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Original article

# *Catasetum krahlii* (Orchidaceae, Catasetinae): a new and threatened species from the Brazilian Amazon

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**ABSTRACT**

In the present study we propose a new *Catasetum* taxon belonging to the group of species with symmetrical and converging antennae. It was found in a vegetation of "terra firme" and "campinarana" in the central Brazilian Amazon. A detailed description of the taxon is given as well as a photograph plate and comments relating to distribution, habitat, phenology and conservation status. It is compared to *C. rivularium* and *C. barbatum* which are sympatric species and somewhat similar to the new taxon. Furthermore, we present a key to *Catasetum* species with symmetrical and convergent antennae occurring in the Brazilian Amazon.

**Keywords:** Amazon basin, biodiversity, Manaus, orchid, epiphyte, taxonomy.

## Introduction

*Catasetum* Rich. *ex* Kunth is one of the eight genera in the subtribe Catasetinae which deserves attention as it presents a high species richness (Chase *et al.* 2015), with about 200 species (Petini-Benelli & Chiron 2020; Damián *et al.* 2021; Krahl *et al.* 2021a; b; Govaerts *et al.* 2022; Krahl *et al.* 2022a; b) and a total of 35 natural hybrids (Cantuária *et al.* 2021; Govaerts *et al.* 2022; Krahl *et al.* 2023). This genus has an exclusively Neotropical distribution and occurs from Mexico to Brazil and northern Argentina (Romero & Jenny 1993; Romero & Carnevali 2009).

Based on vegetative morphology, *Catasetum* species are almost indistinguishable, with few exceptions, such as *C. longifolium*, which presents a very characteristic vegetative morphology (see Pessoa *et al.* 2015). Under these conditions only floral characters, especially from staminate flowers, are used as efficient to differentiate them (Holst 1999; Walker-Larsen & Harder 2000). These flowers are characterized by the presence of two modified staminodes placed in front of the gynostemium and so-called "antennae", whose main function is to throw the pollinarium onto the body of the pollinator visiting the flower (Romero 1992; Gerlach 2007). These structures have also a great taxonomic importance as it is possible to induce a subgeneric classification based on

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their presence/absence and their morphology (*e.g.* Cogniaux 1904; Bicalho & Barros 1988; Senghas 1990; 1991; Mansfeld 1932; Pabst & Dungs 1977).

Historically, *Catasetum* has been divided into two subgenera: subgenus *Pseudocatasetum* (antennae poorly developed to rudimentary or even absent, in addition to having a non-resupinate helmet-shaped lip) and subgenus *Catasetum* (antennae clearly developed). The latter is subdivided into two different sections, the section *Catasetum* (crossed and asymmetrical antennae) and section *Isoceras* (symmetrical antennae) in which three subsections (or alliances) are considered: I) *Isoceras*, with parallel antennae; II) *Divaricatae*, with diverging antennae; and III) *Convergentia*, with converging and in contact antennae (Bicalho & Barros 1988; Senghas 1990; 1991). However, it has been recently found that these subgenera are not monophyletic and that the antennae morphology does not reflect the evolutive history of the genus (Perez-Escobar *et al.* 2017; Petini-Benelli 2017; Mauad *et al.* 2022). According to Mauad *et al.* (2022) evolutionary hypothesis of *Catasetum* species can be explained by biogeography instead of antennae morphology. Indeed, the variation of the antennae is homoplastic as we can observe more than one reversion to the ancestral state (absence of antennae) along the evolution history.

The Amazon basin is considered as the diversity center of the genus (Romero & Carnevali 2009) and many species occur in the Brazilian Amazon (Silva & Silva 1998; Petini-Benelli 2022). In Brazil 126 species are recorded (Petini-Benelli & Chiron 2020; Krahl *et al.* 2021a; b; Krahl *et al.* 2022a; b; Petini-Benelli 2022), of which 38 are present in the state of Amazonas (Krahl *et al.* 2021a; Petini-Benelli 2022). We also emphasize that a total of 15 species with symmetrical and convergent antennae occur in the Brazilian Amazon (Petini-Benelli 2022).

The present work aims to propose a new *Catasetum* species from Central Brazilian Amazon. Detailed morphological description, data on geographic distribution, habitat, phenology and conservation status for the species are provided. The new species is compared to its closest and sympatric relatives as said in the following section. An identification key for species with symmetrical and converging antennae for the Brazilian Amazon is also provided.

## Material and methods

The new taxon was collected in various places of the municipalities of Manaus and Presidente Figueiredo, Amazonas, Brazil (Fig. 1). These collections were intended

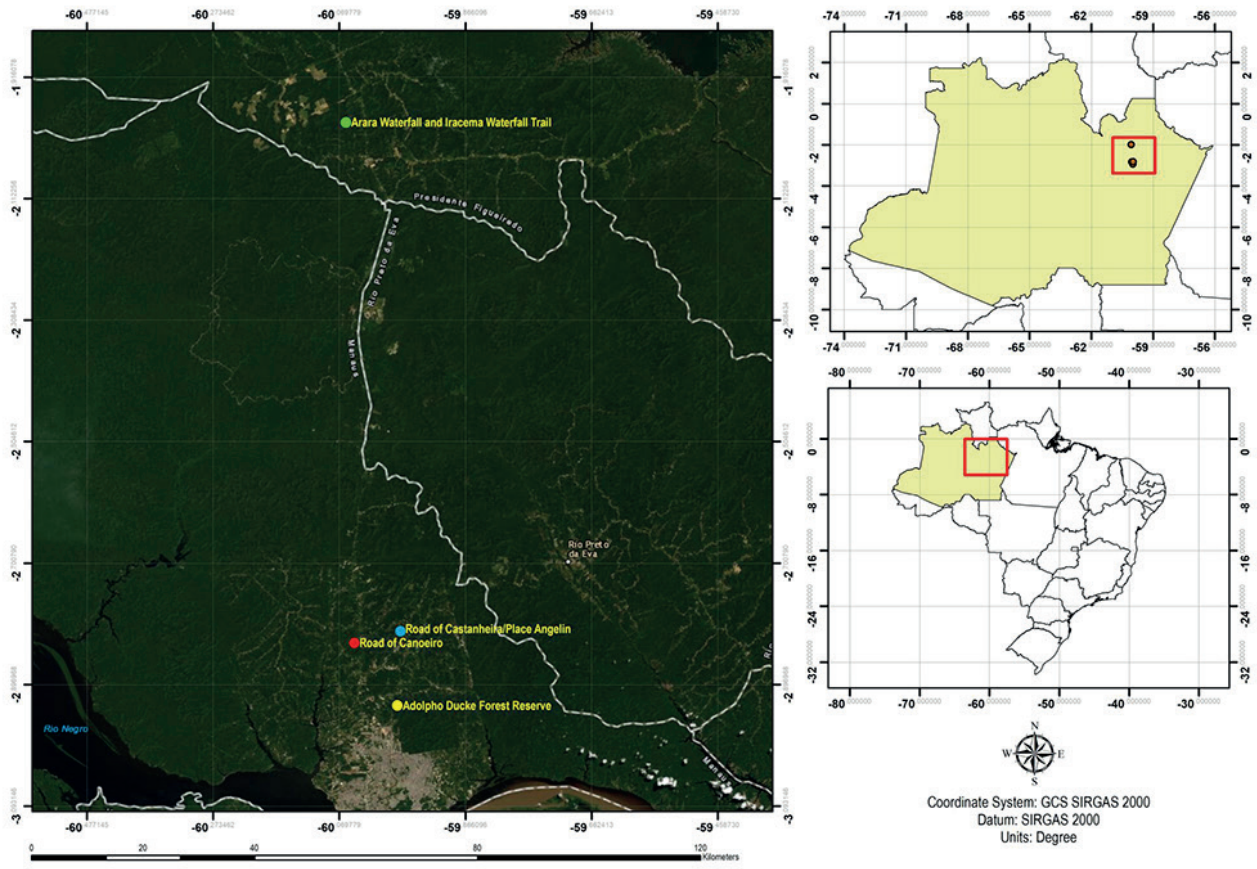


**Figure 1.** Map with the occurrence points of *Catasetum krahlii*.

to register species for the taxonomic survey of Orchidaceae in these places and, consequently, to register species for the project denominated "Flora of the Amazon: Orchidaceae". The collected material was herborized according to the usual process described in Mori *et al.* (1989) in view of subsequent incorporation into the INPA herbarium (acronym after Thiers 2021). The new taxon was compared with *C. rivularium* Barb. Rodr. (Barbosa-Rodrigues 1877) and *C. barbatum* (Lindl.) Lindl. (Lindley 1836; 1844) which are sympatric species with it. Due to the sympatric distribution and overlapping of the flowering periods of *C. rivularium* and *C. barbatum*, we further discuss and rule out the possibility of the new taxon being a natural hybrid between these two species. In table 1 we present the distinctive characters between the three taxa. The identification key for *Catasetum* species with symmetrical and convergent antennae occurring in the Brazilian Amazon was basically based on Petini-Benelli (2022).

The Extent of Occurrence (EOO) and the Area of Occupancy (AOO), two parameters used in the process of evaluating the conservation status, were calculated using the on-line platform Geospatial Conservation Assessment Tool (GeoCAT – http://geocat.kew.org/). The AOO was scaled using 2 × 2 km grid cells (Bachman *et al.* 2011). The conservation status was evaluated in accordance with the criteria of IUCN (2022).

## Results

***Catasetum krahlii* D.R.P.Krahl, Cantuária, J.B.F.Silva & Chiron, *sp. nov*.** Type: Brazil: Amazonas: Manaus: Ramal do Canoeiro, km 17 da BR 174, 2°49'46.02"S, 60°2'43.7"W, 53 m a.s.l., 10/III/2021, ♂, *A.H. Krahl 1555* (holotype HAMAB). (Figs. 2, 3).

*Catasetum krahlii Catasetum rivularium Barbosa Rodrigues similis est, ambae species antennas symmetricas convergentesque efficientes, sed labello oblongo (versus triangulare), labelli callo basale acuto unguiforme (versus cylindrico apice laciniato), fimbriis in labelli apice conjunctis (versus liberis), differt.*

Plant epiphytic cespitose. Rhizome inconspicuous, short. Pseudobulb 2.9–7.5 × 1.2–2 cm, fusiform, 4–7-leaved, covered by green leafy sheaths. Leaves 5.4–28.8 × 2.4–4.3 cm, oblanceolate, membranous, plicate, with 5–7 prominent nerves, green, margin entire, apex acute. Staminate inflorescence 20.5–27.6 cm long, lateral, racemose, sub-erect, loose, 6–12 flowers; peduncle cylindric purplish; floral bract 0.6–0.8 × 0.3–0.4 cm, lanceolate, greenish, margin entire, apex acute. Staminate flowers grouped in the distal third, pedicellate; pedicel 2.2–2.7 cm long, cylindric, erect, purplish; sepals elliptical, concave, symmetrical, greenish with brown spots, margin entire, apex acute; the dorsal one 2.6–2.8 × 0.7–0.8 cm, the lateral ones 2.5–2.8 × 0.8–0.9 cm; petals 2.2–2.3 × 0.5–0.6 cm, narrowly elliptical, symmetrical, greenish with brown spots, margin entire and reflexed, apex acute; lip 1.3–1.6 × 0.4–0.5 cm (excluding fimbriae), entire, oblong, with a callosity at the base (claw-shaped), inner surface glabrous and somewhat forming a trough in the center after the central cavity, margin fimbriate, greenish in the center with whitish fimbriae; fimbriae 0.2–0.5 cm long, filiform, rather short, thick and spaced, merging at apex to form a "V", whitish; with a conical sac 0.3–0.4 cm deep near the base, conical; basal callus 0.5–0.6 cm long, oblong, falcate, flanked by 2–3 small side horns, apically acute, whitish; column subtriangular, 1.8–2.2 × 0.5–0.6 cm long, fleshy, rostrate, brownish to lightly greenish at base in dorsal view, greenish with small brownish spots in ventral view; antennae 0.5–0.6 cm long, symmetrical, converging, greenish with pale brownish spots; anther cap 0.9–1 × 0.3–0.4 cm, rostrate, greenish; viscidium ca. 0.15 × 0.15 cm, rounded, sticky, whitish; stipe ca. 0.3 × 0.15 cm, blade-like, wound inwards, yellowish; pollinia 2, ca. 0.2 × 0.1 cm, yellowish, oblong, hard, compressed, sulcate. Pistillate inflorescence not seen. Fruit not seen.

*Etymology:* the specific epithet is given in honor of M.Sc. Amauri Herbert Krahl, a Brazilian botanist who specialized in Orchidaceae from Brazilian Amazon and described many species from the region. Moreover, he was the collector of the type and paratype specimens.

*Distribution and habitat:* the new species are apparently distributed in the Brazilian Central Amazon, more specifically, restricted to the State of Amazonas (Fig. 1). It has been found in dense rain forest habitats as well as in "terra firme" forest (non-flood habitats) and in "campinarana" vegetation (habitats of sandy soils).

*Phenology:* the taxon blooms at the beginning of the year, usually between January and March, period during which we can observe a high rainfall index in the region (Luizão 1995). It can bloom as well out of season (October) as it was observed in the population of Presidente Figueiredo, located more to the north, at about 100 km from Manaus.

*Conservation status*: the global population (as defined in IUCN Guidelines art. 4.1) is small (estimated at 100-200 mature individuals) and distributed into 2 groups (criterium Ba), one in Manaus and another in Presidente Figueiredo. The Extent of Occurrence (EOO) has been evaluated at 443 km² (corresponding to "Endangered" according to criterium B1) and the Area of Occupancy (AOO) at 16 km² (corresponding to "Endangered" according to criterium B2). Besides, although one of the subpopulations is located within a Conservation Unit, the habitats of the taxon suffer continuing deforestation (criterium Bb[ii]) and the taxon itself (a showy orchid) is extensively (and illegally) collected so that we may infer a continuing decline of the number of mature individuals (criterium Bb[v]). Finally, according to IUCN (2022), the taxon can be treated as EN (Endangered) based on criterium B: B1B2ab(v).

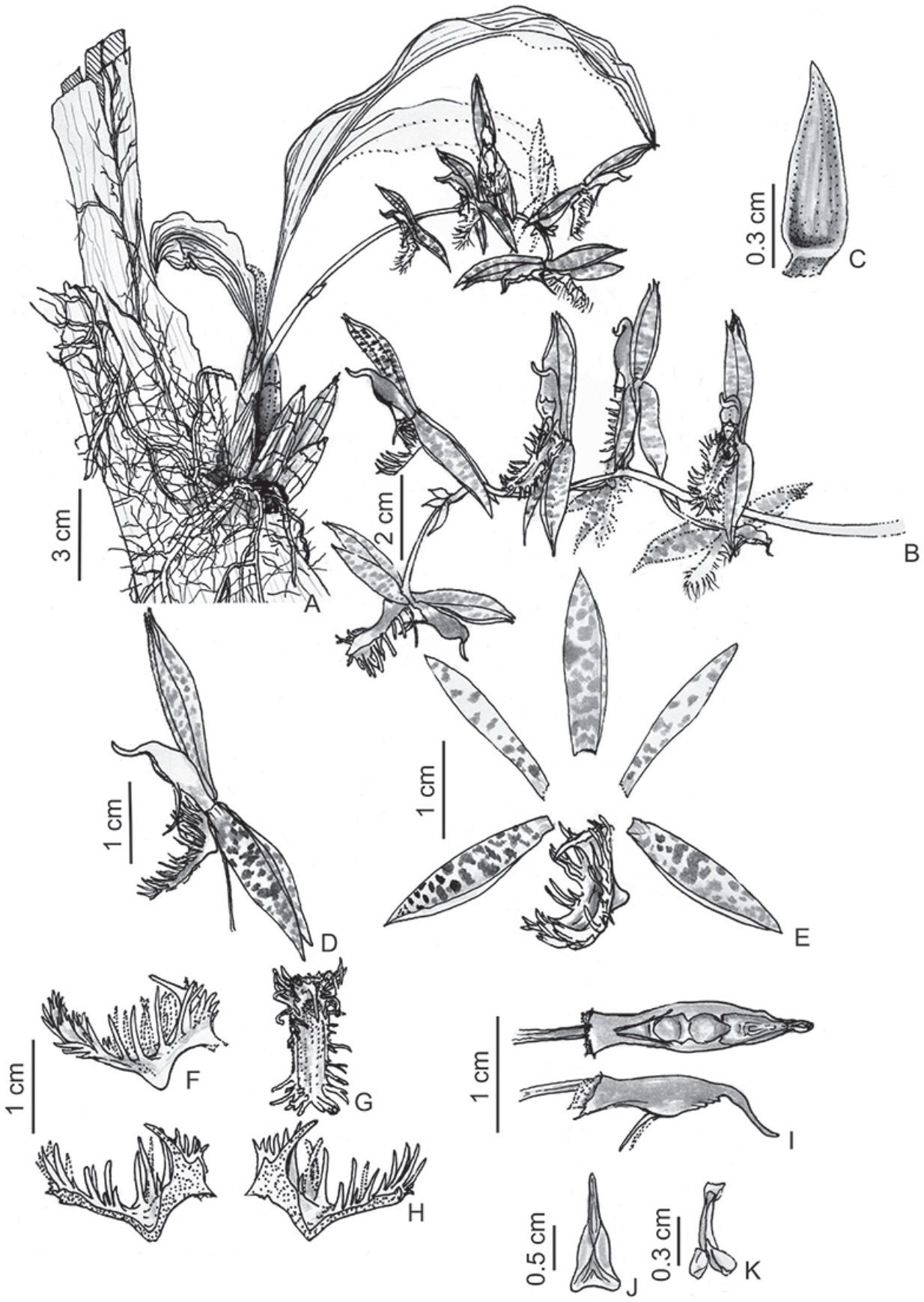


**Figure 2.** *Catasetum krahlii*. A – Habit. B – Inflorescence. C – Floral bract. D – Flower. E – Floral segments. F-H – Lip. I – Column. J – Anther cap. K – Pollinarium. Ilustration by M.F. Negrão.


**Figure 3.** *Catasetum krahlii*. A – Habit. B – Inflorescence. C – Floral bract. D-E – Flower. F – Floral segments. G-I – Lip. J-K – Column. L – Anther cap. M – Pollinarium. Photos by A.H. Krahl.

## Discussion

*Taxonomic notes*: *Catasetum krahlii* (Fig. 3) is related to *C. rivularium*, a species endemic and widely distributed in the State of Amazonas (Petini-Benelli 2022), and *C. barbatum*, present in the entire Brazil and even outside (Petini-Benelli 2022; Govaerts *et al.* 2022). They all have a sympatric distribution and differ mainly in some particular floral characters. In *C. krahlii*, when compared to *C. rivularium*, the peduncle of the staminate inflorescence and the pedicel of the flowers present a purplish coloring (vs. greenish), the sepals are elliptical (vs. oblong), the lateral ones being symmetrical (vs. asymmetrical) and the petals are elliptical (vs. lanceolate). However, the lip is the more different structure between the species and can be used to differentiate them. In *C. krahlii* the lip is oblong, with, on the margins, rather short, thick and spaced fimbriae which are fused at apex to form a "V"; moreover, the inner surface of the lip is glabrous and forms a trough as described above. In *C. rivularium* the lip is widely triangular with, on the margins, rather thin fimbriae which concentrate at apex. Besides both species differ markedly in the form of the basal callus of the lip: in the former it is oblong falcate and apically acute (claw-shaped) and a set of 2-3 small lateral horns are observed. In the latter it is cylindrical with a laciniate apex (see Barbosa-Rodrigues 1877; Silva & Silva 1998; Krahl 2020; Petini-Benelli 2022) (Fig. 4). Table 1 gives more details differentiating the taxa.

Additionally, we excluded the possibility of *C. krahlii* being a variation of *C. barbatum* because of the differences in the shape of the lip, according to the holotype of the latter (K000294039). The lip of *C. krahlii* is oblong

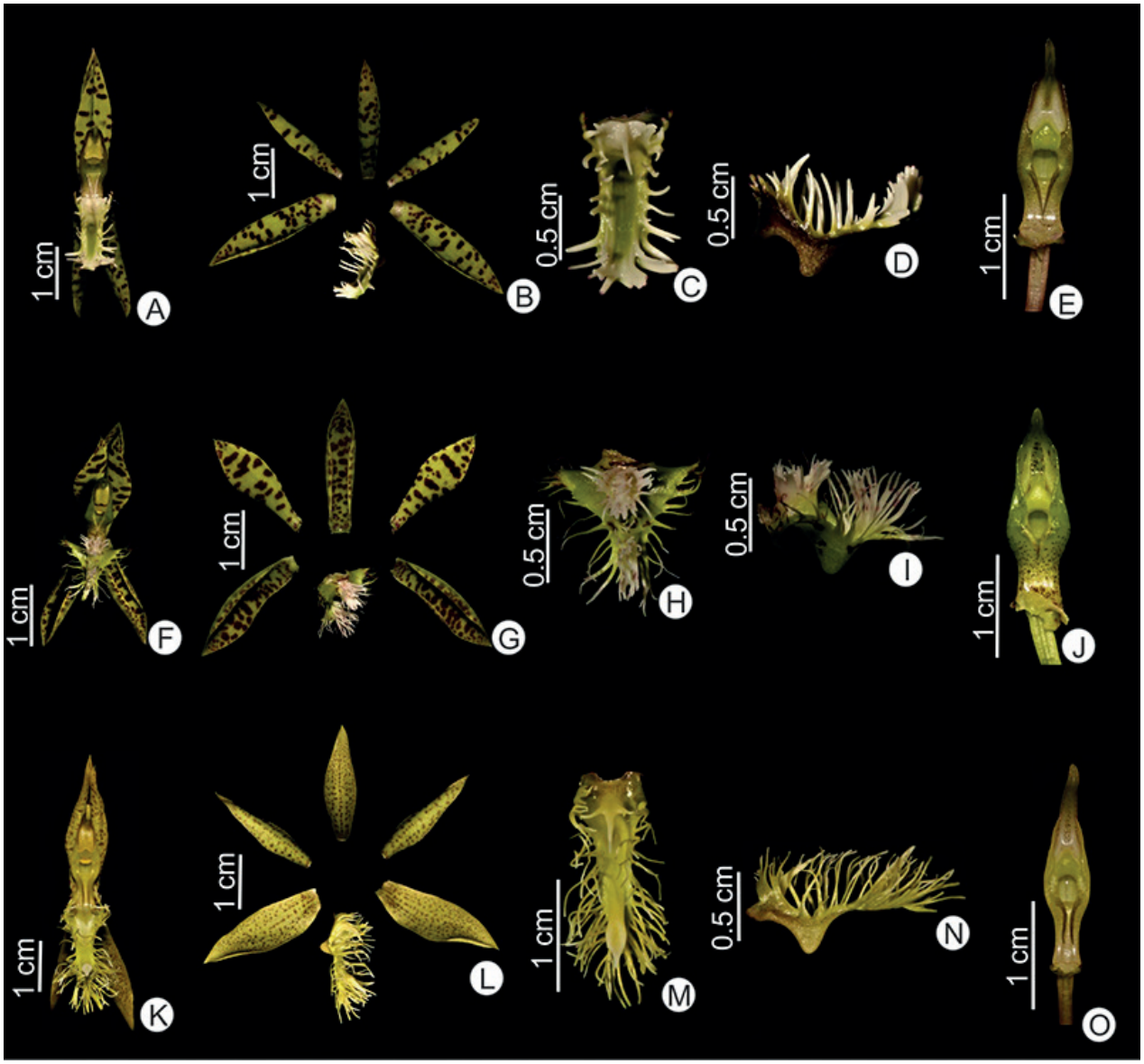


**Figure 4.** Comparison between *Catasetum krahlii* (A-E), *C. rivularium* (F-J) and *C. barbatum* (K-O).

**Table 1.** Comparison between *Catasetum krahlii*, *C. rivularium* and *C. barbatum* based on the taxonomic concepts of [1]this study, [2] Barbosa-Rodrigues (1877), [3]Krahl (2020), [4]Petini-Benelli (2022), [5]Lindley (1836), [6]Lindley (1844), [7]Petini-Benelli (2017), [8]Oliveira *et al.* (2021) and [9]personal observations.

| Characters | *C. krahlii*[1] | *C. rivularium*[2,3,4,9] | *C. barbatum*[4, 5, 6, 7, 8, 9] |
|---|---|---|---|
| Inflorescence | **Suberect, 20.5–27.6 cm long, 6–12-flowered** | Suberect or arched, 10–20 cm long, 4–15–flowered | Suberect or arched, 15–60 cm long, with up to 20 flowers |
| Pedicel | **2.2–2.7 cm long, purplish** | ca. 1.5 cm long, greenish | ca. 1.4 cm long, green and slightly purplish |
| Dorsal sepal | **2.6–2.8 × 0.7–0.8 cm, elliptic** | ca. 2.3 × 0.8 cm, oblong | 2.3–3.2 × 0.6–0.9 cm, lanceolate |
| Lateral sepals | **2.5–2.8 × 0.8–0.9 cm, elliptic, symmetrical** | ca. 2.1 × 0.9 cm, oblong, asymmetrical | 2.1–3.2 × 0.7–0.9 cm, lanceolate, symmetrical |
| Petals | **2.2–2.3 × 0.5–0.6 cm, elliptic, symmetrical** | ca. 1.9 × 0.7 cm, lanceolate, asymmetrical | 2.2–3.1 × 0.4–0.8 cm, lanceolate, symmetrical |
| Lip | **1.3–1.6 × 0.4–0.5 cm, 0.4–0.5 cm deep, oblong, the margin with rather short, thick and spaced fimbriae apically fused to form a "V"; inner surface glabrous forming a light trough** | 1.2 × 1.2 cm, 0.4 cm deep, widely triangular, the margin with rather thin fimbriae concentrated at apex; inner surface partially glabrous with fimbriae concentrated in the distal portion | 1.5–3 × 0.3–1.5 cm, 0.3 deep, oblong to oblong triangular or subtriangular, margin with dense fimbriae relatively long, thin, congested, simple and usually fringed at apex; inner surface densely fimbriated and flat |
| Basal callus of the lip | **Oblong, falcate, acute (claw-shaped), with a set of 2-3 small lateral horns** | Cylindrical apically laciniate | 3-dentate, central segment falcate, larger and more evident |
| Apical callus of the lip | **Absent** | Absent | 1–2-dentate |
| Column | **1.8–2.2 cm long** | ca. 1.8 cm long | 1.4–1.7 cm long |
| Antennae | **Symmetrical converging, 0.5–0.6 cm long** | Symmetrical converging, ca. 0.5 cm long | Parallel symmetrical, ca. 0.7 cm long |

(*vs.* oblong to subtriangular), with, on the margins, rather short, thick and spaced fimbriae which are fused at apex to form a "V" (*vs.* margin with dense fimbriae relatively long, thin, congested, simple and usually fringed at apex) and moreover, the inner surface of the lip is glabrous and forms a trough as described above *vs.* inner surface usually densely fimbriated and flat, respectively. In *C. barbatum*, a callus is still observed at the apex of the lip that can be simple or bifurcated, while in *C. krahlii* this callus is absent (Lindley 1836; 1844; Oliveira *et al.* 2021; Petini-Benelli 2017; 2022). Furthermore, these two taxa belong to different subsections of the genus according to the antennae characteristics. *C. krahlii* has symmetrical and convergent antennae, thus belonging to the subgenus *Catasetum* section *Isoceras* subsection *Convergentia*, while *C. barbatum* also has symmetrical antennae, however parallel, which makes it belonging to the subgenus *Catasetum* section *Isoceras* subsection *Isoceras* (Bicalho & Barros 1988; Senghas 1991).

As said above, in view of sympatric distributions and overlapping flowering times, we have to consider the possibility of natural hybridization between *C. rivularium* and *C. barbatum* and of *C. krahlii* being the result of it. However, as it is usually observed, each character of a natural hybrid is intermediate between those of the parents. It is not the case with *C. krahlii*. So, it is with the lip morphology, a very diagnostic feature in *Catasetum*. The lip shape would present a base much wider than the apical part in accordance with the triangular lip in *C. rivularium* and *C. barbatum*, whereas *C. krahlii* presents an oblong lip. Dealing with a hybrid the lip apex would present thinner and more free fimbriae as observed in *C. rivularium* and *C. barbatum*; the basal callus in the lip would be somewhat reminiscent of the cylindrical, apically laciniate callus observed in *C. rivularium*; a second callus would be present at the lip apex as observed in *C. barbatum*: none of these characters is present in *C. krahlii*. We can also note discrepancies in flower pedicels (ca. 1.5 cm in *C. barbatum* and *C. rivularium vs.* 2.2-2.7 cm in *C. krahlii*). Consequently we discarded the hypothesis of natural crossing.

Additional material examined (paratypes): BRAZIL: AMAZONAS: Manaus: Reserva Florestal Adolpho Ducke, próximo ao igarapé do Barro Branco, 2°55'50.1"S, 59°58'33.9"W, 80 m a.s.l., 06/I/2019, ♂, *A.H. Krahl & D.R.P. Krahl 940* (INPA); Ramal das Castanheiras, km 17 da BR 174, Sítio Angelim, 2°48'38.4"S, 59°58'16.3"W, 90 m a.s.l., 24/II/2019, ♂, *A.H. Krahl 1111* (INPA); Presidente Figueiredo: trilha entre a cachoeira da Iracema e cachoeira da Arara, 1°59'21.1"S, 60°3'31.8"W, 99 m a.s.l., 18/X/2020, ♂, *A.H. Krahl 1521* (INPA).

*Key to **Catasetum** species with symmetrical and convergent antennae from the Brazilian Amazon*

1. Non-resupinate flowers ..... 2
1'. Resupinate flowers ..... 3
2. Arched inflorescence; lip midlobe with a conical or semicircular callus ..... *C. fimbriatum*
2'. Pendent inflorescence; lip midlobe without any callosity ..... *C. kraenzlinianum*
3. Trilobed lip ..... *C. colidense*
3'. Entire lip ..... 4
4. Lip presenting fimbriae ..... 5
4'. Lip without fimbriae ..... 7
5. Lip oblong ..... *C. krahlii*
5'. Lip triangular or ovoid ..... 6
6. Triangular lip bordered by spaced fimbriae that are concentrated at the apex ..... *C. rivularium*
6'. Ovoid and densely fimbriated lip ..... *C. reichenbachianum*
7. Lip margin rather smooth ..... 8
7'. Lip margin crenate or denticulate ..... 12
8. Lip oblong to ligulate ..... *C. tigrinum*
8'. Lip obovate to ovate or triangular to deltoid ..... 9
9. Inflorescence erect to arched; lip slightly bag-shapped; apex of lip with callosity ..... 10
9'. Inflorescence arched to pendent; lip deeply bag-shapped; apex of lip without callosity ..... 11
10. Lip apex ending into an obtuse to truncate callus ..... *C. tenebrosum*
10'. Lip apex with an acute callus ..... *C. sophiae*
11. Inflorescence arched to pendent with spaced flowers; flattened lip in side view; lip apex discreetly tridentate ..... *C. complanatum*
11'. Inflorescence pendent with congested flowers; rounded lip in side view; lip apex obviously tridentate ..... *C. pulchrum*
12. Inflorescence erect to arched ..... 13
12'. Inflorescence completely pendent ..... 14
13. Lip deltoid to triangular; lip margins crenate ..... *C. juruenense*
13'. Lip oblong-ovate; lip margins denticulate ..... *C. schunkei*
14. Inflorescence with spaced flowers; lip elliptic ..... *C. denticulatum*
14'. Inflorescence with congested flowers; lip oval ..... *C. ivaneae*

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