A sketch of the lichen biota in a Renosterveld vegetation habitat

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Abstract
A sketch of the lichen vegetation of the Haarwegskloof Renosterveld Reserve near Bredasdorp (Western Cape, South Africa) is presented. This reserve is a representative example of renosterveld vegetation, which replaces the better known fynbos in relatively dry regions on more fertile, clay- and shale-based soils. Our sketch is a first attempt to characterize the lichen biota of a renosterveld area. The rather low number of 76 encountered species reflects the absence of aged trees and large rock formations and occasional bushfires. However, the significance of the species is great because most have very restricted distributions in southern Africa. Among the epiphytic lichens Physciaceae and *Xanthoria*-relatives prevail, while on soil and on rock the genus *Xanthoparmelia* is by far the most important, with 22 species, among them several endemics.

Kurzfassung
Eine Skizze der Flechtenbiota in einem Renosterveld-Habitat.
Die Flechtenvegetation des Haarwegskloof Renosterveld Reserve bei Bredasdorp (Western Cape, Südafrika) wird skizziert als ein Beispiel für die Flechtenbiota in der Renosterveld-Vegetation, welche gegenüber dem auf sauren, nährstoffarmen Böden wachsenden Fynbos auf relativnährstoffreichen Ton- und Schieferböden und in trockeneren Gebieten vorkommt. Mit dieser Artenliste wird erstmals die Flechtenvegetation eines Renosterveld-Gebietes charakterisiert. Die nicht sehr hohe Zahl von 76 registrierten Arten spiegelt das Fehlen von älteren Bäumen und größeren Felsbildungen sowie Brandereignisse wider. Dem gegenüber steht die flechtengeographische Bedeutung der Arten, deren Verbreitung zu einem großen Teil auf das südlichste Afrika beschränkt ist. Unter den auf Sträuchern wachsenden Epiphyten herrschen Physciaceae und *Xanthoria*-Verwandte vor, unter den boden- und gesteinsbewohnenden Flechten Arten der Gattung *Xanthoparmelia*, von der 22 Arten gefunden wurden.

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1 Introduction

The Cape Floristic Region (CFR) in the southernmost region of South Africa is recognized as one of the World's 34 Biodiversity Hotspots (Myers 1990, Myers 2003), is the richest of the World's six Floral Kingdoms (with over 9000 species) and is significantly threatened by a plethora of issues, including infestations by exotic invasive plants, transformation for development and agriculture and general habitat degradation associated with mismanagement (Rebelo 1992, Rouget et al. 2003, Raimondo et al. 2009). Within the CFR are two main Biomes: the Karoo and the Fynbos Biomes. Within these Biomes are over 120 different vegetation types. 'True' fynbos vegetation tends to be concentrated in mountainous and coastal regions within the CFR and is generally associated with poor, acidic, sandy soils. Fynbos vegetation types are typified by a dominance of proteas, ericas (heather) and restios (reeds) and are fire-adapted and fire-dependent systems. However, in the lowlands of the CFR, vegetation typically changes to renosterveld, in response to interactions between lower rainfall and a change to relatively more fertile, clay- and shale-based soils. Renosterveld is typified by the absence of the three main 'fynbos indicators' (proteas, ericas and restios) and tends to be dominated by Asteraceous shrubs (i.e. woody shrubs belonging to the daisy family) and perennial C_3 and C_4 grasses.

Compared with adjacent fynbos habitats, renosterveld tends to have an overall grey appearance, due to the dominance of asteraceous shrubs and in particular, the renosterbos *Elytropappus rhinocerotis*. It is also a grassier habitat and is richer in forbs, annuals and geophytes than fynbos habitats (Rebelo 1992). Renosterveld is renowned for its exceptionally high levels of geophyte diversity (Cowling 1983, Paterson-Jones 1998).

Lowland renosterveld vegetation types have been severely transformed, with > 90 % of them having been ploughed for agricultural development (Kemper et al. 1999, McDowell & Moll 1992). According to the Sanbi & Deat's (2009)

Threatened Ecosystems of South Africa, about 12 % of the original extent of all renosterveld types in the Overberg still remains – although other estimates are as low as 4-6 %. Renosterveld is listed as Critically Endangered and is at high risk of functional extinction. The viability of renosterveld as a functioning ecosystem is influenced by a suite of factors, from those occurring as a result of significant shifts in management regimes to those occurring as a result of significant fragmentation and habitat loss.

The man-induced transformation of renosterveld started with the arrival of the first European settlers in the mid-late 1600's, who started by exterminating most large game species and then began to plough land for crop cultivation. However, the most significant losses occurred over the last 50-100 years. Today, almost all remnant renosterveld is found on privately-owned land, making it very vulnerable to the deleterious effects of poor management.

There are four different types of Renosterveld in the Overberg: Rûens Silcrete Renosterveld, Western Rûens Shale Renosterveld, Central Rûens Shale Renosterveld and Eastern Rûens Shale Renosterveld (Mucina & Rutherford 2006). All are listed as Critically Endangered (Sanbi & Deat 2009). The Overberg 'grain-belt' (i.e. previously renosterveld regions) comprises a variety of cash crops (wheat, barley, canola, oats) as well as lucerne pastures for livestock (mostly sheep and cattle). Essentially, food crops are planted on a rotational basis and alternated with lucerne as artificial pasture for livestock. Almost all crops depend on winter rain and as with all extensive monocultures, a substantial amount of pesticide and herbicide is used on these crops.

Research has shown that even a fragment of only a few hectares of renosterveld can contain exceptionally high plant diversity (Curtis et al. 2013, Kemper et al. 1999) and new plant species are still being discovered (Curtis et al. 2013, Duncan 2017, Magee et al. 2016). While the flora in renosterveld is generally well-described, the lichen biota have been poorly explored, suggesting that there are species and communities of lichen yet to be discovered and described.

There are very few descriptions of the lichen biota at distinct sites or locations within South Africa and particularly in any of the Critically Endangered Renosterveld vegetation types, which have been largely unexplored by lichen biologists. In this study, we explore the lichen diversity on a renosterveld reserve in the Eastern Rûens Shale Renosterveld and present a register of the species recorded here to date, during three short site visits. Despite the short sampling period, given the scarcity of information on cryptogams in this region, this study adds great value to the overall biodiversity inventory for this vegetation type. It also highlights potential indicator species found in healthy, intact patches of renosterveld, which may assist with ecological assessments of other renosterveld sites in future.

Lichens are adapted to special substrate types. They are often specialized on the bark of trees and shrubs, on soil or on rock, where the substrate pH is responsible for further differentiated site selection. Acidic, SiO_2 rich rock types such as quartzite, bear different lichens than rock types poor in SiO_2 and rich in minerals, such as is the case with many magmatic orshale rock (the latter found in the study area). Foliose lichens which grow relatively fast may switch from one substrate type to another, mostly within a small pH-range. Thus some of the more spectacular lichen species may be found on rock or on soil (especially in dry climate regions), or on twigs and on rock.

2 Study area

This study took place on the Haarwegskloof Renosterveld Reserve, in the Overberg region of the Western Cape, South Africa. The Overberg essentially lies between Grabouw and Heidelberg (west to east), and includes the Agulhas Plain in the south, with the Riviersonderend and Langeberg Mountains forming its boundary in the north.

There are 23 types of Renosterveld described in the Cape Floristic Region (Mucina & Rutherford 2006) and these are broadly divided into mountain and lowland renosterveld. The lowlands of the Cape Floristic Region are further divided into two broad types: West Coast and South Coast Renosterveld. The Overberg comprises South Coast Renosterveld, which is further divided into four different vegetation types (Eastern-, Western-, Central-Rûens Shale Renosterveld and Rûens Silcrete Renosterveld).

Due to the extensive transformation of the Overberg lowlands, renosterveld now only persists as hundreds of isolated remnants in a sea of monoculture, varying in size from under 1 ha to 500 ha. However, fewer than 50 remnants are larger than 100 ha. One of the largest and most contiguous remaining remnants is found at Haarwegskloof Renosterveld Reserve, owned by WWF-SA and

managed by the Overberg Renosterveld Conservation Trust. Haarwegskloof (elevation up to 250 m asl.) is located between the towns of Swellendam and Bredasdorp, north of the well-known De Hoop Nature Reserve, east of Cape Agulhas.
Haarwegskloof comprises of Eastern Rûens Shale Renosterveld vegetation and its slopes are dominated by a combination of woody asteraceous shrubs (mostly *Elytropappus rhinocerotis, Oedera squarrosa, O. uniflora* and *Pteronia incana*) and bunch C_3 grasses (*Pentameris eriostoma*). The valleys form thickets of large, woody shrubs and small trees (up to 2-3 m in height) such as *Chrysanthamoides monilifera*, *Diospyros* spp., *Olea capensis* and *Buddleja saligna*. Hilltops are often dominated by 'quartz patches', comprising a layer of quartz pebbles on shale-derived soils, giving rise to a suite of endemic plants (CURTIS et al. 2013). Scattered on the reserve are low outcrops and piles of quartz and shale rocks that were dumped on the natural portions of the farm when the production lands were developed (Fig. 1, Fig. 2). The shale rocks are fine-grained sedimentary rocks consisting of a mix of flakes of clay minerals and tiny fragments of other minerals, and are thus more base rich and less acidic on its weathered surface than the quartz rocks.

3 Methods

In order to collect a representative sample of the lichen biodiversity of the area, we collected specimens over three short visits to the reserve (October 2015, August and October 2017) from soil, rock and vegetation. The samples were investigated by thin layer chromatography (H. SIPMAN, M. HEKLAU) following ORANGE et al. (2001), except those which were confidentially determinable in the field such as *Teloschistes* species, *Ramalina celastri, Physcia adscendens, Ph. jackii* and *Ph. erumpens*. For determination of the species of *Xanthoparmelia* s.l., by far the most important genus in open biota of the Cape region, HALE (1987, 1989, 1990), ELIX (1994, 1997, 1999, 2002), and ESSLINGER (1977, 1986, 2000) were used, for other genera mainly SWINSCOW & KROG (1988), for Physciaceae MOBERG (2004), for *Buellia* s.l. MARBACH (2000), for *Diploschistes*

Figure 1. Renosterveld vegetation near Haarwegskloof Research Center northeast of Bredasdorp (Western Cape) with quartz boulders and *Aloe arborescens*. – all photos: V. WIRTH.

Guderley & Lumbsch (1996), for *Teloschistes* Almborn (1989) and Frödén & Kärnefelt (2007), for *Acarospora* Magnusson (1933). ITS sequences were obtained from Alvalab (Oviedo, Spain) and deposited in Genbank.
During the excursion pictures were made in the field with a Canon EOS, MP-E 65 mm macro lens, using a twin flash. From these, photographs of more than 20 species are presented in this paper, mainly of the genus *Xanthoparmelia*; its members are difficult to determine but often discernable in the field by their habit. The pictures will help conservation managers and ecologists to recognize important species in the region. Many were not published in colour pictures before.
Collecting data: Western Cape, Overberg: 32 km NE of Bredasdorp, Renosterveld Nature Reserve. Locality 1: south of Renosterveld Research Centre, alt. 150-190 m asl, c. 34°21'13" S, 20°19'05" E – 34°21'11" S, 20°19'00" E – 34°21'17" S, 20°18'39" E – 34°21'30" S, 20°18'48" E, 13 and 17 Oct. 2015, leg. Volkmar Wirth, accompanied by Odette Curtis-Scott, Jannie Groenewald and Renate Wirth, and Oct. 2017, leg. Odette Curtis-Scott, accompanied by Jannie Groenewald – Locality 2: NW of Renosterveld Research Centre, alt. 140-190 m asl, 34°19'48.756" S, 20°18'51.588" E – 34°19'57.468" S, 20°18'52.775" E – 34°19'47.352 S, 20°18'52.308" E – 34°19'46.452" S, 20°18'52.667 E, 144 m – 34°19'46.81" S, 20°18'52.416" E, 144 m, leg. Odette Curtis-Scott, Oct. 2017.
Samples are deposited in the herbaria of the Botanical Museum at Berlin (B) and (a small set) of the State Museum of Natural History at Stuttgart (STU).

4 Recorded species

Acarospora laevigata H. Magn.
On shale rock outcrops; known only from South Africa. Samples: B 60 0198380, B 60 0201715, B 60 0198380.

Acarospora sp.
A brown species with reddish apothecia on quartz rocks; not collected.

Arthonia sytnikii S.Y. Kondr.
A lichenicolous fungus forming little black dots on *Dufourea dissectula* on *Galenia africana* twigs; known from Australasia and South Africa. Sample: B 60 0202456.

Arthonia sp.
A lichenicolous fungus growing in apothecia of cf. *Immersaria athroocarpa*, on shale rock outcrops. Sample: B 60 0201766.

Baculifera micromera (Vain.) Marbach
A common species on twigs of shrubs (*Diospyros, Dodonaea, Oederia squarrosa*, *Olea europaea* subsp. *africana*, *Searsia*); widely distributed in tropical to subtropical South America and southern Africa. Samples: B 60 0202466, B 60 0202459; ITS sequences: MH714512, MH714513.

Buellia stellulata (Taylor) Mudd s.l.
A species of the *Buellia stellulata*-group, often as a pioneer on hard quartz rocks; widespread on acidic and on basic siliceous rock, frequent, also in southern Africa.

Buellia tetrapla (Nyl.) Müll. Arg. (Fig. 3)
On twigs and stemlets of shrubs (e.g. *Gymnosporia heterophylla*), with *Hypotrachyna revoluta, Haematomma persoonii* and cf. *Ramboldia*; known from all subtropical regions of the southern hemisphere. Samples: B 60 0198379, STU-Wirth 37084 (with *Haematomma p.*)

Caloplaca haematodes
(A. Massal.) Zahlbr. (Fig. 2)
On quartz ridges, usually with *Buellia* cf. *stellulata*; known from southern Africa. Samples: B 60 0201753, B 600198375.

Caloplaca rubelliana (Ach.) Lojka
On shale rock outcrops; widespread in warm-temperate to subtropical regions. Sample: B 60 0198374.

Caloplaca sp.
A tiny lichen, regularly associated with *Baculifera micromera*; it occurs as scattered, tiny, orange apothecia between *Baculifera* on twigs of *Dodonaea*, *Oedera squarrosa*, *Galenia africana*. Samples: B 60 0202467, B 60 0202460.

Candelaria cf. ***pacifica*** Westb.
On *Asparagus, Dodonaea, Oedera*; forming very small squamules, unusually small for *C. pacifica*. Samples: B 60 0202459, B 60 0202469.

Candelariella sp.
On shale rock, species with soralia, with *Lecidella* sp. Sample: B 60 0201749.

Figure 2. Renosterveld near Haarwegskloof Research Center; quartz outcrops in the investigated area, covered by the pale greenish *Xanthoparmelia phaeophana* and the red *Caloplaca haematodes*.

Figure 3. *Buellia tetrapla* on twigs of shrubs (width 1.1 cm).

Figure 4. *Diploschistes euganeus* on shale rock (width 0.7 cm).

Catillaria sp.
On shale rock. Sample: B 60 0198381.

Chrysothrix xanthina (Vain.) Kalb
On stems of shrubs and small trees on rain-protected sites, as powdery bright yellow to yellowish green covering; widespread and common in tropics and subtropics. Samples: STU-Wirth, B 60 0202469; ITS sequence: MH714516.

Dufourea dissectula (S.Y. Kondr. & Kärnefelt) Frödén, Arup & Søchting
On twigs of *Galenia africana* and *Gymnosporia heterophylla*; known mainly from South Africa. Samples: STU-Wirth 38303, B 60 0202463, B 60 0202479; ITS sequence: MH714518.
Resembles the widespread and well-known *Xanthoria parietina* (L.) Th. Fr., but differs by the more deeply dissected, narrower, flatter lobes without raised terminal margins.

Dufourea inflata (Eichenb., Aptroot & Honegger) Frödén, Arup & Søchting
On *Gymnosporia heterophylla* twig, together with *Flavoparmelia soredians, Physcia jackii, Ramalina celastri, R. lacera, Parmotrema reticulatum, Usnea leprosa*; known only from South Africa. Sample: B 60 0202480.

Diploschistes euganeus
(A. Massal.) Zahlbr. (Fig. 4)
On shale rock, with *Flavoparmelia soredians*; known in semiarid warm zones world-wide, in Europe northwards up to temperate regions (very rare in France, Germany and Poland). Sample: B 60 0201764 (no substances).

Flavoparmelia rutidota (Hook. f. & Tayl.) Hale
On stems and twigs of asteraceous shrubs; one of the few foliose epiphytes in the reserve producing apothecia; in substropical regions of the southern hemisphere, extending into North America. Sample: accompanying *Physcia jackii* in B 60 0198394.

Flavoparmelia soredians (Nyl.) Hale
On shrubs (e.g. *Asparagus mariae, Diospyros* sp., *Dodonaea* sp., *Gymnosporia heterophylla*) and on rock; widespread in warm-temperate to tropical, more or less oceanic regions. Samples: B 60 0201769, B 60 0198396 (usnic, salazinic acids).

Haematomma persoonii
(Fée) A. Massal. (Fig. 5)
On shrubs (e.g. *Elytropappus, Gymnosporia* sp., *Olea europaea*), with *Hypotrachyna revoluta, Ochrolechia africana, Buellia tetrapla*; in tropical and adjacient regions worldwide (Staiger & Kalb 1995). Samples: B 60 0201756 (atranorin, ?sphaerophorin), STU-Wirth 37004 (atranorin, sphaerophorin), STU-Wirth 36562 (atranorin, sphaerophorin), STU-Wirth 37084.

Heterodermia speciosa (Wulfen) Trevis.
On shrubs, rare; widespread species.

Hypotrachyna revoluta (Flörke) Hale
On shrubs, with *Haematomma persoonii*; widespread in oceanic regions of the tropical to temperate zones. Samples: B 60 0201756 (atranorin, tr. lecanoric, gyrophoric, ?methylhiascic agg. acids); B 60 0198379, STU-Wirth 36562 (with *Haematomma p.*)

Lecanora pseudargentata Lumbsch
On shrubs (*Elytropappus, Olea europea* subsp. *africana, Gymnosporia heterophylla, Searsia rehmanniana*); widespread from tropical America to Australasia. Samples: B 60 0198366 (atranorin, gangaleoidin), B 60 0198394 (atranorin, gangaleoidin), B 60 0202457, B 60 0202477; ITS sequences: MH714514, MH714515.
The species resembles *L. argentata* by the apothecia with white margins and brown discs, and differs by the brownish epihymenium with crystal layer on top (Pol +) which dissolves after applying KOH (Lumbsch 1994).

Lecanora sp.
On rock, species with a whitish thallus and blackish apothecia. Sample: B 60 0201768 (atranorin, gangaleoidin, zeorin).

Lecidea terrena Nyl.
On shale rock; in Australasia and South Africa. Samples: B 60 0201751, B 60 0201765 (both with confluentic acid).

Lecidella sp.
On shale rock; with *Flavoparmelia soredians, Candelariella* sp., *Buellia* sp. Samples: B 60 0201749, B 60 0198376.

Ochrolechia africana Vain. (Fig. 6)
On shrubs (e.g. *Elytropappus rhinocerotis*, *Olea*), with *Usnea leprosa, Buellia* sp.; widespread in

Figure 5. *Haematomma persoonii* on stems of little trees (width ca. 3.8 cm).

Figure 6. *Ochrolechia africana* on twigs of shrubs (width 1.1 cm).

Figure 7. *Parmotrema austrosinense* on twigs of shrubs (width ca. 8 cm).

tropics and subtropics. Samples: B 60 0198377, B 60 0202472, STU-Wirth.

Parmotrema austrosinense (Zahlbr.) Hale
(Fig. 7)
On twigs and stems of shrubs (e.g. *Elytropappus rhinocerotis*, *Dodonaea, Gymnosporia* sp., *Olea europaea* ssp. *africana*, *Diospyros* sp.), with *Parmotrema reticulatum*; widespread in tropics and subtropics. Sample: STU-Wirth.
One of the most frequent and striking species on shrubs in the study area.

Parmotrema cooperi (J. Steiner & Zahlbr.) Sérus.
On twigs and stems of shrubs, with *Parmotrema reticulatum*; south and central Africa, tropical Asia, Australia. Sample: B 60 0198368 (atranorin, lecanoric acid).

Parmotrema norsticticatum (G. N. Stevens) A. Crespo, Divakar & Elix
A common but inconspicuous lichen on twigs of various shrubs, e.g., *Asparagus mariae*, *Dodonaea* sp., *Elytropappus rhinocerotis*, *Gymnosporia heterophylla* and *Oedera squarrosa*. First report of this Australian species in South Africa. Samples: B 60 0202461, B 60 0202464, B 60 0202473 (all three atranorin, norstictic, salazinic acids), present as admixture in further samples; ITS sequences: MH714509, MH714510, MH714511.
This foliose lichen resembles much *Crespoa carneopruinata* (Zahlbr.) Lendemer & B. P. Hodk. and *C. crozalsianum* (B. de Lesd. ex Harm.) Lendemer & B. P. Hodk. However, it forms smaller thalli with few, elongate lobes, which are tightly adnate on the twigs. Chemically it differs by the absence of stictic acid and the presence of norstictic and salazinic acid as dominant secondary products. The Australian specimens of *P. norsticticatum* (Elix 1994, sample sent by J. Elix tested) differ by the absence of salazinic acid and the presence of substantial amounts of stictic acid. Their ITS sequences are very similar, however, and are closer to *Parmotrema* than to *Crespoa*.

Parmotrema reticulatum (Taylor) M. Choisy
On shrubs (*Elytropappus*) and on rock (with *Xanthoparmelia phaeophana*); widespread in tropical/subtropical regions and in oceanic temperate areas. Sample: B 60 0201778 (atranorin, salazinic acid).

Parmotrema tinctorum (Despr. ex Nyl.) Hale
On stems of shrubs and little trees; widespread in tropical and subtropical regions.

Pertusaria dispersa Vain.
On twigs of shrubs, frequent on smooth bark (e.g. *Asparagus, Elytropappus rhinocerotis*, *Gymnosporia*, *Oedera*), with *Ochrolechia africana, Pertusaria pustulata, Teloschistes puber*. Distribution poorly known, perhaps restricted to South Africa. Samples: B 60 0201757 (thiophaninic, stictic acids), B 60 0202465 (thiophaninic, stictic, constictic acids), B 60 0202475 (thiophaninic, stictic, constictic acids), B 60 0202471 (thiophaninic, stictic, constictic acids).
Habitually quite similar to *P. leioplaca* but thallus yellowish, C+ orange, and ascospores two per ascus.

Pertusaria pustulata (Ach.) Duby
On twigs of shrubs on smooth bark (e.g. *Elytropappus rhinocerotis*), with *Ochrolechia africana, Pertusaria dispersa*, *Teloschistes puber*; widespread, also in temperate regions of the northern hemisphere. Sample: B 60 0201757 (2-chloro-6-O-methylnorlichexanthone, hypostictic, stictic, constictic acids).

Phacopsis australis Aptroot & Triebel
Parasitic on *Xanthoparmelia condyloides*; known only from South Africa. Sample: in its host, B 60 0201799.

Physcia adscendens (Fr.) Oliv.
On twigs of shrubs (e.g. *Gymnosporia heterophylla*); very widespread in cold to subtropical regions worldwide and frequent on nutrient-rich bark. Sample: B 60 0202478.

Physcia erumpens Moberg
On stems of shrubs; known from central and southern Africa, the Americas, the Philippines and Macaronesia. Sample: B 60 0198378 (atranorin, zeorin).

Physcia jackii Moberg
On stems of shrubs (e.g. *Searsia rehmanniana*, *Gymnosporia*), with *Usnea leprosa, Flavoparmelia rutidota, Lecanora pseudargentata, Ramalina celastri, Traponora, Physcia adscendens*; restricted to Australia and South Africa. Samples: B 60 0198394, B 60 0202474.

Physcia poncinsii HUE
On twigs of *Asparagus mariae* and *Gymnosporia heterophylla*; widespread in America, Africa and Australia. Sample: B 60 0202470.

Protoparmelia rogersii ELIX
On quartz rocks; first African record for the species described from Australia. Sample: B 60 0201750 (alectoronic acid); STU-Wirth.

Psora aff. ***crenata*** (TAYLOR) REINKE (Fig. 8)
On loamy and stony soil; known from southern Africa. Samples: B 60 0201763; B 60 0201817; STU-Wirth.
The probably new species is under investigation by EINAR TIMDAL.

Ramalina celastri (SPRENG.) KROG & SWINSCOW
On twigs of shrubs (e.g. *Asparagus mariae, Dodonaea* sp*., Elytropappus rhinocerotis*, *Gymnosporia heterophylla, Oederia squarrosa, Olea europaea, Searsia rehmanniana*), frequent, with *Parmotrema, Hypotrachyna, Usnea*, *Ramalina* cf. *pusiola*; frequent in Western Cape; widespread in tropical and subtropical regions worldwide. Samples: B 60 0198371 (tr. usnic acid), B 60 0202452, STU-Wirth; ITS sequences: MH714506, MH714507.

Ramalina lacera (WITH.) J. R. LAUNDON
On twigs of *Gymnosporia heterophylla*; widespread in subtropical, coastal areas of America, Africa and Europe. Samples: B 60 0202478, B 60 0202477; ITS sequence: MH714508.

Ramalina cf. ***pusiola*** MÜLL. ARG.
On twigs of shrubs, with *Ramalina celastri*; widespread in tropical regions. Sample: B 60 0198371 (sekikaic acid agg.).

cf. ***Ramboldia***
On shale rock outcrop. Sample: B 60 0201767 (atranorin, ?2'-methylperlatolic acid).

Rinodina ficta (STIZENB.) ZAHLBR.
Small thalli on twigs of *Dodonaea* sp. and *Oederia squarrosa*; known from subtropical regions in both hemispheres. Samples: B 60 0202462, B 60 0202468.

Teloschistes chrysophthalmus
(L.) TH. FR. (Fig. 9)
On shrubs (e.g. *Oederia squarrosa*, *Gymnosporia heterophylla)*; widespread in warm regions of Africa, North and South America, Australia, New Zealand and southern Europe. Sample: STU-Wirth, B 60 0201777, B 60 0202459; ITS sequence: MH714519.
Often found as very tiny, nevertheless fruiting specimens.

Teloschistes flavicans (SW.) NORM.
On asteraceous shrubs; worldwide in tropical and subtropical and mild temperate regions.

Teloschistes puber (ACH.) ALMB.
On twigs and stemlets of shrubs; endemic to western and southern parts of South Africa and Namibia. Sample: B 60 0201815.

Traponora globosa APTROOT
On stemlets and twigs of shrubs (*Dodonaea, Diospyros, Olea*), with *Physcia jackii, Usnea leprosa, Flavoparmelia rutidota, Lecanora pseudargentata, Ramalina celastri, Physcia adscendens*. Samples: B 60 0198394, B 60 0202459.
This genus of minute lichens is poorly known and rarely reported. The small size makes these lichens difficult to identify. The species is pantropical, known from Papua New Guinea, Thailand, Philippines, Brazil and Madagascar (APTROOT 2009), Dr A. Aptroot (Soest, The Netherlands) was so kind to check specimen B 60 0202459.

Usnea leprosa MOTYKA (Fig. 10)
On stemlets and twigs of shrubs (*Diospyros, Dodonaea* sp*., Gymnosporia heterophylla, Oederia squarrosa*), with *Ramalina celastri, Physcia adscendens, Ph. jackii, Flavoparmelia rutidota*; distribution unclear, in view of the taxonomic difficulties in the genus *Usnea*. Samples: B 60 0198394 (usnic, norstictic acids), B 60 0198369 (usnic, norstictic acids), B 60 0201816 (usnic, norstictic acids), B 60 0202478 (usnic, norstictic, stictic, constictic acids).

Usnea rubicunda var. ***spilota***
(STIRT.) G. N. STEVENS (Fig. 11)
On twigs of shrubs (with *Usnea leprosa*) and on quartz rock; in mild and warm oceanic regions worldwide. Sample: B 60 0198370 (usnic, norstictic, salazinic acids).

Usnea undulata STIRT.
On twigs and stemlets of shrubs; world distribution uncertain, known from Africa. Sample: B 60 0198373 (usnic, norstictic, galbinic acids).

Figure 8. *Psora* aff. *crenata* on loamy earth (width 2.1 cm).

Figure 9. *Teloschistes chrysophthalmus* (width 2 cm).

Figure 10. *Usnea leprosa* on dead twigs (width ca. 9 cm).

Figure 11. *Usnea rubicunda* on quartz rock (width ca. 10 cm).

Figure 12. *Xanthoparmelia amphixanthoides* (width 2.1 cm).

Figure 13. *Xanthoparmelia cafferensis* (width 2.1 cm).

Xanthoparmelia amphixanthoides
(J. Steiner & Zahlbr.) Hale (Fig. 12)
On loamy soil, with *X. molliuscula*; endemic to the Cape Provinces. Samples: B 60 0201808 (usnic, tr. norstictic, chalybaeizanic, salazinic acids), B 60 0201807 (usnic, chalybaeizanic, salazinic acids).
Characteristic are the often free-growing cushions and carpets of sublinear lobes only 0.7-1.5 mm wide, a pale brown underside and the K+ red reaction of the medulla. Similar to *X. molliuscula* which is K+ yellow and which produces often many terete lobes.

Xanthoparmelia cafferensis
(Essl.) O. Blanco et al. (Fig. 13)
On loamy soil and on quartz rock; known only from South Africa. Samples: B 60 0201814, B 600201781, B 60 0201782, B 60 0201779, B 60 0201780 (all with olivetoric acid), STU-Wirth.

Xanthoparmelia capensis Hale (Fig. 14)
On rock, often with *X. phaeophana* on top of rocks, also with *X.* vs. *squamariata*; endemic to Cape Provinces. Samples: B 60 0201801 (usnic, tr. norstictic, chalybaeizanic, salazinic acids), B 600201789 (usnic, tr. norstictic, ?galbinic, salazinic acids); ITS sequences: MH714500, MH714501.
A species tightly adnate on rock and producing globose to subcylindrical isidia. *X. isidiigera* is distinguished by the thinner cylindrical isidia and the occurrence of pycnidia.

Xanthoparmelia chalybaeizans
(J. Steiner & Zahlbr.) Hale (Fig. 15)
On shale rock; southern Africa. Samples: B 60 0201773 (usnic, chalybaeizanic, salazinic acids), B 60 0201774 (usnic, tr. norstictic, chalybaeizanic, salazinic acids), B 60 0201774 (usnic, tr. norstictic, chalybaeizanic, salazinic acids), B 60 0201783 (usnic, norstictic, tr. ?lusitanic, chalybaeizanic, salazinic acids); ITS sequences: MH714503, MH714504.

Xanthoparmelia condyloides
(Kurok.) Elix (Fig. 16 below)
On quartz rock, with *Xanthoparmelia substenophylloides*; endemic to Cape Provinces. Sample: B 60201799 (atranorin, tr. norstictic, chalybaeizanic, salazinic acids).

Xanthoparmelia diadeta (Hale) Hale
On rock, with *Buellia stellulata*; in eastern and southern Africa. Sample: B 60 0198384 (usnic, norstictic, salazinic acids).

Xanthoparmelia glabrans
(Nyl.) O. Blanco et al. (Fig. 17)
On shale rock; widespread in mediterranean and subtropical biomes, in both hemispheres. Sample: B 60 0201784 (α-collatolic, alectoronic acids).

Xanthoparmelia gyrophorica Hale (Fig. 18)
On loamy soil; southern Africa. Sample: B 60 0201803 (usnic, methylhiascic acid agg.).

Xanthoparmelia hypopsila
(Müll. Arg.) Hale (Fig. 19)
On loamy soil, with *Acarospora* sp.; southern Africa and southern South America. Sample: B 60 0201810 (usnic, norstictic, ?lusitanic, stictic, tr. cryptostictic, ?constictic acids).
A species with irregular to sublinear lobes, adnate to loosely adnate on rock, more rarely on soil, with a black underside (medulla K+ red).

Xanthoparmelia leonora
(Spreng. ex A. Massal.) Hale (Fig. 20)
On loamy soil, often with *X. amphixanthoides*. Samples: B 60 0201804 (usnic, tr. fumarprotocetraric, succinprotocetraric acids), B 60 0201788 (usnic, tr. fumarprotocetraric, ?protocetraric acids), STU-Wirth.
A very conspicuous species which is nearly free-growing on soil, often together with the tiny-lobed *X. amphixanthoides* (Fig. 12) or *X. molliuscula*. The up to 4 mm broad, long lobes with big apothecia (up to 5 mm wide) are diagnostic.

Xanthoparmelia marroninipuncta
(Brusse) Hale (Fig. 21)
On quartz rocks; known only from South Africa. Samples: B 60 0201793, B 60 0201792 (usnic, protocetraric acids, red pigments), STU-Wirth 38134.
The black spots on the thallus are unique in the genus. They give the impression of being a parasite.

Xanthoparmelia molliuscula
(Ach.) Hale (Fig. 22)
On soil, on rocks and pebbles of sandstone, quartz; known from southern Africa, Australia, New Zealand. Samples: B 60 0201796 (usnic, norstictic, ?lusitanic, stictic, tr. cryptostictic, ?constictic acids.), B 60 0201797 (usnic, norstictic, lusitanic, stictic, ?constictic acids), B 60 0201795 (usnic, norstictic, ?lusitanic, stictic, tr. cryptostictic, ?constictic acids), B 60 0201811

Figure 14. *Xanthoparmelia capensis* (width 2.1 cm).

Figure 15. *Xanthoparmelia chalybaeizans* (width 3.7 cm).

Figure 16. *Xanthoparmelia condyloides* (below) and *X.* cf. *substenophylloides* (width 1.1 cm).

Figure 17. *Xanthoparmelia glabrans* (width 2.1 cm).

Figure 18. *Xanthoparmelia gyrophorica* (width 4.8 cm).

Figure 19. *Xanthoparmelia hypopsila* (width 2.8 cm).

Figure 20. *Xanthoparmelia leonora* (width 2.1 cm).

Figure 21. *Xanthoparmelia marroni-nipuncta* (width c. 3.2 cm).

Figure 22. *Xanthoparmelia molliuscula* (width 4.2 cm).

(usnic, norstictic, ?lusitanic, stictic, tr. cryptostictic, ?constictic acids), B 60 0201798 (usnic, norstictic, lusitanic, stictic, ?constictic acids), STU-Wirth 36549 (usnic, norstictic, lusitanic, stictic, cryptostictic, ?constictic acids).
A nearly vagrant species, quite similar in habitus to *X. amphixanthoides* which has a K+ red medulla. One of the most important foliose lichens on soil in the area.

Xanthoparmelia molybdiza (Nyl.) Elix
On shale rock, with *Xanthoparmelia chalybaeizans*, *Buellia* sp.; known from East Africa, South Africa. Sample: B 60 0201772 (atranorin, lecanoric acid).

Xanthoparmelia perplexa
(Stizenb.) Hale (Fig. 23)
On quartz rock outcrop, with *Buellia* sp.; endemic to Cape Provinces. Samples: B 60 0201754 (usnic, norstictic, chalybaeizanic, salazinic acids), B 60 0201802 (usnic, tr. norstictic, chalybaeizanic, salazinic acids).
A species which grows closely adnate to rock. It appears nearly areolate-crustose in the center.

Xanthoparmelia phaeophana
(Stirt.) Hale (Fig. 2, 24)
On soil and quartz rock, covering often several dm², overgrowing other lichens; widespread in eastern and southern Africa, furthermore in Bourbon, Madagascar, Kerguelen Islands. Samples: B 60 0201787 (usnic, tr. fumarprotocetraric, protocetraric, physodalic acids), B 60 0201786 (usnic, tr. fumarprotocetraric, protocetraric acids), B 60 0201785 (usnic, tr. fumarprotocetraric, ?protocetraric acids), STU-Wirth 38291. One of the most important foliose lichens on rock in the area.

Xanthoparmelia prodomokosii
Hale, Elix & J. Johnst. (Fig. 25)
On quartz and shale rock; known from Australia and southern Africa. Samples: B 60 0201791, B 60 0201790 (both usnic, hypoprotocetraric, 4-O-demethylnotatic acids).
The species is centrally more or less bullate-areolate, at the thallus margin distinctly foliose.

Xanthoparmelia prolata
(Hale) Elix & J. Johnst. (Fig. 26)
On soil and rock, loosely attached or nearly free growing; endemic to the Cape Provinces. Sample: B 60 0201762 (atranorin, scabrosins); ITS sequence: MH714505.

Xanthoparmelia vs. ***squamariata***
(Nyl. ex Cromb.) O. Blanco et al.
On quartz rocks, north facing areas. Samples: B 60 0198392 (protocetraric, tr. fumarprotocetraric acids?), B 60 0201770, B 60 0198388, B 60 0198385.

Xanthoparmelia subramigera (Gyeln.) Hale
On top of quartz rocks, with *Xanthoparmelia* vs. *squamariata*; widespread in the subtropics of America, Africa and Japan. Sample: B 60 0198385 (physodalic, fumarprotocetraric, succinprotocetraric acids).

Xanthoparmelia cf. ***substenophylloides***
Hale (Fig. 16)
On quartz rocks, with *X. condyloides, X.* vs. *squamariata*. Samples: B 60 0201799 (usnic, norstictic, lusitanic, stictic, ?constictic acids), B 60 0201805 (usnic, norstictic, tr. lusitanic?, stictic, ?constictic acids).

Xanthoparmelia waboomsbergensis
Elix (Fig. 27)
Known only from the Cape provinces in South Africa. Sample: B 60 0201809 (usnic, norstictic, stictic, ?constictic acids); ITS sequence: MH714502. Characteristic are the small sublinear lobes and a nearly areolate center of the thallus.

Xanthoparmelia xanthomelanella Elix (Fig. 28)
On quartz rock; endemic to the Cape Provinces. Samples: B 60 0201812, B 60 0201818, B 60 0201800 (all with atranorin, norstictic, lusitanic?, stictic, tr. cryptostictic, ?constictic acids).

Xanthoria parietina (L.) Th. Fr.
On *Gymnosporia heterophylla* twigs, a species with a world-wide distribution in cooler climate zones. Sample: accessory in *Usnea leprosa* (B 60 0202478); ITS sequence: MH714517.
At first mistaken for the very similar *Dufourea dissectula*, and recognized by its quite distinct ITS sequence.

5 The lichen vegetation

Four main habitat types can be distinguished in the studied area in respect to the lichen vegetation and their adaptation: 1. loamy soil; 2. acid rock, represented by quartz ridges and rocks; 3. mineral-rich rock with subneutral surface conditions (mainly shale rock); 4. bark of stems and twigs of shrubs, e.g. *Elytropappus rhinocerotis*,

Figure 23. *Xanthoparmelia perplexa* (width ca. 4 cm).

Figure 24. *Xanthoparmelia phaeophana* (width ca. 10 cm).

Figure 25. *Xanthoparmelia prodomokosii (*width 2.1 cm).

Figure 26. *Xanthoparmelia prolata* (width 2.1 cm).

Figure 27. *Xanthoparmelia waboomsbergensis* (width 1.8 cm).

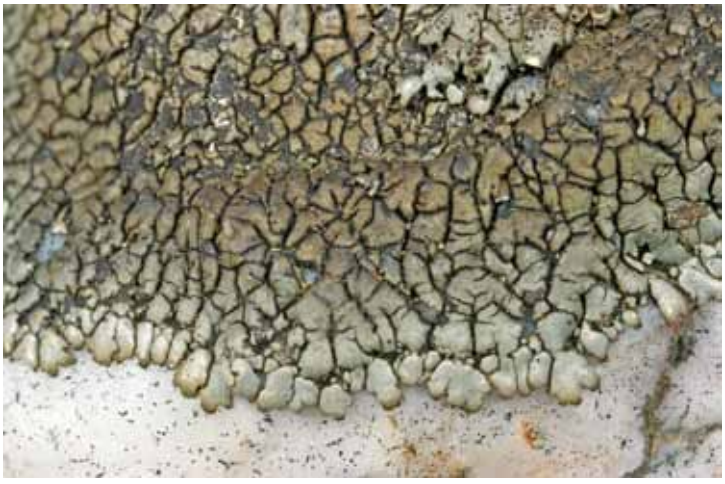

Figure 28. *Xanthoparmelia xanthomelanella* (width 2.1 cm).

Galenia africana, *Gymnosporia heterophylla*, *Oederia squarrosa*, *Olea europaea, Searsia rehmanniana*.

The lichen vegetation on soil is not very rich in species; it is confined to rather stable patches of naked loamy soil. Quite frequent are a species of the *Psora crenata*-group (Fig. 8), *Xanthoparmelia amphixanthoides* (Fig. 12) with its cushions of very small lobed thalli, *X. molliuscula* (Fig. 22) the very broad-lobed *X. leonora* (20) and the brown *X. cafferensis* (Fig. 13). In the vicinity of rocks some of the species, especially *Xanthoparmelias* may spread from rock to soil (as *X. phaeophana*) and vice versa, or from bark to rock, as in *Usnea rubicunda* or *Parmotrema cooperi*.

The quartz rocks are usually coloured by the pale greenish thalli of *Xanthoparmelia* species, such as *X. marroninipuncta*. On top of the rocks, one often encounters *X. capensis*, together with *X. phaeophana*, the latter being the most frequent representative of the genus in southern Africa according to HALE (1990). Associated with typical foliose *Xanthoparmelia*-species are species from the same genus with thalli which resemble placodioid crustose lichens strongly appressed to the rock surface, which formerly were assigned to the genus *Paraparmelia* (*X. condyloides, X. prolata*). Steeper faces bear *Caloplaca haematodes* which colours the corresponding areas deep red. Most crustose species are inconspicuous and of a greyish to brownish color, as in the quite common *Buellia* cf. *stellulata, Lecidea terrena, Diploschistes euganeus.* Usually parts of the quartz rocks are naked, showing that colonisation of that hard, nutrient-poor substrate is also difficult for lichens. The colonisation by foliaceous lichens in semi-arid environments may occasionally be interrupted by fires (which form a natural part of the cycle in this region). Similarly, parts of the carpet-like covers of some fast growing species such as *Xanthoparmelia phaeophana* may drop during storms and heavy rainfalls.

The epiphytic vegetation houses also some fruticose species which are typically associated with twigs, such as beard lichens of the genus *Usnea*, and *Teloschistes* (*T. flavicans, Usnea rubicunda*) and species with flattened to strap-shaped lobes, such as the greenish *Ramalina celastri* and the Golden-eye lichen (*Teloschistes chrysophthalmus*) with its yellow-grey thalli and orange fruiting bodies. The thicker stems are covered mainly by grey foliose species of the genera *Parmotrema, Hypotrachyna, Heterodermia*, together with the yellowish *Flavoparmelia soredians* and *Flavoparmelia rutidota* and crustose species as *Haematomma persoonii*, easily recognizable by its deep red fruiting bodies with white margins. All these species may also colonize small twigs.

6 Discussion

Habitually the lichen vegetation of Haarwegkloof Renosterveld Reserve on soil and on rock surfaces is dominated by foliaceous thalli of the genus *Xanthoparmelia* s.str., which is characterized by the pale yellowish green to grey green color of the upper thallus surface. Fourteen species were identified in the small study area. Some species may cover several square meters. The genus (sensu stricto, HALE 1990) which is most abundantly represented in semi-arid regions has an evolution center in South Africa containing ca. 250 species. A taxonomical concept of the genus on a molecularphylogenetic basis also includes brown species of the former genus *Neofuscelia* which is represented by three species in the Renosterveld reserve and *Paraparmelia* which is represented by four species. It is predicted that several additional species will be found on forthcoming visits to the reserve.

The dominance of *Xanthoparmelia* within the investigated area is not a peculiar characteristic of renosterveld vegetation; it is equally characteristic to fynbos vegetation, even for that in the Cederberg mountains or in Namaqualand. However, the species composition is considerably different in the Overberg-region.

Other foliose genera do not play any considerable role on rock surfaces. Occasionally *Parmotrema* species from mainly epiphyte habitats also occur on rock surfaces. Apart from *Xanthoparmelia* the epilithic communities are built up by crustose species, mainly from the genera *Buellia*, *Lecidea*, *Diploschistes* and *Acarospora*. Characteristic for dry habitats are yellow representatives of the latter genus, which is well represented in South Africa (MAGNUSSON 1933).

As trees with thick stems are missing in the renosterveld vegetation, epiphytes are confined to twigs and the relatively thin stems of shrubs. Consequently the spectre/amplitude of ecological potentials is quite limited with regard to substrate and climatic quality. Thick bark with deep crevices which guarantee microhabitats protected against rain are missing, as are bark types with spongy, water storing properties. Only the bright yellow to yellow-green powdery crusts of *Chrysothrix xanthina* represents the ombrophobous life type.

Despite the low substrate diversity, branches of shrubs may contain a considerably rich lichen community. This is especially true for *Gymnosporia heterophylla* (Celastraceae): We found a total of 19 lichen species living on five thin twigs of this phorophyte, collected from one individual plant and collectively measuring only c. 50 cm.

The lifespan of the epiphytes is influenced by the relatively short age of the phorophytes, and is shortened by fire events, thus these species have a higher probability of a shorter lifespan than their rock-inhabiting counterparts. These factors collectively contribute to the phenomenon that the epiphytic biota are comprised mainly of species which are able to reproduce and spread rapidly and effectively and therefore are widespread and frequent on trees or shrubs in open landscape. Some are nearly cosmopolites, such as *Physcia adscendens*, while others are pantropical, such as *Parmotrema austrosinense, P. reticulatum, Flavoparmelia soredians, Ramalina celastri, Teloschistes flavicans*, and *Haematomma persoonii*. Endemic species are an exception, for example *Dufourea inflata*, *Teloschistes puber*.

The epilithic lichen biota of the renosterveld and fynbos vegetation types are unique, in terms of their diversity and levels of endemism. The species, in particular the members of the dominant genus *Xanthoparmelia*, tend to have a much more restricted distribution than their epiphytic counterparts. Only very few are widespread. Many are endemic to South Africa, mainly the Cape Region, while some show a south African-Australian disjunction (a Gondwanaland distribution), as with *X. molliuscula*. In Australia the genus has a second major center of speciation with very similar species numbers, comprising ca. 170 species (sensu str.) or 250 (sensu lato) respectively, but spread over a much larger area and without a concentration like in Cape Province. Of 20 completely identified *Xanthoparmelia* species on our list, eight are known only from the Cape Province, four only from South Africa in wide sense; three are more widespread in southern Africa; two are shared between South Africa and Australasia, one is shared between South Africa and South America, and two are widespread over several continents.

The fact that a very short collecting trip in a very restricted area of the Renosterveld Reserve provided evidence of 73 lichen species, including eight endemics of the Cape Province, and three lichenicolous fungi (among them one possibly undescribed *Arthonia* sp.), illustrates that lichens are a valuable part of the plant diversity for which this vegetation type is renowned. The total figure of 73 lichens is not particularly high and reflects the scarcity of large rocks and big trees. In some tropical forests a single tree may have well over 100 species. Special is the high proportion of *Xanthoparmelia* species endemic to the Cape Province.

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Literature

Almborn, O. (1989): Revision of the lichen genus *Teloschistes* in Central and Southern Africa. – Nordic Journal of Botany **8**: 521-537.

Aptroot, A. (2009): The lichen genus *Traponora*. – Bibl. Lichenol. **100**: 21-30.

Cowling, R. M. (1983): The occurrence of C_3 and C_4 grasses in fynbos and allied shrublands in the southeastern Cape, South Africa. – Oecologia **58**(1): 121-127.

Curtis, O. E., Stirton, C. H. & Muasya, M. (2013): A conservation and floristic assessment of poorly known species rich quartz-silcrete outcrops within Rûens Shale Renosterveld (Overberg, Western Cape), with taxonomic descriptions of five new species. – South African Journal of Botany **87**: 99-111.

Duncan, G. (2017): Two new species, two rediscoveries and a range extension in *Lachenalia* (Asparagaceae: Scilloidea) from southern and western South Africa. – Phytotaxa **316**(3): 261-270.

Elix, J. A. (1994): Parmeliaceae. – Flora of Australia, Volume **55**: 1-380.

Elix, J. A. (1997): New species and new combinations in the lichen family Parmeliaceae (Ascomycotina) from South Africa. – Mycotaxon **63**: 335-343.

Elix, J. A. (1999): New species of *Neofuscelia* (lichenized Ascomycotina, Parmeliaceae) from the Southern hemisphere. – Mycotaxon **71**: 431-456.

Elix, J. A. (2002): New species of *Xanthoparmelia* (lichenized Ascomycotina, Parmeliaceae) from Africa. – Lichenologist **34**: 283-291.

Esslinger, T. L. (1977): A chemosystematic revision of the brown Parmeliae. – Journal of the Hattori Botanical Laboratory **42**: 1-211.

Esslinger, T. L. (1986): Further reports on the brown Parmeliaceae of southern Africa. – Nordic Journal of Botany **6**: 87-91.

ESSLINGER, T. L. (2000): Notes on the brown-colored Parmeliaceae (lichenized Ascomycota) in southern Africa. – The Bryologist **103**: 568-591.

FRÖDÉN, T. & KÄRNEFELT, I. (2007): Two new species of *Teloschistes* J. M. NORMAN: *T. arabicus* and *T. inflatus* and notes on the *Teloschistes* flora of Africa. – Bibl. Lichenol. **95**: 183-224.

GUDERLEY, R. & LUMBSCH, H. TH. (1996): The lichen genus *Diploschistes* in South Africa (Thelotremataceae). – Mycotaxon **58**: 269-292.

HALE, M. E. (1987): Additions to the *Xanthoparmelia* flora of southern Africa (lichenized Ascomycota, Parmeliaceae). – Mycotaxon **29**: 251-266.

HALE, M. E. (1989): New species in the lichen genus *Xanthoparmelia* (Ascomycotina, Parmeliaceae). – Mycotaxon **34**: 541-564.

HALE, M. E. (1990): A synopsis of the lichen genus *Xanthoparmelia* (VAINIO) HALE (Ascomycotina, Parmeliaceae). – Smithonian Contributions to Botany **74**: 1-250.

KEMPER, J., COWLING, R. M. & RICHARDSON, D. M. (1999): Fragmentation in South African renosterveld shrublands: effects on plant community structure and conservation implications. – Biological Conservation **90**: 103-111.

LUMBSCH, H. TH. (1994): Die *Lecanora subfusca*-Gruppe in Australasien. – Journal of the Hattori Botanical Laboratory **77**: 1-175.

MAGEE, A. R., CURTIS, O. E. & VAN WYK, B.-E. (2016): A refined circumscription of *Notobubon striatum* and the resurrection of *Dregea collina* ECKLON & ZEYHER (Apiaceae, Apioideae). Phytotaxa **266**(1): 27-32.

MAGNUSSON, A. H. (1933): Supplement to the monograph of the genus *Acarospora*. I. A survey of the species from Southern and Central Africa. – Annales de Cryptogamie Exotique **6**: 13-48.

MARBACH, B. (2000): Corticole und lignicole Arten der Flechtengattung *Buellia* sensu lato in den Subtropen und Tropen. – Bibl. Lichenol. **74**: 1-384.

MCDOWELL, C. & MOLL, E. (1992): The influence of agriculture on the decline of West Coast Renosterveld, south-western Cape, South Africa. – Journal of Environmental Management **35**: 173-192.

MOBERG, R. (2004): Notes on foliose species of the lichen family Physciaceae in southern Africa. – Symb. Bot. Ups. **34**(1): 257-288.

MUCINA, L. & RUTHERFORD, M. C. (eds) (2006): The vegetation of South Africa, Lesotho and Swaziland. – Strelitzia **19**: 1-816; South African National Biodiversity Institute, Pretoria.

ORANGE, A., JAMES, P. W. & WHITE, F. J. (2001): Microchemical methods for the identification of lichens. − British Lichen Society.

PATERSON-JONES, C. (1998): Renosterveld's Floral Treasure: Headed for extinction. – Africa – Environment and Wildlife **6**: 27-32.

RAIMONDO, D., VON STADEN, L., FODEN, W., VICTOR, J. E., HELME, N. A., TURNER, R. C., KAMUNDI, D. A. & MANYAMA, P. A. (eds) (2009): Red List of South African Plants 2009. – Strelitzia **25**: 1-668; South African National Biodiversity Institute, Pretoria.

REBELO, A. G. (1992): Red Data Book species in the Cape Floristic Region: Threats, Priorities and Target Species. – Transaction of the Royal Society of South Africa **48**: 55-83.

ROUGET, M., RICHARDSON, D. M., COWLING, R. M., LLOYD, J. W. & LOMBARD, A. T. (2003): Current patterns of transformation and future threats to biodiversity in terrestrial ecosystems of the Cape Floristic Region, South Africa. – Biological Conservation **112**: 63-85.

STAIGER, B. & KALB, K. (1995): *Haematomma*-Studien. I. Die Flechtengattung *Haematomma*. – Bibl. Lichenol. **59**: 3-198.

SWINSCOW, T. D. V. & KROG, H. (1988). Macrolichens of East Africa. – 7 + 390 S.; London, British Museum (Natural History).