genera and suggests that currently recognized multispecies-genera cannot be upheld.

Based on recent floristic work (Tucker & Vanderpool 2010), the NA cleomoid clade includes the following five genera: *Carsonia* Greene (1 sp.), *Cleomella* Candolle (11 spp.), *Oxystylis* Torrey & Frémont (1 sp.), *Peritoma* Candolle (6 spp.), and *Wislizenia* Engelmann (3 spp.). However, neither *Peritoma* nor *Cleomella* are monophyletic as currently circumscribed (Fig. 2; Feodorova *et al*. 2010, Riser *et al*. 2013, Patchell *et al*. 2014). Further, *Oxystylis* and *Wislizenia* are clearly derived from within a portion of *Cleomella* (Riser *et al*. 2013). Nearly exhaustive sampling of currently

Accepted by Karol Marhold: 23 Feb. 2015; published: 21 Apr. 2015

Homotypic synonym: *Peritoma serrulata* (Pursh) Candolle (1824: 237).

Heterotypic synonyms: *Peritoma integrifolia* Nuttall (1834: 14). *Cleome integrifolia* (Nuttall) Torrey & Gray (1838: 122). Type: USA. [Towards the southern sources of the Missouri], s.d., *N. J. Wyeth s.n.* (holotype: BM 000629039; isotype: NY 00387725!).—*Cleome integrifolia* (Nuttall) Torrey & Gray var. *angusta* Jones (1895: 625). *Peritoma angusta* (Jones) Rydberg (1917: 371, 1062). *Cleome serrulata* Pursh subsp. *angusta* (Jones) Tidestrom (1925: 248, 249). Type: USA. Utah: Piute Co., Marysvale Peak, alt. 7000 ft. [2134 m], Aug 1894, *M. E. Jones 6057a* (holotype: POM; isotype: US 364999).—*Cleome albiflora* Cockerell (1896: 34), a misprint for *C. serrulata* f. *albiflora* according to Cockerell (1902: 42). *Peritoma serrulata* (Pursh) Candolle f. *albiflora* (Cockerell) Cockerell (1902: 42). Type: no specimen cited; possibly *T. D. A. Cockerell s.n.*, Watrous, Mora Co., N.M. (following Holmgren & Cronquist 2005).—*Cleome inornata* Greene (1899: 16). *Peritoma inornata* (Greene) Greene (1900: 210). *Cleome serrulata* Pursh f. *inornata* (Greene) Weber (in Weber *et al*. 1981: 325). Type: USA. Colorado: Grand Junction, 26 Aug 1896, *E. L. Greene s.n.* (holotype: NDG 04819).—*Peritoma serrulata* (Pursh) Candolle var. *clavata* Lunell (1919: 236). Type: USA. North Dakota: Benson Co., York, 09 Aug 1918, *J. Lunell s.n.* (isotypes: MO 1011554, NY 00387726).

25. Cleomella sparsifolia (Watson) J.C.Hall & E.H.Roalson, *comb. nov.*

Basionym: *Cleome sparsifolia* Watson (1871: 32, plate 5).

Type: USA. Nevada: NW Nevada, Carson Desert, alt. 4000 ft. [1219 m], July 1867, *S. Watson 133* (holotype: US 6564; isotypes: GH 00042298, NY).

Homotypic synonym: *Carsonia sparsifolia* (Watson) Greene (1900: 212).

References

Angiosperm Phylogeny Group (2009) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. *Botanical Journal of the Linnean Society* 161: 105–121. http://dx.doi.org/10.1111/j.1095-8339.2009.00996.x

Brandegee, T.S. (1899) New species of western plants. *Botanical Gazette* 27: 444–457. http://dx.doi.org/10.1086/327855

Candolle, A.P. de (1824) Trib. 1. Cleomeae. *In: Prodromus Systematis Naturalis Regni Vegetabilis. Vol.1*. Sumptibus Sociorum Treuttel et Würtz, Paris, pp. 237–242.

Cochrane, T.S. & Iltis, H.H. (2014) Studies in Cleomaceae VII: Five new combinations in *Corynandra*, an earlier name for *Arivela*. *Novon* 23: 21–26. http://dx.doi.org/10.3417/2013023

Cockerell, T.D.A. (1896) The bees of the genus *Perdita* F.Smith. *Proceedings of the Academy of Natural Sciences of Philadelphia* 48: 25–107.

Cockerell, T.D.A. (1902) Notes on southwestern plants. *Torreya* 2: 42–43.

Coville, F.V. (1892) Descriptions of new plants from southern California, Nevada, Utah, and Arizona. *Proceedings of the Biological Society of Washington* 7: 65–80.

Eastwood, A. (1900) New species of California plants. *Zoe* 5 (4–5): 80–90.

Eastwood, A. (1903) New species of western plants. *Bulletin of the Torrey Botanical Club* 30: 490–491. http://dx.doi.org/10.2307/2478536

Engelmann, G. (1848) Botanical Appendix. *In:* Wislizenus, F.A. (Ed.) *Memoir of A Tour to Northern Mexico*. Tippin & Streeper, Printers, Washington, pp. 87–115.

Feodorova, T.A., Voznesenskaya, E.V., Edwards, G.E. & Roalson, E.H. (2010) Biogeographic patterns of diversification and the origins of C_4 in *Cleome* (Cleomaceae). *Systematic Botany* 35: 811–826. http://dx.doi.org/10.1600/036364410X539880

Gray, A. (1853) Plantae Wrightianae, Texano-Mexicanae: Part II. *Smithsonian Contributions to Knowledge* 5 (6): 1–119.

Gray, A. (1865) Characters of some new plants of California and Nevada, chiefly from the collections of Professor William H. Brewer, botanist of the State Geological Survey of California, and of Dr. Charles L. Anderson, with revisions of certain genera or groups. *Proceedings of the American Academy of Arts and Sciences* 6: 519–556.

Gray, A. (1873) Characters of new genera and species of plants. *Proceedings of the American Academy of Arts and Sciences* 8: 620–661.

Gray, A. (1876) Micellaneous botanical contributions. *Proceedings of the American Academy of Arts and Sciences* 11: 71–104. http://dx.doi.org/10.2307/20021458

Greene, E.L. (1888) The botany of Cedros Island. *Pittonia* 1: 194–208.

Greene, E.L. (1899) New chloropetalous exogens. *Pittonia* 4: 14–21.
Greene, E.L. (1900) Neglected generic types. II. *Pittonia* 4: 207–212.
Greene, E.L. (1906) Revision of the genus *Wislizenia*. *Proceedings of the Biological Society of Washington* 19: 127–132.
Hall, J.C. (2008) Systematics of Capparaceae and Cleomaceae: An evaluation of the generic delimitations of *Capparis* and *Cleome* using plastid DNA sequence data. *Canadian Journal of Botany-Revue Canadienne de Botanique* 86: 682–696. http://dx.doi.org/10.1139/B08-026
Hall, J.C., Sytsma, K.J. & Iltis, H.H. (2002) Phylogeny of Capparaceae and Brassicaceae based on chloroplast sequence data. *American Journal of Botany* 89: 1826–1842. http://dx.doi.org/10.3732/ajb.89.11.1826
Holmgren, P.K. (2004) Lectotypifications and a new combination in western North American Cleomaceae. *Brittonia* 56: 103–106. http://dx.doi.org/10.1663/0007-196X(2004)056[0103:LAANCI]2.0.CO;2
Holmgren, P.K. & Cronquist, A. (2005) Cleomaceae. *In:* Holmgren, N.H., Holmgren, P.K. & Cronquist, A. (Eds.) *Intermountain Flora: Vascular Plants of the Intermountain West, U.S.A. Vol. 2. Pt. B: Subclass Dilleniidae*. New York Botanical Garden, Bronx, pp. 160–174.
Hooker, W.J. (1830) *Flora Boreali-Americana. Vol. 1.* Botany of the northern Parts of British America, London, 351 pp.
Iltis, H.H. (1950) *Morphology and generic delimitation in the Cleomoideae of the New World*. Master's thesis, Washington University, St. Louis, Missouri, pp. 1–32. [unpublished]
Iltis, H.H. (1952) *A revision of the New World species of Cleom*e. Ph.D. thesis, Wash- ington University, St. Louis, Missouri, 335 pp. [unpublished]
Iltis, H.H. (1955) Capparidaceae of Nevada. *In:* Archer, W.A. (Ed.) *Contributions to a Flora of Nevada*. U. S. Department of Agriculture, Bureau of Plant Industry 35, Government Printing Office, Washington, pp. 1–24.
Iltis, H.H. (1956) Studies in the Capparidaceae. II. The Mexican species of *Cleomella*: Taxonomy and evolution. *Madroño* 13: 177–208.
Iltis, H.H. (1957) Studies in the Capparidaceae. III. Evolution and phylogeny of the western North American Cleomoideae. *Annals of the Missouri Botanical Garden* 44: 77–119. http://dx.doi.org/10.2307/2394679
Iltis, H.H. & Cochrane, T.S. (2007) Studies in Cleomaceae V: A new genus and ten new combinations for the *Flora of North America*. *Novon* 17: 447–451. http://dx.doi.org/10.3417/1055-3177(2007)17[447:SITCVA]2.0.CO;2
Iltis, H.H. & Cochrane, T.S. (2014) Studies in Cleomaceae VI: A new genus and sixteen new combinations for the *Flora Mesoamericana*. *Novon* 23: 51–58. http://dx.doi.org/10.3417/2013017
Iltis, H.H., Hall, J.C., Cochrane, T.S. & Sytsma, K.J. (2011) Studies in Cleomaceae I. On the separate recognition of Capparaceae, Cleomaceae, and Brassicaceae. *Annals of the Missouri Botanical Garden* 98: 28–36. http://dx.doi.org/10.3417/2007017
Inda, L.A., Torrecilla, P., Catalán, P. & Ruiz-Zapata, T. (2008) Phylogeny of *Cleome* L. and its close relatives *Podandrogyne* Ducke and *Polanisia* Raf. (Cleomoideae, Cleomaceae) based on analysis of nuclear ITS sequences and morphology. *Plant Systematics and Evolution* 274: 111–126. http://dx.doi.org/10.1007/s00606-008-0026-y
Jepson, W.L. (1936) Capparidaceae. *In*: Jepson, W.L. (Ed.) *A Flora of California. Vol.* 2. California School Book Depository, San Francisco, pp. 9–16.
Johnston, I.M. (1924) Expedition of the California Academy of Sciences to the Gulf of California in 1921. The Botany (The vascular plants). *Proceedings of the California Academy of Sciences, Series 4* 12: 1027–1029.
Jones, M.E. (1891) New species and notes of Utah plants. *Zoe* 2: 236–252.
Jones, M.E. (1895) Contributions to western botany. No. VII. *Proceedings of the California Academy of Sciences, Series 2* 5: 611–732.
Kearney, T.H. & Peebles, R.H. (1951) *Arizona Flora*. University of California Press, Berkeley, pp. 1–1032.
Keller, S. (1979) A revision of the genus *Wislizenia* (Capparidaceae) based on population studies. *Brittonia* 31: 333–351. http://dx.doi.org/10.2307/2806125
Lunell, J. (1919 [1918]) Enumerantur plantae dakotae septentrionalis vasculares. XIV. *American Midland Naturalist* 5: 233–241. http://dx.doi.org/10.2307/2992781
Macbride, J.F. (1922) Various North American spermatophytes, new or transferred. *Contributions from the Gray Herbarium of Harvard University* 65: 39–46.
McVaugh, R. (2000) *Botanical Results of the Sessé & Mociño Expedition (1787–1803). Vol. 7. A Guide to Relevant Scientific Names of Plants*. Hunt Institute for Botanical Documentation, Pittsburgh, 626 pp.
Munz, P. (1974) *A Flora of Southern California*. University of California Press, Berkeley, 1086 pp.

Nelson, A. (1905) New plants from Nevada. *Proceedings of the Biological Society of Washington* 18: 171–176.

Nuttall, T. (1834) A catalogue of a collection of plants made chiefly in the valleys of the Rocky Mountains or Northern Andes, towards the sources of the Columbia River, by Mr. Nathaniel B. Wyeth. *Journal of the Academy of Natural Sciences of Philadelphia* 7: 5–60.

Parish, S.B. (1907) Notes on the flora of Palm Springs. *Muhlenbergia* 3: 121–128.

Patchell, M.J., Roalson, E.H. & Hall, J.C. (2014) Resolved phylogeny of Cleomaceae based on all three genomes. *Taxon* 63: 315–328 http://dx.doi.org/10.12705/632.17

Pax, F. & Hoffman, K. (1936) Capparidaceae. *In*: Engler, A. & Prantl, K. (Eds.) *Die Natürlichen Pflanzenfamilien. 2nd Edition.* 17b, pp. 146–223.

Payson, E.B. (1915) New and noteworthy plants from southwestern Colorado. *Botanical Gazette* 60: 374–382. http://dx.doi.org/10.1086/331675

Payson, E.B. (1922) A synoptical revision of *Cleomella*. *University of Wyoming Publications in Science, Botany* 1: 29–46.

Pursh, F.T. (1813 [1814]) *Flora Americae septentrionalis. Volume 2*. White, Cochrane, and Co., London, pp. 359–751.

Rafinesque, C.S. (1838) *Sylva Telluriana. Mantisa Synoptica. New Genera and Species of Trees and Shrubs of North America*. Published for the author and publisher, Philadelphia, 184 pp.

Reveal, J.L., Moulton, G.E. & Schuyler, A.E. (1999) The Lewis and Clark collections of vascular plants: names, types, and comments. *Proceedings of the Academy of Natural Sciences of Philadelphia* 149: 1–64.

Riser II, J.P., Cardinal-McTeague, W.M., Hall, J.C., Hahn, W.J., Sytsma, K.J. & Roalson, E.H. (2013) Phylogenetic relationships among the North American cleomoids (Cleomaceae): A test of Iltis' reduction series. *American Journal of Botany* 100: 2102–2111. http://dx.doi.org/10.3732/ajb.1300096

Rydberg, P.A. (1903) Studies on the Rocky Mountain flora—X. *Bulletin of the Torrey Botanical Club* 30: 247–262. http://dx.doi.org/10.2307/2478784

Rydberg, P.A. (1906) Studies on the Rocky Mountain flora—XVI. *Bulletin of the Torrey Botanical Club* 33: 137–161. http://dx.doi.org/10.2307/2478824

Rydberg, P.A. (1917) *Flora of the Rocky Mountains and Adjacent Plains*. Published by the author, New York, 1110 pp.

Sánchez-Acebo, L. (2005) A phylogenetic study of the New World *Cleome* (Brassicaceae, Cleomoideae). *Annals of the Missouri Botanical Garden* 92: 179–201.

Tidestrom, I. (1923) New or noteworthy species of plants from Utah and Nevada. *Proceedings of the Biological Society of Washington* 36: 181–184.

Tidestrom, I. (1925) Flora of Utah and Nevada. *Contributions from the U. S. National Herbarium* 25: 1–665.

Tidestrom, I. (1935) New Arizona plant names. *Proceedings of the Biological Society of Washington* 48: 39–44.

Torrey, J. (1828) Some account of a collection of plants made during a journey to and from the Rocky Mountains in the summer of 1820, by Edwin P. James, M. D. Assistant Surgeon U. S. Army. *Annals of the Lyceum of Natural History of New York* 2: 161–254.

Torrey, J. (1850) Notes on *Cleomella*. *Hooker's Journal of Botany and Kew Garden Miscellany* 2: 254–255.

Torrey, J. (1874) Phanerogamia of Pacific North America. *United States Exploring Expedition During the Year 1838–1842, Under the Command of Charles Wilkes, U. S. N*. 17: 205–514.

Torrey, J. & Frémont, J.C. (1845) *Report of the exploring expedition to the Rocky Mountains in the year 1842 and to Oregon and North California in the years 1843-'44.* Government Printing Office, Washington, 583 pp.

Torrey, J. & Gray, A. (1838) *A Flora of North America* 1 (1): 1–711.

Tucker, G.C. & Vanderpool, S.S. (2010) Cleomaceae. *In:* Flora of North America Editorial Committee (Eds.) *Flora of North America North of Mexico. Vol. 7. Magnoliophyta: Salicaceae to Brassicaceae*. Oxford University Press, New York, pp. 199–223.

Vanderpool, S.S. (1993) Capparaceae, Caper Family. *In:* Hickman, J.C. (Ed.) *The Jepson manual. Higher plants of California*. University of California Press, Berkeley, pp. 469–471.

Vanderpool, S.S. (2010a) *Cleomella*. *In:* Flora of North America Editorial Committee (Eds.) *Flora of North America north of Mexico. Vol. 7. Magnoliophyta: Salicaceae to Brassicaceae*. Oxford University Press, New York, pp. 209–213.

Vanderpool, S.S. (2010b) *Oxystylis*. *In:* Flora of North America Editorial Committee (Eds.) *Flora of North America North of Mexico. Vol. 7. Magnoliophyta: Salicaceae to Brassicaceae*. Oxford University Press, New York, pp. 215.

Vanderpool, S.S. & Iltis, H.H. (2010) *Peritoma*. *In:* Flora of North America Editorial Committee (Eds.) *Flora of North America North of Mexico. Vol. 7. Magnoliophyta: Salicaceae to Brassicaceae*. Oxford University Press, New York, pp. 205–208.

Vanderpool, S.S., Elisens, W.J. & Estes, J.R. (1991) Pattern, tempo, and mode of evolutionary and biogeographic divergence in *Oxystylis* and *Wislizenia* (Capparaceae). *American Journal of Botany* 78: 925–937. http://dx.doi.org/10.2307/2445171

Villegas-Flores, E. & Ramírez-Delgadillo, R. (2000) Una nueva especie de *Cleomella* (Capparidaceae) del estado de Jalisco. *Boletín del Instituto de Botánica (Guadalajara)* 6: 179–185.

Watson, S. (1871) *Botany (Fortieth Parallel)*. Government Printing Office, Washington, 525 pp.

http://dx.doi.org/10.5962/bhl.title.55176
Watson, S. (1882) Contributions to American botany. *Proceedings of the American Academy of Arts and Sciences* 17: 316–382. http://dx.doi.org/10.2307/25138655
Weber, W.A., Johnston, B.C. & Wittmann, R. (1981) Additions to the flora of Colorado-VII. *Brittonia* 33: 325–331. http://dx.doi.org/10.2307/2806422
Welsh, S.L. (1986) New taxa in miscellaneous families from Utah. *Great Basin Naturalist* 46: 261–264.
Wiggins, I.L. (1950) Taxonomic notes on plants from the Sonoran Desert. *Contributions from the Dudley Herbarium of Stanford University* 4: 15–31.
Wooton, E.O. & Standley, P.C. (1913) Description of new plants preliminary to a report upon the flora of New Mexico. *Contributions from the U.S. National Herbarium* 16: 109–196.