

Cyperus kilelai (Cyperaceae), a new species from a thermal spring in Katanga (Democratic Republic of the Congo)

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Abstract

Background – During field work performed in 2018 by the University of Lubumbashi in the Katanga region of D.R. Congo, a peculiar *Cyperus* species was discovered at the edges of a thermal spring in the southwest corner of the Upemba graben, near the city of Luena.

Material and methods – Herbarium material from the collected plant was studied and used as a basis for illustrations and a SEM study of the nutlets. A preliminary IUCN Red List assessment was performed according to the IUCN Guidelines and Criteria.

Results – *Cyperus kilelai*, a new species from Katanga in D.R. Congo, is described and illustrated. This small tussocky species is characterised by weakly 3–4 angled dimerous nutlets with stigma branches in ad- and abaxial positions and glumes of 2.5–3.2 mm long. It is currently only known from its type location. Thermal springs in this region are of interest for the development of geothermal power plants in the near future. Based on the restricted area, a small population size, and a plausible future threat, the conservation status of this species is preliminarily assessed as Vulnerable.

Keywords

Cyperus, Cyperaceae, Democratic Republic of the Congo, thermal spring

INTRODUCTION

The Cyperaceae genus *Cyperus* L. comprises about 960 species worldwide (Larridon et al. 2021). In its current circumscription (Larridon et al. 2013), *Cyperus* consists of two subgenera characterised by different photosynthetic pathways. While the C3 species (*C.* subg. *Anosporum*) form a well-resolved grade at the basis of the phylogeny, the majority of the species are nested in a monophyletic but poorly-resolved clade characterised by C4 photosynthesis (*C.* subg. *Cyperus*). Within both subgenera, several specialised lineages have developed which have previously been considered as separate genera

but are now sunk into *Cyperus* s.l. based on molecular phylogenetic data (Larridon et al. 2013, 2014). With 120 species, *Pycreus* P.Beauv. was the largest of these former genera (Goetghebeur 1986). All the species of this group use C4 photosynthesis and are characterised by a combination of laterally compressed dimerous pistils with deciduous glumes and nutlets (Clarke 1908; Goetghebeur 1986). The centre of diversity of *Pycreus* can be found in Africa, where it is well represented in the Sudano-Zambesian phytochorion (Hoenselaar 2010; Vollesen 2020). The Zambesian region is one of the richest parts of Africa with 36 *Pycreus* species (Vollesen 2020).

As the relationships within the C4 clade of *Cyperus* are still poorly resolved, it has not been possible yet to produce a modern sectional classification of this group. The last global sectional classification of *Pycurus* species dates back to Kükenthal (1936), who treated the genus on the subgeneric level in *Cyperus*. He including 12 sections grouped into two main groups according to the shape of the nutlet epidermal cells, which were either isodiametric (often with silica bodies) or elongated. However, there are many species which appear to have an intermediate shape and this character does not seem to be reliable for sectional delimitations (Reynders 2013). Despite the overall low resolution, molecular data suggest a clear relationship between Kükenthal's sections *Rhizomatosi* Kük., *Albomarginati* Kük., *Pumili* Kük., and *Polystachyi* C.B. Clarke (= sect. *Pycurus*), which are generally linked to lowland ruderal or pioneer habitats (Reynders 2013), while the other sections cluster together in a morphologically and ecologically more heterogenous group, consistently sister to *Cyperus laevigatus* L., a species with dorsiventrally flattened dimerous pistils. Therefore, *Pycurus* is most likely to be considered as para- to polyphyletic (Reynders 2013; Larridon et al. 2014).

There are many hot springs and salt pans in the area covered by the former province of Katanga. Unfortunately, detailed botanical inventories have not yet been carried out for most of these localities. The Mwanshya salt pan, the most extensive and best maintained in the region, is the only one that has been studied in depth (Symoens 1953; Malaisse 1988). Water with a temperature of 35 to 40°C is coming out of the cracks and joints of the platform of the Mwanshya saline. At least one endemic plant species (*Sphaeranthus salinarum* Symoens) and one fish species (*Tilapia salinicola* Poll, 1948) have been described. There is a lack of knowledge about other salt pans and hot springs, some of which, like the Njuba saline, are currently being destroyed or threatened by human activities.

During field work performed in 2018 by the University of Lubumbashi in the Katanga region of D.R. Congo, a peculiar *Cyperus* species was discovered at the edges of a thermal spring called “Mayi ya moto” in the south-western corner of the Upemba graben, ca 20 km from the city of Luena. In this work, we describe this new *Cyperus* species which seems to be restricted to its type locality.

MATERIAL AND METHODS

This study was performed using herbarium material and applying standard herbarium techniques (de Vogel 1987). Acronyms of institutes holding herbarium collections follow Thiers (2024). The BR and LSHI herbaria were thoroughly checked for unidentified specimens belonging to the new taxon.

The preliminary IUCN Red List assessment follows the criteria and guidelines of the IUCN (IUCN Standards and Petitions Committee 2024). After publication, the assessment will be delivered to the appropriate IUCN

Authority (CARLA, Central African plants Red List Authority) through their Species Information System (SIS) for final approval and publication on their Red List website.

For the Scanning Electron Microscopy, nutlets were transferred to stubs and placed in a Sputter Coater for gold coating (Balzers Union SCD 020, Balzers Union Ltd., Liechtenstein). SEM was carried out using a JEOL JSM-7100FLV Field Emission SEM (JEOL, Peabody, MA, USA).

RESULTS AND DISCUSSION

The new species was discovered in the Haut-Lomami province, upper Katanga region. This province is part of the former Katanga province, which is well-known for its high level of endemism, often associated with the presence of copper, cobalt, and other heavy metals (Malaisse et al. 2016). It is part of the Central Zambebian bioregion which has 23% of endemic plant species (Droissart et al. 2018) and is also one of the centres of diversity of this peculiar group of *Cyperus*. Especially in seasonally wet habitats, many (often therophytic) species of the former genus *Pycurus* occur there. These are each characterised by very peculiar, derived morphologies, but are also very hard to place among the existing sections. The specimens of the new species also display such unique characteristics. Based on the diagnostic features (shape of the nutlet epidermal cells and size of the glumes), the new species best fits *C. sect. Propinqui* C.B. Clarke in Kükenthal's (1936) classification, which though has been proven to be a very heterogeneous, unnatural section (Reynders 2013).

The nutlet of *Cyperus kilelai* has 3–4 angles of which the abaxial one is clear but the adaxial ones are variable and weaker. Reynders et al. (2012) showed the presence of congenital fusion of the carpels in Cyperaceae facilitate the origin of peculiar pistil types with stigma branches in new positions as is the case for the laterally compressed dimerous pistils in some derived lineages of *Cyperus*, such as *Pycurus*. The four angled condition in *C. kilelai* might represent an intermediate state with the ancestral trimerous condition but can also be a more derived state as observed also in *C. subtrigonus* (C.B. Clarke) Kük.

Cyperus subtrigonus is a species from Central Africa, but otherwise, it differs significantly from the new species in its spikelets (denser, and shorter), glumes (dark reddish brown with green midrib, shorter 1.6–2 mm), zig-zag rachilla, and ecology (disturbed freshwater swamps in the Guineo Congolese phytochorion). In addition, it has strongly elongated nutlet epidermal cells and is undoubtedly belongs to the *C. flavescens* L. alliance.

Cyperus kilelai also superficially resembles to *C. flavidus* Retz. in its habit, leaves with long sheaths, basal ones often reduced to their sheaths, the long spikelets with straight rachilla, and glumes with a similar shape. The latter is a primarily Asian species, which also occurs in South Africa, the Mediterranean basin, and Madagascar.

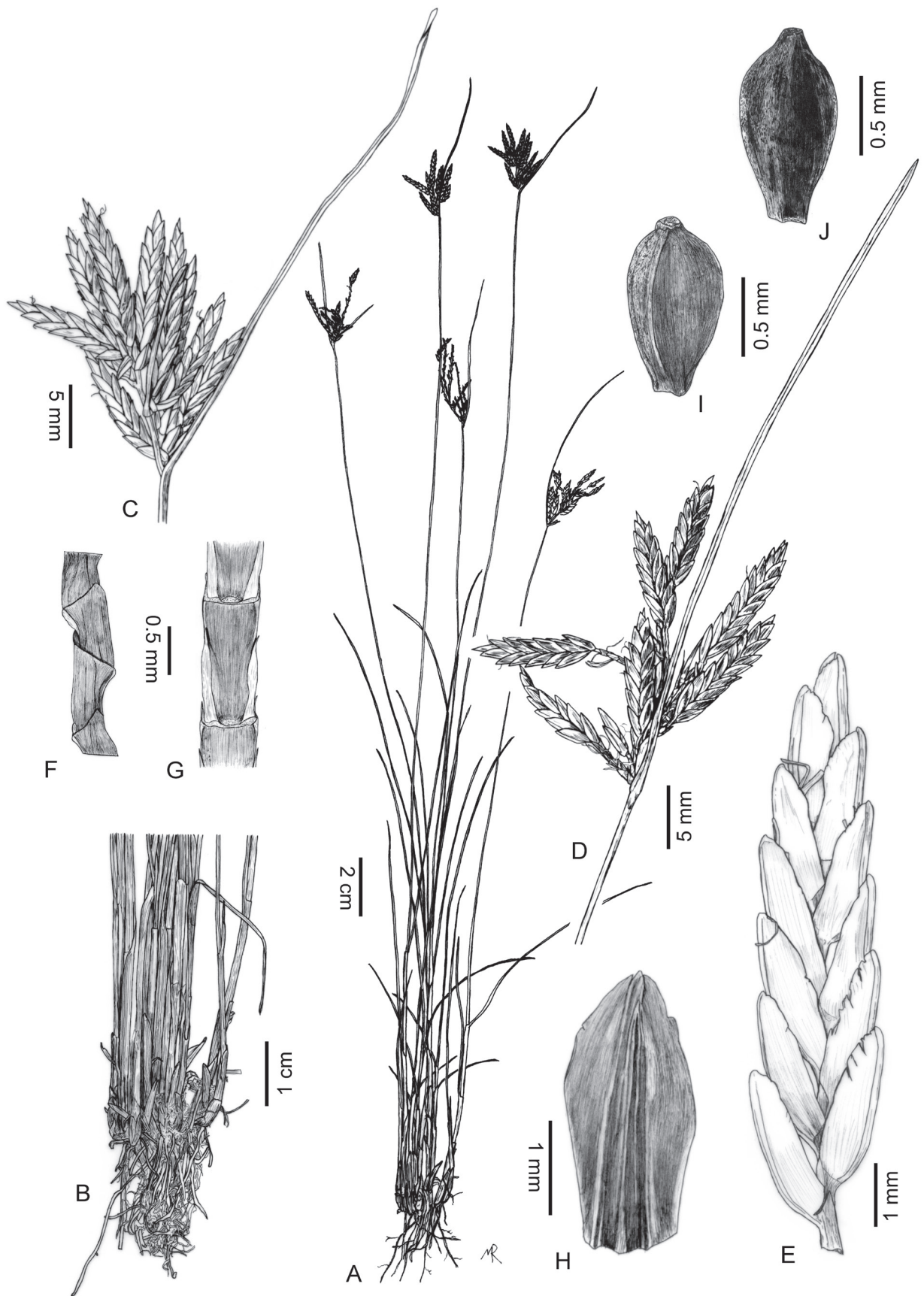


Figure 1. Morphological characteristics of *Cyperus kilelai*. A. Plant habit. B. Plant base. C, D. Inflorescence. E. Spikelet. F, G. Details of the rachilla. H. Glume. I, J. Nutlets. Drawn from *J. Kilela* 25 (BR) by Marc Reynders.

However, *C. flavidus* has smaller (2–2.2 mm) glumes with a hyaline margin and strongly compressed nutlets with strictly isodiametric cells with silica bodies.

There are more restricted Cyperaceae species known from the thermal springs of the Katanga region, most of them belonging to *Cyperus*. Our new species is possibly related to the other *Cyperus* species inhabiting thermal springs. The Cyperaceae species in these habitats are all C4 species, annuals or tussock perennials (Beentje 2010). *Cyperus lipothermalis* Goetgh. (= *Lipocarpha thermalis* J. Raynal ex Goetgh.) was found in only one spring near Kiabukwa (region Manono) (Goetghebeur and Van den Borre 1989). *Pycreus sanguineosquamatus* Van der Veken was also considered an endemic of some thermal salt springs of Katanga, but recently, this species was synonymised with *C. fontinalis* (Cherm.) Kük. (*Cyperus* sect. *Fontinales* Kük.), which was described from the Central Madagascar thermal springs (Larridon et al. 2014). Both *C. kilelai* and *C. fontinalis* have smooth nutlets with only slightly elongated epidermal cells, lacking silica bodies. However, they differ in the shapes and sizes of their nutlets, *C. fontinalis* having larger glumes of more than 3 mm and lenticular, round shaped nutlets larger than 1.5 mm. *Cyperus fontinalis* is sometimes associated with *Cyperus juncelliformis* Peter & Kük. (*C.* sect. *Globosi* C.B. Clarke), which is very scattered in the Katanga region and it is also known from the Uvinza region of Tanzania, where many salt seepage springs occur that are economically exploited (Sutton and Roberts 1968). The latter is easily recognisable by its glumes with rounded tips and broad hyaline margins. In addition, *Cyperus xantholepis* (Nelmes) Lye is often present but is not restricted to this habitat (Symoens 1953). Along thermal and salty springs and lakes (not only in Katanga), the most common *Cyperus* species is *C. laevigatus*. Although this species has dorsoventrally flattened pistils, it is closely related to a clade including, among others, all of the other mentioned hot spring *Cyperus* species (with exception of *C. lipothermalis*) (Larridon et al. 2014).

TAXONOMIC TREATMENT

Cyperus kilelai Mesterházy & Reynders, **sp. nov.**

urn:lsid:ipni.org:names:77347854-1

Figs 1–3

Type. DEMOCRATIC REPUBLIC OF THE CONGO • Haut-Lomami, Upemba region, 22 km SW of Kanonga village, edges of a thermal spring called “Mayi ya moto” (which means warm water in Swahili); 09°22′44″S, 25°59′08″E; 665 m; 26 Jun. 2018; *J. Kilela* 25; holotype: LSHI; isotypes: BR [BR0000026212845V]; BP.

Diagnosis. This small tussocky species differs from all other *Cyperus* species by the combination of (weakly) 3–4 angled nutlets of the laterally compressed dimerous type, pale glumes 2.5–3.2 mm long, and an ecological restriction to mineral-rich thermal springs.

Description. Small annual or tussocky perennial. Culms many per tussock, erect, 20–37 cm long, new ones originating from higher nodes of older culms. Leaf blade filiform, 2–23 cm long × 0.3–1 mm wide, the lower ones often reduced to their sheaths. Inflorescence a single (or two) sessile clusters of 3–6 spikelets (rarely a single spikelet). Involucral bracts usually two, spreading to erect, 0.5–7 cm long. Spikelets 6–24 × 1.8–2.5 mm, lanceolate, rachilla 0.4–0.5 mm wide, slightly zigzag, persistent. Glumes not closely imbricate, 2.5–3.2 × 0.8–1.2 mm, deciduous, strongly concave, yellow to light brown, elliptic, flanks veinless, without hyaline margin, obtuse with pale, 3-veined midrib reaching the tip. Stamens 2, anthers yellow, 1–1.4 mm long. Stigma branches 2, in ad- and abaxial positions. Nutlet dark-brown, obovate, variable with 3–4 angles (often 1 strong and 3 weaker), apiculate, 1.2–1.5 × 0.5–0.7 mm, smooth, epidermal cells slightly elongated, without silica bodies.

Distribution. Endemic to the south-east of the Democratic Republic of the Congo. Currently, this species is only known from its type location. As botanical studies

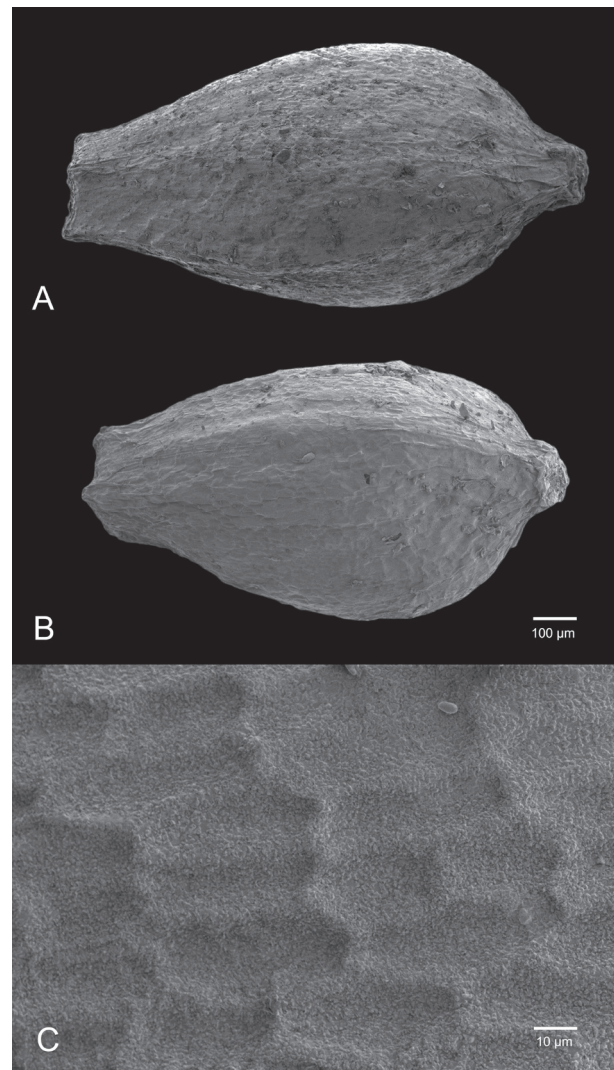


Figure 2. SEM photographs of *Cyperus kilelai*. A, B. Nutlet. C. Detail of the nutlet epidermal cells. Taken from *J. Kilela* 25 (BR).

have not yet been performed in many of the hot springs in the Upemba graben and new springs are still being discovered (Odhipio et al. 2020), this species may have a much larger range. The case of *C. fontinalis*, which has been collected from southern D.R. Congo, Zambia, and Central Madagascar shows that strongly disjunct hot spring habitats are possible for similar species (Reynders 2013). Within the Zambesian phytochorion, several other rift related regions possess many hot springs that could be suitable habitats for *C. kilelai*: the Zambezi rift on the border of Zambia and Zimbabwe and the graben of the Sabe river in eastern Zimbabwe (Gerald et al. 1965).

Habitat and ecology. The species is locally abundant and monodominant, growing in patches of 1 to 3 metres on wet mud along the edge of the thermal spring (“Mayi ya moto”). Its regrowth from higher nodes of older culms allows it to overcome addition of sediments by water or wind. The thermal spring where *C. kilelai* grows is very hot, with a temperature about 70–80°C at the source. *Cyperus kilelai* occurs at the sites where the water is cooler,

at about 30–40°C. The soil is white due to the deposition of carbonate minerals and the soil layer on the bedrock is shallow. The species becomes less abundant when the mineral concentration and temperatures are decreasing, approx. 25–30 m from the spring. These springs are further relatively species poor, dominated by grass-like plants, except some palms and small trees. In higher areas, *C. kilelai* is replaced by *Imperata cylindrica* (L.) P.Beauv. (Poaceae) and *Cyperus laevigatus* L.

Phenology. The type collection was made in June during which both flowering and fruiting culms were observed. Most likely the phenology of this species is similar to other Cyperaceae species in this region: it starts flowering shortly after the rainy season periods. Presumably, the flowering period lasts from May to July. Although *C. kilelai* primarily seems to be a perennial species inhabiting permanently wet soils, it is very likely to have a short generation cycle which allows it to survive drier periods as an annual.



Figure 3. Field photographs. **A.** The discoverer of the new species Jacques Kilela Mwanasomwe collecting a specimen at the thermal spring. **B.** Part of the population of *C. kilelai* existing of scattered tussocks on salty wed mud. **C.** Detail of a tussock of *C. kilelai*. Photographs: A by Diedo Mutombo Ngoy, B–C by Jacques Kilela Mwanasomwe.

Etymology. The species name commemorates Jacques Kilela Mwanasomwe, a plant ecologist of the University of Lubumbashi, who collected the type material of the species.

Preliminary IUCN conservation assessment.

Vulnerable: VU (D2). *Cyperus kilelai* seems to be a restricted species, which is only known from the type locality in the southwest corner of the Upemba graben, about 17.5 km south of lake Kabwe. The Upemba graben is very rich in thermal springs and these Rift-related springs are in general characterized by their high temperature and sulphurous-carbonated chemical composition (Mathieu 1912; Odhipio et al. 2020). Brine springs containing chloride are also present but very scarce in the Upemba region (Salines de Ganza near the Kanandula river, see Van Meel 1966). These are more common in the south of Katanga due to the likable presence of a precambrian halite evaporative deposit, but the latter springs are generally much colder (Buffard and Grujenschi 1979). Although many thermal springs in the Katanga region were visited by botanists (Jean Jacques Symoens, Gaston François de Witte, Stanisław Lisowski) during the 20th century, our new taxon did not appear in their collections. Deep botanical and vegetation researches were done only in the south of Katanga, in the salt springs of Mwashya (Symoens 1953; Malaisse 1988), where *C. kilelai* does not seem to be present. Therefore, we think that even if it would occur in other thermal springs, this must be a rare species, and the local area of occupancy would always be very limited. The single known population is estimated to grow over an area of approx. 1600 m², with a population size between 250 and 1000 mature individuals. The type locality of *C. kilelai* is located outside of the Upemba National Park near several small villages (Saka, Kakesa), where farming families live. The local people consider the thermal spring as a holy place, where ancestors and extra-human powers are present and they therefore do not disturb it. In addition, this spring can be found on a hard bedrock where the salt cover is thin and probably poor in chloride. Therefore, it is unsuitable for salt exploitation. However, the locality is situated in a study area for the installation of large geothermal power plants, especially the very hot springs of the Upemba graben are of high interest (Makuku 2019; Odhipio et al. 2020). Based on this, the only known location for *C. kilelai*, and other locations in the region where the species may occur are potentially highly threatened by human activities in the near future. Another potential threat are the use and alteration of these thermal spring for bathing. For example, in Antsirabe (Central Madagascar), at the type locality of *Cyperus fontinalis*, a spa hotel was built shortly after the collection of this species, as was annotated on the type specimen. Also, the other thermal springs around the town are adjusted and exploited for bathing and in none of these locations, *C. fontinalis* was found during the expedition of Larridon et al. in 2010 (Reynders 2013). However, exploitation for bathing does not seem to be a common or traditional practice in the Katanga region but

might gain interest in the future, especially in touristic locations. Due to the small population size, the small AOO and EOO, and the presence of a future threat, we assess *C. kilelai* as Vulnerable (VU), following criterion D2 (IUCN Standards and Petitions Committee 2024).

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