

Bothalia

# AFRICAN BIODIVERSITY & CONSERVATION

ISSN: 0006-8241



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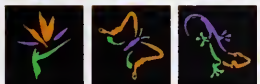
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Biodiversity for Life

South African National Biodiversity Institute



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Vol. 45 No. 1 2015



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Email: [publishing@aosis.co.za](mailto:publishing@aosis.co.za)  
Website: <http://www.aosis.co.za>  
Circulation Enquiries: [orders@aosis.co.za](mailto:orders@aosis.co.za)

Journal Title: *Bothalia - African Biodiversity & Conservation*  
Website: <http://www.abjournal.org>  
General Enquiries: [submissions@abjournal.org](mailto:submissions@abjournal.org)

ISSN: 0006-8241 (print)  
ISSN: 2311-9284 (online)

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ISSN: 0006-8241 (print)  
ISSN: 2311-9284 (online)

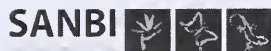
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South African National  
Biodiversity Institute  
(South Africa).



South African National Biodiversity Institute

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# Impacts of fire and grazing management on South Africa's moist highland grasslands: A case study of the Steenkampsberg Plateau, Mpumalanga, South Africa

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## Dates:

Received: 07 Dec. 2014

Accepted: 12 Aug. 2015

Published: 26 Nov. 2015

## How to cite this article:

Little, I.T., Hockey, P.A.R. & Jansen, R., 2015, 'Impacts of fire and grazing management on South Africa's moist highland grasslands: A case study of the Steenkampsberg Plateau, Mpumalanga, South Africa', *Bothalia* 45(1), Art. #1786, 15 pages. <http://dx.doi.org/10.4102/abc.v45i1.1786>

**Background:** Grasslands are heavily utilised for livestock agriculture and the resultant degradation through mismanagement contributes to an estimated 60% of this biome being permanently transformed. This study focused on the impact of fire and grazing in moist highland grasslands.

**Objectives:** To determine the contribution of burning frequency and grazing intensity combined (for domestic livestock and indigenous ungulates) on vegetation structure heterogeneity and species diversity.

**Methods:** Eight study sites under different management regimes were sampled over two summers. Vegetation structure characteristics and diversity data were collected monthly within multiple replicates in each study site. A disc pasture meter was used to assess standing biomass. Differences in vegetation structure characteristics, plant community composition and plant species assemblage structure across sites were statistically analysed using analyses of variance, indicator species analyses, multidimensional scaling ordinations and two-way cluster analyses.

**Results:** The combination of heavy grazing and annual burning leads to a distinct plant community dominated by disturbance specialist species. Selective grazing by indigenous herbivores promotes a community of unpalatable species. This study illustrates that fenced indigenous herbivores, even at moderate stocking densities, have a greater detrimental impact on plant diversity and structure than do domestic livestock.

**Conclusion:** Intensive grazing and burning have a detrimental impact on plant species diversity and structure. This also affects resultant palatability for grazing livestock and fenced game. To promote both grazing quality and ecological integrity we recommend a minimum sustainable 'fodder capacity' or standing phytomass of 5000 kg per large-animal unit per hectare for domestic livestock in moist highland grasslands.

## Introduction

Grasslands are ancient, complex and slowly evolving systems of diverse plant communities that generally lack the ability to recover after severe disturbance (Jacobs, Kingston & Jacobs 1999; Little *et al.* 2005). South African grasslands are being increasingly degraded through the cumulative influence of overgrazing (Neke & Du Plessis 2004; O'Connor *et al.* 2011), extensive, frequent burning (Uys, Bond & Everson 2004), plantation forestry (Allan *et al.* 1997; Lipsey & Hockey 2010) and invasion by alien plant species (Le Maitre *et al.* 1996). In South Africa, it is estimated that 60% of the grassland biome has been permanently transformed, whilst as little as 15% remains as natural grassland. Of the grassland biome, 25% is degraded to some degree and only about 2% is formally conserved (Carbutt *et al.* 2011; Macdonald 1989). Of particular concern is that the majority of the remaining natural grassland is highly fragmented and most is poorly managed (Mucina & Rutherford 2006:362; South African National Biodiversity Institute 2014). Grasslands have traditionally been used for livestock farming, which has allowed some of the natural ecological processes to continue fairly undisturbed. However, livestock grazing does not simulate the natural herbivore–grassland interaction that would have occurred in the area historically, at least from the late Miocene and early Pliocene (Jacobs *et al.* 1999; McNaughton 1986), and impacts of intensive grazing on species diversity in this system are poorly understood (Uys *et al.* 2004).

Note: †, 1956–2013

This article is based on the thesis 'Bird reproductive success and faunal habitat selection as tools for understanding the impacts of land-use management on moist highland grassland biodiversity in South Africa' for the degree of Doctor of Philosophy in the Percy FitzPatrick Institute of African Ornithology, Department of Zoology, University of Cape Town (July 2011). Supervised by Prof. Philip Hockey and co-supervised by Prof. Raymond Jansen.

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The use of grazing, and more commonly fire, for managing grassland is primarily to provide a green flush of nutrient-rich grass, remove old moribund grass material and control tick abundance (Bond 1997; Van Wilgen & Scholes 1997). However, grazing by livestock and the associated trampling and nutrient enrichment have a significant impact on grassland plant diversity (O'Connor *et al.* 2010; O'Connor *et al.* 2011; Veen *et al.* 2008), as does the use of fire (Veen *et al.* 2008). Furthermore, selective grazing has been shown to alter the structure and species composition of grasslands (Milchunas, Sala & Lauenroth 1988; Owen-Smith 1999), often favouring unpalatable species, which, in turn, causes a change in community species composition (Milchunas *et al.* 1988; Sternberg *et al.* 2000). Fire also modifies the grazing pattern and behaviour of herbivores, because it reduces above-ground biomass (Van Wilgen & Scholes 1997).

Although South African grassland systems are naturally maintained by winter and spring fires (Mucina & Rutherford 2006:356), there is concern over the possible detrimental effect of unnaturally frequent fires on plant diversity (Collins & Calabrese 2012; Swengel 2001). It has been suggested that the natural fire frequency in moist highland grasslands would have been only every 4 years or more (Manry & Knight 1986). It has further been suggested that controlled burning should be based on the rate of litter accumulation and that grazing should not start until sward height reaches 250 mm (Mentis 1981). This is manageable with domestic livestock, but indigenous game species tend to graze burnt areas selectively and therefore their stocking rates in fenced areas need to be sufficiently low so that the total number of animals congregating on burnt areas alone is not detrimental (Van Rooyen, Bredenkamp & Theron 1986). Annual burning of grasslands after the first rains has become common practice amongst farmers (Everson 1999), irrespective of litter accumulation (Everson 1999; Van Wilgen & Scholes 1997). However, without frequent burning, some species (e.g. *Themeda triandra* Forssk 1775 and *Heteropogon contortus* Roem & Schult 1954) become moribund and decrease in abundance, whereas other species are more tolerant of self-shading and increase (Owen-Smith & Danckwerts 1997).

Tainton (1999) has suggested that the carrying capacity for high-altitude climax grassland lies somewhere between 3 ha and 5 ha per large-animal unit (ha LAU<sup>-1</sup>). One LAU is defined as being equivalent to one cow or five sheep and represents the metabolic equivalent of a 454-kg cow (Owen-Smith & Danckwerts 1997; Tainton 1999). However, many farmers exceed this stocking rate and thereby exceed the ecological carrying capacity of the grasslands. Together with annual burning the system's ecological integrity and future livestock productivity are likely to be adversely affected (Fuhlendorf *et al.* 2012; Limb *et al.* 2011; Little, Hockey & Jansen 2013).

Historically, indigenous game species in moist highland grasslands moved seasonally along rainfall gradients, which resulted in a temporal and spatial easing of the

grazing pressure (Rowe-Rowe & Scotcher 1986). Indeed, there probably was no grazing by indigenous game species in high-altitude grasslands during the dry winter months (Mucina & Rutherford 2006:357). The effects of indigenous game species on plant diversity under current management practices have yet to be investigated.

Previous studies on the effect of fire (Uys *et al.* 2004) and grazing (Owen-Smith & Danckwerts 1997) on the grassland biome in South Africa have focused on their independent impacts, with limited attention given to their combined effect. O'Connor *et al.* (2010) highlighted the need to assess the combined effect on plant communities. Previous studies in moist grasslands have not included a detailed analysis of the influence of grazing regimes or burning frequency on vegetation structure, which may have a profound effect on grassland ecosystem functioning. Therefore, the objective of this study was to assess the interactive effect of burning frequency and stocking rates on plant community (vegetation) structure and diversity in moist highland grasslands. It is hypothesised that with increased stocking rates plant diversity will decrease, accompanied by a shift from predominantly decreaser to predominantly increaser grasses (Tainton 1999). Decreasers are species that are sensitive to degraded grassland conditions as a result of either too much or too little disturbance. Increaser I species increase in abundance as a result of too little disturbance (typically when the grassland becomes moribund), increaser II species increase in abundance in response to heavy disturbance (e.g. by fire, grazing or a combination), and increaser III species proliferate in response to selective grazing (i.e. are unpalatable species – Tainton [1999]). The study also compares the impacts of indigenous game (predominantly blesbok [*Damaliscus dorcas*]) to those of (more heavily stocked) domestic livestock on vegetation structure and diversity.

## Research method and design

### Study sites

The study area falls within the Moist Highland Grassland Bioregion and is specifically identified as Lydenburg Montane Grassland (Mucina & Rutherford 2006:405) (previously referred to as the North-Eastern Sandy Highveld grassland; Burgoyne, Bredenkamp & Van Rooyen [2000]). All the study sites were on the plateau around Dullstroom (centred at 25°25'S, 30°10'E) and were between 1900 m a.s.l. and 2200 m a.s.l. The soils are mostly derived from quartzite of the Steenkampsberg and Lakenvlei formations (Burgoyne *et al.* 2000). The Dullstroom Plateau Grassland (encompassing this entire study area) has been classified as endangered owing to very high irreplaceability of species (Department of Environmental Affairs 2011). The topography within the geographic range of this vegetation type includes high-altitude plateaus and undulating plains. The predominant vegetation is short grass in the high-lying areas, which becomes taller on the lower slopes. Although grass species diversity is relatively low, the diversity of non-graminoid elements of the vegetation ('forbs' from here on) is high

**TABLE 1:** Grazing, stocking regime and burning frequency of the study sites.

Study site	Type of site	Grazing intensity (ha LAU <sup>-1</sup> )	Burning regime	Grazing stock
NRLu†	Nature reserve; low-intensity grazing	63.671	Unburnt reserve	Indigenous ungulates
NRL	Nature reserve; low-intensity grazing	46.714	Burnt reserve	Indigenous ungulates
NRHu	Nature reserve; high-intensity grazing	13.613	Unburnt reserve	Indigenous ungulates
NRH	Nature reserve; high-intensity grazing	14.408	Burnt reserve	Indigenous ungulates
BFu	Commercial farm	2.092	Unburnt biennially	Cattle
BF	Commercial farm	1.963	Burnt biennially	Cattle
AF	Commercial farm	1.251	Annual	Cattle
Com	Communally grazed land	1.071	Irregular	Mixed (domestic livestock)

ha LAU<sup>-1</sup>, hectares per large-animal unit.

†, The identifier 'u' indicates a site that was unburnt in the study year.

(Mucina & Rutherford 2006:405). Orographic and convection-based precipitation (660 mm year<sup>-1</sup> – 1180 mm year<sup>-1</sup>; Mucina and Rutherford [2006:405]) and heavy mists throughout most months of the year have promoted a unique flora, including a rich diversity of mesophytic plants such as the Orchidaceae. In fact, the high forb diversity (over 2260 taxa and 51 endemic species) has prompted this grassland type to be proposed as a 'centre of plant endemism' (Mucina & Rutherford 2006:360).

Eight study sites of similar soil type and underlying geology but under different management regimes (Table 1) were sampled over two summers. These sites (reported with their stocking rates) represent the most common types of management in the moist highland grasslands:

- an annually burnt farm (AF); 1.251 ha LAU<sup>-1</sup>
- communally grazed lands (Com); 1.071 ha·LAU<sup>-1</sup>
- a biennially burnt farm that was either burnt (BF; 1.963 ha LAU<sup>-1</sup>) or left unburnt (BFu; 2.092 ha LAU<sup>-1</sup>) in the study year
- a nature reserve site, with a high density of indigenous grazing ungulates, which was either burnt (NRH; 14.408 ha LAU<sup>-1</sup>) or left unburnt (NRHu; 13.613 ha LAU<sup>-1</sup>) in the study year
- a nature reserve site, with a low density of indigenous grazing ungulates, which was either burnt (NRL; 46.715 ha LAU<sup>-1</sup>) or left unburnt (NRLu; 63.671 ha LAU<sup>-1</sup>) in the study year.

Numbers of grazing animals were constant throughout the season at all sites. The biennially burnt farm and both the heavily grazed and lightly grazed reserve sites had different stocking rates in the burnt and unburnt years; this was unavoidable and is a result of the flux based on mortality and fecundity. However, these changes in stocking rates between years were minimal and did not affect the categorisation of sites, and the burnt and unburnt sites can be considered as separate treatments. All nature reserve sites were within Verloren Valei Nature Reserve, a site that acted as both a control and a management experiment site in the heavily grazed area (NRH and NRHu). The reserve site was selected based on its good current condition and former management for conservation: the reserve was proclaimed in 1983 and has been block-burnt biennially since 1985 (Heyns 1985). All of the sites (except communally grazed lands where fire has not been used as a management tool for

more than 50 years) are burnt in early spring after the first rains. Both the annually burnt and biennially burnt farms have been managed this way for at least three generations (> 100 years). The commercially farmed areas (AF and BF) were rotationally grazed by cattle on a four-day cycle by the same herd. In all cases the rotation was between two large camps. The stocking rate on communal lands (mixed grazing by cattle, sheep, horses, goats and pigs), where there is no stock rotation, is thus the number of animals in the area of both camps combined. Offspring of both livestock and indigenous grazers born in early summer were treated as 0.5 LAUs.

Within each study site, four 25-ha replicates were marked out with at least 500 m between replicates. Sampling plots and transects were randomly selected within each 500 m × 500 m replicate. Thus, plots and transects were nested within each of the four replicates, which, in turn, were nested within each of the eight study sites. As far as possible, these replicates were sufficiently far apart to avoid pseudo-replication but sufficiently close together to standardise for extrinsic factors such as geology, rainfall, aspect, slope and temperature within and between land-use treatments (Hurlbert 1984). The climatic aspects were comparable primarily owing to the limited altitudinal variation between sites (Burgoyne *et al.* 2000).

Fieldwork was conducted in the summer (October – March) for 2 years (2007–2009). Grazing data were collected by interviewing farmers or managers of chosen sites and were validated with animal counts. Relative grazing intensity was recorded as the area of grazing land available per LAU (ha LAU<sup>-1</sup>).

## Vegetation structure

To assess the response of vegetation structure to management, it was important to understand which of the measured structural indices were most sensitive to the disturbance effects and which one could act as a surrogate for overall vegetation structure. When all 10 of the structural indices were included in the analysis (Table 2), any of the indices could have been used to differentiate between management practices but some were more effective than others. For this reason, a stepwise analysis was required to identify the most effective indices for sampling grassland structure.

**TABLE 2:** Discriminant functions analysis illustrating the differences in vegetation structure indices that have the most important roles in predicting structural differences across management types.

Vegetation	Wilks's $\lambda$	Partial $\lambda$	F	P	r <sup>2</sup>
<b>Discriminant functions analysis†</b>					
%Grass	0.014	0.807	4.351	0	0.961
%Forb	0.016	0.697	7.875	0	0.464
%Veg	0.013	0.819	4.008	0.001	0.961
AveMaxHt	0.012	0.895	2.133	0.045	0.882
AvHorDen	0.013	0.823	3.898	0.001	0.876
AvVerDen	0.012	0.887	2.321	0.029	0.942
HorHetHt	0.016	0.669	8.984	0	0.286
HorHetTo	0.016	0.700	7.777	0	0.807
Patchine	0.018	0.610	11.613	0	0.845
DPM	0.014	0.767	5.514	0	0.687
<b>Backward stepwise discriminant functions analysis‡</b>					
AvHorDen	0.186	0.268	51.968	0	0.234
HorHetHt	0.080	0.626	11.354	0	0.080
Patchine	0.083	0.603	12.497	0	0.392
DPM	0.091	0.548	15.642	0	0.266

Note: Table 2-A1 reflects detailed structural data.

%Grass, average percentage grass cover; %Forb, average percentage forb cover; %Veg, average percentage vegetation cover; AvHorDen, average horizontal vegetation density; AveMaxHt, average maximum vegetation height; AvVerDen, average vertical vegetation density; DPM, disc pasture meter; HorHetHt, average horizontal heterogeneity of vegetation canopy; HorHetTo, overall average horizontal heterogeneity of vegetation structure; Patchine, average vegetation patchiness.

†, Overall Wilks's  $\lambda = 0.011$ ,  $F = 12.453$ ,  $P < 0.001$ ; ‡, Overall Wilks's  $\lambda = 0.050$ ,  $F = 22.29$ ,  $P < 0.001$ .

A backward stepwise discriminant functions analysis (Table 2) identified four of the original 10 structural indices as performing best at discriminating between management types. These were subsequently used in the multidimensional scaling plot analyses.

Vegetation structure was sampled monthly throughout the sampling season using two techniques. The first, modified from Wiens and Rotenberry (1981), involved establishing three 500-m transects within each of the four replicates per study site. Along each of these, at 50-m intervals, a 10-m long tape was laid out perpendicular to the transect line. Vegetation was sampled at 1-m intervals along the tape, yielding 100 point samples per transect (in total, 1200 samples per site per month). At each sampling point, a rod of 6-mm diameter was positioned vertically through the vegetation to the ground. This rod was marked at eight height intervals (0 mm – 50 mm, 50 mm – 100 mm, 100 mm – 200 mm, 200 mm – 300 mm, 300 mm – 400 mm, 400 mm – 500 mm, 500 mm – 600 mm and 600 mm – 1000 mm). At each sampling point the number of vegetation contacts with the rod per height interval was recorded, as well as whether the contact was with a grass or a forb. Open ground (in the case of no contact with vegetation) and overall maximum height of vegetation were also recorded. From these data we calculated three sets of vegetation structure indices (Table 2):

- Cover: Percentage grass cover (%grass), forb cover (%forb) and total plant cover in the form of grass and forbs combined (%veg), calculated as the percentage of point records with each of these parameters present.
- Structural measures: Average maximum height of vegetation (AveMaxHt) and horizontal density (AvHorDen), derived from the mean number of contacts with the rod in the 0 mm – 100 mm interval, and vertical

density (AvVerDen), derived from the mean number of contacts over the entire length of the rod.

- Heterogeneity measures: Canopy heterogeneity (HorHetHt), given by the coefficient of variation of the maximum height contacts, overall heterogeneity (HorHetTo), given by the coefficient of variation of the mean total number of contacts over the entire rod, and a patchiness index (Patchine), in which the 10 samples per 50 m are grouped and then used to calculate the landscape patchiness according to the equation of Wiens and Rotenberry (1981):

$$\text{Patchiness} = \frac{\sum (Max - Min)}{\sum x} \quad [\text{Eqn 1}]$$

where *Max* represents the maximum number of contacts recorded in each sample group, *Min* represents the minimum number of contacts recorded in each sample group, and *x* represents the mean number of contacts recorded in each sample group.

The second technique quantifies vegetation density, which is a proxy for forage availability. Measurement of forage availability is essential for determining stocking rates for the management of herbivores (Ganguli *et al.* 2000; Smith 2006). A relative measure of forage availability was developed to assess how stocking density affected vegetation density through the season in a particular area. Vegetation density (kg ha<sup>-1</sup>) was combined with grazing intensity (ha LAU<sup>-1</sup>) to produce an index of available vegetation per LAU (kg LAU<sup>-1</sup>), which gives a clear indication of both the available above-ground biomass for grazing and the seasonal effect of grazing on vegetation biomass.

Vegetation density was sampled using a disc pasture meter (DPM), following Bransby and Tainton (1977), Danckwerts and Trollope (1980) and Trollope and Potgieter (1986). The DPM consists of a disc (1.5 kg, 457 mm in diameter) mounted onto a central rod, with a measuring scale set in 5-mm increments. The disc is dropped vertically from 0.6 m above the ground onto the grass sward and the settling height of the disc is recorded. Vegetation was sampled every 5 m along the three 500-m transects, yielding 100 DPM samples per transect and a total of 1200 samples per site per month.

The DPM is calibrated for a specific vegetation type to convert the reading into biomass estimates (kg ha<sup>-1</sup>). DPM calibrations are available for a number of vegetation types both within and outside of South Africa (Bransby & Tainton 1977; Danckwerts & Trollope 1980; Trollope & Potgieter 1986) for comparative purposes, but a calibration for moist highland grassland has not yet been done. To calibrate the DPM for moist highland grassland, monthly data were collected throughout the season from all the management types. The data were analysed using a regression analysis, with the standing crop of plant material harvested (removed and weighed) from below each disc measurement (converted to kg ha<sup>-1</sup>) as the dependent variable and the mean settling height of the disc as the independent variable. The regression analyses were repeated with the standing crop of grass subjected to logarithmic, square,

square-root and reciprocal transformations to obtain the best linear fit between disc height and the standing crop of herbaceous plant material. The best fit was then compared with previous calibrations of the DPM.

## Plant species diversity

Plant species diversity in the five management types was assessed only in the years that sites were not burnt. Sampling was conducted in late January (when the majority of species were in flower), which allowed for species identification (Table 1-A1). Plants that could not be identified in the field were pressed and sent to the herbarium of the South African National Biodiversity Institute, Pretoria, for expert identification. Modified Whittaker nested vegetation sampling plots (O'Connor 2005; Figure 1-A1) were used to sample floral species diversity based on the methods of Stohlgren, Falkner and Schell (1995). Overall relative floral diversity assessments were based on one modified Whittaker plot per replicate (four per site). All species were recorded and abundance (percentage cover) of each species was estimated from each of the 10-m<sup>2</sup> and 1-m<sup>2</sup> subplots. Estimated abundances per subplot were summed and the overall estimated abundance per species was calculated as a percentage. Plant species names were based on Germishuizen and Meyer (2003).

## Statistical analyses

The software packages PC-ORD 5.10 (McCune & Mefford 2006) and STATISTICA 9.0 (StatSoft) were used for data analysis.

To assess the relative impacts of management practices on vegetation structure variables, analysis of variance (ANOVA) with post hoc Tukey tests were performed. A discriminant function analysis was subsequently undertaken, followed by a backward stepwise discriminant function analysis, which incorporated only the significant parameters, to extract the parameters that best revealed the effects of management on vegetation structure.

To assess sampling efficiency, species–area curves were fitted to the plant species richness data. First- and second-order jackknife estimates of species richness were derived separately for grasses, forbs and all species.

Plant community compositions were contrasted amongst management types using a one-way pairwise permutation-based non-parametric multivariate analysis of variance (PerManova; Anderson 2001; McCune & Mefford 2006). We used the Sørensen (Bray–Curtis) distance measure because it is appropriate for abundance data and gives robust outputs with zero-dominated datasets (McCune & Grace 2002). To assess the contribution of each species' abundance to the community and how much their response to disturbance has influenced each of these communities, we ran an indicator species analysis (McCune & Mefford 2006) using a Monte Carlo test of significance with 5000 permutations (Dufrêne & Legendre 1997); this method combines species' abundance

and occurrence. A 'perfect indicator' should be present in all replicates within a site and not present in any other sites. To test whether grasses and forbs respond in a similar manner to site management, we performed a Mantel test (Douglas & Endler 1982), which tests the null hypothesis of no relationship between matrices and uses a *t*-distribution with infinite degrees of freedom. To test whether grass species experienced shifts from high to low palatability (based on Tainton [1999]) and from decreaser to increaser grasses with increasing disturbance, we ran Mann–Whitney *U* tests and ANOVA by ranks.

Multidimensional scaling (MDS) ordination was used in the analysis of vegetation structure between study sites as it is the statistical method of choice in community ecology when data are discontinuous or not normally distributed (McCune & Grace 2002). MDS was run (in PC-ORD) using a Euclidean distance measure with Bray–Curtis original endpoint selection for vegetation structure space and a Sørensen distance measure, which is recommended for community analyses, with Bray–Curtis original endpoint selection for plant species space. These ordinations fit matrix data into a two-dimensional space: in this case, the two data matrices analysed were vegetation structure diversity and species diversity (Bray & Curtis 1957; McCune & Grace 2002). DPM data were overlaid on the ordination and vegetation structure indices were included as a biplot.

Finally, to assess the shift in plant species assemblages as a result of land use, we ran a two-way cluster dendrogram (McCune & Mefford 2006) with a Sørensen distance measure and group-average linking method without relativisation.

## Ethical considerations

This study was approved by the Scientific and Ethics Committee, University of Cape Town, and a plant collecting permit (MPB 1161) was obtained from the Mpumalanga Tourism and Parks Agency for the study period.

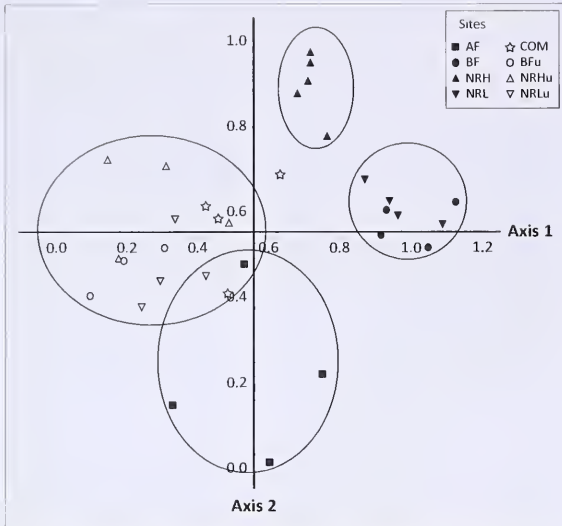
## Results

### Disc pasture meter calibration

The best calibration for moist highland grassland (locally known as 'sourveld') was linear ( $y = 358.7x - 746.4$ , with  $r = 0.95$ ,  $r^2 = 0.91$ ;  $P < 0.0001$ ) and had a higher  $r^2$  value than calibrations derived from the other grassland systems, which rendered it a better fit. Nonetheless, existing calibrations (Bransby & Tainton 1977; Danckwerts & Trollope 1980; Trollope & Potgieter 1986) exhibit very similar trends to the moist highland grassland calibration.

### Impact of management on vegetation structure

High densities of indigenous herbivores depleted grass and vegetation to the point that the NRH site (13.61 ha LAU<sup>-1</sup>) had both less grass cover ( $P < 0.01$ ,  $df = 136$ ) and less vegetation cover ( $P < 0.0005$ ,  $df = 136$ ) than any other site. This site also had the greatest vegetation patchiness ( $P < 0.01$ ).



The following vegetation parameters were included in the analysis: percentage forb cover (log transformed), percentage vegetation cover (log transformed), average maximum vegetation height, average horizontal density, total horizontal heterogeneity, patchiness and standing stock of vegetation ( $\text{kg ha}^{-1}$ ). Axes 1 and 2 accounted for 49.49% and 20.35% of the variance, respectively. These two axes are graphical representations of how the management sites group in ordination space based on their respective vegetation parameters. Site abbreviations are as defined in Table 1. The identifier ‘u’ indicates a site that was unburnt in the study year.

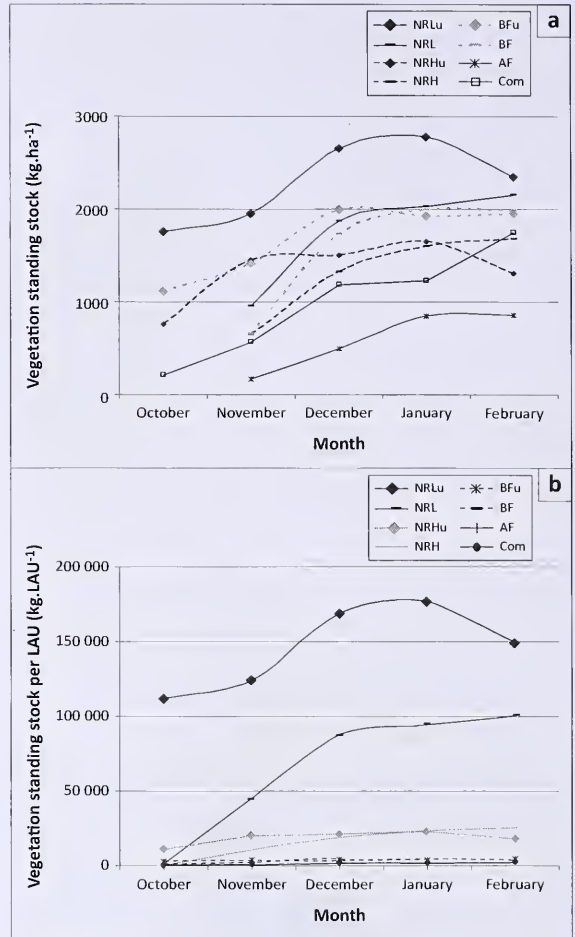
**FIGURE 1:** Multidimensional scaling plot (based on Euclidean distance and Bray–Curtis measures) showing how treatments clustered with regard to vegetation characteristics.

Biennial burning, coupled with heavy grazing by domestic stock, resulted in the BF site ( $2.09 \text{ ha LAU}^{-1}$ ) having less forb cover than any other site ( $P < 0.05$ ). Extremely heavy grazing, regardless of burning as occurs in the AF ( $1.25 \text{ ha LAU}^{-1}$ ) and Com ( $1.07 \text{ ha LAU}^{-1}$ ) sites, resulted in both higher horizontal vegetation density ( $P < 0.001$  and  $P < 0.05$ , respectively) and lower vegetation biomass ( $P < 0.05$  in both cases) than in any of the other sites.

The reserve site NRL ( $63.67 \text{ ha LAU}^{-1}$ ), which is managed for conservation, had greater vegetation biomass ( $P < 0.05$ ) and lower average horizontal vegetation density than any other site ( $P < 0.05$ ).

An ordination analysis was performed to gain a better understanding of how management type differentially affects vegetation structure (Figure 1). This allowed differentiation between management effects, including separating out the relative importance of fire frequency and stocking rate in influencing vegetation structure. Axes 1 and 2 accounted for 49.49% and 20.35% of the variance, respectively. (The two axes are graphical representations of how the management sites group in ordination space based on their respective vegetation parameters.)

Grazing and burning directly influenced phytomass, which was highest in the site experiencing the lowest grazing pressure (NRL); this was true towards the end of the season even in the year that this site was burnt (Figure 2a). The BF site had the second-highest standing stocks and again, even in the year it was burnt, recovered to support a higher vegetation biomass



LAU, large-animal unit. Site abbreviations are as defined in Table 1. The identifier ‘u’ indicates a site that was unburnt in the study year. Burning takes place in early September in all management types except Com. AF and Com curves register only barely in late summer.

**FIGURE 2:** (a) Standing stock of vegetation ( $\text{kg ha}^{-1}$ ) in each of the eight management treatments during the growing season and (b) standing stock ( $\text{kg LAU}^{-1}$ ; measured using a disc pasture meter) as a function of grazing pressure (livestock density) across all eight management treatments.

than other commercially farmed sites. The AF and Com sites consistently had the lowest standing stocks of vegetation. However, intensive grazing by indigenous ungulates in the conservation area (NRH) resulted in lower phytomass by the end of the year than was present in the communally grazed lands. The results were similar for vegetation available per LAU (Figure 2b) for NRL, with low stocking rates.

### Impact of management on plant species diversity

Species–area curves and jackknife estimates showed a small difference between observed and expected species richness (Table 3).

Between-site species diversity was assessed using PerManova (Table 4). A randomisation test of significance of pseudo  $F$ -values between all sites showed a significant overall difference between sites ( $F = 2.9022, P < 0.0005, df = 35$ ).

**TABLE 3:** Jackknife estimates of species richness derived for grasses, forbs and all plant species combined for all modified Whittaker plots combined.

Vegetation class	Number of species observed	First-order jackknife estimate	Second-order jackknife estimate
Grasses	20	21	28
Forbs	94	117	123
All species	114	138	142

**TABLE 4:** PerManova analysis used to evaluate differences in botanical composition between sites. Asterisks denote significant differences.

Site comparison†	PerManova	
	<i>t</i>	<i>P</i>
NRL vs NRH	2.309	0.025*
NRL vs BF	2.313	0.031*
NRL vs AF	2.218	0.029*
NRL vs Cam	1.827	0.026*
NRH vs BF	1.425	0.028*
NRH vs AF	1.382	0.083
NRH vs Com	1.361	0.057
BF vs AF	1.314	0.152
BF vs Com	1.371	0.056
AF vs Cam	1.453	0.060

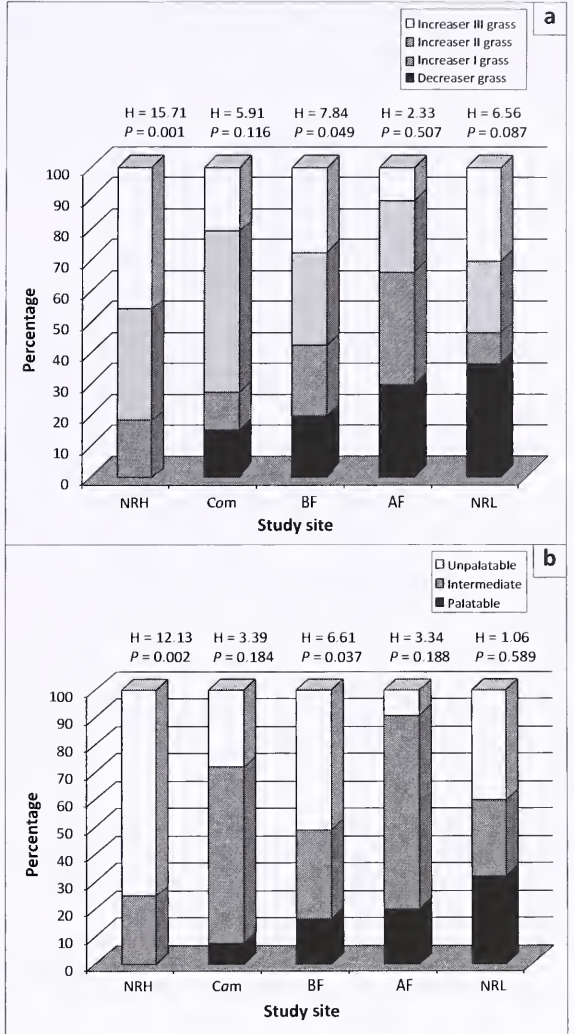
†, Study site abbreviations are as defined in Table 1.  
\*, Significant at  $P < 0.05$

**TABLE 5:** Indicator plant species for the different management types based on indicator species analysis.

Species	Site†	Observed indicator values (IV)	IV from randomised groups		
			Mean	s.d.	<i>P</i>
<i>Wotsonia pulchra</i>	NRL	60.7	24.9	12.4	0.022
<i>Eriasperrum flagelliforme</i>	NRH	75.0	20.9	13.9	0.019
<i>Dierama insigne</i>	BF	72.7	24.4	12.1	0.006
<i>Trachypogon spicatus</i>	BF	100.0	23.3	12.8	0.001
<i>Acolypha punctata</i>	AF	57.6	32.0	8.9	0.008
<i>Asclepios olbens</i>	AF	97.3	24.5	12.0	0.002
<i>Crassulo lanceoloto</i>	AF	60.0	26.6	10.6	0.035
<i>Helichrysum pilasellum</i>	AF	56.9	28.2	10.5	0.022
<i>Plantago myosuroides</i>	AF	95.0	29.6	14.7	0.002
<i>Schaenaxiphium spartaeum</i>	AF	75.0	26.5	13.1	0.018
<i>Setaria sphocelata</i>	AF	100.0	23.5	12.9	0.002
<i>Sporobolus pectinatus</i>	AF	47.2	30.2	8.4	0.043
<i>Vernonia monacephala</i>	AF	72.7	25.3	13.4	0.017
<i>Indigofera hiliaris</i>	Com	69.6	25.5	13.6	0.034
<i>Panicum natalensis</i>	Com	7.5	26.4	13.9	0.048
<i>Digitaria monodactyla</i>	Com	60.7	27.0	12.1	0.017
<i>Anthaspenum pumilum</i>	Com	83.9	27.5	11.9	0.001
<i>Vernania natalensis</i>	Com	66.3	28.4	9.8	0.002

IV, indicator values; s.d., standard deviation.  
†, Study site abbreviations are as defined in Table 1.

In support of the findings from the pairwise PerManova (Table 4), 37.7% of species occurred in only one management type (NRL). Only 3.51% and 7.89% of species were unique to NRH and BF, respectively. Two species found in the study area (*Eucomis autumnalis* Chit. 1951 and *Hypoxis hemerocallidea* Fisch 1842, both in AF and NRL) are currently threatened (Raimondo *et al.* 2009). One species, *Plantago myosuroides* Lam. 1972 (in AF and Com), is an exotic weed from South America.



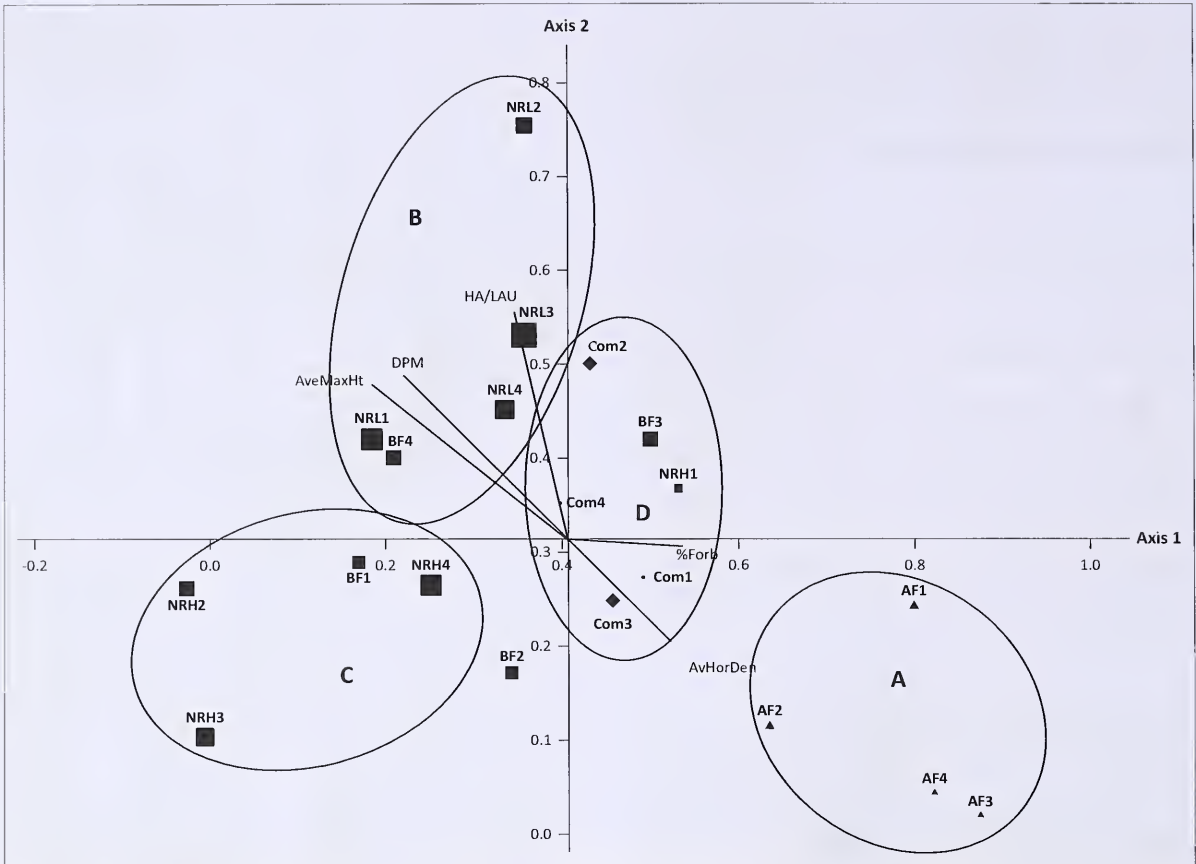
Site abbreviations are as defined in Table 1.

Kruskal-Wallis *H* denote differences in palatability scores, which estimates nutrient availability for grazers (Tainton 1999), and vegetation species status (increaser vs decrease) of grasses in different management types. NRH and BF have significantly more unpalatable than palatable plants as well as more increase than decrease species.

**FIGURE 3:** (a) Proportion of increase versus decrease grasses based on species abundances across the five management treatments and (b) relative proportions of palatable and unpalatable grasses based on species abundances across the five management treatments.

A large number of increase and pioneer species are present in the system (Table 5), as illustrated by the species that are confined to high disturbance areas, including the AF and Com sites. Two species were restricted to the conservation area and one of these was most abundant in the area that was heavily grazed by indigenous herbivores (NRH).

Grasses and forbs responded in a similar manner to management according to Mantel's asymptotic approximation (Mantel test,  $r = 0.26$ ,  $P < 0.0005$ ). The heavily grazed conservation area (NRH) showed significantly reduced abundance of decrease grasses relative to increase grasses ( $Z = -1.59$ ,  $P < 0.05$ ; Figure 3a) and had a high proportion



AveMaxHt, average maximum vegetation height; AvHorDen, average horizontal vegetation density; DPM, disc pasture meter; Ha/LAU, hectares per large-animal unit. Study site abbreviations are as defined in Table 1.

Sites are separated out according to species diversity (assemblage structure). The sizes of symbols reflect standing stock of vegetation ( $\text{kg ha}^{-1}$ ).

Filled triangles ( $\blacktriangle$ ) represent burning; filled squares ( $\blacksquare$ ) represent biennial burning; filled diamonds ( $\blacklozenge$ ) represent no planned burning.

**FIGURE 4:** Multidimensional scaling ordination of plant species diversity using Bray–Curtis measures to illustrate the relative influences of fire and grazing according to management type. The two axes are graphical representations of how the management sites group in ordination space based on their respective vegetation diversity as a result of management activities at each site.

of increaser III grasses. There was also a significantly lower overall abundance of palatable versus unpalatable grasses ( $Z = 1.76$ ,  $P < 0.05$ ; Figure 3b). The part of the nature reserve experiencing low grazing pressure supported the highest proportion of palatable grass species (Figure 4).

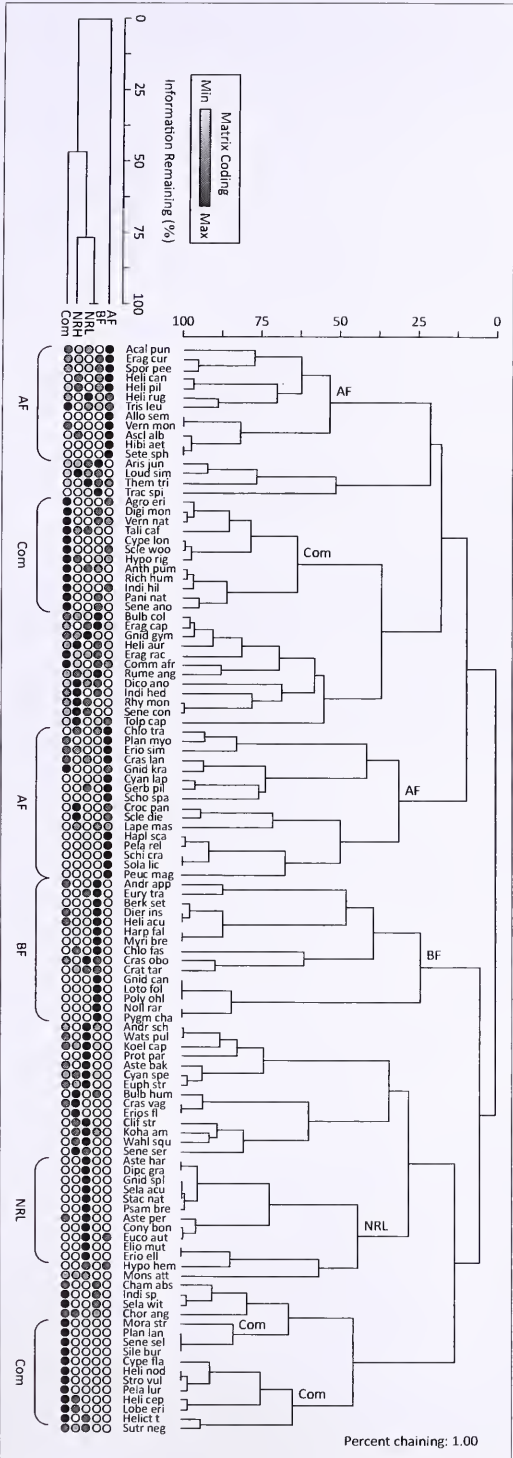
Fire frequency had an overriding effect on plant species diversity, with grazing intensity having a secondary role in distinguishing the effect of different management practices (Figure 4). Axis 1 separates sites according to burn frequency, whereas axis 2 indicates a response to grazing pressure. Sites in group B are defined primarily by the vegetation density as measured by DPM, average maximum vegetation height and stocking density. Sites in group A were mostly characterised by their average horizontal vegetation density (AvHorDen). Sites in group C were different from the rest but did not differ based on any specific parameter. Similarly, sites in group D were not found to be different from other sites based on any specific parameters, but shared aspects of each of the other groupings with regard to their vegetation parameters.

Communal lands were defoliated to such an extent that it was difficult to distinguish the two responses. DPM data were overlaid to illustrate the importance of phytomass in separating out sites. Axis 1 extracted 29.8% of the original distance matrix and axis 2 extracted 19.9% (total 49.7%).

Plant species diversity responded strongly to disturbance (Figure 5). AF separates out first, followed by the sites Com, BF and NRL, which cluster very closely. These, in turn, cluster with NRH. Six distinct assemblages separate out according to land use. One of these is specific to the conserved area whereas the other five are associated with disturbed areas.

## Discussion

Fire and grazing combined act as the primary disturbance mechanisms in grassland systems, shaping the structure and composition of the vegetation (Van Wilgen & Scholes 1997; Veen *et al.* 2008). An understanding of the interplay between these disturbance effects in driving the system facilitates



Circles illustrate a relative abundance gradient of species at a given site: darker circles depict high abundance, whereas unfilled circles indicate the absence of that species as depicted in the scale at the top of the figure. Six clear assemblages are specific to particular management types. For full species names, see Table 1-A1. Study site abbreviations are as defined in Table 1.

**FIGURE 5:** Two-way cluster dendrogram of vegetation diversity illustrating the relative diversity of species in each management type and how species and sites group based on these abundances. The axes illustrate the strength of the groupings, with group splits closer to 100% having higher similarity.

their being managed to influence ecosystem stability and biological intactness (Ferwerda *et al.* 2006). Fuhlendorf *et al.* (2012) accordingly suggested that fire and grazing should be viewed as essential ecosystem processes rather than tools for production goals. Annual burning (irrespective of litter accumulation), together with high grazing pressure (Everson 1999; Van Wilgen & Scholes 1997), has a detrimental effect on plant diversity in South Africa’s moist highland grasslands (Joubert, Pryke & Samways 2014) and the high proportion of grasslands that are burnt annually is of concern for grassland conservation (Everson 1999).

### Impact of management on vegetation structure

The current dominant management system in these grasslands combines high stocking rates (exceeding the ecological carrying capacity) with frequent (annual) fires.

To understand the effects of burning and grazing on vegetation structure, and to allow farmers to assess pasture condition rapidly, an easy-to-implement and efficient technique is required. The DPM has been recommended for these purposes (Bransby & Tainton 1977; Danckwerts & Trollope 1980; Trollope & Potgieter 1986). However, for this technique to be useful, the DPM must be calibrated for the vegetation type in question. The calibration for moist highland grasslands was both strong and linear and has a similar trend to previous calibrations in other grassland types.

Of the ten vegetation structure measures calculated in this study, four proved useful for illustrating the effects of different management practices (Table 2). Of these, three differentiated the impacts of management practices on vegetation structure. Patchiness was highest and vegetation cover (auto-correlated with grass cover because grass accounts for > 90% of vegetation cover) was lowest in the nature reserve stocked with ungulates (NHR). Although historically indigenous game species would not have grazed the high-altitude grasslands during the dry winter months (Mucina & Rutherford 2006:357), current management on a portion of the conservation area has indigenous ungulates fenced at relatively high density (13.5 ha LAU<sup>-1</sup> – 14.5 ha LAU<sup>-1</sup>) throughout the year. Resultant selective grazing, predominantly by blesbok, leads to a high proportion of bare ground and unpalatable vegetation. Grazing herbivores modify the structural heterogeneity of vegetation within a particular successional sere (Milchunas *et al.* 1988; Owen-Smith & Danckwerts 1997), but vegetation biomass alone does not reflect this because biomass of the unpalatable component remains relatively high (Figures 2a and 3b). The data presented here suggest that indigenous game species, stocked at a high density, have a greater impact on both plant diversity and structure than domestic livestock. Even at fairly low stocking rates, selective grazing by indigenous game species clears all decreaser species and creates a mosaic of patchy, unpalatable vegetation (Figure 3). Few studies focusing on the potential impact of indigenous game species on moist highland grasslands have been carried out. Modern fencing practices for conservation, wildlife

ranching or agriculture have restricted free movement of indigenous game species and, in some cases, resulted in overabundance and overgrazing in wildlife preserves (Coughenour 1991). Thus far, ecological studies in grassland systems have stressed the importance of fire more than native ungulate grazing (Wilsey & Martin 2015), which may be equally important when examining the ecological integrity of grassland systems.

By contrast, moderate to heavy bulk grazing by domestic livestock has no significant impacts on vegetation structure or diversity, provided that the burning interval is at least 2 years. However, the similarity of the AF and Com sites, which are burnt annually or have never been burnt intentionally, respectively, suggests that when grazing pressure is intense, the relative importance of fire in controlling vegetation structure diminishes. Few grassland specialist plant species require low disturbance levels and few pioneer species require high disturbance levels to thrive (Fox 1979).

In the study area, farmers introduce livestock immediately following a spring burn. As plant growth is limited to the summer period (Tainton, Groves & Nash 1977), this inevitably influences the phenological stages of grasses and eventually the vegetation structure. Excessive bulk grazing does not necessarily lead to loss of grass species (Figure 3b), because the basal meristem of grass leaves enables regrowth after defoliation. However, frequent and excessive defoliation can shift species assemblages towards grasslands being dominated by increaser II species (Milchunas *et al.* 1988; Figure 3a). As a result, horizontal vegetation density can be used as a surrogate for the presence of a 'carpet-like' layer of thick, low vegetation close to the ground. This habitat homogenisation is expected when grazing pressure is high and largely unselective (Swengel 2001). Not surprisingly, these conditions result in low vegetation biomass (Figure 1) and a correspondingly low carrying capacity for grazers (Figure 2a). Limb *et al.* (2011) illustrated that management that involves infrequent fire and moderate stocking rates results in improved livestock production.

Conservative management (e.g. biennial burning as seen in BF) resulted in high vegetation biomass, along with a greater proportion of decreaser grass species and an increase in overall palatability of the vegetation (Figures 2b and 3a, Table 5). When heavy grazing and frequent burning are combined, high horizontal vegetation density results. The nature reserve with low grazing levels (NRL) had the lowest horizontal vegetation density and thus current management practices in this part of the conserved area appear to be ecologically sound.

We recommend that a DPM method is used in future assessments of vegetation structure integrity and forage availability, without the need for any other form of sampling. The DPM (Figure 1) has proved an effective surrogate for all structural indices. By combining these data with grazing intensity (expressed as ha LAU<sup>-1</sup>), an estimate of forage availability can be obtained per LAU (referred to as a 'fodder

capacity index') (Figure 2a). This new approach encompasses both the current standing stock of vegetation (which has already been affected by grazing and fire) and the future potential grazing impact based on current stocking rate. The approach recommended here is user friendly, time efficient and accurate, and allows for adaptive management.

The available stocks of forage on communal lands and the annually burnt farm are, on average, less than 1100 kg LAU<sup>-1</sup> throughout the summer season. According to the recommended minimum of 3 ha LAU<sup>-1</sup> (Tainton 1999), and assuming that the stocking rate on BF is sufficient for sustainability of current phytomass, the recommended minimum sustainable threshold of forage per LAU for domestic livestock should be 5000 kg LAU<sup>-1</sup> (see Figure 2a, where BF standing stocks resemble those of NRL).

### Impact of management on plant species diversity

The use of plant species as indicators of disturbance has been shown to be ineffective (Lindenmayer *et al.* 2002; Öster, Persson & Eriksson 2008); however, assemblages of grassland species reflect different disturbance pressures (McIntyre & Lavorel 1994; Milchunas *et al.* 1988). In our analysis, grasses and forbs responded in a similar manner to management, suggesting that either group on its own would be sufficient for assessment of plant ecological integrity. The presence of *P. myosuroides* at AF is a strong signal of habitat degradation, as this species is a known weed and is often spread through livestock dung. Land degradation is characterised more by the gain of pioneer-type species than by the loss of specialist grassland species. The combination of heavy grazing and annual burning leads to a distinct plant community (group A in Figure 4), with nine species characterising this group. The large number of 'disturbance specialists' (species found only in the heavily disturbed AF, Com and NRH sites) illustrates the sensitivity of this system to assemblage shifts favouring increaser or pioneer species. High-intensity selective grazing by indigenous herbivores promotes a community of unpalatable species (Figure 3), which are largely generalist taxa (Figure 5). Of particular interest is the significantly reduced abundance of decreaser grasses relative to increaser grasses in the heavily grazed conservation area (Figure 3a). This is supported by the high proportion of increaser III grasses.

In Figure 4, group B (biennially burnt nature reserve with low grazing pressure) and group A (annually burnt farm) differ most markedly, as they are furthest apart in ordination space. This illustrates the differing effects of high-frequency burning (A) and low-intensity grazing (B). The low-intensity grazing within the nature reserve shows a floral community that is significantly different from all other sites (Table 4). The (rarely burnt) communal grazing lands (group D) and the biennially burnt lands are intermediate in plant community structure and do not separate out as clear groups. Grazing intensity and fire frequency are therefore considered complementary disturbance factors. The separation of sites is driven primarily by high phytomass associated with, in

this case, low grazing intensity on the low disturbance/defoliation extreme and by high horizontal vegetation density and forb cover on the high disturbance/defoliation extreme.

The 114 plant species identified fall into six distinct management-specific communities and four generalist groupings (Figure 5), which implies that plants show strong responses to both grazing and burning. Two of the 114 species – *E. autumnalis* and *H. hemerocallidea* – are classified as threatened and both are listed as decreasing (Raimondo *et al.* 2009). *Eucomis autumnalis*, a popular plant for use in traditional medicine, is confined to the conserved area, suggesting that it is sensitive to disturbance. *Hypoxis hemerocallidea*, also used in traditional medicine, is confined to unconserved, communal lands that burn infrequently. The only detectable effect in areas grazed by domestic livestock and that are burnt biennially was the low representation of forbs (Scott-Shaw & Morris 2014). This suggests that grazing may have an important role in determining forb diversity; indeed, Uys *et al.* (2004) found that annual versus biennial burning made little difference to forb diversity in grassland systems. This may also be attributed to an intermediate disturbance effect, causing species to be lost both as a result of intensive management and in response to a lack of fire management when grasses become moribund, thereby stifling forbs; however, this would need to be illustrated more robustly.

## Conclusion

The data presented here suggest that indigenous game species, stocked at high density, have a greater impact on both plant diversity and vegetation structure than domestic livestock. Even at fairly low stocking rates, selective grazing by indigenous game species clears all decreaser species and creates a mosaic of patchy, unpalatable vegetation. However, burning biennially (even with commercially viable stocking rates) resulted in high vegetation biomass along with a greater proportion of decreaser grass species and an increase in overall palatability of the vegetation.

Based on the results of this study, we recommend that future assessments of vegetation structure integrity and forage availability use a DPM method. Based on the novel 'fodder capacity index' presented here, the recommended minimum sustainable threshold of forage per LAU for high domestic livestock production and for sustaining biological diversity (and ecosystem services) should be 5000 kg LAU<sup>-1</sup>.

## Acknowledgements

We thank Balongile Bhengu and her staff at Verloren Valei Nature Reserve for their support and assistance with historical data. Farm managers and owners (Thys, the Grobbelaars, Bafana and Job of Sakhelwe, and Roger Croall) are thanked for allowing the research to be conducted on their properties. We gratefully acknowledge Luciano Makaka, Maxwell Boakye, Thabo Mabuza, Thomas Birch, Jessica da Silva, Grant Cannon and others who assisted

in the field. We are also grateful to Colin Everson for the data he provided and Thomas Birch for computer assistance. This research was funded by the National Research Foundation of South Africa, the South African National Biodiversity Institute, the Rufford Small Grant Foundation, Tshwane University of Technology and the University of Cape Town.

## Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

## Authors' contributions

I.T.L. (University of Cape Town) was the project leader and was responsible for data collection, analysis and interpretation, as well as drafting the initial manuscript and raising funds for the research. P.A.R.H. (University of Cape Town) and R.J. (Tshwane University of Technology) were both responsible for project design and contributed to the analysis and interpretation of data, revising the manuscript and obtaining funding.

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# Appendix 1

**TABLE 1-A1: Plant species presence/absence records per management type.**

Plant species <sup>a</sup>	AF	BF	NRL	NRH	Com
<i>Acolypha punctata</i> Krauss 1845	X	X	X	X	X
<i>Agrostis eriantha</i> Hack 1904	X				X
<i>Alloteropsis semialata</i> Hitch 1909	X				
<i>Andropogon appendiculatus</i> Nees 1841		X			X
<i>Andropogon schirensis</i> Hochst 1851		X	X		X
<i>Anthaspermum pumilum</i> Sand. 1865		X	X		X
<i>Aristido junciformis</i> Trin. & Rupr. 1842	X	X	X	X	X
<i>Asclepias albens</i> Schlechter 1896	X			X	
<i>Aster bokerianus</i> Burt Davy ex C.A. Sm			X		X
<i>Aster harveyanus</i> Kuntze 1891			X		
<i>Aster perfoliatus</i> Oliv. 1887			X		X
<i>Berkheya setifera</i> DC. 1838		X			
<i>Bulbostylis callina</i> Clarke 1894		X	X	X	X
<i>Bulbostylis humilis</i> Clarke 1894		X		X	
<i>Chomoecrista absus</i> Irwin & Barneby 1982		X			X
<i>Chlorophytum fasciculatum</i> Katiwu 1993		X		X	
<i>Chlorophytum transvaalense</i> Baker 1993	X	X		X	
<i>Chartalirion angalense</i> Berger 1908		X		X	X
<i>Cliffortia strabilifero</i> Murray 1774			X	X	
<i>Cammelina africana</i> L. 1753	X	X		X	X
<i>Canyzo bonariensis</i> (L.) Cronquist 1943			X		
<i>Crossula lanceolata</i> Endl. 1843	X		X		X
<i>Crossula obovata</i> Haw. 1819		X	X		X
<i>Crossula vaginata</i> Eckl. & Zeyh. 1837				X	X
<i>Crateracapsa tarsades</i> Hilliard & Burt 1973		X	X	X	
<i>Cracasmia paniculata</i> Goldblatt 1971	X			X	
<i>Cyanotis lopicado</i> Phillips 1928	X				
<i>Cyanotis speciosa</i> (L.f.) Hassk 1870		X	X	X	X
<i>Cyperus flovisimum</i> Schrad. 1821					X
<i>Cyperus langus</i> A. Rich. 1850					X
<i>Dicoma onomolo</i> Sond. 1850		X	X	X	X
<i>Dierama insigne</i> N.E.Br. 1929		X			X
<i>Digitaria monodactylo</i> Stapf 1898		X			X
<i>Dipcadi gracillimum</i> Baker 1897			X		
<i>Elionurus muticus</i> Kuntze 1898			X		
<i>Eragrostis capensis</i> Trin. 1831	X	X	X	X	X
<i>Eragrostis curvulo</i> (Schrad.) Nees 1841	X	X	X	X	X
<i>Eragrostis racemosa</i> Steud 1854		X	X	X	X
<i>Eriosema ellipticifolium</i> Schinz 1921			X		
<i>Eriosema simulans</i> C.H.Stirtan	X			X	X
<i>Eriospermum flagelliforme</i> Baker 2000				X	
<i>Eucamis autumnalis</i> Chit. 1951	X		X		
<i>Euphorbia striato</i> Boiss. 1846			X	X	X
<i>Euryaps transvaalensis</i> Klatt		X	X		
<i>Gerbero piloselloides</i> Less 1830	X		X		
<i>Gnidia canaargentea</i> C.H.Wright 1921		X			
<i>Gnidia gymnostochya</i> Gilg 1894		X	X	X	X
<i>Gnidia kraussiana</i> Meisn. 1843	X				X
<i>Gnidia splendens</i> Meisn. 1841			X		
<i>Haplacarpha scapasa</i> Harv. 1865		X			
<i>Horpochloa folx</i> Kuntze 1891		X			X
<i>Helichrysum acutotum</i> DC. 1838	X	X	X	X	X
<i>Helichrysum aureanitens</i> Sch.Bip.	X	X		X	
<i>Helichrysum candalleianum</i> H.Buek 1840				X	X
<i>Helichrysum cephaloideum</i> DC. 1838					X
<i>Helichrysum nudifolium</i> Less. 1832	X	X	X	X	X
<i>Helichrysum pilasellum</i> Less. 1832	X	X	X	X	X

AF, annually burnt farm; BF, biennially burnt farm that was burnt in the study year; Com, communally grazed lands (no planned burns); NRH, nature reserve site, with a high density of indigenous grazing ungulates, which was biennially burnt; NRL, nature reserve site, with a low density of indigenous grazing ungulates, which was biennially burnt.

<sup>a</sup>, Species names according to Germishuizen and Meyer (2003).

Table 1-A1 continues on next page →

TABLE 1-A1 (Continues...): Plant species presence/absence records per management type.

Plant species <sup>a</sup>	AF	BF	NRL	NRH	Com
<i>Helichrysum rugulosum</i> Less. 1832			X		X
<i>Helictatrichon turgidulum</i> Stapf 1937	X				
<i>Hibiscus aethiopicus</i> L. 1771	X				
<i>Hypoxis hemerocollidea</i> Fisch. 1842	X		X		
<i>Hypoxis rigidula</i> Baker 1878	X	X		X	X
<i>Indigafera hedyantha</i> Eckl. & Zeyh. 1836		X		X	X
<i>Indigafera hiliaris</i> Eckl. & Zeyh. 1836	X				X
<i>Indigafera</i> sp.		X			X
<i>Koeleria capensis</i> Nees 1832		X	X	X	X
<i>Kahautia omatymbico</i> Eckl. & Zeyh. 1837		X	X	X	
<i>Lapeirousia masukuensis</i> Vaupel & Schltr. 1912	X	X		X	
<i>Labelia erinus</i> L. 1753				X	X
<i>Latananias foliosa</i> Balus 1887		X			
<i>Loudetia simplex</i> C.E.Hubb. 1934		X	X	X	X
<i>Mansania attenuate</i> Harv. & Sand. 1860			X	X	X
<i>Maraea stricta</i> Baker 1904					X
<i>Myrica brevifolia</i> Meyer 1864		X			
<i>Nalletia rarifolia</i> Steetz 1864		X			
<i>Panicum natalense</i> Hochst. 1846		X			X
<i>Pelarganium luridum</i> R.Sweet					X
<i>Pelarganium rehmannii</i> Szyszyl 1888	X				
<i>Peucedanum magalismontanum</i> Sond. 1862	X				
<i>Plantago lanceolata</i> L. 1753					X
<i>Plantago myosuroides</i> Lam. 1792	X				X
<i>Polygala ahlenдорфiana</i> Eckl. & Zeyh. 1835		X			
<i>Prateo parvula</i> Beard 1958			X		
<i>Psammotrapha breviscapa</i> Burtt Davy 1926			X		
<i>Pygmaeathamnus chamaedendrum</i> Robyns 1928		X			
<i>Rhynchosia manaphylla</i> Schltr. 1897			X	X	X
<i>Richardia humistrata</i> Steud. 1841					X
<i>Rumex acetosella</i> L. 1753		X	X	X	X
<i>Schistastephium crataegifolium</i> Harv. & Sond. 1865	X				
<i>Schoenaxiphium sparteanum</i> Clarke 1908	X				
<i>Scleria dieterlenii</i> Turill 1914	X			X	
<i>Sclerio waadii</i> Clarke 1895	X				X
<i>Selago ocutibrocteo</i> Hilliard 1995			X		
<i>Selago witbergensis</i> E. Mey. 1836		X			X
<i>Senecia anomalachraus</i> Hilliard 1975		X			X
<i>Senecia canrathii</i> N.E.Br. 1914			X	X	X
<i>Senecia serratulalides</i> DC. 1838					X
<i>Senecia serratus</i> Sand. 1865			X	X	
<i>Seteria sphacelota</i> Stapf. & Hubb. 1929	X				
<i>Silene burchellii</i> Otth 1824					X
<i>Solonum lichtensteinii</i> Willd. 1809	X				
<i>Sporobolus pectinatus</i> Hack. 1903	X	X	X	X	X
<i>Stachys natalensis</i> Hochst. 1845			X		
<i>Stoebe vulgaris</i> Levyns 1937					X
<i>Sutero neglecto</i> Harvey 1904			X	X	X
<i>Talinum coffrum</i> Eckl. & Zeyh. 1836		X	X	X	X
<i>Themeda triandra</i> Forsk 1775	X	X	X	X	X
<i>Talpis capensis</i> Sch. Bip. 1861	X	X	X	X	X
<i>Trochypogon spicatus</i> Kuntze 1891		X			
<i>Tristachya leucothrix</i> Trin. 1829	X	X	X	X	X
<i>Vernonia manacephala</i> Gardner 1847	X				X
<i>Vernonia natalensis</i> Sch. Bip. 1847	X	X			X
<i>Wahlenbergia squamifolia</i> Rehmer 1915			X	X	
<i>Watsania pulchra</i> N.E.Br. ex Goldblatt 1989			X		X

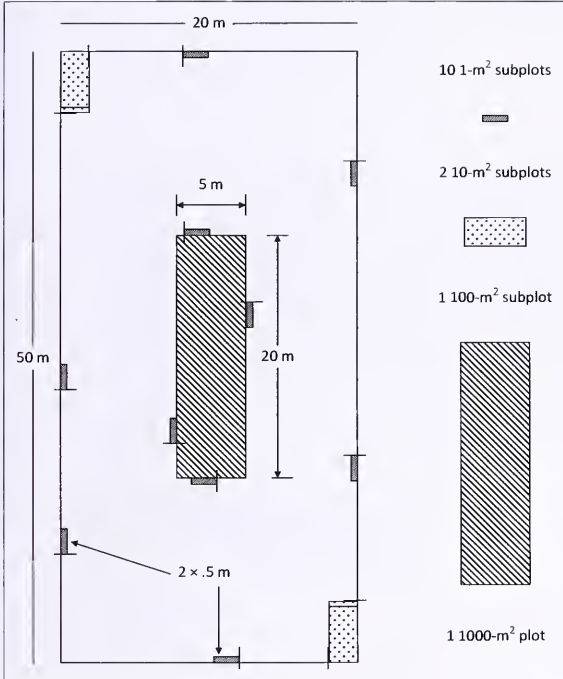
AF, annually burnt farm; BF, biennially burnt farm that was burnt in the study year; Com, communally grazed lands (no planned burns); NRH, nature reserve site, with a high density of indigenous grazing ungulates, which was biennially burnt; NRL, nature reserve site, with a low density of indigenous grazing ungulates, which was biennially burnt.

<sup>a</sup>, Species names according to Germishuizen and Meyer (2003).

**TABLE 2-A1:** Summary of vegetation structure data per study site.

Study site†	Percentage grass cover	Percentage forb cover	Percentage vegetation cover	Average maximum vegetation height (mm)	Average horizontal density	Average vertical density	Overall horizontal heterogeneity	Patchiness
NRLu	78.05	6.83	82.18	172.30	0.15	0.47	1.85	2.03
NRL	88.73	16.02	91.02	145.03	0.60	0.92	1.27	1.82
NRHu	66.80	7.38	71.13	144.54	0.23	0.46	1.63	2.31
NRH	80.40	14.50	83.73	122.00	0.51	0.73	2.50	2.27
BFu	78.87	2.95	80.88	138.90	0.24	0.48	2.16	1.95
BF	88.69	21.17	91.48	131.27	0.57	0.83	1.94	1.83
AF	76.10	10.90	81.31	101.10	1.49	2.02	2.15	2.00
Com	82.68	7.67	86.68	119.43	0.4	0.55	1.95	1.85

†, Site abbreviations are as defined in Table A1. The identifier 'u' indicates a site that was unburnt in the study year.



**FIGURE 1-A1:** Modified Whittaker plot design.

# Land transformation and its implication for biodiversity integrity and hydrological functioning from 1944 to 1999, Karkloof catchment, South Africa

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## Dates:

Received: 24 Feb. 2015  
Accepted: 08 Sept. 2015  
Published: 30 Nov. 2015

## How to cite this article:

Weyer, V.D., Granger, J.E., Hill, T.R. & O'Connor, T.G., 2015, 'Land transformation and its implication for biodiversity integrity and hydrological functioning from 1944 to 1999, Karkloof catchment, South Africa', *Bothalia* 45(1), Art. #1907, 13 pages. <http://dx.doi.org/10.4102/abc.v45i1.1907>

**Background and objectives:** Land transformation of the Karkloof catchment is described for the period 1944–1999, together with implications for biodiversity integrity and hydrological functioning.

**Method:** Maps of land categories were generated by using aerial photographs and a geographical information system. Property ownership and extent were mapped based on title deed searches and analysis of property grants. Implications of land transformation on biodiversity integrity and hydrological functioning were determined according to an expert approach using the analytic hierarchy process.

**Results:** More than half (54%) of the natural grassland area has been transformed to commercial timber plantations (427% increase) and commercial agricultural cropping (311% increase). Loss of grassland in the Karkloof catchment is considered to be representative of the general trend in the moist eastern portion of the Grassland Biome of South Africa. Both combined forest and woodland and areas of dense alien vegetation increased (26% and 397%, respectively), whereas the area under subsistence cultivation decreased (98%). Land ownership has changed from private individuals to private business entities (31%) and corporate forestry (26%). Biodiversity integrity of the catchment is estimated to have decreased by 326% and hydrological functioning for the support of aquatic biodiversity by 166%.

**Conclusion:** Continued pressure to change patterns of ownership and land use is expected. This is likely to occur within the global context of climate change, population growth and shortages of land and its products. Immense pressure on the land areas, and specifically water services and biodiversity, is likely to occur, with associated environmental impacts.

## Introduction

The phenomenon of land transformation is common to all past and present human cultures and occurs in all regions of the world. Since the early habitation of the Earth, human actions have affected the soil and biotic resources as a result of basic human needs. Land transformation has accelerated and diversified with the onset of the Industrial Revolution, globalisation of the world economy, and the expansion of the human population and technological capacity. As human pressures on the Earth system accelerate, several critical global, regional and local thresholds are being exceeded, which could result in abrupt – and possibly irreversible – changes to the life-support functions of the planet. Such changes are likely to have substantial implications for human well-being (United Nations Environment Programme 2012:6).

Land transformation involves changes in land use and land cover. Land use refers to the human utilisation of land and change may involve either a shift to a different use or an intensification of an existing one. Land cover refers to the physical state of the land and embraces the quality and type of surface vegetation, water and earth materials (Turner & Meyer 1994:5). Land use and land cover influence each other. For the purpose of this study, the term 'land categories' has been used to encompass aspects of both land use and land cover.

A change in land use may be initiated to achieve a specific aim. However, it may result in irreversible changes to land cover, with associated negative impacts such as extensive loss of grassland. In South Africa, the Grassland Biome hosts a high diversity and endemism of plant and animal species (Egoh *et al.* 2011:2). The biome ranges from dry in the west to mesic in the

**Note:** This article is based on an MSc dissertation completed in the Centre for Environment and Development, University of Natal, Pietermaritzburg. Mrs Weyer is currently a PhD candidate with the Centre for Environmental Studies, University of Pretoria, South Africa.

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Moist Grassland and Southern Mistbelt Forest (Mucina & Rutherford 2006:778). Based on the geographical information system (GIS) dataset of the Karkloof catchment boundary (Weyer 2000:7–8) overlaid digitally onto the dataset of Mucina and Rutherford (2006:749), Midlands Mistbelt Grassland and Drakensburg Foothill Moist Grassland would have occupied 80% of the catchment. The biodiversity importance of the catchment is evident from the recorded occurrence of many South African red data species (Appendix 1).

## Historical land use

An understanding of early historical land use provides context for this study.

The natural resources of the Karkloof catchment were likely used by the hunter-gatherers of the Later Stone Age (ca. 40 000–100 BP), and by the agro-pastoralists of the early (ca. AD 280–1100) and late Iron Age (ca. AD 1100–1840) (L. van Schalkwyk pers. comm., 28 July 2014). The existence of the Later Stone Age overlapped with the early and late Iron Age. These peoples were likely to have burnt grasslands to manipulate grazing patterns (L. van Schalkwyk pers. comm., 28 July 2014). Large areas of KwaZulu-Natal, including probably the Karkloof, were depopulated prior to 1824, after which colonial hunter-traders likely began exploring the area (Ellis 1998:11, 19, 24).

The region was occupied by Dutch Voortrekkers from the late 1830s (Christopher 1994:15), who burnt grassland regularly to ensure suitable grazing for their livestock (Ellis 1998:37). This group was gradually displaced from the catchment with the arrival of British settlers from the late 1850s (Ellis 1998:135, 137).

Between 1860 and 1900, livestock and crop farming (mostly maize) became firmly established in the area (Ellis 1998:161–163). Livestock farming initially consisted of beef cattle, whose numbers were greatly reduced by bovine pleuropneumonia in the 1860s. Sheep were introduced in 1844 and their numbers grew quickly, particularly from 1870 to the early 1900s (Scotney 2010:18, 231). Sheep farming gradually declined owing to scab disease and stock theft and the improved profitability of beef and dairy farming (Scotney 2010:18, 41, 60). The type of livestock would likely have affected defoliation patterns in grassland (Tainton 1999:130), whereas overstocking is likely to have had an effect on grassland species composition and diversity. Land use intensified and diversified following the construction of the railway line between Durban and Pietermaritzburg by the end of the 19th century. Wattle plantations were established by the early 1870s (Scotney 2010:22). By 1944, white land owners in the Karkloof catchment were using the land for commercial crop cultivation, beef cattle and dairy farming, commercial timber plantations and for extraction of indigenous timber from the Karkloof Forest. Black farm employees practised subsistence cultivation and kept cattle and goats on land allocated by land owners.

## Methods

### Land transformation and ownership

Land transformation for the period 1944–1999 was quantified according to a set of land categories (Table 1) based on a refinement of a physiognomic-structural vegetation classification system incorporating growth form, stratification (height), projected canopy cover and crown-to-gap ratio (Edwards 1983:705–712). Hard-copy panchromatic

**TABLE 1:** Comparison of area occupied by different land categories between 1944 and 1999.

Land category	1944		1999		Change <sup>a</sup> in area (km <sup>2</sup> )	Change <sup>a</sup> in proportion of catchment (%)	Relative change <sup>b</sup> (%)
	Area (km <sup>2</sup> )	Proportion of total catchment (%)	Area (km <sup>2</sup> )	Proportion of total catchment (%)			
Forest	37.91	9.9	39.57	10.3	1.66	0.4	4.4
Woodland	6.29	1.6	7.66	2.0	1.37	0.4	21.7
<b>Total: Grassland</b>	<b>264.22</b>	<b>68.9</b>	<b>122.62</b>	<b>32.0</b>	<b>-141.60</b>	<b>-37.0</b>	<b>-53.6</b>
Aquatic grassland	7.59	2.0	4.74	1.2	-2.85	-0.7	-37.6
Riparian grassland	14.09	3.7	13.32	3.5	-0.78	-0.2	-5.5
Other grassland	242.54	63.3	104.56	27.3	-137.98	-36.0	-56.9
<b>Total: Commercial timber plantations</b>	<b>26.34</b>	<b>6.9</b>	<b>138.71</b>	<b>36.2</b>	<b>112.38</b>	<b>29.3</b>	<b>426.7</b>
<i>Acacia</i> spp.	23.89	6.2	14.20	3.7	-9.69	-2.5	-40.6
<i>Eucalyptus</i> spp.	1.82	0.5	29.27	7.6	27.45	7.2	1508.5
<i>Populus</i> spp.	None	None	0.25	0.1	0.25	0.1	-
<i>Pinus patula</i>	None	None	58.87	15.4	58.87	15.4	-
Other <i>Pinus</i> spp.	0.63	0.2	35.10	9.2	34.47	9.0	5475.2
<i>Quercus</i> spp.	None	None	0.14	0.0	0.14	0.0	-
Unknown species	None	None	0.90	0.2	0.90	0.2	-
<b>Total: Exotic vegetation – wild</b>	<b>1.94</b>	<b>0.5</b>	<b>9.66</b>	<b>2.5</b>	<b>7.71</b>	<b>2.0</b>	<b>397.3</b>
Riparian exotic vegetation: wild	1.21	0.3	3.25	0.8	2.04	0.5	168.4
Other exotic vegetation: wild	0.73	0.2	6.41	1.7	5.68	1.5	776.4
Exotic vegetation: human habitation	1.94	0.5	5.63	1.5	3.69	1.0	190.3

Table 1 continues on the next page →

**TABLE 1 (Continues...):** Comparison of area occupied by different land categories between 1944 and 1999.

Land category	1944		1999		Change <sup>a</sup> in area (km <sup>2</sup> )	Change <sup>a</sup> in proportion of catchment (%)	Relative change <sup>b</sup> (%)
	Area (km <sup>2</sup> )	Proportion of total catchment (%)	Area (km <sup>2</sup> )	Proportion of total catchment (%)			
Commercial agricultural cropping	12.29	3.2	50.55	13.2	38.25	10.0	311.2
Cultivation: subsistence	23.00	6.0	0.48	0.1	-22.52	-5.9	-97.9
Rocky outcrops	0.10	0.0	0.07	0.0	-0.04	0.0	-36.3
<b>Total: Erosion</b>	<b>6.78</b>	<b>1.8</b>	<b>3.46</b>	<b>0.9</b>	<b>-3.32</b>	<b>-0.9</b>	<b>-49.0</b>
Severe erosion	4.40	1.1	1.26	0.3	-3.14	-0.8	-71.3
Moderate erosion	2.27	0.6	1.16	0.3	-1.10	-0.3	-48.7
Slight erosion	0.11	0.0	1.03	0.3	0.92	0.2	824.6
Quarry	None	None	0.02	0.0	0.02	0.0	-
Farm dams	0.09	0.0	2.32	0.6	2.23	0.6	2503.1
Buildings	0.89	0.2	1.10	0.3	0.21	0.1	23.4
Main roads	1.48	0.4	1.52	0.4	0.03	0.0	2.3
<b>Rounded total</b>	<b>383.00</b>	<b>100.0</b>	<b>383.00</b>	<b>100.0</b>	<b>0.00</b>	<b>0.0</b>	<b>11414.8</b>

<sup>a</sup> Change values are calculated as the difference between the area or proportion in 1944 and 1999. Negative values therefore represent a decrease in area or proportion.

<sup>b</sup> Relative change is the calculated change in area relative to the original area as measured in 1944. Negative values therefore represent a proportional decrease.

aerial photographs of the catchment in 1944 (first time flown) and 1996 (most recent at time of study), as well as the corresponding orthophotographs compiled from aerial photographs taken in 1976 and 1981, were obtained. Areas occupied by the land categories (Table 1) that were present in 1944 and 1996 were delineated on tracing film overlaid on the orthophotographs of 1976 and 1981. Areas mapped using aerial photographs from 1996 were updated to 1999 by field verification, justified owing to the lack of change over that time. The tracings were then digitised and land area statistics were extracted using the GIS package ArcView 3.0. The poor quality of the 1944 aerial photographs precluded the use of geo-referencing, orthorectifying and on-screen digitising.

GIS databases of property ownership as in 1944 and 1999 were created for the area based on title deed searches at the Deeds Office, Surveyor General, Pietermaritzburg.

### Implications for biodiversity integrity and hydrological functioning

We sought to understand the implications of land transformation on biodiversity integrity and hydrological functioning, as relevant to aquatic biodiversity, based on the approach of O'Connor and Kuyler (2009:387). Their study determined the relative impact of different land uses on biodiversity integrity and hydrological functioning for the moist Grassland Biome based on the analytic hierarchy process (Saaty 1990:9–26). Experts were interviewed to score 37 indicators across a predefined set of land uses with regard to the effect on ecosystem composition, structure and functioning. Hydrological functioning, a component of ecosystem functioning, was scored as an integrated effect of a land use on the amount, quality and seasonality of water flow.

The scores from each reviewer for a specific indicator are integrated into a single weight, which quantifies the effect of each land use per unit area for the indicator. From these, an integrated weight across all indicators is derived

to express the effect of land use on biodiversity integrity per unit area. The overall effect of a particular land use is then determined as the product of this weight and the proportion of the catchment area covered by that land use. The weights for land use provided by O'Connor and Kuyler (2009:390) are directly applicable to this study, as the area was part of their broader study area. Specifically, a natural asset was accorded a weight of zero as its value per unit area should not change. Plantations and alien plants (infestations, habitation) were accorded the value for plantation forestry, commercial cropping was accorded the mean of dryland and irrigated cropping, subsistence cropping was accorded the value for rural settlement, and fairly irreversible transformations were accorded the value for an urban environment (see Results).

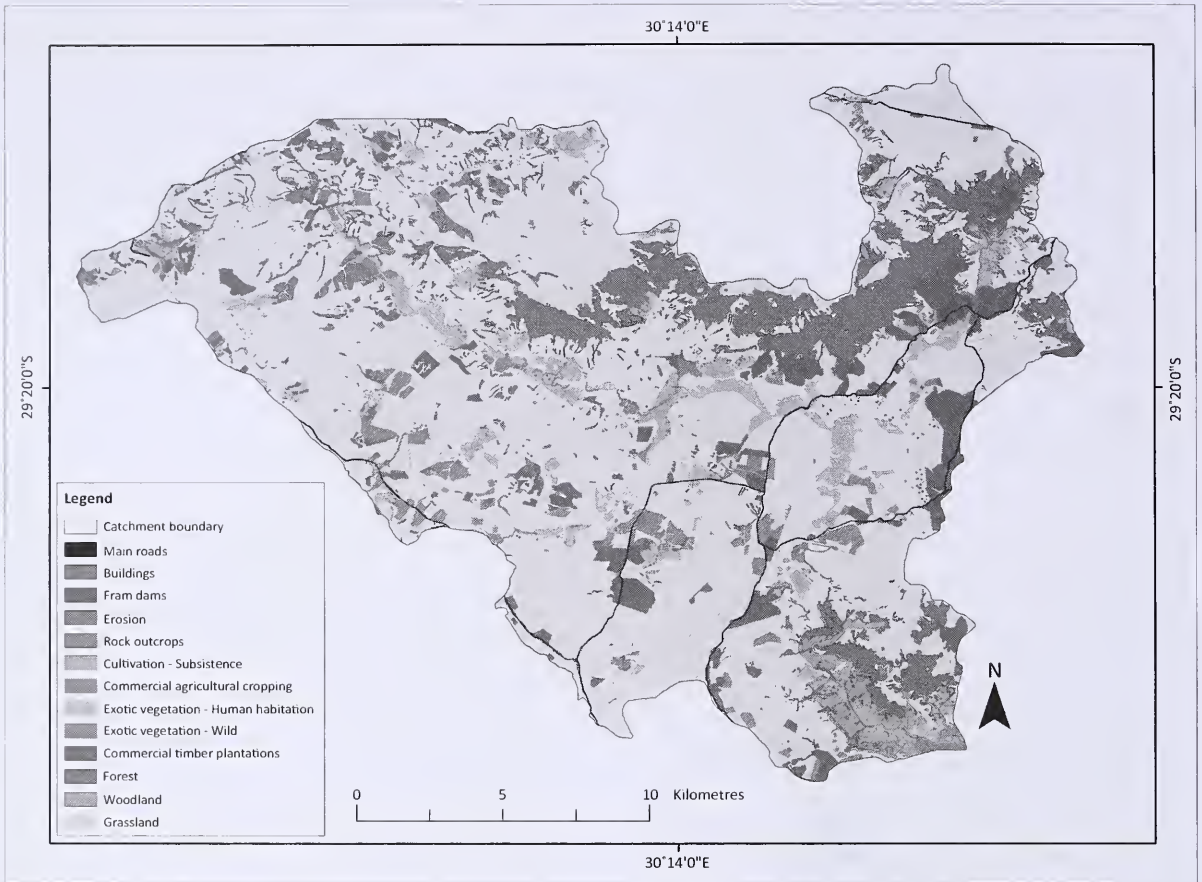
## Results

### Land transformation and ownership

Values represent a change in area of each land category between 1944 and 1999 as a percentage of the area occupied in 1944. The most notable land transformation was the loss of grassland (54% decrease) to commercial timber plantations (427% increase) and commercial agricultural cropping (311% increase) (Table 1; Figures 2 and 3). In contrast, subsistence cultivation had almost disappeared (98% decrease). Aquatic systems were transformed through an increase in the number and size of farm dams (2503% increase). Forest and woodland, although a minor part of the catchment, increased (4% and 22%, respectively).

The number of registered properties increased by 61%, with mean property size decreasing by 41% (Table 2).

In 1944, land was owned predominantly by private individuals, with private trusts or trustees and state-owned land accounting for the remainder (Table 3; Figure 4). By 1999, however, there were 10 additional categories of ownership (Figure 5). Although private individual ownership remained the largest category, more than half the catchment area had become the property of private



Source: Weyer, D., 2000, 'Land transformation in the Karkloof catchment between 1944 and 1999: Towards a database for future planning', MSc dissertation, Centre for Environment and Development, University of Natal

**FIGURE 2:** Land categories in the Karkloof catchment in 1944.

businesses (31%) and commercial timber plantation companies (26%).

### Implications for biodiversity integrity and hydrological functioning

The loss of grassland to commercial timber plantations and agricultural cropping resulted in the biodiversity integrity and hydrological functioning index deteriorating by 326% and 166%, respectively (Table 4). The relative change in area of other land covers, whether positive (such as an increase in types of natural asset) or negative (such as an increase in the area affected by alien plants), was too small to influence the overall trend. However, the potential future threat of alien plants should be recognised on the basis of their rapid rate of establishment and consequent increase (Table 1). The increase in commercial timber plantations and agricultural cropping has had a pronounced effect on all three of the main components of biodiversity integrity. Landscape composition is changed extensively as a result of the extent of land transformation. Loss of habitat and the proliferating invasion of alien invasive plants, which affect indigenous species negatively, are the result of such transformation. Landscape

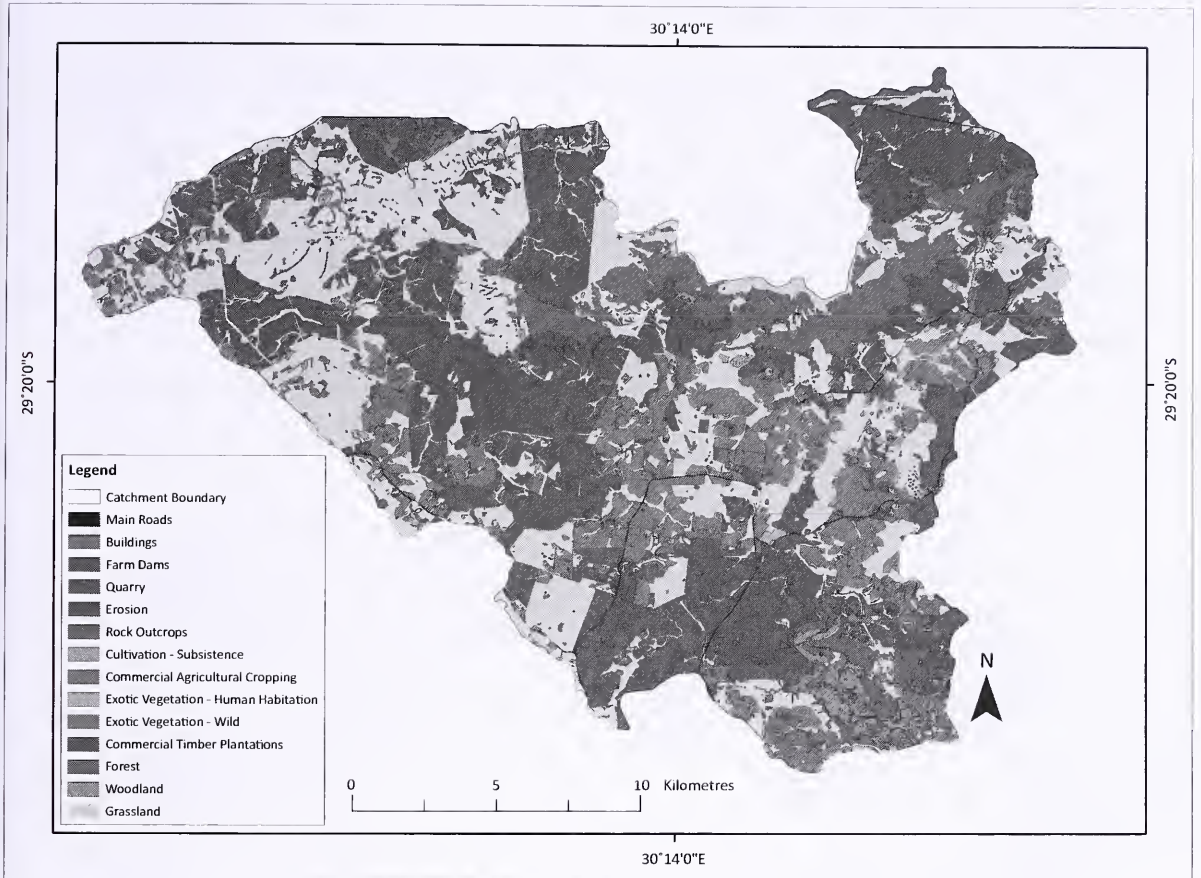
structure is substantially impaired by transformation, due mostly to commercial timber operations, with an associated negative effect imposed on the extent, porosity, connectivity and geometry of fragments.

Landscape functioning is impaired through altered regimes of fire and grazing, accelerated soil erosion associated with perturbed bio-geochemical processes, including reduced carbon storage, and altered patterns of hydrological functioning. The latter is impaired through impacts on the amount of water and its seasonality of flow, in particular the reduction of base flows during the dry season, which are critical for aquatic biodiversity. In the case of commercial agricultural cropping, water quality (independent of soil erosion) is also severely adversely affected.

## Discussion

### The nature of land transformation

The most notable land transformation in the Karkloof catchment between 1944 and 1999 is grassland (54%) being lost to commercial timber plantations and agricultural



Source: Weyer, D., 2000, 'Land transformation in the Karkloof catchment between 1944 and 1999: Towards a database for future planning', MSc dissertation, Centre for Environment and Development, University of Natal

FIGURE 3: Land categories in the Karkloof catchment in 1999.

TABLE 2: Number of properties and the associated sizes in 1944 and 1999

Statistics	1944	1999	Change <sup>a</sup>	Change (%)
Property numbers	191	308	117	61.25
Total area occupied by all properties (km <sup>2</sup> )	516.33	490.31	-26.02	-5.03
Mean area (km <sup>2</sup> )	2.70	1.59	-1.11	-41.11
Largest area (km <sup>2</sup> )	15.46	31.33	-15.87	-102.65
Smallest area (km <sup>2</sup> )	0.014	0.003	-0.011	-78.57

<sup>a</sup>, Negative values represent a decrease. Positive values represent an increase.

cropping. The area of grassland within the catchment prior to colonial settlement was 334 km<sup>2</sup> (Weyer 2000:57, 59). It is estimated that 63% of this had been lost by 1999. Mucina and Rutherford (2006:423) and Jewitt (2011:11) estimate similar losses (50% and 76%, respectively) for the Midlands Mistbelt Grassland, which extends beyond the Karkloof catchment. These estimates are based on the assumed potential for indigenous vegetation if human influence on vegetation was removed and on outlines of remnant vegetation determined for the period 2004–2006 (Mucina & Rutherford 2006:15) and 2008 (Jewitt 2011:11). Estimates for transformation of the Grassland Biome overall are 26% between 1988 and 2000 (Fairbanks *et al.* 2000:77) and 47% for 1994–1995 (Neke & Du Plessis 2004:472). The loss of grassland in the Karkloof

catchment therefore parallels the general trend in the moist eastern portion of the Grassland Biome of South Africa. The remaining grasslands are particularly suitable for commercial timber plantations and agricultural cropping owing to a favourable climate and fertile soils and are therefore highly threatened.

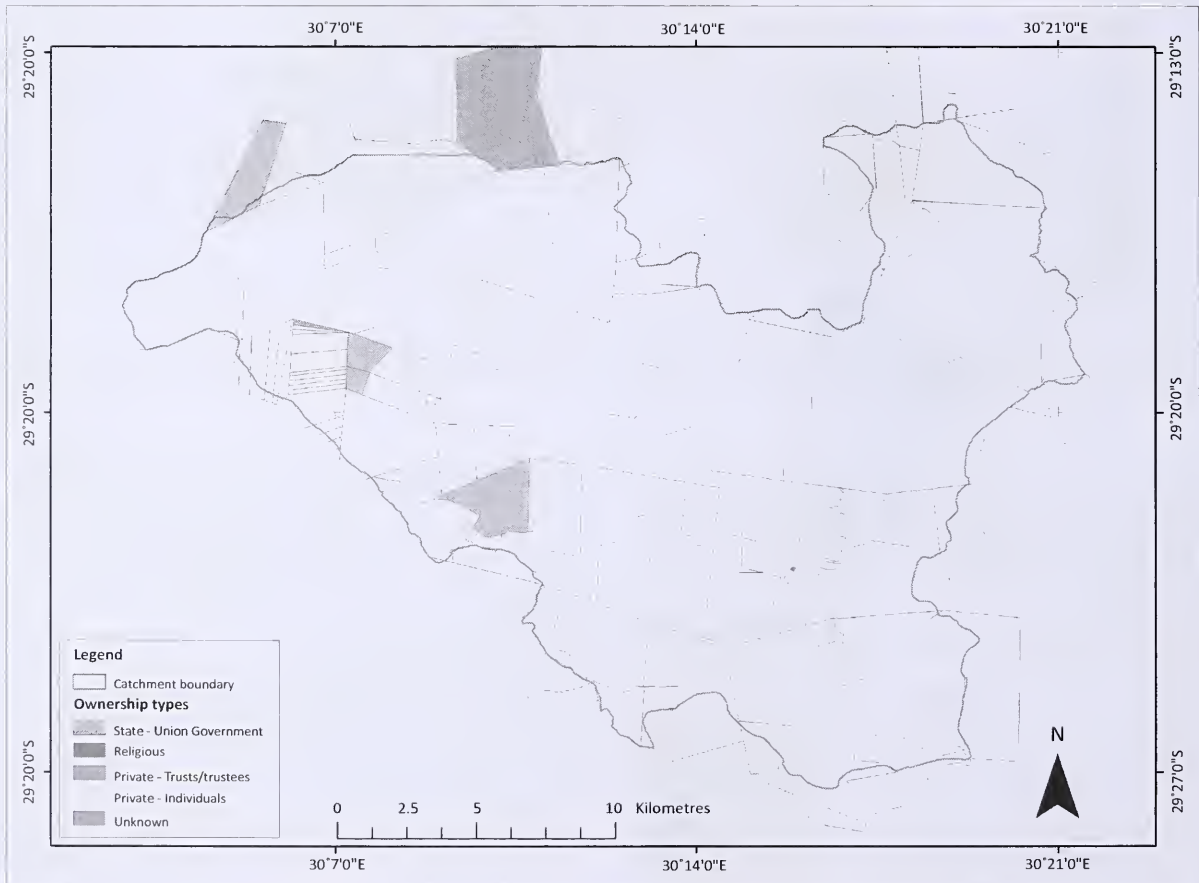
In the 55-year period reviewed in this study, the combined area of forest and woodland did not decrease as it did between 1880 and 1942 (Rycroft 1944:20), but rather increased by 3.02 km<sup>2</sup>. This increase is ascribed to a number of influences. In 1944, subsistence cultivation was practised in areas within and adjacent to the indigenous forest. When these areas were abandoned, they were re-colonised by indigenous woody vegetation. Expansion of forest and woodland in the eastern portion of South Africa is constrained by fire (Bond, Midgley & Woodward 2003:80). Discussions with land owners revealed that grasslands are burnt less frequently than they were in 1944. A reduction in fire frequency may account for the increase in indigenous woody cover (O'Connor, Puttick & Hoffman 2014:75). In contrast to our findings, Lawes, Macfarlane and Eeley (2004:620) reported a decrease of 5.7% in the area covered by the Karkloof–Balgowan forest

**TABLE 3:** Categories of land ownership in the Karkloof catchment in 1944 and 1999.

Ownership category	1944		1999	
	Area (km <sup>2</sup> )	Percentage of total area	Area (km <sup>2</sup> )	Percentage of total area
State-owned land (conservation)	0.00	0.0	7.90	1.6
State-owned land (Union Government)	9.84	1.9	0.00	0.0
Religious	0.02	0.0	0.02	0.0
Mondi Ltd <sup>a</sup>	0.00	0.0	44.96	9.2
Sappi Forests (Pty) Ltd <sup>a</sup>	0.00	0.0	83.47	17.0
Sappi Forests (leased) <sup>a</sup>	0.00	0.0	1.02	0.2
Private: Incorporated <sup>b</sup>	0.00	0.0	1.74	0.4
Private: Proprietary limited company <sup>b</sup>	0.00	0.0	85.71	17.5
Private: Close corporation <sup>b</sup>	0.00	0.0	12.06	2.5
Private trusts/trustees	11.65	2.3	53.57	10.9
Private administrators	0.00	0.0	9.61	2.0
Private clubs	0.00	0.0	0.03	0.0
Private individuals	494.63	95.8	179.50	36.6
Unknown	0.19	0.0	10.72	2.2
<b>Total</b>	<b>516.33</b>	<b>100.0</b>	<b>490.31</b>	<b>100.0</b>

<sup>a</sup> Commercial timber plantation companies (26.4% of total area in 1999).

<sup>b</sup> Private business entities (30.9% of total area in 1999).

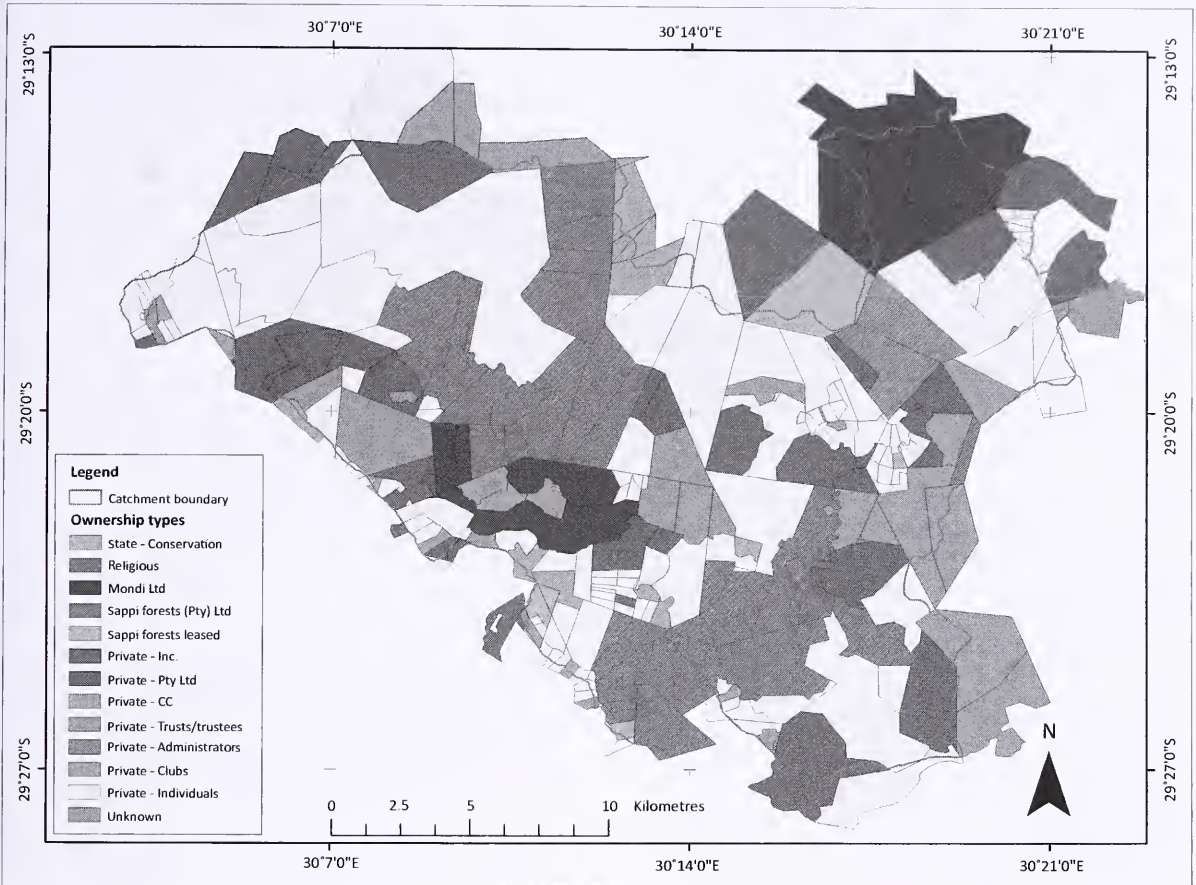


Source: Weyer, D., 2000, 'Land transformation in the Karkloof catchment between 1944 and 1999. Towards a database for future planning', MSc dissertation, Centre for Environment and Development, University of Natal

**FIGURE 4:** Categories of land ownership in the Karkloof catchment in 1944.

archipelago in the midlands of KwaZulu-Natal between 1944 and 1996. This difference may be due to differences in mapping methodologies and category interpretations and a larger study area being used in their study.

The total area of alien invasive plants increased by 7.71 km<sup>2</sup> (397%). Alien invasive vegetation poses a major threat to indigenous grassland and forest of eastern South Africa and their associated biodiversity and uses more water than



Source: Weyer, D., 2000, 'Land transformation in the Karkloof catchment between 1944 and 1999: Towards a database for future planning', MSc dissertation, Centre for Environment and Development, University of Natal

**FIGURE 5:** Categories of land ownership in the Karkloof catchment in 1999.

**TABLE 4:** Effect of land transformation on the biodiversity integrity and hydrological functioning of the Karkloof catchment between 1944 and 1999, based on weights of impact defined by O'Connor and Kuyler (2009).

Land category	Proportional area		Weight	Biodiversity integrity		Hydrological functioning		
	Percentage of area in 1944	Percentage of area in 1999		Relative impact: <sup>c</sup> 1944	Relative impact: <sup>c</sup> 1999	Weight	Relative impact: <sup>c</sup> 1944	Relative impact: <sup>c</sup> 1999
Grassland	68.9	32.0	0.000	0.000000	0.000000	0.000	0.000000	0.000000
Other natural asset <sup>a</sup>	11.6	12.3	0.000	0.000000	0.000000	0.000	0.000000	0.000000
Plantation forestry	6.9	36.2	0.136	0.009384	0.049232	0.116	0.008004	0.041992
Alien plants/habitation	1.0	4.0	0.136	0.001374	0.040299	0.116	0.001172	0.004628
Commercial cropping	3.2	13.2	0.117	0.003728	0.015378	0.141	0.004496	0.018546
Subsistence cropping	6.0	0.1	0.121	0.007260	0.000121	0.129	0.008514	0.000129
Irreversible transformation <sup>b</sup>	2.4	2.2	0.156	0.003728	0.003432	0.150	0.003585	0.003300
<b>Total</b>	-	-	-	<b>0.025474</b>	<b>0.108462</b>	-	<b>0.025771</b>	<b>0.068595</b>

<sup>a</sup> Forest, woodland and rocky areas.

<sup>b</sup> Buildings, quarries, roads, eroded areas and dams.

<sup>c</sup> Relative impact is calculated as the product of the proportional area and the weight of a category.

indigenous vegetation (Driver *et al.* 2012:135). Commercial timber plantations similarly may cause an estimated mean annual stream flow reduction of 3% and a low-flow (dry-season flow) reduction of 8% (Scott, Le Maitre & Fairbanks 1998:193). By 1999, 36% of the total catchment area was under commercial timber plantations (Table 1; Figure 3).

### Property size, patterns of ownership and water resource needs

The number of properties increased and the mean size of a property decreased between 1944 and 1999, as similarly recorded by Scotney (1970:185) and Rivers-Moore (1997:35) for adjacent regions. This may be attributed to population growth in

South Africa, which increased fourfold in the reviewed period, from 11 415 000 people in 1946 to 43 054 000 in 1999 (Statistics South Africa 2002:8, 10). This may have driven the subdivision of large properties. Furthermore, in 1944 no legislation existed to regulate farm size and it was only with the promulgation of the *Subdivision of Agricultural Land Act* (Act 70 of 1970) that the indiscriminate subdivision of land was halted. (This act is still in force, but will be repealed once the Draft Preservation and Development of Agricultural Land Framework Bill, as gazetted on the 13 March 2015, is enacted.) Smaller property sizes have implications for reduced biodiversity and hydrological functioning, as farmers are forced to intensify agricultural production to remain economically viable. The aerial photographs of 1996 show clear examples of commercial timber plantations abutting directly onto indigenous forests and commercial cultivation encroaching into wetland areas.

There is a distinct difference between registered farm sizes and managed operational farm sizes. Although mean property size in the catchment generally decreased, the shift from private ownership towards corporate forestry and business entities (agricultural cropping farms and some corporate forestry) suggests that, by 1999, a large proportion of the small properties were farmed as large, consolidated land holdings, with land use and management being influenced accordingly. The economic difficulties of farming small rangeland cattle and agricultural cropping farms that existed prior to 1970 may have precipitated the move towards corporate business ownership of farms. Other economic factors in the late 1970s and early 1980s also had an influence. Worldwide demand for soluble pulp peaked in the 1980s and, in response, two large corporate timber companies began purchasing large tracts of land from as early as 1950, intensifying from 1986 to 1990 (Cairns 2000:7). This is supported by title deed searches, which show ownership transfers taking place in the 1980s. In the 1980s, beef prices were low and many cattle farmers in the catchment sold their land, seeing it as an opportunity for economic survival. The farms sold comprised mostly grassland and at that time no environmental legislation existed to control the potential environmental impacts of development changes and the conversion of natural land cover. Although an environmental clause is included in the Bill of Rights of the Constitution of South Africa, the first specific protective environmental legislation was the *Environment Conservation Act* 73 of 1989. This has been followed by the *National Environmental Management Act* (Act 107 of 1998) and the most recent Environmental Impact Assessment regulations of 2014, which afford current protection.

The increase in the number of farm dams in the catchment (Table 1) is directly related to the increase in the number of properties. The increase in dam size can be attributed to the need to optimise or intensify land use on the smaller property sizes. In the adjacent Midmar catchment, reservoirs upstream of the Midmar Dam could reduce median annual streamflow into the dam by 6% (Tarboton & Schulze 1991:229). Increases in the number and area of farm dams in the Karkloof

catchment may have a similar effect on water availability in the uMngeni catchment.

### Implications for biodiversity integrity and hydrological functioning

Loss of grassland has affected a number of grassland types and parallels similar losses noted elsewhere (e.g. Rivers-Moore 1997:35). Such losses have been sufficient to render some grassland types of conservation concern in South Africa (Mucina & Rutherford 2006:362). Midlands Mistbelt Grassland (53% transformed) is endangered, whereas Ngongoni Veld (39% transformed), Mooi River Highland Grassland (24% transformed) and KwaZulu-Natal Hinterland Thornveld (22% transformed) are classified as vulnerable. In contrast, Drakensberg Foothill Moist Grassland (18% transformed) is classified as least threatened (Mucina & Rutherford 2006:423, 511, 422, 510, 424). Under the *National Forest Act* (Act 84 of 1998 as amended) forests are afforded protection in South Africa and, consequently, Southern Mistbelt Forest (5% transformed) is classified as least threatened, concordant with the slight increase observed in the Karkloof catchment (Table 1).

The Karkloof catchment is home to a number of red data species (Appendix 1), including 10 plant, 21 bird, two amphibian, one reptile and 11 mammal species (excluding bats). The majority of these are associated with grassland, for which loss of habitat due to land transformation is one of the main threats to their persistence. Six of the ten plant species are grassland species. Of these, five occur in the remaining areas of Midlands Mistbelt Grassland, with three being classified as vulnerable. In contrast, harvesting presents the primary threat to two forest red data plant species, as their habitat has remained secure (Table 1). The vulnerable aquatic species *Hydrostachys polymorpha* (rivers) and *Nerine pancratioides* (wetland) are indirectly threatened by loss of grassland to plantation forestry and cropping owing to their sensitivity to altered hydrological functioning.

Although only 12 of the 21 bird species are grassland species, with another two using grassland and forest (Appendix 1), all the bird species use all grassland types in the catchment. The social units of these species use a fairly large home range (Hockey, Dean & Ryan 2005), which for some is greater than 100 km<sup>2</sup>. Seven of the mammal species rely on grassland (Appendix 1). Oribi antelope, serval and weasel (Friedman & Daly 2004) require large tracts of grassland and are therefore expected to have been adversely affected by the degree of fragmentation in the catchment (compare Figure 2 and 3). The blue swallow has become locally extirpated in this catchment and is threatened with local extinction in South Africa (Wakelin & Hill 2007:252, 254). In contrast, the two amphibian species, as well as the other mammal, reptile and insect species, show fine-grained use of the habitat owing to their smaller body sizes (Appendix 1). These species will therefore likely be less affected by fragmentation, provided the remaining fragments contain the specific habitat features

they require. Bird and mammal species whose habitat is forest are unlikely to have been negatively impacted by land transformation, as forests have increased marginally in size and have been spared harvesting in recent decades; however, increases in human density may have escalated indirect pressures.

The decline in biodiversity integrity due to a loss in grassland is probably confounded by deterioration in the botanical composition of grassland for livestock production and a decline in plant species diversity. Grassland dominated by the palatable *Themeda triandra* has been widely replaced by the unpalatable *Aristida junciformis* (Camp 1997:16; Scotney 1970:154), ostensibly as a consequence of poor grassland management practices earlier, including overstocking, frequent burning, burning early in winter followed immediately by grazing, and continuous selective overgrazing (Acocks 1988:7; Camp 1997:16; Tainton 1999:281). This compositional change has been associated with a loss of forb species (Scott-Shaw & Morris 2015:24).

## Conclusion

The Karkloof catchment has been transformed profoundly over half a century. The transformation offers an example of the increasing demand for land at the expense of natural resources. The Midlands Mistbelt Grassland has incurred the most significant loss, resulting in a deterioration of biodiversity integrity and hydrological functioning of the catchment.

Continued pressure to alter patterns of land ownership and, consequently patterns of land use, is expected. This will likely not take place in isolation, but within a global context of climate change, an increasing world population and shortages of land and its products, particularly food and water (Foley *et al.* 2011:337; World Economic Forum 2014:13), and in a changing local sociopolitical and -economic setting.

The ability of the catchment to sustain continued pressure will depend on both government and land owners working towards innovative ways to balance development with environmental conservation.

## Acknowledgements

The financial assistance of the Wildlife and Environment Society of Southern Africa and the National Research Foundation is acknowledged. The following individuals and organisations are thanked for their assistance: the land owners of the Karkloof catchment; staff at the Surveyor General's office and the Msunduzi Local Municipality, Pietermaritzburg and K. Cooper, R. Hunt, K. Camp, S. Moodley, D. Scotney, T. Bodington, S. Davies and J. Marshall.

## Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

## Authors' contributions

V.D.W. (University of KwaZulu-Natal) was the project leader. J.E.G. (South African Environmental Observation Network), T.G.O'C. (South African Environmental Observation Network) and T.R.H. (University of KwaZulu-Natal) were the co-authors. Each co-author contributed their expert knowledge to the research, provided strategic guidance on the direction of the article and edited and commented on the article in preparation for submission. The article is based on original research conducted towards the first author's MSc dissertation (Weyer 2000), supervised by J.E.G. and T.R.H. Although the research was conducted over a decade ago, the data gathered are considered valuable in light of environmental change that has occurred since. The research formed a base to which the co-authors added their area of expertise: J.G. contributed as a specialist grassland ecologist, specifically with regard to the Midlands Mistbelt Grassland; T.R.H. contributed as a geographer and provided knowledge of environmental history and future trends, and T.G.O'C. applied the expert system approach to determine the implications of the land transformation on the biodiversity integrity and hydrological functioning of the catchment.

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Appendix 1 starts on next page →

# Appendix 1

**TABLE 1-A1:** List of red data species recorded or predicted to occur within the Karkloof catchment of KwaZulu-Natal, South Africa.

Species	Common name	Status	Habitat	Observed/predicted	Source
<b>Plants</b>					
<i>Cryptacarya myrtifolia</i>	Wild camphar	LR	Forest	Observed	Scott-Shaw (1999)
<i>Dierama luteaalbidum</i>	None	Vu	Mistbelt Grassland	Observed	Scott-Shaw (1999)
<i>Eulaphia streptopetala</i>	None	LC	Grassland	Observed	Ezemvela KwaZulu-Natal Wildlife (EKZNW) (2014)
<i>Geranium natalense</i>	Mistbelt geranium	DD	Mistbelt Grassland	Observed	Scott-Shaw (1999)
<i>Hydrastachys polymarpha</i>	None	Vu	Rivers	Observed	Scott-Shaw (1999)
<i>Nerine pancrotioides</i>	None	Vu	Wetland	Observed	EKZNW (2014)
<i>Ocateo bullota</i>	Black stinkwaad	Vu	Mistbelt Forest	Observed	Scott-Shaw (1999)
<i>Schizaglossum ingamense</i>	None	Vu	Mistbelt Grassland	Observed	Scott-Shaw (1999)
<i>Senecia dregeanus</i>	None	LR	Mistbelt Grassland	Observed	Scott-Shaw (1999)
<i>Watsonia canaliculata</i>	None	Vu	Mistbelt Grassland	Observed	Scott-Shaw (1999)
<b>Mammals (excluding bats)</b>					
<i>Cercopithecus mitis lobiotus</i>	Syke's monkey	En	Forest	Observed	Friedman and Daly (2004)
<i>Chrysospolox villosus dobsoni</i>	Rough-haired golden mole	CE	Grassland	Observed	EKZNW (2014)
<i>Craciduro maquassiensis</i>	Maquassie musk shrew	Vu	Grassland	Expected	Friedman and Daly (2004)
<i>Dendrohyrox orbareus</i>	Tree hyrax	Vu	Forest	Observed	Friedman and Daly (2004)
<i>Georchus capensis</i> (KZN)	Cape mole-rat	En	Grassland	Expected	Friedman and Daly (2004)
<i>Leptotylurus serval</i>	Serval	NT	Grassland	Observed	EKZNW (2014)
<i>Lutro moculicollis</i>	Spotted-necked otter	NT	River	Expected	Friedman and Daly (2004)
<i>Mystromys albicaudatus</i>	White-tailed rat	En	Grassland	Expected	Friedman and Daly (2004)
<i>Ourebio ourebi</i>	Oribi	En	Grassland	Observed	EKZNW (2014)
<i>Philantambo manticolo</i>	Blue duiker	Vu	Forest	Observed	Friedman and Daly (2004)
<i>Poecilagole olbinucho</i>	African striped weasel	DD	Grassland	Observed	EKZNW (2014)
<b>Birds</b>					
<i>Anthropoides paradisea</i>	Blue crane	Vu	Grassland	Observed	EKZNW (2014)
<i>Bolearica regularum</i>	Crowned crane	Vu	Grassland	Observed	EKZNW (2014)
<i>Bugeranus carunculatus</i>	Wattled crane	CE	Grassland	Observed	EKZNW (2014)
<i>Bucorvus leodbeoteri</i>	Ground hornbill	Vu	Grassland	Observed	EKZNW (2014)
<i>Calumbo delegorguei</i>	Delegorgue's pigeon	Vu	Forest	Observed	EKZNW (2014)
<i>Eupodatis cofra</i>	White-bellied karhaan	Vu	Grassland	Expected	Barnes (2000)
<i>Falca biarmicus</i>	Lanner falcon	NT	Grassland/Forest	Observed	EKZNW (2014)
<i>Geranticus colvus</i>	Bald ibis	Vu	Grassland	Observed	EKZNW (2014)
<i>Gyps caprathores</i>	Cape vulture	Vu	Grassland	Observed	EKZNW (2014)
<i>Hirunda atrocaerulea</i>	Blue swallow	LE	Grassland	Expected	Barnes (2000)
<i>Liaptilus nigricapillus</i>	Bush blackcap	NT	Forest	Observed	EKZNW (2014)
<i>Micraparra capensis</i>	Lesser jacana	NT	Wetland	Observed	EKZNW (2014)
<i>Neatis denhami</i>	Denham's bustard	Vu	Grassland	Observed	EKZNW (2014)
<i>Paicephalus robustus</i>	Cape parrot	En	Forest	Observed	EKZNW (2014)
<i>Palaemetus bellicus</i>	Martial eagle	Vu	Grassland/Forest	Observed	EKZNW (2014)
<i>Sagittarius serpentarius</i>	Secretary bird	NT	Grassland	Observed	EKZNW (2014)
<i>Sarathruo affinis</i>	Striped flufftail	Vu	Wetland	Observed	EKZNW (2014)
<i>Stephanaeetus caranatus</i>	Crowned eagle	NT	Forest	Observed	EKZNW (2014)
<i>Tyta capensis</i>	Grass owl	Vu	Grassland	Observed	EKZNW (2014)
<i>Vonellus melanopterus</i>	Black-winged lapwing	NT	Grassland	Observed	EKZNW (2014)
<i>Zoothera gurneyi</i>	Orange ground thrush	NT	Forest	Observed	EKZNW (2014)
<b>Amphibians</b>					
<i>Afrilus spinifrons</i>	Natal spiny reed frog	Vu	Grassland	Modelled	Minter et al. (2004)
<i>Cocosternum striatum</i>	Striped caco	DD	Grassland	Expected	Minter et al. (2004)
<b>Reptiles</b>					
<i>Bradypanian thamnabates</i>	Midlands dwarf chameleon	Re		Observed	EKZNW (2014)
<b>Insects</b>					
<i>Bowkerio phosphor boreolis</i>	Scarce scarlet	Rare		Observed	EKZNW (2014)
<i>Orachrysops oriodne</i>	Karkloof blue	Rare		Observed	EKZNW (2014)
<i>Popilio euphronor</i>	Bush-kite swallowtail	Ind		Observed	EKZNW (2014)
<b>Invertebrates</b>					
<i>Darataganus natalensis</i>	Natal black millipede	Vu		Observed	EKZNW (2014)

Note: Please see the full reference list of the article, Weyer, V.D., Granger, J.E., Hill, T.R. & O'Connor, T.G., 2015, 'Land transformation and its implication for biodiversity integrity and hydrological functioning from 1944 to 1999, Karkloof catchment, South Africa', *Bothalia* 45(1), Art. #1907, 13 pages. <http://dx.doi.org/10.4102/abc.v45i1.1907>, for more information.

CE, critically endangered; DD, data deficient; En, endangered; Ind, indeterminate; LE, locally extirpated; LR, lower risk; NT, near threatened; Re, restricted; Vu, vulnerable

\*. Species appear in alphabetical order in the references according to Latin binomial within a relevant group. Lit et omnimolupis site volumqu undaniam aiorepuditi aequai alituri?

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# An assessment of the information content of South African alien species databases

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Received: 28 Oct. 2014

Accepted: 14 Mar. 2015

Published: 29 May 2015

## How to cite this article:

Faulkner, K.T., Spear, D., Robertson, M.P., Rouget, M. & Wilson, J.R.U., 2015, 'An assessment of the information content of South African alien species databases', *Bothalia* 45(1), Art. #1103, 11 pages. <http://dx.doi.org/10.4102/abc.v45i1.1103>

National alien species databases indicate the state of a country's biodiversity and provide useful data for research on invasion biology and the management of invasions. In South Africa there are several different published alien species databases, but these databases were created for different purposes and vary in completeness and information content. We assessed the information content of published South African alien species databases in the context of other such databases globally, and evaluated how the information content of South African databases varies across taxonomic groups. Although introduction pathway, date of introduction, region of origin and current broad-scale distribution data are available for most taxonomic groups assessed (60% – 90%), data on invasion status, introduction effort and introduction source are available for few taxonomic groups (5% – 18%). South African alien species databases have lower information content than the detailed databases available in other parts of the world and thus cannot be utilised to the same extent. We conclude with 11 recommendations for improving South African alien species databases. In particular, we highlight the data types that should be incorporated in future databases and argue that existing data should be collated in a single, standardised meta-database to facilitate cross-taxon comparisons, highlight gaps in effort, and inform managers and policy makers concerned with alien species.

## Introduction

Humans are introducing species to regions beyond their native range; however, few of these species become invasive and have deleterious impacts (Blackburn *et al.* 2011). National lists of alien species provide the taxonomic identities of introduced species. These data are required to assess the current state of biodiversity; for example, they are used to measure progress towards meeting the Convention on Biological Diversity's (CBD) Strategic Plan for Biodiversity (2011–2020) Aichi target 9 (Butchart *et al.* 2010; McGeoch *et al.* 2010, 2012; UNEP 2011). Alien species databases contain much more data than a simple list of introduced species. The valuable data stored in these databases (e.g. on pathways and dates of introduction, distribution and invasion success) can be used to inform the management of invasions and further our understanding of biological invasions (Table 1) (also see Cadotte, Murray & Lovett-Doust 2006; Pyšek *et al.* 2012). For example, alien species databases are a data source for research on the predictors of invasion success, pathways of introduction and species distribution modelling. Such research underpins invasive species risk assessments and aids in the prioritisation of species, pathways and areas for surveillance and management.

The documented knowledge of introduced organisms varies greatly across countries (Pyšek *et al.* 2008). Although some databases provide minimal data others are quite detailed. For example, an alien plant catalogue for the Czech Republic provides 13 fields of data on 1454 species (Pyšek *et al.* 2012; Pyšek, Sádlo & Mandák 2002). The data provided in this Czech catalogue have been used in studies covering many topics, including range filling, associations with pollinators and the interaction of traits (Pyšek *et al.* 2012). In contrast, databases that lack detail, or that are incomplete or poorly contextualised, pose a biosecurity risk and may reduce management effectiveness and research quality and scope (McGeoch *et al.* 2012; Pyšek 2003). Moreover, global research effort on alien species (Pyšek *et al.* 2008) and alien species databases (Crall *et al.* 2006; Ricciardi *et al.* 2000) are taxonomically biased.

The consequences of inadequate databases and taxonomically biased data can be averted through the identification of data gaps and efforts made to alleviate the detected disparities. However, increasing the amount of data does not necessarily lead to an equal increase in benefits for research, decision making and management (Grantham *et al.* 2008; Pyšek *et al.* 2008; Simberloff 2003). For example, detailed data (e.g. on population biology) is often not required to eradicate recently introduced species, but may be vital for the management of established alien species

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**TABLE 1:** Research questions or topics that can be addressed using the data in alien species databases, the usefulness of each question or topic for management or policy, the types of data provided by alien species databases required to address each question and examples from literature.

Research question	Use for management or policy	Data required	Examples
What are the determinants of invasion success?	Informs pre- and post-border risk assessment.	Taxonomic identity, invasion status, pathway and date of introduction, biological trait data, introduction effort, introduction source and origin and other potential predictors of invasion success.	Dawson, Burslem & Hulme (2009); Pyšek, Jarošík & Pergl (2011); Williamson (2006)
How accurate are risk assessments?	Indicates risk assessment performance.	Taxonomic identity, invasion status, failure.	Reichard & Hamilton (1997)
What traits are related to invasion status?	Informs pre- and post-border risk assessment.	Taxonomic identity, invasion status, biological trait data.	Kolar & Lodge (2002)
What are the important pathways of introduction?	Informs prevention strategies (e.g. inspection strategies). Required to meet Convention on Biological Diversity (CBD) goals.	Taxonomic identity, pathway of introduction.	Gollasch & Nehring (2006); Kenis <i>et al.</i> (2007); Pyšek, Jarošík & Pergl (2011)
Have the pathways of introduction changed temporally?	Informs prevention strategies (e.g. inspection strategies).	Taxonomic identity, pathway and date of introduction.	Genovesi <i>et al.</i> (2012); Pyšek, Jarošík & Pergl (2011)
How have introductions or invasions changed over time?	Required to measure progress towards CBD goals.	Taxonomic identity, date of introduction, invasion success.	Gollasch & Nehring (2006); McGeoch <i>et al.</i> (2010)
How many and what type of organisms may be introduced in the future?	Informs prevention strategies (e.g. inspection strategies).	Taxonomic identity, date of introduction.	Levine & D'Antonio (2003)
Are introduced species non-random (e.g. with regards region of origin, source regions or taxonomy)?	Informs prevention strategies (e.g. inspection strategies).	Taxonomic identity, region of origin and/or source region.	Gollasch & Nehring (2006); Kenis <i>et al.</i> (2007); Richardson & Rejmánek (2004)
Does the level of invasion or invasibility vary spatially?	Informs early detection and eradication strategies.	Distribution data.	Chytrý <i>et al.</i> (2008)
What factors affect the current distribution and future dispersal of alien species?	Informs early detection and eradication strategies, as well as distribution modelling.	Distribution data, biological traits, records of introductions, dispersal pathways.	Williamson <i>et al.</i> (2005)
What is the potential distribution and spatio-temporal spread of an alien species?	Informs risk assessment as well as early detection and eradication strategies.	Current distribution data, date of collection data.	Jarnevich <i>et al.</i> (2010); Rouget <i>et al.</i> (2004); Smolik <i>et al.</i> (2010)

Note: Please see the full reference list of the article, Faulkner, K.T., Spear, D., Robertson, M.P., Rouget, M. & Wilson, J.R.U., 2015, 'An assessment of the information content of South African alien species databases', *Bothalia* 45(1), Art. #1103, 11 pages. <http://dx.doi.org/10.4102/abc.v45i1.1103>, for more information.

(Simberloff 2003). Additionally, comprehensive data on a limited number of species is often sufficient to generalise and develop theories on biological invasions (Pyšek *et al.* 2008). Thus, although the data contained in detailed alien species databases is valuable, the types and amount of data required will depend on the research question or management strategy (Table 1).

South Africa has a large number of alien species from a wide variety of taxonomic groups, including the Insecta, Mammalia, Mollusca and Plantae (Henderson 2001; Herbert 2010; Picker & Griffiths 2011; Van Rensburg *et al.* 2011). For many taxonomic groups recent alien species databases are available, some of which provide many types of data. However, these databases were developed for different purposes and vary in information content. Consequently, it is unknown whether South African alien species databases can be used to the same extent as the detailed databases in other countries. We aimed to assess the overall information content of South African alien species databases in terms of introduction (dates, pathways, effort and source), region of origin, distribution and invasion status (current status and failure). We explore how the information content of these databases varies across taxonomic groups. Finally, we identify knowledge gaps and suggest key areas for future work.

## Methods

### Database identification

Alien species databases published up until December 2012 in peer-reviewed papers, books and reports were identified and assessed. A large number of databases pertain to South African alien species, but many are either poorly integrated

or do not focus entirely on alien species. Therefore, we obtained a sample that was of a manageable size and that was representative of all taxonomic groups. These databases were identified using expert opinion and by consulting the references of previously assessed publications. We only assessed databases developed for a national level or databases developed for a regional or global level from which national level data could be extracted. Although comprehensive lists of alien Reptilia in captivity (Van Wilgen *et al.* 2010) and Plantae under cultivation (Glen 2002) are available, lists of species in the introduction stage of the invasion continuum (Blackburn *et al.* 2011) are not available for many other taxonomic groups. Furthermore, many of the data types assessed here (e.g. distribution data) are not applicable for species that have not yet spread outside of captivity or under cultivation. Thus databases of species in captivity or under cultivation were not evaluated. A total of 34 alien species databases spanning 23 taxonomic groups were assessed, such that an indication of the number of alien taxa and the data content housed in each database was obtained (Tables A1 & A2).

For each taxonomic group we selected (from the sample of 34 databases) recent databases (2000–2012) that list a high number of alien taxa and that provide numerous types of data (Tables A1 & A2). We focussed on more recent alien species databases as such databases collate and update the data found in previous inventories, and should incorporate more recent taxonomic revisions. Additionally, for taxonomic groups that occur in a range of environments (e.g. Mollusca and Crustacea), care was taken to ensure that the selected databases spanned the various environments inhabited (Table A2). Consequently for some groups, databases that list few species but focus on a specific

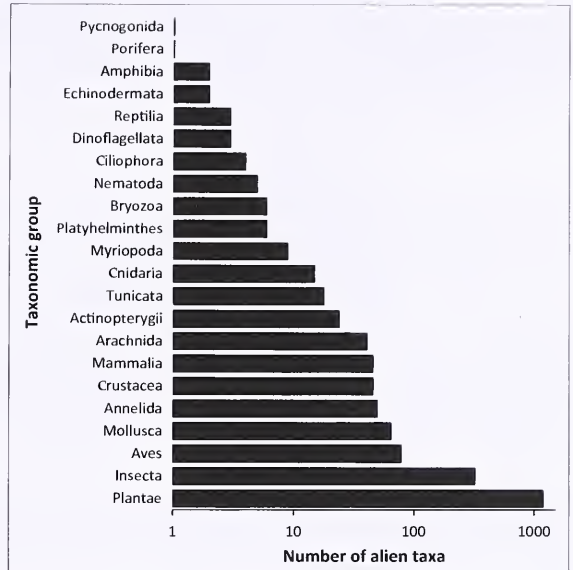
environment were included. For example, Insecta that are associated with the intertidal zone are discussed in a paper by Mead *et al.* (2011) on estuarine and marine taxa (Table A2). For taxonomic groups for which multiple, recent alien species databases exist, we used expert opinion to further confirm our selection. For each taxonomic group (i.e. marine invertebrate groups [e.g. Tunicata], Plantae, Aves, Reptilia, Crustacea, Insecta, Actinopterygii [ray-finned fishes], Mollusca and Mammalia), at least one South African expert that has worked on alien species listing was contacted. Each expert was asked to identify, for the taxonomic group of interest, the published alien species database that is currently the most comprehensive with regards to both the listed taxa and information content. Based on the opinion of these experts, two databases (i.e. De Moor & Bruton 1988 and Germishuizen *et al.* 2006) were added to our selection as they currently contain the most recent, comprehensive lists available for the Actinopterygii and Plantae – despite De Moor and Bruton (1988) being published before 2000. Finally, as an updated version of Germishuizen *et al.* (2006) is available online (<http://posa.sanbi.org>), this online database was used in the full analysis. In total, 14 databases spanning 23 taxonomic groups were selected for the full analysis (Tables A1 & A2).

## Data extraction

Data on taxon name and taxonomic group were extracted from the 14 selected alien species databases. Taxa were assigned to taxonomic groups based on the taxonomy used by the selected databases. Although such definitions may influence results and lead to groupings at various taxonomic levels, these groupings reflect the taxonomic levels at which alien taxa are often listed and managed.

Taxa listed that are translocated indigenous species (e.g. the Mozambique tilapia *Oreochromis mossambicus*; see Van Rensburg *et al.* 2011), suspected to be indigenous or listed as 'dubious records' (e.g. the mollusc *Vertigo antiverigo*, which has been found only as a subfossil; see Herbert 2010) were not included in the analysis. As the listing of species in captivity or under cultivation is not comprehensive, any species listed that has entered the country but is not found outside of captivity or cultivation was excluded from the analysis. Furthermore, the Brachiopoda, one of the 23 taxonomic groups included in the selected databases, were not included in the analysis as the only introduced species, *Disciniscia tenuis*, is found exclusively within aquaculture facilities (Mead *et al.* 2011).

Although for each taxonomic group recent alien species databases that list many species were utilised to develop the resultant list of taxa (Figure 1), there may be alien taxa in South Africa, besides those discussed in the paragraph above, that have been excluded. Such exclusions may be a result of listing errors (McGeoch *et al.* 2012) or the rapid rate at which new species are introduced. However, the aim of this work was not to create a comprehensive list of South African alien taxa but rather to assess the data



Note: Pycnogonida (sea spiders), Porifera (sponges), Echinodermata (e.g. star fish and sea urchins), Nematoda (round worms), Bryozoa (moss animals), Platyhelminthes (flat worms), Myriopoda (e.g. centipedes), Cnidaria (e.g. jelly fish), Tunicata (ascidians), Actinopterygii (ray-finned fishes), Annelida (e.g. earthworms), Aves (birds).

**FIGURE 1:** The number of alien taxa listed for each taxonomic group in the selected alien species databases and included in the analysis.

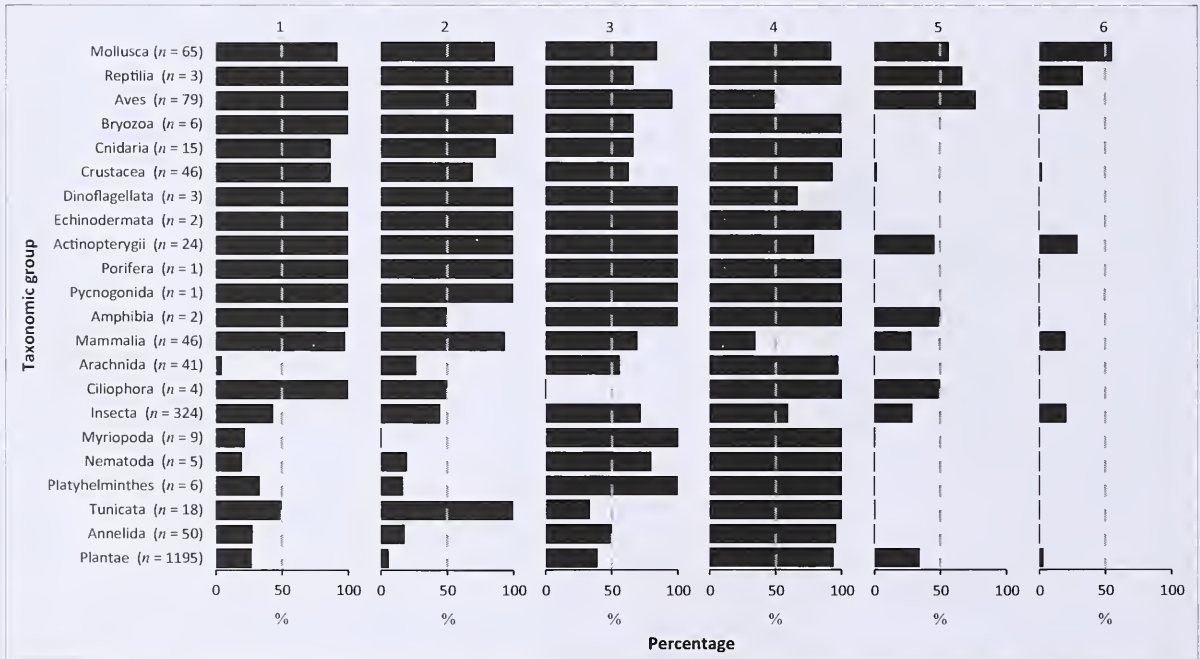
provided by a representative sample of existing alien species databases. Additionally, our aim can be achieved by using a representative list that contains a large proportion of South African alien taxa.

Date of introduction, pathway of introduction, region of origin, distribution and invasion status data were extracted from the selected alien species databases (Table 2). Notes were also taken on whether data on introduction source (region from which the organism was introduced), introduction effort (number of individuals introduced and/or introduction events) and failure (taxa that failed to establish) were provided (Table 2). Approximate dates of introduction or regions of origin (e.g. continent) and distribution data in descriptive form or point distribution maps were included as available data (Table 2). Invasion status data were only deemed available if the invasion status of the organism as per Richardson *et al.* (2000) or Blackburn *et al.* (2011) was stated or the category of the taxon under legislation – Conservation of Agricultural Resources Act (CARA) and National Environmental Management Biodiversity Act (NEMBA) – was specified (Table 2). Although various invasion status classifications exist, the classifications of Richardson *et al.* (2000) and Blackburn *et al.* (2011) were employed as they are used internationally (e.g. Pyšek *et al.* 2012) and as the classification of Blackburn *et al.* (2011) is applicable to all taxa. These classifications divide the invasion continuum into four stages: transport, introduction, establishment and spread (Blackburn *et al.* 2011; Richardson *et al.* 2000). Based on the invasion stage occupied, an organism's invasion status is classified as (1) introduced or casual, (2) naturalised or established and (3) invasive (Blackburn *et al.* 2011;

**TABLE 2:** Categories of information content used in the analysis of the South African alien species databases and ranked value.

Category	Units	Example	Rank†
Pathway of introduction	Description of how the organism was introduced	'ship fouling or ballast water'	1
	Description of why the organism was introduced	'biological control agent'	1
Date of introduction	Year of introduction	'1930'	1
	Year of first record	'1940'	2
	Period of time	'1930–1940', 'early 1980s'	3
	Approximate year of introduction	'~1833'	2
Introduction effort	The number of introduction events	-	1
	Years of introduction events	'1920, 1930'	2
	The number of introduced individuals	-	1
	Indication that there has been multiple introduction events	'additional introduction events after first known introduction date'	3
Introduction source	Name of country	'Scotland'	1
Region of origin	Name of continent or ocean	'North America', 'Pacific'	4
	Name of region	'West Africa'	3
	Name of country	'Argentina'	2
	Name of place	'Amazon'	1
Distribution	Point distribution maps	-	1
	Descriptions	'Widespread', 'Western and Eastern Cape', 'Single site record at Durban'	2
Invasion status	Status as per Richardson <i>et al.</i> (2000) and Blackburn <i>et al.</i> (2011)	'Casual'/'Not Established', 'Established'/'Naturalised', 'Invasive'	1
	CARA or NEMBA category provided	'Declared invader (category 2)'	2
Failure	Inclusion of taxa with descriptions of current status that indicate a failure to establish	'Possibly extinct, failed to establish', 'Extinct'	1

†, A value of 1 represents a high ranking.



**FIGURE 2:** Percentage of the total number of alien taxa per taxonomic group for which data on (1) pathway of introduction, (2) date of introduction, (3) region of origin, (4) distribution, (5) invasion status and (6) all the aforementioned categories were provided. The number of species in each taxonomic group is given in round brackets and taxonomic groups are arranged according to descending data comprehensiveness (i.e. the number of categories for which data is available for greater than 50% of taxa).

Richardson *et al.* 2000). Data were classified as unavailable if either no data were available or the characteristics were listed as 'unknown'. The information content of the selected alien species databases for each taxonomic group was determined by calculating the total number of alien taxa in each taxonomic group (Figure 1), and determining the percentage of taxa in each group for which the data of interest were provided. Results were plotted in R version 3.0.0 (R Core Team 2013).

## Results

For the majority of the taxonomic groups, pathway (64% of taxonomic groups) and date of introduction data (59% of taxonomic groups) are available for over 50% of taxa (Figure 2). These introduction data are available for a large proportion of the vertebrate and invertebrate groups (Figure 2). However, the availability of both pathway and date of introduction data are poor for the two taxonomic

groups with the greatest number of recorded taxa, namely the Plantae and Insecta (Figure 2). The availability of other introduction data, in general, is poor and introduction source data are only available for the Actinopterygii, whereas introduction effort data are available for the Aves, Actinopterygii, Mammalia and Reptilia.

Data on region of origin are available for a large proportion (50% or greater) of taxa from all taxonomic groups except the Plantae, Tunicata and Ciliophora – that is, 82% of taxonomic groups (Figure 2). For the majority of taxonomic groups, these data are available at a continental scale (Table 2).

Distribution data are available for over 50% of the taxa from all taxonomic groups except the Mammalia – that is, 91% of taxonomic groups (Figure 2). For most taxa these data are in a descriptive form and point data are only available for the terrestrial Mollusca and some introduced Plantae (Table 2).

Invasion status data are not available for most taxonomic groups (86%), with the exception of the Aves, Reptilia and Mollusca, for which these data are available for more than 50% of taxa (Figure 2). When all taxonomic groups are considered, invasion status data are available for 33% (633 of 1945) of taxa. For those taxa for which invasion status data are available, 14% (88 of 633) were classified as introduced or casual, 23% (145 of 633) as established and 63% (400 of 633) as invasive. Data on introductions that failed to establish are only available for the Actinopterygii (4 taxa), Aves (52 taxa), Mammalia (1 taxon) and Insecta (23 taxa released as biological control agents).

Across the taxonomic groups few taxa (172 taxa or 9%) had data available for all data categories (Figure 2). Additionally, for only one taxonomic group (Mollusca) data for all categories are available for the majority of taxa (Figure 2). No data are available for 8% of the introduced Insecta. However, across taxonomic groups, data for at least one data category are available for 98% of introduced taxa. Therefore, the level of data provided by South African alien species databases is high for some taxonomic groups (e.g. Mollusca, Reptilia, Aves, Crustacea and some marine invertebrate groups), but low for others (e.g. Plantae and Insecta) (Figure 2).

## Discussion

The information content of South African alien species databases varies taxonomically and based on the type of data assessed. Although only 10% of countries have adequate invasive species data (McGeoch *et al.* 2012), the information content of South African alien species databases is less than that of the alien species databases of other nations. For example, less data (pathway of introduction, date of introduction, region of origin and current broad-scale distribution) are available for alien taxa in South Africa in comparison to data available for organisms in Europe (Genovesi *et al.* 2012; Kenis *et al.* 2007; Pyšek *et al.* 2012), for vertebrates in Brazil (Rocha, Bergallo & Mazzoni 2011) and for Plantae in Chile (Ugarte *et al.* 2011). However, although

the availability of invasion status data in South Africa is poor in comparison to some nations – for example, alien Plantae of the Czech Republic (Pyšek *et al.* 2012) and New Zealand (Howell & Sawyer 2006) – it is similar to the availability of these data in other countries – for example, aquatic species in Germany (Gollasch & Nehring 2006).

Consequently, the degree to which South African alien species databases can be used for research and management varies across taxa and depends on the type of data required (Table 1). For instance, pathway of introduction analyses, work on the predictors of invasion success and distribution modelling are possible for the Mollusca, and pathway analyses are feasible for Aves (Table 1). However, as they currently stand, even the most detailed South African alien species databases cannot be utilised to the same degree as the detailed catalogues that are available in other parts of the world. For example, South African alien species databases cannot be used to tackle the wide range of research topics – for example, species invasiveness, habitat invasibility and rates of spread (Table 1) – that have been addressed using the alien plant catalogues of the Czech Republic (Pyšek *et al.* 2012).

The data gaps identified here may be attributed to two main sources, namely a lack of data and data inaccessibility (McGeoch *et al.* 2012). A lack of data may be ascribed to difficulty recording and collecting data on some organisms. For example, data on intentional introductions (e.g. pathway and date of introduction) may be more easily recorded than for unintentional introductions (Lehan *et al.* 2013). However, as shown here, the data available for taxonomic groups that are often introduced accidentally (e.g. Mollusca and Crustacea) are comparable to the data available for organisms that are often introduced intentionally (e.g. Aves and Reptilia). Moreover, the relatively poor data available for the Plantae and Insecta may be ascribed to difficulties in collecting, recording and maintaining data for a large number of organisms. A lack of data can be remedied by directed action. For example, the MammalMAP project will improve distribution data for African Mammalia, including aliens (T. Hoffman [Animal Demography Unit, University of Cape Town] pers. comm., 20 February 2013). Data inaccessibility is a consequence of unpublished or diffused data and of data not always being accessible electronically (McGeoch *et al.* 2012). For instance, distribution data for alien Aves are available through the Southern African Bird Atlas Programme (SABAP) but have not been included in alien species databases. Additionally, although the Southern African Plant Invaders Atlas (SAPIA) is an important source of data, this atlas has not been printed in hard-copy since 2001 and, because of technical issues with the website, the online version of these data has not been updated since 2007 (L. Henderson [Agricultural Research Council, Plant Protection Research Institute] pers. comm., 08 May 2013). These data availability problems are not unique (Crall *et al.* 2006; Ricciardi *et al.* 2000), for example only 43% of invasive species databases in the USA are available online (Crall *et al.* 2006).

**BOX 1:** Recommendations on how South African alien species databases can be improved.

1. Future databases should include data on species name, synonyms, family, date of introduction, pathway of introduction (which could be classified according to Hulme *et al.* (2008) as release, escape, contaminant, stowaway, corridor and unaided), introduction effort, point of introduction, introduction source, region of origin, date of last record, distribution, invasion status, impact and biological data. The collation of such data for individual species would require considerable effort, numerous data sources and consultation with experts.
2. Further surveys, particularly focusing on poorly surveyed organisms, for example soil organisms and other invertebrates (see Spear *et al.* 2011), should be undertaken and more taxonomists should be trained and funded (Pyšek *et al.* 2013). Such targeted investments often lead to a large increase in the number of recorded alien taxa (Hulme *et al.* 2009b; Mead *et al.* 2011). Additionally, sampling should be focussed on introduction hotspots, for example, harbours for marine organisms (Griffiths, Robinson & Mead 2009).
3. Lists of alien taxa in captivity or under cultivation need to be collated. Such lists are vital to prevent introductions through escapes. The collation of these lists would require information from various sources, for example, lists of terrestrial vertebrates kept in zoos (Spear & Chown 2008, 2009), Actinopterygii in aquaria stores (Semmens *et al.* 2004), vertebrates in pet stores and Plantae in nurseries (see Van Wilgen *et al.* 2010).
4. Standardised, internationally recognised terminologies and definitions must be utilised. For the purpose of invasion status designations we recommend the framework of Blackburn *et al.* (2011). This scheme is applicable across taxa, although the categories might need additional interpretation for particular groups (e.g. Wilson *et al.* 2014 for introduced trees). For recording current environmental impact we recommend another recent scheme by Blackburn *et al.* (2014).
5. The metadata for databases need to state the purpose for which the database was developed.
6. Estimates of the effort taken in constructing the databases are needed. For example, which areas of the country were sampled and with what intensity. Additionally, information on the sources of additional data and the effort expended to identify these sources would be useful.
7. Estimates of the error rates in existing databases (e.g. the number of taxonomic misidentifications) are difficult to measure, but crucial if the databases are to be used with confidence, and can have important consequences for management (Paterson *et al.* 2011; Pyšek *et al.* 2013). Updated databases could report errors made in previous versions and justifications for changes could be provided (e.g. Pyšek *et al.* 2012).
8. Existing expertise should be utilised. This could be facilitated through the use of an expertise registry that is regularly updated (e.g. Musil & Macdonald 2007).
9. Taxonomies must be standardised and synonymies avoided. For example, for the Plantae the Angiosperm Phylogeny Group (e.g. APG 2009) can be used to standardise the taxonomy of angiosperm species. See [www.theplantlist.org](http://www.theplantlist.org) for accepted nomenclature.
10. Data from different sources need to be collated, shared and published (Crall *et al.* 2006). Various unpublished sources of data exist and to identify these sources the assistance of many experts would be required.
11. Finally, a single meta-database should be developed for the purpose of housing data on all South African alien taxa (see the Conclusion for details).

Lists of alien species suffer from a wide variety of errors (McGeoch *et al.* 2012), and any inaccuracies in the taxonomic data contained in the utilised databases would have influenced our conclusions (Pyšek *et al.* 2013). Alien plants and vertebrates in South Africa are relatively well studied (Richardson *et al.* 2003); in contrast, as a result of inadequate sampling and poor taxonomic knowledge, data on invertebrates are inadequate (Griffiths, Robinson & Mead 2009; Picker & Griffiths 2011; Richardson *et al.* 2011). These taxonomic biases may be a result of research needs (plants dominate the alien species pool), the ease with which plants may be recorded and studied (Crall *et al.* 2006; Pyšek *et al.* 2008), and the high degree of human assistance required for vertebrate introductions (Van Rensburg *et al.* 2011; Vitousek *et al.* 1996). As a consequence, the taxonomic data and related alien species richness estimates for plants and vertebrates may be more reliable than that available for invertebrates. However, determining the number and identity of introduced taxa in a region is difficult and differing definitions, methodologies or years of assessment can lead to disparate results (Bastos *et al.* 2011; Pyšek *et al.* 2004; Vitousek *et al.* 1996).

Finally, a wide range of alien and invasive species definitions exist and the use of disparate definitions may lead to listing differences and confusion (McGeoch *et al.* 2012; Richardson *et al.* 2000). In this assessment we only included invasion status designations made using the terminologies of Richardson *et al.* (2000) and Blackburn *et al.* (2011). Thus the inclusion of other terminologies and definitions may have increased the number of taxa (particularly for the Plantae) for which invasion status data are available (Richardson *et al.* 2000). For example, SAPIA designates species into categories that include transformer weeds, special effect weeds and ruderal weeds. However, the classifications of Richardson *et al.* (2000) and Blackburn *et al.* (2011) are utilised internationally and it is vital for

research and management that such standardised and recognised terminologies and classifications are employed (Pyšek *et al.* 2004).

## Conclusion

We conclude with 11 recommendations for improving South African alien species databases in Box 1. We argue that the last recommendation (that of creating a meta-database) is currently the highest priority. A meta-database should have a standard format that would facilitate analyses within and across taxonomic groups. Currently, the wide variety of data formats in use makes these analyses difficult. The database would potentially resolve issues of accessibility, and could be formally published periodically (Cadotte, Murray & Lovett-Doust 2006; Pyšek, Sádlo & Mandák 2002; Pyšek *et al.* 2012). A database such as this, which can be rapidly updated, would better manage the rapidly changing nature of alien species data. The database could include known failed introductions, hybrids and taxa in captivity or under cultivation. Additionally, invasive alien taxa that pose an introduction risk because of their presence in neighbouring countries could be included (Hulme *et al.* 2009a). As it would work across different databases, data quality checks could be developed (Crall *et al.* 2006) and independent reviews would be easier to undertake (Hulme *et al.* 2009a). These checks could focus on the various errors that may influence the data quality of alien species databases (McGeoch *et al.* 2012) and which in turn affect the management and research that rely on these data (Crall *et al.* 2006; Pyšek 2003). We believe that trying to combine databases into a single meta-database will help resolve, or at least highlight, many of the gaps in our knowledge of alien species in South Africa, and will certainly help work towards regular, detailed biodiversity assessments.

## Acknowledgements

We thank the following experts for their help: Christopher Appleton, Charles Griffiths, Lesley Henderson, Dai Herbert, Faansie Peacock, Mike Picker, Berndt van Rensburg, Nicola van Wilgen and Olaf Weyl. Thank you to Andrew Davies and anonymous reviewers for useful comments on earlier drafts of the manuscript. This work was supported by the South African National Department of Environment Affairs through its funding of the South African National Biodiversity Institute's Invasive Species Programme. Additional support was provided by the DST-NRF Centre for Invasion Biology. M.R. acknowledges support from the South African Research Chairs Initiative of the Department of Science and Technology and National Research Foundation of South Africa.

## Competing interests

The authors declare that they have no financial or personal relationships which may have inappropriately influenced them in writing this article.

## Authors' contributions

K.T.F. (South African National Biodiversity Institute), and D.S. (South African National Biodiversity Institute) collected the data. K.T.F. analysed the data. K.T.F., D.S., M.P.R. (University of Pretoria), M.R. (University of KwaZulu-Natal) and J.R.U.W. (South African National Biodiversity Institute) wrote the manuscript.

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## Appendix 1

**TABLE A1:** Assessed alien species databases.

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Note: Only references that appear in bold font were included in the full analysis.

TABLE A2: Results of the assessment of alien species databases.

Taxonomic group	Reference	Type	Year	Region	Habitat	# Taxa	# Categories	Path	Date	Origin	Distribution	Status	Failure	Effort
Actinopterygii	8ruton & Merron (1985)	r	1985	sthrn A	f	20	3	Yes	No	No	No	Yes	Yes	No
Actinopterygii	8ruton & Van As (1986)	b	1986	SA	f	20	2	No	Yes	No	Yes	No	No	No
Actinopterygii	<b>*De Moor &amp; Bruton (1988)</b>	r	1988	sthrn A	f	21	7	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Actinopterygii	Mead <i>et al.</i> (2011)	jp	2011	SA	m	1	4	Yes	Yes	Yes	Yes	No	No	No
Actinopterygii	Van Rensburg <i>et al.</i> (2011)	b	2011	SA	f	15	5	Yes	Yes	Yes	Yes	Yes	No	No
Actinopterygii	Picker & Griffiths (2011)	b	2011	SA	f	18	4	Yes	Yes	Yes	Yes	No	No	No
Amphibia	Van Rensburg <i>et al.</i> (2011)	b	2011	SA	t & f	2	6	Yes	Yes	Yes	Yes	Yes	Yes	No
Annelida	Plisko (2010)	jp	2010	SA	t	50	4	Yes	Yes	Yes	Yes	No	No	No
Annelida	Mead <i>et al.</i> (2011)	jp	2011	SA	m	10	4	Yes	Yes	Yes	Yes	No	No	No
Annelida	Picker & Griffiths (2011)	b	2011	SA	t & m	48	4	Yes	Yes	Yes	Yes	No	No	No
Arachnida	Dippenaar-Schoeman & Harvey (2000)	jp	2000	SA	t	1	1	No	No	No	Yes	No	No	No
Arachnida	Picker & Griffiths (2011)	b	2011	SA	t	40	4	Yes	Yes	Yes	Yes	No	No	No
Aves	Long (1981)	b	1981	g	t & f	18	6	Yes	Yes	Yes	Yes	No	Yes	Yes
Aves	8ruton & Merron (1985)	r	1985	sthrn A	f	5	1	Yes	No	No	No	No	No	No
Aves	Deacon (1986)	b	1986	SA	t	1	1	No	Yes	No	No	No	No	No
Aves	8ruton & Van As (1986)	b	1986	SA	f	5	0	No	No	No	No	No	No	No
Aves	De Moor & Bruton (1988)	r	1988	sthrn A	f	2	7	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Aves	Dean (2000)	jp	2000	sthrn A	t & f	46	5	Yes	Yes	No	Yes	Yes	Yes	No
Aves	Picker & Griffiths (2011)	b	2011	SA	t & f	10	5	Yes	Yes	Yes	Yes	No	No	Yes
Aves	<b>*Van Rensburg <i>et al.</i> (2011)</b>	b	2011	SA	t & f	77	7	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8rachiopoda	Mead <i>et al.</i> (2011)	jp	2011	SA	m	1	4	Yes	Yes	Yes	Yes	No	No	No
8ryozoa	Robinson <i>et al.</i> (2005)	jp	2005	SA	m	2	1	No	No	No	Yes	No	No	No
8ryozoa	Griffiths, Robinson & Mead (2009)	b	2009	SA	m	2	2	No	Yes	No	Yes	No	No	No
Bryozoa	Mead <i>et al.</i> (2011)	jp	2011	SA	m	6	4	Yes	Yes	Yes	Yes	No	No	No
Bryozoa	<b>*Picker &amp; Griffiths (2011)</b>	b	2011	SA	m	6	4	Yes	Yes	Yes	Yes	No	No	No
Ciliophora	8ruton & Merron (1985)	r	1985	sthrn A	f	2	1	Yes	No	No	No	No	No	No
Ciliophora	8ruton & Van As (1986)	b	1986	SA	f	2	0	No	No	No	No	No	No	No
Ciliophora	De Moor & Bruton (1988)	r	1988	sthrn A	f	2	3	Yes	No	No	Yes	Yes	No	No
Ciliophora	Mead <i>et al.</i> (2011)	jp	2011	SA	m	2	1	No	No	No	Yes	No	No	No
Cnidaria	8ruton & Merron (1985)	r	1985	sthrn A	f	1	1	Yes	No	No	No	No	No	No
Cnidaria	8ruton & Van As (1986)	b	1986	SA	f	1	0	No	No	No	No	No	No	No
Cnidaria	De Moor & Bruton (1988)	r	1988	sthrn A	f	1	6	Yes	Yes	Yes	Yes	Yes	Yes	No
Cnidaria	Robinson <i>et al.</i> (2005)	jp	2005	SA	m	4	3	Yes	Yes	No	Yes	No	No	No
Cnidaria	Griffiths, Robinson & Mead (2009)	b	2009	SA	m	4	3	No	Yes	Yes	Yes	No	No	No
Cnidaria	<b>*Picker &amp; Griffiths (2011)</b>	b	2011	SA	f & m	13	4	Yes	Yes	Yes	Yes	No	No	No
Cnidaria	Mead <i>et al.</i> (2011)	jp	2011	SA	m	15	4	Yes	Yes	Yes	Yes	No	No	No
Crustacea	8ruton & Merron (1985)	r	1985	sthrn A	f & m	2	1	Yes	No	No	No	No	No	No
Crustacea	8ruton & Van As (1986)	b	1986	SA	f & m	2	0	No	No	No	No	No	No	No
Crustacea	De Moor & Bruton (1988)	r	1988	sthrn A	f & m	3	5	Yes	Yes	Yes	Yes	Yes	No	No
Crustacea	Robinson <i>et al.</i> (2005)	jp	2005	SA	m	15	3	Yes	Yes	No	Yes	No	No	No
Crustacea	Griffiths, Robinson & Mead (2009)	b	2009	SA	m	17	4	Yes	Yes	Yes	Yes	No	No	No
Crustacea	Mead <i>et al.</i> (2011)	jp	2011	SA	m	33	4	Yes	Yes	Yes	Yes	No	No	No
Crustacea	<b>*Picker &amp; Griffiths (2011)</b>	b	2011	SA	t & f & m	36	4	Yes	Yes	Yes	Yes	No	No	No
Dinoflagellata	Mead <i>et al.</i> (2011)	jp	2011	SA	m	3	3	Yes	Yes	No	Yes	No	No	No
Echinodermata	Robinson <i>et al.</i> (2005)	jp	2005	SA	m	1	1	No	No	No	Yes	No	No	No
Echinodermata	Griffiths, Robinson & Mead (2009)	b	2009	SA	m	2	3	No	Yes	Yes	Yes	No	No	No
Echinodermata	Mead <i>et al.</i> (2011)	jp	2011	SA	m	2	4	Yes	Yes	Yes	Yes	No	No	No
Echinodermata	<b>*Picker &amp; Griffiths (2011)</b>	b	2011	SA	m	2	4	Yes	Yes	Yes	Yes	No	No	No
Insecta	Annecke & Moran (1982)	b	1982	SA	t	63	3	Yes	Yes	Yes	No	No	No	No
Insecta	8ruton & Merron (1985)	r	1985	sthrn A	f	4	1	Yes	No	No	No	No	No	No
Insecta	Deacon (1986)	b	1986	SA	t	1	1	No	Yes	No	No	No	No	No
Insecta	De Moor & Bruton (1988)	r	1988	sthrn A	f	5	7	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Insecta	Millar (1990)	b	1990	SA	t	68	2	No	Yes	Yes	No	No	No	No
Insecta	Vári, Kroon & Krüger (2002)	b	2002	sthrn A	t	25	1	Yes	No	No	No	No	No	No
Insecta	Visser (2009)	b	2009	SA	t	12	3	Yes	Yes	Yes	No	No	No	No

Notes: For each taxonomic group only references in bold were included in the full analysis. References with an asterisk (\*) were identified by experts as the most comprehensive. Publication type (Type): b, book; jp, journal paper; r, report; Region: South Africa (SA); southern Africa (sthrn A); southern hemisphere (sthrn H); global (g); Habitat covered (Habitat): t, terrestrial; f, freshwater; m, marine; Approximate number of listed alien taxa (# Taxa); Number of data types provided (# Categories); Whether data on pathway of introduction (Path), date of introduction (Date), region of origin (Origin), distribution (Distribution), invasion status (Status), failure (Failure) and introduction effort (Effort) are provided.

TABLE A2 continues on the next page →

TABLE A2 (Continued...): Results of the assessment of alien species databases.

Taxonomic group	Reference	Type	Year	Region	Habitat	# Taxa	# Categories	Path	Date	Origin	Distribution	Status	Failure	Effort
Insecta	<b>Mead et al. (2011)</b>	jp	2011	SA	m	1	3	Yes	No	Yes	Yes	No	No	No
Insecta	Gillioee (2011)	jp	2011	SA	t	13	2	Yes	Yes	No	No	No	No	No
Insecta	<b>Klein (2011)</b>	jp	2011	SA	t	222	4	Yes	Yes	No	No	Yes	Yes	No
Insecta	<b>*Picker &amp; Griffiths (2011)</b>	b	2011	SA	t	287	5	Yes	Yes	Yes	Yes	No	No	Yes
Mammalia	Bruton & Merron (1985)	r	1985	sthrn A	f	1	1	Yes	No	No	No	No	No	No
Mammalia	Lever (1985)	b	1985	g	t	10	5	Yes	Yes	Yes	Yes	No	No	Yes
Mammalia	Deacon (1986)	b	1986	SA	t	12	1	No	Yes	No	No	No	No	No
Mammalia	<b>Long (2003)</b>	b	2003	g	t	39	5	Yes	Yes	Yes	Yes	No	No	Yes
Mammalia	<b>Picker &amp; Griffiths (2011)</b>	b	2011	SA	t	13	5	Yes	Yes	Yes	Yes	No	No	Yes
Mammalia	<b>*Van Rensburg et al. (2011)</b>	b	2011	SA	t	51	4	Yes	Yes	No	No	Yes	Yes	No
Mollusca	Bruton & Merron (1985)	r	1985	sthrn A	f & m	7	1	Yes	No	No	No	No	No	No
Mollusca	Bruton & Van As (1986)	b	1986	SA	f & m	7	0	No	No	No	No	No	No	No
Mollusca	De Moor & Bruton (1988)	r	1988	sthrn A	f & m	6	5	Yes	Yes	Yes	Yes	Yes	No	No
Mollusca	<b>Appleton (2003)</b>	jp	2003	SA	f	10	5	Yes	Yes	Yes	Yes	Yes	No	No
Mollusca	Robinson et al. (2005)	jp	2005	SA	m	3	3	Yes	Yes	No	Yes	No	No	No
Mollusca	Griffiths, Robinson & Mead (2009)	b	2009	SA	m	5	4	Yes	Yes	Yes	Yes	No	No	No
Mollusca	Visser (2009)	b	2009	SA	t	8	2	Yes	No	Yes	No	No	No	No
Mollusca	<b>*Herbert (2010)</b>	b	2010	SA	t	36	6	Yes	Yes	Yes	Yes	Yes	No	Yes
Mollusca	<b>Mead et al. (2011)</b>	jp	2011	SA	m	21	4	Yes	Yes	Yes	Yes	No	No	No
Mollusca	<b>*Picker &amp; Griffiths (2011)</b>	b	2011	SA	t & f & m	51	4	Yes	Yes	Yes	Yes	No	No	No
Myriapoda	Hamer (1998)	jp	1998	sthrn A	t	7	2	No	No	Yes	Yes	No	No	No
Myriapoda	<b>*Picker &amp; Griffiths (2011)</b>	b	2011	SA	t	9	3	Yes	No	Yes	Yes	No	No	No
Nematoda	<b>Picker &amp; Griffiths (2011)</b>	b	2011	SA	t	5	4	Yes	Yes	Yes	Yes	No	No	No
Plantae	Poynton (1979b)	b	1979	sthrn A	t	77	6	Yes	Yes	Yes	Yes	No	Yes	Yes
Plantae	Poynton (1979a)	b	1979	sthrn A	t	200	6	Yes	Yes	Yes	Yes	No	Yes	Yes
Plantae	Von Breitenbach (1984)	b	1984	SA	t	741	0	No	No	No	No	No	No	No
Plantae	Deacon (1986)	b	1986	SA	t & f	18	1	No	Yes	No	No	No	No	No
Plantae	Richardson, Williams & Hobbs (1994)	jp	1994	sthrn H	t	11	1	No	Yes	No	No	No	No	No
Plantae	<b>Henderson (2001)</b>	b	2001	SA	t & f	243	5	Yes	Yes	Yes	Yes	Yes	No	No
Plantae	Richardson & Rejmánek (2004)	jp	2004	g	t	14	1	No	No	No	No	Yes	No	No
Plantae	Nel et al. (2004)	jp	2004	SA	t	204	0	No	No	No	No	No	No	No
Plantae	Robinson et al. (2005)	jp	2005	SA	m	3	2	No	Yes	No	Yes	No	No	No
Plantae	<b>*Germishuizen et al. (2006)</b>	b	2006	SA	t & f	978	1	No	No	No	Yes	No	No	No
Plantae	Griffiths, Robinson & Mead (2009)	b	2009	SA	m	3	3	No	Yes	Yes	Yes	No	No	No
Plantae	Poynton (2009)	b	2009	sthrn A	t	252	7	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Plantae	<b>Bromilow (2010)</b>	b	2010	SA	t & f	572	5	Yes	Yes	Yes	Yes	Yes	No	No
Plantae	<b>Mead et al. (2011)</b>	jp	2011	SA	m	10	4	Yes	Yes	Yes	Yes	No	No	No
Platyhelminthes	Bruton & Merron (1985)	r	1985	sthrn A	f	1	1	Yes	No	No	No	No	No	No
Platyhelminthes	Bruton & Van As (1986)	b	1986	SA	f	1	0	No	No	No	No	No	No	No
Platyhelminthes	De Moor & Bruton (1988)	r	1988	sthrn A	f	1	5	Yes	Yes	Yes	Yes	Yes	No	No
Platyhelminthes	<b>*Picker &amp; Griffiths (2011)</b>	b	2011	SA	t & f	6	4	Yes	Yes	Yes	Yes	No	No	No
Porifera	Griffiths, Robinson & Mead (2009)	b	2009	SA	m	1	0	No	No	No	No	No	No	No
Porifera	<b>Mead et al. (2011)</b>	jp	2011	SA	m	1	3	Yes	Yes	No	Yes	No	No	No
Porifera	<b>*Picker &amp; Griffiths (2011)</b>	b	2011	SA	m	1	4	Yes	Yes	Yes	Yes	No	No	No
Pycnogonida	<b>*Picker &amp; Griffiths (2011)</b>	b	2011	SA	m	1	2	No	No	Yes	Yes	No	No	No
Pycnogonida	<b>Mead et al. (2011)</b>	jp	2011	SA	m	1	4	Yes	Yes	Yes	Yes	No	No	No
Reptilia	Bruton & Merron (1985)	r	1985	sthrn A	f	1	2	Yes	No	No	No	No	Yes	No
Reptilia	Bruton & Van As (1986)	b	1986	SA	f	1	0	No	No	No	No	No	No	No
Reptilia	De Moor & Bruton (1988)	r	1988	sthrn A	f	1	5	Yes	No	Yes	Yes	Yes	No	Yes
Reptilia	<b>Picker &amp; Griffiths (2011)</b>	b	2011	SA	t & f	1	4	Yes	Yes	Yes	Yes	No	No	No
Reptilia	<b>*Van Rensburg et al. (2011)</b>	b	2011	SA	t & f	3	6	Yes	Yes	Yes	Yes	Yes	No	Yes
Tunicata	Robinson et al. (2005)	jp	2005	SA	m	4	2	No	Yes	No	Yes	No	No	No
Tunicata	Griffiths, Robinson & Mead (2009)	b	2009	SA	m	5	4	Yes	Yes	Yes	Yes	No	No	No
Tunicata	<b>*Picker &amp; Griffiths (2011)</b>	b	2011	SA	m	9	4	Yes	Yes	Yes	Yes	No	No	No
Tunicata	<b>Mead et al. (2011)</b>	jp	2011	SA	m	18	4	Yes	Yes	Yes	Yes	No	No	No

Notes: For each taxonomic group only references in bold were included in the full analysis. References with an asterisk (\*) were identified by experts as the most comprehensive. Publication type (Type): b, book; jp, journal paper; r, report; Region: South Africa (SA); southern Africa (sthrn A); southern hemisphere (sthrn H); global (g); Habitat covered (Habitat): t, terrestrial; f, freshwater; m, marine; Approximate number of listed alien taxa (# Taxa); Number of data types provided (# Categories); Whether data on pathway of introduction (Path), date of introduction (Date), region of origin (Origin), distribution (Distribution), invasion status (Status), failure (Failure) and introduction effort (Effort) are provided.

# Two new subspecies of *Dietes* (Iridaceae: Iridoideae), *Dietes iridioides* subsp. *angolensis* from Angola and *Dietes bicolor* subsp. *armeniaca* from eastern South Africa, with notes and range extensions for *Dietes butcheriana* and *Dietes iridioides*

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## Dates:

Received: 15 Oct. 2014

Accepted: 30 Mar. 2015

Published: 29 May 2015

## How to cite this article:

Goldblatt, P. & Manning, J.C., 2015, 'Two new subspecies of *Dietes* (Iridaceae: Iridoideae), *Dietes iridioides* subsp. *angolensis* from Angola and *Dietes bicolor* subsp. *armeniaca* from eastern South Africa, with notes and range extensions for *Dietes butcheriana* and *Dietes iridioides*', *Bothalia* 45(1), Art. #883, 6 pages. <http://dx.doi.org/10.4102/abc.v45i1.883>

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**Background:** Recent collections of *Dietes* have extended the known geographical range and morphological variation in several species.

**Objectives:** To describe additional taxa in *Dietes* to reflect the morphological and geographical variation in the species more accurately and to record significant range extensions.

**Method:** Recent collections were compared with existing herbarium material and published literature.

**Results:** Two new subspecies in *Dietes* are described, viz. *Dietes iridioides* subsp. *angolensis* from Angola, constituting the first record of the species from that country, and *Dietes bicolor* subsp. *armeniaca* from eastern South Africa, which represents a range extension into southern KwaZulu-Natal. We also document a range extension for the local endemic *Dietes butcheriana* from KwaZulu-Natal into the Eastern Cape and discuss an anomalous population of *D. iridioides*, with long-lived flowers, from near Hankey in the Eastern Cape.

**Conclusions:** The range extensions and new infraspecific taxa increase our understanding of the diversity of *Dietes* in southern and south tropical Africa.

## Introduction

With five species in sub-Saharan Africa and one on Lord Howe Island (Australasia), *Dietes* Salisb. ex Klatt has one of the more remarkable distributions for Iridaceae, in which large disjunctions at generic rank are rare. Of the African species, four are relatively narrow endemics restricted to southern Africa. The fifth, *Dietes iridioides* (L.) Sweet ex Klatt, however, is widely distributed through eastern southern Africa, from the Riviersonderend Mountains in the Western Cape to Kenya and Uganda (Goldblatt 1981). Here we report substantial range extensions for *Dietes butcheriana* Gerstner, previously endemic to KwaZulu-Natal but now recorded from Pondoland in the Eastern Cape, *Dietes bicolor* (Steud.) Sweet ex Klatt, previously known from East London to Grahamstown but now recorded as far north as southern KwaZulu-Natal, and an important new country record for *D. iridioides* in Angola. Lastly, we discuss a novel variant from near Hankey in the Eastern Cape, South Africa, which we provisionally refer to *D. iridioides*. Three species of the genus, *D. bicolor*, *Dietes grandiflora* N.E.Br. and *D. iridioides*, are widely cultivated in parts of the world where the climate is suitable, both in gardens and in street and park plantings. They are valued for their drought resistance, tolerance of a range of growing conditions and, with the exception of *D. iridioides*, their attractive flowers produced over an unusually long time.

## Research method and design

We examined all relevant herbarium collections at the primary southern African herbaria, namely the Bolus Herbarium, University of Cape Town (BOL), the Compton Herbarium, South African National Biodiversity Institute, Cape Town (NBG), the National Herbarium, South African National Biodiversity Institute, Pretoria (PRE) and the South African Museum Herbarium, South African National Biodiversity Institute, Cape Town (SAM) (acronyms after Holmgren, Holmgren & Barnett 1990). Plants were also examined alive, either in cultivation at the Kirstenbosch National Botanical Garden or in the field wherever possible.

## Results

1. *Dietes bicolor* (Steud.) Sweet ex Klatt: Records of the species available to Goldblatt (1981) were from a limited area of the Eastern Cape, extending eastwards from near Grahamstown to the mouth of the Kei River in southern Transkei. New collections since then from eastern Transkei in the Mkhambathi Nature Reserve, along the Nyameni River, and from Umtamvuna in southern KwaZulu-Natal just across the Eastern Cape border, extend the known range of this species some 200 km to the north-east. The three northern stations are from a stretch of coast, some 60 km in extent, along the Msikaba, Nyameni [MnYameni] and Umtamvuna rivers. The species should thus also be looked for along the Mtentu River, which lies between the Msikaba and Nyameni. The habitat of *D. bicolor* is unusual for *Dietes*. Plants always grow close to water and all three new records are from populations growing along or in the riverbed in situations that are seasonally inundated.

The northern populations appear typical for the species except for details of the flowers. In typical *D. bicolor* the flowers are a pale lemon-yellow, with small or large dark brown, semicircular blotches at the base of the limb of the outer tepals, the claws of which are minutely dotted with brown (Figure 1a). In the eastern populations, flowers are paler in colour, white to creamy white with orange markings, with diffuse edges at the base of the outer tepal limbs, the claws spotted with orange (Figure 1b). Although the outer tepal claws were described as unmarked by Duncan (2008), his photographs indicate spotting, as in the collections that we examined. This colour variant, collected along the Mzamba River in Pondoland, was accorded cultivar status as 'Mzamba River' by Duncan (2008), but has not been documented in herbaria. Recent new collections extend the known range of this variant, which we recognise as a distinct subspecies.

### *Dietes bicolor* subsp. *armeniaca* Goldblatt & J.C.Manning, subsp. nov.

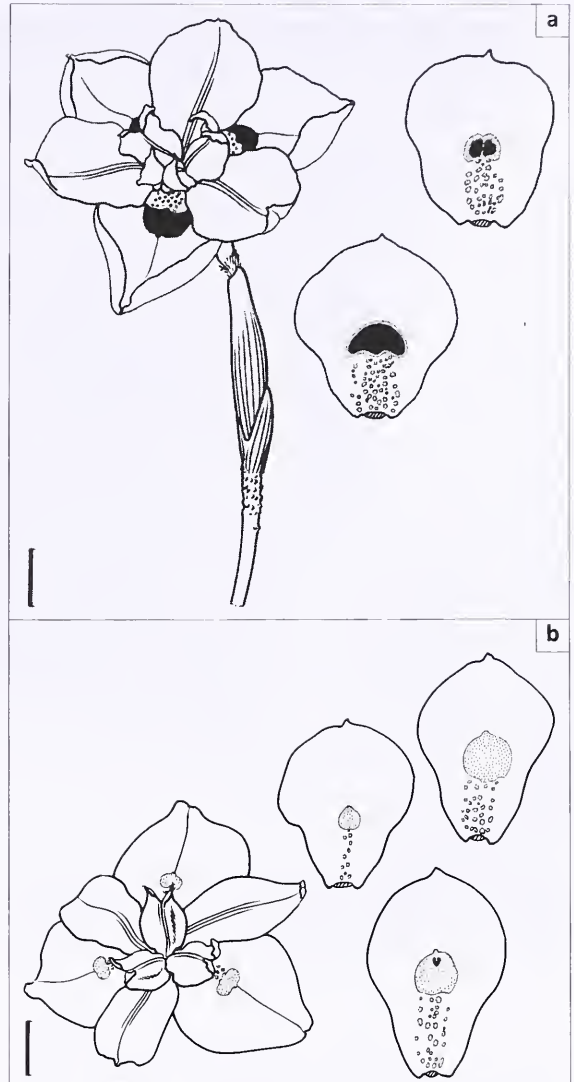
Type: SOUTH AFRICA. KwaZulu-Natal: 3130 (Port Edward): Leopard Beach, river bed, (-AA), Nov. 2011 [without day], Abbott 9381 (NBG, holo.; MO, iso.).

### Description

Inner rhipidial spathe 35 mm – 40 mm long. *Flowers*: white to creamy white, with orange nectar guides at bases of outer tepals, sometimes with minute pale or dark spot in centre of guides; outer tepals 23 mm – 33 mm × 21 mm – 29 mm, claws 9 mm – 10 mm long; inner tepals 23 mm – 33 mm × 17 mm – 22 mm. *Filaments*: 5 mm – 6 mm long; anthers 4.5 mm – 6.0 mm long. *Ovary*: 9 mm – 10 mm long; style branches 8 mm – 15 mm × 9 mm – 12 mm, crests 5 mm – 9 mm long. *Capsules*: 18 mm – 20 mm long (Figure 1b).

### Distribution

Extending from southern KwaZulu-Natal to the Mkhambathi Gorge in the northern coastal part of the Eastern Cape



Source: Artist – John Manning

**FIGURE 1:** Diagrammatic representation of *Dietes bicolor* flowers and detached outer tepals showing variation in shape, size and markings (a) for subsp. *bicolor*, from a garden plant, and (b) subsp. *armeniaca*, based on the Abbott 9381 specimen.

(Figure 2). A record from Town Bush Valley, Pietermaritzburg, probably does not represent a native population. Subsp. *bicolor* occurs well to the south and has been recorded from near the mouth of the Kei River southward to Grahamstown (Figure 2), thus some 150 km distant from the nearest recorded station for subsp. *armeniaca*. Further collecting may narrow that distance.

### Diagnosis

Recognised immediately by the white to palest yellow flowers with orange nectar guides and orange-spotted outer tepal claws, but also by the somewhat smaller (33 mm – 40 mm long) rhipidial spathes (34 mm – 45 mm long in subsp. *bicolor*) and generally slightly smaller outer tepals (23 mm – 33 mm ×

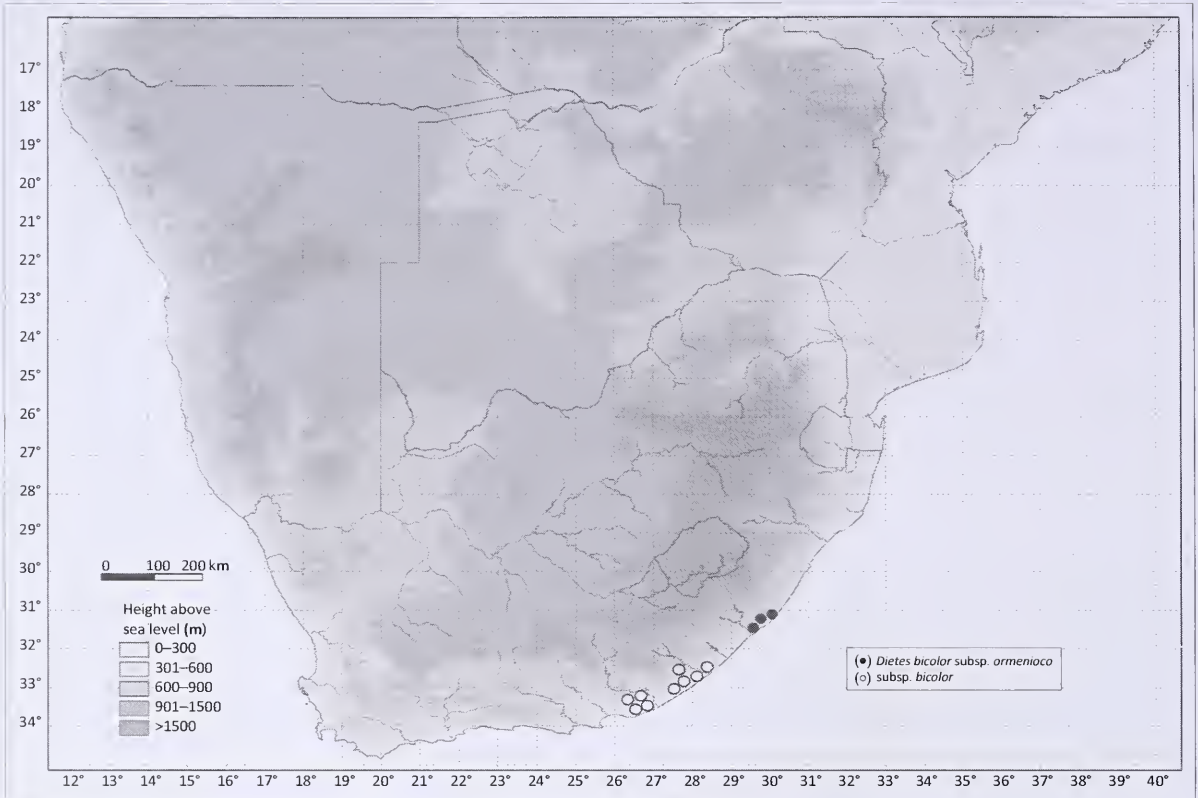


FIGURE 2: Map showing the geographic distribution of *Dietes bicolor* subsp. *armeniaco* and subsp. *bicolor*.

TABLE 1: Comparison of important taxonomic characters of the subspecies of *Dietes bicolor*.

Subspecies	Outer tepal: Claw length (mm)	Inner tepal (mm)	Anther length (mm)	Flower colour
<i>bicolor</i>	30–35 × 20–31: 9–12	26–33 × 17–27	6–9	Yellow with brown nectar guides
<i>armeniaca</i>	23–33 × 21–29: 9–10	23–33 × 17–29	4.5–6	White to pale yellow with orange nectar guides

21 mm – 29 mm vs 30 mm – 35 mm × 20 mm – 31 mm) and anthers (4.5 mm – 6 mm long vs 6 mm – 9 mm long in subsp. *bicolor*) (Figure 1b, Table 1). The ovary and capsules in subsp. *armeniaca* are also slightly shorter than in subsp. *bicolor*. Flowers of subsp. *bicolor* are pale yellow and the outer tepal limbs show solid, dark brown nectar guides (rarely brown-speckled) and brown-spotted claws (Figure 1a).

#### Additional specimens seen

KWAZULU-NATAL.—2930 (Pietermaritzburg): Pietermaritzburg, Town Bush Valley, (–CB), 25 Oct. 1939, *Fairall* 143 (NBG) [? native]. 3130 (Port Edward): Leopard Beach, river bed, (–AA), 06 Oct. 1984, *Abbott* 2184 (PRU).

EASTERN CAPE.—3129 (Port St. Johns): Mkhambathi Gorge, flood plain in rocky ground, (–BD), 26 Jan. 1986, *Goldblatt* 7611 (MO). 3130 (Port Edward): Nyameni River [Mnyameni], (–AA), Nov. 2010 [without day], *Burring* s.n. (NBG, photographs only).

2. *Dietes butcheriana* Gerstner: The eastern southern African *D. butcheriana* is recognised by its very broad, sword-shaped

leaves, seldom less than 25 mm and up to 50 mm wide in healthy, mature plants, and by the large, broadly ovoid-oblong capsules of 25 mm – 35 mm × approximately 20 mm, which are nodding or pendent at maturity. The capsules do not dehisce, except near the apex, and remain attached to the flowering stems for months after ripening so that plants are seldom without capsules in some stage of development. Seeds are shed after gradual disintegration of the capsule walls (Goldblatt 1981). The relatively small flowers are white, with yellow and orange markings at the base of the limb and along the claw of the outer tepals. The outer tepals are up to 30 mm long and 13 mm at the widest, and the inner tepals are somewhat shorter. The style branches are also white, not pale to deep violet as in the related *D. grandiflora* and also often in *D. iridioides*, and are relatively short (approximately 7 mm long), with crests of approximately 5 mm long. The flowers are not often seen, because they open late in the afternoon and fade early in the evening, but the plants are readily identified by their wide leaves and large capsules.

First recorded in Zululand (Gerstner 1943), *D. butcheriana* was understood by Goldblatt (1981) to be restricted to

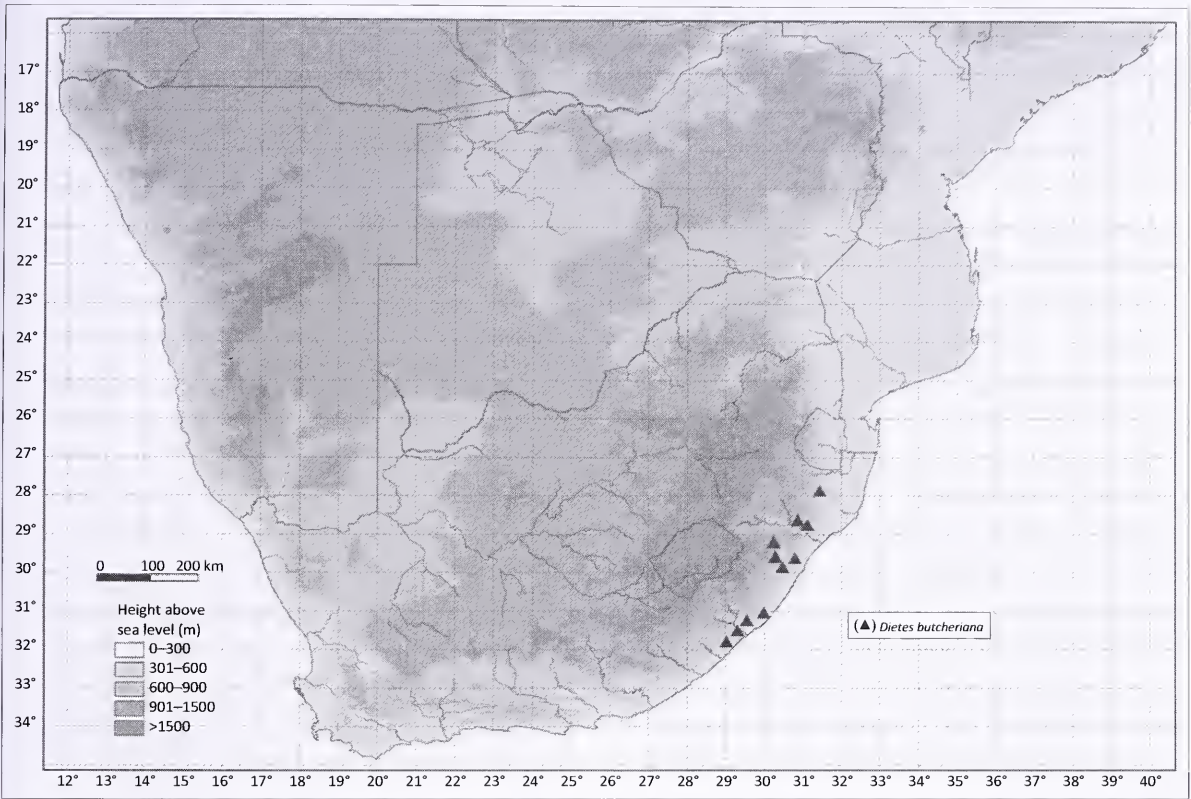


FIGURE 3: Map showing the geographic distribution of *Dietes butcheriana*.

the forests of Zululand and the central KwaZulu-Natal mist belt. A report that leaves of *D. butcheriana* are used locally in the Transkei of the Eastern Cape, South Africa (Hutchings 1996), indicated that the range is wider than until then reported. New records from the forests of the Umtamvuna Gorge on the KwaZulu-Natal/Eastern Cape border and from the Lusikisiki-Port St. Johns area of the central Transkei have considerably extended the known range of the species (Figure 3). The expanded knowledge of *D. butcheriana* is the result of the active collecting of Anne Hutchings and Tony Abbott. Hutchings also recorded *D. iridioides* growing in association with *D. butcheriana* in the Qokama Forest near Port St. Johns (Hutchings 2263, MO). The additional records are listed below. Hutchings described several uses for the species: fibres are used as string, plants may be burnt to purify a kraal, and the leaves are sometimes boiled and used as a douche for female ailments. *D. butcheriana* is known as *isiyunga* and *iconya* in Xhosa.

#### Additional specimens seen

KWAZULU-NATAL.—3130 (Port Edward): Umtamvuna Nature Reserve, Valley of the Giants, forest floor, (–AA), Abbott 3316B (MO).

EASTERN CAPE.—3129 (Port St. Johns): Mbotyi, coastal forest, (–BC), Hutchings 778 (KEI); Qokama Forest, frequent

on steep, shady slopes in forest, (–CC/CD), Hutchings 2287 (MO), 2264 (MO), 2265 (MO); along road 24 km from Hluleka Nature Reserve, forest margin on steep slope, (–CD), Hutchings 2268 (KEI, MO); north side of the Umzimvubu River above the bridge, (–DA), Hutchings & Johnson 2254 (KEI, MO), Hutchings 2271 (MO).

3. *Dietes iridioides* (L.) Sweet ex Klatt: This is the most widespread species of the genus, extending from forested valleys of the Riviersonderend Mountains in the Western Cape, South Africa, northward through wooded habitats in eastern southern Africa, Mozambique and Zimbabwe into Tanzania, Kenya and Uganda. The species occurs in shady habitats under bush or in evergreen forest. Leaves are typically linear to narrowly sword shaped, 6 mm – 15 mm wide and almost as long as the stems, which reach 20 cm – 60 cm in height. Flowers are predominantly white, apart from the style branches, which are usually pale violet (rarely white). The outer tepals have yellow markings at the limb bases and rows of brown spots along the claws. The inner tepals are unmarked. The flowers last about eight hours, opening in the late morning and fading and collapsing in the late afternoon. This is similar to other species of *Dietes*, in which flowers also last just one day, except for *D. grandiflora*, in which blooms last three days.

A population of plants from tropical thicket near Hankey in the Eastern Cape presents an unusual combination of

TABLE 2: Comparison of important taxonomic features in *Dietes grandiflora* and *Dietes iridioides*.

Taxon	Leaf width (mm)	Outer tepals (mm)	Inner tepal length (mm)	Filament length (mm)	Anther length (mm)	Style branch length (mm)	Style crest length (mm)
<i>Dietes grandiflora</i>	10–15	40–60 × 25–35	36–45	10–13	7–10	12–20	12–15
<i>Dietes iridioides</i> subsp. <i>iridioides</i>	5–15(–23)	24–35 × 12–16	24–30	5–9	3–6	7–9	5 (approx.)
Hankey population	5–6	30 × 14–20 (approx.)	25–30	9 (approx.)	5–6	10–11	4–6
<i>Dietes iridioides</i> subsp. <i>angolensis</i>	25–30	22–27 × 13	23–28	4	4	6 (approx.)	4–5

characteristics. Vegetatively the plants resemble *D. iridioides* in height and leaf width, and also in the production of small fans of leaves at the tips of old flowering stalks, capable of rooting when reaching the ground as a means of vegetative reproduction. This feature is common in *D. iridioides* but less so in the related and taller *D. grandiflora*. The Hankey plants also resemble *D. iridioides* in their smaller flowers and in the rostrate capsules, but differ from that species in the long-lived flowers, which open at about midday to early afternoon (12:00–13:00) and last through the night and into the following day, with the tepals collapsing only from mid morning to early afternoon. The style branches are consistently violet and the inner tepals, which remain suberect, either are uniformly white or have lines of dark brown dots in the lower half. The outer tepals also have unusually wide claws (10 mm wide), narrowing abruptly only at the base, much as in *D. grandiflora*. Outer tepals of other collections of *D. iridioides* have the claws tapering almost uniformly from the apex to the narrow base. Thus, floral longevity, tepal markings and the shape (but not the size) of the outer tepal claw are closer to the larger-flowered *D. grandiflora* than to *D. iridioides* (Table 2).

The conjunction of vegetative characteristics of *D. iridioides* with some floral characteristics of *D. grandiflora* makes us question the status of the Hankey population. Does it merit recognition as an infraspecific taxon and if so, of *D. iridioides* or *D. grandiflora*? Or might it be a separate species? We may, presumably, rule out the possibility of it being a hybrid, as the nearest known station for *D. grandiflora* is near Grahamstown, which is some 180 km east of Hankey. Provisionally, we conclude that it is best to include the Hankey population in *D. iridioides*. We also note that the habitat (shade under relatively dense thicket) differs from that for typical *D. iridioides*, which, according to our experience and herbarium records, is found in evergreen forest or woodland under relatively mesic conditions and often along streams. The occurrence of typical *D. iridioides*, with flowers that last only one day, in the nearby Baviaanskloof and in the Gamtoos River lowlands, makes the Hankey population appear all the more intriguing.

EASTERN CAPE.—3324 (Steytlerville): Road from Hankey to Loerie, evergreen thicket, 915 ft [280 masl], (–DD), 24 Sept. 2003, Goldblatt & Porter 12355 (MO, NBG); Hankey to Loerie via Kleinfontein, well-drained slopes in shade, 862 ft [260 masl], (–DD), 01 Oct. 2014, Goldblatt & Porter 14051 (MO, NBG, PRE).

Even more notable than the Hankey population is the discovery of a population of *Dietes* in central Angola, also evidently referable to *D. iridioides*. Plants discovered on Mt. Mocu by Adam Harrower, horticulturist at the Kirstenbosch

National Botanical Garden, and later cultivated there, are unusual in both vegetative and floral morphology. The glossy, dark green leaves are consistently broader (generally 25 mm–30 mm wide) than any recorded in other populations of the species and up to 45 cm long, slightly overtopping the flowering stems. The flowers are smaller than usual for *D. iridioides* (Table 2) and are almost uniformly white, with faint, dull yellow bilobed arcs at the bases of the outer tepal limbs and light, yellow-brown submarginal lines along the claw margins. The channelled outer tepal claws are minutely papillate (smooth to the naked eye), unlike those in typical *D. iridioides*, which have a broad, densely velvety, hairy, raised ridge along the midline. The style branches and crests (approximately 6 mm and 4 mm–5 mm long, respectively) of the Angolan plants are only faintly suffused with violet and are smaller than encountered elsewhere in the species. The Angolan plants are clearly closely allied to eastern and southern African *D. iridioides*, but they seem sufficiently different to us to merit taxonomic recognition at the level of subspecies. Until now, no species of *Dietes* has been recorded in Angola and the genus is listed neither by Figueiredo and Smith (2008) nor in the online checklist 'Flora of Angola Online' (<http://flan.sanbi.org>, version as of September 2011).

### *Dietes iridioides* subsp. *angolensis* Goldblatt & J.C.Manning, subsp. nov.

Type: ANGOLA. Huambo: Mt. Mocu, evergreen forest floor, cultivated and flowered in Hort. Kirstenbosch, Harrower s.n. (NBG, holo.; MO, iso.).

Plants 0.45 m high. *Leaves*: glossy, dark green, generally 25 mm–30 mm wide, approximately as long as stems. *Rhipidia*: generally with 2–3 flowers; inner spathes approximately 50 mm long, outer spathes approximately two-thirds as long. *Flowers*: predominantly white; outer tepals with faint, dull yellow bilobed arches at limb bases; claws with yellow-brown longitudinal lines adjacent to margins; style branches faintly suffused with violet; outer tepals 22 mm–27 mm × approximately 13 mm, claw approximately 11 mm long, channelled, minutely papillate but smooth along edges; inner tepals 23 mm–28 mm long, limb approximately 15 mm × 9 mm. *Stamens*: free, white; filaments 4 mm–5 mm long, broadened in lower half and contiguous at bases, filiform above; anthers approximately 4 mm long. *Ovary*: approximately 8 mm long; style branches approximately 6 mm long, crests 4 mm–5 mm long. *Capsules*: ovoid oblong, approximately 25 mm long, often shortly rostrate, surface rough, not fissured. *Flowering time*: erratically, almost throughout the year in cultivation, not known in the wild.

## Distribution

Known only from the forest floor on the flanks of Mt. Mocu, the highest peak in Angola. The population may have been more extensive, but logging and forest clearing have destroyed suitable habitat at lower elevations.

## Diagnosis

We refer the Angolan population to *D. iridioides* but note several significant differences, which provide the basis for recognition at subspecies rank. The leaves, generally 25 mm – 30 mm wide, are significantly wider than in subsp. *iridioides*, in which leaves are usually 6 mm – 15 mm wide, rarely wider in some populations from the KwaZulu-Natal Drakensberg. Notably, our sampling of collections of *D. iridioides* from Zambia and Congo, the locations nearest to the Angolan station, have leaves quite typical of the species (10 mm – 18 mm wide). Flowers of the Angolan plants are predominantly white with faint markings on the outer tepals, which are 22 mm – 27 mm long, and have minutely papillate claws. In typical *D. iridioides*, the outer tepals are 25 mm – 35 mm long, the claws are densely hairy and the style branches are usually pale violet but sometimes white.

## Acknowledgements

We are grateful to Jan Burring of Durban, who discovered the Mzamba population of *D. bicolor* in 2004, for bringing

the Nyameni plants to our attention, Adam Harrower for specimens and notes regarding *D. iridioides* in Angola, and Anne Hutchings for bringing new records of *D. butcheriana* to our attention. Anthony Magee and Michelle Smith prepared the digital figures.

## Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

## Authors' contributions

P.G. (University of KwaZulu-Natal) and J.C.M. (University of KwaZulu-Natal) contributed equally to this article.

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# *Ficus sur* (Moraceae) and *Gymnanthemum coloratum* (Asteraceae: Vernonieae) – first distribution records for Namibia

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## Dates:

Received: 25 July 2013  
Accepted: 09 Dec. 2014  
Published: 30 Mar. 2015

## How to cite this article:

Swanepoel, W. & Van  
Jaarsveld, E.J., 2015,  
'*Ficus sur* (Moraceae) and  
*Gymnanthemum coloratum*  
(Asteraceae: Vernonieae) –  
first distribution records for  
Namibia', *Bothalia* 45(1), Art.  
#1865, 5 pages. <http://dx.doi.org/10.4102/abc.v45i1.1865>

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**Background:** The distribution of *Ficus sur* includes most of tropical Africa, but whilst this species was suspected to occur in Namibia, this has not been verified. *Gymnanthemum coloratum* is a tropical African savannah shrub or tree that has been recorded for Botswana, Swaziland and South Africa, but which has not previously been recorded for Namibia.

**Objectives:** To formally document the first records of two plant species from Namibia and provide habitat details of the localities from which these species were recorded.

**Method:** The data presented have resulted from botanical expeditions to the poorly known Baynes Mountains in the Koakoveld region of Namibia. Specimens of the two species in the National Herbarium, Pretoria were examined to verify the identity in the case of *G. coloratum*, and to document additional records in Namibia for *F. sur*.

**Results:** *Ficus sur* was recorded from two localities, and a third locality based on a specimen in the National Herbarium, Pretoria, was verified. *Gymnanthemum coloratum*, a member of the Asteraceae, was recorded from a single locality.

**Conclusion:** The fact that *F. sur* was collected at more than one location in the Kaakoveld suggests that it is probably more widespread in suitable microhabitats. *Ficus sur* also occurs further north in Angola, suggesting that the Kaakoveld plants represent a cross-border outlier of the much more widespread Angolan population. *Gymnanthemum coloratum* was only recorded from the one locality in the Koakoveld. The species also occurs in Angola, which suggests that the Kaakoveld plant represents a cross-border outlier of the population in that country.

## Introduction

*Ficus* (Family Moraceae) is a large pantropical genus with almost 800 species, of which roughly 100 are native to Africa (Burrows & Condy 2011). Most species are from subtropical and tropical regions and the plants vary from shrubs, lianas and epiphytes to large trees. *Ficus* is well represented in those parts of southern Africa where frost is not severe. In the Flora of southern Africa (FSA) region 28 species have been recorded (Jordaan 2003). Of these, 11 species have been reported for Namibia, 8 of which are shared with South Africa.

*Ficus sur* Forssk. is a round-crowned tree up to 25 m tall, occurring in a wide range of habitats including grassland, woodland, riverine forest, semi-deciduous forest and occasionally rocky outcrops. Its distribution extends from the Cape Verde Islands and Senegal in the west, Ethiopia and Yemen in the north and east, through most of tropical Africa to Zimbabwe, Mozambique and throughout eastern South Africa to the forests of the southern coastal belt and it is, together with *F. burtt-davyi* Hutch., the southernmost representative of *Ficus* in Africa (Burrows & Burrows 2003). It is also widespread in Angola (Figueiredo & Smith 2008). In the FSA region, *F. sur* has hitherto been recorded for Botswana, Limpopo, Mpumalanga, Swaziland, KwaZulu-Natal, Eastern Cape and Western Cape (Jordaan 2003). It is not listed in the *Prodromus einer Flora von Südwesafrika* (Friedrich-Holzhammer 1967). Craven (ed. 1999) listed it as a taxon for which the presence in Namibia needs verification and she mentioned a specimen from the Kaakoveld [Davies, Thompson & Miller 63 (PRE)]. As references, Craven cited Van Greuning (1990) and Berg and Wiebes (1992). However, no mention regarding the presence of *F. sur* in Namibia could be found in the former and in the latter the taxon is merely mentioned as occurring in Namibia. *Ficus sur* was recently thoroughly treated by Burrows and Condy (2011). They included a map showing its distribution in Africa, but there were no records for Namibia indicated.

*Gymnanthemum coloratum* (Willd.) H. Rob. & B. Khan [= *Vernonia colorata* (Willd.) Drake subsp. *colorata*] is a tropical African savannah shrub or tree, with a distribution that extends from West

Africa, through East Africa to southern Africa (Pope 1992). In the FSA region, *G. coloratum* has hitherto only been recorded and mapped for Botswana, Swaziland and South Africa, for the latter in the provinces Limpopo, Mpumalanga and KwaZulu-Natal (Herman *et al.* 2003; Van Wyk *et al.* 2011).

Expeditions to the botanically poorly explored Baynes Mountains on the southern side of the Kunene River in the Kaokoveld of north-western Namibia were undertaken by the authors in 2005 (Van Jaarsveld 2005) and 2009. The biologically rich Kaokoveld forms part of the Kaokoveld Centre of Endemism, a biogeographical region rich in restricted-range animals, and plants and extending from north-western Namibia into south-western Angola (Van Wyk & Smith 2001). The expedition and subsequent visits resulted in the identification of *F. sur* and *G. coloratum* from the region, and this paper formalises the first records of these two species for Namibia.

## Research methods

Specimens were collected for later verification and lodging in the herbarium of the National Botanical Research Institute, Windhoek, Namibia (WIND). Existing material in the National Herbarium, Pretoria (PRE) was examined for comparative purposes and to verify the identity of the two species documented here. Details of the specimens collected and examined are provided below.

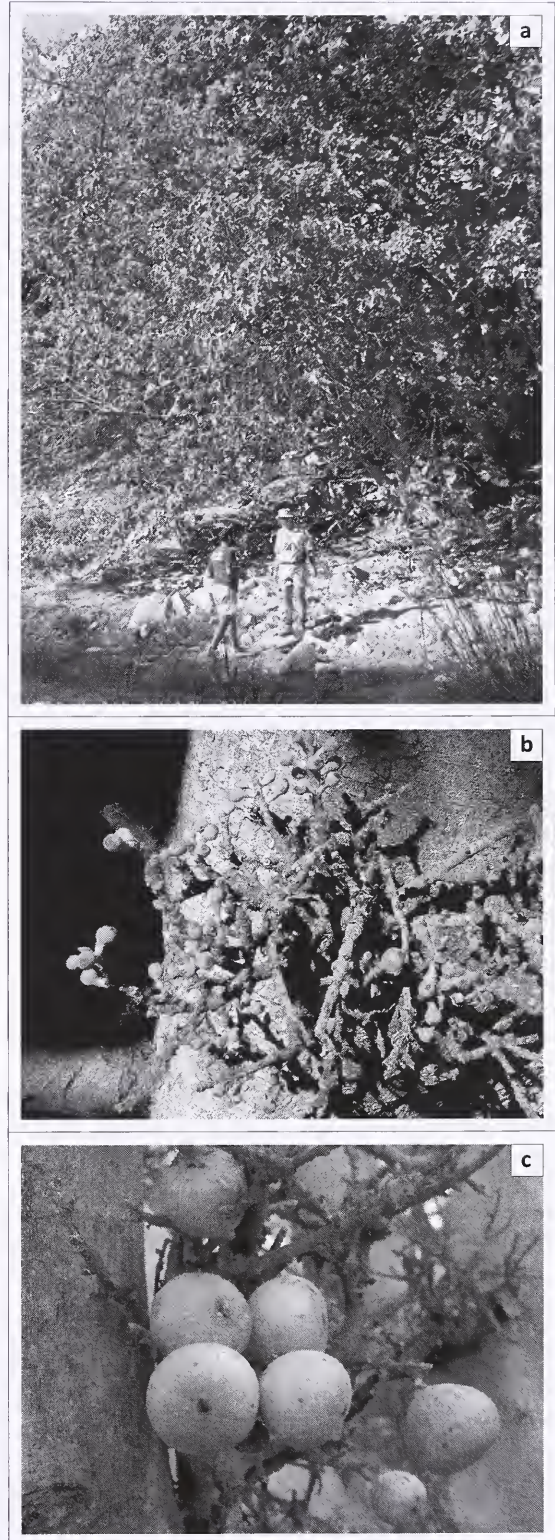
## Ethical considerations

Collecting/research permits for the study were issued by the Ministry of Environment and Tourism, Republic of Namibia.

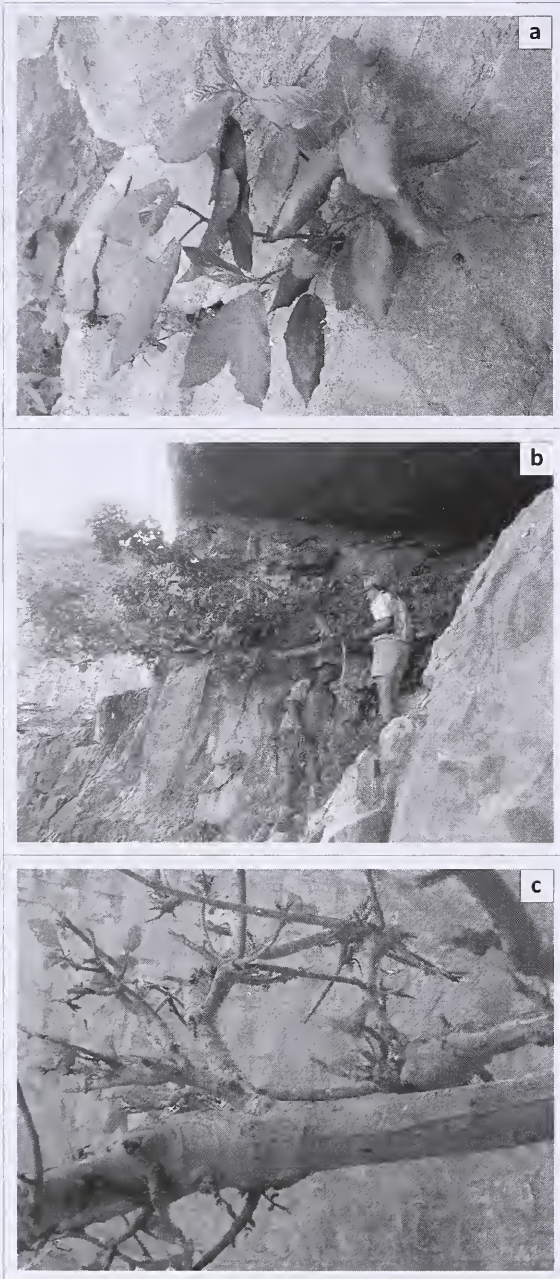
## Results

Whilst exploring the deeply dissected Slangkloof gorge through the north-central portion of the Baynes Mountains in the Kaokoveld in 2005, an unfamiliar *Ficus* tree ( $\pm 9$  m tall) and a single unfamiliar member of the family Asteraceae (tree,  $\pm 4$  m tall) were spotted growing amongst *Diospyros mespiliformis* Hochst. ex A.DC. along the banks of a small perennial stream. Closer examination revealed three specimens of *F. sur* on the fringe of the perennial stream. All were in healthy condition, and in fruit (Figure 1). Other fig trees growing in the immediate vicinity were *F. bubu* Warb., *F. cordata* Thunb., *F. glumosa* Delile, *F. sycomorus* L. subsp. *gnaphalocarpa* (Miq.) C.C Berg.

During a subsequent expedition to the Kaokoveld in April 2008 the authors recorded yet another location of *F. sur* in the Baynes Mountains. At Omavanda (south-eastern part of the Baynes Mountains), which is about 20 km to the south-east of Slangkloof, two trees as well as some seedlings were found in rock crevices just above an accessible broad rock ledge on a damp south-facing cliff (Figure 2a, 2b). Moisture draining from various spots along the cliff creates a microclimate (oasis), enabling various mesophytic plant species such as the ferns *Adiantum capillus-veneris* L., *Christella dentata* (Forssk.) Brownsey & Jermy (another first record for



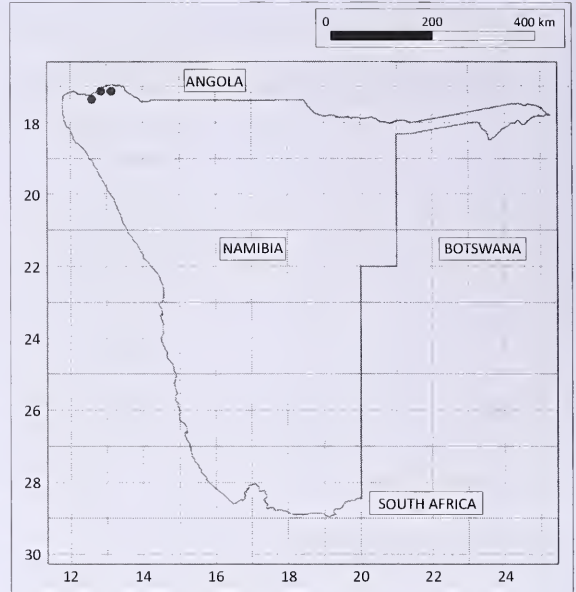
Source: (a and b) Photos taken by Ernst van Jaarsveld, (c) photo taken by Wessel Swanepoel  
**FIGURE 1:** *Ficus sur* growing in Slangkloof, Kaokoveld, Namibia: (a) tree approximately 6 m tall, (b) twig with fruit (July 2005) and (c) close-up of a fruiting branch (July 2005).



Source: Photos taken by Ernst van Jaarsveld

**FIGURE 2:** *Ficus sur* at Omavanda, Kaokoveld, Namibia: (a) young plant growing in a rock crevice with characteristic dentate leaves (April 2008), (b) a larger specimen on the cliff ledge with one of the authors, Wessel Swanepoel and uPhakamani Xaba (South African National Botanical Institute) standing next to the tree (April 2008) and (c) the same specimen as in (b), heavily utilised by Rosy-faced lovebirds damaging the growth tips (June 2012).

Namibia) and others to survive. The particular ledge is formed by an impermeable quartzitic sandstone bedrock layer which causes groundwater to surface from crevices at various points. On a subsequent visit in 2012, we observed that the figs were being systematically damaged by Rosy-faced lovebirds feeding on the young growth tips (Figure 2c). Other trees



Source: Distribution map prepared by Hester Steyn

**FIGURE 3:** Known distribution of *Ficus sur* in Namibia.

and herbs growing in the vicinity were *Ficus bubu*, *F. burkei* (Miq.) Miq., *F. iliciua* (Sond.) Miq., *F. glumosa*, *Aeollanthus rydingianus* van Jaarsv. & A.E.van Wyk, *Cotyledon orbiculata* L., *Nuxia* sp., *Manuleopsis dinteri* Thell., *Cussonia angolensis* Hiern., *Solanum nigrum* L., *Pegolettia* sp., *Leonotis ocyimifolia* (Burm.f.) Iwarsson, *Obetia carruthersiana* (Hiern.) Rendle, *Kalanchoe lanceolata* Pers., *Plectranthus hereroensis* Engl. and *Tetradenia riparia* (Hochst.) Codd.

A sterile specimen of *F. sur* from the Otjihipa Mountains, 50 km to the south-west of the Baynes Mountains [Davies, Thompson & Miller 63 (PRE)], corresponds to the Baynes Mountain plants with regard to shape and leaf indumentum. This specimen in PRE was probably overlooked in the past and represents the first record of *F. sur* for Namibia.

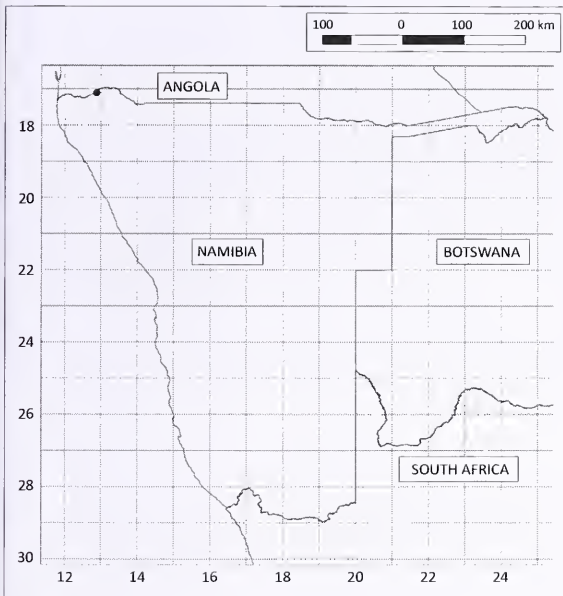
The plants of *F. sur* in the Namibian part of the Kaokoveld Centre of Endemism (Figure 3) represent a range extension of  $\pm 1650$  km to the north-west of the nearest hither to known localities for the FSA region in south-eastern Botswana (Van Wyk *et al.* 2011).

Flowering material of the unfamiliar specimen of Asteraceae was collected in May 2009 at the Slangkloof gorge site [Swanepoel 301 (WIND)], and it was subsequently identified as *G. coloratum* (Figure 4). Diagnostic morphological characters of this species are, amongst other, the tomentose branches, elliptic to broadly oblong-elliptic or ovate leaves which are scabridulous adaxially, thinly pubescent abaxially, the indumentum comprising 1-armed T-shaped hairs, the undulate leaf margins, subglobose-cyathiform involucre, ecaudate phyllaries, white florets, 10-ribbed, tapering and sub-cylindric achenes which are glandular but otherwise



Source: Photo taken by Wessel Swanepoel

**FIGURE 4:** *Gymnanthemum coloratum* in the Kaokoveld, showing leaves and flowers.



Source: Distribution map prepared by Hester Steyn

**FIGURE 5:** Known distribution of *Gymnanthemum coloratum* in Namibia.

glabrous, tipped with a pappus of copious ridged slender barbellate setae, widening towards the apex. Elsewhere in Africa *G. coloratum* is reported as being a tree up to 10 m tall or a shrub occurring in woodland, savannah and grassland, occupying a similar habitat as in the Baynes Mountains and in addition on termite mounds (Coates Palgrave 2002; Pope 1992). The Kaokoveld plant was flowering in May, which corresponds to the time (April–September) given for *G. coloratum* in the eastern half of southern Africa (Boon 2010; Coates Palgrave 2002).

The specimen recorded here represents the first record of *G. coloratum* for Namibia (Figure 5), and a range extension of  $\pm 1250$  km to the west of the nearest hitherto known localities for the FSA region in northern Botswana.

## Specimens examined

### *Ficus sur*

NAMIBIA: **1712** (Posto Velho): Slangkloof, large trees, along the main stream 16 May 2009, *Swanepoel 300* (WIND); 05 July 2005, *Van Jaarsveld & Swanepoel 19608* (WIND) (–BB); About 9 miles up the Kapupa River south of Otjhipaberg summit, near spring in kloof, 1959, *Davies, Thompson & Miller 63* (PRE) (–BC). **1713** (Swartbooisdrif): Omavanda, on ledge east of cave, 22 Apr. 2008, *Swanepoel & Van Jaarsveld 298*, *Van Jaarsveld & Swanepoel 22074* (WIND) (–AA).

### *Gymnanthemum coloratum*

NAMIBIA: **1712** (Posto Velho): Baynes Mountains, 15 km north-northwest of Otjipemba, on bank of stream, 16 May 2009, *Swanepoel 301* (WIND) (–BB).

### A selection of additional specimens examined for *Gymnanthemum coloratum*

ANGOLA: *Cooper 177* (PRE); *Teixeira 1253* (PRE); *Teixeira & Andrade 5.009* (PRE). BOTSWANA: *Miller B/1321* (PRE). MALAWI: *Hall-Martin 418* (PRE). MOZAMBIQUE: *Petrogão 275* (PRE); *Rodin 4180* (PRE). SOUTH AFRICA: *Gerstner 5427* (PRE); *Hemm 689* (PRE); *Koekemoer 2288* (PRE); *Meyer 4845* (PRE); *Netshiungani 1308* (PRE); *Van der Schijff 3831* (PRE); *Van Jaarsveld 1277* (PRE). ZAMBIA: *Robinson 5617* (PRE). ZIMBABWE: *Gilges 633* (PRE); *Hornby 2255* (PRE); *Mowbray 108* (PRE); *Plowes 47644* (PRE).

## Discussion

*Ficus sur* is closely related to *F. sycomorus* and *F. vallis-choudae* Delile. Both *F. sycomorus* and *F. sur* have fruit which are borne on short, much branched leafless branches (trusses), hence the English common name ‘broom cluster fig’ recorded for both species (Van Wyk *et al.* 2011). However, *F. sur* has glabrous leaves, occasionally with fine hairs, and the margins are irregularly dentate. The fruit (syconia) is glabrous or slightly hairy. The leaves in both subspecies of *F. sycomorus* are rounder with uniform margins, the apex is also rounder and the leaf surface very often scabrid. In *F. sycomorus* the fruit is densely and finely hairy, sometimes glabrous, and in subsp. *gnaphalocarpa* (the subspecies which occurs in the Kaokoveld) the figs are borne singly in the leaf axils. *Ficus vallis-choudae* also has fruits which are borne singly in the leaf axil. However the resemblance ends there. The larger leaves have blunt or rounded tips (Burrows & Burrows 2003). The latter species has not been recorded for Namibia or South Africa.

The fact that *F. sur* was collected at more than one location in the Kaokoveld suggests that it is probably more widespread in suitable microhabitats. *Ficus sur* also occurs further north in Angola, suggesting that the Kaokoveld plants represent a cross-border outlier of the much more widespread Angolan population.

*Gymnanthemum coloratum* was only recorded from the one locality, and was not seen at any other sites in the Kaokoveld by the authors during expeditions to the area. The species also occurs in Angola (Figueiredo & Smith 2008), which

suggests that the Kaokoveld plant represents a cross-border outlier of the population in that country.

## Acknowledgements

We would like to thank Prof. A.E. van Wyk (University of Pretoria) for advice and support and Ms Hester Steyn (SANBI) for preparing the distribution maps. Financial assistance from the University of Pretoria is acknowledged with thanks.

## Competing interests

The authors declare that they have no financial or personal relationships which may have inappropriately influenced them in writing this article.

## Authors' contributions

W.S. (University of Pretoria) prepared the manuscript, and was responsible for fieldwork and research in the Windhoek (WIND) and SANBI Pretoria (PRE) herbaria. E.J.v.J. (Kirstenbosch National Botanical Garden) was responsible for manuscript editing, provision of important additional information, fieldwork and research in the Compton (COMPT) herbarium.

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# Taxonomic significance of the abaxial lemma surface in southern African members of *Helictotrichon* (Poaceae)

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Dates:  
Received: 13 May 2013  
Accepted: 26 Feb. 2014  
Published: 25 Mar. 2015

How to cite this article:  
Mashau, A.C., Fish, L. & Van Wyk, A.E., 2015, 'Taxonomic significance of the abaxial lemma surface in southern African members of *Helictotrichon* (Poaceae)', *Bothalia* 45(1), Art. #1393, 8 pages. <http://dx.doi.org/10.4102/abc.v45i1.1393>

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**Background:** *Helictotrichon* (excluding *Amphibromus*, *Avenula*, *Helictochloa* and *Tricholemma*), a genus of temperate C<sub>3</sub> grasses, is represented by 14 species in southern Africa. Members of the genus are difficult to identify at species level on the basis of macromorphology alone.

**Objectives:** The primary objective of this study was to investigate the usefulness of the micromorphology of the lemma surface for differentiating amongst the southern African members of *Helictotrichon*.

**Method:** Lemma surfaces were studied with scanning electron microscopy (SEM). Lemmas were obtained from herbarium specimens housed in the National Herbarium, Pretoria (PRE). These were mounted on aluminium stubs using double-sided adhesive tape, sputter-coated with gold, and photographs were taken using a J840 scanning electron microscope.

**Results:** Based on whether the lemma surface is smooth, papillate, scaberulous, scabrid or a combination of these, five groups of species are distinguished. All species, except *Helictotrichon barbatum* which has a smooth lemma surface, have small prickles (scaberulous). *Helictotrichon leoninum*, *Helictotrichon quinquesetum* and *Helictotrichon rogerellisii* have only small prickles, whilst *Helictotrichon dodii*, *Helictotrichon hirtulum*, *Helictotrichon namaquense* and *Helictotrichon roggeveldense* have, in addition, medium to large prickles (scabrid). *Helictotrichon capense*, *Helictotrichon longifolium*, *Helictotrichon longum* and *Helictotrichon turgidulum* have a combination of small prickles and papillae whilst *Helictotrichon galpinii* and *Helictotrichon natalense* have a combination of all three. A key to the groups and photos of the different types of surfaces are provided.

**Conclusion:** The micromorphology of the lemma surface was shown to be of considerable taxonomic significance and to be extremely useful for differentiating amongst species.

## Introduction

*Helictotrichon* Besser ex Schult. & Schult.f. (Mashau, Fish & Van Wyk 2010b) [excluding *Amphibromus* Nees, *Avenula* (Dumort.) Dumort., *Helictochloa* Romero Zarco and *Tricholemma* (Röser) Röser] (Romero-Zarco 2011; Röser *et al.* 2009) is a genus of C<sub>3</sub> grasses belonging to the subfamily Pooideae and tribe Poeae (Soreng, Davis & Voionmaa 2007) in the Poaceae. The genus, with about 40 species worldwide (Gibbs Russell *et al.* 1990; Mabberley 2008), is most diverse in the temperate regions of the northern hemisphere, especially Europe, from where it extends southwards through the East African mountains (with about five species) to southern Africa, with 14 species in the Flora of southern Africa (FSA) region and one species in Madagascar. Biogeographically the link between the African and Mediterranean members of the group is via Frank White's Afromontane Archipelago-like Regional Centre of Endemism (Van Wyk & Smith 2001).

Schweickerdt (1937) revised *Helictotrichon* in South Africa and recognised 12 species, one of which was only known from the type collection, and a number of other species only from a very few herbarium specimens. The present availability of more herbarium collections has necessitated a revision of the group for the FSA region, this having already resulted in the description of two new species (Mashau, Fish & Van Wyk 2010a).

Southern African members of *Helictotrichon* have an inflorescence which is a narrow, open, contracted to spike-like panicle with solitary and pedicelled spikelets. Spikelets are 7 mm – 30 mm long (excluding awns), laterally compressed and disarticulate above the glumes and between the 2–6 florets. Glumes are usually shorter than the spikelet, equal or unequal,

hyaline or subhyaline, and the apex is acute, acuminate or shortly awned. Lemmas are firmer than the glumes, being firmly membranous to leathery, and they have scarious or hyaline apices. The lemma is rounded dorsally, 5–11-nerved, the apex acute or acuminate and 2-lobed (rarely 4-lobed). The awn, which is longer than the body of the lemma, is geniculate and twisted, or only slightly so, and the callus is hairy. The palea is shorter than the lemma, 2-keeled and ciliate.

As many species of *Helictotrichon* are difficult to identify using only macromorphology, the primary objective of this study was to investigate the usefulness of the micromorphology of the lemma surface for differentiating amongst the southern African members of *Helictotrichon*. The elucidation of new features to facilitate identification will contribute towards knowledge of the southern African flora in general and infrageneric diversity of *Helictotrichon* in particular. Moreover, most species of *Helictotrichon* are relatively valuable grazing grasses as they remain green until late in winter. Reliable species identification will therefore benefit many end users of plant names, including ecologists, pasture scientists and farmers.

## Research methods

### Materials

The abaxial lemma surface features were studied in 14 species of *Helictotrichon* (Table 1) from the FSA region. Lemmas were dissected from herbarium specimens housed in the National Herbarium (PRE), Pretoria (Table 1).

### Procedures

Dry lemmas (24 samples) were mounted on aluminium stubs using double-sided adhesive tape, sputter-coated with gold and viewed under a Jeol J840 scanning electron microscope (SEM). The entire lemma, as well as enlargements of the middle-dorsal and distal (below the awn insertion) areas were photographed and compared. Terminology used to describe the surface features follows Ellis (1979).

**TABLE 1:** List of species and specimens (all in the National Herbarium, Pretoria) examined using scanning electron microscopy.

Species	Specimens
<i>H. borbotum</i> (Nees) Schweick.	Acocks 18632
<i>H. copense</i> Schweick.	Story 3803 & 4509
<i>H. dodii</i> (Stapf) Schweick.	Adomson 1230 & 1367
<i>H. galpinii</i> Schweick.	Ellis 1389 & 1401
<i>H. hirtulum</i> (Steud.) Schweick.	Smook 5859; Ellis 589
<i>H. leoninum</i> (Steud.) Schweick.	Spies 3164; Ellis 5124
<i>H. longifolium</i> (Nees) Schweick.	Scheepers 1820; Smook 1184
<i>H. longum</i> (Stapf) Schweick.	Acocks 19730; Von Bredo 4168
<i>H. nomoquense</i> Schweick.	Ellis 5997
<i>H. notalense</i> (Stapf) Schweick.	Rennie 1534; Huntley 415
<i>H. quinquesetum</i> (Steud.) Schweick.	Ecklon 929
<i>H. rogerellisii</i> Mashau, L.Fish & A.E.van Wyk	Ellis 4663
<i>H. roggeveldense</i> Mashau, L.Fish & A.E.van Wyk	Acocks 17178; Ellis 5117
<i>H. turgidulum</i> (Stapf) Schweick.	Burrows 2196; Moss 1224
<i>H.</i> , <i>Helictotrichon</i> .	

## Ethical considerations

The study did not involve the collection of any fresh samples as only previously collected dried herbarium material was used.

## Results

The lemma provides some of the most useful diagnostic features to differentiate amongst the species of *Helictotrichon* in the FSA region. In some species the micromorphology of the abaxial lemma surface is variable from the base to the point of awn insertion, but the particular pattern of variability appears to be constant for a species. Taxonomically useful lemma characters as seen with the SEM are compared in Table 2. The main character states are whether the lemma surface is smooth, papillate, scaberulous (prickles small) or scabrid (prickles medium or large) (Figures 1a–h and 2a–f). Prickles are described as small if they are shorter than 42 µm, and as medium or large if they are longer than 56 µm. Based on lemma surface micromorphology the species can be classified into five groups. These are keyed out in Box 1.

### Group 1: Lemma surface smooth

*Helictotrichon barbatum*. A smooth lemma is the most obvious character distinguishing *H. barbatum* from all other southern African members of *Helictotrichon* (Figure 1a).

### Group 2: Lemma surface papillate and scaberulous

*Helictotrichon capense*, *Helictotrichon longifolium*, *Helictotrichon longum* and *Helictotrichon turgidulum* (Figure 1b, g & h; 2f).

### Group 3: Lemma surface papillate, scaberulous and scabrid

*Helictotrichon galpinii* and *Helictotrichon natalense* are the only two species which have a combination of all the features that may be present on the lemma surface, namely papillae, small prickles and medium or large prickles (Figure 1d; 2b).

TABLE 2: Comparison of the abaxial lemma surface micromorphology in southern Africa species of *Helictotrichon*.

Species	Lemma surface topography			
	Smooth	Papillate	Scaberulous (prickles small, shorter than 42 µm)	Scabrid (prickles medium to large, longer than 56 µm)
<i>H. barbatum</i>	†	-	-	-
<i>H. capense</i>	-	†	†	-
<i>H. longifolium</i>	-	†	†	-
<i>H. langum</i>	-	†	†	-
<i>H. turgidulum</i>	-	†	†	-
<i>H. galpinii</i>	-	†	†	†
<i>H. natalense</i>	-	†	†	†
<i>H. dodii</i>	-	-	†	†
<i>H. hirtulum</i>	-	-	†	†
<i>H. namaquense</i>	-	-	†	†
<i>H. roggeveldense</i>	-	-	†	†
<i>H. leoninum</i>	-	-	†	-
<i>H. quinquesetum</i>	-	-	†	-
<i>H. rogerellisii</i>	-	-	†	-

*H.*, *Helictotrichon*.

†, indicates presence of state.

#### Group 4: Lemma surface scaberulous and scabrid

*Helictotrichon dodii*, *Helictotrichon hirtulum*, *Helictotrichon namaquense* and *Helictotrichon roggeveldense* (Figure 1c & e; 2a & e).

#### Group 5: Lemma surface scaberulous

*Helictotrichon leoninum*, *Helictotrichon quinquesetum* and *Helictotrichon rogerellisii* (Figure 1f; 2c & d).

## Discussion

Although Schweickerdt (1937) included the lemma surface characters for each species description in his key, he only used it to separate some species that are closely related and then usually only as one of the many distinguishing characters used. In southern Africa, Chippindall (1955) closely followed Schweickerdt's key, whilst Stapf (1899) mentioned the lemma surface in the species descriptions but did not use it at all in the key. Descriptive terms such as granulate, finely or coarsely granular, scaberulous and scabrid are used by the various authors, but there is no doubt that they all refer to the prickles as seen under the SEM and referred to as such in the present contribution.

*Helictotrichon dodii*, with its very dense contracted panicle and long lemma lobes (6 mm – 8 mm, including awn), is a fairly well defined species. However, it does resemble *H. turgidulum*, which has shorter lemma lobes (3 mm – 5 mm, including awn); it also resembles *H. natalense*, which has a shorter spikelet (7 mm – 9 mm), and *H. longifolium*, which has setaceous leaves.

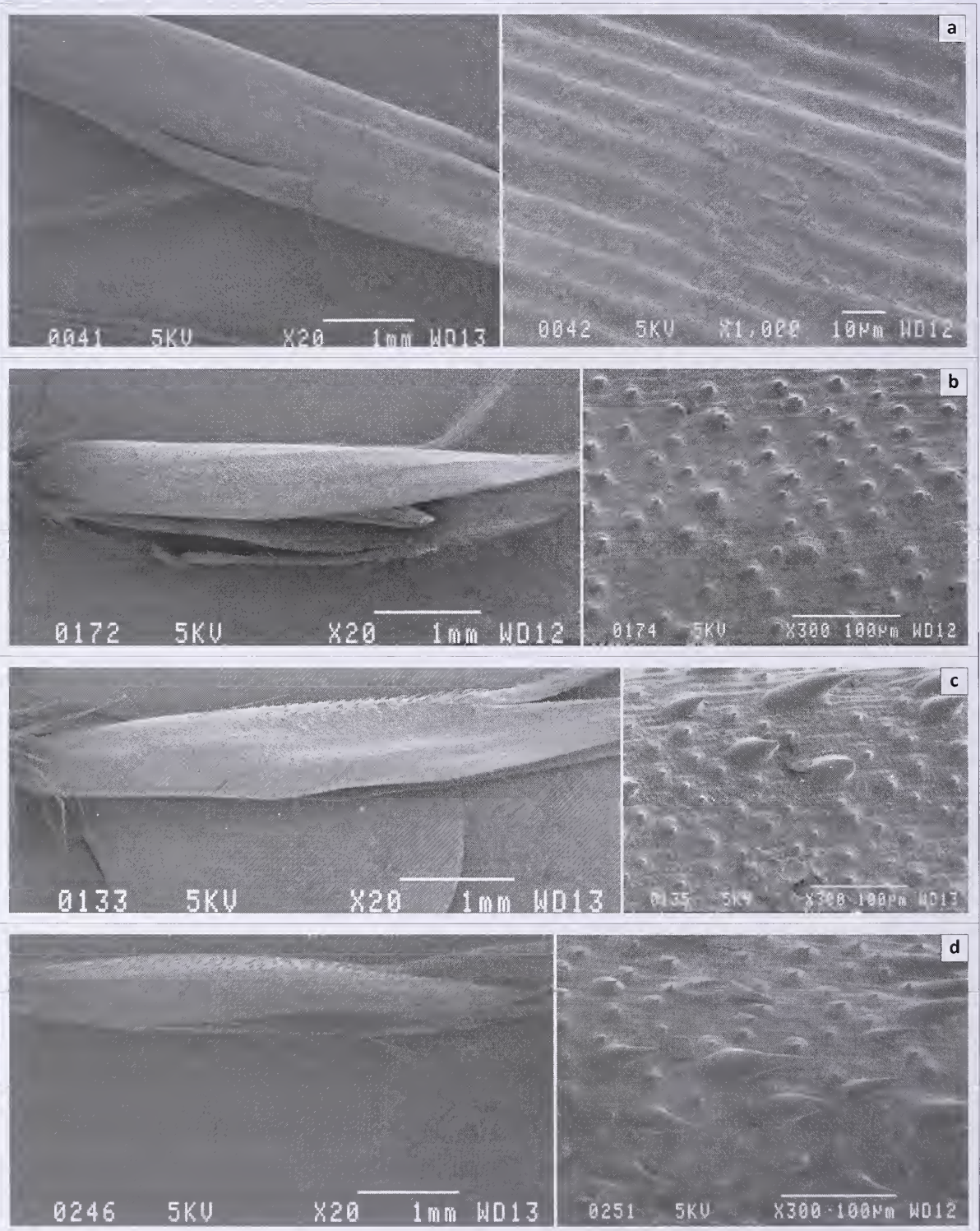
In addition to all these characters, the SEM shows that the lemma surface of *H. dodii* has small (scaberulous) as well as medium to large prickles (scabrid). This makes it easily distinguishable from *H. turgidulum*, *H. natalense* and *H. longifolium*, which have lemma surfaces with small prickles (scaberulous) mixed with papillae. *Helictotrichon*

*capense* and *H. langum*, both winter rainfall species, fall in the same group as *H. longifolium*, a summer rainfall species from the mountains of Lesotho, KwaZulu-Natal and Eastern Cape, and *H. turgidulum*, the most widespread but predominately summer rainfall species.

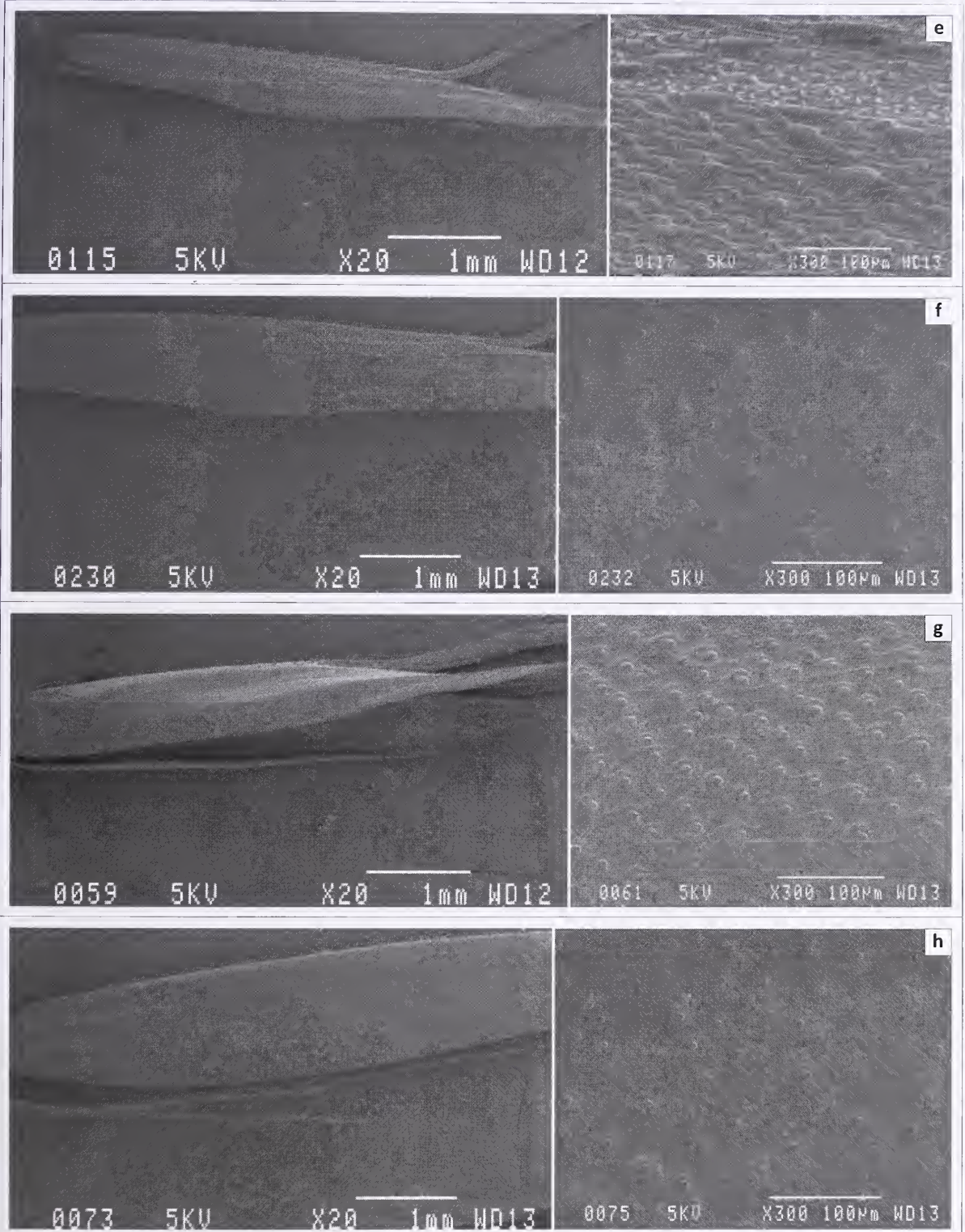
*Helictotrichon roggeveldense* resembles *H. namaquense* in having a scabrid lemma and conspicuously hairy keels of the palea, but the two species differ in a number of other characters easily seen under the light microscope, such as inflorescence pulvinii and anther length (Mashau *et al.* 2010a). *Helictotrichon roggeveldense* occurs in the Sutherland District (Roggeveld Subcentre, Hantam-Roggeveld Centre of Endemism) (Van Wyk & Smith 2001) whilst *H. namaquense* is found mainly in the Kamiesberg, Namaqualand (Kamiesberg Centre of Endemism), with an outlier on the Hantamsberg, Calvinia. The SEM shows that the lemma surface of these two species has a combination of small (scaberulous) and medium to large prickles (scabrid).

*Helictotrichon galpinii* is easily distinguished by the broad glumes that are as long as the spikelet and the apparently scabrid lemma surface which is easily seen under a light microscope. However, the SEM images show the lemma surface of *H. galpinii* matching that of *H. natalense* as both have a combination of all three lemma surface types, namely papillate, small and medium to large prickles, present. *Helictotrichon natalense* occurs at lower altitudes (1900 m) than *H. galpinii* and both are summer rainfall species.

*Helictotrichon rogerellisii* is similar to *H. longifolium* in that both species have setaceous leaves and loosely flowered spikelets. However, they differ in their distribution (geographical range) as *H. rogerellisii* has only been found in the Bredasdorp District, Western Cape (Agulhas Plain Subcentre, Cape Floristic Region), in fynbos, mainly in shallow, humic soils between limestone outcrops on coastal plain. *Helictotrichon longifolium* is found along the



**FIGURE 1:** Scanning electron microscopy micrographs of the abaxial lemma surface in species of *Helictotrichon*: (a) *Helictotrichon barbotum*, lemma smooth, (b) *Helictotrichon copense*, lemma papillate and scaberulous, (c) *Helictotrichon dodii*, lemma scaberulous and scabrid, (d) *Helictotrichon golpinii*, lemma ± papillate, scabrid and scaberulous, (e) *Helictotrichon hirtulum*, lemma scaberulous and scabrid, (f) *Helictotrichon leoninum*, lemma scaberulous, (g) *Helictotrichon longifolium*, lemma ± papillate and scaberulous and (h) *Helictotrichon longum* lemma papillate and scaberulous.



**FIGURE 1 (Continues...):** Scanning electron microscopy micrographs of the abaxial lemma surface in species of *Helictotrichon*: (a) *Helictotrichon borbotum*, lemma smooth, (b) *Helictotrichon copense*, lemma papillate and scaberulous, (c) *Helictotrichon dodii*, lemma scaberulous and scabrid, (d) *Helictotrichon golpinii*, lemma  $\pm$  papillate, scabrid and scaberulous, (e) *Helictotrichon hirtulum*, lemma scaberulous and scabrid, (f) *Helictotrichon leoninum*, lemma scaberulous, (g) *Helictotrichon longifolium*, lemma  $\pm$  papillate and scaberulous and (h) *Helictotrichon longum* lemma papillate and scaberulous.

Drakensberg Range, centred in Lesotho (Drakensberg Alpine Centre), especially in grasslands, and mainly on moist and rocky mountain slopes. These two species also differ in a number of other characters (Mashau *et al.* 2010a) and under the SEM the lemma surface of *H. longifolium* has papillae and small prickles (scaberulous) (Group 2) whereas *H. rogerellisii* has small prickles only (Group 5).

Using macromorphological characters, *H. leoninum* is the only southern African species with the rachilla internodes glabrous – this character state makes the species distinctly

different from all others. The lemma surface of *H. leoninum*, *H. quinquesetum* and *H. rogerellisii* are covered only with small prickles (scaberulous; Group 5). All three species occur in the winter rainfall area in and around Cape Town, to as far east as Bredasdorp.

Although the lemma surface in the FSA species of *Helictotrichon* is not sufficiently variable to distinguish between all species, it is still a very useful character for identification. It also allows for species that are possibly closely related to be grouped together. The use of the SEM

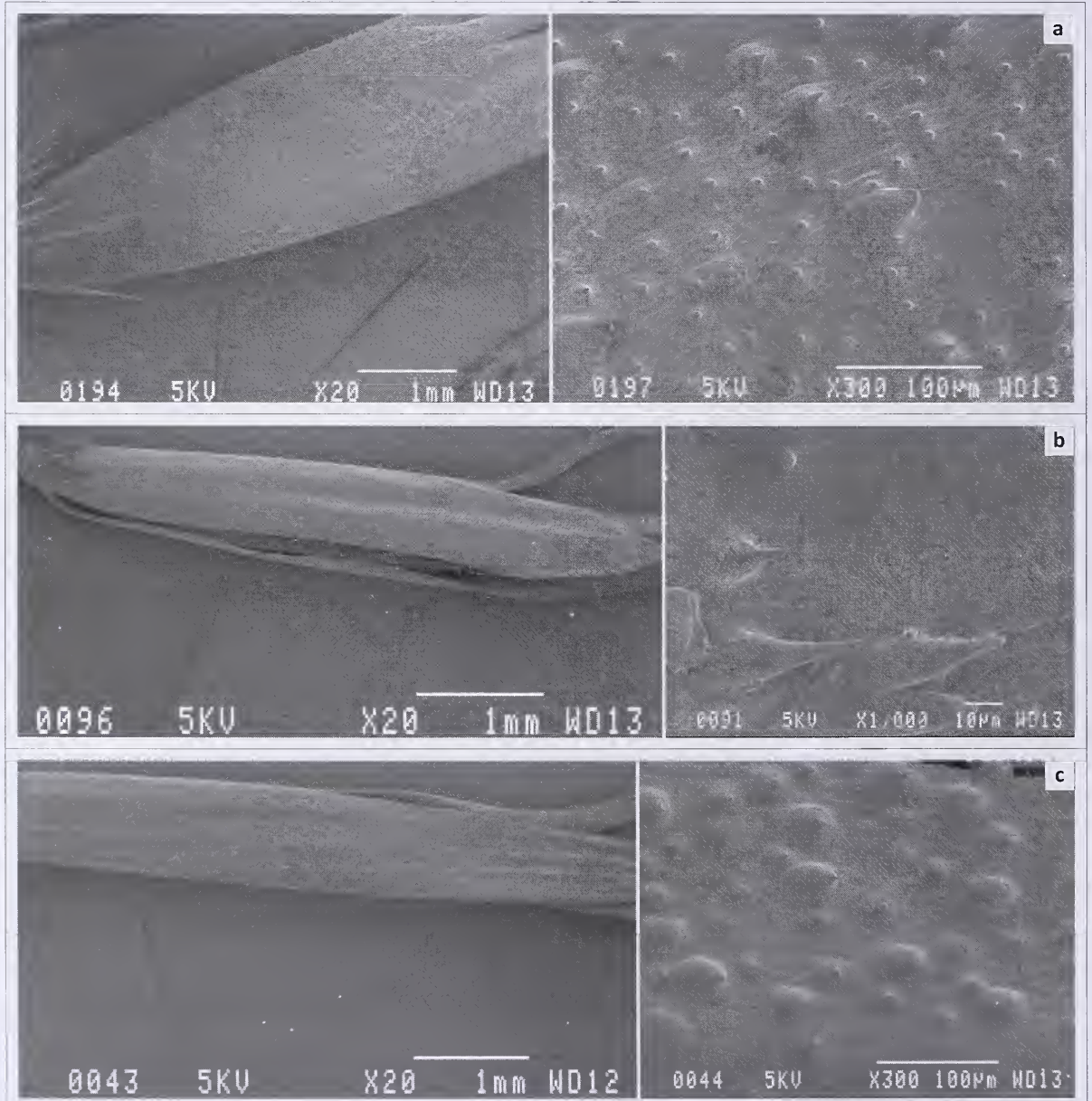
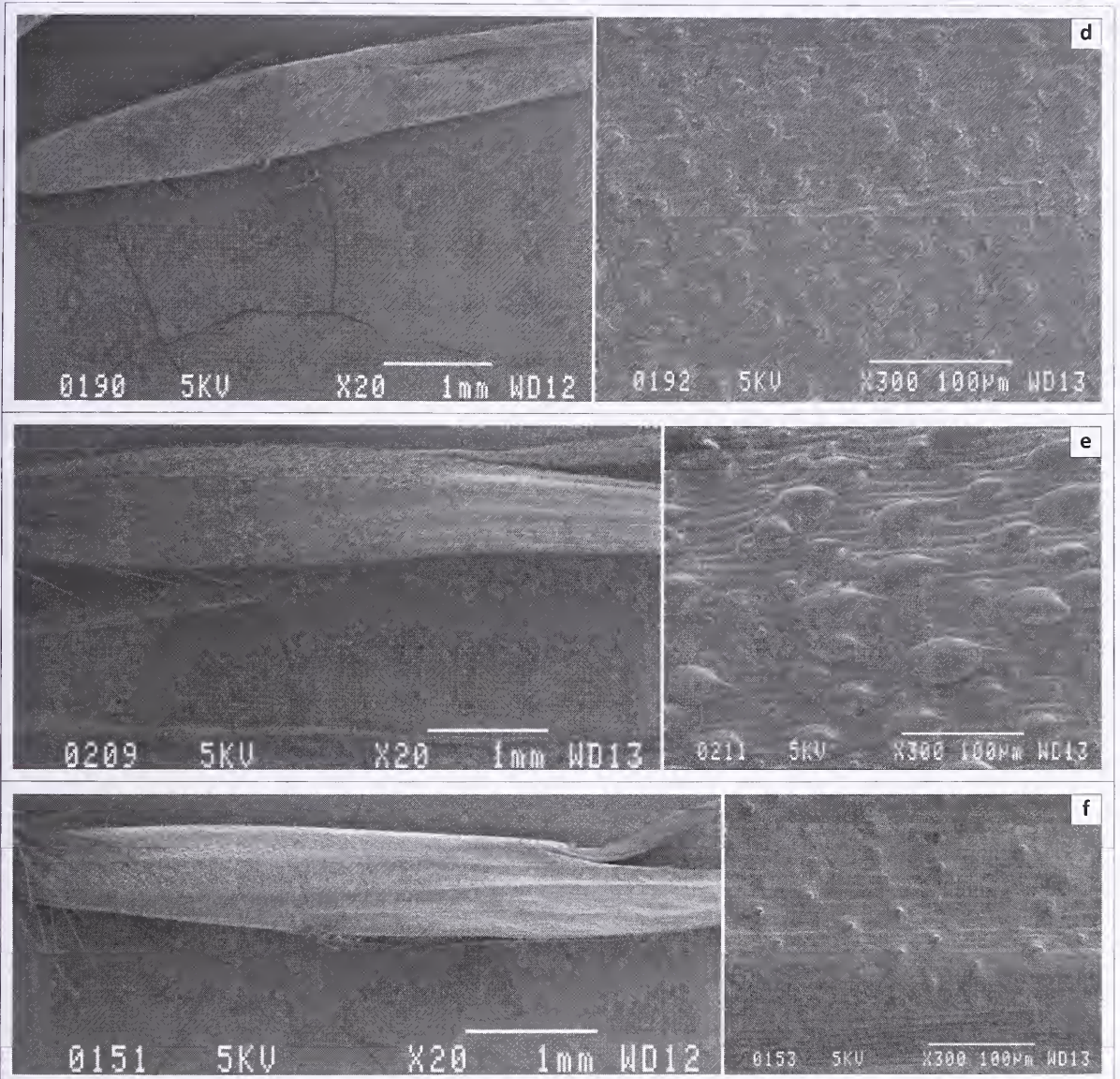


FIGURE 2: Scanning electron microscopy micrographs of the abaxial lemma surface in species of *Helictotrichon*: (a) *Helictotrichon namaquense*, lemma scaberulous and scabrid, (b) *Helictotrichon notolense*, lemma ± papillate, scabrid and scaberulous, (c) *Helictotrichon quinquesetum*, lemma scaberulous, (d) *Helictotrichon rogerellisii*, lemma scaberulous, (e) *Helictotrichon roggeveldense*, lemma scaberulous and scabrid and (f) *Helictotrichon turgidulum*, lemma papillate and scaberulous.



**FIGURE 2 (Continues...):** Scanning electron microscopy micrographs of the abaxial lemma surface in species of *Helictotrichon*: (a) *Helictotrichon nomoquense*, lemma scaberulous and scabrid, (b) *Helictotrichon notolense*, lemma ± papillate, scabrid and scaberulous, (c) *Helictotrichon quinquesetum*, lemma scaberulous, (d) *Helictotrichon rogerellisii*, lemma scaberulous, (e) *Helictotrichon roggeveldense*, lemma scaberulous and scabrid and (f) *Helictotrichon turgidulum*, lemma papillate and scaberulous.

**BOX 1:** Key to the species groups of *Helictotrichon* based on the micromorphology of the abaxial lemma surface.

1A. Lemma surface smooth .....	Group 1
1B. Lemma surface papillate, scaberulous or scabrid:	
2A. Lemma surface papillate and scaberulous or scabrid:	
3A. Lemma surface papillate and scaberulous.....	Group 2
3B. Lemma surface papillate, scaberulous and scabrid.....	Group 3
2B. Lemma surface not papillate, but scaberulous or scabrid:	
4A. Lemma surface scaberulous and scabrid.....	Group 4
4B. Lemma surface scaberulous.....	Group 5

enhances this character especially to distinguish whether the lemma surface is smooth, papillate or has small prickles mixed with larger prickles – details not seen or not easily identified under the light microscope.

## Acknowledgements

A special word of thanks to Chris van der Merwe and Alan Hall of the Laboratory for Microscopy and Microanalysis, University of Pretoria, for assistance in using the SEM. The South African National Biodiversity Institute is thanked for financial support. Two anonymous reviewers are thanked for their comments on the manuscript.

## Competing interests

The authors declare that they have no financial or personal relationships which may have inappropriately influenced them in writing this article.

## Authors' contributions

A.C.M. (South African National Biodiversity Institute) prepared the samples and analysed the data, A.E.v.W. (University of Pretoria) was project leader and supervisor, and L.F. (South African National Biodiversity Institute) acted as mentor and made conceptual contributions.

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# A new checklist of lichenised, lichenicolous and allied fungi reported from South Africa

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**Dates:**  
Received: 10 June 2014  
Accepted: 07 Nov. 2014  
Published: 18 May 2015

**How to cite this article:**  
Fryday, A.M., 2015, 'A new  
checklist of lichenised,  
lichenicolous and allied  
fungi reported from South  
Africa', *Bathalia* 45(1), Art.  
#148, 4 pages. [http://dx.doi.  
org/10.4102/abc.v45i1.148](http://dx.doi.org/10.4102/abc.v45i1.148)

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org/10.4102/abc.v45i1.148-  
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Appendix 3: [http://dx.doi.  
org/10.4102/abc.v45i1.148-  
3](http://dx.doi.org/10.4102/abc.v45i1.148-3) and Online Appendix 4:  
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abc.v45i1.148-4](http://dx.doi.org/10.4102/abc.v45i1.148-4).

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**Background:** The last comprehensive list of lichenised, lichenicolous and allied fungi reported from South Africa was published in 1950. A checklist is important to provide basic information on the extent of the diversity, and to provide the most recent name and classification.

**Objective:** To present a list of all the lichenised, lichenicolous and allied fungi reported from South Africa.

**Methods:** The list presented is entirely literature based and no attempt has been made to check the report of any taxa or their status by checking the specimens upon which they are based. Firstly, all taxa that were not reported from within the modern boundaries of South Africa were excluded. Next, the *Recent literature on lichens* database was searched for literature on South African lichens since 1945 and all references checked for new species or new reports, which were then added to the list. These names were then checked against Index Fungorum to ensure that the most current name was being used. Finally, the list was rationalised by excluding all synonyms and dubious infraspecific taxa.

**Results:** The current list includes 1750 taxa in 260 genera from mainland South Africa, with an additional 100 species and 23 genera from the sub-Antarctic Prince Edward Islands, which are treated separately. The replacement name *Verrucaria dagolavii* Fryday is proposed for *Verrucaria umbilicata* Øvstedal.

**Conclusion:** It is estimated that, when fully explored, the lichen biota of South Africa will consist of somewhere between 2500 and 3000 taxa.

## Introduction

### History of the exploration of the lichen biota of South Africa

A checklist of South African lichens was last produced by Ethel Doidge in her monumental work on South African fungi (Doidge 1950). This has been partially updated online by Feuerer (2013) but is incomplete because it includes literature reports up to only 2002, and even before that there are numerous taxa that are not included: many of the macrolichens are included but for microlichens the list is far less complete. Feuerer's list also failed to acknowledge that Doidge's 'South Africa' covered a much larger area than the present country, including all of southern Africa up to the 15th parallel; that is, not only Lesotho and Swaziland but also Namibia, Botswana, Zimbabwe, most of Mozambique, along with southern Angola, Zambia and Malawi.

In the introduction to his paper on the lichens of high altitude in South Africa, Almborn (1987) was optimistic concerning the future of South African lichenology. He reported renewed interest in the lichen biota with the preparation of a 'lichen flora' and anticipated the publication of the first volume within a few years. However, he acknowledged that many groups were poorly studied and it was difficult to find competent lichenologists to work on them. Unfortunately the same is true today; genera such as *Buellia*, *Lecanora*, *Lecidea* and *Usnea* have received very little attention in the country and are in desperate need of revision, some records dating back to the end of the 18th century.

An account of the investigation of the lichen biota of South Africa was published by Thomas and Bhat (1995, 1996) and Thomas, Bhat and Weber (1997), and work since then has been rather patchy, with most recording being carried out by visiting European lichenologists (see Schultz, Zedda & Rambold 2009) who tended to concentrate on their specialist genera or groups. A notable exception to this was the work of Franklin Brusse of the National Herbarium in Pretoria who, from 1985 to 1994, published over 30 papers (see references to Online Appendix 1) describing new species from the country and often including new reports of other species. Brusse worked mainly with the Parmeliaceae, but also described many new crustose species and genera. Strangely, the

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only area of South Africa where all groups have been studied is the Prince Edward Islands, which have been the subject of an intensive study by Øvstedal and Gremmen (2001, 2007), although undoubtedly much more remains to be discovered there as well.

Unfortunately, none of these visiting lichenologists took the time to compile a lichen checklist for the country and the dispersed nature of the literature and the fact that new reports were often added to the end of a paper describing new, unrelated species meant that some species have been reported as new to South Africa (or southern Africa) on more than one occasion.

## Research methods and materials

The list includes lichens, lichenicolous fungi (indicated with \*) and other allied fungi that, although neither lichenised or lichenicolous, are often studied by lichenologists (indicated with †).

The list presented here is entirely literature based and no attempt has been made to check the report of any taxon or its status by checking the specimen upon which it is based. Many reports are based on 19th (or even 18th) century collections made by Europeans and named after European species and, without examining the original collection (which is outside the scope of this present study), there is no way of knowing to which species the collection should properly be referred. In particular, investigation in Australia, where many species have also been reported, has shown that the species present there are often distinct taxa. For example, Elix and Johnston (1988) separated *Punctelia subflava* (Taylor) Elix & J. Johnst., described from Australia, from the northern hemisphere *Punctelia rudecta* (Ach.) Krog., and Elix (1993) separated *Xanthoparmelia masonii* Elix from *Xanthoparmelia neopropagulifera* (Gyeln.) Hale from South America. Without similar investigation of the South African taxa it is uncertain to which species the South African reports refer or, indeed, whether they represent a distinct taxon.

Using Feuerer's list as a base, the first task was to go through Doidge's list and exclude all those taxa that were not reported from within the modern boundaries of South Africa. Next, the *Recent literature on lichens* database (Culberson *et al.* 2014) was searched for literature on South African lichens since 1945 and all references checked for new species or new reports, which were then added to the list. This resulted in the addition of over 350 taxa that were not included in Feuerer's list. These names were then checked against Index Fungorum (Index Fungorum Partnership 2014) to ensure that the most current name was being used. However, it was felt that including the recent splits in the Teloschistales (Arup, Søchting & Frödén 2013) and Collemales (Ottalora, Jørgensen & Wedin 2014) would have been confusing and so these have not been used – although these names are included (in bold) as synonyms. Finally, this list was rationalised by excluding all synonyms and dubious infraspecific taxa.

Synonyms are included (in italics) below the species name to which they are referable. Infraspecific taxa, especially when these are pre-1950 records, are generally not reported as separate taxa but are included as synonyms preceded with 'INC.'. However, where a taxon has been reported only as an infraspecific taxon, the name is preceded by 'AS'. For example, *Anaptychia obesa* Zahlbr. has been reported from South Africa only as *A.obesa* f. *caesiocrocata* Zahlbr., so *Anaptychia obesa* is included in the list with AS: *A.obesa* f. *caesiocrocata* Zahlbr. as a synonym.

## Results

### South African lichen collections

South African lichen collections are scattered throughout numerous herbaria. A major collection is housed in the National Herbarium in Pretoria (PRE), which includes the Bolus Herbarium lichen collection (BOL) that was recently transferred from Cape Town, but collections also exist in European herbaria; most importantly the extensive collections of Almborn in Lund (LD) and Stizenberger in Zurich (ZT). Type material of taxa described from South Africa is even more widely scattered with collections being housed, not only in those herbaria already mentioned, but also in herbaria throughout Europe: London (BM), Munich (M), Stockholm (S), Trondheim (TRH), Turku (TUR), Uppsala (UPS), Vienna (W); as well as North America: Cambridge, Massachusetts (FH), Durham, North Carolina (DUKE) and Washington, DC (US).

### The current list

The current list includes 1750 species and one variety (see below) in 260 genera from mainland South Africa (Online Appendix 1). This includes nine species of lichenicolous fungi in five genera and seven allied fungi (see above) in five different genera. Only one genus (*Arthonia*) contains both lichenised and lichenicolous fungi, and no genera contain lichenised and allied fungi or lichenicolous and allied fungi. Four subspecies are included in the list, but for only one of these (*Ramalina inflata* subsp. *perpusilla*) is the typical variety also reported. Six varieties are also reported but these are all the typical varieties and the varietal name is only included to distinguish them from other varieties that have not been reported from South Africa.

The subantarctic Prince Edward Islands are treated separately (Online Appendix 3). One hundred and twenty-two species in 63 genera have been reported from these islands, and of these only 22 species and 43 genera have also been reported from mainland South Africa. Consequently, including these islands adds a further 100 species and 20 genera to the total for South Africa.

One new combination is made:

*Verrucaria dagolavii* Fryday **nom. nov.**

Mycobank: MB 810620

*Verrucaria umbilicata* Øvstedal, *S. African Journal of Botany. Afr. J. Bot.* 67(4): 569. 2001 (nom. illegit.), non *Verrucaria umbilicata* Hoffm., *Deutschl. Flora*: 171. 1796.

The new epithet honours Dag Olav Øvstedal for his work on the lichen biota of the Subantarctic.

Names that have been used for South African taxa but are illegitimate because they are later, heterotypic homonyms are included in Online Appendix 2.

The genus *Blastenia*, as understood here, has been synonymised with *Caloplaca*, but the South African taxa appear to have been overlooked. Recently, Arup *et al.* (2013) reorganised the Teloschistales into over 30 genera, of which *Blastenia* is one – although with a different circumscription. Unfortunately, Arup *et al.* (2013) did not include the South African species previously referred to *Blastenia* in their analysis and so their generic placement in their system is unknown. Rather than create several new, probably superfluous, names in *Caloplaca*, the species are retained here in *Blastenia* pending further work.

## Discussion

South Africa is a biodiversity hotspot (Schnitzler *et al.* 2011) with a vascular plant flora in excess of 21 000 species, but the current lichen checklist compiled here contains only 1750 taxa, which is a meager number when compared with, for example, the 1838 taxa reported from Great Britain (Feuerer 2013), which is only one fifth of the size.

Doidge (1950) reported 1159 species from 'South Africa' (Almborn 1966) but, as noted above, this encompassed much of southern Africa and so included 106 species not reported from within the current boundaries of the country (see Online Appendix 4). Consequently, only 1053 lichen species in Doidge's list were from South Africa. Feuerer (2013) listed 1728 taxa but this included the 106 non-South African taxa listed by Doidge (1950) as well as numerous infraspecific taxa of dubious taxonomic status. When these are removed, Feuerer's list adds a further 330 species, bringing the total to 1383. The current list adds a further 367 species, making a total of 1750.

Crous *et al.* (2006) estimated that the lichen biota of South Africa, when fully explored would amount to some 2000 taxa. However, this estimate is based on a comparison with the numbers reported from similar areas, which assumes that the lichen biota of these other areas is completely known, which is almost certainly not the case. A more realistic estimate of the potential total lichen biota of the country can be made by comparison with other areas that have been extensively inventoried. The recording of the lichen biota of an area invariably begins with the reporting of macrolichens (foliose and fruticose species), whereas the microlichens (crustose species), which are generally much more difficult to collect and identify, are only recorded when a more thorough investigation is undertaken. Consequently,

an incompletely recorded lichen biota will be under-representative of microlichens and be weighted towards macrolichens. However, when an area is intensively studied it is found that macrolichens comprise only approximately one third of the total lichen biota (Lendemer, Harris & Tripp 2013; Spribille *et al.* 2010) and so a better estimate of the total lichen biota is obtained by multiplying the number of macrolichens reported by three. Even this is probably an underestimate because it makes the almost certainly incorrect assumption that the macrolichen biota of the area is completely known. The known South Africa lichen biota reported here contains significantly more macrolichens (928) than microlichens (822), suggesting that the biota is very incompletely known and that when fully explored the total lichen biota should approach 3000 taxa and that in excess of 1000 microlichens remain to be discovered. However, the number of macrolichens is heavily inflated by the plethora of *Xanthoparmelia* species reported – a total of 353 species, more than one fifth of the total reported lichen biota. Many of these have been described from a single collection, often from South Africa, and it remains to be seen whether these are all good species or if some are better recognised at a lower taxonomic rank. Even if the number of *Xanthoparmelia* species is reduced by 100, which seems unlikely, this still suggests a total lichen biota of c. 2500 species with c. 900 microlichens still to be discovered.

As with many other areas, it is the saxicolous crustose species that are most under-reported. For example, in the introduction to his work on the lichens of the Blouberg Mountains, Brusse (1991) states that 'saxicolous lichens are very abundant here, with the southern aspect of many boulders being completely covered by a mosaic of crustose lichens' but does not mention any by name although he goes on to mention several foliose taxa. Also seriously under-recorded are lichenicolous fungi, only nine species (in five genera) having been reported. Clearly, there is much more to be discovered in the South African lichen biota – even conservative estimates such as that by Crous *et al.* (2006) suggest that hundreds of species remain to be discovered. The hope therefore is that the publication of this new checklist will encourage renewed investigation of the lichen biota of South Africa – especially by local researchers.

## Conclusion

The lichen biota of South Africa is poorly known, as only 1750 taxa have been reported and many groups and genera, especially amongst the microlichens, are lacking a modern revision. It is estimated that, when fully explored, the lichen biota of South Africa will consist of somewhere between 2500 and 3000 taxa.

## Acknowledgements

I thank Tassilo Feuerer (Hamburg) for his initial work in partially updating the South African checklist. Special thanks are due to Jack Elix (Canberra) for guiding me through *Xanthoparmelia*, and also to Patrik Frödén (Lund, *Xanthoria*),

Irwin Brodo (Ottawa, *Ochrolechia*), Philippe Clerc (Geneva, *Usnea*) and Thorsten Lumbsch (Chicago, *Diploschistes*) for help and advice with their respective groups, and Dag Øvstedal (Bergen) for help with the Prince Edward Islands list. I also thank Linda in Arcadia (Kastri, Greece) for nomenclatural advice.

## Competing interests

The author declares that he has no financial or personal relationships which may have inappropriately influenced him in writing this article.

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# Appendix 1: List of lichenized, lichenicolous and allied fungi reported from South Africa

<b>Acanthothis</b> Clem. (1909)	
<i>dialeucoides</i> Kalb & Staiger	Kalb et al. 2009
<b>Acarospora</b> A. Massal. (1852)	
<i>bella</i> (Nyl.) Jatta	Doidge 1950
<i>bylii</i> H. Magn.	Doidge 1950
<i>calviniensis</i> H. Magn.	Doidge 1950
<i>capensis</i> Zahlbr.	Doidge 1950
<i>cervina</i> A. Massal.	Doidge 1950
<i>deserticola</i> Zahlbr.	Doidge 1950
<i>insculpta</i> H. Magn.	Doidge 1950
<i>intrusa</i> H. Magn.	Doidge 1950
<i>laevigata</i> H. Magn.	Doidge 1950
<i>longispora</i> H. Magn.	Doidge 1950
<i>lucida</i> H. Magn.	Doidge 1950
<i>luederitzensis</i> H. Magn.	Doidge 1950
<i>macrospora</i> (Hepp) Bagl.	Doidge 1950
<i>meridionalis</i> H. Magn.	Doidge 1950
<i>negligens</i> H. Magn.	Doidge 1950
<i>ochrophaea</i> H. Magn.	Doidge 1950
<i>porinoides</i> (Stizenb.) Zahlbr.	Doidge 1950
<i>schleicheri</i> (Ach.) A. Massal.	Almborn 1988b
<i>socialis</i> H. Magn.	Doidge 1950
<i>subbadia</i> H. Magn.	Doidge 1950
<i>subochracea</i> H. Magn.	Doidge 1950
<i>subtersa</i> H. Magn.	Doidge 1950
<i>tenuis</i> (Vain.) H. Magn.	Doidge 1950
<i>thaeodes</i> A. Massal.	Doidge 1950
<i>Lecanora thaeodes</i> (A. Massal.) Stizenb.	
<i>Placodium thaeodes</i> (A. Massal.) Müll. Arg.	
<sup>1</sup> Doubtful, but det. Vainio, and also reported from Namibia (Brusse 1988e).	
<b>Acrosyphus</b> Lév. (1846)	
<i>sphaerophoroides</i> Lév.	Brusse 1989c
<b>Aderkomyces</b> Bat. (1961)	
<i>albostrigosus</i> (R. Sant.) Lücking, Sérus. & Vězda	Brusse 1988e
<i>Tricharia albastrigosa</i> R. Sant.	
<b>Allarthothelium</b> (Vain.) Zahlbr. (1908)	
<i>minimum</i> Vain.	Doidge 1950
<b>Amandinea</b> M. Choisy ex Scheid. & H. Mayrhofer (1993)	
<i>brugierae</i> (Vain.) Marbach	Doidge 1950, Marbach 2000
<i>Buellia brugierae</i> Vain.	
<i>natalensis</i> (Vain.) Marbach	Doidge 1950, Marbach 2000
<i>Buellia natalensis</i> Vain.	
<i>punctata</i> (Hoffm.) Coppins & Scheid.	Doidge 1950, Almborn 1960,
<i>Buellia punctata</i> (Hoffm.) A. Massal.	Almborn 1988b
INC.: <i>Buellia punctata</i> f. <i>marcidula</i> Zahlbr.	
INC.: <i>Buellia punctata</i> f. <i>punctiformis</i> Hazsl.	
<i>xylographella</i> (Nyl.) Marbach	Marbach 2000
<sup>1</sup> At least one record (from Western Cape) is on granite and is possibly <i>A. pelidna</i> (Ach.) Fryday & Arcadia.	
<b>Anaptychia</b> Körb. (1848)	
<i>ciliaris</i> Ach.	Galloway 1995
<i>corallophora</i> (Taylor) Vain.	Doidge 1950
<i>granulifera</i> A. Massal.	Doidge 1950
<i>obesa</i> Zahlbr.	Doidge 1950
AS: <i>A. abesa</i> Zahlbr. f. <i>caesiocracata</i> Zahlbr.	
<i>palpebrata</i> Vain.	Doidge 1950
<b>Anthracothecium</b> Hampe ex A. Massal. (1860)	
<i>biferum</i> Zahlbr.	Doidge 1950
<i>duplicans</i> (Nyl.) Müll. Arg.	Doidge 1950
<i>thwaitesii</i> (Leight.) Müll. Arg.	Doidge 1950
<i>variolosum</i> (Pers.) Müll. Arg.	Doidge 1950

<b>Arctomia</b> Th. Fr. (1860)	
<i>muscolica</i> A. L. Sm.	Doidge 1950
<b>Arctoparmelia</b> Hale (1986)	
<i>centrifuga</i> (L.) Hale	Doidge 1950
<i>Parmelia centrifuga</i> (L.) Ach.	
<b>Arthonia</b> Ach. (1806)	
<i>angulata</i> Fée	Doidge 1950
<i>angulosa</i> Müll. Arg.	Doidge 1950
* <i>anjuti</i> S.Y. Kondr. & Alstrup	Kondratyuk 1996
<i>atra</i> (Pers.) A. Schneid.	Doidge 1950, Galloway 1995
<i>Opegropha atro</i> Pers.	
<i>brussei</i> Egea & Torrente	Egea & Torrente 1996,
<i>A. copensis</i> Egea & Torrente non Stizenb.	Egea & Torrente 1997
<i>calospora</i> Müll. Arg.	Doidge 1950
<i>cinnabarina</i> (DC.) Wallr.	Doidge 1950
<i>circumscissa</i> G. Merr.	Doidge 1950
<i>hormidiella</i> Stirt.	Doidge 1950
<i>lecideicarpa</i> Zahlbr.	Doidge 1950
<i>mira</i> R. Sant.	Brusse 1988e, Farkas, 2004
<i>nana</i> Stizenb.	Doidge 1950
<i>oblongula</i> Müll. Arg.	Doidge 1950
<i>palmicola</i> Ach.	Doidge 1950
<i>polymorpha</i> Ach.	Doidge 1950
<i>Opegropha polymorpha</i> (Ach.) Tuck.	
<i>propinqua</i> Nyl.	Doidge 1950
<i>pyrenuloides</i> Müll. Arg.	Doidge 1950
<i>rubrofuscescens</i> Vain.	Doidge 1950
* <i>sytnikii</i> S.Y. Kondr. & Kärnefelt	Kondratyuk 2002
<i>trilocularis</i> Müll. Arg.	Brusse 1988e
<i>variabilis</i> Müll. Arg.	Doidge 1950
<b>Arthopyrenia</b> A. Massal. (1852)	
<i>alboatra</i> (Kremp.) Müll. Arg.	Doidge 1950
<i>analepta</i> (Ach.) A. Massal.	Doidge 1950
<i>A. follox</i> (Nyl.) Arnold	
<i>capensis</i> Zahlbr.	Doidge 1950
<i>cinchonae</i> (Ach.) Müll. Arg.	Doidge 1950
INC.: <i>A. cinchonae</i> var. <i>fumido</i> (Stizenb.) Zahlbr.	
<i>knysnana</i> Zahlbr.	Doidge 1950
<i>leucanthes</i> Zahlbr.	Doidge 1950
<i>norata</i> A. Massal.	Doidge 1950
<i>paraphysata</i> Zahlbr.	Doidge 1950
<i>pruinogrisea</i> (C. Knight) Müll. Arg.	Doidge 1950
<i>recepta</i> Müll. Arg.	Doidge 1950
<i>simulans</i> Müll. Arg.	Doidge 1950
<i>Verrucario simulans</i> (Müll. Arg.) Stizenb.	
<b>Arthothelium</b> A. Massal. (1852)	
<i>abnorme</i> (Ach.) Müll. Arg.	Doidge 1950
<i>albidum</i> Müll. Arg.	Doidge 1950
<i>Arthonio albedo</i> (Müll. Arg.) Willey	
<i>album</i> Zahlbr.	Doidge 1950
<i>argenteum</i> (Stizenb.) Zahlbr.	Doidge 1950
<i>consanguineum</i> Müll. Arg.	Doidge 1950
<i>Arthonio consanguineo</i> (Müll. Arg.) Willey	
<i>fusco-nigrum</i> (Nyl.) Müll. Arg.	Doidge 1950
<i>melanopsis</i> (Stirt.) Zahlbr.	Doidge 1950
<i>michylum</i> Vain.	Doidge 1950
<i>obvelatum</i> Müll. Arg.	Doidge 1950
<i>Arthonio obveloto</i> (Müll. Arg.) Willey	
<i>phaeosporum</i> Zahlbr.	Doidge 1950
<i>psylloides</i> Zahlbr.	Doidge 1950
INC: <i>A. psylloides</i> var. <i>precursum</i> Zahlbr.	
<i>violascens</i> (Flot.) Zahlbr.	Doidge 1950
<b>Arthrorhaphis</b> Th. Fr. (1860)	
<i>citrinella</i> (Ach.) Poelt	Brusse 1988e,

<b>Aspicilia</b> A. Massal. (1852)	
<i>cinerea</i> (L.) Körb.	Doidge 1950
<i>Leconoro cinereo</i> (L.) Sommerf.	
<i>subdepressa</i> (Nyl.) Arnold	Doidge 1950
<i>Leconoro subdepresso</i> Nyl.	
<b>Asterothyrium</b> Müll. Arg. (1890)	
rotuliforme (Müll. Arg.) Sérus. & J.R. De Sloover	Brusse 1988e
<b>Aulaxina</b> Fée (1825)	
<i>dictyospora</i> R. Sant.	Brusse 1988e
<i>quadrangula</i> (Stirt.) R. Sant.	Brusse 1988e, Farkas, 2004
<b>Bacidia</b> De Not. (1846)	
<i>aemula</i> (Stizenb.) Zahlbr.	Doidge 1950
<i>amylothelia</i> Vain.	Doidge 1950
<i>beckhausii</i> (Stizenb.) Körb.	Doidge 1950
INC.: <i>B. beckhausii</i> var. <i>stenospora</i> f. <i>ocutata</i> Zahlbr.	
<i>capreolina</i> (Stizenb.) Zahlbr.	Doidge 1950
<i>caruncula</i> (Stizenb.) Zahlbr.	Doidge 1950
<i>chlorophaeata</i> (Nyl.) Zahlbr.	Doidge 1950
<i>cyrtocheila</i> (Stizenb.) Zahlbr.	Doidge 1950
<i>effusa</i> (Sm.) Trevis.	Doidge 1950
AS: <i>B. effusa</i> var. <i>intermedio</i> Zahlbr.	
<i>endoleucella</i> (Stizenb.) Zahlbr.	Doidge 1950
<i>epicyanea</i> Vain.	Doidge 1950
<i>friesiana</i> (Hepp) Anzi	Doidge 1950
AS: <i>B. friesiana</i> var. <i>norrinii</i> Vain.	
<i>heteroloma</i> (Vain.) Zahlbr.	Doidge 1950
INC.: <sup>1</sup> <i>B. heteroloma</i> f. <i>firmior</i> Vain.	
<i>inconsequens</i> (Nyl.) Zahlbr.	Doidge 1950
<i>inconveniens</i> (Nyl.) Zahlbr.	Doidge 1950
<i>intermedia</i> Hampe ex A. Massal.	Doidge 1950
<i>laurocerasi</i> (Delise ex Duby) Zahlbr.	Doidge 1950
<i>B. endoleuco</i> (Nyl.) J. Kickx f.	
<i>leucostephana</i> (Stizenb.) Zahlbr.	Doidge 1950
<i>medialis</i> (Tuck.) Zahlbr.	Doidge 1950
<i>millegrana</i> (Taylor) Zahlbr.	Doidge 1950
<i>polychroa</i> (Th. Fr.) Körb.	Doidge 1950
<i>B. fuscorubello</i> (Hoffm.) Bausch	
<i>proposita</i> (Nyl.) Zahlbr.	Doidge 1950
<i>rubella</i> (Hoffm.) A. Massal.	Doidge 1950
<i>B. luteolo</i> (Ach.) Mudd.	
INC.: <i>B. luteolo</i> f. <i>conspendens</i> Zahlbr.	
<i>rufata</i> (Stizenb.) Zahlbr.	Doidge 1950
<i>stuppeosa</i> (A. Massal.) Zahlbr.	Doidge 1950
<i>subluteola</i> (Nyl.) Zahlbr.	Doidge 1950
<i>subspadicea</i> (Müll. Arg.) Zahlbr.	Doidge 1950
<i>trifaria</i> (Stizenb.) Zahlbr.	Doidge 1950
<sup>1</sup> Not in Index Fungorum (? nomen nudum).	
<b>Bacidina</b> Vězda (1991)	
<i>apiahica</i> (Müll. Arg.) Vězda	Brusse 1991b, Farkas 2004
<i>Bacidia opiahico</i> (Müll. Arg.) Zahlbr.	
<i>pallidocarnea</i> (Müll. Arg.) Vězda	Brusse 1991c, Farkas 2004
<b>Baculifera</b> Marbach & Kalb (2000)	
<i>cinereocincta</i> Müll. Arg.	Marbach 2000
<i>Buellio cinereocincto</i> Müll. Arg.	
<i>micromera</i> (Vain.) Marbach	Doidge 1950, Marbach 2000
<i>Buellio micromero</i> Vain.	
<b>Biatora</b> Fr. (1817)	
<i>vernalis</i> (L.) Fr.	Doidge 1950
<i>Lecideo vernalis</i> (L.) Ach.	
<b>Biatorella</b> De Not. (1846)	
<i>armstrongiae</i> (T.A. Jones) Zahlbr.	Doidge 1950
<i>clavulus</i> (Stizenb.) Zahlbr.	Doidge 1950
<i>lugens</i> (Stizenb.) Zahlbr.	Doidge 1950
<i>palmeti</i> (Stizenb.) Zahlbr.	Doidge 1950

robiginans (Stizenb.) Zahlbr.	Doidge 1950
<b>Bilimbia</b> De Not. (1846)	
sabuletatum (Schreb.) Arnald	Doidge 1950
<i>Bacidia sabuletatum</i> (Schreb.) Lettau	
<i>Mycabilimbia sabuletatum</i> (Schreb.) Hafellner	
<b>Blastenia</b> A. Massal. (1852)	
acaciae (Vain.) Zahlbr.	Doidge 1950
aspicilioides Zahlbr.	Doidge 1950
brunnthaleri Zahlbr.	Doidge 1950
imponens (Stizenb.) Zahlbr.	Doidge 1950
laingsburgensis Zahlbr.	Doidge 1950
achracea Schaer.	Doidge 1950
AS: <i>B. achracea</i> var. <i>parvula</i> (Stizenb.) Zahlbr.	
<b>Xanthocarpia ochracea</b> (Schaer.) A. Massal. & De Not.	
praemicans (Nyl.) Zahlbr.	Doidge 1950
psarathecioides (Vain.) Zahlbr.	Doidge 1950
punicae (Vain.) Zahlbr.	Doidge 1950
sedutrix (Stizenb.) Zahlbr.	Doidge 1950
subsalicina Zahlbr.	Doidge 1950
testaceorufa (Vain.) Zahlbr.	Doidge 1950
vasquesia A. Massal.	Doidge 1950
<sup>1</sup> See Results (The Current List).	
<b>Brigantiaea</b> Trevis. (1853)	
fuscalutea (Dicks.) R. Sant.	Doidge 1950
<i>Lapadium fuscaluteum</i> (Dicks.) Mudd.	
leucaxantha (Spreng.) R. Sant.	Doidge 1950
<i>Lapadium leucaxanthum</i> (Spreng.) Zahlbr.	
mariae Trevis.	Doidge 1950
<i>Lapadium mariae</i> (Trevis.) Zahlbr.	
<b>Bryoria</b> Brada & D. Hawksw. (1977)	
fuscescens (Gyeln.) Brada & D. Hawksw.	Kärnefelt 1987b
<b>Bullatina</b> Vězda & Poelt (1987)	
viridis Brusse	Brusse 1992, Farkas 2004
? <i>Calenia nanaspara</i> Vězda	
<b>Buellia</b> De Not. (1846)	
aethalea (Ach.) Th. Fr.	Doidge 1950
<i>B. verruculosa</i> (Sm.) Mudd	
aethalaessa (Stizenb.) Zahlbr.	Doidge 1950
africana (Tuck.) Tuck.	Doidge 1950
albula Müll. Arg.	Doidge 1950
ambuta (Stizenb.) Zahlbr.	Doidge 1950
<i>B. ambusta</i> Zahlbr.	
anataladia A. Massal.	Doidge 1950
aequata (Ach.) Szatala	Doidge 1950
<i>B. punctata</i> var. <i>aequata</i> (Ach.) Zahlbr.	
brunnthaleri Zahlbr.	Doidge 1950
<i>B. angulosa</i> J. Steiner, non B. de Lesd.	
callaina (Stizenb.) Zahlbr.	Doidge 1950
callisparina C.W. Dodge	Doidge 1950
<i>B. callisparoides</i> Vain. (nam illegit.)	
cangaensis Vain.	Doidge 1950
caeruleata (Stizenb.) Zahlbr.	Doidge 1950
cantingens (Nyl.) Zahlbr.	Doidge 1950
dialytella Vain.	Doidge 1950
diarista (Nyl.) Zahlbr.	Doidge 1950
disciformis (Fr.) Mudd.	Doidge 1950
INC.: <i>B. disciformis</i> var. <i>cinereapruinosa</i> Vain.	
<i>B. disciformis</i> var. <i>lecanactina</i> J. Steiner	
( <i>B. lecanactina</i> (J. Steiner) C.W. Dodge)	
<i>B. disciformis</i> var. <i>sanguinea</i> (Müll. Arg.) Zahlbr.	
<sup>1</sup> discolarans Zahlbr	Doidge 1950
dispersa A. Massal.	Doidge 1950
distragens Vain.	Doidge 1950
distrata (Nyl.) Zahlbr.	Doidge 1950

durbana Vain.	Doidge 1950
<i>Diplotommo durbonum</i> (Vain.) C.W. Dodge	
endorhodina Vain.	Doidge 1950
<i>Diplotommo endorhodinum</i> (Vain.) Szatala	
epichlora (Vain.) Zahlbr.	Doidge 1950
glenncairnensis Zahlbr.	Doidge 1950
halonia (Ach.) Tuck.	Doidge 1950
incuriosa (Nyl.) Zahlbr.	Doidge 1950
insidians (Nyl.) Zahlbr.	Doidge 1950
italica A. Massal.	Doidge 1950
<b>INC.:</b> <i>B. itolico</i> var. <i>debonensis</i> Bagl.	
( <i>B. debonensis</i> (Bagl.) C.W. Dodge)	
<i>B. itolico</i> var. <i>recoborino</i> A. Massal	
( <i>B. recoborino</i> (A. Massal.) Müll. Arg.)	
langbaanensis Vain.	Doidge 1950
lauricassiae (Fée) Müll. Arg.	Doidge 1950
<i>B. louricossioe</i> var. <i>mocrospermo</i> Zahlbr.	
leucina Müll. Arg.	Doidge 1950
lutata (Stizenb.) Zahlbr.	Doidge 1950
meizocarpa Vain.	Doidge 1950
melanthina (Stizenb.) Zahlbr.	Doidge 1950
microsperma Müll. Arg.	Doidge 1950
nesiotis (Stizenb.) Zahlbr.	Doidge 1950
ocoteae Vain.	Doidge 1950
oleicola (Nyl.) Zahlbr.	Doidge 1950
pachnodes (Stizenb.) Zahlbr.	Doidge 1950
pachysporoides Vain.	Doidge 1950
perigrapta (Stizenb.) Zahlbr.	Doidge 1950
permodica (Stizenb.) Zahlbr.	Doidge 1950
perspersa J. Steiner	Doidge 1950
praelata (Stizenb.) Zahlbr.	Doidge 1950
<sup>2</sup> protohallina (Kremp.) Vain.	Doidge 1950
<b>INC.:</b> <i>B. protohallino</i> var. <i>indissimilis</i> Vain.	
quaterna Zahlbr.	Doidge 1950
<i>Diploico quoterno</i> (Zahlbr.) C.W. Dodge	
romoletia A. Nordin	Nordin 2000
rudis (Stizenb.) Zahlbr.	Doidge 1950
rusticorum (Stizenb.) Zahlbr.	Doidge 1950
sequax (Nyl.) Zahlbr.	Doidge 1950
<i>B. obstrocto</i> H. Olivier	
spuria (Schaer.) Anzi	Doidge 1950
<b>INC.:</b> <i>B. spurio</i> var. <i>insularis</i> (A. Massal.) Jatta	
stellulata (Taylor) Mudd.	Doidge 1950
<b>INC.:</b> <i>B. stelluloto</i> f. <i>albosporso</i> Zahlbr.	
<i>B. stelluloto</i> f. <i>hybrido</i> Zahlbr.	
<i>B. stelluloto</i> f. <i>murino</i> Zahlbr.	
stizenbergeri Zahlbr.	Doidge 1950
<i>Lecideo dispersulo</i> Stizenb., non <i>B. dispersulo</i> Müll. Arg.	
subdisciformis Vain.	Doidge 1950
subtristis (Nyl.) Zahlbr.	Doidge 1950
transvaalica (Stizenb.) Zahlbr.	Doidge 1950
triplicans Zahlbr.	Doidge 1950
vernicoma (Tuck.) Tuck.	Doidge 1950
<sup>1</sup> Nom. illegit., non <i>B. discolorans</i> H. Olivier (see Appendix 2).	
<sup>2</sup> Nom. illegit., non <i>B. protohallino</i> (Anzi) Jatta (see Appendix 2).	
<b>Bulbothrix</b> Hale (1974)	
coronata (Fée) Hale	Hale 1976b, Swinscow & Krog 1988
decurtata (Kurok.) Hale	Hale 1976b
goebelii (Zenker) Hale	Doidge 1950, Hale 1976b
<i>Pormelio gronotensis</i> Nyl.	
isidiza (Nyl.) Hale	Doidge 1950, Hale 1976b
<i>Pormelio isidizo</i> Nyl.	
sensibilis (J. Steiner & Zahlbr.) Hale	Brusse 1988e, Hale 1976b
<i>Pormelio sensibilis</i> J. Steiner & Zahlbr.	

suffixa (Stirt.) Hale	Doidge 1950, Hale 1976b, Swinscow & Krog 1988
<i>Parmelia suffixa</i> Stirt.	
tabacina (Mont. & Bosch) Hale	Hale 1976b
ventricosa (Hale & Kurok.) Hale	Hale 1976b, Swinscow & Krog 1988
<b>Bunodophoron</b> A. Massal. (1861)	
melanocarpum (Sw.) Wedin	Doidge 1950
<i>Sphaerophorus melanocarpus</i> (Sw.) DC.	
<b>Byssoloma</b> Trevis. (1853)	
leucoblepharum (Nyl.) Vain.	Santesson 1952, Farkas 2004
subdiscordans (Nyl.) P. James	Brusse 1988e
<i>B. rotuliforme</i> (Müll. Arg.) R. Sant.	
tricholomum (Mont.) Zahlbr.	Doidge 1950
<b>INC:</b> <i>B. tricholomum</i> f. <i>confluens</i> Vain.	
<b>Caloplaca</b> Th. Fr. (1860)	
almbornii Kärnefelt	Kärnefelt 1987a, Kärnefelt 1988, Almborn 1988a
amphidoxa (Stizenb.) Zahlbr.	Doidge 1950
arenaria (Pers.) Müll. Arg.	Doidge 1950
<i>C. lamprocheila</i> Flagey	
<b>Rufaplaca arenaria</b> (Pers.) Arup, Søchting & Frödén	
bonae-spei Almb. & Poelt	Almborn 1988a, Kärnefelt 1988
<i>Telaschistopsis bonae-spei</i> (Almb. & Poelt) Frödén, Arup & Søchting	
calviniana Zahlbr.	Doidge 1950
capensis (A. Massal.) Zahlbr.	Doidge 1950
cardinalis Zahlbr.	Doidge 1950
cataschista Zahlbr.	Doidge 1950
cateileoides (Vain.) Plümper & Lumbsch	Doidge 1950
<i>Lecanora cateileoides</i> Vain.	
cerina (Ach.) Th. Fr.	Doidge 1950
cinnabarina (Ach.) Zahlbr.	Doidge 1950, Almborn 1988a, Kärnefelt 1988
( <i>C. pallidior</i> f. <i>opaca</i> (Müll. Arg.) Zahlbr.)	
<b>INC.:</b> <i>C. cinnabarina</i> var. <i>opaca</i> (Müll. Arg.) Zahlbr.	
cinnabariza (Nyl.) Zahlbr.	Doidge 1950
coccinella (Stizenb.) Zahlbr.	Doidge 1950
conchiliata Zahlbr.	Doidge 1950
crocodes (A. Massal.) Zahlbr.	Doidge 1950
delectans Zahlbr.	Doidge 1950
discolorella Zahlbr.	Doidge 1950
ecklonii (A. Massal.) Zahlbr.	Doidge 1950
effusa G. Merr.	Doidge 1950
fecunda Zahlbr.	Doidge 1950
ferruginea (Huds.) Th. Fr.	Doidge 1950
<i>C. aurantiaca</i> (Lightf.) Th. Fr.,	
<b>INC.:</b> <i>C. aurantiaca</i> f. <i>fulva</i> Zahlbr.	
<b>INC.:</b> <i>C. ferruginea</i> f. <i>erysibe</i> Jatta.	
<b>Blastenia ferruginea</b> (Huds.) A. Massal.	
ferrogineovirens (Vain.) Zahlbr.	Doidge 1950
flavovirescens Dalla Torre & Sarnth.	Doidge 1950
gracilescens Zahlbr.	Doidge 1950
granulosa Jatta	Doidge 1950
? <i>C. verruculifera</i> (Vain.) Zahlbr	
gyalectoides 5.Y. Kondr. & Kärnefelt	Kärnefelt et al. 2002b
haematodes (A. Massal.) Zahlbr.	Doidge 1950, Almborn 1960, Kärnefelt 1988
hampeana (A. Massal.) Zahlbr.	Doidge 1950
holocarpa (Hoffm.) A.E. Wade	Doidge 1950
<b>AS:</b> <i>C. pyracea</i> f. <i>subpicta</i> Zahlbr. ("on rock")	
isidiosa (Vain.) Zahlbr.	Kärnefelt 1988
leptopisma (Nyl.) Zahlbr.	Doidge 1950
massula Zahlbr.	Doidge 1950
mastophora (Vain.) Zahlbr.	Doidge 1950
neethlingii Zahlbr.	Doidge 1950
ochraceofulva (Müll. Arg.) Jatta	Almborn 1987, Kärnefelt 1988
<i>C. subnitida</i> (Malme) Zahlbr.	
odoardii (Bagl.) Zahlbr.	Doidge 1950

pallidior (Müll. Arg.) Zahlbr.	Doidge 1950
perexigua (Vain.) Zahlbr.	Doidge 1950
phlogina (Ach.) Flagey	Doidge 1950
<b><i>Polycauliana phlogina</i> (Ach.) Arup, Frödén &amp; Søchting</b>	
placidia J. Steiner	Doidge 1950
platyna Zahlbr.	Doidge 1950
pyropoecila (Nyl.) Zahlbr.	Doidge 1950
pyropoeciloides Zahlbr.	Doidge 1950
regalis (Vain.) Zahlbr.	Doidge 1950
<b>INC.: <i>C. regalis</i> f. <i>prastrato</i> (Hue) Zahlbr.</b>	
<b><i>Gondwania regalis</i> (Vain.) Søchting, Frödér. &amp; Arup</b>	
saxicola (Hoffm.) Nordin	Doidge 1950
<i>C. murarum</i> (Hoffm.) Th. Fr.	
scoriophila (A. Massal.) Zahlbr.	Doidge 1950
<i>C. carphinea</i> var. <i>scariophila</i> (A. Massal.) J. Steiner.	
<b><i>Usnachrama scariophila</i> (A. Massal.) Søchting, Arup &amp; Frödén</b>	
sophodes (Vain.) Zahlbr.	Doidge 1950
subcerina (Nyl.) Zahlbr.	Doidge 1950
sublobulata (Nyl.) Zahlbr.	Almborn 1960, Almborn 1988b, Kärnefelt 1988
subseptata Zahlbr.	Doidge 1950
subsoluta (Nyl.) Zahlbr.	Doidge 1950
<b><i>Squamuleo subsoluta</i> (Nyl.) Arup, Søchting &amp; Frödén</b>	
subunicolor (Nyl.) Zahlbr.	Doidge 1950, Kärnefelt 1988
sympageella (Vain.) Zahlbr.	Doidge 1950
teicophila (A. Massal.) Zahlbr.	Doidge 1950
<b>Calopadia Vězda (1986)</b>	
fusca (Müll. Arg.) Vězda	Bruse 1988e
puiggarii (Müll. Arg.) Vězda	Bruse 1988e
subcoeruleus (Zahlbr.) Vězda	Farkas, 2004
<b>Candelaria A. Massal. (1852)</b>	
concolor (Dicks.) Arnold	Doidge 1950, Almborn 1966,
<b>INC: <i>C. concolor</i> f. <i>phaeocarpa</i> Alb.</b>	
<sup>1</sup> South African records of <i>C. fibrosa</i> (Fr.) Müll. Arg. are referable to <i>C. concolor</i> (Almborn 1988b).	
<b>Candelariella Müll. Arg. (1894)</b>	
coralliza (Nyl.) H. Magn.	Bruse 1988e
elaeophaea (Nyl.) Zahlbr.	Doidge 1950
glaucolivescens (Nyl.) Zahlbr.	Doidge 1950
vitellina (Hoffm.) Müll. Arg.	Doidge 1950
<b>AS: <i>C. vitellina</i> f. <i>athallina</i> (Wedd.) Zahlbr.</b>	
<b>Canomaculina Elix &amp; Hale (1987)</b>	
pilosa (Stizenb.) Elix & Hale	Doidge 1950, Hale 1976c, Swinscow & Krog 1988, Thomas & Bhat 1996
<i>Parmelia pilasa</i> Stizenb.,	
<i>Parmelina pilasa</i> (Stizenb.) Hale	
<i>Parmotrema pilasum</i> (Stizenb.) Krog & Swinscow	
subcaperata (Kremp.) Elix	Hale 1974, Elix 1999a
<i>Parmelia subcaperata</i> Kremp.	
<i>Parmatrema subcaperatum</i> (Kremp.) Hale	
uruguensis (Kremp.) Elix	Doidge 1950
<i>Parmelia perforata</i> var. <i>ciliata</i> Nyl.	
<b>Canoparmelia Elix &amp; Hale (1986)</b>	
antedeluvialis (Bruse & Sipman) Elix	Bruse 1993, Elix 1999
<i>Parmelio antedeluvialis</i> Bruse & Sipman	
aptata (Kremp.) Elix & Hale	Hale 1976a
<i>Pseudoparmelia aptata</i> (Kremp.) Hale	
crozalsiana (B. de Lesd. ex Harm.) Elix & Hale	Hale 1976a
<i>Pseudoparmelia crozalsiana</i> (B. de Lesd. ex Harm.) Hale	
nairobiensis (J. Steiner & Zahlbr.) Elix & Hale	Doidge 1950
<i>Parmelia gracilescens</i> var. <i>angalensis</i> Vain.	
owariensis (Asahina) Elix	Elix 1993, Nash & Elix 1987
<i>Paroparmelia owariensis</i> (Asahina) Elix & J. Johnst.	
pustulescens (Kurok.) Elix	Hale 1976a
<i>Pseudoparmelia pustulescens</i> (Kurok.) Hale	
raunkiaeri (Vain.) Elix & Hale	Nash & Elix 1987

<i>radriguesiana</i> (Hue) Elix <i>Pseudoparmelia rodriguesiana</i> (Hue) Hale <i>Paraparmelia radriguesiana</i> (Hue) Elix & J. Jahnst.	Elix 1999a, Hale 1976a
<i>terrapia</i> Elix <i>texana</i> (Tuck.) Hale <i>Parmelia texana</i> Tuck. <i>Pseudoparmelia texana</i> (Tuck.) Hale <i>Pseudoparmelia eruptens</i> (Kurak.) Hale	Elix 1999a Doidge 1950, Hale 1976a
<i>zambiensis</i> (Hale) Elix & Hale <i>zimbabwensis</i> (Hale) Elix & Hale <i>Pseudoparmelia zimbabwensis</i> (Hale) Hale	Nash & Elix 1987 Hale 1972, Swinscow & Krag 1988
<b>Carbonea</b> (Hertel) Hertel (1983) <i>vorticosa</i> (Flörke) Hertel <i>Lecidea vorticosa</i> (Flörke) Kärb.	Doidge 1950
<b>Catarrhospora</b> Brusse (1994) <i>mira</i> Brusse <i>splendida</i> Brusse	Brusse 1994 Brusse 1994
<b>Catillaria</b> A. Massal. (1852) <i>chalybeia</i> (Barrer) A. Massal. <i>crystallifera</i> H. Kiliias <i>galubkavae</i> Kotlov <i>lenticularis</i> (Ach.) Th. Fr. <b>INC.:</b> <i>C. lenticularis</i> f. <i>chlarapaliza</i> Baist. <i>melampepla</i> (Tuck.) Zahlbr. <i>mollescens</i> Zahlbr. <i>martualis</i> (Stizenb.) Zahlbr. <i>nigroclavata</i> (Nyl.) J. Steiner <i>opacata</i> (Stizenb.) Zahlbr. <i>rhyparaleuca</i> A. Massal. <i>stictella</i> (Stirt.) Zahlbr. <i>subfuscata</i> (Nyl.) Zahlbr.	Doidge 1950, Almborn 1960 Kiliias 1984 Kotlov 2002 Doidge 1950 Doidge 1950 Doidge 1950 Doidge 1950 Doidge 1950 Doidge 1950 Doidge 1950 Doidge 1950 Doidge 1950 Doidge 1950
<b>Cetraria</b> Ach. (1803) <i>aculeata</i> (Schreb.) Fr. <i>Carniculario tenuissima</i> (L.) Zahlbr.	Doidge 1950
<b>Cetrelia</b> W.L. Culb. & C.F. Culb. (1968) <i>cetreliaoides</i> (Delise) W.L. Culb. & C.F. Culb. <i>Parmelia cetreliaoides</i> Delise <i>alivetarum</i> (Nyl.) W.L. Culb. & C.F. Culb. <i>Parmelia alivoria</i> (Ach.) Th. Fr.	Doidge 1950 Doidge 1950
<b>Chapsa</b> A. Massal. <i>diploschistoides</i> (Zahlbr.) Frisch <i>Ocellularia diploschistoides</i> Zahlbr.	Doidge 1950
<b>Chiadectan</b> Ach. (1814) <i>calensoi</i> (A. Massal.) Müll. Arg. <i>C. capense</i> (A. Massal.) Zahlbr. <i>galactinum</i> Zahlbr. <i>natalense</i> Nyl. <b>A5:</b> <i>C. sanguineum</i> f. <i>ruseocincta</i> (Fr.) Vain. <i>vanderbylii</i> Zahlbr.	Doidge 1950 Doidge 1950 Doidge 1950 Doidge 1950
<b>Chroodiscus</b> (Müll. Arg.) Müll. Arg. (1890) <i>mirificus</i> (Kremp.) R. Sant. <i>verrucasus</i> R. Sant., Lücking & Vězda	Brusse 1991b Farkas, 2004
<b>Chrysothrix</b> Mont. (1852) <i>candelaris</i> (L.) J.R. Laundon <i>Lepraria candelaris</i> (L.) Fr.	Doidge 1950
<b>Cladia</b> Nyl. (1870) <i>aggregata</i> (Sw.) Nyl. <i>Cladonia aggregata</i> (Sw.) Spreng.	Doidge 1950
<b>Cladonia</b> P. Bröwne (1756) <i>bacillaris</i> (Ach.) Genth <i>caespiticia</i> (Pers.) Flörke <i>centraphara</i> Müll. Arg. <i>cervicornis</i> subsp. <i>verticillata</i> (Hoffm.) Ahti	Doidge 1950 Doidge 1950 Doidge 1950, Swinscow & Krag 1988 Doidge 1950

<i>C. verticillato</i> Hoffm.	
chlorophaea (Flörke ex Sommerf.) Spreng.	Doidge 1950
<i>C. pyxidato</i> var. <i>chlorophaeo</i> f. <i>staphylea</i> (Ach.) Harm.	
confusa R. Sant.	Almborn 1987
coniocraea (Flörke) Spreng.	Doidge 1950
<i>C. fimbriato</i> var. <i>coniocreo</i> (Flörke) Vain.	
didyma (Fée) Vain.	Doidge 1950, Stenroos 1994
AS: <i>C. didymo</i> var. <i>muscigeno</i> (Eschw.) Vain.	
<i>C. didymo</i> f. <i>subulata</i> Sandst.	
fimbriata (L.) Fr.	Doidge 1950
<i>C. fimbriato</i> var. <i>simplex</i> (Weiss.) Flot.	
(INC.: <i>C. fimbriato</i> var. <i>chlorophaeoides</i> Vain.,	
<i>C. fimbriato</i> var. <i>chondroideo</i> Vain.)	
flabelliformis (Flörke) Vain.	Doidge 1950
AS: <i>C. flabelliformis</i> f. <i>tenello</i> Zahlbr.	
floerkeana (Fr.) Sommerf.	Doidge 1950, Stenroos 1994
furcata (Huds.) Schrad.	Doidge 1950
fuscocinerea Ahti	Brusse 1988e
hedbergii Ahti	Brusse 1988e
macilenta Hoffm.	Doidge 1950, Stenroos 1994
INC.: <i>C. macilento</i> var. <i>corticoto</i> Vain.	
multiformis G. Merr.	Doidge 1950
AS: <i>C. multiformis</i> f. <i>suboscypno</i> (Vain.) Evans	
ochrochlora Flörke	Doidge 1950
<i>C. fimbriato</i> var. <i>ochrochlora</i> (Flörke) Vain.	
pertrícosa Kremp.	Doidge 1950
<i>C. rongiformis</i> var. <i>pungens</i> (Ach.) Vain.	
pocillum (Ach.) O.J. Rich.	Doidge 1950
<i>C. pyxidato</i> var. <i>pocillum</i> (Ach.) Flot.	
poeciloclada Abbayes	Swinscow & Krog 1988
polia R. Sant.	Almborn 1988b
<i>Clodino polio</i> (R. Sant.) W.A. Weber	
portentosa (Dufor) Coem.	Brusse 1993
pyncoclada (Pers.) Nyl.	Doidge 1950
INC.: <i>C. pyncoclado</i> f. <i>exolbescens</i> Vain.	
pyxidata (L.) Fr.	Doidge 1950
ramulosa (With.) J.R. Laundon	Doidge 1950
<i>C. pityreo</i> (Flörke) Fr.	
INC.: <i>C. pityreo</i> var. <i>suboreoloto</i> Vain.	
<i>C. pityreo</i> var. <i>zwockhii</i> Vain. f. <i>scyphifera</i> (Delise) Vain.	
rangiferina (L.) Weber ex F.H. Wigg	Doidge 1950, Almborn 1988b
rangiformis Hoffm.	Doidge 1950
AS: <i>C. rongiformis</i> Hoffm. var. <i>folioso</i> Flörke rei Schaeer.	
<i>C. fimbriato</i> var. <i>nemoxyno</i> (Ach.) Coem.	
<i>C. fimbriato</i> var. <i>nemoxyno</i> f. <i>fibulo</i> (Ach.) Vain.	
squamosa (Scop.) Hoffm.	Doidge 1950
subradiata (Vain.) Sandst.	Doidge 1950
<i>C. fimbriato</i> var. <i>subradioto</i> Vain.	
<i>C. fimbriato</i> var. <i>bolfourii</i> (Cromb.) Vain.	
subulata (L.) Weber ex F.H. Wigg.	Doidge 1950
<i>C. fimbriato</i> var. <i>subuloto</i> (L.) Vain.	
<i>C. fimbriato</i> var. <i>radioto</i> (Schreb.) Coem.	
<b>Clathroporina</b> Müll. Arg. (1882)	
locuples (Stizenb.) Zahlbr.	Doidge 1950
<b>Cliostomum</b> Fr. (1825)	
flavum (Zahlbr.) Brusse	Brusse 1993, Doidge 1950
<i>Toninio flavo</i> Zahlbr.	
<b>Coccocarpia</b> Pers. (1827)	
palmicola (Spreng.) Arv. & D.J. Galloway	Arvidsson 1982, Brusse 1988e
pellita (Ach.) Müll. Arg.	Doidge 1950
AS: <i>Coccocarpia pellito</i> var. <i>pormelioides</i> Müll. Arg.	
<b>Coelopogon</b> Brusse & Kärnefelt (1991)	
abraxas Brusse	Brusse & Kärnefelt 1991

epiphorellus (Nyl.) Brusse & Kärnefelt <i>Coelocoulon epiphorellum</i> (Nyl.) Kärnefelt <i>Corniculario epiphorello</i> (Nyl.) Du Rietz	Kärnefelt 1986, Almborn 1988b, Brusse & Kärnefelt 1991
<b>Coenogonium</b> Ehrenb. (1820)	
afrum A. Massal.	Doidge 1950
flavicans (Vězda & Farkas) Kalb & Lücking	Farkas, 2004
interplexum Nyl.	Doidge 1950
luteum (Dicks.) Kalb & Lücking <i>Microphiale luteo</i> (Dicks.) Zahlbr. <i>Dimerello luteo</i> (Dicks.) Trevis.	Doidge 1950, Brusse 1991c
moniliforme Tuck.	Brusse 1988e
subluteum (Rehm) Kalb & Lücking <i>Dimerello epiphylo</i> (Müll. Arg.) Malme	Brusse 1991b
<b>Collema</b> P. Browne (1756)	
almbornii Degel. <i>Porocollema almbornii</i> (Degel.) Otálora, P.M. Jørg. & Wedin coccophorum Tuck. <i>Enchylium coccophorum</i> (Tuck.) Otálora, P.M. Jørg. & Wedin crispum (L.) Weber ex F.H. Wigg. <i>Blennothollio crispo</i> (L.) Otálora, P.M. Jørg. & Wedin fasciculare (L.) Weber ex F.H. Wigg. <i>C. oggregotum</i> (Ach.) Röhl. <i>Arctomio fascicularis</i> (L.) Otálora & Wedin <i>Goburo fasciculore</i> (L.) P. M. Jørg., furfuraceum (Arnold) Du Rietz <b>AS:</b> <i>C. furfuroceum</i> var. <i>luzonense</i> Degel. hueanum Degel. (var. hueanum) japonicum (Müll. Arg.) Hue kauaiense H. Magn. <i>Scythinium kauaiense</i> (H. Magn.) Otálora, P.M. Jørg. & Wedin leptaleum Tuck. <b>AS:</b> <i>C. leptaleum</i> var. <i>bilosum</i> (Mont.) Degel. nigrescens (Huds.) DC. polycarpon Hoffm. <i>Enchylium polycorpon</i> (Hoffm.) Otálora, P.M. Jørg. & Wedin redundans Nyl. subconveniens Nyl. subflaccidum Degel. tenax (Sw.) Ach. <i>Enchylium tenax</i> (Sw.) Gray texanum Degel. thysaneum Ach.	Degelius 1974 Schultz et al. 2009 Doidge 1950 Doidge 1950, Degelius 1974 Degelius 1974 Degelius 1974, Moberg 1987 Degelius 1974 Degelius 1974 Degelius 1974 Doidge 1950 Degelius 1974 Doidge 1950 Doidge 1950 Galloway 1995 Degelius 1974 Doidge 1950, Degelius 1974 Zedda & Rambold 2004 Doidge 1950
<b>Combea</b> De Not. (1846) mollusca (Ach.) Nyl.	Doidge 1950, Almborn 1988a, Almborn 1988b, Follmann et al. 1994
<b>Conotrema</b> Tuck. (1848) volvarioides (Fée) Müll. Arg.	Doidge 1950
<b>Coniarthonia</b> Grube (2001) wilmsiana (Müll. Arg.) Grube <i>Arthonio wilmsiano</i> Müll. Arg.	Doidge 1950
<b>Corynecystis</b> Brusse (1985) capensis Brusse <i>Peltulo capensis</i> (Brusse) Büdel	Brusse 1985a, Büdel 1987
<b>Cratiria</b> Marbach (2000) aggregiens (Stirt.) Marbach <i>Buellio aggregiens</i> (Stirt.) Zahlbr.	Marbach 2000
<b>Crutarndina</b> Parnmen, Lücking & Lumbsch (2012) ptractoides (P.M. Jørg. & Brodo) Parnmen, Lücking & Lumbsch <i>Thelotremo subtile</i> Tuck.	Brusse 1988e
<b>Culbersonia</b> Essl. (2000) nubila (Moberg) Essl. <i>Pyxine nubilo</i> Moberg	Obermeyer 2009

<b>Cryptothecia</b> Stirt. (1876)	
subnidulans Stirt.	Doidge 1950
<b>Degelia</b> Arv. & D.J. Galloway (1981)	
plumbea (Lightf.) P.M. Jørg. & P. James	Doidge 1950
<i>Pormeliello plumbeo</i> (Lightf.) Vain.	
<b>Dermatiscum</b> Nyl. (1867)	
fallax Brusse	Brusse 1986c
thunbergii (Ach.) Nyl.	Almborn 1987, Almborn 1988b
viride (L.f.) Zahlbr.	Doidge 1950
<b>Dermatocarpon</b> Eschw. (1824)	
deserti Zahlbr.	Doidge 1950
peltatum (Taylor) Zahlbr.	Doidge 1950
<i>Endocarpon peltatum</i> Taylor	
vitellinum Spreng.	Doidge 1950
<b>Dibaeis</b> Clem. (1909)	
<sup>1</sup> baeomyces (L.f.) Rambold & Hertel	Doidge 1950, Almborn 1988a,
<i>Boeomyces roseus</i> Pers.	Thomas & Bhat 1996
<sup>1</sup> Reported as <i>Baeomyces rasens</i> Pers. by Thomas & Bhat 1996).	
<b>Digitothyrea</b> P.P. Moreno & Egea (1992)	
rotundata (Büdel, Henssen & Wessels)	
P.P. Moreno & Egea	Henssen et al. 1985
<i>Thyreo rotundoto</i> Büdel, Henssen & Wessels	
<b>Dimelaena</b> Norman (1853)	
australiensis H. Mayrhofer & Sheard	Mayrhofer et al. 1996
oreina (Ach.) Norman	Doidge 1950
<i>Rinodino oreino</i> (Ach.) A. Massal.	
<b>Diploicia</b> A. Massal. (1852)	
africana (Tuck.) Matzer, H. Mayrhofer & Rambold	Matzer et al. 1998
<b>Diploschistella</b> Vain. (1926)	
urceolata Vain.	Doidge 1950
<b>Diploschistes</b> Norman (1853)	
actinostomus (Pers. ex Ach.) Zahlbr.	Doidge 1950, Almborn 1988b
	Guderley & Lumbsch 1996,
	Zedda & Rambold 2004
aeneus (Müll. Arg.) Lumbsch	Doidge 1950, Guderley & Lumbsch
<i>D. actinostomus</i> var. <i>oeneus</i> (Müll. Arg.) J. Steiner	1996, Zedda & Rambold 2004
austroafricanus Guderley & Lumbsch	Guderley & Lumbsch 1996
cinereocaesius (Sw.) Vain.	Doidge 1950, Guderley & Lumbsch 1996
<sup>1</sup> diacapis (Ach.) Lumbsch	Almborn 1988b
diploschistoides (Vain.) Salisbury	Almborn 1960,
<i>D. olmbornii</i> C.W. Dodge	Guderley & Lumbsch 1996
<i>D. coesioplumbeus</i> (Nyl.) Vain.	
<i>D. actinostomus</i> var. <i>coesioplumbeus</i> (Nyl.)	
J. Steiner (5A collections only)	
euganeus (A. Massal.) J. Steiner	Doidge 1950,
<i>Diploschistes onactinus</i> (Nyl.) Zahlbr.	Guderley & Lumbsch 1996
<i>Diploschistes deuterius</i> (Nyl.) Zahlbr.	
hensseniae Lumbsch & Elix	Guderley & Lumbsch 1996,
	Zedda & Rambold 2004
hypoleucus Lumbsch & Elix	Guderley & Lumbsch 1996
isabellinus Zahlbr.	Doidge 1950, Guderley & Lumbsch 1996
muscorum subsp. <i>bartletii</i> Lumbsch	Doidge 1950,
<i>D. orenorius</i> (Schaer.) Müll. Arg.	Guderley & Lumbsch 1996
<i>D. scruposus</i> var. <i>orenorius</i> (A. Massal.) Müll. Arg.	
scruposus (Schreb.) Norm.	Doidge 1950, Guderley & Lumbsch 1996, Thomas & Bhat 1996
INC: <i>D. scruposus</i> f. <i>iridatus</i> (A. Massal.) Zahlbr.	
sticticus (Körb.) Müll. Arg.	Doidge 1950, Lumbsch 1993,
<i>D. perispicillotus</i> Zahlbr.	Guderley & Lumbsch 1996
<i>D. subcupreus</i> (Nyl.) Zahlbr.	
cf. <i>thelenelloides</i> Lumbsch & Aptroot	Zedda & Rambold 2004
thunbergianus (Ach.) Lumbsch & Vězda	Doidge 1950,
<i>Gyolecta thunbergiana</i> Ach.	Guderley & Lumbsch 1996
<sup>1</sup> Not treated by Guderley & Lumbsch 1996	

<b>Diplotomma</b> Flot. (1849)	
alboatrum (Hoffm.) Flot.	Nordin 2000
<i>Buellio albootro</i> (Hoffm.) Th. Fr.	
<b>Dirina</b> Fr. (1825)	
capensis Fée	Doidge 1950
<b>Dirinaria</b> (Tuck.) Clem. (1909)	
aegialita (Afz.) Moore (var. <i>oegiolito</i> )	Doidge 1950, Awasthi 1975
<i>Physcio oegiolito</i> (Ach.) Nyl.	
africana (Müll. Arg.) D. D. Awasthi	Doidge 1950, Awasthi 1975
<i>Physcio ofricono</i> Müll Arg.	
applanata (Fée) D.D. Awasthi	Doidge 1950
<i>Physcio opplonoto</i> (Fée) Zahlbr.	
aspera (H. Magn.) D. D. Awasthi	Awasthi 1975
coccinea (Müll. Arg.) D. D. Awasthi	Awasthi 1975, Swinscow & Krog 1988
confluens (Fr.) D. D. Awasthi (var. <i>confluens</i> )	Awasthi 1975
flava (Müll. Arg.) C.W. Dodge	Brusse 1988e
melanoclina (C. Knight) D. D. Awasthi	Awasthi 1975
leopoldii (Stein) D. D. Awasthi	Awasthi 1975
<sup>1</sup> picta (Sw.) Schaer. ex Clem.	Doidge 1950, Thomas & Bhat 1994, Thomas & Bhat 1996
<i>Physcio picto</i> (Sw.) Nyl.	
purpurascens (Vain.) B.J. Moore	Awasthi 1975
INC.: <i>Dirinorio purpuroscens</i> f. <i>colorato</i> D. D. Awasthi	
subpicta (Nyl.) C. W. Dodge	Doidge 1950, Awasthi 1975
<i>Physcio subpicto</i> Nyl.	
<sup>1</sup> Reported as <i>Dirinaria pictata</i> (Sw.) Aem & Shear. by Thomas & Bhat 1994.	
<b>Dufourea</b> Ach. (1809)	
physcioides A. Massal.	Doidge 1950
<b>Echidnocymbium</b> Brusse (1987)	
speciosum Brusse	Brusse 1987e
<b>Echinoplaca</b> Fée (1825)	
epiphylla Fée	Brusse 1988e
pellicula (Müll. Arg.) R. Sant.	Brusse 1988e
strigulacea (Müll. Arg.) R. Sant.	Brusse 1991c, Farkas 2004
<i>Actinoploco striguloceo</i> Müll. Arg.	
<b>Endocarpon</b> Hedw. (1738)	
pusillum Hedw.	Doidge 1950
<i>Dermotocarpon pusillum</i> (Hedw.) Anzi	
<b>Enterographa</b> Fée (1825)	
crassa (DC.) Fée	Doidge 1950
<i>Chiodecton venosum</i> (Pers.) Zahlbr.	
<b>Enterostigma</b> Müll. Arg. (1885)	
compunctum (Ach.) Müll. Arg.	Doidge 1950
<b>Ephebe</b> Fr. (1825)	
lanata (L.) Vain.	Doidge 1950
orthogonia Henssen	Henssen 1963
<b>Eremastrella</b> S. Vogel (1955)	
crystallifera (Taylor) Gotth. Schneid.	Almborn 1988b, Vogel 1955
<i>E. tobleri</i> Vogel	
montana Brusse	Brusse 1987f
<i>Psoro olmborniono</i> Lumbsch & Kothe	
<b>Erioderma</b> Fée (1825)	
leylandii (Taylor) Müll. Arg.	Jørgensen 2001, Jørgensen 2003
<b>*Etayoa</b> Diederich & Ertz (2014)	
*trypethelii (Flakus & Kukwa) Diederich & Ertz	Ertz et al 2014
* <i>Phoeosporobolus trypethelii</i> Flakus & Kukwa	
<b>Fellhanera</b> Vězda (1986)	
bouteillei (Desm.) Vězda	Santesson 1952, Farkas 2004
<i>Cotillorio bouteillei</i> (Desm.) A. Zahlbr.	
fuscata (Müll. Arg.) Vězda	Brusse 1991b, Farkas 2004
stanhopiae (Müll. Arg.) Lücking, Lumbsch & Elix	Farkas, 2004
ubternella (Nyl.) Vězda	Farkas, 2004
<b>Flavoparmelia</b> Hale (1986)	
amplexa (Stirt.) Hale	Doidge 1950, Hale 1976a
<i>Pseudoparmelia complexo</i> (Stirt.) Hale	

<i>Pormelio omplexo</i> Stirt.	
<i>caperata</i> (L.) Hale	Doidge 1950
<i>Pormelio coperoto</i> (L.) Ach.	
<i>pachydactyla</i> (Hale) Hale	Brusse 1991c
<i>rutidota</i> (Hook.f. & Taylor) Hale	Doidge 1950, Doidge 1950
<i>Pormelia subcaperatula</i> Nyl.	
<i>Pormelio subconsperso</i> Nyl.	
<i>salazinicæ</i> Elix	Elix 1999a
<i>soredians</i> (Nyl.) Hale	Doidge 1950, Doidge 1950,
<i>Pormelio conspersa</i> var. <i>polyphylla</i> Müll. Arg.	Hale 1976a
<i>Parmelio saredions</i> Nyl.	
<i>Pseudoparmelio soredians</i> (Nyl.) Hale	
<b>Flavopunctelia</b> (Krog) Hale (1984)	
<i>flaventior</i> (Stirt.) Hale	Brusse 1988e
<i>soredica</i> (Nyl.) Hale	Brusse 1988e
<b>Fuscidea</b> V. Wirth & Vězda (1972)	
<i>hottentotta</i> Brusse	Doidge 1950, Brusse 1989a
<i>Lecideo rivuloso</i> Ach. (5A records only)	
<i>Fuscideo cyothoides</i> (Ach.) V. Wirth & Vězda (5A records only)	
<b>Fuscopannaria</b> P.M. Jørg. (1994)	
<i>leucosticta</i> (Tuck.) P.M. Jørg.	Doidge 1950
<i>Pannoria leucosticta</i> var. <i>isidiopsis</i> Nyl.	
<i>subimmixta</i> (C. Knight) P. M. Jørg.	Jørgensen 2002b, Jørgensen 2003
<b>Glyphis</b> Ach. (1814)	
<i>cicatricosa</i> Ach.	Doidge 1950, Almborn 1988b
<b>INC.:</b> <i>G. cicatricosa</i> var. <i>confluens</i> (Zenk.) Zahlbr.	
<i>G. cicatricosa</i> var. <i>simplicior</i> (Vain.) Zahlbr.	
<i>scyphulifera</i> (Ach.) Staiger	Doidge 1950, Almborn 1988b
<i>Gyrostomum scyphuliferum</i> (Ach.) Nyl.	
<b>Glyphopeltis</b> Brusse (1985)	
<i>ligustica</i> (B. de Lesd.) Timdal	Brusse 1985b, Timdal 1988
<i>G. eburino</i> Brusse	
<b>Gomphillus</b> Nyl. (1855)	
<i>calycioides</i> (Delise ex Duby) Nyl.	Brusse 1989c
<b>Gonolecania</b> Zahlbr. (1924)	
<i>umosonigricans</i> (Müll. Arg.) Brusse	Brusse 1991b
<i>Byssalecania fumasnigricons</i> R. Sant.	
<b>Graphina</b> Müll. Arg. (1880)	
<i>acharii</i> (Fée) Müll. Arg.	Doidge 1950, Almborn 1988b
<i>analogæ</i> (Nyl.) Zahlbr.	Doidge 1950
<i>atrofusca</i> Müll. Arg.	Doidge 1950
<i>bylii</i> (Vain.) Zahlbr.	Doidge 1950
<b>INC.:</b> <i>G. bylii</i> var. <i>lividulo</i> (Vain.) Zahlbr.	
<i>obtrita</i> (Fée) Müll. Arg.	Doidge 1950
<i>pergracilis</i> Zahlbr.	Doidge 1950
<i>platycarpa</i> (Eschw.) Zahlbr.	Doidge 1950
<i>polycarpa</i> Müll. Arg.	Doidge 1950
<b>Graphis</b> Adans. (1763)	
<i>denudans</i> Vain.	Doidge 1950
<i>devestiens</i> Nyl.	Doidge 1950
<i>diaphoroides</i> Müll. Arg.	Doidge 1950
<i>intexta</i> Nyl.	Doidge 1950
<i>intricata</i> Fée	Doidge 1950
<i>scripta</i> (L.) Ach.	Doidge 1950
<i>striatula</i> (Ach.) Spreng.	Doidge 1950
<i>subolivacea</i> Zahlbr.	Doidge 1950
<b>Granulopyrenis</b> Aptroot (1991)	
<i>macrocarpoides</i> (Zahlbr.) Aptroot	Doidge 1950
<i>Microthello macrocarpoides</i> Zahlbr.	
<b>Gyalecta</b> Ach. (1808)	
<i>carneola</i> (Ach.) Hellb.	Doidge 1950
<i>Pochyphiole carneola</i> (Ach.) Arnold	
<i>P. corneo</i> Poetsch	

<b>Gyalectidium</b> Müll. Arg. (1881)	
filicinum Müll. Arg.	Bruse 1991b
microcarpum (Vězda) Lücking, Sérus. & Vězda	Bruse 1993
<i>Bullotino microcorpo</i> (Vězda) Bruse	
<b>Gyalideopsis</b> Vězda (1972)	
athalinoides (Nyl.) Vězda	Doidge 1950, Lumbsch 1993
<i>Diploschistes ochroniger</i> Zahlbr.	
<b>Gymnographopsis</b> C.W. Dodge (1967)	
latispora Egea & Torrente	Egea & Torrente 1996
<b>Haematomma</b> A. Massal. (1852)	
africanum (J. Steiner) C.W. Dodge	Doidge 1950, Staiger & Kalb 1995
<i>H. puniceum</i> var. <i>ofriconum</i> J. Steiner	
collatum (Stirt.) C.W. Dodge	Doidge 1950, Staiger & Kalb 1995
<i>H. puniceum</i> var. <i>collotum</i> (Stirt.) Zahlbr.	
fenzlianum A. Massal.	Staiger & Kalb 1995
persoonii (Fée) A. Massal.	Staiger & Kalb 1995
puniceum (Sw.) A. Massal.	Doidge 1950
<i>H. puniceum</i> var. <i>breviculum</i> (Stizenb.) Zahlbr.	
<i>H. puniceum</i> var. <i>rufidulum</i> Zahlbr.	
<i>H. puniceum</i> var. <i>suborthonioideum</i> Zahlbr.	
<b>Hafellia</b> Kalb, H. Mayrhofer & Scheid. (1986)	
demutans (Stirt.) Pusswald	Marbach 2000
<i>Buellia collisporo</i> (C. Knight) J. Steiner	
<i>Buellia demutans</i> Zahlbr.	
dissa (Stirt.) H. Mayrhofer & Sheard	Marbach 2000
<i>Buellia disso</i> (Stirt.) Zahlbr.	
<i>Rinodino disso</i> (Stirt.) H. Mayrhofer	
procellarum (A. Massal.) H. Mayrhofer & Sheard	Doidge 1950
<i>Rinodino procellorum</i> (A. Massal.) H. Mayrhofer	
<i>Buellia procellorum</i> A. Massal.	
INC.: <i>Buellia procellorum</i> var. <i>continuior</i> Steiner	
<i>Buellia procellorum</i> var. <i>repens</i> Steiner	
tetrapla (Nyl.) Pusswald,	Doidge 1950
<i>Buellia collisporo</i> var. <i>tetroplo</i> (Nyl.) J. Steiner	
<i>Buellia tetroplo</i> (Nyl.) Müll. Arg.	
<b>Helminthocarpon</b> Fée (1837)	
natalense Vain.	Doidge 1950
<b>Heppia</b> Nägeli ex A. Massal. (1854)	
adglutinata (Kremp.) A. Massal.	Schultz et al. 2009
euploca Vain.	Almborn 1988b
guepini (Delise) Nyl.	Doidge 1950
<i>H. guepini</i> var. <i>nigrolimboto</i> Nyl.	
lutosa (Ach.) Nyl.	Büdel 1987
<b>Heterodermia</b> Trevis. (1868)	
albicans (Pers.)	Swinscow & Krog 1988, Trass 1992, Moberg 2004
allardii (Kurok.) Trass	Trass 1992
antillarum (Vain.) Swinscow & Krog	Trass 1992, Moberg 2004
boryi (Fée) Kr.P. Singh & S.R. Singh	Doidge 1950
<i>Anoptychia leucomeloeno</i> var. <i>angustifolia</i> (Meyen & Flot.) Müll. Arg.	
chilensis (Kurock.) Swinscow & Krog	Moberg 2004
comosa (Eschw.) Follmann & Redon	Bruse 1988e, Moberg 2004
dactyliza (Nyl.) Swinscow & Krog	Bruse 1988e
diademata (Taylor) D.D. Awasthi	Thomas & Bhat 1994, Moberg 2004
flabellata (Fée) D.D. Awasthi	Bruse 1988e, Moberg 2004
hypocaesia (Yasuda) D.D. Awasthi	Trass 1992
hypoleuca (Muhl.) Trevis.	Doidge 1950, Doidge 1950
<i>Anoptychia hypoleuco</i> A. Massal.	
<i>Anoptychia hypoleuco</i> var. <i>colorato</i> Zahlbr.	
isidiophora (Vain.) D.D. Awasthi	Moberg 2004
japonica (M. Sato) Swinscow & Krog	Moberg 2004
lepidota Swinscow & Krog	Bruse 1988e, Galloway 1995
leucomela (L.) Poelt	Doidge 1950, Almborn 1988b,
<i>Anoptychia leucomeloeno</i> (L.) A. Massal.	Galloway 1995, Thomas & Bhat 1996,

<i>Heterodermio leucomelo</i> (L.) Poelt	
lutescens (Kurock.) Follmann	
magellanica (Zahlbr.) Swinscow & Krog	
microphylla (Kurock.) Swinscow & Krog	
namaquana Brusse	
obscurata (Nyl.) Trev	
podocarpa (Bél.) D.D. Awasthi	
<i>Anoptychio podocorpo</i> (Bél.) A. Massal.	
spathulifera Moberg & Purvis	
speciosa (Wulfen) Trevis.	
<i>Anoptychio specioso</i> (Wulfen) A. Massal.	
<i>Anoptychio specioso</i> var. <i>esoredioto</i> Vain.	
<b>INC.:</b> <i>Anoptychio specioso</i> f. <i>soredioso</i> (Müll. Arg.) Zahlbr	
subcitrina Moberg	
tremulans (Müll. Arg.) W.L. Culb.	
vulgaris (Vain.) Follm. & Redón	
<b>Hyperphyscia</b> Müll. Arg. (1894)	
adglutinata (Flörke) H. Mayrhofer & Poelt	
<i>Physcio odglutinato</i> (Flörke) Nyl.	
cochlearis Scutari	
coralloidea (Lyngé) Scutari	
granulata (Poelt) Moberg	
isidiata Moberg	
pandani (H. Magn.) Moberg	
pruinosa Moberg	
syncolla (Tuck. ex Nyl.) Kalb	
<i>Physcio syncolla</i> Tuck. ex Nyl.	
<b>Hypogymnia</b> (Nyl.) Nyl. (1896)	
bitteri (Lyngé) Ahti	
lugubris (Pers.) Krog.	
<i>Parmelio lugubris</i> Pers.	
physodes (L.) Nyl.	
<i>Parmelio physodes</i> (L.) Ach.	
subphysodes (Kremp.) Filson	
<b>INC.:</b> <i>Hypogymnia subphysodes</i> var. <i>ousterodioides</i> Elix	
<b>Hypotrachyna</b> (Vain.) Hale (1974)	
colensoica Hale, Nash & Elix	
densirhizinata (Kurok.) Hale	
erythrodes (Zahlbr.) Hale	
evansii M.D.E. Knox	
fissicarpa (Kurok.) Hale	
habenula M.D.E. Knox	
heterochroa (Hale & Kurok.) Elix	
<i>H. bohiano</i> (Nyl.) Hale	
imbricatula (Zahlbr.) Hale	
laevigata (Sm.) Hale	
<i>Parmelio laevigato</i> (Sm.) Ach.	
leeukopensis Elix	
ligulata M.D.E. Knox	
neodissecta (Hale) Hale	
orientalis (Hale) Hale	
osseovalba (Vain.) Y.S. Park & Hale	
<i>H. formosono</i> (Zahlbr.) Hale	
pulvinata (Fée) Hale	
<i>Parmelio subsinuoso</i> Nyl.	
revoluta (Flörke) Hale	
<i>Parmelio revoluta</i> Flörke	
scytophylla (Kurok.) Hale	
sinuosa (Sm.) Hale	
<i>Parmelio sinuoso</i> (Sm.) Ach.	
sublaevigata (Nyl.) Hale	
<i>Parmelio sublaevigato</i> Nyl.	
subpustulifera Elix	
	Moberg 2004
	8russe 1988e
	Galloway 1995
	8russe 1988e, Moberg 2004
	Brusse 1992, Moberg 2004
	8russe 1988e, Moberg 2004
	Doidge 1950, Moberg 2004
	Moberg 2004
	Doidge 1950, Galloway 1995,
	Thomas & Bhat 1996,
	Moberg 2004
	Moberg 2004
	Swinscow & Krog 1988, Trass 1992
	Doidge 1950, Moberg 2004
	Scutari 1997
	Moberg 2004
	Moberg 2004
	Moberg 2004
	Moberg 2004
	Moberg 2004
	Doidge 1950, Thomas & Bhat 1996,
	Moberg 2004
	8russe 1993
	Doidge 1950
	Doidge 1950
	8russe 1989c
	Nash & Elix 1987
	Brusse 1988e
	8russe 1988e
	Knox 1982
	Swinscow & Krog 1988
	Knox 1982
	Nash & Elix 1987
	8russe 1988e
	Doidge 1950
	Elix 1999a
	Knox 1982
	Nash & Elix 1987
	Nash & Elix 1987
	Nash & Elix 1987
	Doidge 1950
	Doidge 1950
	Nash & Elix 1987
	Doidge 1950
	Doidge 1950
	Elix 1993, Elix 1999a

<b>Icmadophila</b> Trevis. (1852)	
ericetorum Zahlbr.	Doidge 1950
<b>Immersaria</b> Rambold & Pietschm. (1989)	
athrocarpa (Ach.) Rambold & Pietschm.	Brusse 1988b
<i>Parpidio ofromontono</i> Brusse	
<b>Imshaugia</b> S.L.F. Mey. (1985)	
aleurites (Ach.) S.L.F. Mey.	Brusse 1993
<b>Ingvariella</b> Guderley & Lumbsch (1997)	
bispora (Bagl.) Guderley & Lumbsch	Doidge 1950
<i>Diploschistes bellus</i> Zahlbr.	
<b>Kroswia</b> P.M. Jørg. (2002)	
crystallifera P. M. Jørg.	Jørgensen 2002a, Jørgensen 2003
<b>Lasallia</b> Mérat (1821)	
capensis (Frey) Llano	Frey 1949, Almborn 1987, Almborn 1988b
<i>Umbilicaria capensis</i> Frey	
dilacerata (Frey) Llano	Frey 1949, Almborn 1987
<i>Umbilicario dilocerato</i> Frey	
glauca (Stizenb.) Llano	Doidge 1950, Almborn 1987
<i>Umbilicario glauco</i> Stizenb.	
membranacea (Laurer) Llano	Doidge 1950, Almborn 1987
<i>Umbilicario membronoceo</i> Laurer	
papulosa (Ach.) Llano	Doidge 1950, Almborn 1974, Almborn 1987, Almborn 1988b, Swinscow & Krog 1988
<i>Umbilicario pustulato</i> var. <i>populoso</i> (Ach.) Tuck.	
pustulata (L.) Mérat	Doidge 1950, Almborn 1987 Swinscow & Krog 1988, Galloway 1995
<i>Umbilicario pustulato</i> f. <i>minor</i> Crombie	
<i>Umbilicario pustulato</i> var. <i>popilloto</i> Hampe	
<i>L. rubiginoso</i> (Pers.) Llano	
<i>Umbilicario rubiginoso</i> Pers.	
<i>L. populoso</i> var. <i>rubiginoso</i> (Pers.) Llano	
<b>Lecanactis</b> Eschw. (1824)	
bullata Zahlbr.	Doidge 1950
develans Nyl.	Doidge 1950
emersa (Müll. Arg.) Stizenb.	Doidge 1950
ulcerata (Müll. Arg.) Zahlbr.	Doidge 1950
<b>Lecania</b> A. Massal. (1853)	
arenaria (Anzi) Flagey	Doidge 1950
cyrtella Th. Fr.	Doidge 1950
fructuosa (Stizenb.) Zahlbr.	Doidge 1950
<b>Lecanographa</b> Egea & Torrente	
lyncea (Sm.) Egea & Torrente	Doidge 1950
<i>Opegrapho lynceo</i> (Sm.) Borr.	
subcaesioides Egea & Torrente	Egea & Torrente 1996
<b>Lecanora</b> Ach. (1809)	
albella (Pers.) Ach.	Doidge 1950
<i>L. pollida</i> (Schreb.) Rabenh.	
albospersa Stizenb.	Doidge 1950
allophana Nyl.	Doidge 1950
aspera Stizenb.	Doidge 1950
<i>Squamorino aspera</i> (Stizenb.) C.W. Dodge	
atraeiformis Vain.	Doidge 1950
atrorimata Nyl.	Doidge 1950
<i>Aspicilio atrorimato</i> (Nyl.) C.W. Dodge	
atrosulphurea Ach.	Doidge 1950
<b>INC.:</b> <i>L. atrosulphureo</i> f. <i>leptococco</i> Stizenb.	
<i>L. atrosulphurea</i> f. <i>livens</i> Stizenb.	
bicincta Ramond	Doidge 1950
<i>L. rupicalo</i> var. <i>bicincta</i> (Ramond) Clauzade & Cl. Raux	
bagotana Nyl.	Doidge 1950
breuteliana A. Massal.	Doidge 1950
<i>Aspicilia breuteliano</i> (A. Massal.) C.W. Dodge	
bylii Vain.	Doidge 1950
<i>Aspicilia bylii</i> (Vain.) C.W. Dodge	
<sup>1</sup> bylii Zahlbr.	Doidge 1950

caesiopallens Vain.	Doidge 1950
campestris (Schaer.) Hue	Doidge 1950
<i>L. subfusco</i> var. <i>campestris</i> (Schaer.) Rabenh.	
caesiorubella Ach.	Doidge 1950
<i>L. concriformis</i> (Hoffm.) Vain.	
candidata Stizenb.	Doidge 1950
carneoflava Müll. Arg.	Doidge 1950
carpinea (L.) Vain.	Doidge 1950
chlarotera Nyl.	Doidge 1950
<i>L. subfusco</i> (L.) Ach.	
<b>INC.:</b> <i>L. subfusco</i> var. <i>subcrenulato</i> Nyl	
<i>L. subfusco</i> var. <i>subgronulato</i> Nyl.	
chondroplaca Zahlbr.	Doidge 1950
<i>Aspicillio chondraploco</i> (Zahlbr.) C.W. Dodge	
cinefacta Stizenb.	Doidge 1950
cruda Stizenb.	Doidge 1950
deminuta (Müll. Arg.) Stizenb.	Doidge 1950
diffusilis Nyl.	Doidge 1950
<i>Aspicillio diffusilis</i> (Nyl.) C.W. Dodge	
dispersa (Pers.) Röhl.	Doidge 1950
<b>AS:</b> <i>L. dispersa</i> f. <i>nana</i> Vain.	
<i>L. dispersa</i> f. <i>testoceo</i> Vain.	
elapheia Stizenb.	Doidge 1950
epibryon (Ach.) Ach.	Brusse 1988e
expallens Ach.	Doidge 1950
farinacea Fée	Doidge 1950
<i>L. blondo</i> Nyl.	
flexuosa Stizenb.	Doidge 1950
frustulosa Ach.	Doidge 1950
galactiniza Nyl.	Doidge 1950
glabrata (Ach.) Malme	Doidge 1950
<i>L. ollophono</i> var. <i>globrato</i> (Ach.) Steiner	
helva Stizenb.	Doidge 1950
labiosa Stizenb.	Doidge 1950
leprosa Fée	Doidge 1950
leucoxantha Müll. Arg.	Doidge 1950
nidulans Stizenb.	Doidge 1950
nubila Stizenb.	Doidge 1950
<i>Aspicillio nubila</i> (Stizenb.) Hue	
obvirescens Stizenb.	Doidge 1950
oreinoides (Körb.) Hertel & Rambold	Doidge 1950
<i>Corboneo oreinoides</i> (Körb.) Brusse	
<i>Lecideo ongolensis</i> Müll. Arg.	
ostracoderma (Ach.) Ach.	Doidge 1950
polytypa Vain.	Doidge 1950
prasecha Ach	Doidge 1950
<b>AS:</b> <i>L. prasecho</i> Ach. var. <i>homoloploco</i> (Nyl.) Vain.	
<i>L. hamalaplaca</i> Nyl.	
<i>Aspicillio homolaploco</i> (Nyl.) C.W. Dodge	
psaromela Nyl.	Doidge 1950
pseudistera Nyl.	Zedda & Rambold 2004
pulicaris (Pers.) Ach.	Doidge 1950
<i>L. coilacarpus</i> (Ach.) Nyl.	
<i>L. chlorono</i> f. <i>pinostri</i> Cromb.	
rehmannii Stizenb.	Doidge 1950
rupicola (L.) Zahlbr.	Doidge 1950
sylvestris (Nyl.) Stizenb.	Doidge 1950
thiocheila Stizenb.	Doidge 1950
transvaalensis Lumbsch	Lumbsch et al. 1995
varia (Haffm.) Ach.	Doidge 1950
vincentina Nyl.	Doidge 1950

<sup>1</sup> Nam. illegit. non, *Leconoro byllii* Vain. (See Appendix 2).

**Lecidea** Ach. (1803)

achristella Vain.	Doidge 1950
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aeneola (Arnold) Vain.	Doidge 1950
AS: <i>L. oeneola</i> var. <i>fuscootro</i> (Nyl.) Zahlbr.	
affine G. Merr. (nom inval. Art 38.1(a))	Doidge 1950
anteposita Nyl.	Doidge 1950
aporetica Stizenb.	Doidge 1950
bruguierae Vain.	Doidge 1950
buxea Stizenb.	Doidge 1950
caledonica Zahlbr.	Doidge 1950
capensis Zahlbr.	Doidge 1950
crassa (Nees) Stizenb.	Doidge 1950
cyanocentra Nyl.	Doidge 1950
decrustulata Vain.	Doidge 1950
elginensis Zahlbr.	Doidge 1950
erythrophaea Sommerf.	Doidge 1950
<i>L. tenebricoso</i> (Ach.) Nyl.	
esuriens Zahlbr.	Doidge 1950
exigua Chaub.	Doidge 1950
fucina Stizenb.	Doidge 1950
fuscoatra Ach.	Doidge 1950
<i>L. grisella</i> var. <i>mosigi</i> Zahlbr.	
fuscotabulata Stizenb.	Doidge 1950
geina Stizenb.	Doidge 1950
glebaria Stizenb.	Doidge 1950
glencairnensis Zahlbr.	Doidge 1950
gouritzensis Vain.	Doidge 1950
griseofuscuscula Vain. ex van der Byl	Doidge 1950
guamensis Vain.	Doidge 1950
hysbergensis Vain.	Doidge 1950
inscripta Stizenb.	Doidge 1950
insculpta Flot.	Doidge 1950
<b>INC:</b> <i>L. insculpto</i> f. <i>oxydata</i> Flot.	
lactaria Stizenb.	Doidge 1950
lactens Stizenb.	Doidge 1950
langbaanensis Vain.	Doidge 1950
lapidica (Ach.) Ach.	Doidge 1950
A5: <i>L. lopicido</i> var. <i>pontherino</i> Ach.	
mutabilis Fée	Doidge 1950
natalensis Nyl.	Doidge 1950
obumbrata Nyl.	Doidge 1950
ochroplaca Zahlbr.	Doidge 1950
A5: <i>L. ochroplaco</i> var. <i>intermedia</i> Zahlbr.	
<i>L. ochroplaco</i> var. <i>leproso</i> Zahlbr.	
<i>L. ochroplaco</i> var. <i>polito</i> Zahlbr.	
oligocheila Zahlbr.	Doidge 1950
opalina Stizenb.	Doidge 1950
orbiculata Stizenb.	Doidge 1950
owaniana Müll. Arg.	Doidge 1950
pallidonigra Ach.	Doidge 1950
paraspeirea Stizenb.	Doidge 1950
peltasta Stirt.	Doidge 1950
<i>Psoro peltosto</i> (Stirt.) C.W. Dodge	
peltoloma Müll. Arg.	Doidge 1950
peltulidea Stirt.	Doidge 1950
<i>Psoro peltulideo</i> (Stirt.) C.W. Dodge	
phalerata Stizenb.	Doidge 1950
<i>Psara phalerato</i> (Stizenb.) C.W. Dodge	
quartzina Stizenb.	Doidge 1950
remota Vain. ex van der Byl	Doidge 1950
rhynsdorpensis Zahlbr.	Doidge 1950
squamifera Stizenb.	Doidge 1950
<b>INC.:</b> <i>L. squamifera</i> var. <i>byllyi</i> Zahlbr.	
stellans Stizenb.	Doidge 1950
stupparia Stizenb.	Doidge 1950
subalbicans Nyl.	Doidge 1950

subattingens G. Merr. ex van der Byl	Doidge 1950
subceresina Zahlbr.	Doidge 1950
subexigua Vain.	Doidge 1950
subexiguella Vain.	Doidge 1950
subinquinans Nyl.	Doidge 1950
sublucida Stizenb.	Doidge 1950
subcinerascens Nyl.	Doidge 1950
<i>Buellia subcinerascens</i> (Nyl.) Zahlbr.	
subsquamifera Zahlbr.	Doidge 1950
subrussula J. Steiner	Doidge 1950
sulfurosa Stizenb.	Doidge 1950
terrena Nyl.	Doidge 1950
theiochroa (Darb.) Hue	Doidge 1950
theiophoroides Vain. ex Lynge	Doidge 1950
tragorum Zahlbr.	Doidge 1950
trichiliae Zahlbr.	Doidge 1950
valida Stizenb.	Doidge 1950
vestita (Mønt.) Nyl.	Doidge 1950
zeyheri A. Massal.	Doidge 1950
<b>Lecidella</b> Körb. (1855)	
aurata Knoph & Leuckert	Knoph & Leuckert 2000
elaeochroma (Ach.) M. Choisy	Doidge 1950
<i>Lecidea elaeochroma</i> (Ach.) Ach.	
INC.: <i>Lecidea elaeochroma</i> f. <i>flavicons</i> (Ach.) Th. Fr.	
<i>Lecidea elaeochroma</i> f. <i>geographico</i> (Bagl.) Zahlbr.	
<i>Lecidea elaeochroma</i> var. <i>hyolino</i> (Mart.) Zahlbr.	
epichromatica (Zahlbr.) Hertel	Doidge 1950
<i>Lecidea epichromatica</i> Zahlbr.	
euphorea (Flörke) Hertel	Doidge 1950
<i>Lecidea glomerulosa</i> (DC.) Steud.	
parasema (Ach.) Arnold	Doidge 1950
<i>Lecidea porosema</i> Ach.	
INC.: <i>Lecidea porosema</i> var. <i>areolata</i> G. Merr.	
<i>Lecidea porosema</i> var. <i>otropurpureo</i> Flot.	
stigmatea (Ach.) Hertel & Leuckert	Doidge 1950
<i>Lecidea cinnomea</i> Stizenb.	
<i>Lecidea vulgata</i> Zahlbr.	
viridans (Flot.) Körb.	Doidge 1950
AS: <i>Lecidea viridans</i> var. <i>nigrello</i> (A. Massal.) J. Steiner	
<b>Lepraria</b> Ach. (1803)	
glauca Ach.	Doidge 1950
incana (L.) Ach.	Brusse 1988e
<b>Leprocaulon</b> Nyl. (1879)	
albicans (Th. Fr.) Nyl.	Almborn 1987
<b>Leptogium</b> (Ach.) Gray (1821)	
africanum Zahlbr.	Doidge 1950
austramericanum (Malme) C.W. Dodge	Galloway 1995
azureum (Sw. ex Ach.) Mont.	Galloway 1995, Doidge 1950
<i>L. tremellaiides</i> var. <i>azureum</i> Nyl.	
bullatum (Sw.) Mont.	Doidge 1950
INC.: <i>L. bullatum</i> var. <i>doctylinoideum</i> Nyl.	
burgessii (L.) Mont.	Doidge 1950
caespitosum (Taylor) Swinscow & Krog	Doidge 1950, Swinscow & Krog 1988
<i>L. chloromelum</i> var. <i>caespitosum</i> (Tayl.) Zahlbr.	
capense P. M. Jørg. & A.K. Wallace	Jørgensen 1997
chloromelaidis Nyl.	Doidge 1950
chloromelum (Ach.) Nyl.	Doidge 1950
INC.: <i>L. chloromelum</i> var. <i>crossius</i> Nyl.	
cochleatum (Dicks.) P.M. Jørg. & P. James	Doidge 1950
<i>L. tremelloides</i> (L.f.) S.F. Gray	
carallaideum (Meyen & Flot.) Vain.	Galloway 1995, Thomas & Bhat 1996
<i>L. phyllacarpum</i> var. <i>carallaideum</i> (Mey. & Flot.) Hue	
cyanescens (Pers.) Körb.	Thomas & Bhat 1996
daedaleum Nyl.	Doidge 1950

digitatum (A. Massal.) Zahlbr.	Swinscow & Krog 1988
hildenbrandii (Garov.) Nyl.	Doidge 1950
kraussii (Flot.) Zahlbr.	Doidge 1950
marginellum (Sw.) S.F.Gray	Doidge 1950
menziesii (Sw.) Mont.	Doidge 1950
INC.: <i>Le. menziesii</i> f. <i>fuliginosum</i> Müll. Arg.	
moluccanum (Pers.) Vain.	Doidge 1950
INC.: <i>L. moluconum</i> var. <i>simplicoto</i> Voin.	
palmatum (Huds.) Mont.	Galloway 1995
<b><i>Scytinium palmatum</i> (Huds.) Gray</b>	
phyllocarpum (Pers.) Mont.	Doidge 1950, Thomas & Bhat 1996
INC.: <i>L. phyllocarpum</i> var. <i>mocrocorpum</i> Nyl.	
saturninum Nyl.	Doidge 1950
<b>Leptotrema</b> Mont. & Bosch (1855)	
endoxanthellum Zahlbr.	Doidge 1950
<b>Letrouitia</b> Hafellner & Bellem. (1982)	
aureola (Tuck.) Hafellner & Bellem.	Doidge 1950
<i>Bombyliosporo aureola</i> (Tuck.) Zahlbr.	
domingensis (Pers.) Hafellner & Bellem.	Doidge 1950
<i>Bombyliosporo domingensis</i> (Pers.) Zahlbr.	
INC.: <i>Bombyliosporo domingensis</i> var. <i>coloroto</i> Vain.	
<i>Bombyliosporo domingensis</i> var. <i>flavocroceo</i> Zahlbr	
<i>Bombyliosporo domingensis</i> var. <i>gloucotropo</i> Vain.	
<i>Bombyliosporo domingensis</i> var. <i>inexplicato</i> Malme	
<i>Bombyliosporo domingensis</i> var. <i>insperso</i> Steiner	
flavidula (Tuck.) Hafellner	Doidge 1950
<i>Bombyliosporo flavidulo</i> (Tuck.) Zahlbr.	
vulpina (Tuck.) Hafellner & Bellem.	Doidge 1950
<i>Lopodium vulpinum</i> (Tuck.) Zahlbr.	
* <b>Lichenoconium</b> Petr. & Syd. (1927)	
*follmannii S.Y. Kondr. & Galloway	Kondratyuk & Galloway 1995
† <b>Lichenothelia</b> D. Hawksw. (1981)	
†intermedia Henssen	Henssen 1987
†tenuissima Henssen	Henssen 1987
<b>Lichina</b> C. Agardh (1817)	
macrospora Henssen, Budel & Wessels	Henssen et al. 1985
<b>Lichinella</b> Nyl. (1873)	
stipatula Nyl.	Schultz et al. 2009
<b>Lithoglypha</b> Brusse (1988)	
aggregata Brusse	Brusse 1988a
<b>Lithographa</b> Nyl. (1857)	
cerealis Stizenb.	Doidge 1950
fumida Nyl.	Doidge 1950
<b>Lobaria</b> (Schreb.) Hoffm.)	
interversans (Nyl.) Vain.	Doidge 1950
isidiosa (Müll. Arg.) Vain.	Doidge 1950
meridionalis Vain.	Doidge 1950
patinifera (Taylor) Hue	Doidge 1950
pulmonaria (L.) Hoffm.	Doidge 1950, Almborn 1988b
<i>L. pulmonario</i> f. <i>hypomelo</i> (Delise) Cromb.	
<i>L. pulmonario</i> f. <i>popillaris</i> (Delise) Hue	
<i>L. pulmonario</i> f. <i>pleurocorpo</i> Cromb.	
quercizans (Ach.) Michx.	Doidge 1950
retigera (Bory) Trevis.	Doidge 1950, Swinscow & Krog 1988
scrobiculata (Scop.) P. Gaertn.	Doidge 1950
<i>Loborio verrucoso</i> (Huds.) Hoffm.	
<b>Lopadium</b> Körb. (1855)	
woodii (Stizenb.) Zahlbr.	Doidge 1950
<b>Lopezaria</b> Kalb & Hafellner (1990)	
versicolor (Flot.) Kalb & Hafellner	Doidge 1950
<i>Megolosporo versicolor</i> (Flot.) Zahlbr.	
<b>Malmidea</b> Kalb, Rivas Plata & Lumbsch (2011)	
granifera (Ach.) Kalb, Rivas Plata & Lumbsch	Doidge 1950

<i>Lecidea granifera</i> Ach.	
<b>Maronea</b> A. Massal. (1856)	
<i>afralpina</i> Brusse	Brusse 1989b
<i>constans</i> (Nyl.) Hepp	DoIDGE 1950
<i>crassilabra</i> (Müll. Arg.) H. Magn.	DoIDGE 1950
<b>Mazosia</b> A. Massal. (1854)	
<i>melanophthalma</i> (Müll. Arg.) R. Sant.	Brusse 1991c, Farkas 2004
<i>phylloasma</i> (Nyl.) A. Zahlbr.	Santesson 1952
<b>Megalaria</b> Hafellner (1984)	
<i>intermixta</i> (Nyl.) Kalb	DoIDGE 1950
<i>Catillaria intermixta</i> (Nyl.) Arnold	
INC.: <i>C. intermixta</i> f. <i>cyanacentra</i> Zahlbr.	
<b>Megalospora</b> Meyen (1843)	
<i>tuberculosa</i> (Fée) Sipman	DoIDGE 1950
<i>Bombyliaspura tuberculosa</i> (Fée) A. Massal.	
<i>Bombyliaspura tuberculosa</i> f. <i>geatrapa</i> (Stizenb.) Zahlbr.	
<i>Bombyliaspura zuluensis</i> Vain.	
<i>stellenbaschiana</i> (Vain.) Zahlbr.	DoIDGE 1950
<i>Lecidea stellenbaschiono</i> Vain.	
<i>sulphurata</i> Meyen	Galloway 1995, Brusse 1993
INC.: <i>M. sulphurata</i> var. <i>nigricans</i> (Müll. Arg.) Riddle	
<i>tuberculosa</i> (Fée) Sipman	DoIDGE 1950
<i>Bombyliaspura incana</i> A. L. Sm.	
<b>Melampyldium</b> Stirt. ex Müll. Arg. (1894)	
<i>1africana</i> (Zahlbr.) Zahlbr.	DoIDGE 1950
<i>Melampyldium metabalum</i>	
subsp. <i>africanum</i> Zahlbr.	
* <i>Melampyldium metabalum</i> (Nyl.) Müll. Arg. subsp. <i>metabalum</i> has been transferred to <i>Boctrospora</i> .	
<b>Melanelia</b> Essl. (1978)	
<i>panniformis</i> (Nyl.) Essl.	DoIDGE 1950
<b>Melanelixia</b> O. Blanca, et al. (2004)	
<i>fuliginosa</i> (Lamy) O. Blanca et al.	DoIDGE 1950
<i>glabra</i> (Schaer.) O. Blanca et al.	DoIDGE 1950
<b>Melanthea</b> Fée (1837)	
<i>aculea</i> Stizenb.	DoIDGE 1950
<b>Melaspilea</b> Nyl. (1857)	
<i>gemella</i> Nyl.	DoIDGE 1950
<b>Micarea</b> Fr. (1825)	
<i>albornii</i> Cappins	Almborn 1974, Cappins 1999
<i>endavialascens</i> Cappins	Cappins 1999
<i>melaenida</i> (Nyl.) Cappins	Cappins 1999
<i>Catillaria schumannii</i> var. <i>meridionalis</i> Cl. Raux & Vězda	
† <b>Microthelia</b> Kärb. (1855)	
† <i>confluens</i> Müll. Arg.	DoIDGE 1950
<b>Mælleropsis</b> Gyeln. (1939)	
<i>nebulosa</i> (Hoffm.) Gyeln.	Jørgensen 2003
† <b>Mycoporellum</b> Müll. Arg. (1884)	
† <i>lahmii</i> Müll. Arg.	DoIDGE 1950
<b>Myelochroa</b> (Asahina) Elix & Hale (1987)	
<i>aurulenta</i> (Tuck.) Elix & Hale	Hale 1976c
<i>Parmelina aurulenta</i> (Tuck.) Hale	
<i>degelii</i> (Hale) Elix & Hale	Brusse 1988e, Elix & Hale 1987
<i>Hypotrachyna degelii</i> (Hale) Hale	
<i>Parmelia degelii</i> Hale	
<i>perisidians</i> (Nyl.) Elix & Hale	DoIDGE 1950
<i>Parmelia perisidiasa</i> Nyl.	
<b>Neoheppia</b> Zahlbr. (1909)	
<i>brasiliensis</i> Zahlbr.	Budel 1995
<b>Nephrama</b> Ach. (1809)	
<i>africanum</i> Gyeln.	DoIDGE 1950
<i>capense</i> A. Massal.	DoIDGE 1950
<i>cellulosum</i> Ach.	DoIDGE 1950
<i>flavireagens</i> Gyeln.	DoIDGE 1950

helveticum Ach.	Doidge 1950
<i>N. resupinotum</i> Ach. f. <i>helveticum</i> Rabenh.	
laevigatum Ach.	Doidge 1950
tropicum (Müll. Arg.) Zahlbr.	Doidge 1950
<b>Niebla</b> Rundel & Bowler (1978)	
bourgaeana (Mont. ex Nyl.) Rundel & Bowler	Doidge 1950
<i>Romolino bourgaeano</i> Nyl.	
<b>Normandina</b> Nyl. (1855)	
pulchella (Borrer) Nyl.	Doidge 1950, Almborn 1987, Almborn 1988a
<b>Ocellularia</b> G. Mey. (1825)	
capensis Zahlbr.	Doidge 1950
AS: <i>O. copensis</i> var. <i>ferocior</i> Zahlbr.	
<i>O. copensis</i> var. <i>leiothollino</i> Zahlbr.	
cavata (Ach.) Müll. Arg.	Doidge 1950
galactina Zahlbr.	Doidge 1950
henatomma (Ach.) Müll. Arg.	Doidge 1950, Almborn 1974
<b>Ochrolechia</b> A. Massal. (1852)	
africana Vain.	Doidge 1950, Brodo 1991
<sup>1</sup> <i>O. africano</i> Zahlbr. (nom illeg., non Vain.)	
pallescens (L.) A. Massal.	Doidge 1950
parella (L.) A. Massal.	Doidge 1950
<sup>1</sup> Although based on different types, both <i>O. africana</i> Vain. and <i>O. africana</i> Zahlbr. represent the same species, although different chematypes.	
<b>Opegrapha</b> Ach. (1809)	
adpicta Zahlbr.	Doidge 1950
agelaea Fée	Doidge 1950
bacillosa Zahlbr.	Doidge 1950
capensis Müll. Arg.	Doidge 1950
diagraphoides Nyl.	Doidge 1950
diaphorella Stizenb.	Doidge 1950
exiguella Zahlbr.	Doidge 1950
interalbata Nyl.	Doidge 1950
lactifera Zahlbr.	Doidge 1950
lutulenta Nyl.	Egea & Torrente 1996
parvula Nyl.	Doidge 1950
prosodea Ach.	Doidge 1950
AS: <i>O. prosodeo</i> var. <i>microcorpello</i> Zahlbr.	
semiatra Müll. Arg.	Doidge 1950
signatella Vain.	Doidge 1950
tapetica Zahlbr.	Doidge 1950
zanei A. Massal.	Doidge 1950
<b>Pannaria</b> Delise ex Bory (1828)	
capensis J. Steiner	Doidge 1950
centrifuga P.M. Jørg.	Jørgensen 2003
conoplea (Ach.) Bory	Jørgensen 2003
globigera Hue	Jørgensen 2003
hookeri (Borrer) Nyl.	Doidge 1950
lurida (Mont.) Nyl.	Doidge 1950, Swinscow & Krog 1988 Galloway 1995, Jørgensen 2003
planiuscula P.M. Jørg.	Jørgensen 2003
rubiginosa (Thunb. ex Ach.) Delise	Doidge 1950, Almborn 1966, Almborn 1988b, Swinscow & Krog 1988, Jørgensen 2003
<i>P. rubiginoso</i> var. <i>lonuginoso</i> (Hoffm.) Zahlbr.	
<i>P. rubiginoso</i> var. <i>phloeodes</i> Stizenb.	
squamulosa P. M. Jørg.	Jørgensen 2003
tavaresii P. M. Jørg.	Krog 2000, Jørgensen 2003
<b>Paralecanographa</b> Ertz & Tehler (2011)	
grumulosa (Dufour) Ertz & Tehler	Egea & Torrente 1996
<i>Lecanographo grumulo</i> (Dufour) Egea & Torrente	
<b>Parmelia</b> Ach. (1803)	
caffrorum Zahlbr.	Doidge 1950
erumpens Kurok.	Hale 1986
kerguelensis F. Wilson	Hale 1986, Bruse 1988e
oleagina Stizenb.	Doidge 1950
omphalodes (L.) Ach.	Doidge 1950

<i>P. ompholades</i> var. <i>pannifarmis</i> Ach.	
<i>saxatilis</i> (L.) Ach.	Doidge 1950, Brusse 1993
<i>stenophylloides</i> (Müll. Arg.) Vain.	Doidge 1950
<i>sulcata</i> Taylor	Almbarn 1988b
<i>xanthotropa</i> Stirt.	Doidge 1950
<b>Parmeliella</b> Müll. Arg. (1862)	
<i>brisbanensis</i> (C. Knight) P.M. Jørg. & D.J. Galloway	Galloway 1995
<i>Pannaria brisbanensis</i> C. Knight	
<i>coelestina</i> Zahlbr.	Doidge 1950, Jørgensen 1998, Jørgensen 2003
<i>dactylifera</i> P. M. Jørg.	Jørgensen 2003
<i>furfuracea</i> P. M. Jørg.	Jørgensen 2001, Jørgensen 2003
<i>imbricatula</i> (Müll. Arg.) P. M. Jørg.	Jørgensen 2003
<i>lacerata</i> P. M. Jørg.	Jørgensen 1998, Jørgensen 2003
<i>mariana</i> (Fr.) P. M. Jørg. & D. J. Galloway	Galloway 1995
<i>triptophylla</i> (Ach.) Müll. Arg.	Doidge 1950
<i>P. corallinaides</i> (Haffm.) Zahlbr	
<b>Parmelina</b> Hale (1974)	
<i>quercina</i> (Willd.) Hale	Doidge 1950
<i>Parmelia quercina</i> (Willd.) Vain.	
INC.: <i>Parmelio quercina</i> f. <i>cupiseda</i> Vain.	
<i>tiliacea</i> (Haffm.) Hale	Doidge 1950
<i>Parmelia scartea</i> (Ach.) Ach.	
<b>Parmelinella</b> Elix & Hale (1987)	
<i>wallichiana</i> (Taylor) Elix & Hale	Doidge 1950, Hale 1976c
<i>Parmelia junadii</i> J. Steiner	
<i>Parmelina wallichiono</i> (Taylor) Hale	
<b>Parmelinopsis</b> Elix & Hale (1987)	
<i>ectypa</i> (Brusse) DePriest & B.W. Hale	Brusse 1991c, DePriest & B.W. Hale 1998
<i>Parmelia ectype</i> Brusse	Hale 1976c
<i>harrescens</i> (Taylor) Elix & Hale	
<i>Parmelina dissecta</i> (Nyl.) Hale	
<i>Parmelina harrescens</i> (Taylor) Hale	
<i>spatulata</i> (Kurak.) Elix & Hale	Hale 1976c
<i>Parmelina spatulata</i> (Kurok.) Hale	
<i>spumosa</i> (Asahina) Elix & Hale	Hale 1976c
<i>Parmelina spumosa</i> (Asahina) Hale	
<i>subfaticens</i> (Kurak.) Elix & Hale	Hale 1976c
<i>Parmelina subfaticens</i> (Kurak.) Hale	
<b>Parmentaria</b> Fée (1825)	
<i>capensis</i> Zahlbr.	Doidge 1950
<b>Parmotrema</b> A. Massal. (1860)	
<i>abessinicum</i> (Kremp.) Hale	Doidge 1950
<i>Parmelio abessinica</i> Nyl.	
<i>andinum</i> (Müll. Arg.) Hale	Doidge 1950, Almbarn 1988b, Thomas & Bhat 1996
<i>Parmelia andina</i> Müll. Arg.	Almbarn 1988b, Thomas & Bhat 1994
<i>austrosinense</i> (Zahlbr.) Hale	
<i>Parmelia austrosinensis</i> Zahlbr.	
<i>blanchettianum</i> (Müll. Arg.) Kalb	Elix 1993, Elix 1999a
<i>ceptratum</i> (Ach.) Hale	Doidge 1950, Hale & Fletcher 1990
<i>Parmelia ceprata</i> Ach.	
<i>Rimelia ceprata</i> (Ach.) Hale & A. Fletcher	
<i>Parmelio owoniana</i> Stirt.	
INC.: <i>Parmelia ceprato</i> f. <i>ciliata</i> Viaud-Gr.-Mar.	
<i>cammensuratum</i> (Hale) Hale	Brusse 1991c
<i>Rimelia cammensurata</i> Hale & A. Fletcher	
<i>caaperi</i> (J. Steiner & Zahlbr.) Sérus.	Doidge 1950
<i>Parmelia caaperi</i> J. Steiner & Zahlbr.	
<i>crinitum</i> (Ach.) M. Chaisy	Doidge 1950, Almbarn 1988b
<i>Parmelia pilasella</i> Hue	
<i>Parmelia probascideo</i> Taylor	
<i>Parmelia crinita</i> Ach.	
<i>cristiferum</i> (Taylor) Hale	Doidge 1950, Doidge 1950

<i>Parmelia cristifera</i> Taylor	
cryptoxanthum (Abbayes) Hale	Swinscow & Krag 1988
defectum (Hale) Hale	Swinscow & Krag 1988,
<i>Parmelia defecta</i> Hale	Almborn 1991
dilatatum (Vain.) Hale	Almborn 1988b
<i>Parmelia dilatata</i> Vain.	
direagens (Hale) Hale	Swinscow & Krag 1988
eciliatum (Nyl.) Hale	Doidge 1950
<i>Parmelia resupina</i> Stirt.	
eunetum (Stirt.) Hale	Doidge 1950
<i>Parmelia euneta</i> Stirt.	
grayanum (Hue) Hale	Almborn 1988a, Almborn 1988b
hababianum (Gyeln.) Hale	Doidge 1950
<i>Parmelia abessinica</i> var. <i>sorediasa</i> Müll. Arg.	
latissimum (Fée) Hale	Doidge 1950
<i>Parmelia latissima</i> Fée	
macleyanum (Müll. Arg.) Hale	Doidge 1950
<i>Parmelia maclejana</i> Müll. Arg.	
mellissii (C.W. Dodge) Hale	Brusse 1988e
<i>Parmelia mellissii</i> C.W. Dodge	
natalensis J. Steiner & Zahlbr.	Doidge 1950
<i>Parmelia natalensis</i> J. Steiner & Zahlbr.	
nilgherrense (Nyl.) Hale	Doidge 1950
<i>Parmelia nilgherrensis</i> Nyl.	
perforatum (Jacq.) A. Massal.	Doidge 1950
<i>Parmelia perforata</i> (Jacq.) Ach.	
perlatum (Huds.) M. Choisy	Doidge 1950
<i>Parmelia perlata</i> (Huds.) Ach.	
<i>Parmotrema chinense</i> (Osbeck) Hale & Ahti	
( <b>INC.</b> : <i>Parmelia perlata</i> var. <i>ciliata</i> f. <i>sarediifera</i> Müll. Arg.).	
poolii (C. W. Dodge) Krag & Swinscow	Doidge 1950
<i>Parmelia praboscidea</i> var. <i>sarediifera</i> Müll. Arg.	
reticulatum (Taylor) M. Choisy	Doidge 1950, Almborn 1988b,
<i>Parmelia reterimulasa</i> J. Steiner & Zahlbr.	Galloway 1995
<i>Parmelia reticulata</i> Taylor	
<i>Rimelia reticulata</i> (Taylor) Hale & A. Fletcher	
stuhlmannii (C.W. Dodge) Krag & Swinscow	Brusse 1991b
<i>Parmelia stuhlmannii</i> C.W. Dodge	
sulphuratum (Nees & Flot.) Hale	Doidge 1950
<i>Parmelia persulphurata</i> Nyl.	
tinctarum (Despr. ex Nyl.) Hale	Doidge 1950
<i>Parmelia tinctarum</i> Despr. ex Nyl.	
xanthinum (Müll. Arg.) Hale	Nash & Elix 1987
<b>Peccania</b> A. Massal. ex Arnold (1858)	
arabica (Müll. Arg.) Henssen	Schultz et al. 2009
arizonica Herre	Schultz et al. 2009
aff. cerebriformis Henssen & Büdel	Zedda & Rambald 2004
aff. fantequeriana P.P. Morena & Egea	Zedda & Rambald 2004
subnigra (B. de Lesd.) Wetmore	Schultz et al. 2009
<b>Peltigera</b> Willd. (1787)	
africana (Jatta) Swinscow & Krag	Swinscow & Krag 1988
canina (L.) Willd.	Doidge 1950, Almborn 1988b
<b>INC.</b> : <i>P. canina</i> f. <i>leucorrhiza</i> Flörke	
didactyla (With.) J.R. Laundon	Verseghy 1962, Almborn 1966
<i>P. erumpens</i> (Taylor) Lange	
<i>P. hazsiinszkyi</i> Gyeln.	
<i>Peltigera leptaderma</i> Nyl.	
<i>Solarina sorediifera</i> Nyl.	
hymenina (Ach.) Delise	Doidge 1950
<i>P. polydactyla</i> f. <i>hymenina</i> (Ach.) Flot.	
malacea (Ach.) Funck	Doidge 1950
membranacea (Ach.) Nyl.	Doidge 1950
<i>P. canina</i> f. <i>membranacea</i> (Ach.) Duby	
polydactylon (Neck.) Hoffm.	Doidge 1950

<i>P. polydoctylo</i> (Neck.) Hoffm.	
sorediifera (Nyl.) Vitik.	Doidge 1950
<i>Solarino sorediifero</i> Nyl.	
<b>Peltula</b> Nyl. (1853)	
africana (Jatta) Swinscow & Krog	Büdel 1987
bolanderi (Tuck.) Wetmore	Büdel 1987
boletiformis (Hue) Henssen & Büdel	Büdel 1987
clavata (Kremp.) Wetmore	Büdel 1987
coriacea Büdel	Büdel & Henssen 1986, Büdel 1987, Zedda & Rambold 2004
euploca (Ach.) Poelt ex Ozenda & Clauzade	Büdel 1987
farinosa Büdel	Büdel & Lange 1994, Büdel & Nash 2002
impressa (Vain.) Swinscow & Krog	Büdel 1987, Swinscow & Krog 1988
lingulata (Vain.) Swinscow & Krog	Büdel 1987, Swinscow & Krog 1988
marginata Büdel	Büdel 1987
obscurans (Nyl.) Gyeln.	Büdel 1987
<b>AS:</b> <i>P. obscurans</i> var. <i>hossei</i> (Zahlbr.) Wetmore	
patellata (Bagl.) Swinscow & Krog	Schultz et al. 2009
placodizans (Zahlbr.) Wetmore	Büdel 1987
rodriguesii (Cromb.) Büdel	Büdel 1987, Büdel 1989
tortuosa (Nees) Wetmore	Büdel 1987, Swinscow & Krog 1988
umbilicata (Vain.) Swinscow & Krog	Büdel 1987, Swinscow & Krog 1988
<b>†Peridiothelia</b> D. Hawksw. (1985)	
†fuliguncta (Norman) D. Hawksw.	Doidge 1950
<i>Microthelio miculo</i> Körb. (misapplied name)	
<b>Pertusaria</b> DC. (1805)	
amara (Ach.) Nyl.	Doidge 1950
<b>INC.:</b> <i>P. omoro</i> var. <i>copensis</i> J. Steiner	
ambigens (Nyl.) Tuck.	Doidge 1950
aperta Stizenb.	Doidge 1950
casta Zahlbr.	Doidge 1950
chiodectonoides Bagl. ex A. Massal.	Doidge 1950
<i>P. inquinoto</i> (Ach.) Th. Fr.	
coccodes Nyl.	Doidge 1950
commutans Vain.	Doidge 1950
cryptostoma Müll. Arg.	Doidge 1950
diaziana A. Massal.	Doidge 1950
dispersa Vain.	Doidge 1950
duplicata Vain.	Doidge 1950
<i>P. vorioloso</i> Müll. Arg. (non <i>P. vorioloso</i> (Kremp.) Vain.)	
elator Stirt.	Doidge 1950
enterostigmoides Zahlbr.	Doidge 1950
euglypta Tuck.	Doidge 1950
eyelpistia A. Massal.	Doidge 1950
flavens Nyl.	Doidge 1950
flavicunda Tuck.	Doidge 1950
granulata (Ach.) Müll Arg.	Doidge 1950
<b>INC.:</b> <i>P. granuloto</i> var. <i>voriolorioides</i> Flot.	
laevigata Arnold	Doidge 1950
leioplaca DC.	Doidge 1950
<i>P. olpino</i> Hepp.	
<b>INC.:</b> <i>P. leioplaco</i> var. <i>pyncocorpo</i> Nyl.	
leioplacella Nyl.	Doidge 1950
leonina Stizenb.	Doidge 1950, Almborn 1988b
leucosoroides Nyl.	Doidge 1950
limosa Zahlbr.	Doidge 1950
melanospora Nyl.	Doidge 1950
multiplicans Vain.	Doidge 1950
nivea G. Merr.	Doidge 1950
orbiculata (Schreb.) Zahlbr.	Doidge 1950
pustulata (Ach.) Duby	Doidge 1950
<i>P. meloleuco</i> (Turn. & Borr.) Duby	

spaniostoma Vain.	Doidge 1950
subdealbata Nyl.	Doidge 1950
subvelatula Vain.	Doidge 1950
thiostoma Nyl.	Doidge 1950
trypetheliiformis Nyl.	Doidge 1950
velata (Turner) Nyl.	Doidge 1950
vepallida Nyl.	Doidge 1950
wawreana A. Massal.	Doidge 1950
wawreanoides Nyl.	Doidge 1950
wilmsii Stizenb.	Doidge 1950
xanthomelaena Müll Arg.	Doidge 1950
<b>*Phacopsis Tul. (1852)</b>	
*australis Aptroot & Triebel	Aptroot & Triebel 2002
*falcispora Triebel & Rambold (var. falcispora)	Triebel et al. 1995
*oxyspora (Tulasne) Triebel & Rambold	Triebel et al. 1995
AS: <i>Phacopsis oxyspora</i> var. <i>fusco</i> Triebel & Rambold	
<b>Phaeographina Müll. Arg. (1882)</b>	
caesiopruinosa (Fée) Müll. Arg.	Doidge 1950
limbata Müll. Arg.	Doidge 1950
subfarinacea (Nyl.) Zahlbr.	Doidge 1950
<b>Phaeographis Müll. Arg. (1882)</b>	
conjungens Zahlbr.	Doidge 1950
cryptica Zahlbr.	Doidge 1950
inusta (Ach.) Müll. Arg.	Doidge 1950
INC.: <i>P. inusta</i> var. <i>emergens</i> Vain.	
mesographa Müll. Arg.	Doidge 1950
<b>Phaeophyscia Moberg (1977)</b>	
adiostola (Essl.) Essl.	Moberg 2004
ciliata (Körb.) Moberg	Doidge 1950
<i>Physcio obscuro</i> (Ehrh.) Hampe ex Füllnr.	
confusa Moberg	Moberg 2004
endococcina (Körb.) Moberg	Doidge 1950, Moberg 2004
<i>Physcio endococcino</i> (Körb.) Nyl.	
fumosa Moberg	Moberg 2004
hirsuta (Mereschk.) Essl.	Thomas & Bhat 1996, Moberg 2004
hispidula (Ach.) Essl.	Doidge 1950, Moberg 2004
AS: <i>Physcio setoso</i> (Ach.) Nyl.	
INC.: <i>Physcio setoso</i> f. <i>deminuto</i> Cromb.	
<i>Physcio setoso</i> f. <i>virello</i> B.deLesd.	
orbicularis (Neck.) Moberg	Doidge 1950, Moberg 2004
AS: <i>Physcio obscuro</i> var. <i>gloucovirens</i> Zahlbr.	
<b>Phyctella Kremp. (1876)</b>	
andensis Nyl.	Doidge 1950
capillaris (Stirt.) Stizenb.	Doidge 1950
<b>Phyctidia Müll. Arg. (1895)</b>	
boliviensis (Nyl.) Müll. Arg.	Doidge 1950
<b>Phyctis (Wallr.) Flot. (1850)</b>	
argena Flot.	Doidge 1950
candida Zahlbr.	Doidge 1950
<b>Phyllopsora Müll. Arg. (1894)</b>	
albicans Müll. Arg.	Timdal & Krog 2001
breviuscula (Nyl.) Müll. Arg.	Doidge 1950
corallina (Eschw.) Müll. Arg.	Doidge 1950, Timdal & Krog 2001, Almborn 1988a, Almborn 1988b, Galloway 1995
INC: var. <i>ochroxantho</i> (Nyl.) Brako	
<i>Lecideo ochroxantho</i> Nyl.	
<i>Lecideo ochroxantho</i> f. <i>oethiopico</i> Stizenb.	
furfuracea (Pers.) Zahlbr.	Timdal & Krog 2001
nemoralis Timdal & Krog	Timdal & Krog 2001
pannosa Müll. Arg.	Brusse 1989e
<i>P. hoemophoe</i> sensu Brusse 1988e	
parvifolia (Pers.) Müll. Arg.	Doidge 1950
INC.: <i>P. parvifolia</i> var. <i>fibrillifero</i> (Nyl.) Müll. Arg.	
<i>P. parvifolia</i> var. <i>pulvinoto</i> J. Steiner	
parvifoliella (Nyl.) Müll. Arg.	Doidge 1950

thaleriza (Stirt.) Gotth. Schneider <i>Lecidea thaleriza</i> Stirt.	Doidge 1950, Swinscow & Krog 1988
<b>Physcia</b> (Schreb.) Michx. (1803)	
adscendens (Fr.) H. Olivier	Doidge 1950, Moberg 2004
affixa Nyl.	Doidge 1950
aipalia (Ehrh. ex Humb.) Fűrnr.	Doidge 1950
albata (F. Wilson) Hale	Moberg 2004
alnophila (Vain.) Låht., Moberg, Myllys & Tehler <i>Physcia aipalia</i> var. <i>alnophila</i> Vain.	Doidge 1950
astrostriata Moberg	Moberg 2004
biziana (A. Massal.) Zahlbr.	Almbarn 1988a, Almbarn 1988b, Moberg 2004
caesia (Haffm.) Hampe ex Fűrnr.	Doidge 1950
clementei (Turner) Lyngæ <i>Physcia clementiana</i> J. Kickx f.	Doidge 1950
crispa (Pers.) Nyl. <b>INC.:</b> <i>Physcia crispa</i> f. <i>melanophthalma</i> Vain.	Doidge 1950
dearticata Moberg	Moberg 2004
dilatata Nyl.	Doidge 1950
dimidiata Nyl.	Doidge 1950
dubia (Haffm.) Lettau	Brusse 1988e
endachrysea Hampe	Doidge 1950
erumpens Moberg	Moberg 2004
erythracardia Vain.	Doidge 1950
integrata Nyl. <b>INC.:</b> <i>Physcia integrata</i> var. <i>abessa</i> Vain.	Doidge 1950, Moberg 2004
jackii Moberg	Moberg 2004
krægiæ Moberg	Moberg 2004
pancinsii Hue	Moberg 2004
stellaris (L.) Nyl.	Doidge 1950, Almbarn 1988b, Thomas & Bhat 1994
tribacea (Ach.) Nyl.	Brusse 1988e, Moberg 2004
tribacoides Nyl.	Doidge 1950, Moberg 2004
undulata Moberg	Moberg 2004
venustula Stizenb.	Doidge 1950
<sup>1</sup> zuluensis Vain.	Doidge 1950
<sup>2</sup> Nom invalid : ICNArt. 32.1c.	
<b>Physciella</b> Essl. (1986)	
chlaantha (Ach.) Essl. <i>Physcia abscura</i> var. <i>chlaantha</i> (Ach.) Rabenh.	Doidge 1950
<b>Physconia</b> Pæelt (1965)	
distarta (With.) J.R. Laundon <i>Physcia pulverulenta</i> (Schreb.) Hampe	Doidge 1950
grisea (Lam.) Pæelt	Brusse 1988e
<b>Phyma</b> A. Massal. (1854)	
byrsaemum (Ach.) Tuck.	Galloway 1995
byrsinum (Ach.) Müll. Arg.	Doidge 1950
allicarpum Hue	Doidge 1950
<b>Pilophorus</b> Th. Fr. (1857)	
aciculare (Ach.) Th. Fr. <i>Pilapharan aciculare</i> (Ach.) Nyl.	Doidge 1950
<b>Placidium</b> A. Massal. (1855)	
acarasparoides (Zahlbr.) Breuss <i>Catapyrenium acarasparoides</i> (Zahlbr.) J.W. Thamsan <i>Heteraplacidium acarasparoides</i> (Zahlbr.) Breuss	Breuss 1993
kaernefeltii (Breuss) Breuss <i>Catapyrenium kaernefeltii</i> (Breuss) Breuss	Breuss 1993
semaforanense (Breuss) Breuss	Zedda & Rambald 2004
squamulosum (Ach.) Breuss <i>Catapyrenium squamulosum</i> (Ach.) Breuss	Breuss 1993, Breuss 1995, Zedda & Rambald 2004
tenellum (Breuss) Breuss <i>Catapyrenium tenellum</i> Breuss	Breuss 1993, Zedda & Rambald 2004
<b>Placopsis</b> (Nyl.) Linds. (1866)	
gelida (L.) Linds.	Almbarn 1988b

<b>Placynthiopsis</b> Zahlbr. (1932)	
<i>africana</i> Zahlbr.	Doidge 1950
<b>Platismatia</b> W.L. Culb. & C.F. Culb. (1968)	
<i>glauca</i> (L.) W. L. Culb. & C. F. Culb.	Kärnefelt 1987b, Almborn 1991
† <b>Pleurotrema</b> Müll. Arg. (1885)	
† <i>trichosporum</i> Müll Arg.	Doidge 1950
† <i>uniseriale</i> (Zahlbr.) D. Hawksw.	Doidge 1950
<i>Microthelio uniseriolis</i> Zahlbr.	
<i>Anisomeridium uniseriale</i> (Zahlbr.) R.C. Harris	
<b>Poeltiaria</b> Hertel (1984)	
<i>corralensis</i> (Räsänen) Hertel	Brusse 1988e
<i>Porpidio corralensis</i> (Räsänen) Brusse	
<i>howickensis</i> (Vain.) Rambold & Haiduk	Doidge 1950
<i>Lecidea howickensis</i> Vain.	
<i>turgescens</i> (Körb.) Hertel	Brusse 1989d
<i>Porpidio turgescens</i> (Körb.) Brusse	
<i>urbanskyana</i> (Zahlbr.) Hertel	Brusse 1989c
<i>Porpidio urbanskyana</i> (Zahlbr.) Brusse	
<b>Polyblastiopsis</b> Zahlbr. (1903)	
<i>alba</i> (Müll. Arg.) Zahlbr.	Doidge 1950
<i>transvaalensis</i> (Müll. Arg.) Zahlbr.	Doidge 1950
<b>Polychidium</b> (Ach.) Gray (1821)	
<i>dendriscum</i> (Nyl.) Henssen	Brusse 1988e
<b>Porina</b> Ach. (1809)	
<i>albella</i> Müll. Arg.	Doidge 1950
<i>balanina</i> Brusse	Brusse 1986b
<i>chlorotica</i> (Ach.) Müll. Arg.	Doidge 1950
<i>Bocidio luteolo</i> f. <i>chlorotico</i> (Ach.) Zahlbr.	
<i>dwesica</i> Brusse & Dickinson	Brusse & Dickinson 1991, Farkas 2004
<i>epiphylla</i> (Fée) Fée (var. <i>epiphylla</i> )	Santesson 1952, Lücking & Vězda 1998, Farkas 2004
<i>epiphyloides</i> Vězda	Farkas, 2004
<i>euryspermum</i> Zahlbr.	Doidge 1950
<i>fulvella</i> Müll. Arg.	Santesson 1952, Farkas 2004
<i>mitatrix</i> Müll. Arg.	Santesson 1952, Farkas 2004
<i>knysnana</i> Zahlbr.	Doidge 1950
<i>mazosioides</i> Lücking & Vězda	Farkas, 2004
<i>nitidula</i> Müll. Arg.	Brusse 1988e, Farkas, 2004
<i>palmicola</i> Malcolm & Vězda	Farkas, 2004
<i>tetracerae</i> (Ach.) Müll Arg.	Doidge 1950
<i>trichothelioides</i> R. Sant.	Brusse 1991b, Farkas 2004
<i>variegata</i> Fée	Doidge 1950
<b>Porocyphus</b> Körb. (1855)	
<i>effiguratus</i> Henssen	Henssen et al. 1985
<b>Porpidia</b> Körb. (1855)	
<i>albocaerulescens</i> (Wulfen) Hertel & Knoph	Doidge 1950
<i>Lecideo albocaerulescens</i> (Wulf.) Ach.	
<i>crustulata</i> (Ach.) Hertel & Knoph.	Doidge 1950, Doidge 1950
<i>Lecideo crustulato</i> Ach.,	
<i>Lecideo meiosporo</i> Nyl.	
<i>flavicunda</i> (Ach.) Gowan	Doidge 1950
<i>Lecideo albocaerulescens</i> var. <i>flovocaerulescens</i> (Hornem.) Schaer.	
<i>soredizodes</i> (Lamy) J. R. Laundon	Brusse 1993
<i>speirea</i> (Ach.) Kremp.	Doidge 1950
<i>Lecideo speireo</i> (Ach.) Ach.	
<b>Protoparmelia</b> M. Choisy (1929)	
<i>badia</i> (Hoffm.) Hafellner	Doidge 1950
<i>Leconoro bodio</i> var. <i>cineroscens</i> Flot.	
<b>Psathyrophlyctis</b> Brusse (1987)	
<i>serpentaria</i> Brusse	Brusse 1987c
<b>Pseudocyphellaria</b> Vain. (1890)	
<i>argyracea</i> (Delise) Vain.	Doidge 1950

<i>Sticta argyrocea</i> Delise.	
<b>INC.:</b> <i>Sticta argyrocea</i> f. <i>rigidula</i> Zahlbr.	
<i>Sticta argyrocea</i> var. <i>aspera</i> Kremp.	
<i>Sticta argyrocea</i> var. <i>flavescens</i> Zahlbr.)	
aurata (Ach.) Vain.	Doidge 1950, Almbarn 1988a,
<i>Sticta aurata</i> Ach.	Almbarn 1988b
<b>INC.:</b> <i>Sticta aurata</i> var. <i>pallens</i> Nyl.	
carpaloma (Delise) Vain.	Doidge 1950
<i>Sticta carpaloma</i> var. <i>albacyphellata</i> Nyl.	
clathrata (De Not.) Malmé	Doidge 1950
<i>Sticta clathrata</i> DeNot.	
<b>INC.:</b> <i>Sticta clathrata</i> var. <i>subhirsuta</i> Vain. ex Van der Byl	
crocata (L.) Vain.	Doidge 1950, Almbarn 1988a
<i>Sticta crocata</i> (L.) Ach.	
<b>INC.:</b> <i>Sticta crocata</i> var. <i>isidalia</i> Gyeln.	
caranata (Müll. Arg.) Malmé	Doidge 1950, Galloway 1995
<i>Sticta endachrysea</i> Delise	
gilva (Ach.) Malmé	Doidge 1950
<i>Sticta gilva</i> Ach.	
<b>INC.:</b> <i>Sticta gilva</i> var. <i>angustilobata</i> Gyeln.	
<i>Sticta gilva</i> var. <i>lanata</i> Gyeln.	
<i>Sticta gilva</i> var. <i>pseudogilva</i> Gyeln.	
intricata (Delise) Vain.	Doidge 1950
<i>Sticta intricata</i> Delise	
<b>INC.:</b> <i>Sticta intricata</i> var. <i>hesseana</i> Zahlbr.	
maugeotiana (Delise) Vain.	Doidge 1950
<i>Sticta maugeotiana</i> Delise	
<b>INC.:</b> <i>Sticta maugeotiana</i> var. <i>aurigera</i> Nyl.	
norvegica (Gyeln.) P. James	Doidge 1950
<i>Sticta thoursii</i> Delise	
* <i>Pseudonitschkia</i> Coppins & S.Y. Kondr. (1995)	
* <i>parmatrematis</i> Coppins & S.Y. Kondr.	Coppins & Kondratyuk 1995
<b>Pseudoparmelia</b> Lynge (1914)	
chapidensis (Lynge) Hale	Elix & Nash 1997
chlarea (Stizenb.) Krog & Swinscow	Doidge 1950, Doidge 1950,
<i>Parmelia chlarea</i> Stizenb.	Elix & Nash 1997
<i>Parmelia subschenkiana</i> Gyeln.	
convexa Elix & T.H. Nash	Elix & Nash 1997
uleana (Müll. Arg.) Elix & T.H. Nash	Elix & Nash 1997
<b>Pseudopyrenula</b> Müll. Arg. (1883)	
papulosa (Nyl.) Müll Arg.	Doidge 1950
<b>Psora</b> Hoffm. (1796)	
cf. <i>cerebriformis</i> W.A. Weber	Zedda & Rambald 2004
crenata (Taylor) Reinke	Doidge 1950,
<i>Lecidea crenata</i> (Tayl.) Stizenb.	Zedda & Rambald 2004
<b>INC.:</b> <i>Lecidea crenata</i> var. <i>caraniformis</i> (Kremp.) Zahlbr.	
<i>Lecidea crenata</i> var. <i>speirea</i> (Tayl.) Zahlbr.	
deceptaria (Nyl.) Flagey	Doidge 1950
<i>Lecidea deceptaria</i> Nyl.	
decipiens (Hedw.) Hoffm.	Doidge 1950, Almborn 1988b
<i>Lecidea decipiens</i> (Hedw.) Ach.	
<b>Psoroma</b> Ach. ex Michx. (1803)	
asperellum Nyl.	Doidge 1950, Jørgensen 2003
fruticulosum P. James & Henssen	Jørgensen 2003
sphinctrinum (Mant.) Nyl.	Doidge 1950
<b>Psorotheciopsis</b> Rehm (1900)	
patellariaoides (Rehm) R. Sant.	Farkas 2004
<b>Pterygiopsis</b> Vain. (1890)	
convexa Henssen, Budel & Wessels	Henssen et al. 1985
melanophthalma Henssen, Budel & Wessels	Henssen et al. 1985
submersa Budel, Henssen & Wessels	Henssen et al. 1985
<b>Punctelia</b> Krag (1982)	
barreri (Sm.) Krag	Doidge 1950, Doidge 1950

<i>Pormelio oleurizo</i> Vain. ex Lynge	
<i>Pormelio borrieri</i> (Sm.) Turner	
<i>Pormelio insignito</i> Stizenb	
<i>Pormelio subaequans</i> Nyl.	
constantimontium Sérus.	Swinscow & Krog 1988
rudecta (Ach.) Krog	Doidge 1950, Doidge 1950
<i>Pormelio rudecto</i> Ach.	
<i>Pormelio toxodes</i> Stirt.	
stictica (Delise ex Duby) Krog	Doidge 1950
<i>Pormelia borrieri</i> var. <i>stictico</i> Delise ex Duby	
subrudecta (Nyl.) Krog	Doidge 1950
<i>Pormelio bylilii</i> Vain. ex Lynge	
<i>Pormelio subrudecto</i> Nyl.	
<b>Pyrenopsis</b> (Nyl.) Nyl. (1858)	
mackenziei T.A. Jones	Doidge 1950
<b>Pyrenowilmsia</b> R.C. Harris & Aptroot (1991)	
ferruginosa (Müll. Arg.) Aptroot	Doidge 1950
<i>Porino ferruginoso</i> Müll. Arg.	
<b>Pyrenula</b> Ach. (1814)	
aspistea (Afzel. ex Ach.) Ach.	Doidge 1950
cinerea Zahlbr.	Doidge 1950
knightiana Müll. Arg.	Doidge 1950
laevigata (Pers.) Arnold	Doidge 1950
AS: <i>Pyrenulo loevigato</i> var. <i>incuso</i> (Flot.) Zahlbr.	
mamillana (Ach.) Trevis.	Doidge 1950
<i>P. morginoto</i> Hook.	
mastophora (Nyl.) Müll. Arg.	Doidge 1950
nitida (Schrad.) Ach.	Doidge 1950
nitidella (Flörke ex Schaer.) Müll. Arg.	Doidge 1950
obtectata G. Merr.	Doidge 1950
pinguis Fée	Doidge 1950
<i>P. emergens</i> (Müll. Arg.) Vain.	
AS: <i>P. pinguis</i> var. <i>emergens</i> (Müll. Arg.) Müll. Arg.	
pyrenuloides (Mont.) R.C. Harris	Doidge 1950
<i>Anthrothecium pyrenuloides</i> (Mont.) Müll. Arg.	
subducta (Nyl.) Müll. Arg.	Doidge 1950
subglabruscula Vain.	Doidge 1950
AS: <i>P. subglabrusculo</i> Vain. var. <i>notolensis</i> Vain.	
transparens Zahlbr.	Doidge 1950
wilmsiana Müll. Arg.	Doidge 1950
<b>Pyxine</b> Fr. (1825)	
berteriana (Fée) Imshaug	Doidge 1950
<i>P. meisssneri</i> Tuck.	
cocoes (Sw.) Nyl.	Doidge 1950, Moberg 2004
eschweileri Vain.	Doidge 1950
nubila Moberg	Moberg 2004
obscurascens Malme	Moberg 2004
petricola Nyl.	Doidge 1950, Moberg 2004
<i>P. endoleuco</i> (Müll. Arg.) Vain.	
reticulata (Vain.) Vain.	Brusse 1988e
sorediata (Ach.) Mont.	Moberg 2004
subcinerea Stirt.	Moberg 2004
<b>Ramalina</b> Ach. (1809)	
angulosa Laurer	Doidge 1950
arabum (Dill. ex Ach.) Meyen & Flot.	Doidge 1950
arbuscula Stizenb.	Doidge 1950
aspera Räsänen	Thomas & Bhat 1994
attenuata (Pers.) Tuck.	Verseghy 1962
calicaris (L.) Röhl.	Doidge 1950
capensis Th. Fr.	Fries 1861,
	Jürgens & Niebel-Lohmann 1995
celastri (Spreng.) Krog & Swinscow	Doidge 1950, Galloway 1995,
<i>Pormelio celostris</i> Spreng.	Thomas & Bhat 1994
<i>R. yemensis</i> var. <i>membronoceo</i> (Laurer) Nyl.	

<i>R. yemensis</i> var. <i>tenuissima</i> (Meyen & Flat.) Zahlbr.	
complanata (Sw.) Ach.	Daïdige 1950, Versegghy 1962
<b>INC.:</b> <i>R. complanata</i> v <i>paraguayensis</i> (Gyeln.) Szatala	
cuspidata (Ach.) Nyl.	Daïdige 1950
<b>INC.:</b> <i>R. cuspidata</i> f. <i>implexa</i> H. Olivier	
denticulata (Eschw.) Nyl.	Daïdige 1950
ecklanii (Spreng.) Meyen & Flat.	Daïdige 1950, Almbarn 1960
<i>R. yemensis</i> var. <i>ecklanii</i> (Spreng.) Vain	
farinacea (L.) Ach.	Daïdige 1950
fastigiata Ach.	Daïdige 1950
fraxinea (L.) Ach.	Daïdige 1950
gracilis (Pers.) Nyl.	Daïdige 1950
<i>R. filicaulis</i> G.N. Stevens	
<i>R. exiguella</i> Stirt. (Australia records)	
inflata (Hoak. f. & Taylor) Haak. f. & Taylor	Daïdige 1950
<i>R. geniculata</i> Haak. f. & Tayl.	
inflata subsp. <i>perpusilla</i> (Stirt.) G.N. Stevens	Daïdige 1950
<i>R. geniculata</i> var. <i>alivacea</i> Müll. Arg.	
intermedia (Delise ex Nyl.) Nyl.	Daïdige 1950
lacera (With.) J.R. Laundon	Daïdige 1950
<i>R. duriaei</i> Jatta	
lanceolata Nyl.	Daïdige 1950
linearis Ach.	Daïdige 1950
<i>R. celastri</i> (Spreng.) Krog & Swinscaw (Australia records)	
melananthrix Laurer	Nylander 1860, Daïdige 1950, Rundel & Bawler 1974
peruviana Ach.	Daïdige 1950, Versegghy 1962, Brusse 1988e
<i>R. forinoceo</i> var. <i>squarrosa</i> Müll. Arg., ? <i>R. dendriscaides</i> Nyl.	
pallinaria Ach.	Daïdige 1950
<b>INC.:</b> <i>R. pallinaria</i> f. <i>cariosa</i> Laur.	
pratensa (Nyl.) Zahlbr.	Versegghy 1962
pusilla Le Prévast	Daïdige 1950
<i>R. inflata</i> subsp. <i>australis</i> G.N. Stevens (Australia records)	
reducta Krag & Swinscaw	Krag & Swinscaw 1976
raesleri (Hachst. ex Schaer.) Nyl.	Versegghy 1962
siliquosa (Huds.) A.L. Sm.	Daïdige 1950
<i>R. scopularum</i> Ach.	
<i>R. scopularum</i> var. <i>cornuto</i> Ach.	
<i>R. scopularum</i> var. <i>humilis</i> Schaer.	
subasperata Nyl.	Versegghy 1962
subfraxinea Nyl.	Daïdige 1950
tenella Müll. Arg.	Brusse 1988e
usnea (L.) R. Howe	Daïdige 1950
<b>INC.:</b> <i>R. usnea</i> var. <i>capensis</i> (Nyl.) Zahlbr.	
<i>R. usnea</i> var. <i>cantorta</i> (Flat.) Zahlbr.	
yemensis (Ach.) Nyl.	Daïdige 1950
<b>INC.:</b> <i>R. yemensis</i> f. <i>fenestralis</i> Stizenb.	
<i>R. yemensis</i> f. <i>sublinearis</i> Nyl.	
<b>Ramboldia</b> Kantvilas & Elix (1994)	
russula (Ach.) Kalb, Lumbsch & Elix	Daïdige 1950
<i>Lecidea russula</i> Ach	
sanguinolenta (Kremp.) Kalb, Lumbsch & Elix	Brusse 1991c
<i>Pyrrhospara sanguinolenta</i> (Kremp.) Rambold & Hafellner	
<b>Relicina</b> (Hale & Kurak.) Hale (1974)	
limbata (Laurer) Hale	Daïdige 1950
<i>Parmelia sphaeraspara</i> Nyl.	
<i>Pseudoparmelia sphaeraspara</i> (Nyl.) Hale	
planiuscula (Kaurak.) Hale	Elix 1999a
<b>Rhizocarpon</b> Ramond ex DC. (1805)	
affine G. Merr.	Daïdige 1950
badioatrum (Flörke ex Spreng.) Th. Fr.	Daïdige 1950

<i>AS: Rhizocarpon badiastrum</i> var. <i>albastrum</i> Malme (nom. rejic. 56.1)	
capense Zahlbr.	Doidge 1950
disporum (Nägeli ex Hepp) Müll. Arg.	Doidge 1950
<i>R. disparum</i> var. <i>mantagnei</i> (Flot.) Zahlbr.	
geographicum (L.) DC.	Doidge 1950, Almborn 1988b
<b>INC.:</b> <i>R. geographicum</i> f. <i>atravirens</i> A. Massal.	
<i>R. geographicum</i> f. <i>intermedium</i> (Stizenb.) Zahlbr.	
lecanorinum Anders	Feuerer 2013
patellarium (Stizenb.) Zahlbr.	Doidge 1950
reductum Fr.	Feuerer 2013
<i>R. obscuratum</i> auct non (Ach.) A. Massal.	
superficiale (Schaer.) Vain.	Brusse 1991b
viridiatrum (Wulfen) Körb.	Doidge 1950
<i>Buellia viridiatra</i> (Wulfen) H. Olivier	
<sup>3</sup> Nom invalid : ICNArt. 38.1.	
<b>Rinodina</b> (Ach.) Gray (1821)	
albocincta Zahlbr.	Doidge 1950
capensis Hampe	Doidge 1950
confragulosa Müll. Arg.	Doidge 1950
deminutula (Stizenb.) Zahlbr.	Doidge 1950
detecta (Stizenb.) Zahlbr.	Doidge 1950
exigua (Ach.) S. F. Gray	Doidge 1950
exiguella (Vain.) H. Magn.	Doidge 1950
<i>Lecidea exiguella</i> Vain.	
ficta (Stizenb.) Zahlbr.	Doidge 1950
huefferiana Müll. Arg.	Doidge 1950
microlepida Müll. Arg.	Doidge 1950
roboris Arnold	Doidge 1950
sophodes A. Massal.	Doidge 1950
<b>INC.:</b> <i>Rinodina sophades</i> var. <i>atraalbida</i> (Nyl.) Zahlbr.	
reagens Matzer & H. Mayrhofer	Matzer & H. Mayrhofer 1994
teichophiloides (Stizenb.) Zahlbr.	Doidge 1950
<b>Roccella</b> DC. (1805)	
arnoldii Vain.	Almborn 1988b, Galloway 1995
capensis Follm.	Follmann et al. 1994
fuciformis (L.) Lam. & DC.	Doidge 1950
montagnei Bél.	Doidge 1950
<i>R. linearis</i> var. <i>guineensis</i> Vain.	
<i>R. linearis</i> var. <i>primaria</i> Vain.	
phycopsis Ach.	Doidge 1950
<i>R. fucoides</i> (Dicks.) Vain.	
<i>R. tinctoria</i> DC.	
<b>Roccellina</b> Darb. (1898)	
hypomecha (Ach.) Tehler	Doidge 1950, Almborn 1988a,
<i>Roccella hypomecha</i> (Ach.) Bory	Almborn 1988b, Follmann et al. 1994
<b>INC.:</b> <i>Roccella hypomecha</i> var. <i>benguellensis</i> (Welw.) Vain.	
<b>Roccellographa</b> J. Steiner (1902)	
circumscripta (Taylor) Ertz & Tehler	Egea & Torrente 1996
<i>Sclerophyton circumscriptum</i> (Leight.) Zahlbr.	
<b>Ropalospora</b> A. Massal. (1860)	
lugubris (Sommerf.) Poelt	Doidge 1950
<i>Bacidia lugubris</i> (Sommerf.) Zahlbr.	
<b>Sarcographa</b> Fée (1825)	
disjectans (Nyl.) Zahlbr.	Doidge 1950
<b>Sarcogyne</b> Flot. (1851)	
regularis Körb.	Feuerer 2013
<b>Schaereria</b> Körb. (1855)	
fuscocinerea (Nyl.) Clauzade & Cl. Roux	Hertel 2001
<b>Schismatomma</b> Flot. & Körb. ex A. Massal. (1852)	
septenarium (Stizenb.) Zahlbr.	Doidge 1950
<b>Schizodiscus</b> Brusse (1988)	
afroalpinus Brusse	Brusse 1988c

<b>Schistoplaca</b> Brusse (1987)	
<i>alvearialis</i> Brusse	Brusse 1987g
<b>Siphula</b> Fr. (1831)	
<i>ceratites</i> (Wahlenb.) Fr.	Doidge 1950
<i>decumbens</i> Nyl.	Doidge 1950
<i>S. toruloso</i> (Thunb. ex Ach.) Nyl.	
<i>dregei</i> ( <i>nomen nudum</i> )	Doidge 1950
<i>flavovirens</i> Kantvilas, Zedda & Elix	Zedda & Rambold 2004
<i>incrustans</i> Vain.	Doidge 1950
<i>minor</i> Vain.	Doidge 1950
<i>verrucigera</i> (J. F. Gmel.) R. Sant.	Almborn 1987, Almborn 1988b,
<i>S. tabularis</i> (Thunb. ex Ach.) Nyl.	Galloway 1995, Doidge 1950
<b>Solorina</b> Ach. (1808)	
<i>simensis</i> Flot.	Almborn 1987, Almborn 1988b
<b>Sphaerophorus</b> Pers. (1794)	
<i>globosus</i> (Huds.) Vain.	Brusse 1991b
<b>Sphinctrina</b> Fr. (1825)	
<i>anglica</i> Nyl	Doidge 1950
<i>S. microcephala</i> (Sm.) Nyl.	
<i>fuscescens</i> Nyl.	Doidge 1950
<i>meridionalis</i> Stizenb.	Doidge 1950
<i>turbinata</i> (Pers.) De Not	Doidge 1950
<i>S. gelasinoto</i> (With.) Zahlbr.	
<b>Sporopodium</b> Mont. (1851)	
<i>xanthleucum</i> (Müll. Arg.) Zahlbr.	Brusse 1991b, Farkas 2004
<b>Squamarina</b> Poelt (1958)	
<i>cartilaginea</i> (With.) P. James	Galloway 1995
<b>Staurothele</b> Norman (1853)	
<i>clopima</i> (Wahlenb.) Th. Fr.	Doidge 1950
<b>Stegobolus</b> Mont. (1845)	
<i>austroafricanus</i> Frisch	Frisch & Kalb 2006
<i>wrightii</i> (Tuck.) Frisch	Brusse 1991c
<i>Thelotremo wrightii</i> Tuck.	
<b>Stereocaulon</b> Hoffm. (1796)	
<i>atlanticum</i> (I.M. Lamb) I.M. Lamb	Almborn 1987
<i>claviceps</i> Th. Fr.	Swinscow & Krog 1988
<i>corticatum</i> Nyl.	Almborn 1987, S�erusiaux 1979,
<i>delisei</i> Bory ex Duby	Swinscow & Krog 1988
<i>esterhuyseniae</i> I.M. Lamb	Almborn 1987,
<i>meyeri</i> Stein	Almborn 1987,
<i>ramulosum</i> Raesch.	Swinscow & Krog 1988
<i>S. proximum</i> Nyl.	Doidge 1950
<b>Sticta</b> (Schreb.) Ach. (1803)	
<i>ambavillaria</i> Ach.	Doidge 1950
<i>damicornis</i> (Sw.) Ach.	Doidge 1950
<i>fuliginosa</i> (Dicks.) Ach.	Doidge 1950, Almborn 1988b
<i>hornemanni</i> Fr.	Doidge 1950
<i>limbata</i> Ach.	Doidge 1950
<i>subcrocata</i> Gyeln.	Doidge 1950
<i>sublimbata</i> (J. Steiner) Swinscow & Krog	Doidge 1950
<i>S. weigelii</i> var. <i>sublimbata</i> J. Steiner	
<i>sylvatica</i> Ach.	Doidge 1950
<i>tomentosa</i> (Sw.) Ach.	Doidge 1950
<i>variabilis</i> (Bory) Ach.	Doidge 1950
<i>weigelii</i> (Ach.) Vain.	Doidge 1950
<b>Strigula</b> Fr. (1823)	
<i>actinoplacoides</i> Vain.	Doidge 1950
<i>africana</i> Vain.	Doidge 1950
<i>argyronema</i> M�ull Arg.	Doidge 1950

maculata (Cooke & Masee) R. Sant.	Bruse 1988e
nemathora Mont. (var. nemathora)	Santesson 1952, Farkas 2004
nitidula Mont.	Bruse 1991c, Farkas 2004
obducta (Müll. Arg.) R.C. Harris	Santesson 1952, Farkas 2004
orbicularis Fr.	Doidge 1950, Santesson 1952, Farkas 2004
<i>Strigulo complonoto</i> (Fée) Mont.	
INC.: <i>Strigulo complonoto</i> var. <i>virescens</i>	
pallida Kalchbr.	Doidge 1950
phyllogena (Müll. Arg.) R.C. Harris	Bruse 1991b
<i>Porino phyllogeno</i> Müll Arg.	
smaragdula Fr.	Doidge 1950, Alborn 1988b, Santesson 1952, Farkas 2004
<i>Strigulo elegans</i> (Fée) Müll Arg.	
INC.: <i>Strigulo elegans</i> var. <i>stelloto</i> (Nyl. & Cromb.) R. Sant.	
subtilissima (Fée) Müll. Arg.	Bruse 1988e
<sup>1</sup> Not in Index Fungorum.	
<b>Synalissa</b> Fr. (1825)	
austroafricana Zahlbr.	Doidge 1950
<b>Tapellaria</b> Müll. Arg. (1890)	
epiphlla (Müll. Arg.) R. Sant.	Bruse 1991c, Farkas 2004
<b>Teloschistes</b> Norman (1853)	
capensis (L.f.) Müll. Arg.	Doidge 1950, Alborn 1988b, Alborn 1989
chrysophthalmus (L.) Th. Fr.	Doidge 1950, Alborn 1988b, Alborn 1989, Verseggy 1963
INC.: <i>T. chrysophthalmus</i> var. <i>subpulvinoris</i> Gyeln.	
<i>T. chrysophthalmus</i> f. <i>ormotus</i> (Rabenh.) Hillmann	
<i>T. chrysophthalmus</i> f. <i>cinereus</i> Müll. Arg.	
<i>T. chrysophthalmus</i> f. <i>dilototus</i> Hillmann	
cymbalifer (G. Mey.) Müll. Arg	Verseggy 1962
exilis (Michx.) Vain.	Doidge 1950, Alborn 1989, Galloway 1995
<i>T. flovicons</i> f. <i>minor</i> (Cromb.) Hillmann	
INC.: <i>T. exilis</i> var. <i>deolbotus</i> Hillmann	
<i>T. exilis</i> var. <i>pulvinotus</i> Hillmann	
flavicans (Sw.) Norm.	Doidge 1950, Alborn 1988 Alborn 1989
INC.: <i>T. flovicons</i> var. <i>croceus</i> (Ach.) Müll. Arg.	
<i>T. flovicons</i> var. <i>intermedius</i> Müll. Arg.	
hypoglaucus (Nyl.) Zahlbr.	Doidge 1950, Alborn 1989, Thomas & Bhat 1994
perrugosus Müll Arg. em. Almb.	Doidge 1950, Swinscow & Krog 1988, Alborn 1989
<i>T. costotus</i> (J. Steiner) Hillmann	
<i>T. volidus</i> (Müll. Arg.) Hillmann	Doidge 1950, Alborn 1989
puber (Ach.) Almb.	
<i>T. copensis</i> f. <i>puber</i> Malme	
<i>T. verrucosus</i> Hillmann	
<i>T. flovicons</i> var. <i>puber</i> (Ach.) Müll. Arg.	
pulvinaris (Zahlbr.) Almb.	Doidge 1950, Alborn 1989
<i>T. chrysophthalmus</i> var. <i>pulvinoris</i> Zahlbr.	
<b>Tephromela</b> M. Choisy (1929)	
atra (Huds.) Hafellner	Doidge 1950
<i>Leconoro otro</i> (Huds.) Ach.	
promontorii (Zahlbr.) Kalb	Doidge 1950
<i>Lecideo promontorii</i> Zahlbr.	
<b>Thelenella</b> Nyl. (1855)	
brasiliensis (Müll. Arg.) Vain.	Mayrhofer & McCarthy 1991
luridella (Nyl.) H. Mayrhofer	Mayrhofer 1987
<b>Thelopsis</b> Nyl. (1855)	
obscura Egea & Torrente	Egea & Torrente 1996
<b>Thelotrema</b> Ach. (1803)	
berkeleyanum (Mont.) Bruse	Bruse 1988e
capense Zahlbr.	Doidge 1950
leiopiacoides Nyl.	Doidge 1950
lepadinum Ach.	Doidge 1950
<b>Thyrea</b> A. Massal. (1856)	
otaviana Bruse	Bruse 1987b

<b>Tomasellia</b> A. Massal. (1856)	
<i>africana</i> Zahlbr.	Doidge 1950
<b>Toninia</b> A. Massal. (1852)	
<i>aromatica</i> (Sm.) A. Massal.	Brusse 1993
<i>australis</i> Timdal	Timdal 1992, Zedda & Rambold 2004
<i>bumamma</i> (Nyl.) Zahlbr.	Doidge 1950, Almborn 1988b, Swinscow & Krog 1988
<i>caesiopallida</i> (Nyl.) Zahlbr.	Doidge 1950
<i>cinereovirens</i> (Schaer.) A. Massal.	Brusse 1993
<i>incretata</i> (Stizenb.) Zahlbr.	Doidge 1950
<i>lutosa</i> (Ach.) Timdal	Brusse 1993, Brusse 1991b, Zedda & Rambold 2004
<i>T. toniniona</i> (A. Massal.) Zahlbr. (sensu Brusse 1991b)	
<i>nigropallida</i> (Nyl.) Abbayes	Doidge 1950
<i>Lecideo nigropallido</i> Nyl.	
<i>aff. ruginosa</i> (Tuck.) Herre	Zedda & Rambold 2004
<b>Topeliopsis</b> Kantvilas & Vězda (2000)	
<i>muscigena</i> (Stizenb.) Kalb	Doidge 1950
<i>Thelotremo muscigenum</i> Stizenb.	
<b>Trapelia</b> M. Choisy (1929)	
<i>chiodectonoides</i> Brusse	Brusse 1987d
<i>coarctata</i> (Turner) M. Choisy	Doidge 1950
<i>Leconoro coarctato</i> (Turner) Ach.	
<i>INC.: Leconoro coarctato f. cotorio</i> Ach.	
<i>Leconoro coarctato f. fulgiono</i> Zahlbr	
<i>Leconoro coarctato var. fossulans</i> Stizenb.	
<i>rediviva</i> Brusse	Brusse 1991d
<b>Trapeliopsis</b> Hertel & Gotth. Schneid. (1980)	
<i>granulosa</i> (Hoffm.) Lumbsch	Doidge 1950, Brusse 1991b
<i>Lecideo granuloso</i> (Hoffm.) Ach.	
<i>parilis</i> Brusse	Brusse 1991d
<b>Tylophoron</b> Nyl. ex Stizenb. (1862)	
<i>africanum</i> Vain.	Doidge 1950
<i>bylilii</i> G. Merr. ex van der Byl	Doidge 1950
* <b>Tremella</b> Dill. ex L. (1753)	
* <i>parmeliarum</i> Diederich	Diederich 1996
<b>Trypethelium</b> Spreng. (1804)	
<i>austroafricanum</i> Zahlbr.	Doidge 1950
<i>eluteriae</i> Spreng.	Doidge 1950
<i>phlytaena</i> Fée	Doidge 1950
<b>Tuckermannopsis</b> Gyeln. (1933)	
<i>chlorophylla</i> (Willd.) Hale	Almborn 1987, Kärnefelt 1987b
<i>Cetrario chlorophyllo</i> (Willd.) Poetsch	
<b>Umbilicaria</b> Hoffm. (1789)	
<i>bolusiana</i> Frey	Frey 1949
<i>cylindrica</i> (L.) Delise	Frey 1949
<i>decussata</i> (Vill.) Zahlbr.	Frey 1949
<i>haplocarpa</i> Nyl.	Frey 1949, Almborn 1987
<i>hirsuta</i> (Sw. ex Westr.) Ach.	Frey 1949
<i>laevis</i> Pers.	Frey 1949
<i>AS: U. laevis var. gorsidei</i> Frey	
<i>polyphylla</i> (L.) Baumg.	Frey 1949, Swinscow & Krog 1988
<i>schelpei</i> Frey	Frey 1949
<i>subglabra</i> (Nyl.) Frey	Frey 1949, Swinscow & Krog 1988
<i>umbilicarioides</i> (Stein) Krog & Swinscow	Swinscow & Krog 1988
<b>Usnea</b> Dill. ex Adans. (1763)	
<i>aequatoriana</i> Motyka	Doidge 1950
<i>africana</i> Motyka	Motyka 1938, Doidge 1950
<i>amplissima</i> Stirt.	Motyka 1938, Doidge 1950
<i>articulata</i> (L.) Hoffm.	Doidge 1950
<i>INC.: U. articulato f. minor</i> Kremp.	
<i>australis</i> Fr.	Doidge 1950
<i>baileyi</i> (Stirt.) Zahlbr.	Doidge 1950, Brusse 1988e

<i>U. implicato</i> (Stirt.) Zahlbr.	
<i>Eumitrio baileyi</i> Stirt.	
<sup>1</sup> <i>barbata</i> (L.) F.H. Wigg.	Doidge 1950
<i>U. plicato</i> (L.) Weber ex F.H. Wigg.	
<i>bornmuelleri</i> J. Steiner	Motyka 1938
<sup>2</sup> <i>capensis</i> Motyka	Motyka 1938, Doidge 1950
<i>cartilaginea</i> Laurer	Motyka 1938, Doidge 1950
<i>complanata</i> (Müll. Arg.) Motyka	Bruse 1988e
<i>contorta</i> Jatta	Motyka 1938, Doidge 1950
<i>cornea</i> Motyka	Motyka 1938
<i>cornuta</i> Körb.	Doidge 1950
<i>dasaea</i> Stirt.	Doidge 1950, Almborn 1960,
<i>U. unduloto</i> Stirt.	Swinscow & Krog 1988,
	Clerc & Herrera-Campos 1997
<i>dasopoga</i> (Ach.) Röhl.	Doidge 1950
A5: <i>U. dasypogo</i> (Ach.) Röhl. (dubious)	
<i>dasypogoides</i> Nyl.	Doidge 1950
<i>delicata</i> Vain.	Motyka 1938, Doidge 1950
<i>densirostra</i> Taylor	Doidge 1950
<i>diffracta</i> Vain.	Doidge 1950
<i>Dolichousnea diffracto</i> (Vain.) Articus	
<i>distensa</i> Stirt.	Motyka 1936, Motyka 1938,
	Doidge 1950
<i>exasperata</i> (Müll. Arg.) Motyka	Swinscow & Krog 1978,
<i>U. floccido</i> (Müll. Arg.) Motyka (nom. illegit.), non <i>U. floccido</i> Hoffm.	Swinscow & Krog 1988
<i>filamentosa</i> Motyka	Motyka 1938
<i>flexilis</i> Stirt.	Motyka 1936, Doidge 1950
<i>florida</i> (L.) Weber ex F.H. Wigg.	Doidge 1950
INC.: <sup>3</sup> <i>U. florida</i> var. <i>osperrimo</i> Müll. Arg.	
<i>U. florida</i> var. <i>scobroso</i> Vain.	
<i>flotowii</i> Zahlbr.	Doidge 1950
A5: <i>U. flotowii</i> var. <i>subhispidio</i> Zahlbr.	
<i>fusca</i> Motyka	Motyka 1938, Doidge 1950
<i>gonioides</i> Stirt.	Motyka 1938, Doidge 1950,
	Swinscow & Krog 1988
<i>havaasii</i> Motyka	Motyka 1938, Doidge 1950
<i>hirta</i> (L.) Weber ex F.H. Wigg.	Motyka 1936, Doidge 1950,
<i>U. leproso</i> Motyka	Swinscow & Krog 1988,
	Clerc 1997
<i>hispidula</i> Motyka	Almborn 1960
<i>hispidula</i> (Müll. Arg.) Zahlbr.	Doidge 1950
<i>horridula</i> (Müll. Arg.) Motyka	Motyka 1938, Doidge 1950,
	Almborn 1960
<i>laevis</i> (Eschw.) Nyl.	Doidge 1950
<i>liechtensteinii</i> J. Steiner	Bruse 1988e
<i>Eumitrio liechtensteinii</i> (J. Steiner) Vain.	
<i>longissima</i> Ach.	Doidge 1950
<i>maculata</i> Stirt.	Motyka 1938, Doidge 1950,
	Swinscow & Krog 1988,
	Almborn 1991
<i>molliuscula</i> Stirt.	Motyka 1938, Doidge 1950
<i>moniliformis</i> Motyka	Doidge 1950
<i>mutabilis</i> Stirt.	Motyka 1938, Doidge 1950
<i>nidifica</i> Taylor	Doidge 1950
<i>U. intercoloris</i> Kremp.	
<i>ochrophora</i> (Stizenb.) Motyka	Motyka 1936, Doidge 1950
<i>perplexans</i> Stirt.	Bruse 1988e
<i>picta</i> (J. Steiner) Motyka	Doidge 1950
<i>poliothrix</i> Kremp.	Doidge 1950
<i>praelonga</i> Stirt.	Motyka 1936, Doidge 1950
<i>primitiva</i> Motyka	Motyka 1938, Doidge 1950
<i>promontorii</i> Motyka	Motyka 1938, Doidge 1950
<i>pulverulenta</i> (Müll. Arg.) Motyka	Doidge 1950
<i>pulvinata</i> Fr.	Doidge 1950, Swinscow & Krog 1988,

rubicunda Stirt.	Almborn 1960, Almborn 1988b
<i>U. rubiginea</i> (Michx.) A. Massal.	Doidge 1950, Almborn 1974,
<i>U. lurida</i> Stirt.	Almborn 1988b
<b>INC.:</b> <i>U. rubicunda</i> var. <i>spilota</i> (Stirt.)	
G.N. Stevens	
<i>U. spilota</i> Stirt.	
rubrotincta Stirt.	Motyka 1938, Doidge 1950
<i>U. rubescens</i> Stirt. var. <i>rubrotincta</i> (Stirt.) Motyka	
sorediosula (Müll. Arg.) Motyka	Motyka 1938, Doidge 1950
steineri Zahlbr.	Doidge 1950, Galloway 1995,
<i>U. subflorida</i> (Zahlbr.) Motyka	Truong et al. 2011
strigosa (Ach.) Eaton	Doidge 1950
strigosella J. Steiner	Motyka 1938, Doidge 1950
subfloridana Stirt.	Doidge 1950
<i>U. comosa</i> (Ach.) Röhl.	
subgracilis Vain.	Clerc 1997, Truong et al. 2013
<i>U. hesperina</i> Motyka	
subleprosa Motyka	Motyka 1938
sublurida Stirt.	Motyka 1938, Doidge 1950
submollis J. Steiner	Thomas & Bhat 1996
sulcata Motyka	Motyka 1938, Doidge 1950
trichina Motyka	Motyka 1938, Doidge 1950
trichodeoides Vain. ex Motyka	Doidge 1950, Almborn 1960
<i>Dalichousneo trichodeoides</i> (Vain.	
ex Motyka) Articus	
welwitschiana Motyka	Brusse 1988e
<sup>1</sup> Extremely dubious. This species is not known from South Africa (P. Clerc, pers. comm.)	
<sup>2</sup> Nom. illegit., non <i>U. capensis</i> (L.f.) Hoffm. (See Appendix 2).	
<sup>3</sup> Not in Index Fungarum. <i>U. barbata</i> var. <i>asperrima</i> Müll. Arg. is <i>U. baileyi</i> .	
<b>Vainionora</b> Kalb (1991)	
flavovirens (Fée) Kalb	Doidge 1950
<i>Lecanora flavovirens</i> Fée	
<b>Verrucaria</b> Schrad. (1794)	
compacta aggr. (A. Massal.) Jatta	Zedda & Rambold 2004
erodens Müll. Arg.	Doidge 1950
microlepeidea Zahlbr.	Doidge 1950
<b>INC.:</b> <i>microlepeidea</i> var. <i>hilarior</i> Zahlbr.	
nigrescens Pers.	Doidge 1950
rebellans Zahlbr.	Doidge 1950
viridula Ach.	Doidge 1950
<b>Xanthodactylon</b> P.A. Duvign. (1941)	
alexanderbaai (S.Y. Kondr. & Kärnefelt)	Kärnefelt et al 2002a,
S.Y. Kondr. & Kärnefelt	Kondratyuk et al. 2008
<i>Xanthoria alexanderbaai</i> S.Y. Kondr.	
& Kärnefelt	
<b>Dufoureo alexanderbaai</b> (S.Y. Kondr.	
& Kärnefelt) Frödén, Arup & Sjøchting	
flammeum (L.f.) C.W. Dodge	Doidge 1950, Almborn 1988b
<i>Xanthoria flammea</i> (L. f.) Hillmann	
<b>Dufoureo flammeo</b> (L. f.) Ach.	
turbinatum (Vain.) C.W. Dodge	Kondratyuk et al. 2008
<i>Xanthoria turbinata</i> Vain.	
<b>Dufoureo turbinata</b> (Vain.) Frödén,	
Arup & Sjøchting	
wirthii S.Y. Kondr. & Kärnefelt	Kondratyuk et al. 2008
<b>Xanthomendoza</b> S.Y. Kondr. & Kärnefelt (1997)	
mendozae (Räsänen) S.Y. Kondr. & Kärnefelt	Kondratyuk & Kärnefelt 1997
<b>Xanthoparmelia</b> (Vain.) Hale (1974)	
abraxas (Brusse) Elix	Brusse 1991b, Elix 1997
<i>Parmelia abraxas</i> Brusse	
adamantea (Brusse) O. Blanco et al.	Brusse 1991b, Elix 1997,
<i>Parmelia adamantea</i> Brusse	Esslinger 2000, Blanco et al. 2004
<i>Neofuscelia adamantea</i> (Brusse) Elix	

adhaerens (Nyl.) Hale <i>Parmelia adhaerens</i> Nyl. <i>Karaawia adhaerens</i> (Nyl.) Hale <i>Parmelia interrupta</i> Stizenb. <i>X. interrupta</i> (Stizenb.) Krog & Swinscow	Daidge 1950, Elix et al. 1986a, Nash & Elix 1987, Swinscow & Krag 1988, Hale 1989, Hale 1990
adligans (Brusse) G. Amo, et al. <i>Karaawia adligans</i> (Brusse) Hale <i>Parmelia adligans</i> Brusse	Brusse 1988e, Hale 1989, Amo, et al. 2010
affinis Hale	Hale 1987b, Hale 1990
africana Hale	Hale 1986
afraincerta Elix	Elix 1999c
afrolavicola Hale	Hale 1990
agamalis (Brusse) Elix <i>Parmelia agamalis</i> Brusse <i>Paraparmelia agamalis</i> (Brusse) Elix	Brusse 1989c, Elix 1997, Elix 2003
aggregata M.D.E. Knox	Almbarn 1988a, Almbarn 1988b, Hale 1990
albamaculata Hale	Hale 1985, Hale 1990
aliphatica Hale	Hale 1986, Hale 1990
aliphaticella A. Thell et al. <i>Namakwa aliphatica</i> Elix	Thell et al 2006
almbarnii (Hale) Hale <i>Parmelia olmbarnii</i> Hale	Hale 1971, Hale 1990
amphixanthoides (J. Steiner & Zahlbr.) Hale <i>Parmelia amphixanthoides</i> J. Steiner & Zahlbr.	Daidge 1950, Hale 1990, Zedda & Rambold
amplexuloides Hale	Nash & Elix 1987, Hale 1990
annexa (Kurak.) Elix <i>Parmelia annexa</i> Kurak. <i>Pseudoparmelia annexa</i> (Kurak.) Hale <i>Paraparmelia annexa</i> (Kurak.) Elix & J. Johnst.	Hale 1976a, Hale & Kurakawa, 1964
antleriformis (Elix) Elix & J. Johnst. <i>Parmelia antleriformis</i> Elix	Hale 1990
applicata Hale <i>Parmelia salax</i> Brusse	Hale 1987b, Hale 1990
applicatella (Elix) O. Blanca <i>Neofuscelia applicatella</i> Elix	Elix 1999b, Blanca et al. 2004
arcana (Kurak.) Elix <i>Parmelia arcana</i> Kurak. <i>Paraparmelia arcana</i> (Kurak.) Elix & J. Johnst. <i>Pseudoparmelia arcana</i> (Kurak.) Hale	Hale 1976a, Elix 2001
areolata Hale <i>Parmelia areolata</i> (Hale) Brusse	Hale 1987a, Hale 1990
arida Egan & Derstine	Hale 1987a, Hale 1990
arquata (Brusse) G. Amo, et al. <i>Parmelia arquata</i> Brusse <i>Karoowia arquata</i> (Brusse) Hale	Brusse 1988e, Hale 1989, Amo, et al. 2010
asilaris (Brusse) Elix <i>Parmelia asilaris</i> Brusse <i>Paraparmelia asilaris</i> (Brusse) Elix	Brusse 1988d, Elix 1997, Elix 2003
assimilis (Brusse) Elix <i>Parmelia assimilis</i> Brusse <i>X. triebeliae</i> Elix	Brusse 1991b, Elix 1997
astricta (Brusse) Elix <i>Parmelia astricta</i> Brusse <i>Paraparmelia ostricta</i> (Brusse) Elix <i>Paraparmelia alivetrica</i> T.H. Nash & Elix	Brusse 1984, Nash & Elix 1987, Brusse 1988e, Elix, 2003
atroviridis (Essl.) O. Blanca et al. <i>Parmelia atroviridis</i> Essl. <i>Neofuscelia atroviridis</i> (Essl.) Essl.	Esslinger 1977, Esslinger 2000, Blanca et al. 2004
atroventralis (Hale) Hale <i>Parmelia atroventralis</i> Hale	Hale 1971, Swinscow & Krag 1988
ausiana Hale	Hale 1990
australasica D. Galloway	Elix et al. 1986a, Hale 1990
austroafricana (Stirt.) Hale	Daidge 1950, Swinscow & Krag 1988,

<i>Parmelia subquercino</i> Müll. Arg.	Hale 1990
<i>Parmelia oustroofricano</i> Stirt.	
<i>Parmelia consperso</i> var. <i>oustroofricano</i> (Stirt.) Stizenb.	
<i>austracapensis</i> Hale	Hale 1987b, Hale 1990
<i>azaniensis</i> (Brusse) A. Thell	Thell et al. 2006, Brusse 1991a
<i>Almbornio ozaniensis</i> Brusse	
<i>bainskloofensis</i> Elix & T.H. Nash	Elix 2002
<i>barda</i> (Brusse) Elix	Brusse 1987a, DePriest & B. Hale 1998, Esslinger 2000, Elix 2001
<i>Parmelia bardo</i> Brusse	Elix 2003
<i>Neofuscelio bardo</i> (Brusse) DePriest & B.W. Hale	Hale 1986, Hale 1990
<i>Paroparmelia bardo</i> (Brusse) Elix	Hale 1976a, Elix 2001
<i>barclyensis</i> Hale	
<i>basutoensis</i> (Hale) Elix	
<i>Parmelio bosutoensis</i> Hale	
<i>Paroparmelio bosutoensis</i> (Hale) Elix & J. Johnst.	
<i>Pseudoparmelio bosutoensis</i> (Hale) Hale	
<i>beatricea</i> Hale	Hale 1987a, Hale 1990
<i>beckeri</i> O. Blanco et al	Elix 1999b, Blanco et al. 2004
<i>Neofuscelio wesselsii</i> Elix	
<i>bibax</i> (Brusse) Hale	Doidge 1950, Brusse 1986a, Hale 1990
<i>Parmelio bibax</i> Brusse	Nash & Elix 1987, Hale 1990
<i>bicontinens</i> Elix & T.H. Nash	Elix 1999b, Blanco et al. 2004
<i>brandwagensis</i> (Elix) O. Blanco et al.	
<i>Neofuscelio brandwagensis</i> Elix	
<i>brevilobulata</i> Hale	Doidge 1950, Hale 1986, Hale 1987a, Brusse 1989c, Hale 1990, Brusse 1991b
<i>Parmelio brevilobata</i> (Hale) Brusse	Doidge 1950, Hale 1990
<i>brunnthaleri</i> (J. Steiner & Zahlbr.) Hale	
<i>Parmelio brunnthaleri</i> J. Steiner & Zahlbr.	
<i>brussei</i> (Elix) O. Blanco et al.	Elix 1997, Blanco et al 2004
<i>Neofuscelio brussei</i> Elix	
<i>burmeisteri</i> (Elix) Egan	Brusse 1988e, Hale 1990
<i>Parmelio burmeisteri</i> Elix	
<i>cafferensis</i> (Essl.) O. Blanco et al.	Esslinger 1977, Almborn 1988b, Esslinger 2000, Blanco et al. 2004
<i>Parmelio cofferensis</i> Essl.	
<i>Neofuscelio cofferensis</i> (Essl.) Essl.	Esslinger 1977, Almborn 1988b, Esslinger 2000, Blanco et al. 2004
<i>caliginosa</i> (Essl.) O. Blanco et al.	
<i>Neofuscelio caliginoso</i> (Essl.) Essl.	
<sup>1</sup> <i>calvinia</i> Hale	Hale 1986, Hale 1990
<i>capensis</i> Hale	Hale 1986, Hale 1990
<i>Parmelio copicalo</i> Brusse	
<sup>2</sup> <i>cedri-montana</i> Brusse	Hale 1990, Brusse 1988e
<i>Parmelio cedri-montano</i> (Brusse) Brusse	
<i>ceresella</i> (Elix) O. Blanco et al.	Elix 1999b, Esslinger 2000, Blanco et al. 2004
<i>Neofuscelio ceresello</i> Elix	
<i>ceresensis</i> Hale	Hale 1986
<i>ceresina</i> (Lyngé) Hale	Doidge 1950, Elix et al. 1986a, Nash & Elix 1987, Hale 1990
<i>Parmelio ceresino</i> Vain.	Doidge 1950, Doidge 1950, Hale 1990
<i>chalybaeizans</i> (J. Steiner & Zahlbr.) Hale	
<i>Parmelio schreuderiano</i> Gyeln.	
<i>Parmelio schenckiano</i> var. <i>cholyboeizans</i> J. Steiner & Zahlbr.	
<i>chionophila</i> (Brusse) Elix	Brusse 1994, Elix 1997
<i>Parmelio chionophilo</i> Brusse	
<i>cirrhomedullosa</i> Hale	Hale 1990
<i>clivorum</i> (Brusse) Hale	Hale 1990, Brusse 1984
<i>Parmelio clivorum</i> Brusse	
<i>colensoica</i> T.H. Nash, Elix & J. Johnst.	Elix & Johnston 1988b, Hale 1990
<i>Parmelio colensoico</i> (T.H. Nash, Elix & J. Johnst.) Brusse	
<i>colorata</i> (Gyeln.) Hale	Doidge 1950, Hale 1990
<i>Parmelio colorato</i> Gyeln.	

competita Hale	Brusse 1986d, Hale 1986, Brusse 1988e, Hale 1990
<i>Parmelia eximia</i> Brusse	
cancelar (Spreng.) Hale	Doidge 1950, Nash & Elix 1987, Hale 1990
<i>Parmelia cancelar</i> Spreng.	
<b>INC.:</b> <i>Parmelia cancelar</i> var. <i>multifida</i> (Flot.) Zahlbr.	
<i>Parmelia cancelar</i> var. <i>platyphylla</i> (A. Massal.) Zahlbr.	
candyloides (Kurak.) Elix	Hale 1972, Hale 1976a Nash & Elix 1987, Elix 2003
<i>Parmelia candyloides</i> Kurok.	
<i>Pseudoparmelia candyloides</i> (Kurak.) Hale	
<i>Paraparmelia candyloides</i> (Kurak.) Elix & J. Jahnst.	
caneruptens Hale	Hale 1990
cangensis (Stein) Hale	Nash & Elix 1987, Elix et al. 1986a
<i>Parmelia cangensis</i> Stein	
<i>X. crateriformis</i> Elix & J. Jahnst.	
<sup>3</sup> conspersa (Ach.) Hale	Doidge 1950, Doidge 1950, Brusse 1988e
<i>Parmelia conspersa</i> (Ehrh. ex Ach.) Ach.	
<b>INC.:</b> <i>Parmelia conspersa</i> var. <i>benguellensis</i> Vain.	
<i>Parmelia conspersa</i> var. <i>hypamelaena</i> Vain.	
<i>Parmelia conspersa</i> f. <i>isidiata</i> (Anzi) Stizenb.	
<i>Parmelia conspersa</i> var. <i>lacinulata</i> Gyeln.	
<i>Parmelia conspersa</i> var. <i>palyphylla</i> Müll. Arg.	
<i>Parmelia digitulata</i> Nyl.	
conspersula (Nyl.) Hale	Doidge 1950, Hale 1990
<i>Parmelia conspersula</i> Nyl.	
constrictans (Nyl.) Hale	Crambie 1877, Doidge 1950, Elix et al. 1986a, Hale 1990
<i>Parmelia constrictans</i> Nyl.	
<i>Parmelia conspersa</i> var. <i>constrictans</i> (Nyl.) Müll. Arg.	
contrastata Hale	Hale 1987a, Hale 1990
canturbata (Müll. Arg.) O. Blanco, et al.	Doidge 1950, Esslinger 2000, Blanco et al. 2004
<i>Parmelia canturbata</i> Müll. Arg.	
<i>Neofuscelia canturbata</i> (Müll. Arg.) Essl.	
coriacea Hale	Hale 1987a, Hale 1990
crassilobata Hale	Hale 1986, Hale 1990, Zedda & Rambold 2004
cravenii Elix & J. Jahnst	Elix 1999a, Elix 2003
crustulasa (Essl.) O. Blanco et al.	Esslinger 1977, Esslinger 2000, Blanca et al. 2004
<i>Parmelia crustulasa</i> Essl.	
<i>Neofuscelia crustulasa</i> (Essl.) Essl.	
cumberlandia (Gyeln.) Hale	Hale 1990
<i>Parmelia cumberlandia</i> Gyeln.	
denudata Hale	Hale 1986, Hale 1990
diacida Hale	Hale 1986, Hale 1990
diadeta (Hale) Hale	Hale 1971, Swinscaw & Krag 1988, Hale 1990
<i>Parmelia diadeta</i> Hale	
dichromatica (Hale) Hale	Hale 1971, Hale 1990
diffractaica Hale	Hale 1987a, Brusse 1989c, Hale 1990
<i>X. lesothaensis</i> Hale	
diutina (Brusse) O. Blanco et al.	Brusse 1993, Blanca et al. 2004
<i>Parmelia diutina</i> Brusse	
<i>Karaawia diutina</i> (Brusse) Elix	
damakosii (Gyeln.) Hale	Doidge 1950, Hale 1990
<i>Parmelia damakosii</i> Gyeln.	
damokosioides Elix & T.H. Nash	Elix 1999c
dregeana (Hampe) O. Blanco et al.	Doidge 1950, Esslinger 2000, Blanca et al. 2004
<i>Parmelia dregeana</i> Hampe	
<i>Neofuscelia dregeana</i> (Hampe) Essl.	
dubitella Elix	Elix 2002
duplicata Hale	Hale 1986, Hale 1990
dwaasbergensis (Brusse) Elix	Brusse 1989d, Elix 2001, Elix 2003
<i>Parmelia dwaasbergensis</i> Brusse	
<i>Paraparmelia dwaasbergensis</i> (Brusse) Elix	

dysprasa Brusse & M.D.E. Knox	Hale 1990
effigurata Hale	Hale 1986, Hale 1990
emalumenta (Brusse) Elix	Brusse 1994, Elix 1997
<i>Parmelia emalumenta</i> Brusse	
endachromatica Hale	Hale 1986, Hale 1990
endamiltaoides (Nyl.) Hale	Hale 1990
<i>Parmelia conspersa</i> var. <i>endamiltaoides</i> (Nyl.) Müll. Arg.	
enteroxantha Hale	Hale 1986, Hale 1990
epacridea (Brusse) Elix	Brusse 1993, Elix 1997
<i>Parmelia epacridea</i> Brusse	
epigaea Hale	Hale 1986, Hale 1990, Zedda & Rambold 2004
eradicata (Nyl.) Hale	Doidge 1950, Elix et al. 1986a, Hale 1990
<i>Parmelia eradicata</i> (Nyl.) Gyeln.	
<i>Parmelia conspersa</i> var. <i>eradicata</i> (Nyl.) Müll. Arg.	
<i>Parmelia hypoleia</i> var. <i>tenuifida</i> Nyl.	
erebea (Brusse) Elix	Brusse 1993, Elix 1997, Elix 2003
<i>Parmelia erebea</i> Brusse	
<i>Paraparmelia erebea</i> (Brusse) Elix	
eruptens Hale	Hale 1987a
<i>Parmelia phylladactylaris</i> Brusse	
esslingeri O. Blanca et al.	Doidge 1950, Esslinger 1977, Blanca et al. 2004
<i>Parmelia pralixa</i> var. <i>applicata</i> Stizenb.	
<i>Parmelia applicata</i> (Stizenb.) Essl.	
<i>Neafuscelia applicata</i> (Stizenb.) Essl.	
esterhuyseniae Hale	Hale 1986, Hale 1990, Brusse 1991b
<i>Parmelia esterhuyseniae</i> (Hale) Brusse	
exarnata (Zahlbr.) Brusse & M.D.E. Knox	Doidge 1950, Hale 1988, Knox & Brusse 1983, Thell et al 2006
<i>Parmelia canturbata</i> var. <i>exarnata</i> Zahlbr.	
<i>Namakwa exarnata</i> (Zahlbr.) Hale	
fausta (Brusse) Elix	Brusse 1986d, Brusse 1988e, Elix 2001, Elix 2003
<i>Parmelia fausta</i> Brusse	
<i>Paraparmelia fausta</i> (Brusse) Elix	
*festiva (Brusse) Elix	Brusse 1989e, Brusse 1991b, Elix 1997, Elix 2003
<i>Parmelia festiva</i> Brusse	
fissurina (Zahlbr.) O. Blanca et al.	Doidge 1950, Esslinger 1977, Almbarn 1991, Esslinger 2000, Blanca et al. 2004
<i>Parmelia fissurina</i> Zahlbr.	
<i>Neafuscelia fissurina</i> (Zahlbr.) Essl.	
faveolata (Essl.) O. Blanca et al.	Esslinger 1977
<i>Parmelia faveolata</i> Essl.	
<i>Neafuscelia faveolata</i> (Essl.) Essl.	
frandosa (Hale) A. Thell et al.	Hale 1971, Hale 1985, Thell et al 2006
<i>Parmelia frandosa</i> Hale	
<i>Xanthamaculina frandosa</i> (Hale) Hale	
fucina Hale	Hale 1990
fumarafricana Elix	Elix 1999c
fynbasiana (Elix) Elix	Elix 2001, Elix 2003
<i>Paraparmelia fynbasiana</i> Elix	
ganymedea (Brusse) G. Ama, et al.	Brusse 1988e, Hale 1989, Ama, et al. 2010
<i>Parmelia ganymedea</i> Brusse	
<i>Karaawia ganymedea</i> (Brusse) Hale	
geesterani (Hale) Hale	Hale 1976a, Nash & Elix 1987, Hale 1990
<i>Parmelia geesterani</i> Hale	
<i>Pseudoparmelia geesterani</i> (Hale) Hale	
gemmulifera (Elix & Nash) Elix	Elix 2001, Elix 2003
<i>Paraparmelia gemmulifera</i> Elix	
glabrans (Nyl.) O. Blanca et al.	Esslinger 1977, Esslinger 2000, Blanca et al. 2004
<i>Parmelia glabrans</i> Nyl.	
<i>Neafuscelia glabrans</i> (Nyl.) Essl.	
glabrisidiata Hale	Hale 1986, Hale 1990
glamelliferanica (Elix) O. Blanca et al.	Elix 1999b, Blanca et al. 2004
<i>Neafuscelia glamelliferanica</i> Elix	
greytanensis Hale	Hale 1990
gyrapharica Hale	Hale 1986, Hale 1990

heteradaxa (Hale) Hale <i>Parmelia heteradaxa</i> Hale	Hale 1971, Hale 1990
hattentatta (Ach.) A. Thell et al. <i>Parmelia cuprea</i> Pers. <i>Parmelia hattentatta</i> (Ach.) Ach. <b>INC.:</b> <i>Parmelia hattentatta</i> var. <i>diachrasta</i> Sirt. <i>Parmelia hattentatta</i> var. <i>pachythalla</i> Nyl. <i>Parmelia hattentatta</i> var. <i>phalacro</i> Zahlbr. <i>Xonthamaculina hattentatta</i> (Ach.) Hale,	Daidge 1950, Almbarn 1988b, Galloway 1995, Thell et al. 2006
hybrida Hale	Hale 1986, Brusse 1988e, Hale 1990
hypoleia (Nyl.) Hale <i>Parmelia hypoleia</i> Nyl. <b>INC.:</b> <i>Parmelia hypoleia</i> var. <i>crenata</i> Nyl <i>Parmelia hypoleioides</i> Vain.	Daidge 1950, Elix et al. 1986a, Almbarn 1988a, Almbarn 1988b, Swinscow & Krag 1988, Hale 1990
hypoleiella Elix	Elix 2002
hypopratacetrarica (Kurak. & Elix) Hale <i>Parmelia hypopratacetrarica</i> Kurak. & Elix	Elix et al. 1986a, Nash & Elix 1987, Hale 1990
hypopsila (Müll. Arg.) Hale <i>X. australis</i> Hale <i>Parmelia subcanspersa</i> f. <i>lobulifera</i> Gyeln.	Daidge 1950, Nash & Elix 1987, Hale 1990
hyporhytida (Hale) Hale <i>Parmelia hyporhytida</i> Hale	Hale 1971, Almbarn 1988a, Almbarn 1988b, Hale 1990, Zedda & Rambald 2004
ianthina Brusse	Hale 1990
imitatrix (Taylor) O. Blanco et al. <i>Parmelia imitatrix</i> Taylor <i>Neofuscelia imitatrix</i> (Taylor) Essl.	Esslinger 1977, Almborn 1988b, Esslinger 2000, Blanca et al. 2004, Zedda & Rambald 2004
incerta (Kurak. & Filson) Elix & J. Jahnst. <i>Parmelia incerta</i> Kurak. & Filson	Nash & Elix 1987, Hale 1990
inconspicua Hale <i>Parmelia tontillum</i> Brusse (non <i>Parmelia inconspicua</i> Spreng.)	Hale 1987a, Hale 1990
indumenica Hale	Hale 1986, Hale 1990
infausta (Brusse) Elix <i>Parmelia infausta</i> Brusse	Brusse 1989e, Elix 1997
inops (Brusse) Elix <i>Parmelia inops</i> Brusse <i>Paroparmelia inops</i> (Brusse) Elix	Brusse 1989d, Elix 2003, Elix 2001
iniquita Elix & J. Jahnst.	Nash & Elix 1987, Hale 1990
insipida (Brusse) G. Ama, et al. <i>Parmelia insipida</i> Brusse <i>Karaawia insipida</i> (Brusse) Hale	Brusse 1986e, Brusse 1988e, Hale 1989, Ama, et al. 2010
inuncta (Brusse) Hale <i>Parmelia inuncta</i> Brusse	Brusse 1986d, Hale 1990
ischnoides (Kurak.) Elix <i>Parmelia ischnoides</i> Kurok. <i>Pseudoparmelia ischnoides</i> (Kurak.) Hale <i>Paroparmelia ischnoides</i> (Kurok.) Elix & J. Jahnst.	Hale & Kurakawa 1964, Hale 1976a Elix et al. 1986b
isiidigera (Müll. Arg.) Elix & J. Jahnst.	Nash & Elix 1987, Hale 1990
karoo M.D.E. Knax & Brusse	Hale 1990
karooensis Hale	Hale 1986, Hale 1990
keralensis Hale	Hale 1987a, Hale 1990
kleinswartbergensis Elix	Elix 2002
knaxii Elix	Elix 1999c
laciniata Hale	Hale 1987a, Hale 1990
lapidula (Essl.) O. Blanco et al. <i>Neofuscelia lapidula</i> Essl.	Esslinger 2000, Blanca et al. 2004
latilobata Hale	Hale 1987a, Hale 1990
laxchalybaeizans Hale	Hale 1987a
laxencrustans Elix & J. Jahnst.	Elix et al 1986
lecanaracea (Müll. Arg.) Elix <i>Parmelia lecanaracea</i> Müll. Arg. <i>Pseudoparmelia lecanaracea</i> (Müll. Arg.) Hale <i>Paroparmelia lecanaracea</i> (Müll. Arg.) Elix & J. Jahnst.	Daidge 1950, Hale 1971, Hale 1976a, Elix 2001

leonara (A. Massal.) Hale <i>Parmelia leonara</i> Spreng. ex A. Massal. <i>X. ocrato</i> D. Knox & Hale	Hale 1986, Swinscow & Krag 1988, Almbarn 1988a, Almbarn 1988b, Hale 1990, Zedda & Rambald 2004
leptoplaca (Brusse) G. Ama, et al. <i>Lecanora leptoplaca</i> Zahlbr. (nom illeg.) <i>Parmelia leptoplaca</i> Brusse <i>Karaawia leptoplaca</i> (Brusse) Hale	Daidge 1950, Brusse 1986e, Ama et al. 2010
leucostigma Brusse	Hale 1990
lichinoidea (Nyl.) O. Blanca et al. <i>Parmelia lichinoidea</i> Nyl. ex Cramb. <i>Neofuscelia lichinoidea</i> (Nyl. ex Cramb.) Essl.	Crambie 1876, Doidge 1950, Esslinger 1977, Almborn 1987, Almborn 1991, Esslinger 2000, Blanca et al. 2004 Esslinger 1977, Blanca et al. 2004
lineella (Essl.) O. Blanca et al. <i>Parmelia lineella</i> Essl. <i>Neofuscelia lineella</i> (Essl.) Essl.	Hale 1990
lineola (E.C. Berry) Hale <i>Parmelia lineola</i> E.C. Berry	Hale 1986, Brusse 1988e
lividica Hale <i>Paraparmelia lividica</i> (Hale) DePriest & B.W. Hale	Elix 1999b, Blanco et al. 2004
lobarica (Elix) O. Blanca et al. <i>Neofuscelia lobarica</i> Elix	Hale 1986, Hale 1990 Elix 2002
lobulifera Hale lobuliferella Elix	Esslinger 1977, Almbarn 1988a, Esslinger 2000, Blanco et al. 2004
larilaba (Essl.) O. Blanca et al. <i>Parmelia larilaba</i> Essl. <i>Neofuscelia larilaba</i> (Essl.) Essl.	Brusse 1991b, Elix 1997
lucrasa (Brusse) Elix <i>Parmelia lucrasa</i> Brusse	Hale 1990
luminosa (Elix) Hale <i>Parmelia luminosa</i> Elix	Brusse 1988d, Elix 1997
lurida (Brusse) Elix <i>Parmelia lurida</i> Brusse	Brusse 1989d, Elix 1999a, Ama et al. 2010
lyrigeria (Brusse) G. Ama, et al. <i>Parmelia lyrigeria</i> Brusse <i>Karaawia lyrigeria</i> (Brusse) Elix	Elix 1999c Elix 1999c Brusse 1993, Elix 1997, Blanca et al. 2004
maculadeciens Elix	Elix 1999a, Elix 2003
magnificans Elix	Brusse 1988e, Hale 1990
manina (Brusse) O. Blanca et al. <i>Parmelia manina</i> Brusse <i>Neofuscelia manina</i> (Brusse) Elix	Hale 1990 Hale 1987b, Hale 1990 Esslinger 2000, Blanca et al. 2004
maritima (Elix) Elix <i>Paroparmelia maritima</i> Elix	Daidge 1950, Blanco et al. 2004 O. Blanca et al.
marraninipuncta (Brusse) Hale <i>Parmelia morroninipuncta</i> Brusse	Brusse 1994, Elix 1997
maxima Hale	Hale 1987b, Hale 1990
mbabanensis Hale	Elix 2002
mehalei (Essl.) O. Blanca et al. <i>Neofuscelia mehalei</i> Essl.	Hale 1989, Ama, et al. 2010
melancholica (J. Steiner & Zahlbr.)  <i>Parmelia melancholica</i> J. Steiner & Zahlbr. <i>Neofuscelia melancholica</i> (J. Steiner & Zahlbr.) Essl.	Hale 1986, Nash & Elix 1987, Hale 1990, Brusse 1991b Esslinger 1977, 1978, Blanco et al. 2004 Hale 1986, Hale 1990,
mesmerizans (Brusse) Elix <i>Parmelia mesmerizans</i> Brusse	
micralabulata Hale	
micromaculata Elix	
micrascapica (Hale) G. Ama, et al. <i>Koroowia micrascapica</i> Hale	
minuta M.D.E. Knox & Hale	
minutella O. Blanca et al. <i>Parmelia minuta</i> Essl. <i>Neofuscelia minuta</i> (Essl.) Essl. mollis Hale	

<i>molliuscula</i> (Ach.) Hale <i>Parmelia molliuscula</i> Ach. <i>Parmelia pseudacanspersa</i> Gyeln. <i>Parmelia steineri</i> Gyeln. <i>Parmelia canspersa</i> var. <i>thamnidiella</i> (Stirt.) Stizenb.	Almbarn 1988a, Almbarn 1988b Daidge 1950, Elix et al. 1986a, Hale 1990
<i>malybdiza</i> (Nyl.) Elix <i>Parmelia atrichoides</i> Nyl. <i>Parmelia brachyphylla</i> Müll. Arg. <i>Parmelia malybdiza</i> Nyl. <i>Paraparmelia malybdiza</i> (Nyl.) Elix & J. Jahnst.	Daidge 1950, Hale 1976a, Elix 1999a
<i>mangaensis</i> (Elix) Elix <i>Parmelia mangaensis</i> Elix <i>Parmelia insignis</i> Brusse <i>Paraparmelia mangaensis</i> (Elix) Elix & J. Jahnst.	Brusse 1986d, Brusse 1988e, Nash & Elix 1987
<i>maugeatii</i> (Schaer.) Hale <i>Parmelia maugeatii</i> Schaer.	Daidge 1950, Hale 1990, Brusse 1991b
<i>mucinae</i> G. Ama, et al. <i>Parmelia squamatica</i> Brusse <i>Parmelia princeps</i> Brusse <i>Neafuscelia princeps</i> (Brusse) DePriest & B.W. Hale <i>Karaowia squamatica</i> (Brusse) Hale	Brusse 1986e, Hale 1990, Brusse 1987a, DePriest & B. Hale 1998, Esslinger 2000, Ama, et al. 2010
<i>multiacida</i> Elix	Elix 1999c
<i>musculina</i> (Brusse) Elix <i>Parmelia musculina</i> Brusse	Brusse 1991b, Elix 1997
<i>mutabilis</i> (Taylor) Hale <i>Parmelia mutabilis</i> Taylor	Brusse 1988e, Hale 1990, Thomas & Bhat 1994
<i>namakwa</i> Hale	Hale 1986, Hale 1990
<i>namaquensis</i> Hale	Hale 1986, Hale 1990
<i>natalensis</i> Hale <i>Parmelia perfuncta</i> Brusse ( <i>non Parmelia natalensis</i> J. Steiner & Zahlbr.)	Daidge 1950, Hale 1987a, Brusse 1989c, Hale 1990
<i>naudesnekia</i> Hale	Hale 1987b, Hale 1990
<i>nautilamantana</i> (Brusse) O. Blanca et al. <i>Parmelia nautilamantana</i> Brusse <i>Neafuscelia nautilamantana</i> (Brusse) Elix	Brusse 1993, Elix 1999a, Esslinger 2000, Blanca et al. 2004
<i>neacangensis</i> Hale	Hale 1990
<i>neacangruensis</i> Hale	Hale 1990
<i>neacanspersa</i> (Gyeln.) Hale <i>Parmelia neacanspersa</i> Gyeln.	Elix 2002
<i>neacumberlandia</i> T.H. Nash & Elix <i>neaeaterhuyseniae</i> O. Blanca et al. <i>Neafuscelia esterhuyseniae</i> Essl.	Elix 2002 Esslinger 1986, Esslinger 2000, Blanca et al. 2004
<i>neananreagens</i> O. Blanca et al. <i>Neafuscelia nanreagens</i> Essl.	Esslinger 1986, Esslinger 2000, Blanca et al. 2004
<i>neaprapagulifera</i> (Gyeln.) Hale <i>X. neaprapaguloides</i> Hale ( <i>nom. superfl.</i> )	Hale 1987b, Hale 1990
<i>neareptans</i> Hale	Hale 1987a, Hale 1990
<i>nearimalis</i> (Elix & P.M. Armstr.) Elix & T.H. Nash <i>Parmelia nearimalis</i> Elix & P.M. Armstr.	Nash & Elix 1987, Hale 1990
<i>neasyntestia</i> Hale	Hale 1986, Hale 1990
<i>neatasmanica</i> Hale	Hale 1986, Hale 1990
<i>neatumidasa</i> Hale	Hale 1987b, Hale 1990
<i>neweberi</i> Hale	Hale 1987a, Hale 1990
<i>nigrapsaramifera</i> (T.H. Nash) Egan	Brusse 1988e, Hale 1990
<i>nimbicala</i> (Brusse) Elix <i>Parmelia nimbicala</i> Brusse <i>Paraparmelia nimbicala</i> (Brusse) Elix	Brusse 1986em Elix 1997
<i>narlabaridanica</i> (T. H. Nash & Elix) Elix <i>Paraparmelia narlabaridanica</i> T.H. Nash & Elix	Nash & Elix 1987
<i>narlabarunica</i> Hale	Brusse 1988e, Nash & Elix 1987, Hale 1989, Hale 1990

abscurata Hale	Hale 1987b, Hale 1990
achrapulchra Hale	Hale 1986, Hale 1990
alifantensis Hale	Hale 1986, Hale 1990, Elix et al. 1986a
<sup>5</sup> olivetorica Hale	Hale 1986, Brusse 1988e, Hale 1990
areaphila (Brusse) Elix	Brusse 1991b, Elix 1997
<i>Parmelia areaphila</i> Brusse	
aribensis Hale	Hale 1986, Hale 1990
avealmbarnii A. Thell et al.	Thell et al 2006, Esslinger 1981, Almbarn 1987, Almbarn 1988a, Almbarn 1991
<i>Almbarnia cafferensis</i> Essl.	Nash & Elix 1987, Elix 2001, Elix 2003
aveana (Elix) Elix	
<i>Paraparmelia aveana</i> Elix	
pachyclada Hale	Hale 1987a, Hale 1990
paradaxa Hale	Hale 1997a, Hale 1990
<i>Parmelia mixta</i> Brusse	
parvilaba (Essl.) O. Blanca et al.	Esslinger 1978, Brusse 1988e, Brusse 1993, Esslinger 2000, Blanca et al. 2004
<i>Parmelia parvilaba</i> Essl.	
<i>Neafuscelia parvilaba</i> (Essl.) Essl.	
parvincerta Elix & J. Jahnst.	Hale 1990
patula (Brusse) Elix	Brusse 1984, Brusse 1988e, Elix 2002
<i>Parmelia patula</i> Brusse	
perfissa (J. Steiner & Zahlbr.) Elix	Elix 2001, Elix 2003
<i>Parmelia perfissa</i> J. Steiner & Zahlbr.	
perplexa (Stizenb.) Hale	Daidge 1950, Hale 1990
<i>Parmelia perplexa</i> Stizenb.	
perrugosa Hale	Hale 1987a, Hale 1990
perspersa (Stizenb.) G. Ama, et al.	Daidge 1950, Hale 1989, Ama, et al. 2010
<i>Parmelia perspersa</i> Stizenb.	
<i>Karaawia perspersa</i> (Stizenb.) Hale	
<i>Parmelia encrustans</i> Hale	
phaeaphana (Stirt.) Hale	Daidge 1950, Hale 1986, Hale 1990
<i>Parmelia phaeaphana</i> Stirt.	
<i>Parmelia citrinireagens</i> Gyeln.	
INC.: <i>Parmelia citrinireagens</i> var. <i>angustiar</i> Gyeln.	
<i>Parmelia digitulata</i> var. <i>esaxicala</i> Gyeln.	
<i>Parmelia imitans</i> f. <i>prataimbricatoides</i> Gyeln.	
<i>Parmelia terricala</i> J. Steiner & Zahlbr.	
X. <i>nuwarensis</i> Hale	
plittii (Gyeln.) Hale	Hale 1990
<i>Parmelia plittii</i> Gyeln.	
<i>Parmelia imitans</i> f. <i>prataimbricatoides</i> Gyeln.	
<i>Parmelia subcanspersa</i> var. <i>africana</i> Gyeln.	
(ANGOLA)	
<i>Parmelia terricala</i> J. Steiner & Zahlbr.	
polystictica (Elix) Blanca et al.	Elix 1999b, Blanca et al. 2004
<i>Neafuscelia polystictica</i> Elix	
panderasa (Brusse) Elix	Brusse 1989e, Elix 1997
<i>Parmelia panderasa</i> Brusse	
pristilaba (Brusse) Elix	Brusse 1984, Elix 1997, Elix 2001, Elix 2003
<i>Parmelia pristilaba</i> Brusse	
<i>Neafuscelia pristilaba</i> (Brusse) Elix	
<i>Paraparmelia pristilaba</i> (Brusse) Elix	
prabarbella Hale	Hale 1986, Hale 1990
pradamakasii Hale, Elix & J. Jahnst.	Elix & Jahnst 1988a, Hale 1990
pralata (Hale) Elix	Hale 1972, Hale 1976a, Elix 2003, Zedda & Rambold 2004
<i>Parmelia pralata</i> Hale	
<i>Paraparmelia pralata</i> (Hale) Elix & J. Jahnst.	
<i>Pseudoparmelia pralata</i> (Hale) Hale	
pralixula (Cramb.) O. Blanca et al.	Daidge 1950, Blanca et al. 2004
<i>Parmelia pralixula</i> Nyl.	
<i>Neafuscelia pralixula</i> (Nyl.) Essl.	
pratacetarica (Hale) G. Ama, et al.	Hale 1989, Ama, et al. 2010
<i>Karaawia pratacetarica</i> Hale	

protodysprosa Hale	Hale 1987a, Hale 1990
protomatrae (Gyeln.) Hale	Doidge 1950, Hale 1990
protoquintaria Hale	Hale 1990, Brusse 1994
<i>Pormelio protoquintorio</i> (Hale) Brusse	
proximata Hale	Hale 1987a, Hale 1990
pseudepheboides (Essl.) O. Blanco et al.	Esslinger 2000, Blanco et al. 2004
<i>Neofuscelio pseudepheboides</i> Essl.	
pseudocafferensis (Essl.) O. Blanco et al.	Esslinger 2000, Blanco et al. 2004
<i>Neofuscelio pseudocafferensis</i> Essl.	
pseudocongensis Hale	Hale 1987b, Hale 1990
pseudoglabrans (Essl.) O. Blanco et al.	Esslinger 2000, Blanco et al. 2004
<i>Neofuscelio pseudoglabrans</i> Essl.	
pseudohypoleia (Elix) Elix & J. Johnst.	Nash & Elix 1987, Hale 1990
<i>Pormelio pseudohypoleio</i> Elix	
pseudopulla (Essl.) O. Blanco et al.	Esslinger 2000, Blanco et al. 2004
<i>Neofuscelio pseudopulla</i> Essl.	
psornorstictica Hale	Hale 1990
psoromica Hale	Hale 1987b, Hale 1990
psoromifera (Kurok.) Hale	Brusse 1988e, Hale 1990
<i>Pormelio psoromifera</i> Kurok.	
pudens (Brusse) Elix	Brusse 1986d, Elix 2001
<i>Pormelio pudens</i> Brusse	
<i>Poropormelio pudens</i> (Brusse) Elix	
pulla (Ach.) O. Blanco et al.	Doidge 1950, Esslinger 2000, Blanco et al. 2004
<i>Pormelio prolixo</i> (Ach.) Carroll	
<i>Neofuscelio pullo</i> (Ach.) Essl.	
pustulifera Hale, T.H. Nash & Elix	Hale 1986, Hale 1990
pustulosorediata Hale	Hale 1990
putida (Brusse) Elix	Brusse 1991b, Esslinger 2000, Elix 1997
<i>Pormelio putido</i> Brusse	
putsoa Hale	Hale 1987b, Hale 1990, Brusse 1993
<i>Pormelio putsoo</i> (Hale) Brusse	
pyrenaica (Essl.) O. Blanco et al.	Esslinger 2000, Blanco et al. 2004
<i>Pormelio pyrenaico</i> Essl.	
<i>Neofuscelio pyrenaico</i> (Essl.) Essl.	
quinonella (Elix) O. Blanco et al.	Elix 1997, Blanco et al. 2004
<i>Neofuscelio quinonella</i> Elix	
quintaria (Hale) Hale	Hale 1971, Hale 1990
<i>Pormelio quintorio</i> Hale	
quintarioides (Essl.) O. Blanco et al.	Esslinger 2000
<i>Neofuscelio quintarioides</i> Essl.	
ralla (Brusse) G. Amo, et al.	Brusse 1986e, Brusse 1988e, Hale 1989, Amo, et al. 2010
<i>Pormelio rallo</i> Brusse	
<i>Koroowio rallo</i> (Brusse) Hale	
rubromedulla Hale	Hale 1986, Hale 1990
rubropustulata Hale	Hale 1987a, Hale 1990
rugulosa Hale	Hale 1987b, Hale 1990
salamphixantha Hale	Hale 1990
salazinica (Hale) G. Amo, et al.	Hale 1989, Amo, et al. 2010
<i>Koroowio salazinico</i> Hale	
saleruptens Hale	Hale 1990, Brusse 1989c
<i>Pormelio geckonolis</i> Brusse	
saniensis Hale	Brusse 1989c, Hale 1990
<i>Pormelio soniensis</i> (Hale) Brusse	
saxeti (Stizenb.) G. Amo, et al.	Doidge 1950, Hale 1989, Amo, et al. 2010
<i>Pormelio saxeti</i> Stizenb.	
<i>Koroowio saxeti</i> (Stizenb.) Hale	
scabrella (Essl.) O. Blanco et al.	Esslinger 1977, Esslinger 1978, Esslinger 2000, Blanco et al. 2004
<i>Pormelio scobrello</i> Essl.	
<i>Neofuscelio scobrello</i> (Essl.) Essl.	
scabrosa (Taylor) Hale	Doidge 1950, Elix et al. 1986a, Brusse 1988e, Hale 1990
<i>Pormelio scobroso</i> Taylor	
<i>Pormelio consperso</i> var. <i>hypoclystoides</i> Mull. Arg.	

scabrosinita (Essl.) Elix	Esslinger 2000
<i>Paraparmelia scabrosinita</i> Essl.	
schenckiana (Müll. Arg.) Hale	Doidge 1950, Hale 1990
<i>Parmelia schenckiana</i> Müll. Arg.	
<b>INC.:</b> <i>Parmelia schenckiana</i> f. <i>imperfecto</i> Gyeln.	
scitula (Brusse) G. Amo, et al.	Brusse 1988e, Hale 1989, Amo, et al. 2010
<i>Koraawia scitula</i> (Brusse) Hale	
shebaiensis T. H. Nash & Elix	Nash & Elix 1987, Hale 1990
sigillata (Brusse) Hale	Brusse 1988e, Hale 1990
<i>Parmelia sigillata</i> Brusse	
simulans Hale	Hale 1986, Zedda & Rambold 2004
sipmanii T.H. Nash & Elix	Elix 2002
sitiens (Brusse) Elix	Brusse 1989d, Elix 2001, Elix 2003
<i>Parmelia sitiens</i> Brusse	
<i>Paraparmelia sitiens</i> (Brusse) Elix	
skyrinifera Hale	Hale 1986, Hale 1990
spargens Hale	Brusse 1988e, Hale 1990
spesica (Essl.) O. Blanca et al.	Esslinger 1977, Blanca et al. 2004
<i>Parmelia spesica</i> Essl.	
<i>Neafuscelia spesico</i> (Essl.) Essl.	
spissa (Brusse) G. Amo, et al.	Brusse 1988d, Brusse 1989c, Hale 1989, Ama, et al. 2010
<i>Karaawia spissa</i> (Brusse) Hale	
springbakensis Hale	Hale 1990
squamans (Stizenb.) O. Blanca et al.	Doidge 1950, Esslinger 1977, Almbarn 1988b, Esslinger 2000, Blanca et al. 2004
<i>Parmelia squamans</i> Stizenb.	
<i>Neafuscelia squamans</i> (Stizenb.) Essl.	
squamariata (Nyl.) O. Blanca et al.	Crombie 1876, Doidge 1950, Esslinger 1977, Esslinger 1978, Henssen & Titze 1992, Esslinger 2000, Blanca et al. 2004
<i>Parmelia squamariata</i> Nyl. ex Cramb.	
<b>INC.:</b> <i>Parmelia squamariata</i> f. <i>cinerascens</i> Nyl.	
<i>Neafuscelia almbarnii</i> Henssen	
<i>Neafuscelia squamariata</i> (Nyl. ex Cramb.) Essl.	
squamatica Elix & T.H. Nash	Elix 1999c
standaertii (Gyeln.) Hale	Doidge 1950, Hale 1990
<i>Parmelia standaertii</i> var. <i>africana</i> Gyeln.	
stenasporonica Hale	Hale 1986, Hale 1990
subbullata Hale	Hale 1990
subchalybaeizans (Hale) G. Ama, et al.	Hale 1989, Ama, et al. 2010
<i>Karaawia subchalybaeizans</i> Hale	
subcolorata Hale	Hale 1986, Hale 1990
subconvoluta Hale	Hale 1990
subcrustasa Hale	Hale 1986
subdecipiens (Vain. ex Lyngé) Hale	Doidge 1950, Doidge 1950, Hale 1990
<i>Parmelia brunthaleri</i> f. <i>irregularis</i> Gyeln.	
<i>Parmelia subdecipiens</i> Vain. ex Lyngé	
subdamakasii Hale	Hale 1971, Elix et al. 1986a, Hale 1990
suberadicata (Abbayes) Hale	Elix et al. 1986a
<i>Parmelia suberadicata</i> Abbayes	
subflabellata (J. Steiner) Hale	Doidge 1950, Hale 1990
<i>Parmelia subflabellata</i> J. Steiner	
subhosseana (Essl.) O. Blanca et al.	Esslinger 2000, Blanco et al. 2004
<i>Parmelia subhosseana</i> Essl.	
<i>Neafuscelia subhosseana</i> (Essl.) Essl.	
subimitatrix (Essl.) O. Blanca et al.	Esslinger 1977, Esslinger 2000, Blanca et al. 2004
<i>Parmelia subimitatrix</i> Essl.	
<i>Neafuscelia subimitatrix</i> (Essl.) Essl.	
subincerta (Essl.) O. Blanca et al.	Esslinger 2000, Blanca et al. 2004
<i>Parmelia subincerta</i> Essl.	
<i>Neafuscelia subincerto</i> (Essl.) Essl.	
sublaevis (Cout.) Hale	Doidge 1950, Hale 1990
<i>Parmelia sublaevis</i> Caut.	
<i>Parmelia conspersa</i> var. <i>hypaclysta</i> Nyl.	
subnigra Hale	Hale 1986, Hale 1990
subachracea Hale	Hale 1986, Hale 1990

subpallida Hale	Hale 1987a, Hale 1990
subpigmentosa Hale	Hale 1990
subplittii Hale	Hale 1987b, Hale 1990
subramigera (Gyeln.) Hale	Nash & Elix 1987, Hale 1990
<i>Parmelia subramigera</i> Gyeln.	
subruginosa Hale	Hale 1986
subsquamariata (Elix) O. Blanca et al.	Elix 1999b, Esslinger 2000,
<i>Neofuscelia subsquamariata</i> Elix	Blanca et al. 2004
substenophyllaides Hale	Hale 1990
substygiades (Essl.) O. Blanca et al.	Esslinger 2000,
<i>Neofuscelia substygiades</i> Essl.	Blanca et al. 2004
supposita (Brusse) O. Blanca et al.	Brusse 1994, Elix 1997,
<i>Parmelia supposita</i> Brusse	Blanca et al. 2004
<i>Karaawia supposita</i> (Brusse) Elix	
surragata Hale	Hale 1986, Hale 1990
swartbergensis Hale	Hale 1987a, Hale 1990
synestia (Stirt.) Hale	Doidge 1950, Hale 1990
<i>Parmelia synestia</i> Stirt.	
tablensis Hale, T.H. Nash & Elix	Hale 1986, Hale 1990
tasmanica (Haak.f. & Taylor) Hale	Doidge 1950, Elix et al. 1986a,
<i>Parmelia tasmanica</i> Haak.f. & Taylor.	Nash & Elix 1987,
<i>Parmelia laxa</i> f. <i>lacinulata</i> Gyeln.	Almbarn 1988a, Almbarn 1988b,
<i>Parmelia canspersa</i> var. <i>incisa</i> (Taylor) Zahlbr.	Hale 1990
tegeta Elix & J. Jahnst.	Elix et al. 1986a, Nash & Elix 1987,
	Hale 1990
tenuiloba Hale	Hale 1987b, Hale 1990
terrícola Hale, T. H. Nash & Elix	Hale 1986, Nash & Elix 1987,
	Hale 1990
thamnalica Hale	Hale 1986, Brusse 1988e, Hale 1990
toninioides Hale	Hale 1986, Hale 1990
tartula (Kurak.) Elix	Hale & Kuokawa 1964, Hale 1976a
<i>Parmelia tartula</i> Kurak.	
<i>Paraparmelia tartula</i> (Kurak.) Elix & J. Jahnst.	
<i>Pseudoparmelia tartula</i> (Kurak.) Hale	
trachythallina (Essl.) O. Blanca et al.	Esslinger 1977, Esslinger 2000,
<i>Parmelia trachythallina</i> Essl.	Blanca et al. 2004
<i>Neofuscelia trachythallina</i> (Essl.) Essl.	
transvaalensis Hale, T. H. Nash & Elix	Hale 1986, Hale 1990
treurenensis Hale, T. H. Nash & Elix	Hale 1986, Hale 1990
tsekensis Hale	Hale 1989, Brusse 1991b
<i>Parmelia tsekensis</i> (Hale) Brusse	
tzaneenensis (Elix) Elix	Elix 2001, 2003
<i>Paraparmelia tzaneenensis</i> Elix	
tumidosa Hale	Hale 1986, Hale 1990
tyrrhea (Brusse) Elix	Brusse 1993, Elix 1997
<i>Parmelia tyrrhea</i> Brusse	
umtamvuna Hale	Hale 1987a, Brusse 1989c, Hale 1990
<i>Parmelia umtamvuna</i> (Hale) Brusse	
unctula Hale	Brusse 1988e, Hale 1990
usitata (Brusse) Elix	Brusse 1986a, Elix 1997, Elix 2003
<i>Parmelia usitata</i> Brusse	
<i>Paraparmelia usitata</i> (Brusse) Elix	
vanderbylii (Zahlbr.) Elix	Doidge 1950, Hale 1976a, Elix 2001
<i>Parmelia vanderbylii</i> Zahlbr.	
<i>Pseudoparmelia vanderbylii</i> (Zahlbr.) Hale	
<i>Paraparmelia vanderbylii</i> (Zahlbr.) Elix	
vendensis Hale	Hale 1987a, Hale 1990
verecunda (Brusse) Hale	Brusse 1988e, Hale 1990
<i>Parmelia verecunda</i> Brusse	
verisidiasa (Essl.) O. Blanca et al.	Esslinger 1977, Almbarn 1988b,
<i>Parmelia verisidiasa</i> Essl.	Esslinger 2000,
<i>Neofuscelia verisidiasa</i> (Essl.) Essl.	Blanca et al. 2004
verrucella (Essl.) O. Blanca et al.	Esslinger 1977, Almbarn 1988b,
<i>Parmelia verrucella</i> Essl.	Esslinger 2000,

<i>Neofuscelia verrucello</i> (Essl.) Essl.	Blanco et al. 2004
verruciformis Elix & J. Johnst.	Nash & Elix 1987, Hale 1990
verrucigera (Nyl.) Hale	Swinscow & Krog 1988, Hale 1990
<i>Parmelia verrucigero</i> Nyl.	
<i>X. lusitono</i> (Nyl.) Krog	
verruculifera (Nyl.) O. Blanco et al.	Doidge 1950, Blanco et al. 2004
<i>Parmelia verruculifera</i> Nyl.	
<i>Neofuscelia verruculifera</i> (Nyl.) Essl.	
victoriana Elix & J. Johnst.	Hale 1990
violacea (Kurok.) Elix	Brusse 1984, Brusse 1991b, Hale 1976a, Elix 2003, Elix 1997, Esslinger 2000
<i>Pseudoparmelia violacea</i> (Kurok.) Hale	
<i>Paroparmelia violacea</i> (Kurok.) Elix & J. Johnst.	
<i>Neofuscelia violacea</i> (Kurok.) Elix	
<i>Neofuscelia porilis</i> (Brusse) Elix	
<i>Parmelia porilis</i> Brusse	
<i>Parmelia verrucosus</i> Brusse	
<i>Paroparmelia verrucosus</i> (Brusse) Essl.	
<i>Neofuscelia verrucosus</i> (Brusse) Elix	
viridis Hale	Hale 1986, Hale 1990
waboombergensis (Essl.) O. Blanco et al.	Esslinger 2000, Blanco et al. 2004
<i>Neofuscelia waboombergensis</i> Essl.	
waboomburgensis Elix	Elix 2002
weberi Hale	Elix et al. 1986a, Hale 1990
wesselsii Hale	Hale 1986, Hale 1990, Alborn 1988a, Alborn 1988b Elix 2001, Elix 2003
wirthii (Elix) Elix	
<i>Paroparmelia wirthii</i> Elix	
worcesteri (J. Steiner & Zahlbr.) Hale	Doidge 1950, Hale 1990
<i>Parmelia worcesteri</i> J. Steiner & Zahlbr.	
xanthomelaena (Müll. Arg.) Hale	Doidge 1950, Elix et al. 1986a, Nash & Elix 1987, Hale 1987b Hale 1990
<i>Parmelia xanthomelaena</i> Müll. Arg.	
xanthomelanella Elix	Doidge 1950, Hale 1990 Nash & Elix 1987
<i>Parmelia mougeotii</i> var. <i>dealbata</i> A. Massal.	
<i>Paroparmelia xanthomelonoides</i> Elix & Nash	
<i>X. xanthomelonoides</i> Elix & J. Johnst.	
<sup>1</sup> Brusse (1988) considers this species a synonym of <i>X. competitiva</i> .	
<sup>2</sup> Published as <i>cedrus-montana</i> .	
<sup>3</sup> Old records are dubious. Correctly reported by Brusse 1988.	
<sup>4</sup> Possibly a synonym of <i>X. olivetorica</i> (Brusse 1991b).	
<sup>5</sup> Brusse (1988e) considered this 'species' a mixture of <i>X. ostrica</i> and <i>X. endochromatica</i> .	
<b>Xantharia</b> (Fr.) Th. Fr. (1861)	
aureola (Ach.) Erichsen	Doidge 1950
<i>X. parietina</i> var. <i>aureola</i> (Ach.) Th. Fr.	
bonae-spei S.Y. Kandr. & Kärnefelt	Kondratyuk et al. 2004
<i>Dufourea bonae-spei</i> (S.Y. Kandr. & Kärnefelt) Frödén, Arup & Søchting	
candelaria (L.) Th. Fr.	Doidge 1950
<i>Palycauliona candelaria</i> (L.) Frödén, Arup & Søchting	
AS: <i>X. condolorio</i> f. <i>fibrillosa</i> Hillm.	
<i>X. condolorio</i> var. <i>semigranularis</i> Zahlbr.	
capensis Kärnefelt, Arup & L. Lindblom	Alborn 1988b, Kärnefelt et al. 1995
<i>Dufourea capensis</i> (Kärnefelt, Arup & L. Lindblom) Frödén, Arup & Søchting	
dissectula S.Y. Kandr. & Kärnefelt	Kondratyuk et al. 2004
<i>Dufourea dissectula</i> (S.Y. Kandr. & Kärnefelt) Frödén, Arup & Søchting	
doidgeae Eichenb., Aptroot & Honegger	Eichenberger, et al. 2007
<i>Dufourea doidgeae</i> (Eichenb., Aptroot & Honegger) Frödén, Arup & Søchting	
elegans (Link) Th. Fr.	Doidge 1950, Alborn 1988b
<i>Rusavskia elegans</i> (Link) S. Y. Kandr. & Kärnefelt	

<i>Coloplaca elegans</i> (Link) Th. Fr.	
<i>Coloploca tegularis</i> (Ehrh.) Sandst	
ectaneoides (Nyl.) Zahlbr.	Doidge 1950
hirsuta Eichenb., Aptroot & Honegger	Eichenberger, et al. 2007
<i>Dufourea hirsuta</i> (Eichenb., Aptroot & Honegger) Frödén, Arup & Søchting	
inflata Eichenb., Aptroot & Honegger	Eichenberger, et al. 2007, Kondratyuk et al. 2008
<i>Dufourea inflata</i> (Eichenb., Aptroot & Honegger) Frödén, Arup & Søchting	
karrooensis S.Y. Kondr. & Kärnefelt	Kärnefelt et al. 2002a
<i>Dufourea karrooensis</i> S.Y. Kondr. & Kärnefelt) Frödén, Arup & Søchting	
ligulata (Körb.) P. James	Kondratyuk et al 2009
<i>Dufourea ligulata</i> (Körb.) Frödén, Arup & Søchting	
marlothii Zahlbr.	Doidge 1950
<i>Dufourea marlothii</i> (Zahlbr.) Frödén, Arup & Søchting	
<sup>1</sup> monofoliola S.Y. Kondr. & Kärnefelt	Kondratyuk et al. 2008
parietina (L.) Th. Fr.	Doidge 1950, Almborn 1988b, Galloway 1995, Verseghy 1963
<i>X. parietino</i> f. <i>albicans</i> (Müll. Arg.) Hillmann	
<i>X. parietino</i> f. <i>rutilans</i> Th. Fr.,	
<i>X. parietino</i> var. <i>ectaneo</i> (Ach.) J. Kickx f.,	
<i>X. parietino</i> var. <i>macrophylla</i> (Stizenb.)	
INC.: <i>X. parietina</i> var. <i>irregularis</i> Gyeln. (nomen nudum)	
sipmanii S.Y. Kondr. & Kärnefelt	Kondratyuk et al. 2008
<i>Dufourea sipmanii</i> (S.Y. Kondr. & Kärnefelt) Frödén, Arup & Søchting	
<sup>1</sup> Nom. illegit., holotype not designated (See Appendix 1).	
<b>Zwackhia</b> Körb. (1855)	
bonplandii (Fée) Ertz	Doidge 1950
<i>Opegrapha bonplandii</i> Fée	

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## Appendix 2: Illegitimate Names

During the preparation of this checklist a number of names were discovered that were later homonyms of previously published names and, therefore, are illegitimate. New names for these taxa are not provided here because further work is required to ascertain their correct status and it is possible that any new names created would be superfluous. The exception is *Verrucaria dogolovii*, which is well known to the author and clearly a good species.

### Buellia discolorans Zahlbr.

*Lecideo discolor* Stizenb., *Berich 1t über die Thötigk. St. Gallisch. Naturw. Gesellsch. 1889–1890*: 173. 1891, (nom illeg.) non *Lecideo discolor* Hepp, *Flecht. Europ.*: no. 319, 1857, *Buellio discolor* (Hepp) Anzi, *Cot. Lich. Sondr.*: 87. 1860.

*Buellio discolorans* Zahlbr. *Catalogus Lichenum Universalis* 7: 256. 1930, (nom illegit.) non *Buellia discolorans* H. Olivier, *Flore analytique et dichotomique des lichens de l'Orne et départements circonvoisins, précédée d'un traité élémentaire de lichénographie*. 1884.

Stizenberger's name is illegitimate because it is a later homonym of *L. discolor* Hepp, and the epithet is also not available in *Buellio* because Hepp's name had already been transferred to that genus by Anzi. Zahlbrucker realized this and introduced the new name *Buellia discolorans* Zahlbr. but, unfortunately, this name is also illegitimate because it is a later homonym of *B. discolorans* H. Olivier (1884).

### Buellia protothallinella (Kremp.) Vain.,

*Buellio protothollino* (Kremp.) Vain., *Résult. Voy. Belgico. Lich.*: 25. 1903 (nom. illegit.), non *Buellio protothollino* (Anzi) Jatta, *Syll. Lich. Itol.*: 400. 1900.

### Lecanora bylii Zahlbr.

*Leconora bylii* Zahlbr. *Annoles de Cryptogomie Exotique* 5: 248. 1932 (nom. illegit.), non *Leconoro bylii* Vain., *Annal. Univers. Fennic. Abcënsis*, ser A, vol, 2(3): 2. 1926—*Aspicilio bylii* (Vain.) C.W. Dodge, *Beihefte zur Novo Hedwigio* 38.:5. 1971.

### Usnea capensis Motyka

*Usneo copensis* Motyka, *Lich. Gen Usneo Stud. Monogr., Pors System.* 2: 321. 1937 (nom illegit.), non *Usneo copensis* (L.f.) Hoffm (1790), *Descript. Et Adumbr. Plont Lich.* 1: 48 (1790) = *Teloschistes copensis* (L.f.) Müll. Arg.

### Verrucaria umbilicata Øvstedal

*Verrucorio umbilicoto* Øvstedal, *S. Africon Journal of Botony* 67(4): 569. 2001 (nom. illegit.), non *Verrucorio umbilicoto* Hoffm., *Deutschl. Floro*: 171. 1796.

Øvstedal (2001) introduced this name for a distinctive species with thick areoles that become umbilicate from the Prince Edward islands that is also known from Îles Kerguelen (AMF - unpublished data). Unfortunately, *V. umbilicota* is illegitimate (non *Verrucaria umbilicoto* Hoffm., *Deutschl. Floro*: 171. 1796.) and so the new name *Verrucorio dogolovii* is proposed (see Results). The new epithet honours Dag Olav Øvstedal for his work on the lichen biota of the Antarctic and Subantarctic.

### Xanthoria monofoliola S.Y. Kondr. & Kärnefelt

*Xonthorio monofoliosio* S.Y. Kondr. & Kärnefelt, in Kondratyuk, et al. *Souterio* 15: 275. 2008 (nom. inval. – ICN Art. 40.1, 40.2).

Kondratyuk & Kärnefelt neglected to designate a holotype for this name. The species is close to, and possibly conspecific with, *X. porietino* and more work is required to clarify its taxonomic position.

Note: This is the Online Appendix of Fryday, A.M., 2015, 'A new checklist of lichenised, lichenicolous and allied fungi reported from South Africa', *Bathalia* 45(1), Art. #148, 4 pages. <http://dx.doi.org/10.4102/abc.v45i1.148>

## Appendix 3: Prince Edward Islands

Politically, the Prince Edward Islands are part of South Africa, but as they are situated c. 1,750 km from the mainland in the sub Antarctic region of the southern Indian Ocean, they are here treated separately from the rest of the country. All records are from Øvstedal & Gremmen 2001, 2007 & 2014, unless otherwise indicated.

### **Acarospora** A. Massal. (1852)

- impressula* Th. Fr.,
- cf. *otagensis* H. Magn.

### **Amandinea** M. Choisy ex Scheid. & H. Mayrhofer (1993)

- subplicata* (Nyl.) Øvstedal

### **Arctomia** Th. Fr. (1860)

- subantarctica* Øvstedal

### **Arthothelium** A. Massal. (1852)

- evanscens* Øvstedal

### **Arthrorhaphis** Th. Fr. (1860)

- citrinella* (Ach.) Poelt

### **Buellia** De Not. (1846)

- fuscoatrula* Zahlbr.
- tristiuscula* (Nyl.) Zahlbr.

### **Caloplaca** Th. Fr. (1860)

- castellana* (Räsänen) Poelt
- cirrochrooides* (Vain.) Zahlbr.
- cribrosa* (Hue) Zahlbr.
- isidioclada* Zahlbr.

#### *Villophora isidioclada* (Zahlbr.) Søchting, Frödén & Arup

- lucens* (Nyl.) Zahlbr.
- sublobulata* (Nyl.) Zahlbr.
- tiroliensis* Zahlbr.

#### *Parvoplaca tiroliensis* (Zahlbr.) Arup, Søchting & Frödén

### **Carbonea** (Hertel) Hertel (1983)

- assentiens* (Nyl.) Hertel
- phaeostoma* (Nyl.) Hertel
- subjecta* (Nyl.) Hertel

### **Catillaria** A. Massal. (1852)

- impolita* D.C. Linds.
- lenticularis* (Ach.) Th. Fr.

### **Chrysothrix** Mont. (1852)

- chlorina* (Ach.) J.R. Laundon

### **Cladonia** P. Browne (1756)

- albata* S. Stenroos
- cervicornis* subsp. *mawsonii* (C.W. Dodge) Stenroos & Ahti
- chlorophaea* (Flörke ex Sommerf.) Spreng.
- gracilis* (L.) Willd. subsp. *turbinate* (Ach.) Ahti
- marionii* S. Stenroos

- ochrochlora* Flörke
- pocillum* (Ach.) O. J. Rich.

- cf. *poeciloclada* Abbayes
- sarmentosa* (Hook. f. & Taylor) C.W. Dodge
- ustulata* (Hook. f. & Taylor) Leight.
- cf. *tapperi* Ahti & Krog

### **Coenogonium** Ehrenb. (1820)

- cf. *weberi* Vězda,

### **Edwardiella** Henssen (1986)

- mirabilis* Henssen

### **Eiglera** Hafellner (1984)

- flavida* (Hepp) Hafellner,

### **Fuscidea** V. Wirth & Vězda (1972)

- asbolodes* (Nyl.) Hertel & V. Wirth

### **Gyalecta** Ach. (1808)

- azorellae* Øvstedal

### **Gyalideopsis** Vězda (1972)

- subantarctica* Henssen & Lumbsch

### **Haematomma** A. Massal. (1852)

- erythromma* (Nyl.) Zahlbr.

### **Hertella** Henssen (1985)

- subantarctica* Henssen Henssen 1985b

### **Lecanora** Ach. (1809)

- disjungenda* (Cromb.) Hertel & Rambold
- flotowiana* Spreng.
- polytropa* (Ehrh. Ex Hoffm.) Rabenh.

### **Lecidea** Ach. (1803)

- lapicida* (Ach.) Ach.
- lygomma* Nyl.
- medusula* (C.W. Dodge) Hertel
- Zosterodiscus russellii* Hertel

### **Leciophysma** Th. Fr. (1865)

- subantarcticum* Henssen Henssen 2007

### **Lepraria** Ach. (1803)

- <sup>1</sup>*lobificans* Nyl.
- neglecta* (Nyl.) Lettau

<sup>1</sup>The species previously called *L. lobificans* is now called *L. finckii* (B. de Lesd.) R.C. Harris. *Lepraria lobificans* is the correct name for the species previously called *L. sontosii* Argüello & A. Crespo. It is unclear to which species the Prince Edwards Islands collection belongs.

### **Leptogium** (Ach.) Gray (1821)

- tasmanicum* F. Wilson

### **Lithographa** Nyl. (1857)

- graphidioides* (Cromb.) Imshaug ex Coppins & Fryday
- Lithographa subantarctica* Hertel & Rambold
- marionensis* Hertel & Rambold

- Massalongia** Körb. (1855)  
carnosa (Dicks.) Körb.
- Mastodia** Hook. f. & Harv. (1847)  
tessellata (Hook. f. & Harv.) Hook. f. & Harv.  
*Turgidosculum complicatulum* (Nyl.) Kohlm. & E. Kohlm.
- Mycoblastus** Norman (1853)  
caesius (Coppins & P. James) Tønsberg
- Opegrapha** Ach. (1809)  
diaphoriza Nyl.
- Orceolina** Hertel (1970)  
keruelensis (Tuck.) Hertel
- Pannaria** Delise ex Bory (1828)  
dichroa (Hook. f. & Taylor) Cromb.  
pulvinula P.M. Jørg. Jørgensen 2000
- Parmelia** Ach. (1803)  
keruelensis F. Wilson  
sulcata Taylor
- Parmotrema** A. Massal. (1860)  
crinitum (Ach.) M. Choisy  
perlatum (Huds.) M. Choisy
- Peltigera** Willd. (1787)  
aubertii C.W. Dodge Vitikainen 2002  
*Peltigera keruelensis* C.W. Dodge  
lepidophora (Vain.) Bitter,  
truculenta De Not. Vitikainen 2002
- Pertusaria** DC. (1805)  
cineraria Nyl.  
werthii Zahlbr.  
cf. perrimosa Nyl.
- Phyllisciella** Henssen (1984)  
marionensis Henssen Henssen & Budel 1984
- Placopsis** (Nyl.) Linds. (1866)  
bicolor (Tuck.) B. de Lesd.  
macrophthalma (Hook. f. & Taylor) Nyl.  
*Aspiciliopsis macrophthalma* (Hook. f. & Taylor) B. de Lesd.  
stellata (Øvstedal) Henssen  
*Coccotrema stellata* Øvstedal
- Poeltiaria** Hertel (1984)  
subcontinua (Nyl.) Hertel & Fryday Fryday & Hertel 2014  
*Notolecidea subcontinua* (Nyl.) Hertel  
urbanskyana (Zahlbr.) Hertel
- Poeltidea** Hertel (1984)  
perusta (Nyl.) Hertel & Hafellner
- Poeltinula** Hafellner (1984)  
cerebrinella (Nyl) Øvstedal
- Porina** Ach. (1809)  
leptalea (Durieu & Mont.) A.L. Sm.
- Pseudocyphellaria** Vain. (1890)  
crocata (L.) Vain.  
intricata (Delise) Vain.
- Psoroma** Ach. ex Michx. (1803)  
asperellum Nyl.
- Ramalina** Ach. (1809)  
subfarinacea (Nyl. ex Cromb.) Nyl.
- Ramonia** Stizenb. (1862)  
subantarctica Øvstedal
- Rhizocarpon** Ramond ex DC. (1805)  
geographicum (L.) DC.  
nidificum (Hue) Darb.  
postumum (Nyl.) Arnold
- Rinodina** (Ach.) Gray (1821)  
aff. griseosoralifera Coppins  
peloleuca (Nyl.) Müll. Arg.
- Scoliciosporum** A. Massal. (1852)  
umbrinum (Ach.) Arnold
- Siphulastrum** Müll. Arg. (1889)  
mamillatum (Hook. f. & Taylor) D.J. Galloway
- Sporastatia** A. Massal. (1854)  
testudinea (Ach.) A. Massal.
- Steinera** Zahlbr. (1906)  
radiata subsp. edwardiensi Øvstedal  
sorediata P. James & Henssen
- Stephanocyclus** Hertel (1984)  
henssenianus Hertel
- Stereocaulon** Hoffm. (1796)  
cymosum Cromb.  
heardii Øvstedal  
implexum Th. Fr
- Sticta** (Schreb.) Ach. (1803)  
fuliginosa (Hoffm.) Ach.
- Tephromela** M. Choisy (1929)  
atra (Huds.) Hafellner  
probably *Tephromela skottsbergii* (Darb.) Fryday  
eatonii (Cromb.) Hertel

**Thelenella** Nyl. (1855)  
kerguelena (Nyl.) H.Mayrhofer

**Thelidium** A. Massal. (1855)  
pyrenophorum (Ach.) Mudd

**Thelocarpon** Nyl. (1853)  
subantarcticum Øvstedal

**Tremolecia** M. Choisy (1953)  
atrata (Ach.) Hertel

**Usnea** Dill. ex Adans. (1763)  
antarctica Du Rietz  
maculata Stirton

**Verrucaria** Schrad. (1794)  
bubalina P.M.McCarthy,  
ceutocarpa Wahlenb.  
dagolavii Fryday  
*Verrucaria umbilicata* Øvstedal (nom. illeg.,  
non *V. umbilicatula* Hoffm.)  
cf. ditmarsica Erichsen  
durietzii I.M. Lamb  
efflorescens Øvstedal  
halizoa Leight.  
maura Wahlenb. ex Ach.  
mawsonii C.W. Dodge  
mucosa Wahlenb.  
psycrophila I.M. Lamb  
subdiscreta P.M.McCarthy  
tesselatula Nyl.

**Xanthoparmelia** (Vain.) Hale (1974)  
mougeotii (Schaer.) Hale

**Xanthoria** (Fr.) Th. Fr. (1861)  
candelaria (L.) Th. Fr.  
***Polycauliona candelaria* (L.) Frödén, Arup & Søchting**

**Zahlbrucknerella** Herre (1912)  
marionensis Henssen  
Henssen 1985a

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**Note:** This is the Online Appendix of Fryday, A.M., 2015, 'A new checklist of lichenised, lichenicolous and allied fungi reported from South Africa', *Bothalia* 45(1), Art. #148, 4 pages. <http://dx.doi.org/10.4102/abc.v45i1.148>

## Appendix 4: Excluded Taxa

### i) Taxa included by Doidge (1950) but reported only from outside South Africa

*Acaraspara angalensis* H. Magn.  
*Acarospora fuscata* (Nyl.) Arnold  
*Acaraspora initialis* var. *perfectiar* H. Magn.  
*Acaraspora perexigua* (Müll. Arg.) Hue  
*Acaraspora rhadesiae* H. Magn.  
*Anaptychia leucomelaena* var. *multifida* f. *squarrosa* Vain.  
*Anaptychia speciosa* var. *labulifera* Vain.  
*Anthracothecium thelemarphum* (Vain.) Zahlbr.  
*Arthania antillarum* Nyl.  
*Arthania dispersa* (Schrad.) Nyl.  
*Arthania platygraphidea* Nyl.  
*Blastenia canfluens* Müll. Arg.  
*Blastenia paliatera* (Nyl.) Müll. Arg.  
*Bambylaspara lepralyta* (Nyl.) Zahlbr.  
*Buellia afra* Vain.  
*Buellia albinea* Müll. Arg.  
*Buellia disciformis* f. *vulgata* H. Olivier  
*Buellia inquilina* Tuck.  
*Buellia alivacea* Müll. Arg.  
*Buellia pura* Vain.  
*Buellia rhadesiaca* Zahlbr.  
*Buellia spuria* var. *ferruginea* Vain.  
*Buellia subalbula* (Nyl.) Müll. Arg.  
*Calaplaca benguellensis* (Nyl.) Zahlbr.  
*Calaplaca cinnabarina* var. *apaca* (Müll. Arg.) Zahlbr.  
*Calaplaca elegantissima* (Nyl.) Zahlbr.  
*Calaplaca flava* (Müll. Arg.) Zahlbr.  
*Calaplaca mastaphara* var. *flavarubescens* Vain.  
*Calaplaca pyracea* f. *pyrithramoides* H. Olivier  
*Calaplaca pyracea* f. *pyrapaecila* (Nyl.) Zahlbr.  
*Calaplaca zambesica* (Müll. Arg.) Zahlbr.  
*Chiadectan subnanum* Vain.  
*Cladania bacillaris* f. *pityrapada*  
*Cladania garganina* var. *subrangiferina* (Nyl.) Vain.  
*Cladania pyxidata* var. *chlaraphaea* Floerke  
*Callema furfum* (Ach.) DC.  
*Cracynia membranacea* (Dicks.) Zahlbr.  
*Dermatina pyrenacarpa* (Nyl.) Zahlbr.  
*Haematamma caccineum* var. *parphyricum* (Pers.) Th. Fr.  
*Heppia azurea* Vain.  
*Heppia guepini* (Del.) Nyl.  
*Heppia mossamedana* Vain.  
*Lecanara atra* var. *americana* Féé  
*Lecanara epichlara* Vain.  
*Lecanara hypacracina* Nyl.  
*Lecanara impressa* (Kremp.) Zahlbr.  
*Lecanara subcarnea* (Sw.) Ach.  
*Lecidea leptabala* Nyl.  
*Lecidea lithagaga* Vain.  
*Lecidea massamedana* Vain.  
*Lecidea placadina* Nyl.  
*Lepraria citrina* Schaer.  
*Lepraria xanthina* Vain.  
*Leptagium adpressum* Nyl.  
*Leptagium brebissanii* Mont.

*Leptatrema micraglaenoides* (Vain.) Zahlbr.  
*Maranea harizoides* (Müll. Arg.) Vain.  
*Opegrapha medusulina* Nyl.  
*Opegrapha menyharthii* Müll. Arg.  
*Parmelia concretescens* Vain.  
*Parmelia coronata* var. *denudata* Vain.  
*Parmelia ecarperata* Müll. Arg.  
*Parmelia hypacraea* Vain.  
*Parmelia majaris* Vain.  
*Parmelia maugatii* var. *abscurata* Müll. Arg.  
*Parmelia nitens* Müll. Arg.  
*Parmelia zallingeri* Hepp  
*Peccania minuscula* (Nyl.) Zahlbr.  
*Pertusaria cariacea* var. *abducens* Zahlbr.  
*Pertusaria mamillana* Müll. Arg.  
*Pertusaria microthelia* Vain.  
*Pertusaria rhadesica* Vain.  
*Pertusaria trapica* Vain.  
*Pertusaria xanthathelia* Müll. Arg.  
*Physcia adglutinata* var. *pyrithrocardia* Müll. Arg.  
*Physcia aipalia* var. *acrita* Hue  
*Physcia melanacarpoides* Vain.  
*Physcia achroleuca* Müll. Arg.  
*Placathelium staurathelioides* Müll. Arg.  
*Psaraticchia cataractae* Zahlbr.  
*Psaraticchia fuliginella* (Nyl.) Vain.  
*Pyrenopsis robustula* Müll. Arg.  
*Pyrenula cerina* f. *expallens* Zahlbr.  
*Pyrenula pleiameriza* (Nyl.) Zahlbr.  
*Pyxine meissneri* var. *sarediasa* Müll. Arg.  
*Pyxine meissneri* var. *subobscurans* Malme  
*Pyxine petricala* Nyl.  
*Pyxine rhadesiaca* Vain.  
*Ramalina dendriscaides* Nyl.  
*Ramalina eupharbiae* Vain.  
*Rinadina bicalar* Zahlbr.  
*Rinadina canspersa* Müll. Arg.  
*Rinadina huillensis* Vain.  
*Raccella fucaides* var. *arnaldi* Zahlbr.  
*Raccella hereraensis* Vain.  
*Raccella hypomecha* var. *isabellina* Vain.  
*Raccella massamedana* Vain.  
*Raccella padacarpa* (Welw.) Vain.  
*Raccella tinctoria* f. *camplanata* Vain.  
*Raccella tinctoria* var. *subpadicellata* Vain.  
*Thelatrema diplachistoides* Vain.  
*Usnea acanthera* Motyka  
*Usnea malacea* Zahlbr. var. *subelegans* Zahlbr.  
*Usnea perspinosa* Motyka  
*Usnea submusciformis* Vain.

### ii) Names of uncertain application reported by Doidge (1950)

*Cladania sylvatica* (L.) Hoffm : This name has been used for a number of species in the *C. rangiferina* group.

*Dermatacarpon hepaticum* (Ach.) Th. Fr.: probably *Placidium squamulosum* (Ach.) Breuss.

*Lecanara chlarana* (Ach.) Nyl.: Either *L. chlaratera* Nyl. or *L. pulcaris* (Pers.) Ach. (*L. chlarana* f. *geographica* Nyl. also reported by Daidge 1950)

*Lecanora subfusca* (L.) Ach.: This name has been used for a number of carticalous species of *Lecanora*.

*Parmelia alivacea* Nyl.: Feuerer refers Daidge's report of *P. alivacea* to *P. pannifarmis* (= *Melanelia pannifarmis*). However, the name *Parmelia alivacea* was previously used for a number of brawn parmelioid species and so its application is uncertain.

*Parmelia taractica* Kremp.: South African records are probably misdeterminations of *X. laxchalybaeizans* or *X. bibax*.

*Physcia hispida* (Schreb.) Frege: Either *P. adscendens* (Fr.) H. Olivier, *P. leptalea* (Ach.) DC. or *P. tenella* (Scap.) DC.

*Physcia picta* f. *isidiifera* Nyl.: this name is not in Index Fungorum. Possibly *Physcia picta* f. *isidiophara* Nyl. (= *Heteradermia isidiophara* (Nyl.) D.D. Awasthi).

*Taninia caeruleanigricans* Th. Fr.: possibly *T. australis* Timdal

### iii) Taxa incorrectly reported by Brusse (1988e)

*Dimerella zanata* (Müll. Arg.) R. Sant.: corrected to *Caenaganium luteum* (Dicks.) Kalb & Lücking (Brusse 1991c).

*Heteradermia erinacea* (Ach.) W. Weber: corrected to *Heteradermia* cf. *comosa* (Eschw.) Fallm. & Redan (Brusse 1991c).

*Lecanara gangaleaides* Nyl.: not this species (Brusse 1991b).

*Phyllapsara haemophae* (Nyl.) Müll. Arg.: corrected to *Phyllapsara pannasa* Nyl. (Brusse 1989d).

*Parmelia usambarensis* J. Steiner & Zahlbr.: corrected to *Parmelinella wallichiana* Taylor (Brusse 1991c).

*Toninia taniniaides* (A. Massal.) Zahlbr.: corrected to *Taninia lutasa* (Ach.) Timdal (Brusse 1993)

### iv) Australian species of *Xanthoparmelia* incorrectly reported from South Africa

South African collections of several taxa that were described from Australia have subsequently been shown to represent different taxa (all J. Elix pers comm.).

*Xanthoparmelia amplexula* (Stirt.) Elix & J. Jahnst.: Reported by Nash & Elix (1987) - South African records are misdeterminations of *X. amplexuloides* Hale.

*Xanthoparmelia digitiformis* (Elix & Amstr.) Filson: Reported by Nash & Elix (1987) but South African records are misdeterminations of *X. concolor* (Spreng.) Hale

*Xanthoparmelia dissitifolia* Kurok. ex Elix & J. Jahnst.: Reported by Elix et al (1986a) but South African records are misdeterminations of *X. alifantensis* Hale.

*Xanthoparmelia filarszkyana* (Gyeln.) Hale: Reported by Brusse (1988e) as *Parmelia filarszkyana* Gyeln. but South African records are misdeterminations of *X. narlabaranica* Hale.

*Xanthoparmelia filsanii* Elix & J. Jahnst.: Reported by Nash & Elix (1987) but South African records are misdeterminations of *X. minuta* D. Knox & Hale.

*Xanthoparmelia isidiasa* (Müll. Arg.) Elix & J. Jahnst.: Reported by Nash & Elix (1987) but South African records are misdeterminations of *X. geesterani* (Hale) Hale & Elix.

*Xanthoparmelia maugeatina* (Nyl.) D.J. Gallaway: Reported by Elix et al (1986a) but South African records are misdeterminations of *X. cangensis* (J. Steiner) Hale.

*Xanthoparmelia numinbahensis* (Elix) Elix: Reported by Nash & Elix (1987) as *Paraparmelia numinbahensis* (Elix) Elix & J. Jahnst. but South African records are misdeterminations of *X. oveana* (Elix) Elix.

*Xanthoparmelia pertinax* (Kurak. & Filsan) Elix & J. Jahnst.: Reported by Nash & Elix (1987) but South African records are misdeterminations of *X. ceresina* (Vain.) Hale.

*Xanthoparmelia pratamatrae* (Gyeln.) Hale: Reported by Daidge (1950) as *Parmelia digitula* f. *mitravicensis* Gyeln., which according to Hale (1990) is a synonym of this species, but South African records are misdeterminations of *X. phaeaphana* (Stirt.) Hale.

*Xanthoparmelia spadachraa* (Kurak. & Filsan) Elix: Reported by Nash & Elix (1987) as *Paraparmelia spadachraa* (Kurok. & Filsan) Elix & J. Jahnst. but South African records are misdeterminations of *X. candylaides* (Kurak.) Elix.

*Xanthoparmelia stenaphylla* (Ach.) Du Rietz: Reported by Daidge (1950) as *Parmelia stenaphylla* f. *hypamelaena* Vain. ex Lynge but South African records are probably misdeterminations of *X. bibax* (Brusse) Hale.

*Xanthoparmelia subcrustacea* (Gyeln.) Hale: Reported by Daidge (1950) as *Parmelia subcrustacea* (Gyeln.) but South African records are misdeterminations of *X. brevilabata* Hale.

*Xanthoparmelia terrestris* Hale: Reported by (Nash & Elix 1987) but South African records are misdeterminations of *X. terricala* Hale, T.H. Nash & Elix.

### v) Other taxa

*Acaraspara sinapica* (Wahlenb.) Kärb. (Kerr & Zavada 1989): reported as "one of the most abundant saxicolous lichens in the African High Veld region. Its ubiquitous and unrestricted occurrence on a wide variety of rock substrate...". However, *A. sinopica* is an uncommon species restricted to racks with a high iron content and so its report from South Africa is almost certainly incorrect.

*Alectoria chalybeiformis* f. *terrestris* Stizenb. and *A. jubata* (L.) Ach. (Doidge 1950): The specimens upon which the reports of

these two species were based were redetermined by Kärnefelt (1987b) as filamentous cyanobacteria.

Note: This is the Online Appendix of Fryday, A.M., 2015, 'A new checklist of lichenised, lichenicolous and allied fungi reported from South Africa', *Bothalia* 45(1), Art. #148, 4 pages. <http://dx.doi.org/10.4102/abc.v45i1.148>

# Assessment of the invasive status of newly recorded cactus species in the central Tugela River basin

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## Dates:

Received: 19 June 2015

Accepted: 22 Sept. 2015

Published: 09 Dec. 2015

## How to cite this article:

Cheek, M.D. & Crouch, N.R.,  
2015, 'Assessment of the  
invasive status of newly  
recorded cactus species  
in the central Tugela River  
basin', *Bothalia* 45(1), Art.  
#1953, 8 pages. <http://dx.doi.org/10.4102/abc.v45i1.1953>

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**Background:** Current distribution information on cacti in the Tugela River basin in KwaZulu-Natal, South Africa, is scant. Accordingly, surveys in this region substantially improve our understanding of regional invasions by this succulent group. The identification of new or extended invasions requires (re)assessments of their invasion status and consideration of possible management interventions.

**Objectives:** To identify and collect cacti either not previously recorded or poorly known in the central Tugela River basin, and to assess their invasion status.

**Method:** A 40 km section of tertiary road was travelled through the topocadastral square 2830 CC, from the R74 main road northward across the Bloukrans River towards the Tugela River. Herbarium specimens were collected to vouch for new instances of naturalisation of cacti, the colony sizes of which were estimated and invasion stages determined. An applicable weed risk assessment model was used to determine the threat status of one cactus species not previously evaluated for South Africa. Based on the South African Plant Invaders Atlas database records and field observations, management recommendations were suggested for six cacti species.

**Results:** The first naturalised population of *Opuntia microdasys* in KwaZulu-Natal was detected, as was the first confirmed South African record of *Echinopsis oxygona*. Four populations of *Peniocereus serpentinus* were also found, ranging in size from several square metres to 0.4 ha. *Echinopsis oxygona* generated a score that falls into the reject category of the risk assessment model used.

**Conclusion:** It is recommended that *E. oxygona* be added to the Species Under Surveillance for Possible Eradication or Containment Targeting list to investigate whether this species requires formal legal listing and the development of a specific eradication plan. Immediate action from local authorities is recommended for the manual removal of *P. serpentinus* and *O. microdasys* populations.

## Introduction

The extensive and ongoing invasion by cacti in South Africa has been documented since the 20th century, when *Opuntia ficus-indica* (L.) Mill. occupied vast tracts of the Karoo (Henderson 2015). A recent global review of Cactaceae invasions identified South Africa as the second most invaded of all countries in respect of this largely New World family, with 35 taxa recorded (Novoa *et al.* 2014). This study identifies the bioclimatic equivalence of South Africa to the natural range of invading cacti as a factor key to their successful naturalisation on the subcontinent.

In 2008, the Working for Water programme of the South African Department of Environment Affairs funded the South African National Biodiversity Institute Invasive Species Programme (SANBI ISP). The SANBI ISP documents new instances of naturalisation, evaluates taxa on the Species Under Surveillance for Possible Eradication or Containment Targeting (SUSPECT) list, advises on the legal listing of taxa and develops specific eradication plans (Wilson *et al.* 2013).

Earlier surveys documenting the vegetation of Weenen County (West 1951) and the entire Tugela River basin (Edwards 1967) did not record any members of the Cactaceae, apart from the indigenous *Rhipsalis baccifera* (J.S. Muell.) Stearn subsp. *mauritiana* (DC.) Barthlott. However, by 1987 both *Opuntia ficus-indica* and *O. stricta* (Haw.) Haw. var. *stricta* were common in this area, with *O. aurantiaca* Lindl. recorded there since 1999 (Henderson 2007; Southern African Plant Invaders Atlas [SAPIA] database 2015).

The suitability of the central region of the largest catchment in KwaZulu-Natal (KZN), the Tugela basin, for colonisation by succulents necessitates ongoing surveys for new or extended invasions by cacti, the assessment of environmental risks posed by them and the formulation of possible management approaches. The objectives of this study were to survey the cacti in

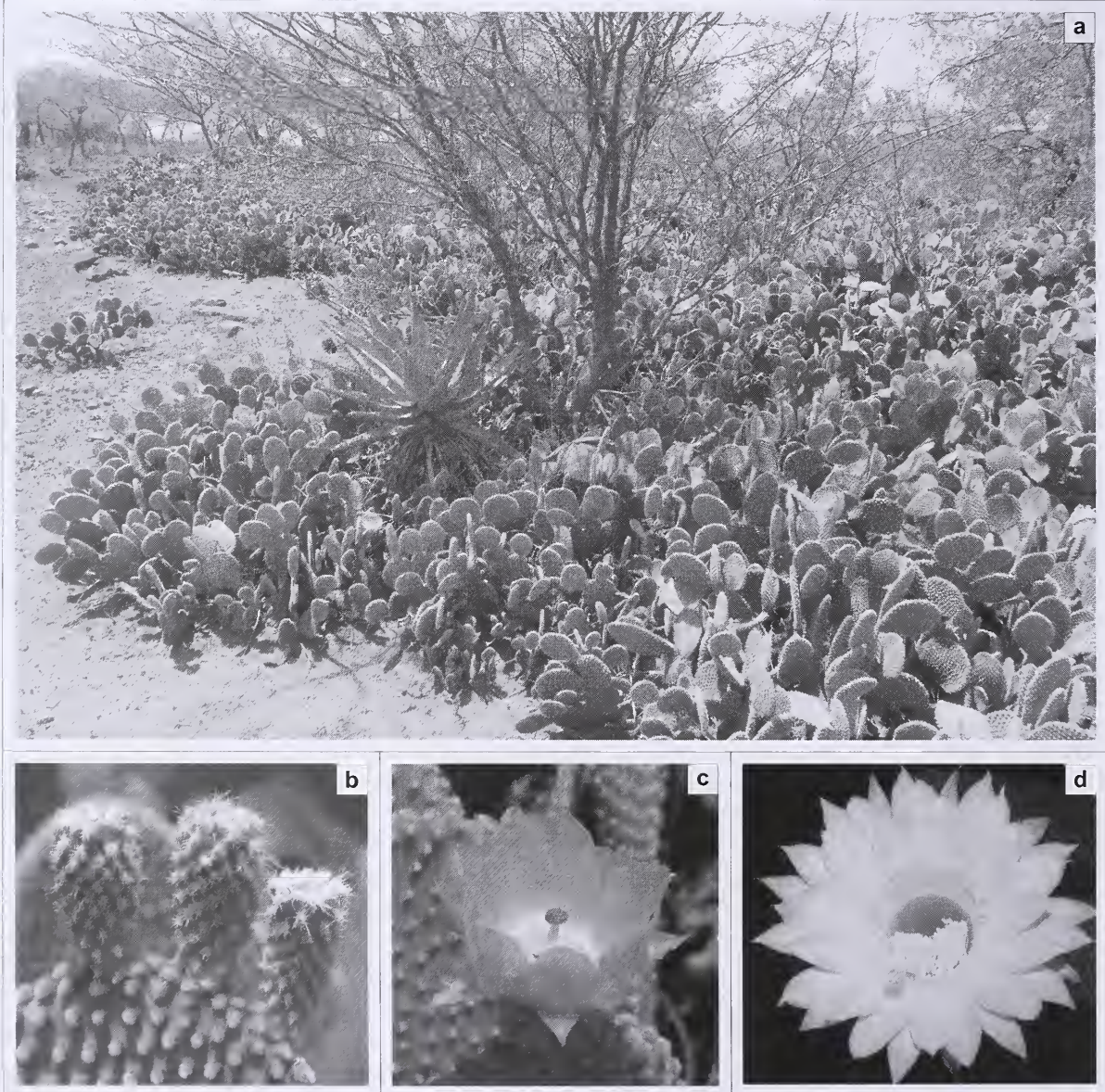
the central Tugela River and to assess the invasion status of those not previously recorded in the area, as well as to make recommendations for the management of exotic cacti encountered during the survey, based on field observations and the SAPIA database.

## Research methods

Field work in the central Tugela River basin near Weenen was undertaken in early December 2014 to gather cacti distribution data and specimens, particularly of *Peniocereus serpentinus*. A 40 km section of tertiary road was travelled

slowly by car through the topocadastral square 2830 CC, from the R74 main road northward across the Bloukrans River towards the Tugela River. Herbarium specimens were gathered and submitted to the KZN Herbarium.

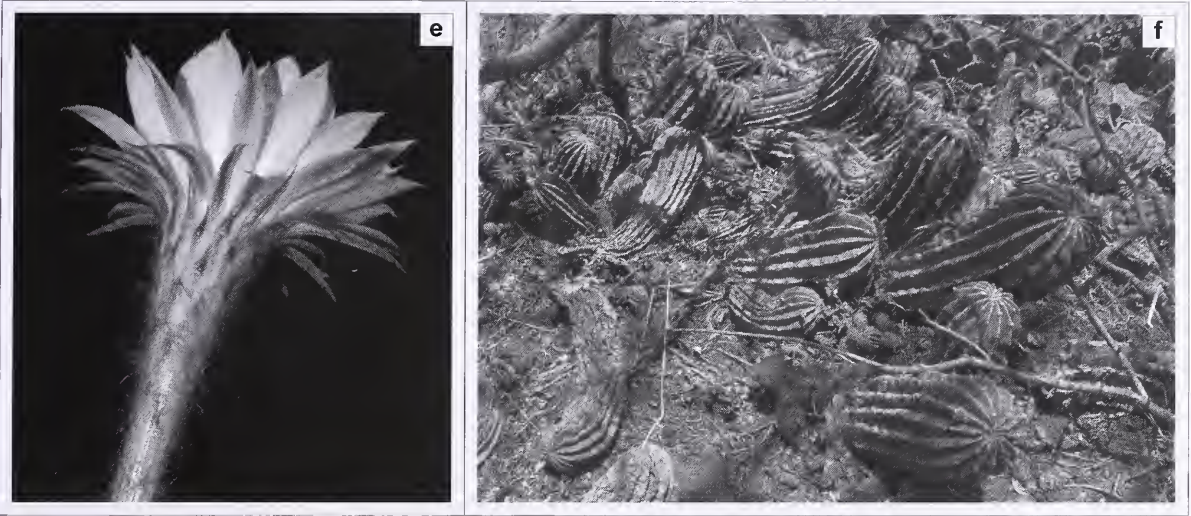
The invasion stages of three cacti species in the region were categorised according to Blackburn *et al.* (2011), following the interpretation of Wilson *et al.* (2014), with management recommendations formulated for all cacti encountered during the survey. A weed risk assessment (Gordon *et al.* 2010; Pheloung, Williams & Halloy 1999) was undertaken for one introduced cactus species not previously evaluated in South Africa.



Source: Figure 1 courtesy of Tanza Crouch

**FIGURE 1:** *Opuntia microdasys*: (a) Invasive population near Weenen; (b) Developing fruit, with prominent areoles bearing numerous glochids, and (c) Flowers orange, usually yellow elsewhere in South Africa. *Echinopsis oxygona*: (d) Flower, apical view, perianth segments spreading, (e) Flower, lateral view, funneiform, scales with long wool; and (f) Colony near Weenen, stems clustered, glaucous, subglobose to cylindrical-clavate.

Figure 1 continues on the next page →



Source: Figure 1 courtesy of Tanza Crouch

**FIGURE 1 (Continues...):** *Opuntia microdasys*: (a) Invasive population near Weenen; (b) Developing fruit, with prominent areoles bearing numerous glochids; and (c) Flowers orange, usually yellow elsewhere in South Africa. *Echinopsis oxygona*: (d) Flower, apical view, perianth segments spreading, (e) Flower, lateral view, funnelform, scales with long wool; and (f) Colony near Weenen, stems clustered, glaucous, subglobular to cylindric-clavate.

## Ethical considerations

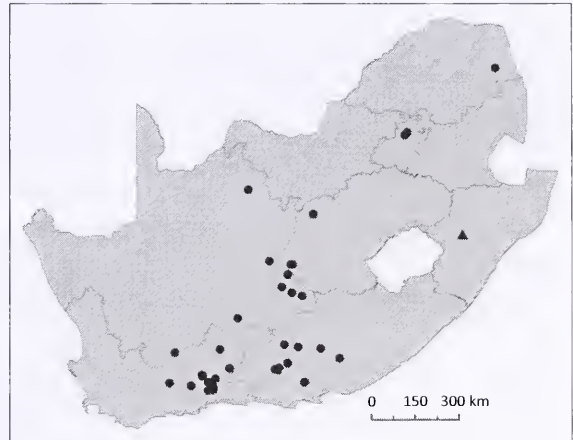
Material was gathered under permit number OP 967/2014 issued by Ezemvelo KZN Wildlife.

## Results

The first record of *Echinopsis oxygona* (Link) Zucc. ex Pfeiff. & Otto outside of cultivation in South Africa was confirmed and the first naturalised population of *Opuntia microdasys* (Lehm.) Pfeiff. in KZN was documented. Four populations of *Peniocereus serpentinus* (Lag. & Rodr.) N.P.Taylor were encountered, ranging in size from several square metres to 0.4 ha.

The population of *O. microdasys* detected in the Tugela River basin (Figure 1) represents a significant range extension ( $\pm 410$  km) into the KZN province (Figure 2). Previously, this species was known in South Africa from 45 sightings (21 localities) in 4 provinces: the Western Cape, Eastern Cape, Gauteng and Limpopo (SAPIA database 2015; Winter, Zimmerman & Mashope 2011). *Opuntia microdasys* is at the D2 stage of invasion, defined as being a self-sustaining population, outside of cultivation and with plants surviving and reproducing a significant distance from their original point of introduction (Blackburn *et al.* 2011) (Table 1).

Descriptions of *O. microdasys* in South Africa have previously been provided by Smith *et al.* (2011) and Winter *et al.* (2011). Smith *et al.* (2011) stated that in South Africa, plants of this species take a number of years to flower and, given that flowers and fruit were observed (Figure 1), the stand is evidently well-established, a notion supported by its expense of  $\pm 0.025$  ha. No cochineal infestation was seen on *O. microdasys*, despite the presence of these insects on



Source: Map courtesy of Haylee Kaplan

**FIGURE 2:** Known distribution of naturalised *Opuntia microdasys* in South Africa, based on the Southern African Plant Invaders Atlas data (●), and recent field voucher (▲).

*O. stricta* var. *stricta* (Figure 3) and *O. aurantiaca* plants (Figure 3) growing in close proximity.

A small colony of *E. oxygona* (Figure 1) was detected adjacent to the *O. microdasys* population. As this remote site (Figure 4) showed no sign of abandoned habitations or cultivated lands, the manner in which this colony started is unknown. However, based on the size of the multiple stems ( $> 35$  cm), it is evidently well-established.

A brief description of *E. oxygona sensu lato* has been provided by Hunt, Taylor and Charles (2006), with expanded descriptions of its synonymised elements published

**TABLE 1:** Categorisation of the invasion status of *Opuntia microdasys*, *Peniocereus serpentinus* and *Echinopsis oxygona* populations observed in the central Tugela River basin, KwaZulu-Natal province, South Africa, according to Blackburn *et al.* (2011), following the interpretation of Wilson *et al.* (2014).

Taxon	Reproduction and recruitment	Distance from known or putative site of original planting?			Invasion state
		< 2 x crown radius	Between 2 x crown radius and 100 m	> 100 m	
<i>Opuntia microdasys</i>	Are viable seeds or other propagules produced and dispersed?	Yes	Yes	Yes	
	Is there a long-lasting seed bank?	Not recorded	Not recorded	Not recorded	
	Are seedlings or vegetative offspring present?	Yes	Yes	Yes	D2
	Do seedlings or vegetative offspring survive for more than a year?	Yes	Yes	Yes	
	Is there survival to reproductive maturity?	Yes	Yes	Yes	
<i>Echinopsis oxygona</i>	Are viable seeds or other propagules produced and dispersed?	Not recorded	Not recorded	Not recorded	
	Is there a long-lasting seed bank?	Not recorded	Not recorded	Not recorded	
	Are seedlings or vegetative offspring present?	Yes	Yes	Yes	C3
	Do seedlings or vegetative offspring survive for more than a year?	Yes	Yes	Yes	
	Is there survival to reproductive maturity?	Yes	Yes	Yes	
<i>Peniocereus serpentinus</i>	Are viable seeds or other propagules produced and dispersed?	Yes	Yes	Yes	
	Is there a long-lasting seed bank?	Not recorded	Not recorded	Not recorded	
	Are seedlings or vegetative offspring present?	Yes	Yes	Yes	D2
	Do seedlings or vegetative offspring survive for more than a year?	Yes	Yes	Yes	
	Is there survival to reproductive maturity?	Yes	Yes	Yes	

elsewhere (Borg 1963; Britton & Rose 1963). The plants of the Tugela River basin possess somewhat glaucous, clustered stems that are subglobular. Later they are short, cylindrical-clavate, up to 65 cm high and 10 cm broad, and sprawling with many shoots at the base and along the sides. The 13 to 16 ribs are continuous, broad at the base and with deep furrows between them. The circular areoles are  $\pm 2$  cm apart, with whitish wool. Young shoots are distinctly spiny, whilst mature stems are relatively spineless. Flowers open at sunset, are narrow-funnelform,  $\pm 20$  cm long and 12 cm in diameter. The inner perianth segments have a spreading growth, and are translucent and rose-coloured. The axils of scales on the flower tube bear long, gray to blackish wool. The filaments and style extend a little beyond the throat, but are shorter than the perianth segments (Figure 1). The genus is reported by Borg (1963) to produce oval, fleshy, hairy berries, at maturity splitting on one side to reveal very small and minutely pitted seeds.

*Echinopsis oxygona* can be considered to be at the C3 stage of invasion, having a self-sustaining colony that is reproducing vegetatively and possibly sexually (flowering, although no fruit was observed) (Table 1). Following the weed risk assessment model of Pheloung *et al.* (1999), designed to screen primarily for invasive plant taxa, *E. oxygona* generates a score of 12, which falls into the reject category. This result is based on the answers to 49 questions that evaluate the plant's current biogeography, the impact of any undesirable attributes it may have and its ecophysiology (Pheloung *et al.* 1999). This means that an application for its import into South Africa should be turned down. As a first record for KZN, *O. microdasys* may still be restricted to a small region in the central Tugela River basin, although it will likely

spread in the absence of control interventions, which are suggested in Table 2.

Four *P. serpentinus* populations, which were over 1 km apart, were detected (Figure 3). These ranged from a few square metres to 0.4 ha in extent. The largest population, of a rectangular, polygon shape, was located at 28°48'24.5" S, 30°3'12.1" E. The most extensive infestation was surrounded by small satellite clumps that were less than 50 m away from the main clump. This taxon is now known from a total of seven localities in KZN and two in Limpopo province (Winter *et al.* 2011). The upright, clambering stems of *P. serpentinus* were observed to attain heights of up to 4.5 m, supported by the branches of trees through which they were growing, in conditions ranging from full sun to shade.

Given the distances between the known *P. serpentinus* populations, and that all but one of these had flowering plants, and in one case fruit, they are classified at the D2 invasion stage (Table 1). It is currently unknown what role people play in the dissemination of this species in the Tugela River basin, and its origin. However, given the rectangular shape of the largest population, it may originally have been cultivated as a barrier plant.

## Discussion

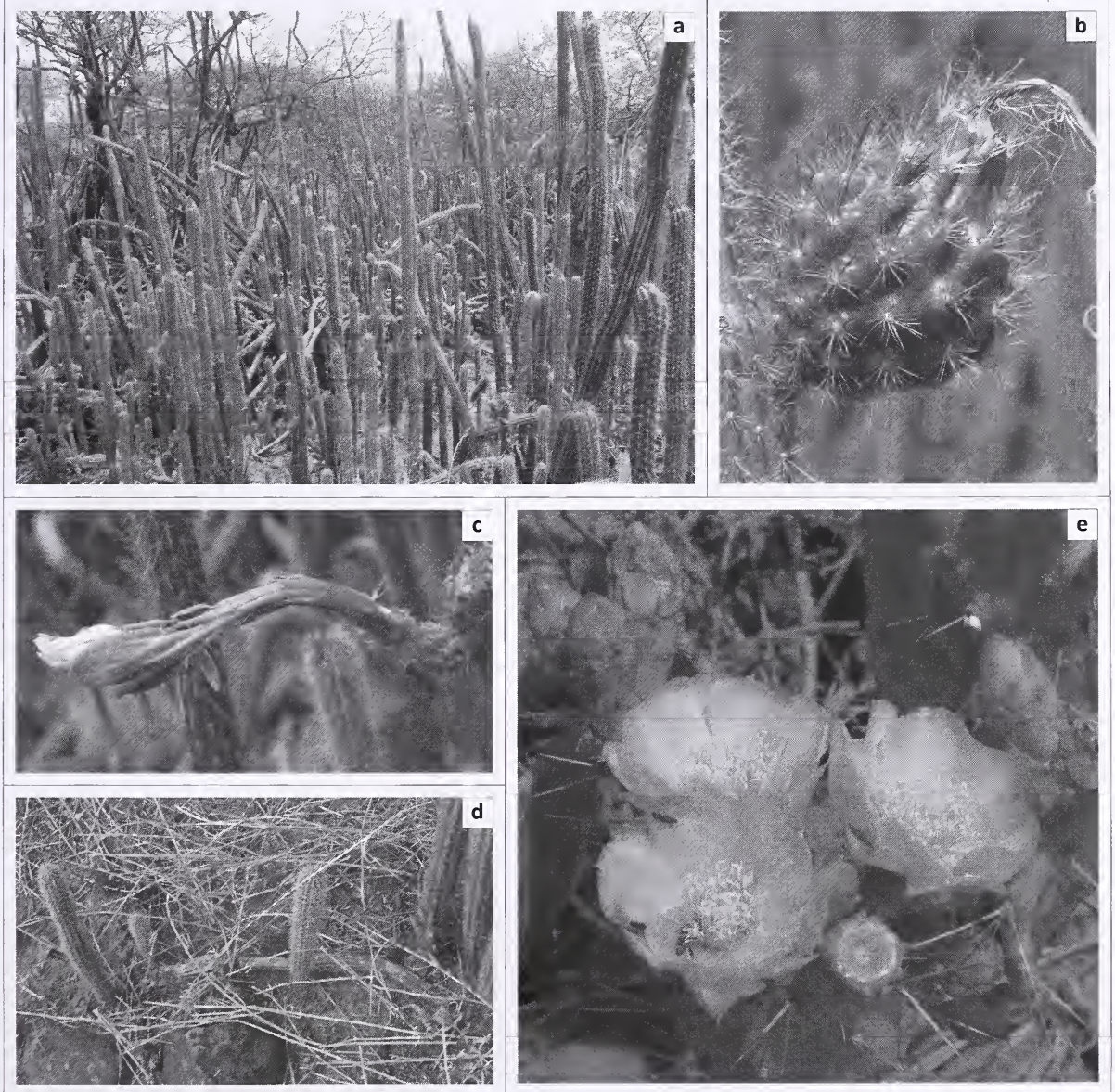
*Opuntia microdasys* (teddy bear cactus) has a wide natural distribution from Texas to southern Mexico. It is considered to be invasive in Australia (United States Department of Agriculture 2015) and South Africa (Smith *et al.* 2011) and naturalised in the Iberian Peninsula (Sanz-Elorza, Sánchez & Vesperinas 2006). At a national level, *O. microdasys* is to

widespread and established to be considered an eradication target for SANBI ISP and is categorised as 1b (Department of Environmental Affairs 2014b), meaning that its control needs to form part of an invasive species management plan (Department of Environmental Affairs 2014a; Wilson *et al.* 2013).

According to the definition by Pyšek *et al.* (2004), *O. microdasys* can be considered naturalised in KZN as this self-sustaining population has likely existed for at least

10 years without direct human intervention, by recruitment from seed and ramets. Manual extraction and chemical control with herbicides should enable eradication at this site, but if the species is found to be more widespread in KZN, the feasibility of biocontrol should be considered.

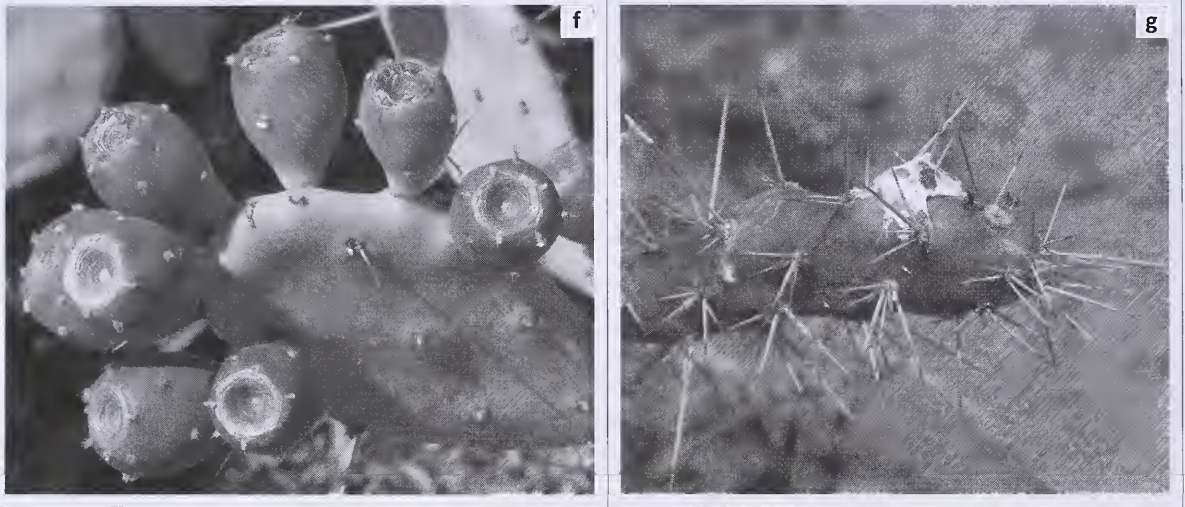
*Echinopsis oxygona*, the Easter lily cactus or sea urchin cactus, is indigenous to Brazil, Paraguay, Uruguay and Argentina (Hunt *et al.* 2006). It is listed in Brazilian state legislation as Vulnerable in the Rio Grande do Sul region (De Freitas *et al.*



Source: Figure 3 courtesy of Tanza Crouch

**FIGURE 3:** *Peniocereus serpentinus*: (a) Extensive invasion near Weenen, narrow scandent stems to 4.5 m supported by tree branches; (b) Developing fruit, turning red at maturity; (c) Flowers nocturnal, closed during day and reopening for a second night; perianth funnelform, white; and (d) Shoot generation following adventitious rooting along length of prostrate stem. *Opuntia stricta* var. *stricta*: (e) Flowers yellow, pericarpel relatively smooth with few (up to 8) areoles; (f) Mature fruits purple, obovoid; and (g) *Opuntia aurantiaca*: cladode section, infested with cochineal.

Figure 3 continues on the next page →



Source: Figure 3 courtesy of Tanza Crouch

**FIGURE 3 (Continues...):** *Peniocereus serpentinus*: (a) Extensive invasion near Weenen, narrow scandent stems to 4.5 m supported by tree branches; (b) Developing fruit, turning red at maturity; (c) Flowers nocturnal, closed during day and reopening for a second night; perianth funnellform, white; and (d) Shoot generation following adventitious rooting along length of prostrate stem. *Opuntia stricta* var. *stricta*: (e) Flowers yellow, pericarpel relatively smooth with few (up to 8) areoles; (f) Mature fruits purple, obovoid; and (g) *Opuntia aurantiaca*: cladode section, infested with cochineal.

2010) and is one of several subjects in an *ex situ* conservation project in Transylvania (Stoie 2007). However, its global Red List status is Least Concern (International Union for the Conservation of Nature 2014).

The only species of *Echinopsis* Zucc. currently listed in the Alien and Invasive Species list (Department of Environmental Affairs 2014b) is the torch cactus, *E. schickendantzii* F.A.C.Weber (syn. *E. spactiana* [Lem.] Friederich & G.D.Rowley), although *E. chamaecereus* H.Friedrich & Glaetzle has recently been recorded outside of cultivation (SAPIA database 2015). *Echinopsis schickendantzii*, a category 1b invader, has naturalised extensively in the central dry interior of South Africa, and remains poorly controlled despite being declared an invader in 2001 (Department of Agriculture 2001). Its succulent fruits are believed to be distributed by both mammals and birds (Henderson 2015) and both of these are likely to also be the dispersal agents of *E. oxygona*.

The Easter lily cactus, *E. oxygona*, is naturalised in Spain (Laguna-Lombereras *et al.* 2014), the Galápagos Islands (Randall 2012) and Australia (McFadyen 2012). It was earlier noted (as *E. multiplex* Pfeiff. & Otto) as having been cultivated within the Kruger National Park and required removal (Foxcroft *et al.* 2003). In the early 19th century, various *Echinopsis* species were introduced into Europe (Mottram & Quail 2009), amongst them the 'pure species' *E. multiplex*, *E. oxygona*, *E. eyriesii* (Turpin) Pfeiff. & Otto and *E. tubiflora* (Pfeiff.) Zucc. ex A.Dietr.

Subsequent crossing of these forms resulted in what were perceived to be a multitude of hybrids of indeterminate parents, such that the pure species were considered to have largely disappeared from cultivation (Bertrand &

Guillaumin 1957). However, Hunt *et al.* (2006) subsequently placed *E. multiplex*, *E. eyriesii* and *E. tubiflora* in synonymy under *E. oxygona*, so circumscribing a much broader species concept under which the central Tugela River basin material is placed. This species has long been a horticultural subject in South Africa (Glen 2004; Pienaar & Smith 2011).

Within the last two years, several reports have been received by SAPIA of round, cushion-type *Echinopsis* colonies occurring in non-cultivated situations (Figure 4). In the absence of flowers, it remains uncertain whether all these are attributable to *E. oxygona*, or to various other taxa in this genus of  $\pm 72$  species (Hunt *et al.* 2006). The risk assessment score of 12 for *E. oxygona*, as determined in this study, leads to a recommendation that this cactus should not be imported into the climatically similar Australia, another cactus invasion hotspot (Novoa *et al.* 2014).

In considering the wide distribution of the congeneric *E. schickendantzii*, and observing that cushion-type *Echinopsis* naturalisations in South Africa occur in four different veld types across three biomes (Mucina & Rutherford 2006; SAPIA database 2015; Figure 4), *E. oxygona* likely has a much wider potential national distribution. An adequate sample size of distribution records of this species is currently unavailable on the Global Biodiversity Information Facility (2014) for a reliable distribution model (fewer than 20 with co-ordinates).

The lack of detailed native range data is common to many cacti and in view of such gaps, the South African Cactus Working Group recently proposed a ban on 'any cacti genera that contain invasive species' (Novoa *et al.* 2015). This approach was put forward by Novoa *et al.* (2015) as the most effective way of regulating the movement of invasive species,

without curtailing the horticultural industry unnecessarily. It is recommended (Table 2) that *E. oxygona* be placed on the SUSPECT list to establish whether its formal regulation is necessary.

*Peniocereus serpentinus*, the serpent cactus or snake cactus, is indigenous to Mexico, in the Sinaloa region and the states between Querétaro and Oaxaca (Arreola *et al.* 2013; Hunt *et al.* 2006). It has naturalised in Queensland, eastern Australia (Atlas of Living Australia 2015; McFadyen 2012). This species is cultivated globally as an ornamental plant (Arreola *et al.* 2013; United States Department of Agriculture 2015) and, under the synonym *Nyctocereus serpentinus* (Lag. & Rodr.) Britton & Rose, has been grown in South Africa since at least the mid-1960s (Rawé 1966). Individuals characteristically produce long, thick, turnip-like roots that comprise a substantial proportion of their biomass. The etymology of the generic name is a reference to the opulence of the root growth relative to the development of aerial parts. Winter *et al.* (2011) provide a description of

*P. serpentinus* and a distribution map that remains largely unaltered by the current report. In South Africa, this species is noted as fast-growing under a range of light conditions (Rawé 1966), as observed in the Tugela River basin.

*Peniocereus serpentinus* is listed as 1b on the most recent national regulations (Department of Environmental Affairs 2014b), and therefore falls outside the ambit of SANBI ISP. However, given the observed tendency of *P. serpentinus* to spread and its current localised distribution in the central Tugela River basin, urgent action is required, with recommendations for control provided in Table 2.

## Specimens examined

### *Opuntia stricta* var. *stricta*

SOUTH AFRICA. KwaZulu-Natal: Alongside the R74, south of Bloukrans River, Tugela River basin, 28°49'32.2" S, 30°1'42.6" E, 901 metres above sea level (m.a.s.l.), 08 Dec. 2014, Cheek, M. 2272 (NH!).

### *Opuntia aurantiaca*

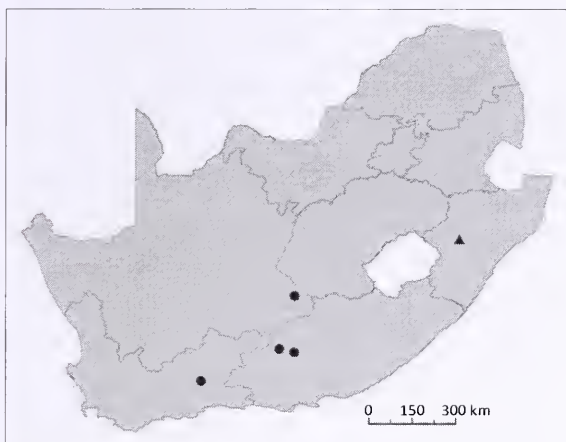
SOUTH AFRICA. KwaZulu-Natal: Alongside the R74, south of Bloukrans River, Tugela River basin, 28°49'31.9" S, 30°1'41.5" E, 901 m.a.s.l., 08 Dec. 2014, Cheek, M. 2273 (NH!).

### *Opuntia microdasys*

SOUTH AFRICA. KwaZulu-Natal: Alongside the R74, south of Bloukrans River, Tugela River basin, 28°49'16.8" S, 30°2'21.5" E, 859 m.a.s.l., 08 Dec. 2014, Cheek, M. 2275 (NH!).

### *Peniocereus serpentinus*

SOUTH AFRICA. KwaZulu-Natal: Alongside the R74, south of Bloukrans River, Tugela River basin, 28°47'34" S, 30°3'22.7" E, 832 m.a.s.l., 09 Dec. 2014, in flower and fruit, Cheek, M. 2291 (NH!); alongside the R74, south of Bloukrans River, Tugela River basin, 28°46'50.1" S, 30°4'8" E, 726 m.a.s.l., 09 Dec. 2014, Cheek, M. 2289 (NH!); Zingela Game Reserve, ~200 m from



Source: Map courtesy of Haylee Kaplan

**FIGURE 4:** Known distribution of naturalised records of cushion-type *Echinopsis* in South Africa, based on the Southern African Plant Invaders Atlas data (●), and recently recorded locality of *Echinopsis oxygona* (▲).

**TABLE 2:** Notes on and recommendations for the management of exotic cacti encountered during a survey of the central Tugela River basin. Information based on field observations and the Southern African Plant Invaders Atlas database (2015).

Taxon	Notes	Recommendation
<i>Opuntia microdasys</i>	45 SAPIA records from Western Cape, Northern Cape, Gauteng and Limpopo; the earliest two sightings were recorded in 1990 from the Swartberg Pass and Oudtshoorn areas. No SAPIA records for KZN prior to this survey. A 1b species on the NEMBA regulations (Department of Environmental Affairs 2014b).	Advise both uThukela District Municipality and KZN Working for Water programme on manual removal.
<i>Opuntia ficus-indica</i>	3231 SAPIA records dating back to 1979, representing the entire country. Recorded as frequent in the 2830 CC quarter degree square on SAPIA by 1987. A 1b species on the NEMBA regulations (Department of Environmental Affairs 2014b), with the spineless cultivars excluded.	ARC-PPRI to ensure that the correct cochineal biotype is present on plants in the Tugela River basin.
<i>Opuntia stricta</i> var. <i>stricta</i>	Frequent in the Weenen/Mooi River area since 1987, with cochineal infection seen on plants near Muden in that year. This species was frequently seen in this survey with cochineal infections on many plants. A 1b species on the NEMBA regulations (Department of Environmental Affairs 2014b).	ARC-PPRI to ensure that the correct cochineal biotype is present on plants in the Tugela River basin.
<i>Opuntia ourantioco</i>	Recorded as present on SAPIA by 1999 for the Weenen/Colenso area. A 1b species on the NEMBA regulations (Department of Environmental Affairs 2014b).	ARC-PPRI to ensure that the correct cochineal biotype is present on plants in the Tugela River basin.
<i>Peniocereus serpentinus</i>	One record from Herbertsdale, Western Cape, and one from Dendron, Limpopo, on SAPIA. Three populations recorded by Winter <i>et al.</i> (2011) from the Tugela basin; four new populations added to SAPIA from this survey. Currently a 1b species on the NEMBA regulations (Department of Environmental Affairs 2014b).	Advise both uThukela District Municipality and KZN Working for Water programme on manual removal.
<i>Echinopsis oxygona</i>	No confirmed SAPIA records for this species prior to this survey. Four SAPIA records of <i>Echinopsis</i> sp. outside of gardens, in the vicinity of the towns of Prince Albert, Colesberg and Graaff-Reinet. Not listed on the NEMBA regulations (Department of Environmental Affairs 2014b).	Add to SUSPECT list for further investigation by SANBI ISP.

SAPIA, Southern African Plant Invaders Atlas; KZN, KwaZulu-Natal; NEMBA, National Environmental Management: Biodiversity Act 10 of 2004; ARC-PPRI, Agricultural Research Council Plant Protection Research Institute; SANBI ISP, South African National Biodiversity Institute Invasive Species Programme; SUSPECT, Species Under Surveillance for Possible Eradication or Containment Targeting

Tugela River, 28°43'21.3" S, 30°3'57" E, 716 m.a.s.l., in flower, *Cheek, M. 2288* (NH!); alongside the R74, south of Bloukrans River, Tugela River basin, 28°48'24.4" S, 30°3'12.1" E, 831 m.a.s.l., *Cheek, M. 2277* (NH!).

### *Echinopsis oxygona*

SOUTH AFRICA. KwaZulu-Natal: Alongside the R74, south of Bloukrans River, Tugela River basin, 28°49'17" S, 30°2'21.4" E, 860 m.a.s.l., 08 Dec. 2014, *Cheek, M. 2276* (NH!).

## Acknowledgements

This work was funded by the South African Department of Environment Affairs' Working for Water (WfW) programme, with field support provided by Zingela Safari and River Company. We gratefully acknowledge the use of SAPIA data. Les Henderson, Llewellyn Foxcroft and Geoff Nichols are thanked for helpful discussions, and two anonymous reviewers for constructive comments. Les Powrie is thanked for providing vegetation map data; and John Wilson, Ingrid Nänni, Philip Ivy and Kanyisa Jama for helpful comments on the manuscript. Tanza Crouch kindly assembled Figures 1 and 3 based on photographs taken by the authors, and Haylee Kaplan provided the distribution maps.

## Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

## Authors' contributions

Both M.D.C. (South African National Biodiversity Institute) and N.R.C. (South African National Biodiversity Institute) were involved in the fieldwork, subsequent research, assessment and drafting of the manuscript. M.D.C. and N.R.C. were responsible for the field survey, plant identification, weed risk assessment and assessment of the invasion categories and concomitant recommendations. M.D.C. made the herbarium collections.

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# *Aristea rufobracteata* (Iridaceae: Aristeoideae), a new species from the southern Western Cape, South Africa

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## Dates:

Received: 16 Mar. 2015  
Accepted: 12 Aug. 2015  
Published: 09 Oct. 2015

## How to cite this article:

Goldblatt, P. & Manning, J.C., 2015, '*Aristea rufobracteata* (Iridaceae: Aristeoideae), a new species from the southern Western Cape, South Africa', *Bothalia* 45(1), Art. #1917, 4 pages. <http://dx.doi.org/10.4102/abc.v45i1.1917>

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**Background:** Collections of a tall species of *Aristea* from the southern coastal mountains of South Africa, with hairless, reddish brown bracts, have been variously identified as *Aristea bakeri* Klatt or *Aristea capitata* (L.) Ker Gawl., but do not accord with either of these two or any other known species.

**Objectives:** To describe a new species in *Aristea* to accommodate material from the southern coastal mountains that cannot be included in any known species.

**Method:** Existing herbarium collections were studied and the relevant published literature consulted.

**Results:** The new species *Aristea rufobracteata* is described for collections of tall plants from the Langeberg, Outeniqua, Tsitsikamma and Baviaanskloof mountains. It has a mostly condensed inflorescence, reddish brown bracts and small capsules.

**Conclusion:** The new species increases our understanding of the diversity in *Aristea* in southern Africa.

## Introduction

In the course of a review of herbarium collections of *Aristea* Aiton, we identified specimens of tall plants with hairless, reddish brown inflorescence spathes and bracts from the Langeberg, Outeniqua, Tsitsikamma and Baviaanskloof mountains in South Africa as an undescribed species. These collections were identified as *Aristea bakeri* Klatt or *Aristea capitata* (L.) Ker Gawl. [or their synonyms *Aristea confusa* Goldblatt, *Aristea major* Andrews or *Aristea thyrsoflora* (D.Delaroche) N.E.Br.], following Weimarck (1940), who included several early collections of the taxon from the George and Knysna districts of the southern Western Cape in his circumscription of *A. capitata*. The name *A. capitata* is now reserved for the Western Cape species from the Cape Peninsula and nearby. We include these early collections and several more recent collections from the southern coastal mountains in the new species *Aristea rufobracteata*, naming it for the unusual dry, reddish brown spathes.

The African and Madagascan genus *Aristea*, now with some 58 species (Goldblatt & Manning 2013), is the sole genus of the Iridaceae subfamily Aristeoideae Vines (Goldblatt & Manning 2008). Centred in western southern Africa, where it is both most diverse and species rich, the genus has some eight species in Madagascar and 11 in tropical Africa; of these, five are shared with southern Africa and one with Madagascar (Goldblatt & Manning 2013; Goldblatt, Phillipson & Manning 2013). *Aristea rufobracteata* is a member of subgenus *Aristea* section *Racemosae* Weim. This section, which is restricted to the winter rainfall zone of southern Africa (Goldblatt [2012] 2013), is recognised by its robust habit, minutely notched style and three winged, apically dehiscent capsules containing flattened, lamellate seeds.

## Research method and design

We examined all relevant collections at the herbaria with significant collections of southern African plants, namely the Bolus Herbarium, University of Cape Town (BOL), Royal Botanic Gardens, Kew (K), the Compton Herbarium, South African National Biodiversity Institute, Cape Town (NBG), the Missouri Botanical Garden, Saint Louis (MO), the National Herbarium, South African National Biodiversity Institute, Pretoria (PRE) and the South African Museum Herbarium, South African National Biodiversity Institute, Cape Town (SAM) (acronyms after Holmgren, Holmgren and Barnett [1990]). We also reviewed the relevant literature and implemented our conclusions with a formal description of the new species.



Source: Compton Herbarium, South African National Biodiversity Institute, Cape Town  
Scale bar, 10 mm.

**FIGURE 1:** Scan of the holotype of *Aristea rufobracteata*, Ruiters 44 (Compton Herbarium, South African National Biodiversity Institute, Cape Town).

## Results

*Aristea rufobracteata* Goldblatt & J.C.Manning, sp. nov.  
Type: SOUTH AFRICA, Western Cape: 3320 (Montagu): Grootvadersbos, throughout Boesmansbos Wilderness area, after fire, 500 m – 1000 m, (–DD), 16 Nov. 1988, Ruiters 44 (NBG, holo.; NBG, PRE, iso.).

## Description

Evergreen, rhizomatous perennials, 0.8 m – 1 m high, solitary or growing in clumps. *Stem*: subterete, with suberect branches borne at lower fertile nodes; lateral flower clusters sessile; branches short, crowded. *Leaves*: several, linear, 7 mm – 14 mm wide, firm and fibrotic. *Flower clusters*: many, crowded, upper clusters mostly sessile but lower nodes with short to long branches; mostly with two to four flowers in each cluster; spathes and bracts rusty brown, 8 mm – 10 mm long, thinner and somewhat translucent near edges, obtuse, glabrous, becoming slightly crinkled and torn with age. *Flowers*: subsessile, blue; tepals obovate, ± 15 mm long. *Stamens*: with filaments ± 4 mm long; anthers ± 4.5 mm long. *Style*: ± 7 mm long, minutely three-notched at apex. *Capsules*: oblong in outline, narrowly three winged, 11 mm – 14 mm long. *Seeds*: lamellate, kidney shaped, mostly two per locule,

margins papillate. *Flowering time*: mainly November and December, sometimes in October (Figure 1).

## Distribution

Scattered along the southern coastal mountains of the Western and Eastern Cape, where it has been recorded from the Langeberg between Heidelberg and Riversdale, the Outeniqua Mountains above George, the Tsitsikamma mountains near Clarkson, and the Baviaanskloof Mountains at Loerie (Figure 2). The species occurs on stony sandstone slopes in fynbos, mainly at an altitude from 400 m a.s.l. to 600 m a.s.l., and flowers primarily after fire.

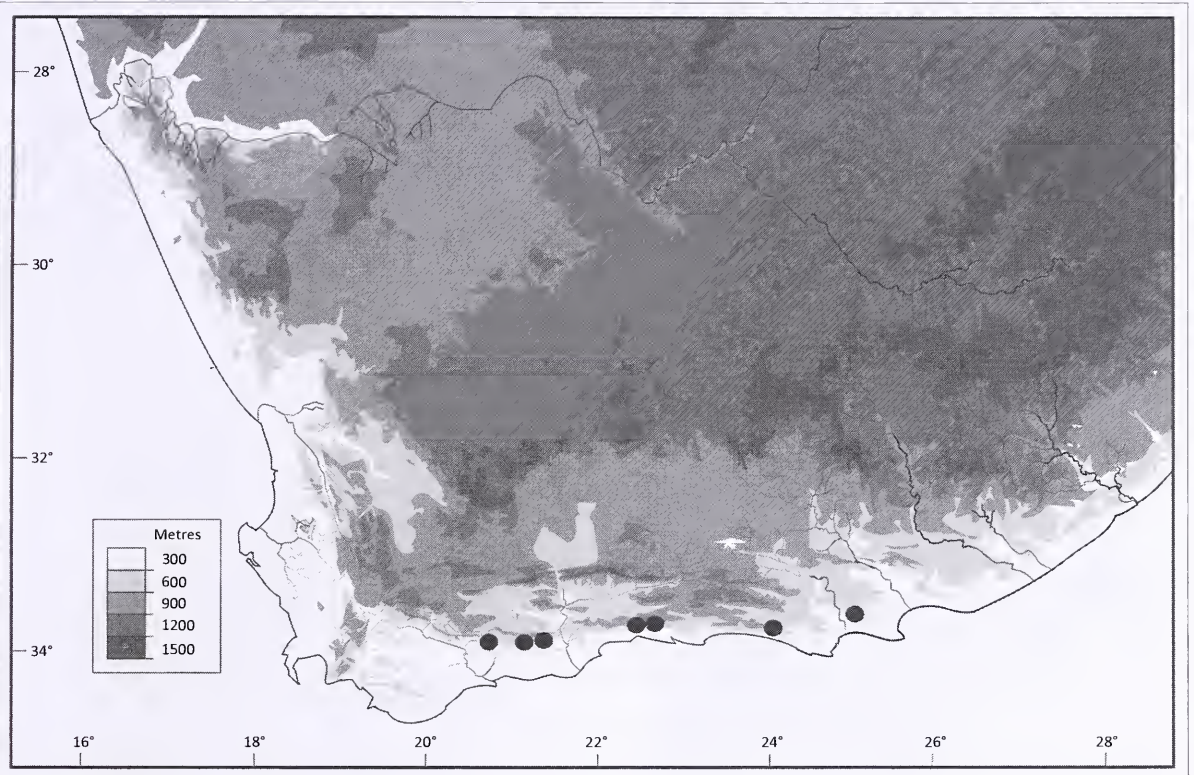
## Diagnosis

*Aristea rufobracteata* is broadly similar to *A. capitata* in its tall stature, often densely columnar flowering axis and relatively short capsules (11 mm – 14 mm long). The flowering stem is branched but the branches are usually fairly short (sometimes up to 150 mm long) and erect or suberect. The individual flower clusters are sessile or subsessile and the inflorescence spathes and floral bracts are rusty brown, thinner and slightly paler toward the margins; the spathes are usually obtuse but are sometimes more or less acute (Figure 3a).

The reddish brown spathes and bracts differ substantially from those of *A. capitata*, which are pale and silvery translucent, with a dark brown central keel extending upwards as an attenuate, cusp-like tip (Figure 3b). *Aristea capitata* is centred on the Cape Peninsula, extending eastwards to the Rivieronderend Mountains and northwards to the Piketberg, thus some distance to the west of the nearest station for *A. rufobracteata*.

Most collections of *A. bakeri* have a rather open, panicle-like inflorescence with well-developed secondary and sometimes even tertiary branches, which are occasionally suberect. The rust-coloured bracts are usually minutely hairy to scabrid beneath and always have evident, narrow, semitransparent margins. *Aristea bakeri* extends from the Cape Peninsula in the west to Uitenhage in the east, thus overlapping considerably with *A. rufobracteata* in the eastern half of its range, and both have been recorded in the mountains above George.

Capsules are particularly important in distinguishing species of section *Racemosae* (Goldblatt & Manning 1997). *Aristea rufobracteata* has capsules 11 mm – 14 mm long, thus shorter than most collections of *A. bakeri*, in which they are typically 18 mm – 30 mm long. The seeds are lamellate and irregularly kidney shaped, with brown papillae along the margins, like those of *A. bakeri* and its allies, *Aristea juncofolia* Baker and *Aristea racemosa* Baker. The margins of the seeds in *A. capitata* are smooth. Plants illustrated under the name *A. capitata* in Curtis's *Botanical Magazine* (Ker Gawler 1802) are almost certainly *A. rufobracteata*.



Source: Michelle Smith

FIGURE 2: Map showing the geographic distribution of *Aristeia rufibracteata*.

The important taxonomic differences amongst the three species are summarised in Table 1.

### Conservation notes

*Aristeia rufibracteata* is relatively widely distributed and occurs in several conservation areas. There are no immediate threats.

### Additional specimens seen

WESTERN CAPE.—3320 (Montagu): Grootvadersbos, lower slopes of mountains, (–DD), 3 Dec. 1958, *G.J. Lewis* 5233 (NBG). 3321 (Ladismith): Riversdale, between the Little Vet river and Kampsheberg, (–CC), [without date], *Burchell* 6879 (K); Corente River Farm, (–CC), Aug. 1909 [without date], *Muir sub Galpin* 5359 (PRE). 3322 (Oudtshoorn): Montagu Pass, south slopes (–CD), 4 Nov. 1928, *Hutchinson* 1213 (BOL, K); Montagu Pass, 2000 ft [600 m], (–CD), 4 Feb. 1951, *Hodge* 8541 (K); between Oudtshoorn and George, (–CD), 14 Nov. 1942, *Chippindall s.n.* (K, PRE); George, below the power station, (–CD), 5 Nov. 1928, *J.B. Gillett* 2096 (NBG); mountains north of George Town [George], (–CD), [without date], *Burchell* 6011 (K); slopes of Cradockberg, 1600 ft [490 m], (–CD), Nov. 1928 [without date], *Fourcade* 4095 (BOL, K); George, Tierkop, 1600 ft [490 m], (–DC), 11

Nov. 1976, *Bond* W653 (PRE); Knysna, Buffelsnek, 2000 ft [600 m], (–DC), Oct. 1923 [without date], *Phillips* 151 (BOL, PRE); Knysna, Van der Waltshoek, (–DC), 20 Oct. 1922, *Keet* 998 (PRE); Knysna, Spitskop, (–DC), 4 Nov. 1970, *Geldenhuijs* 166 (PRE).

EASTERN CAPE.—3325 (Port Elizabeth): Humansdorp, Loerie Forest Reserve, (–CC), 29 Jan. 1934, *W. Long* 66 (NBG).

### Acknowledgements

Michelle Smith prepared the digital map. Anthony Magee prepared the figures.

### Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

### Authors' contributions

P.G. (Missouri Botanical Garden) and J.C.M. (South African National Biodiversity Institute) contributed equally in all parts of this article.



Source: Compton Herbarium, South African National Biodiversity Institute, Cape Town Scale bar, 5 mm.

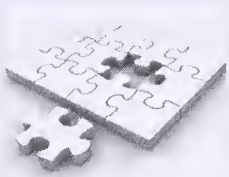
**FIGURE 3:** Flower clusters of *Aristea* species, showing bract differences: (a) *Aristea rufobrocteoto*, based on the specimen from *Ruiters 44* (NBG), showing rusty bracts with obtuse apices; (b) *Aristea copitoto*, based on the specimen from *Orchard 451* (NBG), showing translucent bracts with dark keels and attenuate aristate apices.

**TABLE 1:** Comparison of important taxonomic differences amongst *Aristea bakeri*, *Aristea copitoto* and *Aristea rufobrocteoto*.

Character	Species		
	<i>Aristea bakeri</i>	<i>Aristea copitoto</i>	<i>Aristea rufobrocteoto</i>
Inflorescence	Open and paniculate	Congested and columnar	Congested and columnar or, rarely, weakly paniculate
Bracts	Weakly speckled rusty brown, puberulous below, attenuate cuspidate	Silvery translucent with glabrous blackish keel, attenuate aristate	Densely speckled rusty brown, glabrous, obtuse or acute
Capsules	(15–) 18 mm – 30 mm long	11 mm – 14 mm long	11 mm – 14 mm long
Seed margins	Papillate	Smooth	Papillate
Distribution	Cape Peninsula to Uitenhage	Piketberg to Rivieronderend	Langeberg to Tsitsikamma mountains

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