

## Additions to the bryophyte floras of Angola and São Tomé & Príncipe

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Frank Müller, Thea Lautenschläger & James R. Shevock

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**Abstract:** Five liverwort species (*Cheilolejeunea krakakammae*, *Cololejeunea latilobula*, *Cylindrocolea abyssinica*, *Telaranea nematodes*, *Thysananthus humilis*) and five moss species (*Calyptothecium planifrons*, *Calymperes tenerum*, *Fissidens usambaricus*, *Leptotrichella nitidula*, *Trichostomum lorifolium*) are reported as new for the bryophyte flora of Angola. *Fossombronia indica* is reported as new for the country of São Tomé and Príncipe, Gulf of Guinea, West Africa. An additional two hepatic species (*Lejeunea acuta*, *Solenostoma dusenii*) are reported as new for Príncipe.

**Key words:** biodiversity, bryophytes, distribution, Gulf of Guinea, inventory, tropical forests, liverworts, mosses, new records, Palaeotropis, Africa

### Introduction

Angola is one of the most poorly known countries in Africa for its bryophyte flora. Müller (2015) reported 94 new records of liverwort and moss taxa for Angola. The collections on which these results are based were made mainly by the first author during a 10-day collecting trip in 2013, supplemented by a few additional specimens collected by the second author with Matthias Nuß. These collections were made mainly in the province of Uíge, which is situated in the far north part of Angola about 200 km northeast of the capital Luanda. An additional new species record for Angola was reported by Müller *et al.* (2018). During 2015, 2016, 2017, and 2018 the second author made four trips to Angola and has collected additional bryophyte material. Among this material there are several species new for Angola.

In the last years we have published a series of papers on the bryophyte flora of São Tomé and Príncipe mainly basing on the results of the determination of the extensive material collected by the third author during three collecting expeditions in the years 2010, 2012, and 2013 (Enroth & Shevock 2011, Müller *et al.* 2011, Müller & Shevock 2018, Pócs *et al.* 2015, Shevock *et al.* 2013, Sollman *et al.* 2016). A subsequent expedition in 2016 revealed additional new records for the country or for individual islands.

In this paper we would like to present these new records for Angola and São Tomé & Príncipe.

### Results

The following inventory of taxa lists new distributional records for the countries of Angola and São Tomé & Príncipe, and for individual islands, that have not been previously published. The collections in Angola were made by the second author during 2015-18. If not otherwise stated this material was determined by the first author. The collections in São Tomé and Príncipe were made by the third author on an expedition during November 2016. If not otherwise stated, this material was determined by the first author. Voucher specimens are conserved in the herbaria indicated behind the collection numbers (São Tomé and Príncipe) or behind the collector names (Angola specimens). Ten new country records for Angola, one new country record for São Tomé and Príncipe and two new records for Príncipe are presented.

## ANGOLA

### *Calypothecium planifrons* (Ren. & Card.) Argent

**Angola:** Province Uíge, Quimbele 30 km S, swampy forest area, epiphytic, 1056 m, 6°46'54.5"S, 16°12'30.7"E, 23 Jul 2015, *T. Lautenschläger* (DR 44288).

New for Angola. The species was described from Madagascar and for a long time it was regarded as an African endemic, but later the species was also recorded from the Neotropics (Reese 1985). In Africa the species is relatively rare, and reported from Central African Republic, Chad, Kenya, Madagascar, Tanzania, Democratic Republic of the Congo, and Zambia (O'Shea 2006). At the new site in Angola the species was found growing as epiphyte in a swampy forest embedded in forest savannah (Fig. 1). At this site the species is accompanied by *Leucomium strumosum* (Hornsch.) Mitt., *Pelekium varians* (Welw. & Duby) Touw and *Rhacopilopsis trinitensis* (Müll.Hal.) Dixon. On the forest ground there is growing *Sphagnum planifolium* Müll.Hal., a species just recently reported as new for Angola from Mucaba forest about c. 130 km to the WSW (Müller 2014).

### *Calymperes tenerum* Müll.Hal.

**Angola:** Province Uíge, Uíge 54 km WNW, secondary forest (banana plantation), on rocks, 445 m, 7°31'28.0"S, 14°34'04.1"E, 14 Oct 2016, *T. Lautenschläger* (DR 44428).

New for Angola. This pantropical species is common and abundant in the Indo-Malaysian region and Oceania but rarer in the Americas and Africa (Reese 1987). It is quite widespread on the islands of the western Indian Ocean. In mainland Africa and from the islands in the Gulf of Guinea it is known from Benin, Bioko, Ghana, Ivory Coast, Kenya, Nigeria, South Africa, Tanzania, and D.R. Congo (O'Shea 2006).

### *Cheilolejeunea krakammae* (Lindenb.) R.M.Schust.

**Angola:** Province Uíge, Uíge 25 km NE, Pambu, secondary forest (coffee plantation), epiphytic, 1244 m, 7°25'59.1"S, 15°10'23.1"E, 19 Jul 2015, *T. Lautenschläger* (DR 44301 & 44302).

New for Angola. A palaeotropical species, known from New Zealand, Australia, Asia and Africa. In Africa the species is mainly distributed from the eastern and southern part of mainland Africa and from the East African islands. Müller & Pócs (2007) reported it first for West Africa from Bioko.

### *Cololejeunea latilobula* (Herzog) Tixier

**Angola:** Province Uíge, Uíge 54 km WNW, Gruta de Zenzu, 562 m, wet forest, epiphytic, 7°31'09.5"S, 14°33'53.7"E, 23 Nov 2015, *T. Lautenschläger* (DR 44349)

New for Angola. A pantropical species, previously known to be restricted to Asia and Africa, but in recent years also reported from the Neotropics (Pócs *et al.* 2014). In Africa the species was known for a long time as *C. himalayensis* (Pandé & Misra) R.M.Schust. and under this name it is treated in Wigginton (2004), a species synonymized under *C. latilobula* by Tixier (1985). In Africa the species is previously known from Burundi, Comores, D.R. Congo, Ethiopia, Malawi, Nigeria, Réunion, Rio Muni, Rwanda, Seychelles, Tanzania, Uganda, and Zambia (Wigginton 2018).

### *Cylindrocolea abyssinica* (Gola) Váňa

**Angola:** Province Uíge, Quimbele 10 km S, Kibokolo forest, forest savannah, epiphytic, 834 m, 6°36'47.5"S, 16°12'14.9"E, 21 Jul 2015, *T. Lautenschläger* (DR 44315).

New for Angola. Endemic to Africa where it is already known from Central African Republic, Cameroun, D.R. Congo, Ethiopia, Ghana, Ivory Coast, Lesotho, Madagascar, Mozambique, Nigeria, Rwanda, South Africa, Sierra Leone, Swaziland, Tanzania, Uganda, and Zimbabwe (Wigginton 2018). As reported by Wigginton (2004) this species is not always

confined to sites of high humidity, and therefore, penetrating from the rainforest to the wet savannah zone. The new site in Angola is also situated in forest savannah (Fig. 2), where it is growing as an epiphyte.

***Fissidens usambaricus* Broth.**

**Angola:** Province Uíge, Uíge 21 km SW, Serra Pingano, rainforest, earthy slopes, 666 m, 7°43'43.7"S, 14°54'05.8"E, 20 Feb 2017, *T. Lautenschläger* (DR 54789); Province Uíge, Maquela do Zombo 75 km WNW, forest remnant, 796 m, 5°58'28.7"S, 14°53'08.5"E, 24 Feb 2017, *T. Lautenschläger* (DR 54791)

New for Angola. A widespread African endemic, known from Macaronesia (Cape Verde Islands), west tropical Africa (Ivory Coast, Nigeria), west central tropical Africa (Cameroon, Central African Republic, D. R. Congo, Gabon, Rwanda, São Tomé), northeast tropical Africa (Ethiopia), east tropical Africa (Kenya, Tanzania, Uganda), south tropical Africa (Malawi), and southern Africa (South Africa, Swaziland) (Bruggeman-Nannenga 2017).

***Leptotrichella nitidula* (Mitt.) Ochyra**

**Angola:** Province Uíge, Uíge 170 km N, Maquela, on open soil banks together with *Fissidens intromarginatus*, 855 m, 6°04'24.3"S, 15°12'56.9"E, 17 Feb 2018, *T. Lautenschläger* (DR 54794).

New for Angola. In Africa the genus is still in need of a critical revision. In O'Shea (2006) there are listed about 10 species for sub-Saharan Africa and many of them are only known from a single locality or country. More widely distributed in Africa are *L. minuta* (Hampe) Ochyra, a species restricted to southern and eastern Africa including the East African islands, and *L. nitidula*, a West African species previously known from Central African Republic, Gabon, Ghana, Ivory Coast, Nigeria, Togo, and D.R. Congo (O'Shea 2006). From the same distribution area as *L. nitidula* there is also reported *L. subnitidula* (Thér. & P.de la Varde) Ochyra, but this species could be separated by slightly falcate, more longer tapering leaves and capsules constricted below the mouth (Potier de la Varde 1936).

***Telaranea nematodes* (Austin) M.Howe**

**Angola:** Province Uíge, Mucaba 6 km NE, forest remnant, epiphytic, 1209 m, 7°13'00.7"S, 15°05'44.8"E, 26 Jul 2015, *T. Lautenschläger* (DR 44272).

New for Angola. The species complex of *T. nematodes* was revised by Engel & Smith Merrill (2004). In the past there was a confusion between this species and *T. bicruris* (Steph.) M.Howe, *T. chaetophylla* (Spruce) Schiffn., *T. europaea* Engel & Merr., *T. longifolia* (M.Howe) Engel & Merr., *T. redacta* (Steph.) Engel & Merr., and *T. sejuncta* (Ångstr.) S.Arnell. Therefore, the distribution given in the literature is in need of a critical re-evaluation. On the basis of recently examined specimens, Engel & Smith Merrill (2004) states tropical America and Africa (Ghana, Sierra Leone, Uganda, São Tomé) as the range of the species. Wigginton (2018) lists records of the species from many African countries (Bioko, Burundi, Comores, D.R. Congo, Ethiopia, Gabon, Ghana, Kenya, Madagascar, Malawi, Réunion, Rio Muni, Rwanda, South Africa, São Tomé, Sierra Leone, Tanzania, Togo, Uganda, Zambia, Zimbabwe). In Angola the species was found in a swampy forest developed on nutrient pure sandy soil near of Mucaba (Fig. 3), a remarkable area with many floristically important vascular plants. From a bryological point of view high quantities of *Sphagnum planifolium* are remarkable.

***Thysananthus humilis* (Gottsche) Sukkharak & Gradst.**

**Angola:** Province Uíge, Uíge 21 km NNE: Rio Camacoco near Camacoco, ca. 900 m; 07°26'27"S, 015°06'07"E, 16 Oct. 2013, *F. Müller* (DR 41546); Province Cuanza Norte, N'dalatando 4 km SW: Botanical Garden, ca. 735 m; 9°20'02"S, 14°53'56"E, 17 Oct. 2013, *F. Müller* (DR 41517).

In the past, e. g. in the Flora of E. W. Jones's (Wigginton 2004), which was used for the determination of the *Mastigolejeunea* material cited in Müller (2015), *M. humilis* (Gottsche) Schiffn. is treated as a synonym of *M. auriculata* (Wilson) Steph. In a recent revision

(Sukkharak & Gradstein 2014), both are treated as separate species and later they were transferred in the genus *Thysananthus* (Sukkharak & Gradstein 2017). The material cited in Müller (2015) was partly revised in 2016 by P. Sukkharak. The above mentioned specimens, previously treated under *M. auriculata*, were revised and belonging to *T. humilis*, a palaeotropic species. In Africa this species is probably the most widely distributed species of “*Mastigolejeunea*”, which can herewith be reported for the first time for Angola.

### ***Trichostomum lorifolium* Broth. & Paris**

**Angola:** Province Malanje, Uíge 117 km E, river Cauale, epiphytic, 835 m, 7°37'02.3"S, 16°05'09.7"E, Oct 2016, *T. Lautenschläger* (DR 44439), det. Ph. Sollman. Province Uíge, Uíge 153 km NE, Milunga, epiphytic, 6°56'20.7"S, 16°16'08.1"E, 24 February 2018, *T. Lautenschläger* (DR 54793); Province Uíge, Uíge 54 km WNW, Municipality Ambuila, on limestone rocks, 628 m, 7°31'04.0"S, 14°34'07.4"E, 13 Oct 2015, *T. Lautenschläger* (DR 54792).

New for Angola. The genus *Trichostomum* is still in need of a critical revision in Africa. The species was described by Brotherus & Paris in Paris (1904) from the former Guinée française, now Guinea. The species is known from Central African Republic, Guinea, Malawi, Nigeria, Tanzania, D.R. Congo (O'Shea 2006). *Trichostomum mahaliesmontanum* Rehm., an invalidly published name, collected by Rehman in Transvaal, is treated as a synonym of *T. lorifolium* in Khmil *et al.* (2013). *Trichostomum lorifolium* is characterized by very fragile leaves. In Angola the species was found growing on rocks and as an epiphyte on tree bark.

## **SÃO TOMÉ AND PRÍNCIPE**

### ***Fossombronia indica* Steph.**

**Príncipe:** Along dirt road along the east coast between Nova Estrela and Tirreiro Velho, disturbed secondary hardwood forest, vertical soil bank of road, 200 m alt., 01°36'47.0"N, 07°25'29.3"E, 17 Nov 2016, *Shevock 49870* (CAS, DR, EGR)

New for São Tomé and Príncipe. In Müller *et al.* (2011) we reported the presence of the genus *Fossombronia* for Príncipe. As only material without sporophytes was available, at this time a determination to species level was impossible. During the 2016 expedition it was possible to collect material with ripe sporophytes. The determination using the sporophyte characteristics results in a belonging of the material to *F. indica*. *Fossombronia indica* was described from Mangalore, in the state of Karnataka, southwest India, by Stephani (1917). Later the West African *F. occidento-africana* S.W. Arnell was regarded as synonymous with it (Scott & Pike 1988).

Our material matches well the descriptions and illustrations in Wigginton (2004) and Cargill (2000). The capsule wall thickenings are mostly nodular throughout, including most of the basal portion (Fig. 4D). The distal spore face is composed of a web of lamellae which form a network of small, mostly incomplete reticulæ (Fig. 4A). The proximal spore face has a distinct triradiate mark, with each segment densely covered with short low lamellae (Fig. 4B). The elaters are elongate and composed of 2–3 lax spirals (Fig. 4C).

In Africa the species was hitherto known from Ascension, Ghana, Nigeria, Sierra Leone, and Togo (Wigginton 2018).

### ***Lejeunea acuta* Mitt.**

**Príncipe:** Obô Natural Park de Príncipe: cross-country route across the summit of the Mesa, mixed tropical hardwood cloud forest, on hardwood liana, mixed with *Lejeunea flava*, 500 m alt., 01°34'53.4"N, 07°20'52.4"E, 22 Nov 2016, *Shevock 50003* (CAS, DR, EGR), det. T. Pócs.

The species was already known from São Tomé, but in Wigginton (2018) it is not mentioned for Príncipe. In Sérgio & Garcia (2011) there is an indication of its occurrence on Príncipe, but without citing a relevant specimen. On São Tomé the species is widely distributed at higher elevations in montane rainforests. In the collections of the third author it is presented



by several specimens from São Tomé, but the above mentioned specimen is the only one from Príncipe.

*Lejeunea acuta* is an African endemic known from Annobon, Bioko, Burundi, Cameroun, Comores, D.R. Congo, Kenya, Rio Muni, Rwanda, São Tomé, Tanzania, and Uganda (Wigginton 2018).

***Solenostoma dusenii* (Steph.) Váňa, Hentschel & Heinrichs**

**Príncipe:** Obô Natural Park de Príncipe: Watershed of the Rio Banzu, along the Rio Banzu less than 2 km from ruins of roça S. Carlos do Fundão, mixed hardwood forest, on volcanic rock wall in river, 190 m alt., 01°36'03.0"N, 07°23'13.5"E, 15 Nov 2016, *Shevock 49804* (CAS, DR, EGR); Obô Natural Park de Príncipe: along the Rico Porco about 300 m above confluence with ocean, mixed hardwood forest, on vertical soil bank, 50 m alt., 01°33'06.0"N, 07°22'42.0"E, 18 Nov 2016, *Shevock 49881* (CAS, DR, EGR).

New for Príncipe. The species is a West African endemic and hitherto known from Bioko, Cameroun, and São Tomé (Wigginton 2018). The species was originally described from material collected by Dusén from rocks in rivers on the lower slopes of Mt. Cameroon (Wigginton 2004). From São Tomé the species was hitherto known based on a single Moller's gathering (Váňa 1974, Sérgio & Garcia 2011), but in the recent collection of the third author there are several specimens from São Tomé and the above mentioned specimens from Príncipe, which represent a new record for this island.

## Discussion

The results indicate that additional bryophyte records are very likely to be documented with ongoing field work and exploration. This observation is especially valid for Angola, a bryologically very badly documented country (Müller 2014). In São Tomé and Príncipe the systematic field inventory of the third author has revealed a relatively good status of the knowledge of the hepatic flora for this country. More systematic field inventory sampling in remote areas of Príncipe and at the higher altitudes of São Tomé would be a profitable enterprise and further define the distribution of Gulf of Guinea bryophytes.



**Fig 1:** Swampy forest embedded in forest savannah near Quimbele. At this site *Calypothecium planifrons* was found as epiphyte.

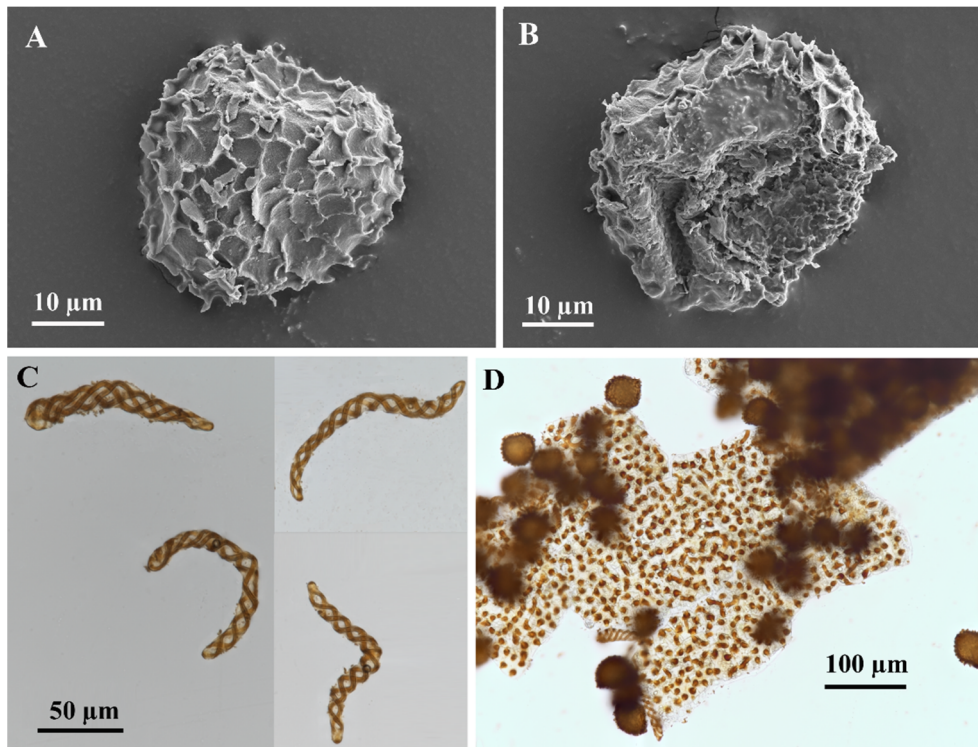




**Fig 2:** Forest savannah near Kibokolo south of Quimbele, the record site of *Cylindrocolea abyssinica* which was found here growing as epiphyte.



**Fig 3:** Swampy forest developed on nutrient pure sandy soil and surrounded by cultivated land near of Mucaba, record site of *Telaranea nematodes*, *Sphagnum planifolium* and remarkable vascular plants.



**Fig 4:** *Fossombronia indica*. **A:** Spore in distal view. **B:** Spore in proximal view. **C:** Elaters. **D:** Part of capsule wall. (All from Shevock 49870 (DR)).

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**Authors' addresses:** Frank Müller, Institut für Botanik, Technische Universität Dresden, Mommsenstr. 13, 01062 Dresden, Germany. E-mail: frank.mueller@tu-dresden.de

Thea Lautenschläger, Institut für Botanik, Technische Universität Dresden, Mommsenstr. 13, 01062 Dresden, Germany. E-mail: thea.lautenschlaeger@tu-dresden.de

James R. Shevock, Department of Botany, California Academy of Sciences, 55 Music Concourse Drive, Golden Gate Park, San Francisco, California 94118-4503, USA. E-mail: jshevock@calacademy.org