

# A contribution to the rust flora (Uredinales) on Aizoaceae in southern Africa<sup>†</sup>

Mechthilde MENNICKEN<sup>1,\*</sup>, Wolfgang MAIER<sup>2</sup>, Pedro W. CROUS<sup>3</sup> and Franz OBERWINKLER<sup>1</sup>

Rust fungi on Aizoaceae in southern Africa have been examined and reported based on 27 specimens collected during a biodiversity study and previously collected herbarium specimens. Eight species including five new species have been recognized, and they are described in detail and illustrated. Together with two additional species in literature, ten species of rust fungi are now recognized on Aizoaceae in southern Africa.

**Taxonomical novelties:** *Puccinia aridariae* Mennicken, Maier, Crous & Oberw.; *Puccinia knersvlaktensis* Mennicken, Maier, Crous & Oberw.; *Puccinia otzeniani* Mennicken, Maier, Crous & Oberw.; *Uredo guerichiani* Mennicken, Maier, Crous & Oberw. and *Uredo leliefontinensis* Mennicken, Maier, Crous & Oberw.

**Keywords:** Biodiversity, Namibia, South Africa, rust fungi, taxonomy

Four rust species have previously been described from representatives of the host family Aizoaceae, three from South Africa, and one from Australia and South Africa (MACOWAN 1880; MCALPINE 1895; SYDOW & SYDOW 1904; DOIDGE 1939). The Aizoaceae in southern Africa are well-known for their great diversity. Therefore, during the course of a biodiversity study (BIOTA Southern Africa: Biodiversity Monitoring Transect Analyses), special emphasis was placed on scrutinizing members of this family for the occurrence of rusts. A total of 27 rust specimens were collected from Aizoaceae during two collection periods. These, as well as four herbarium specimens of the hitherto known species on Aizoaceae, were examined morphologically to summarize the knowledge of Aizoaceae rusts in southern Africa.

## Material and methods

Specimens were mostly collected in the South African BIOTA (Biodiversity Monitoring Transect Analyses) observatories between 17 Nov. 2001 – 3 Dec. 2001, and between 2 Sept.

2002 – 30 Sept. 2002. The 13 BIOTA observatories in South Africa were set up along a transect, parallel to the N7, from the Cape of Good Hope to the Richtersveld. Each observatory comprised one square kilometre. The specimens collected in the course of these excursions as well as additional specimens from herbaria were studied morphologically as we performed freehand sections and scrape mounts of infected plant material. The samples were heated in Hoyer's fluid (Cunningham 1972) and examined with a Carl Zeiss microscope with bright field and phase contrast optics. With the exception of pycnoid and basidiospores, 25 spores of each occurring spore state were measured. In cases where only one collection of a rust species was available, 50 spores of each present spore state were measured. The same was done with type collections. The cells of the peridium were also examined. In our line drawings, which show the cells as optical sections, the outer wall of the cells is on the left hand side, while the inner wall can be seen on the right hand side. All specifications using 'circa' are based on measurements of less than 25 cells.

For the identification of the rust fungi we checked publications concerning the rust flora of Africa and bordering regions, which are available under <http://www.mycology.uni-tuebingen.de/databases/rust-literature/>. The classification of the host family Aizoaceae conforms to HARTMANN (2002 a, b). The nomenclature of the host plants is according to GERBAULET (2002 a-c), HARTMANN (2002 c-f) and KLAKE & GERBAULET (2002).

## Results and discussion

The examined specimens belong to eight rust species, of which five are described as new below. The description of a ninth species, which we have not seen, is added from litera-

<sup>1</sup> Lehrstuhl für Spezielle Botanik & Mykologie, Botanisches Institut, Universität Tübingen, Auf der Morgenstelle 1, D-72076 Tübingen, Germany.

<sup>2</sup> University of Pretoria, Department of Genetics, Forestry and Agricultural Biotechnology Institute (FABI), Pretoria 0002, South Africa.

<sup>3</sup> Centraalbureau voor Schimmelcultures, PO Box 85167, 3508 AD Utrecht, The Netherlands.

\* Corresponding author: E-mail: [info@systbot.uni-tuebingen.de](mailto:info@systbot.uni-tuebingen.de)

<sup>†</sup> Part 223 in the series "Studies in Heterobasidiomycetes" from the Botanical Institute, University of Tübingen.

ture, as well as the description of a tenth species, of which telia were not observed. The rust species are listed in alphabetical order referring to the host subfamily and to the host genus, respectively. The following abbreviations are used: 0 = pycnia = spermogonia; I = aecia; II = uredinia; III = telia, IV = basidia.

***Aecidium tetragoniae* Doidge (DOIDGE 1939: 488).**

Type on leaves of *Tetragonia arbuscula* Fenzl in Harvey & Sonder, South Africa, Fauresmith, leg. Henrici (PREM 25892).

We have not seen this rust. The description is adapted from the Latin diagnosis (DOIDGE 1939):

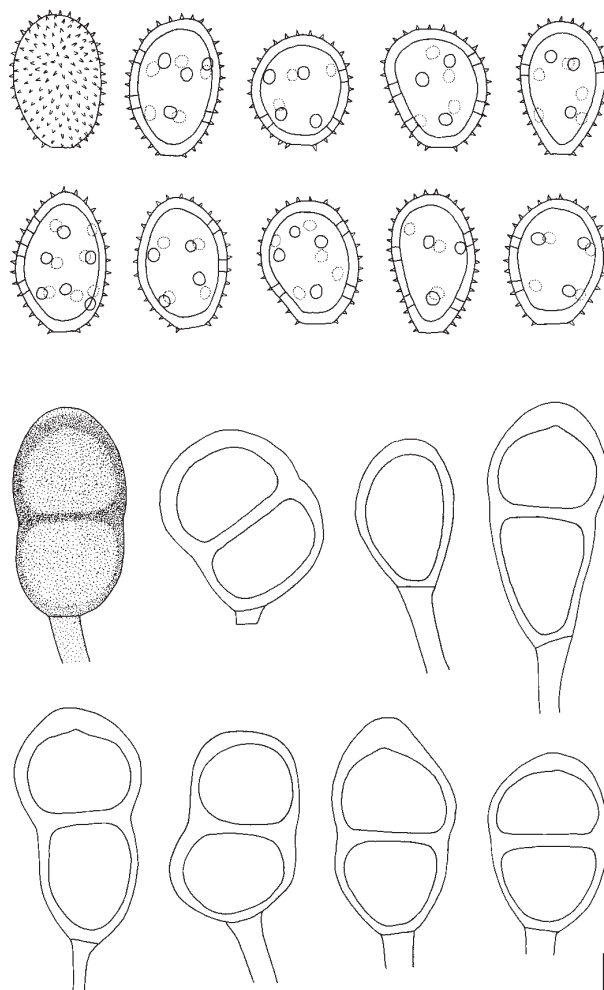
Pycnia amphigenous, abundant or sparse between the aecia, honey-coloured, thereafter blackish brown. Aecia amphigenous, covering densely and uniformly the whole leaf surface or large parts of it, hemispheric, long remaining closed, later cupulate, 300–400 µm diam, surrounded by a quickly disappearing, laciniated white peridium, cells of the peridium loosely connected, irregular, 27–42 × 15–25 µm, outer wall finely striate, 5–8 µm thick, inner wall verrucous, 2–3 µm thick. Aeciospores subglobose, oblong or ovate, mostly angular, 20–32.5 × 15–20 µm, spore wall 2.5–5 µm thick, finely and densely verrucous.

Considering the fact that *Puccinia galeniae* infects, among others, two *Tetragonia* species (see below), *Aecidium tetragoniae* could possibly be the aecial state of *Puccinia galeniae*.

***Puccinia aridariae* Mennicken, Maier, Crous & Oberw., sp. nov.**

Pycnia et aecia ignota. Uredinia amphigena in foliis, subepidermalia, vulpina, usque ad 1 mm diam., mox nuda, pulverulenta. Urediniosporae subgloboideae, ellipsoideae vel pyriformes, (26) 28–36 × 20–26 µm, pariete echinulato, aureo-fusco, lateraliter (1.5) 2–3 µm crasso, apicaliter 2–3.5 µm crasso, (9) 10–12 (16) poris germinationis dispersis. Telia caulicola vel in floribus, subepidermalia, nigra, usque ad 2 mm diam., mox nuda, compacta. Teliosporae bicellulares, ellipsoideae, cylindraceae, subclavatae vel irregulares, medio leviter constrictae, apice rotundato, subacuto vel leviter applanato, base rotundata vel subinde attenuata, (35) 40–55 (58) × 26–35 µm, pariete laevigato, castaneo, lateraliter 1.5–3 µm crasso, apicaliter 4–8 µm crasso, poro germinationis cellulae superioris apicali, cellulae inferioris juxta septum posito, pedicello dilute aureo-fusco vel hyalino, usque ad 120 µm longo. Mesosporae adsunt. In foliis, caulis vel floribus *Aridariae noctiflorae* (L.) Schwantes (Aizoaceae).

Pycnia and aecia unknown. Uredinia amphigenous on leaves, subepidermal, separate or scattered in irregular groups, roundish, subcircular, oblong or irregular in outline, up to 2 mm wide, fulvous to cinnamon-brown, early exposed, pulverulent, surrounded by the torn epidermis, without spots surrounding uredinia. Urediniospores subglobose, ellipsoid or pyriform, (26) 28–36 × 20–26 µm, echinulate, borne singly on short pedicels, spore wall lateral (1.5) 2–3 µm, 2–3.5 µm thick at the apex, golden to yellowish brown, often slightly darker at the apex, germ pores conspicuous (9) 10–12 (16), scattered, with hyaline, weakly developed papillae. Telia on



**Fig. 1.** *Puccinia aridariae* on *Aridaria noctiflora*. Urediniospores and teliospores. RSA 155 Holotype. Scale bar = 10 µm.

stems and flowers, none seen on leaves, subepidermal, separate or scattered, round to elliptic, up to 2 mm wide, black, early exposed, compact, surrounded by the torn epidermis, without spots surrounding telia. Teliospores in general bicellular, ellipsoid, cylindrical, subclavate or irregular in outline, rounded, subacute or slightly flattened at the apex, ± rounded, occasionally attenuate at the base, not or slightly constricted at the septum, chestnut-brown, often apically brightened, (35) 40–55 (58) × 26–35 µm, spore wall smooth, lateral 1.5–3 µm, 4–8 µm thick at the apex, germ pore in the upper cell apical, in the lower cell next to the septum, pedicel persistent, up to 120 µm long, thin-walled, collapsing, yellowish brown to hyaline, sometimes obliquely inserted. Mesosporae present. On leaves, stems, and flowers of *Aridaria noctiflora*.

Etymology. Named after the host plant, *Aridaria noctiflora*.

**Specimens examined:** On *Aridaria noctiflora*. South Africa, Northern Cape Province, Richtersveld, BIOTA observatory at Yellow Dune, S 28°36'48.2'', E 16°39'29.1'', 14 Sept. 2002, leg. M. Mennicken No. RSA 155, II III. Holotype (PREM), Isotype (M). On *Mesembryanthemum guerichianum* Pax. South Africa, Northern

Cape Province, Richtersveld, BIOTA observatory at Yellow Dune, S 28°36'49.22'', E 16°39'45.5'', 14 Sept. 2002, leg. M. Mennicken No. RSA 153, II (PREM, M). This collection is also infected with *Uredo guerichiani*.

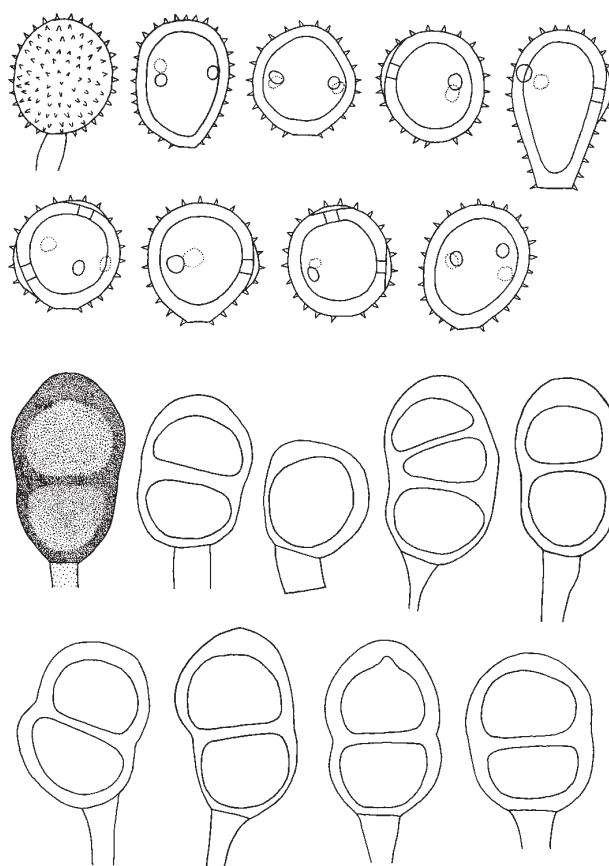
***Puccinia galeniae*** Dietel in SYDOW & SYDOW (1904: 562).

**Fig. 2**

Syntypes on *Galenia africana* L. and on *Galenia sarcophylla* Fenzl ex Sonder in Harvey & Sonder. Namibia, Swakopmund, leg. Stapf & C. Klugkist.

Pycnia and aecia unknown. Uredinia amphigenous on leaves, subepidermal, separate or sparsely scattered, roundish or elongate, small, up to 1 mm wide, dark brown. Urediniospores globoid, subgloboid or ellipsoid, occasionally irregular in outline or somewhat angular, (19) 21–29 (36) × 17–22 (26) µm, echinulate, spore wall uniformly 1.5–3 µm thick, inconspicuously bilaminar, outer layer thin, yellowish to hyaline, inner layer thick, (pale) chestnut-brown, colour marginally brighter than in the teliospores, germ pores inconspicuous, 3–4 (5), ± equatorial, occasionally one additional apical germ pore, with hyaline, well-developed papillae. Telia amphigenous on leaves, developing from the uredinia, separate or sparsely scattered, round to elongate, small, up to 1 mm wide, blackish brown. Teliospores generally bicellular, ellipsoid to cylindrical, ± rounded above and below, normally slightly constricted at the septum, chestnut-brown, 32–41 (46) × 21–27 (30) µm, spore wall inconspicuously finely sulcated or verrucous, lateral 1.5–3 µm, 3–7 µm thick at the apex, germ pore in the upper cell apical, in the lower cell close to the septum, pedicel persistent, up to 65 µm long, thin-walled, mostly collapsing, yellowish to brownish, sometimes obliquely inserted. Mesospores and tricellular teliospores present.

**Specimens examined:** On *Aizoon canariense* L. South Africa, Northern Cape Province, BIOTA observatory at Quaggafontein 478, S 30°11'29.5'', E 17°33'05.6'', 11 Sept. 2002, leg. M. Mennicken No. RSA 148, II III (PREM, M). On *Galenia africana*. South Africa, Northern Cape Province, BIOTA observatory at Quaggafontein 478, S 30°11'18.3'', E 17°33'06.9'', 26 Nov. 2001, leg. M. Mennicken No. RSA 53, II (PREM). On *Galenia africana*. South Africa, Western Cape Province, BIOTA observatory at Moedverloren 208, S 31°27'47.5'', E 18°26'30.9'', 18 Sept. 2002, leg. M. Mennicken No. RSA 179, II (PREM, M). On *Galenia crystallina* (Ecklon & Zeyher) Sonder in Harvey & Sonder. South Africa, Northern Cape Province, Richtersveld, BIOTA observatory at Yellow Dune, S 28°37'01.4'', E 16°39'47.3'', 14 Sept. 2002, leg. M. Mennicken No. RSA 154, II III (PREM, M). On *Galenia crystallina*. South Africa, Northern Cape Province, Richtersveld National Park, BIOTA observatory at Koeroegapvlakte, S 28°14'08.2'', E 17°01'33.2'', 15 Sept. 2002, leg. M. Mennicken No. RSA 162, II III (KSAN, PREM, M). On *Galenia dregeana* Fenzl ex Sonder in Harvey & Sonder. South Africa, Northern Cape Province, Richtersveld National Park, BIOTA observatory at Numees, S 28°17'46.9'', E 16°57'45.3'', 13 Sept. 2002, leg. M. Mennicken No. RSA 151, II (KSAN, PREM, M). On *Galenia sarcophylla*. South Africa, Northern Cape Province, BIOTA observatory at Quaggafontein 478, S 30°11'22.8'', E 17°33'04.7'', 26 Nov. 2001, leg. M. Mennicken No. RSA 54, II (PREM). On *Galenia sarcophylla*. South Africa, Western Cape Province, BIOTA observatory at Moedverloren 208, S 31°27'47.5'',



**Fig. 2:** *Puccinia galeniae* on *Aizoon canariense*. Uredinio- and teliospores. RSA 148. Scale bar = 10 µm.

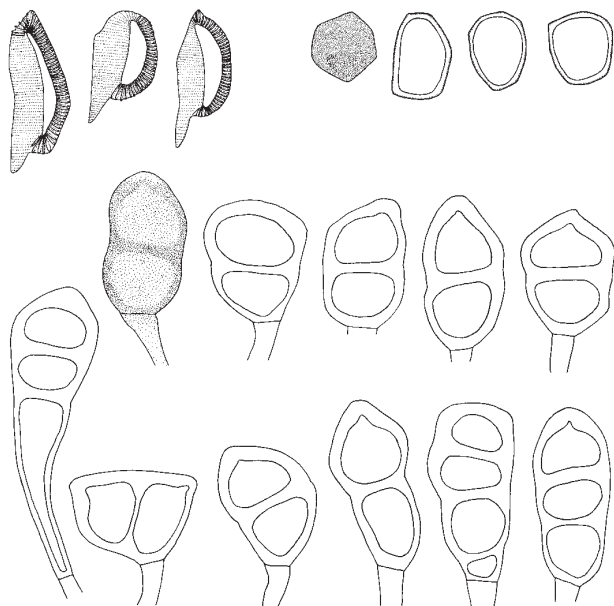
E 18°26'30.9'', 18 Sept. 2002, leg. M. Mennicken No. RSA 178, II (PREM, M). On *Tetragonia* cf. *reduplicata* Welwitsch ex Oliver. South Africa, Northern Cape Province, Richtersveld National Park, BIOTA observatory at Koeroegapvlakte, S 28°14'07.9'', E 17°01'31.8'', 15 Sept. 2002, leg. M. Mennicken No. RSA 159, II (KSAN, PREM, M). On *Tetragonia* sp. South Africa, Northern Cape Province, Richtersveld National Park, BIOTA observatory at Koeroegapvlakte, S 28°14'07.9'', E 17°01'31.8'', 15 Sept. 2002, leg. M. Mennicken No. RSA 158, II (KSAN, PREM, M).

Our collections conform well with the descriptions of the urediniospores given in the diagnoses of DIETEL (SYDOW & SYDOW 1904) and of LAUNDON (1963), but differ in the size of the teliospores. DIETEL reported a few teliospores on *Galenia sarcophylla*. LAUNDON (1963), however, did not observe any teliospores in the type collections. Given the size of the teliospores measured by DIETEL (circa 22 × 30 µm), we believe they were not mature. As far as could be established, *Puccinia galeniae* is new to the rust flora of South Africa. *Aizoon canariense*, *Galenia crystallina*, *Galenia dregeana*, and *Tetragonia reduplicata* seem to be new hosts for this rust fungus.

***Puccinia knersvlaktensis*** Mennicken, Maier, Crous & Oberw., sp. nov.

**Fig. 3**

Pycnia rara, amphigena in foliis, typo 4. Aecia aecidioidea, amphigena vel caulicola, cupulata. Cupulae 2–6 dense aggregatae, cylin-



**Fig. 3:** *Puccinia knersvlaktensis* on *Mesembryanthemum nodiflorum*. Peridium cells, aecio- and teliospores. RSA 176 Holotype. Scale bar = 10  $\mu$ m.

draceae, usque ad 800  $\mu$ m longae, circa 250–300  $\mu$ m diam. Peridia aurantiaca vel albo-aurea, subtiliter laciniata, cellulis peridii firme conjunctis, pariete exteriori striato, circa 9–12  $\mu$ m crasso, pariete interiore subtiliter verruculoso, circa 3–5  $\mu$ m crasso. Aeciosporae angulatae, globoideae, ovatae vel ellipsoideae, 21–33  $\times$  17–27  $\mu$ m, pariete verruculoso, hyalino, 1–2  $\mu$ m crasso, in angulis usque ad 3  $\mu$ m crasso. Uredinia ignota. Telia amphigena vel caulicola, subepidermalia, nigra, usque ad 1.5 mm lata, usque ad 5 mm longa, epidermide diu tecta, tandem nuda, compacta. Teliosporae bicellulares, obovoideae, ellipsoideae vel oblongae, raro diorchidioideae, medio leviter constrictae, apice rotundato vel subacuto, base rotundata vel attenuata, 36–60  $\times$  17–31 (34)  $\mu$ m, pariete laevigato, dilute brunneo, lateraliter 1.5–3.5  $\mu$ m crasso, apicaliter 3–11  $\mu$ m crasso, poro germinationis cellulae superioris apicali, cellulae inferioris juxta septum posito, pedicello dilute aureo-fusco vel hyalino, usque ad 120  $\mu$ m longo. Teliosporae tricellulares et tetracellulares adsunt. In foliis vel caulibus *Mesembryanthemi nodiflori* L. (Aizoaceae).

Pycnia rarely developed, amphigenous on leaves, type 4. Aecia aecidioid, amphigenous on leaves and on stems, subepidermal, densely scattered in small groups of 2 to 6 or more aecial cups, without spots surrounding aecia, aecial cups erumpent, long and small cylindrical, circa 250–300  $\mu$ m diam., up to 800  $\mu$ m tall, spore mass yellow to creamish white, surrounded by finely lacinate, orange to whitish yellow peridium, cells of the peridium firmly connected, outer wall conspicuously striate, circa 9–12  $\mu$ m thick, inner wall finely verrucous, circa 3–5  $\mu$ m thick. Aeciospores angular globoid, ovoid to ellipsoid, 21–33  $\times$  17–27  $\mu$ m, delicately verrucous, spore wall 1–2  $\mu$ m thick, up to 3  $\mu$ m thick in the angles, hyaline, germ pores inconspicuous. Uredinia unknown. Telia amphigenous on leaves and on stems, separate or scattered, often admixed with the aecia, subepidermal, long remaining covered by the epidermis, later exposed, blackish, compact pustules

roundish, ellipsoid or oblong, up to 1.5 mm wide and 5 mm long, without spots surrounding pustules. Teliospores in general bicellular, variable in shape, ovoid, ellipsoid or oblong, occasionally subclavate, rarely diorchidioid, rounded or subacute at the apex, rounded or attenuate at the base, slightly constricted at the septum, 36–60  $\times$  17–31 (34)  $\mu$ m, spore wall smooth, pale brown, lateral 1.5–3.5  $\mu$ m, 3–11  $\mu$ m thick at the apex, germ pore in the upper cell apical, in the lower cell next to the septum, with brightened papillae, pedicel persistent, up to 120  $\mu$ m long, thin-walled, mostly collapsing, brownish yellow to hyaline. Tri- and tetracellular spores present. On the leaves and stems of *Mesembryanthemum nodiflorum*.

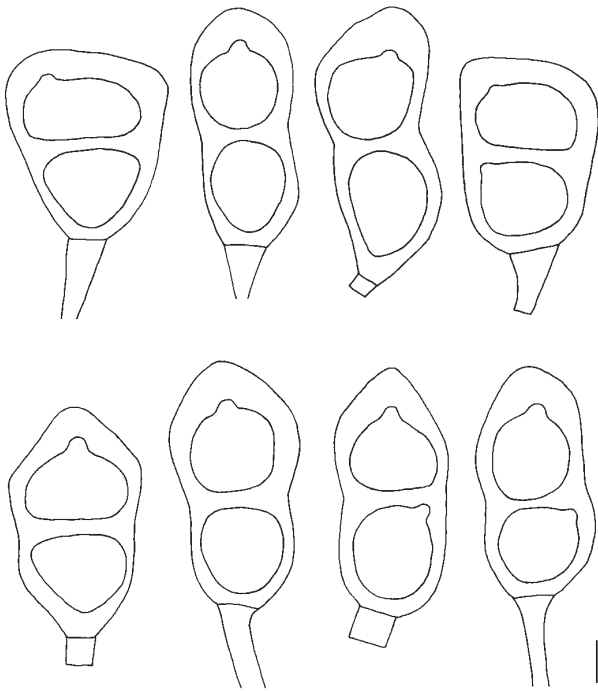
**Etymology.** Named after the Afrikaans word for the region: Knersvlakte.

**Specimens examined:** On *Mesembryanthemum nodiflorum*. South Africa, Western Cape Province, BIOTA observatory at Moedverloren 208, S 31°28'01.0'', E 18°26'31.3'', 18 Sept. 2002, leg. M. Mennicken No. RSA 176, 0 I III. Holotype (PREM), Isotype (M). On *Mesembryanthemum nodiflorum*. South Africa, Western Cape Province, BIOTA observatory at Moedverloren 208, S 31°28'00.6'', E 18°26'25.9'', 5 Sept. 2002, leg. M. Mennicken No. RSA 168, 0 I III. Paratype (PREM). On *Mesembryanthemum nodiflorum*. South Africa, Western Cape Province, BIOTA observatory at Flaminkvlakte 111, S 31°16'57.8'', E 18°36'05.9'', 23 Nov. 2001, leg. Markus Göker No. RSA 33, 0 I III. Paratypes (PREM, M).

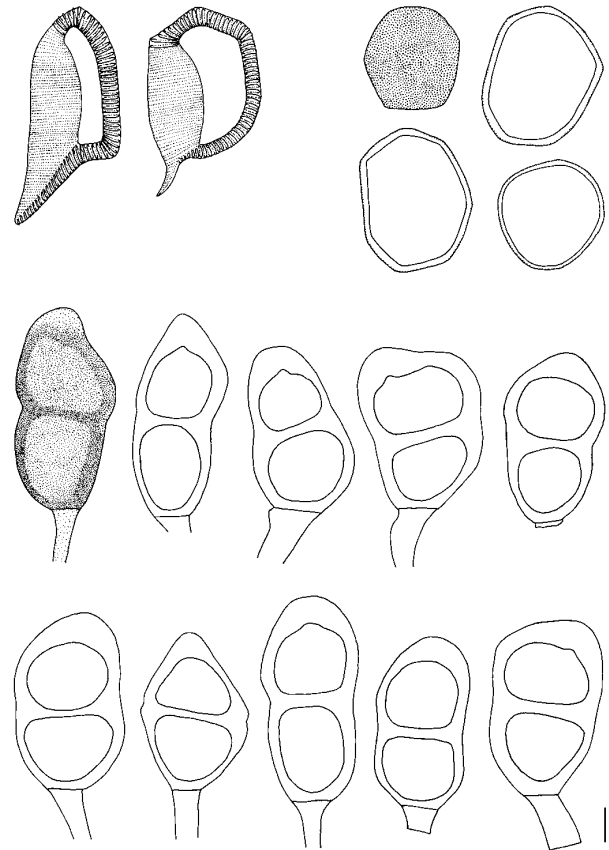
***Puccinia mesembryanthemi* MacOwan (MACOWAN 1880: 90).**

**Figs 4, 5**

Pycnia rarely developed, amphigenous on leaves, admixed with the aecia, type 4. Aecia aecidioid, amphigenous on leaves or on stems, densely scattered in groups which often surround the stems and the leaves, without spots surrounding the cylindrical aecial cups, aecial cups erumpent, circa 350  $\mu$ m diam., up to 1 mm tall, spore mass yellow to creamish white, surrounded by finely lacinate, orange to whitish yellow peridium, cells of the peridium firmly connected, outer wall striate, circa 6–8 (12)  $\mu$ m thick, inner wall medium to coarsely verrucous, circa 3–4  $\mu$ m thick. Aeciospores angular globoid, ovoid to ellipsoid, (25) 31–43 (45)  $\times$  22–35 (37)  $\mu$ m, delicately verrucous, spore wall (0.5) 1–1.5  $\mu$ m thick, hyaline, germ pores inconspicuous. Uredinia unknown. Telia amphigenous on leaves or stems, separate or scattered, subepidermal, long covered by the epidermis which later cracks away exposing dark chocolate-brown to blackish, compact sori, on leaves up to 1 mm wide, on stems up to 1 cm wide, often surrounding the stems, roundish to ellipsoid, without spots surrounding pustules. Teliospores bicellular, ovoid, ellipsoid or oblong ellipsoid, occasionally subclavate, rounded, flattened or subacute at the apex, rounded or attenuate at the base, slightly constricted at the septum, (36) 40–58  $\times$  21–32 (34)  $\mu$ m, spore wall smooth, chestnut-brown, lateral 1.5–3  $\mu$ m, 5–11  $\mu$ m thick at the apex, germ pore in the upper cell apical, in the lower cell next to the septum, pedicel persistent, up to 140  $\mu$ m long, thin-walled, collapsing or not, pale brownish yellow to hyaline, often obliquely inserted.



**Fig. 4:** *Puccinia mesembryanthemi* on *Psilocaulon granulicaule*. Teliospores. Sydow, Fungi exotici exsiccati 157. Scale bar = 10  $\mu$ m.



**Fig. 5:** *Puccinia mesembryanthemi* on *Psilocaulon leptarthron*. Peridium cells, aecio- and teliospores. RSA 166. Scale bar = 10  $\mu$ m.

**Specimens examined:** On *Psilocaulon parviflorum* (Jacquin) Schwantes (= *Mesembryanthemum micranthum* Haw.). South Africa, Graaf-Reinet, Febr. 1880, leg. William Tuck, MacOwan No. 1441, 0 I III. Type (B 70 0007268). On *Psilocaulon granulicaule* (Haw.) Schwantes (= *Mesembryanthemum granulicaule* Haw.). South Africa, Kimberley, Griqualand-West, 19 Sept. 1912, leg. J.C. Moran, Sydow Fungi exotici exsiccati No. 157, III (B 70 0007186). On *Psilocaulon leptarthron* (A. Berger) N.E.Br. South Africa, Western Cape Province, BIOTA observatory at Luiperskop 211, S 31°17'38.3'', E 18°36'14.6'', 7 Sept. 2002, leg. M. Mennicken No. RSA 166, 0 I III (PREM, M). On *Psilocaulon parviflorum* (as *Mesembryanthemum micranthum* Haw.). South Africa, Kimberley, 26 Aug. 1922, leg. D. Schonland, I III (PREM 5126) (only slides). On *Psilocaulon salicornioides* (Pax.) Schwantes (as *Psilocaulon trothai* (Engl.) Schwantes). Namibia, äußere Namib-Nebelküste, Wlotzkasbaken, kleines Rivier zwischen Wlotzbasbaken und Jakkalsputz, 28 Nov. 1958, leg. R. Seydel No. 1677, III (B 10 9009306).

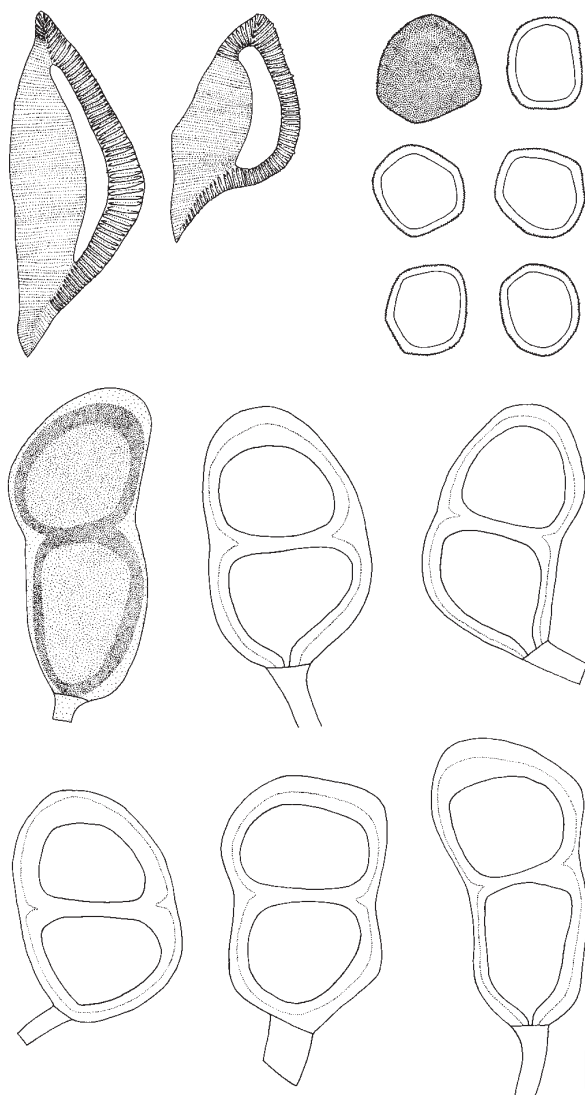
As far as could be established *Puccinia mesembryanthemi* is new to the rust flora of Namibia. *Psilocaulon leptarthron* and *Psilocaulon salicornioides* seem to be new host plants.

***Puccinia otzeniani*** Mennicken, Maier, Crous & Oberw., sp. nov. **Fig. 6**

Pycnia rara, amphigena, typo 4. Aecia aecidioidea, amphigena, cupulata, laxe aggregata. Cupulae conicae vel cylindratae, usque ad 1 mm longae, ad 500  $\mu$ m diam. Peridia aurantiaca vel albo-aurora, re-

curvata, irregulariter laciniata, cellulis peridii firme conjunctis, pariete exteriori striato, circa 18–21  $\mu$ m crasso, pariete interiori subtiliter verruculoso, circa 4–8  $\mu$ m crasso. Aeciosporae angulatae, globoideae vel subgloboideae, 26–33  $\times$  22–29  $\mu$ m, pariete verruculoso, hyalino, 1.5–3  $\mu$ m crasso. Uredinia ignota. Telia amphigena, subepidermalia, atro-brunnea vel nigra, usque ad 1 mm diam., epidermide diu tecta, tandem nuda. Teliosporae bicellulares, ellipsoideae, cylindratae, subclavatae vel irregulares, apice rotundato, subacuto vel applanato, base rotundata, attenuata vel applanata, medio haud vel leviter contractae, 60–80  $\times$  (34) 40–50  $\mu$ m, pariete laevi, lateraliter 3.5–6  $\mu$ m crasso, apicaliter 7–13  $\mu$ m crasso, bilaminato, strato exteriori dilute brunneo vel hyalino, strato interiori dilute castaneo, poro germinationis cellulae superioris apicali, cellulae inferioris juxta septum posito, pedicello dilute fusco vel hyalino, usque ad 130  $\mu$ m longo. In foliis *Lampranthi otzeniani* (Dinter) Friedrich (= *Drosanthemum otzenianum* (Dinter) Friedrich) (Aizoaceae).

Pycnia rarely developed, amphigenous on leaves, admixed with the aecia, type 4. Aecia aecidioid, amphigenous on leaves, subepidermal, loosely scattered in  $\pm$  concentric groups up to 0.8 cm diam., without spots surrounding aecial cups, aecial cups conical to cylindrical, erumpent, up to 500  $\mu$ m diam, and 1 mm tall, spore mass yellow to creamish white, surrounded by recurved, irregularly frayed, orange to whitish yellow peridium, cells of the peridium firmly connected, outer wall finely striate, circa 18–21  $\mu$ m thick, inner wall finely verrucous, circa 4–8  $\mu$ m thick. Aeciospores angular globoid or



**Fig. 6:** *Puccinia otzeniani* on *Lampranthus otzenianus*. Peridium cells, acio- and teliospores. RSA 164 Holotype. Scale bar = 10  $\mu$ m.

subglobose, 26–33  $\times$  22–29  $\mu$ m, verrucous, spore wall uniformly 1.5–3  $\mu$ m thick, hyaline, germ pores inconspicuous. Uredinia unknown. Telia amphigenous on leaves, subepidermal, developing between the aecia, separated or scattered, round to elliptic, up to 1 mm wide, dark brown to blackish, long covered by the epidermis, later exposed, surrounded by the torn epidermis, without spots surrounding telia. Teliospores bicellular, ellipsoid, cylindrical, subclavate or irregular in outline, rounded, subacute or flattened at the apex, rounded, attenuate or flattened at the base, not or slightly constricted at the septum, 60–80  $\times$  (34) 40–50  $\mu$ m, spore wall smooth, 3.5–6  $\mu$ m thick at the sides, 7–13  $\mu$ m thick at the apex, bilaminar, outer layer hyaline to pale brownish, inner layer pale chestnut-brown, germ pore in the upper cell apical, in the lower cell next to the septum, pedicel persistent, up to 130  $\mu$ m long, thin-walled, collapsing, hyaline to brownish, often obliquely inserted. On *Lampranthus otzenianus*.

**Etymology.** Named after the host plant, *Lampranthus otzenianus*.

**Specimen examined:** On *Lampranthus otzenianus*. South Africa, Northern Cape Province, Richtersveld National Park, BIOTA observatory at Koerogapvlakte, S 28°14'02.3", E 17°01'45.5", 15 Sept. 2002, leg. M. Mennicken No. RSA 164, 0 I III. Holotype (KSAN), Isotypes (PREM, M).

***Puccinia* sp.** (CROUS, DENMAN & SCOTT 1999: as *Puccinia mesembryanthemi*).

The description of *Puccinia* sp. is adapted from CROUS et al. (1999):

“Spermogonia and Aecia not observed [...]. Uredinia amphigenous, medium brown, scattered or in small groups, circular to slightly irregular, surrounded by a torn epidermis, 300–800  $\mu$ m diam. Urediniospores broadly ellipsoid to globose with truncate bases, golden-brown, (25) 28–35 (38)  $\times$  (20) 22–26 (28)  $\mu$ m; wall 1.5–2  $\mu$ m diam., inconspicuously echinulate, spines up to 1  $\mu$ m long; pores scattered, circular, 6–10 per spore, 3–4.5  $\mu$ m diam.; spines also present over pores. Telia amphigenous, scattered, 1 (3) mm diam., black, erumpent, cushion-like. Teliospores clavate, apex rounded or bluntly acute, attenuate towards the base, constricted at horizontal septum, medium brown, upper cell slightly darker than lower cell, (40) 50–60 (65)  $\times$  (21) 26–28 (32)  $\mu$ m; upper cell subglobose to ellipsoid, (21) 26–28 (32)  $\mu$ m wide; lower cell cuneiform, (20) 22–25 (27)  $\mu$ m wide; wall smooth, 2–2.5  $\mu$ m diam., thickened at the apex (5–8  $\mu$ m); germ pore apical in upper cell and just below the septum in lower cell; pedicel olivaceous, persistent, 10–110  $\mu$ m long, 6–11  $\mu$ m diam. at spore base.”

**Specimen:** On *Sceletium tortuosum* (L.) N.E. Br. ex Schwantes. South Africa, Namaqualand, Platbakkies, Kougoedvlakte Farm, S 30°20'42", E 18°21'15", Nov. 1995, leg. M. Scott (PREM 55338). In the diagnosis with the addendum: “Telia developed on this material after it was planted out in the Gouda district during May–June 1996”.

The collection PREM 55338 is labelled as holotype of *Puccinia sceletii*. However, *Puccinia sceletii* has never been published. In CROUS et al. (1999) it was reported as *Puccinia mesembryanthemi*. But the characters of *Puccinia* sp. PREM 55338 do not agree with any known rust species from Aizoaceae (see Tab. 1). Therefore, the labelling and/or identification of *Puccinia* sp. as *Puccinia mesembryanthemi* is erroneous. Unfortunately, the specimen PREM 55338 which we investigated did not contain teliospores, and only a slide preparation remains of the original teliospore material. Therefore, we choose not to describe this specimen as a new species at this stage.

***Puccinia tetragoniae* McAlpine** (MCALPINE 1895: 854).

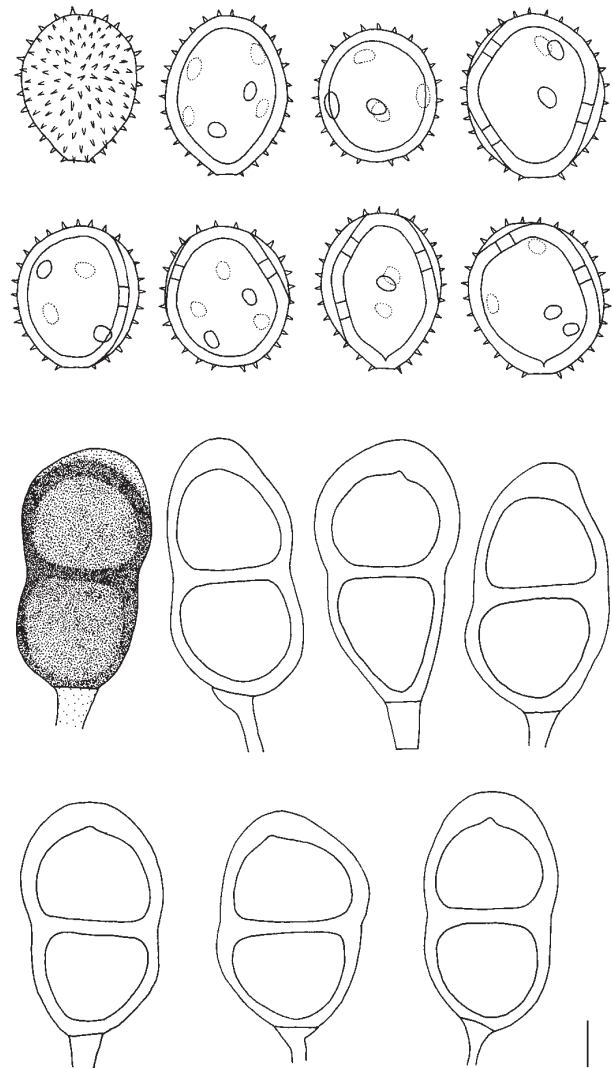
**Fig. 7**

Syn. *Persooniella tetragoniae* (McAlpine) Syd. (SYDOW 1922: 118). Lectotypes? on *Tetragonia implexicoma* J. Hook, Australia, “Brighton, Sandringham, Beaumaris, & c., and generally along the coast of Port Phillip Bay. Very common”.

Pycnia and aecia not seen. Uredinia amphigenous on leaves, mostly abaxial, subepidermal, separate, scattered or in  $\pm$  concentric groups, roundish, subcircular, sometimes elongated or irregular in outline, up to 1 mm wide, fulvous to cinnamon-brown, surrounded by the torn epidermis. Urediniospores globose, subglobose to ellipsoid,  $25\text{--}35 \times 21\text{--}28$  (30)  $\mu\text{m}$ , delicately echinulate, echination coarsely meshed, spore wall uniformly  $1.5\text{--}3$   $\mu\text{m}$  thick, bilaminate, outer layer thin,  $\pm$  hyaline, inner layer thick, pale yellow, amber to yellowish brown, germ pores inconspicuous  $5\text{--}7$  (8), scattered, with hyaline, broadly developed papillae. Telia amphigenous on leaves, mostly abaxial, subepidermal, scattered, round to elliptic, often bullate, up to 1 mm wide, black, long covered by the epidermis, later naked and surrounded by the torn epidermis. Teliospores bicellular, ellipsoid, cylindrical, subclavate or irregular, rounded or subacute at the apex, rounded or attenuate at the base, slightly constricted at the septum, deep chestnut-brown, apical brightened,  $43\text{--}52 \times 25\text{--}31$   $\mu\text{m}$ , spore wall smooth, lateral  $1.5\text{--}3$   $\mu\text{m}$ ,  $6\text{--}8$  (9)  $\mu\text{m}$  thick at the apex, germ pore in the upper cell apical, in the lower cell next to the septum, pedicel persistent, up to  $20$   $\mu\text{m}$  long, thin-walled, collapsing, yellowish, sometimes obliquely inserted.

**Specimens examined:** On *Tetragonia echinata* Aiton. South Africa, Northern Cape Province, Richtersveld, BIOTA observatory at Yellow Dune, S  $28^{\circ}37'03.7''$ , E  $16^{\circ}39'43.7''$ , 14 Sept. 2002, leg. M. Mennicken No. RSA 156, II (PREM). On *Tetragonia echinata*. South Africa, Western Cape Province, BIOTA observatory at Moedverloren 208, S  $31^{\circ}28'00.5''$ , E  $18^{\circ}26'25.7''$ , 5 Sept. 2002, leg. M. Mennicken No. RSA 106, II (PREM). On *Tetragonia fruticosa* L. South Africa, Western Cape Province, BIOTA observatory at Rocherpan Nature Reserve, S  $32^{\circ}36'19.6''$ , E  $18^{\circ}18'51.1''$ , 21 Nov. 2001, leg. M. Mennicken No. RSA 27, II III (PREM, M). On *Tetragonia* sp. South Africa, Western Cape Province, BIOTA observatory at Luiperskop 211, S  $31^{\circ}17'16.8''$ , E  $18^{\circ}36'15.8''$ , 7 Sept. 2002, leg. M. Mennicken No. RSA 123, II (PREM).

Our collections agree well with the diagnosis of *Puccinia tetragoniae* although the spectrum of spore measurements of the urediniospores is wider, whereas the spectrum of the teliospores is narrower in our collections. MCALPINE (1895) stated for the urediniospores  $27\text{--}32 \times 22\text{--}25$   $\mu\text{m}$  (av.  $31 \times 24$   $\mu\text{m}$ ), and for the teliospores  $39\text{--}59 \times 25\text{--}31$   $\mu\text{m}$  (av.  $50 \times 28$   $\mu\text{m}$ ). For determination, the varieties of *Puccinia tetragoniae* (DOIDGE 1948, LAUNDON 1963, McKenzie 1991) were disregarded. However, it is remarkable that our collections do not agree with the South African variety *Puccinia tetragoniae* var. *austro-africana* (DOIDGE 1948: 904) (type on *Tetragonia expansa* Murr., South Africa, Pietersburg, 4. 1944, leg. Palte, PREM 34095). After DOIDGE (1948) the type collection differs from *Puccinia tetragoniae* in having smaller ( $20\text{--}26 \times 17.5\text{--}20$   $\mu\text{m}$ ) and thinner-walled urediniospores ( $1.5\text{--}2$   $\mu\text{m}$  thick) and in having shorter teliospores ( $30\text{--}50 \times 22.5\text{--}35$   $\mu\text{m}$ ). DOIDGE (1948) stated for South African collections urediniospores measuring  $22.5\text{--}32 \times 17.5\text{--}25$   $\mu\text{m}$  and teliospores  $30\text{--}50 \times 25\text{--}35$   $\mu\text{m}$ . *Puccinia tetragoniae* var. *austro-africana* has been reported from the host plant *Tetragonia expansa* in



**Fig. 7:** *Puccinia tetragoniae* on *Tetragonia fruticosa*. Uredinio- and teliospores. RSA 27. Scale bar =  $10$   $\mu\text{m}$ .

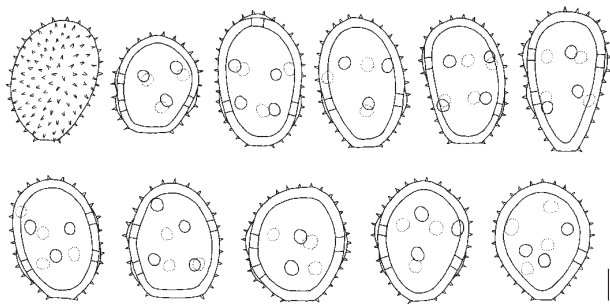
Stellenbosch, Wellington, Wynberg, Paarl, Caledon, and Pietersburg (DOIDGE 1950). As far as could be established *Tetragonia echinata* and *Tetragonia fruticosa* are new host plants for *Puccinia tetragoniae*.

***Uredo guerichiani* Mennicken, Maier, Crous & Oberw., sp. nov.**

**Fig. 8**

Pycnia, aecia et telia ignota. Uredinia amphigena, subepidermalia, cinnamomea, usque ad  $2.5$  mm diam., mox nuda, pulverulenta. Urediniosporae subgloboideae, ellipsoideae, oblongae vel pyriformes,  $28\text{--}45 \times 20\text{--}31$   $\mu\text{m}$ , pariete echinulato, aureo-fusco, lateraliter ( $1.5$ )  $2\text{--}3$   $\mu\text{m}$  crasso, apicaliter  $2\text{--}3.5$   $\mu\text{m}$  crasso, (7)  $8\text{--}10$  poris germinationis dispersis. In foliis *Mesembryanthemi guerichiani* Pax (Aizoaceae).

Pycnia, aecia, and telia unknown. Uredinia amphigenous on leaves, subepidermal, separate, scattered or in irregular groups, roundish, subcircular, elongated or irregular in outline, up to  $2.5$  mm wide, fulvous to cinnamon-brown, early exposed, pul-



**Fig. 8:** *Uredo guerichiani* on *Mesembryanthemum guerichianum*. Urediniospores. RSA 28. Scale bar = 10  $\mu$ m.

verulent, surrounded by the torn epidermis, without spots surrounding uredinia. Urediniospores subglobose, ellipsoid, oblong, or pyriform, 28–45  $\times$  20–31  $\mu$ m, echinulate, borne singly on short pedicels, spore wall lateral (1.5) 2–3  $\mu$ m, 2–3.5  $\mu$ m thick at the apex, golden to yellowish brown, germ pores conspicuous, (7) 8–10, scattered, sometime  $\pm$  bizonate, with hyaline, weakly developed papillae. On the leaves of *Mesembryanthemum guerichianum*.

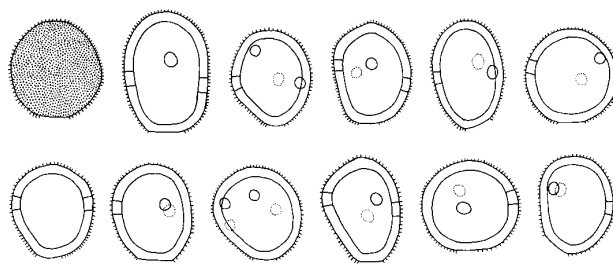
**Etymology.** Named after the host plant, *Mesembryanthemum guerichianum*.

**Specimens examined:** On *Mesembryanthemum guerichianum*. South Africa, Western Cape Province, BIOTA observatory at Moedverloren 208, S 31°27'42.2'', E 18°26'38.4'', 22 Nov. 2001, leg. M. Mennicken No. RSA 29, II. Holotype (PREM), Isotype (M). On *Mesembryanthemum guerichianum*. South Africa, Western Cape Province, BIOTA observatory at Flaminkvlakte 111, S 31°17'07.4'', E 18°35'31.6'', 23 Nov. 2001, leg. M. Mennicken No. RSA 31, II. Paratypes (PREM, M). On *Mesembryanthemum guerichianum*. South Africa, Northern Cape Province, BIOTA observatory at Quagafontein 478, S 30°11'31.0'', E 17°33'11.7'', 11 Sept. 2002, leg. M. Mennicken No. RSA 138, II. Paratypes (PREM, M). On *Mesembryanthemum guerichianum*. South Africa, Northern Cape Province, Richtersveld, BIOTA observatory at Yellow Dune, S 28°36'49.22'', E 16°39'45.5'', 14 Sept. 2002, leg. M. Mennicken No. RSA 153, II (PREM, M). This collection is also infected with *Puccinia aridariae*. On *Mesembryanthemum* sp. South Africa, Western Cape Province, BIOTA observatory at Moedverloren 208, S 31°27'43.2'', E 18°26'41.4'', 22 Nov. 2001, leg. M. Mennicken No. RSA 28, II (PREM, M).

***Uredo lieliefontinensis* Mennicken, Maier, Crous & Oberw., sp. nov.** **Fig. 9**

Pycnia, aecia et telia ignota. Uredinia abaxialia, subepidermalia, ochracea, usque ad 1 mm diam., mox nuda, compacta, pulverulenta. Urediniosporae globoideae, subgloboideae, ellipsoideae vel ovoideae, 22–30  $\times$  18–25  $\mu$ m, pariete verruculoso, aureo-fusco, 1.5–3  $\mu$ m crasso, (2) 3–4 poris germinationis  $\pm$  aequatorialibus. In foliis cf. *Galeniae* sp. (Aizoaceae).

Pycnia, aecia, and telia unknown. Uredinia abaxial on leaves, subepidermal, separate or scattered, roundish or ellipsoid, up to 1 mm wide, pale ochraceous, early exposed, compact, pulverulent, surrounded by the torn epidermis, without spots sur-



**Fig. 9:** *Uredo lieliefontinensis* on cf. *Galenia* sp. Urediniospores. RSA 131 Holotype. Scale bar = 10  $\mu$ m.

rounding uredinia. Urediniospores globose, subglobose, ellipsoid to ovoid, sometimes irregular and somewhat angular, occasionally broader than long, 22–30  $\times$  18–25  $\mu$ m, verrucous, borne singly on pedicels, spore wall uniformly 1.5–3  $\mu$ m thick, golden to yellowish brown, germ pores conspicuous, (2) 3–4,  $\pm$  equatorial, without papillae. On the leaves of cf. *Galenia* sp.

**Etymology.** Named after the habitat, Leliefontein.

**Specimen examined:** On cf. *Galenia* sp. South Africa, Northern Cape Province, BIOTA observatory at Leliefontein 624, S 30°23'29.2'', E 18°16'41.5'', 10 Sept. 2002, leg. M. Mennicken No. RSA 131, II. Holotype (PREM), Isotype (M).

In Tab. 1 we give a synopsis of the most important characters of the 10 known rust species on Aizoaceae.

### Acknowledgements

The authors thank NN and NN for peer review of the manuscript, the curators of B and PREM for the loan of specimens, Matthias Lutz and Michael Weiß for critical comments on the manuscript, Michael Weiß for help with the Latin diagnoses, and Sheila and Brian Longman for improving the English text. The study was made possible by the Federal Ministry of Education and Research in Germany through the sourcing of the BIOTA (Biodiversity Monitoring Transect Analysis) Southern Africa project. The Northern Cape Department of Nature and Environmental Conservation, the Western Cape Nature Conservation Board, and the Conservation Services of the South African National Parks are gratefully acknowledged for issuing research permits. The authors thank all land owners and decision makers for the permission to enter the BIOTA-observatories and to collect rust-infected plants. Finally, we thank the botanical BIOTA working group of Norbert Jürgens from the University of Hamburg for help with the determination of the host plants.

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Tab. 1: Morphological characters of the rust species on Aizoaceae. <sup>1</sup> According to DoIDGE (1939); <sup>2</sup> According to CROUS et al. (1999).

Rust species	Host genus	Aeciospores		Urediniospores			Teliospores					
		Measurement	Measurement	Spore wall	number	Germ pores	Measurement	Measurement	Number of cells			
		$\mu\text{m}$	$\mu\text{m}$	quality	number	arrangement	$\mu\text{m}$	$\mu\text{m}$	1	2	3	4
<i>Aecidium tetragoniae</i> <sup>1</sup>	<i>Tetragonia</i>	20–32.5 × 15–20	–	–	–	–	–	–	–	–	–	–
<i>Puccinia aridariae</i>	<i>Aridaria</i>	–	(26) 28–36 × 20–26	echinulate	(9) 10–12 (16)	scattered	(35) 40–55 (58) × 26–35	(35) 40–55 (58) × 26–35	x	x	–	–
<i>Puccinia galeniae</i>	<i>Aizoon</i> <i>Galenia</i> <i>Tetragonia</i>	–	(19) 21–29 (36) × 17–22 (26)	echinulate	3–4 (5)	± equatorial	32–41 (46) × 21–27 (30)	32–41 (46) × 21–27 (30)	x	x	x	–
<i>Puccinia knersvlaktensis</i>	<i>Mesembryanthemum</i>	21–33 × 17–27	–	–	–	–	36–60 × 17–31 (34)	36–60 × 17–31 (34)	–	x	x	x
<i>Puccinia mesembryanthemi</i>	<i>Psilocaulon</i>	(25) 31–43 (45) × 22–35 (37)	–	–	–	–	(36) 40–58 × 21–32 (34)	(36) 40–58 × 21–32 (34)	–	x	–	–
<i>Puccinia otzeniani</i>	<i>Lampranthus</i>	26–33 × 22–29	–	–	–	–	60–80 × (34) 40–50	60–80 × (34) 40–50	–	x	–	–
<i>Puccinia</i> sp. <sup>2</sup>	<i>Scoletium</i>	–	(25) 28–35 (38) × (20) 22–26 (28)	echinulate	6–10	scattered	(40) 50–60 (65) × (21) 26–28 (32)	(40) 50–60 (65) × (21) 26–28 (32)	–	x	–	–
<i>Puccinia tetragoniae</i>	<i>Tetragonia</i>	not seen	25–35 × 21–28 (30)	echinulate	5–7 (8)	scattered	43–52 × 25–31	43–52 × 25–31	–	x	–	–
<i>Uredo guerichiani</i>	<i>Mesembryanthemum</i>	–	28–45 × 20–31	echinulate	(7) 8–10	scattered	–	–	–	–	–	–
<i>Uredo lilefontinensis</i>	cf. <i>Galenia</i>	–	22–30 × 18–25	verrucous	(2) 3–4	± equatorial	–	–	–	–	–	–

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Accepted: 30.3.2005