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New features of Cuban endemic *Pinguicula filifolia* (Lentibulariaceae) and considerations on its habitat and ecology

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ABSTRACT

Pinguicula filifolia C. Wright ex Griseb. is a carnivorous plant endemic in western Cuba. New features on the generation time habit and leaf morphology of this species are described and illustrated emphasizing its heteromorphic habit, based on studying living plants in nature and vouchers. A comparison of morphological characters of leaves among *P. filifolia* and its close relatives *P. albida* C. Wright ex Griseb. and *P. cubensis* Urquiola & Casper from west Cuba reveals morphological characters such as vertical position of the leaves, filiform blade, circinate apex and absence of edge curling. The description of new characteristics, such as an annual aestival habit and the presence of two kinds of carnivorous leaves during its growth cycle, emphasize the unique position of this species among Cuban taxa, all of them, so far, considered as "tropical homophyllous" within the genus.

Introduction

Pinguicula L., one of the three genera of the Lentibulariaceae, is well represented on Cuba and adjacent islands and Casper and Stimper (2009) have suggested the Central American-Caribbean region as the center of diversity for the genus. Cuban taxa consist of 13 recognized species (Alain, 1957; Casper, 1966, 2003, 2004, 2007; Casper and Urquiola, 2003; Panfet and Temple, 2008), all of them endemic and showing a very restricted and disjointed geographical distribution on the west, center and east of the island.

Three *Pinguicula* species are known from western Cuba: *Pinguicula filifolia* C. Wright ex Griseb., *Pinguicula albida* C. Wright ex Griseb. and *Pinguicula cubensis* Urquiola & Casper (Casper and Urquiola, 2003; Shimai et al., 2007). *Pinguicula filifolia* is the most widespread species on the western part of the archipelago; it grows under direct sun light in open areas of white-sand (siliceous) savannas situated in the Pinar del Río province (island of Cuba) and disjoint in the island Isla de la Juventud. This species is also the most variable among Cuban butterworts, showing a wide range of flower colors that may vary from white and yellow to purple and blue (Casper, 1966; Shimai et al., 2007).

According to Casper (1966) *P. filifolia* belongs to section *Agnata* Casper because of its uniform leaves and subisolobe corolla. The species is included in the group of *Pinguicula* species with tropical growth type; the same author also categorized this taxon as a "tropical homophyllous" one, due to the lack of winter resting buds (hibernaculae) composed by not carnivorous leaves during the plant growth cycle. Due to field observations and microscopic examination of living plants in nature and herbarium specimens, we present some new findings on generation time habit, leaf morphology and ecology of *P. filifolia* compared with closely related species from west Cuba.

Materials and methods

Living plants of *P. filifolia* in two populations ($n = 30$ samples) from Isla de la Juventud and two populations from Pinar del Río province ($n = 50$) were studied. Also, herbarium specimens deposited at Herbario del Jardín Botánico Nacional (HAJB), Herbario de la Academia de Ciencias (HAC) and Herbario del Instituto Superior Pedagógico de Pinar del Río (HPPR) in Cuba were analyzed. The original diagnosis of *P. filifolia* by Grisebach (1866) and later descriptions by Alain (1957), Ernst (1961) and Casper (1966) were also examined.

Both localities from Isla de la Juventud belong to the area of the Ecological Reserve "Los Indios", and are separated by a distance of 7 km with a river flowing between them. Localities in Pinar del Río

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belong to the Ecological Reserve "Los Pretiles" and are separated by a flooded mangrove forest. In all populations studied, plants grow on a siliceous sand savanna near to the coast line. The exsiccatae examined include all known localities for this species (Pinar del Río province and the Isla de la Juventud) representing the whole distribution area of the taxon.

We visited studied populations thrice a year (April, July and November) covering almost all of the species' growing season. Seedlings and mature (flowering and fruiting) plants were observed, photographed and sampled as vouchers (deposited at HAJB) or fixed in 70% ethanol. Morphological analyses were done using a stereo microscope Zeiss Stemi DV4 Spot for exsiccatae and an optical microscope Novel N-400M for alcohol-fixed material. Also scanning electron microscopy (SEM) was used to analyze details on leaves; in this case the material was coated with a thin layer of gold and photographed at 15 kV using a JEOL JSM 5410 microscope. Herbarium specimens of closely related species from west Cuba *Pinguicula albida* and *P. cubensis* which share localities with *P. filifolia*, were also examined and a comparison of morphological characteristics of the leaves among the three species was done.

Results

Generation time habit

Pinguicula filifolia seeds germinate in late spring (May) once the first rains begin. The rainy season (May–October) makes the habitat increasingly more suitable for *P. filifolia* due to high humidity levels (up to 70%) and the optimal temperature required for the species. In summer (July–August) mature plants begin to produce flowers and fruits through the remainder of the rainy season, occasionally during drought periods (November–April), even with lower temperatures and moisture. However, the plants will normally be fading out after the summer rain period is over. Seeds rest on the top soil for the whole winter and part of spring until the next rains.

Leaf morphology

During the present study we observed seedlings showing a tiny rosette of 8–10 mm in diameter (Fig. 1a). Such rosettes consist of 4–6(8) spathulate, flat to suberect leaves (Fig. 1b). Blades are 4–5(6) mm long and (0.5)1–1.5 mm broad. Their base is cuneate, rounded to obtuse at apex; the margin is entire. The adaxial leaf surface is covered with stalked and sessile glands, the former mainly located at the margins (Fig. 1a–e).

Linear-filiform erect leaves, so far known for *P. filifolia*, arise in the center of those small rosettes. They are (50)80–150(200) mm long and (0.25)0.5–1(1.5) mm broad. They are cuneate at base, acute at apex, with entire margin, and moderately covered with stalked and sessile glands on the adaxial surface. These leaves are rolled up in a circinate fashion during prefoliation phase (Fig. 1c–d and g).

Discussion

Generation time habit

Living plants studied and dates given in the examined herbaria suggest that *P. filifolia* is an annual aestival species that grows in seasonally wet or damp, even partially drowned, environments – in contrast with the majority of extant Cuban taxa which live throughout the year (Temple and Panfet, 1998). According to field observations, in the majority of cases, *P. filifolia* exists from May to February, but this period can change depending on climatic conditions and the beginning of rains. *P. filifolia* is the most cultivated species among Cuban butterworts, so possibly the inaccurate belief that the species is a perennial could be associated with observations made on greenhouse grown plants.

In nature, this species thrives near to other typical plants of Cuban sandy savannas (Chang and Vilamajó, 2002), most of them endemic members of the families Asteraceae, Eriocaulaceae, Hypericaceae, Melastomataceae, Polygalaceae, Xyridaceae, and including some other carnivorous plants, for instance *Drosera capillaris* Poir. (Droseraceae), *Genlisea filiformis* A. St.-Hil. (corkscrew plants) and terrestrial *Utricularia* species (bladderworts; Lentibulariaceae).

Leaf morphology and ecology

The name *Pinguicula filifolia* C. Wright ex Griseb., published by Grisebach (1866), was based on a specimen collected by C. Wright (Wr. 2886) in west Cuba. Describing the leaves of the new species, Grisebach only made reference to "*. . .foliis anguste linearibus apicem obtusciculis*. . ." (. . .leaves narrowly linear, apex obtuse. . .) evidently pointing out the well known threat-shaped leaves of this taxon. Later, Casper (1966), in his monograph for the genus, published a detailed description but he did not refer to the existence of other kinds of leaves in this taxon.

Heterophylly, as it is described here for *P. filifolia*, is a common feature of the *Pinguicula* species belonging to sections *Heterophyllum* Casper and *Orcheosanthus* DC. (Casper, 1966). It has also been recorded by Casper (1987) in Cuban epiphytic *Pinguicula lignicola* Barnhart from section *Discoradix* Casper. To date none of the species included in section *Agnata* Casper, to which *P. filifolia* belongs, has been described as a "tropical heterophyllous". On the other hand, the circinate prefoliation and the linearity of the blade of *P. filifolia* resemble "tropical heterophyllous" species from Mexico such as *P. heterophylla* Benth., and *P. medusina* Zamudio & Studnička/section *Heterophyllum*, and *P. gypsicola* Brandegee and *P. moctezumae* Zamudio & R.Z. Ortega/section *Orcheosanthus* (Zamudio and Studnička, 2000; Zamudio, 2006) rather than Cuban taxa. These similarities may be the result of evolutionary convergence, since there is no evidence that *P. filifolia* possesses the typical hibernacula present in these Mexican species. Different phylogenetic studies supported by both morphological and molecular data (Müller et al., 2004; Cieslak et al., 2005) contradict the current subclassification of the genus as proposed by Casper (1966).

The small rosettes, recorded in this study, may represent a first stage in the ontogenetic development of this species, since they were recorded on seedlings, although the primary root was already faded. Furthermore, the spathulate leaves were observed on mature plants showing a well-developed rosette of typical filiform leaves (Fig. 1f–g).

Due to the presence of both types of glands even on the primary rosette, and because of the nature of flypaper-type traps, plants can catch and digest small insects, pollen grains, minute seeds and plant debris (Legendre, 2000). Spathulate leaves are too small in order to perform leaf movements, in contrast with other species of the genus (Lloyd, 1942). However, further research will be necessary to validate this observation.

Pinguicula filifolia and its close relatives, *P. albida* and *P. cubensis*, share many common features, mainly those involving flower morphology. But it is clear that there are marked differences among their leaves (Table 1) and their habitat. Analyzing the leaf margin of the three species, a relationship was observed between inward/outward curling and leaf position. Involute margins are very pronounced in horizontal leaves (i.e. in *P. albida*), revolute or intermediate in semihorizontal ones (i.e. in *P. cubensis*) which before adopting this orientation have a vertical development, and the absence of edge curling was recorded in vertical leaves (i.e. in