RESEARCH PAPER

A new variety of the weed *Borreria densiflora* DC. (Rubiaceae)

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The weed, known commonly as *vassourinha de botão* (buttonweed), is present in several crops in northern and north-eastern Brazil. Its occurrence is common in sugarcane and soybean crops in the states of Goiás, Tocantins, and Maranhão. However, there is no published information in the literature about its taxonomic classification. Thus, this research aimed to classify taxonomically this species in order to develop a classification key based on the morphological characteristics among varieties of *Borreria densiflora* DC., as well as to illustrate it and provide a palynological basis to classify this species as a new variety. For the classification process, data from the literature, morphological characteristics, and palynological evidence were considered. In this article, we describe a new variety, *B. densiflora* DC. var. *latifolia* E.L. Cabral & Martins. The new variety possesses a terrestrial habitat and it is a simple perennial weed species. These results show the importance of an accurate identification, as well as an understanding of the evolutionary changes inherent to weeds (like intraspecific variability), breeding system, genetic potential, and ecological studies. Those factors are essential to the beginning of a long-term weed management strategy.

**Keywords:** *Borreria densiflora*, Brazil, Rubiaceae, taxonomy, weed biology.

Changes that have been created by cropping practises over evolutionary time have led to weed diversity, which is one of the most important reasons as to why weeds are so successful in agroecosystems (Dekker 1997). Weed diversity results from taxonomic diversity, which means trait diversity, leading to differential survival, mortality, and reproduction of individual species (Harper 1977). Their identification is an important part of taxonomy, involving the use of the products of taxonomic research, such as keys, flora, and manuals. Weeds present taxonomic diversity, not only within a genus (Sexsmith 1964; Anonymous 1981; Wang *et al.* 1995a,b; Francis & Warwick 2007) but also at the species level, leading to phenotypic diversity. Thus, correct identification must be considered within integrated weed management. For McNeill (1976), the role of taxonomy at the species level is a far more important one for weed science. When a weed reaches problem proportions, it is referred to taxonomists with adequate herbarium and library resources to make an accurate identification. To date, this information is lacking for the studied weed in this research. Recent field observations have reported that *vassourinha de botão* is occurring in high infestations in soybean and sugarcane crops in northern and north-eastern Brazil and is presenting difficulty in its management, mainly by chemical means, when it occurs in more advanced growth stages (Martins 2008). This species belongs to Rubiaceae, and is a member of the genus *Borreria* G. Mey. This genus belongs to the tribe Spermacoceae, which is one of the most conflicting ones within the family Rubiaceae. Since its original description, some species of this genus either faced some changes related to its true

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Statement of commercial interest: This research was conducted only to classify taxonomically a new weed variety of *Borreria densiflora* DC.

Received 18 September 2008; accepted 18 June 2009

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doi:10.1111/j.1445-6664.2009.00352.x
taxonomic delimitation or were segregated or included in other taxa. One of these reasons would be related to the high richness and variability of the morphological characteristics, mainly the palynological ones. Thus, currently there are divergent opinions among specialists regarding the criteria for the delimitation of the species within the genus *Borreria*. Conflicting delimitations in relation to this genus itself also have been reported. Some authors have included the genus *Spermacoce* L. within the *Borreria* genus (Govaerts 1996; Delprete 2007). Still, the delimitation of the tribe Spermacoce has been modified after results from molecular data (Robbrecht & Manen 2006), although molecular phylogeny studies are pending for the American species of the tribe. Likewise, we consider it to be too abrupt to transfer all the species from the genus *Spermacoce* to *Borreria*. The genus *Borreria* presents ~100 species, from which ~60 species occur in Brazil. According to Steyermark (1972), most of the *Borreria* spp. diversity is located at the Brazilian Plateau. This taxon is one of the few that is representative of the tribe that inhabits the American continent and tropical areas of Africa, Asia, and Australia (Dessein et al. 2002). In order to facilitate the identification of the *Borreria* spp., Bacigalupo and Cabral (1996) accomplished an infrageneric classification, grouping the species according to the characteristics of flower, fruit, seed, and pollen grain. Perhaps, a more common cause of misidentification than ignorance of the occurrence of a species in a region is simply that of insufficient or inadequate taxonomic research. Most often, several different species are included under a single name (McNeill 1976). Likewise, the first step in weed management is to identify the weed that is interfering with crop production. This identification includes the correct identification of the weed species, species group, and subspecific variant (Dekker 1997). For that, data from pollen grain morphology have proved to be particularly informative in elucidating the evolutionary relationships within the family Rubiaceae (Dessein et al. 2005). In this context, this research aimed to classify taxonomically the weed *vassourinha de botão* (*buttonweed*) at the species level, providing an illustration, botanic classification key, and palynological analysis.

**MATERIALS AND METHODS**

The research was conducted in a laboratory, greenhouse, and herbarium during 2 years of study. The matured glomerules of at least 50 plants of *vassourinha de botão* (*buttonweed*) were collected manually from infestations in a soybean production field, located in Pedro Afonso, Tocantins, Brazil (08°58′03″S, 48°10′29″W). Later, the seeds were removed from the glomerules and 25 were sown in plastic germination boxes, containing two layers of white filter paper (Elo’s Comércio e Representações de Aparelhos para Laboratórios de Biotérios LTDA, São Paulo, Brazil). The boxes were placed inside a germination chamber that was set at 8 h light at 30°C and 16 h dark at 20°C. The seedlings were transplanted into 1.5 L plastic pots, containing potting mix. Each pot was fertilized by adding a commercial formula (Ouro Verde; Bunge, São Paulo, Brazil) of 4:14:8 N:P:K fertilizer every 20 days. Representative exemplars containing leaves, flowers, and seeds were harvested and forwarded to the herbarium at Northeast Institute of Botany, Corrientes, Argentina. The anthers were removed from the herbarium specimens and acetolyzed according to the procedures outlined in Erdtman (1966). The slides for light microscopy were made with glycerin jelly and sealed with paraffin. They are deposited at the Palynological Laboratory of Northeast National University in Corrientes, Argentina. Acetolyzed and unacetolyzed pollen grains that were sputter-coated with gold were used and were examined and photographed with a scanning electron microscope (Joel JSM-5800 LV; Laborato, Tokyo, Japan).

**RESULTS**

*Borreria densiflora* DC. belongs to the subgenus *Borreria* as a result of having flowers with stamens and an exerted style and capitate and bilobed stigma, and as a result of having seed drills without a cross (Fig. 1). The calyx of this species presents two distinct lobes. The pollen grains are small, 7–8-zonocolporate, with short colpi. They are oblate-spheroidal or, less frequently, prolate-spheroidal (P/E = 81–100). The exine is tectate-perforate and uniformly spinulate. According to the pollen classification of *Borreria* by Pire (1996), it belongs to Type 3 (Fig. 2).

**Key to identify the new variety**

1. Subshrubs, 20–100 cm tall, stem glabrous or slightly pubescent in the angles, unbranched or shortly branched in the distal part, internodes 1.5–6 cm long. Leaves 1–7 cm × 0.2–1.5 cm, linear, linear-lanceolate, linear-oblong or linear-elliptical, glabrous or pubescent. Flowers 4–6 mm long........................................2

1′ Subshrubs, 7–17 cm tall, stem densely pilose, internodes 0.5–1.5 cm long. Leaves 0.7–1.5 cm × 0.2–0.5 cm, elliptical, pubescent on both sides. Flowers 3–3.5 mm long........... *Borreria densiflora* var. minima.
2 Stem simple or with a few short lateral branches in the distal part. Leaves 0.2–1(1.5) cm wide, sessile, linear, linear-lanceolate, linear-oblong, or linear-elliptical, secondary nerves are inconspicuous, glomerules 1–2(3) per floriferous branch, with 2–8 involucral bracts.....................................................3.

2′ Main stem with numerous oppositely arranged branches, highly ramose from the base. Leaves 0.8–
2.5 cm wide, pseudopetiolated by the significantly attenuated base, elliptical or lanceolate, secondary nerves are conspicuous, glomerules three per floriferous branch with 2(–4) involucral bracts. 

B. densiflora var. latifolia var. nov. 

Leaves glabrous or pubescent, with mid-vein papillose on the ventral side margin scabrous. 

Borreria densiflora var. densiflora. 

Leaves pubescent on both sides. Stems densely pilose. 

Borreria densiflora DC. var. latifolia E.L. Cabral & Martins var. nov. (Figs 1,2). Type: Brazil. Tocantins, 08°58′03″S, 48°10′29″W, 8-V-2007, V.C. Souza & B.A.B. Martins 32954 (holotype: ESA; isotype: CTES).

Affinis B. densiflora var. densiflora, a qua imprimis differt ramis secundarlis lateralibus opositis plurimis. Folis usque ad 2.5 cm latis pseudopetiolatis vs folis usque ad 1(–1.5) cm latis sessilibus.

Subshrubs, 30–100 cm tall, lateral flowering branches, opposite and highly developed from the base, stem subcylindrical to terete, glabrous or slightly pubescent in the angles. Leaves 3–6 cm × 0.8–2.5 cm, apex acute or acuminate, base very attenuate, forming a pseudopetiole, glabrous except scabrous margin, pubescent on the midrib above, papillose on the secondary nerves below. Stipular sheath 4–4.5 mm long, pubescent, the setae 7–8 in number, 3.5–5 mm long, with apical collets. Glomerules three per floriferous branch, 1–1.5 cm wide, involucral bracts 2(–4). Calyx two-lobed, the lobes pilose on the margins. Hypanthium 1–1.5 mm long, with long hairs in the upper third. Corolla white, 5.5–6 mm long, with moniliform hairs in the middle of the tube and papillose on the upper half of the lobes. Anthers exerted, 1 mm long. Style exerted, 3.5–4.5 mm long, stigma capitate and bilobed. Disk bilobed. Capsule 2–2.3 mm long, densely hairy in the upper third. Seed subcylindric with a ventral furrow, 1.8–2 mm long, exotesta orderly foveolate-reticulate, ventral furrow covered by a white granulate strophiole. Geographical distribution: Center-east and north-east of Brazil, in the states of Ceará, Maranhão, Piauí, Tocantins, and Goiás. 

Additional material studied 


DISCUSSION 

Borreria densiflora DC. is a species of wide geographical distribution; it occurs from Mexico to the center of
Argentina. This wide range in which it occurs explains the occurrence of intraspecific variability. Species that occupy a diversity of habitats are thought to be predisposed to become good invaders when introduced into new places (Baker 1974), perhaps related to either phenotypic plasticity or an ability to adapt genetically (Maron et al. 2004). In 2005, a new variety of *B. densiflora* DC. was described and illustrated, called *B. densiflora* DC. var. *pilosa* Bacigalupo, occurring in Bolivia, South America (Cabral & Bacigalupo 2005). According to McNeill (1976), important as it is to ensure that weeds are accurately identified according to careful and critical taxonomic revisions, it is even more important to appreciate the nature and extent of within-species variation and to take suitable account of it in any weed studies. Consequently, it is possible to observe plants from the same species not exhibiting the same responses to particular treatments. Costa and Appleby (1976), for example, described two varieties of yellow nutsedge (*Cyperus esculentus* L. var. *esculentus* L. and *Cyperus esculentus* var. *leptostachyus* Boeckl). Both presented morphological differences, as well as different susceptibility to several herbicides.

In Brazil, *Borreria densiflora* DC. has been reported as a weed recently (Martins 2008), and its taxonomic classification was not done at the intraspecific level. *B. densiflora* DC. has also been reported in Brazil as occurring in sites like forestry reserves, environmental protection areas (Pereira & Alves 2006), and in anthropogenic vegetation (trial and road margins and flooded or unflooded pastures) (Lombardi et al. 2005). Thus, based on the concept of types of weeds according to their habitats by Muzik (1970), we consider this species as a facultative weed. According to McNeill (1976), we must assume that weed flora of any region is not static, but is continually changing, mostly in the relative abundance of species, but also with the arrival or even the evolution of new ones. The developed plant of *B. densiflora* DC. var. *latifolia* E.L. Cabral & Martins is terrestrial and can produce flowers and fruits for longer than 1 year, as recorded in field and greenhouse conditions. Thus, this species is classified as a simple perennial as it does not reproduce by vegetative propagation. Moreover, this weed species is able to regrow after being cut. Cytological and genetic studies present promising ways of representing significant variation outside of the taxonomic hierarchy that could provide more evidence to state delimitations at the species and infraspecific level, as well as to clarify the evolutionary history of species (McNeill 1976). Therefore, research in this sense must be done to enhance the taxonomic delimitations of the species. Still, studies in other biological characteristics, like the growth and development of *B. densiflora* DC. var. *latifolia* E.L. Cabral & Martins, will be of great importance to its management. That information might be useful to resource managers and regulatory officials in assessing which weeds are problematic in adjacent geographical areas and to researchers to help select which weeds to target with new management strategies. Our data should be considered as one tool to help inform managers and decision-makers who are conducting risk assessments and developing weed management strategies.

**ACKNOWLEDGMENTS**

This work was supported by a Coordination for the Improvement of Higher Level – or Education – Personnel (CAPES) scholarship that was granted to the first author. The authors would like to express sincere thanks to Érica Brito Lima, from COAPA (Agricultural Cooperative of Pedro Afonso), who collected and provided the seeds for the study.

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