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## A New Species of *Ceratolacis* (Podostemaceae) from Minas Gerais, Brazil

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**ABSTRACT.** A new species of *Ceratolacis* (*C. pedunculatum*, Podostemaceae) is illustrated and described. The new species is known from four locations in central Minas Gerais, Brazil. *Ceratolacis pedunculatum* is distinguished from the only other species of the genus based on the presence of a prominent peduncle and the oblique orientation of the ovary on the pedicel.

**RESUMO.** Uma nova espécie de *Ceratolacis* (*C. pedunculatum*, Podostemaceae) é descrita e ilustrada. Esta espécie nova é conhecida de quatro localidades no centro de Minas Gerais, Brasil. *Ceratolacis pedunculatum* se distingue da outra espécie do gênero conhecida, pela presença de um pedúnculo proeminente e a orientação oblíqua do ovário sobre o pedicelo.

**Key words:** Brazil, *Ceratolacis*, Podostemaceae.

Prior to this current report *Ceratolacis* was a monotypic genus (*C. erythrolichen* (Tulasne & Weddell) Weddell). *Ceratolacis erythrolichen* is based on the basionym *Dicraea erythrolichen* Tulasne & Weddell of Tulasne (1849: 102). In his description of *D. erythrolichen*, Tulasne (1849) placed the species in his section *Ceratolacis*. In 1873, Weddell (1873: 66) elevated section *Ceratolacis* to the genus level: *Ceratolacis* Weddell.

While conducting field studies in Minas Gerais, Brazil, the authors collected material that represents a new species. Phylogenetic analyses based on morphological characteristics (Philbrick, Novelo, Rutishauser & Les, unpublished) indicated that the new species was monophyletic with *Ceratolacis*

*erythrolichen*. Thus, the new species was placed in the genus *Ceratolacis*.

***Ceratolacis pedunculatum*** C. T. Philbrick, Novelo & Irgang, sp. nov. TYPE: Brazil. Minas Gerais: ca. 16 km SW of Pompeú, along BR-262 on road to Martinhos Campos, rio Pará, 19°16'36.9"S, 45°07'54.2"W, 598 m, 16 July 2001, C. T. Philbrick, A. Novelo R., B. E. Irgang & C. V. de Senna Gastal 5679 (holotype, BHCB; isotypes, ICN, MEXU, MO, NY, WCSU). Figure 1.

Herba aquatica. Radices virides, elongatae et cylindricae ubi juvenes, ubi vetustiores latae thalloidesque. Folia petiolata, disticha, stipulata, ditheca, erecta, 1–6 plo divisa, raro subdichotoma vel pinnata; stipulae asymmetricae, ex folii base amplexicauli cymbiformi constatae. Inflorescentia uniflora, pedunculata. Flores solitarii in axillis foliaribus. Spathella claviformis. Pedunculus et pedicellus post spathellae rupturam elongantes. Tepala 3, uno in andropodii quoque latere, tertio tepalo ad andropodii apicem portato. Stamina 2. Andropodium et filamenta per anthesin elongantia. Pollinis grana in dyadibus. Ovarium ex 2 carpellis aequalibus compositum, 2-loculare, in pedicello oblique dispositum. Stigmata 2, libera, stigmatum base in fructu indurata, persistenti. Fructus capsularis, 2-locularis, apice emarginato, duabus valvis aequalibus, persistentibus, 3-costatis, marginibus suturalibus incrassatis. Pedunculus a pedicello in fructu non distinguibilis.

Aquatic herbs, perennial. Roots green, elongate and cylindrical when young, becoming broad and crust-like, irregular in outline when older, branched, prostrate, flattened to elliptical in cross section, median = 0.9 (0.3–5.2) mm [N = 50] wide, tightly attached to rocks via adhesive hairs, growing intertwined. Stems monomorphic, arising opposite or subopposite along the flanks of roots, 4.9 (0.9–

12) mm [N = 50] apart, obscured by leaf bases, erect, less than 0.1 mm high, unbranched. Leaves petiolate, distichous, stipulate, double-sheathed, upright, compound, 4 (1–6) [N = 50] times divided, rarely subdichotomous or pinnate, 17 (2.9–35.2) mm [N = 100] long, ultimate leaf segments linear to spatulate, 3.1 (0.2–9.5) mm [N = 100] long  $\times$  0.3 (0.1–1) mm [N = 100] wide, midvein faint or lacking, apices acute or obtuse; petiole 3.9 (0.4–14) mm [N = 100] long, elliptical in cross section; stipules asymmetric, composed of an extension of the amplexicaul leaf base, 0.5 (0.1–5.6) mm [N = 50] long, larger on leaves subtending flowers, apex entire. Inflorescence with flowers pedunculate and solitary. Flowers 2 (1–6) [N = 50] per stem, hermaphroditic, zygomorphic, borne singly in a leaf axil, covered by a spathella, pedicellate; peduncle (below attachment point of spathella) 0.8 (0.1–3.1) mm [N = 100] long prior to spathella rupture, elongating to 2.6 (0.3–8.5) mm [N = 100] long after spathella rupture; spathella clavate, 2.4 (1–4.5) mm [N = 100] long  $\times$  1.1 (0.6–1.7) mm [N = 100] wide, rupturing apically, falling away completely in fruit; pedicels 0.8 (0.1–3.1) mm [N = 100] long prior to spathella rupture, elongating to 5.1 (1.8–8.5) mm [N = 50] long after spathella rupture; tepals 3, scale-like, linear, acute, two (one on either side) at the base of the stalk from which the stamens arise (andropodium), 0.6 (0.2–1.8) mm [N = 50] long; a third tepal occurring at the apex of the andropodium, andropodial tepal 0.4 (0.3–0.5) mm [N = 50] long; stamens 2, deciduous; andropodium 1 (0.6–2) mm [N = 50] long prior to spathella rupture, during anthesis elongating to 4.3 (2–7) mm [N = 50] long; filaments 0.4 (0.2–1.8) mm [N = 50] long prior to spathella rupture, during anthesis elongating to 0.9 (0.4–1.8) mm [N = 50] long; anthers quadrangular, with parallel sides, 1.1 (0.7–1.4) mm [N = 50] long, 1 (0.6–1.2) mm [N = 50] wide, dehiscing introrsely and longitudinally, inner and outer thecae of equal length; pollen in dyads, tricolpate, 35 (31–40)  $\mu\text{m}$  [N = 100] long, 24 (19–28)  $\mu\text{m}$  [N = 100] wide; ovary with 2 equal carpels, 2-locular, oval in shape, oriented obliquely on the pedicel, 1.5 (0.7–2.6) mm [N = 50] long, 1 (0.6–1.7) mm [N = 50] wide, with 6 longitudinal dark lines on the ovary wall; ovules 20 (12–32) [N = 25]; stigmas 2, free, each stigma triangular in outline, widest at base, upright prior to spathella rupture, 0.5 (0.3–1) mm [N = 50] long, during anthesis upright or divergent, elongating to 0.9 (0.4–1.1) mm [N = 50] long, base of stigmas becoming hardened and persisting in fruit. Fruit a 2-locular capsule, 1.8 (1.4–2.1) mm [N = 50] long, 1.3 (0.9–1.5) mm [N = 50] wide, capsule apex emarginate due to

persistent stigma bases, with two equal valves, persistent, valves 3-ribbed, suture margins thickened and rib-like; peduncle not distinguishable from pedicel in capsule (due to shedding of spathella and parenchymatous tissues of peduncle and pedicel); length of peduncle and pedicel combined 6.8 (1.5–17) mm [N = 100] long. Mature seeds unknown.

*Ceratolacis pedunculatum* is known from four locations in the central part of the state of Minas Gerais, Brazil (Fig. 2), ranging from about 500 to 650 m elevation. The related *C. erythrolichen* is known only from the type collection (rio Tocantins), which is approximately 1500 km north of the locations where *C. pedunculatum* was collected. Although the type locality of *C. erythrolichen* was in the state of Goias at the time the species was described in 1849, the location is presently in the state of Tocantins.

*Additional observations.* Two reproductive characteristics distinguish *Ceratolacis pedunculatum* from *C. erythrolichen*. *Ceratolacis pedunculatum* possesses a peduncle (Fig. 1b, 1e, 1g, 1h), and the axis of the ovary is offset (oblique) from that of the pedicel by ca. 30–45° (Fig. 1f–h). In contrast, *C. erythrolichen* lacks a peduncle and the ovary axis is parallel to that of the pedicel.

One characteristic of the root also seems to differ between *C. erythrolichen* and *C. pedunculatum*. Tulasne (1852: 126) and Engler (1930: 52) referred to the roots of *C. erythrolichen* as being red while living and turning blackish or whitish upon drying. This character is not evident in *C. pedunculatum*, in which the roots are dark green in living and dried specimens.

Justification for recognizing *Ceratolacis pedunculatum* as distinct from *C. erythrolichen* warrants some discussion of the type material of the latter species. Tulasne (1849) based his description of *C. erythrolichen* on a collection of Weddell. As Weddell worked at Paris and his collections are housed there, it has been reported (Tulasne, 1852: 127; Van Royen, 1954: 224) that the type material of *C. erythrolichen* is deposited in P. Recently, however, the type specimen has not been located there. There is one specimen located in C that seems to be the holotype. Isotypes are located in K and M. The holotype and isotypes are comprised of only vegetative material (roots, stems, leaves). As a consequence, it has not been possible to study the reproductive structures on the type material for *C. erythrolichen*. Van Royen (1954) also noted that the type material was incomplete.

*Ceratolacis erythrolichen* is only known from the

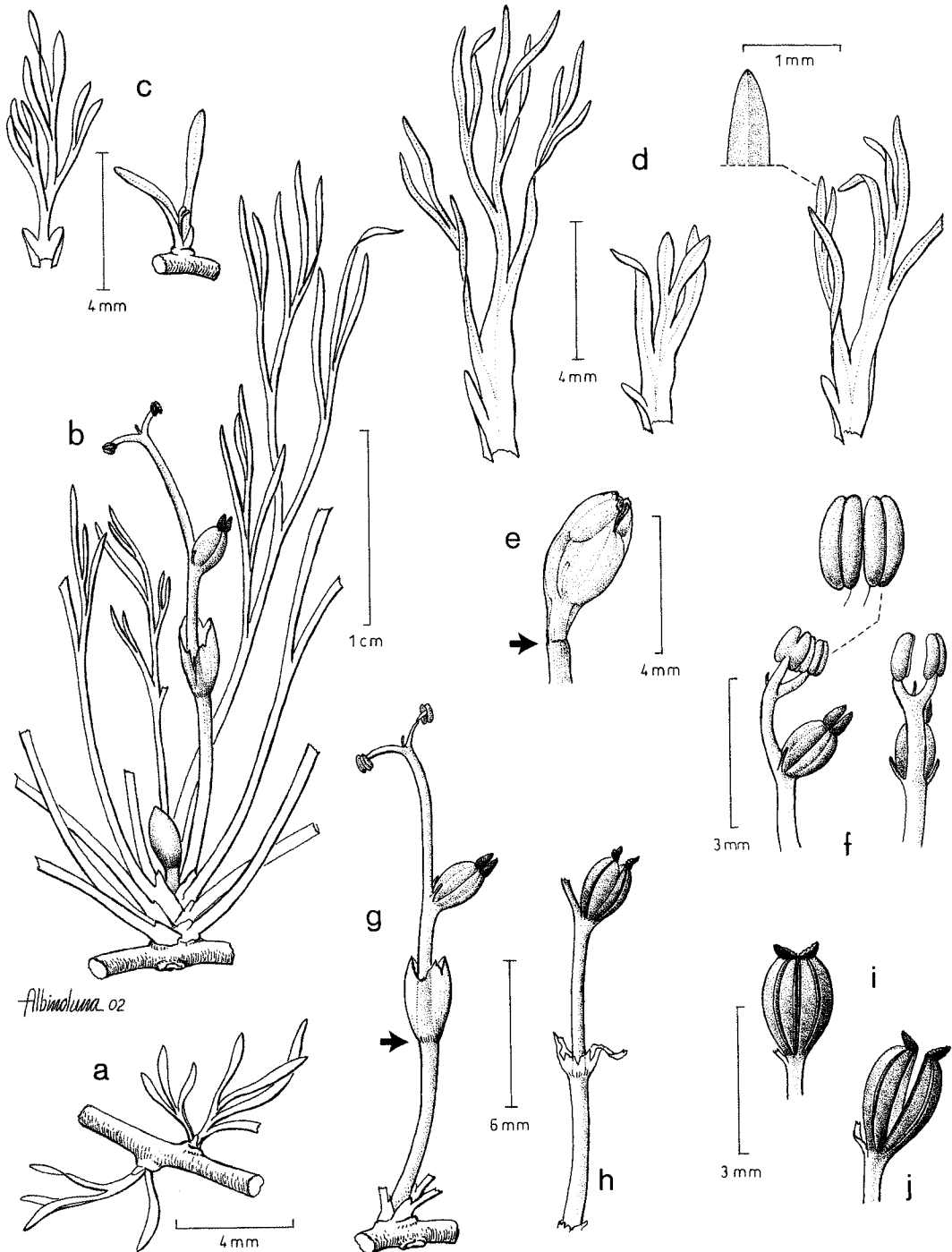


Figure 1. *Ceratolacis pedunculatum* C. T. Philbrick, Novelo & Irgang. Drawings based on the holotype. —a. General habit of plant showing cylindrical root from which leaves arise; stems are obscured by base of leaves. —b. General habit of plant showing cylindrical root, short stem (obscured by sheathing leaf bases), and two flowers—one at anthesis, the other enclosed within an intact spathe. Also showing dichotomously and subdichotomously divided leaves. —c. Details of a double-sheathed leaf with two basal stipules (left) and two simple leaves on a short stem (right). —d. Detail of three leaves showing asymmetric stipule on left side of leaf base and dichotomous to subdichotomous divisions. A detail of the apical segment of a leaf is included. —e. Flower enclosed within a spathe, which is partially ruptured at the apex. Apex of the peduncle is indicated by the arrow. —f. Two views of a flower at anthesis showing the

type collection. Thus, the present authors have had to rely on the descriptions and illustrations in Tulasne (1849, 1852, 1855) for their understanding of the reproductive morphology of the species. In the protologue for *Ceratolacis erythrolichen* (as *Dicraea erythrolichen*) Tulasne (1849: 102) did not make reference to a peduncle (a stalk below the attachment point of the spathella), nor is one indicated in the illustration for the species (his PL. X. 1). Rather, Tulasne (1849) referred only to a pedicel. (In Podostemaceae the pedicel is the stalk of the ovary that arises above the attachment point of the spathella.) Subsequently, Tulasne provided an expanded description of the species in his monograph of Podostemaceae (Tulasne, 1852: 126–128) and again in *Flora brasiliensis* (Tulasne, 1855: 253–254), but in neither case is any reference to a peduncle made. Although illustrations of the species are included in these two later works, they are the same illustrations that accompanied the 1849 description of the species. Given the prominent nature of the peduncle, the authors contended that Tulasne would have noted a peduncle if one had been present in the type material. Thus, the authors are confident that *C. erythrolichen* lacks a peduncle. *Ceratolacis pedunculatum* possesses a distinct peduncle. The peduncle occurs below the attachment of the spathella (arrows in Fig. 1e, 1g), while the pedicel occurs above. Lastly, Tulasne (1849, 1852, 1855) did not make reference to the ovary of *C. erythrolichen* being oblique on the pedicel either in his species description or in the accompanying illustrations. Based on the presence of a peduncle, the oblique orientation of the ovary, and to a lesser degree on the green roots, the authors conclude that *C. pedunculatum* is distinct from *C. erythrolichen*.

Species in three genera of Podostemaceae in the New World possess two stamens, an andropodium, and an asymmetrical sheathing leaf base (Table 1): two species of *Ceratolacis*, all species of *Crenias*, and one species of *Podostemum* (*P. muelleri* Warming). It is thus appropriate to focus on these eight species in a discussion of the characteristics of *Ceratolacis pedunculatum*.

The nature of the leaf base is partially correlated with stipule form among species of *Ceratolacis*, *Crenias*, and *Podostemum*. A single asymmetrical

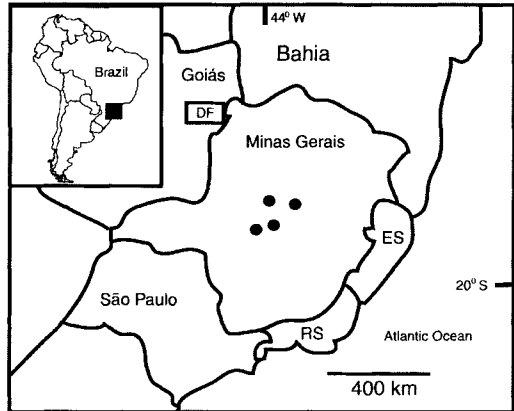


Figure 2. Distribution of *Ceratolacis pedunculatum* in the central region of the state of Minas Gerais, Brazil. DF, Distrito Federal; RS, Rio de Janeiro; ES, Espírito Santo.

stipule (a stipule on one side of the leaf base) and subdichotomous or pinnate leaves occur in species of *Ceratolacis*, *Crenias*, and one species of *Podostemum* (*P. muelleri*). In contrast, a symmetrical boat-shaped stipule (entire or divided into apical teeth) occurs in all species of *Podostemum* (except *P. muelleri* and *P. irgangii* C. T. Philbrick & Novelo); these species all have dichotomously divided leaves. *Podostemum muelleri* deviates from this correlation with its dichotomously divided leaves and asymmetrical stipule, whereas leaves of *P. irgangii* are uniformly verticillate.

*Ceratolacis pedunculatum* is the only New World species that has an asymmetrical stipule, an andropodium, two stamens, a pedicel, and a peduncle. The peduncle (0.1–3.5 mm long) occurs below the location where the sac-like spathella attaches to the pedicel (arrows in Fig. 1e, 1g). In contrast, the spathellas of species of *Podostemum* and *Crenias*, indeed most other species of Podostemoideae in the New World, attach at the base of the pedicel—at the point of attachment to the stem. Thus a peduncle is lacking. A peduncle is known from only three species of Podostemaceae in the New World: *Ceratolacis pedunculatum*, *Macarenia claviger* P. Royen, and *Vanroyenella plumosa* Novelo & C. T. Philbrick.

Characteristics of the capsule distinguish species

←

andropodium (stalk from which stamens arise), two anthers, two basal tepals, and one tepal arising from the apex of the andropodium. A detail of one anther is also shown. —g. A flower at anthesis showing its orientation relative to the root. Arrow indicates the apex of the peduncle. —h. A post-anthesal flower showing the remnants of the spathella arising from the apex of the peduncle. —i. Mature capsule prior to dehiscence showing the persistent and divergent stigma bases and the isolobous capsule. —j. Mature capsule after dehiscence (seeds have been dispersed) showing the two persistent capsule valves.

Table 1. Comparison of the two species of *Ceratolacis* with species of *Podostemum* and *Crenias* based on 10 selected characters.

Character	<i>Ceratolacis pedunculatum</i>		<i>Ceratolacis erythrolichen</i>		<i>Podostemum</i>		<i>Crenias</i>	
	dichotomous, subdichotomous, or pinnate	asymmetrical	dichotomous, subdichotomous, or pinnate	asymmetrical	dichotomous or subdichotomous	asymmetrical	subdichotomous to pinnate	asymmetrical
Leaves	present	absent	absent	absent	symmetrical or asymmetrical	absent	asymmetrical	absent
Stipule	emarginate	emarginate	emarginate	emarginate	rounded	rounded	rounded	rounded
Peduncle and pedicel	bases persistent, divergent	bases persistent, divergent	bases persistent, divergent	bases persistent, divergent	deciduous	deciduous	deciduous	deciduous
Capsule apex	persistent	persistent	persistent	persistent	one valve deciduous	one valve deciduous	one valve deciduous	one valve deciduous
Post-anthesal stigma base	isolobous	isolobous	isolobous	isolobous	anisolobous	anisolobous	anisolobous	anisolobous
Capsule valves	obscured	obscured	obscured	obscured	present	present	present	present
Ovary	cylindrical to flattened	cylindrical to flattened	cylindrical to flattened	cylindrical to flattened	cylindrical	cylindrical	cylindrical	cylindrical
Visible upright stem	oblique	oblique	upright	upright	oblique	oblique	oblique	oblique
Root form								
Ovary orientation								

of *Ceratolacis* from *Crenias* and *Podostemum*. The capsule in the latter two genera is cylindrical in cross section, with a rounded or blunt apex. In contrast, the capsule of *Ceratolacis* is somewhat flattened with an emarginate apex, a character that is largely a consequence of the persistent stigma bases. The stigma bases are deciduous in species of *Crenias* and *Podostemum*. In addition, species in these two genera possess capsules in which one valve is deciduous, the other persists. In contrast, both valves of the capsule of species of *Ceratolacis* persist. Thus, with capsules alone it is possible to distinguish plants of the genus *Ceratolacis* from those of other genera of Podostemaceae.

Species of *Ceratolacis* possess an isolobous ovary, while the ovaries of species of *Crenias* and *Podostemum* are anisolobous. The presence of an anisolobous ovary is usually associated with the ovary set at an angle (oblique) on the pedicel. However, *Ceratolacis pedunculatum* is unusual in that the isolobous ovary is clearly oblique on the pedicel (Fig. 1f–h). There is no indication that *C. erythrolichen* shares this character.

Variation in stem and root form also helps distinguish species of *Ceratolacis*. Elongate stems characterize most species of *Podostemum* and *Crenias*, although stems of some species can be obscured by the sheathing leaf bases. *Ceratolacis pedunculatum* lacks an obvious upright stem; the diminutive stem is obscured among the leaf bases.

Roots of species of *Ceratolacis*, *Crenias*, and *Podostemum* are elongate and cylindrical when young. Roots of mature plants retain their cylindrical form in species of *Podostemum* and *Crenias*. In contrast, mature roots of both species of *Ceratolacis* often become broadened, irregular in outline, flattened, and can resemble a crust. These flattened roots are difficult to remove from the rocks. Thus, to document this character it is necessary to collect specimens and the rocks to which they are attached.

Species of *Crenias* and *Podostemum* possess dyad pollen. Dyad pollen also characterizes *Ceratolacis pedunculatum*. The authors predict that *C. erythrolichen* has dyad pollen as well, although the absence of adequate type material does not allow this prediction to be confirmed.

*Paratypes.* BRAZIL. **Minas Gerais:** on road from Diamantina (Gouveia) to Curvelo, confluence of rio Parauna and rio Cipó, 9 July 2002, *C. T. Philbrick, A. Novelo R., B. E. Irgang & C. V. de Senna Gastal 5649* (BHCB, ICN, MEXU, MO, WCSU); ca. 10 km W of Sao Sebastião, Route BR-420, on road to Pompeú, 9 July 2001, *C. T. Philbrick, A. Novelo R., B. E. Irgang & C. V. de Senna Gastal 5651* (BHCB, ICN, MEXU, MO, WCSU); ca. 16 km SW of Pompeú, along BR-262 on road to Martinhos Campos, rio Pará, 16 July 2001, *C. T. Philbrick, A. Novelo*

*R.*, *B. E. Irgang* & *C. V. de Senna Gastal 5678* (BHCB, ICN, MEXU, MO, NY, WCSU); 2 Aug. 2002, *C. T. Philbrick* & *A. Novelo R. 5781* (BHCB, ICN, MEXU, MO, NY, WCSU); 30 km N of Corinto on BR-496, ca. 200 m upstream of bridge, rio Bicudo, 28 July 2002, *C. T. Philbrick* & *A. Novelo R. 5761* (BHCB, ICN, MEXU, MO, NY, WCSU).

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