Scoring a **lichen hat-trick**

Suddenly lichens are hot after hiding in plain sight for nearly two centuries – a recent expedition rapidly revealed at least three new local lichen species, honouring two of South Africa's botanical stalwarts in the process

BY ALAN FRYDAY, STEFAN SIEBERT & NISHANTA RAJAKARUNA

Beautiful mosaic – crustose lichens in Mpumalanga.

STEFAN SIEBERT

Lichens by numbers

1 751
different species of lichens in mainland South Africa

260
genera from mainland South Africa

100
species from Prince Edward Islands

23
genera from Prince Edward Islands

2 500–3 000
estimated total South African lichen species

ABOUT HALF OF ALL SOUTH AFRICA'S LICHENS are still not known to scientists, specialists estimate. In fact, the relatively little that we currently know about South African lichens is often a century or two out of date. When these 'missing' lichens are discovered, they could further enhance South Africa's reputation as a biodiversity hotspot.

Our expedition confirmed that South Africa's rich and diverse lichen population is seriously under-explored and under-studied. In nearly four weeks in the field, we collected more than 500 lichens, many of which we could not name.

Lichens make up a major part of life on earth, growing on soil, rock or woody plants. Many lichens contain a blue-green alga (cyanobacterium), making them important in fixing nitrogen from the atmosphere and generally helping the nutrient cycle. We need to know more about their environmental contributions.

OUR LICHEN RECCE

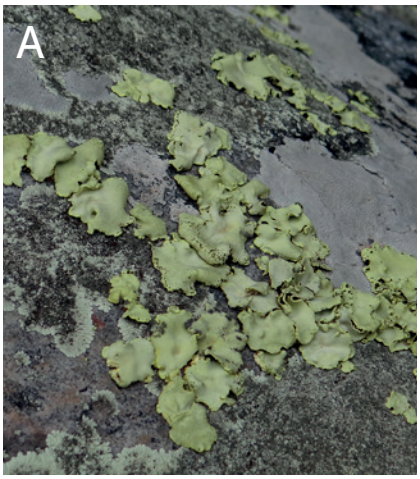
Mpumalanga's Makhonjwa Mountains include the renowned Barberton greenstone belt, home to some of the oldest exposed rocks on the planet. This greenstone is made up of metamorphic serpentinite rocks, which hold extremely high concentrations of heavy metals, such as nickel.

These heavy metals make serpentinite a toxic environment for most plants – except for a minority of highly specialised species. Hundreds of such plant species worldwide occur only on serpentinites. A considerable amount of research has been carried out on plants from the Barberton serpentinite areas, resulting in the discovery of many new flowering plant species, including those that hyperaccumulate nickel (see 'Heavy metal fans', *Veld & Flora*, June 2019).

Only one species of lichen in the world, the European *Porpidia nadvornikiana*, is thought to be restricted to serpentinite, however. We wanted to try to find out why so few lichen species had adapted to survive on serpentinite by documenting the diversity and ecology of lichens on these rocks.

Stefan Siebert and Alan Fryday shortlisted potential sites on a recce. They also jumped right in and collected several lichens there and then, scoring some immediate successes.

One lichen found on rocks in a road cut appeared to be *Fuscidea recensa,* a species not previously reported from the southern hemisphere. Another lichen fungus from roadside serpentinite rocks had unusual bean-shaped spores (ascospores) and has



ALAN FRYDAY

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3 FORMS OF LICHENS

A: Foliose: leafy and not as closely attached – *Dermatiscum thunbergia*.

B: Fruticose: either upright or hanging (pendulous) – *Usnea* species (green, left), *Ramalina* species (green, centre), *Teleoschistes chrysophthalmus* (orange).

C: Crustose: closely attached to surface – *Lecidea tragorum*.

since been described as a new species, *Scoliciosporum fabisporum*.

This was the first discovery of a new serpentinite lichen species from South Africa – and could be the first of many unknowns from these harsh environments. Although perhaps it occurs on other kinds of rock as well and we found it on serpentinite only because that was the type of rock we were investigating!

TRACKING DOWN NEW LICHENS

In our main expedition, we wanted to sample lichen diversity on serpentinite and other rock types at both high and low altitude to assess which parameters affected lichen diversity. Every day we logged three to four sites, counting the number of species and estimating the percentage cover in two or three 25-centimetre-square quadrats for each of several boulders.

To help us achieve this target, we three authors were joined in the field by: Ian Medeiros, who was about to start his PhD in lichen systematics at Duke University, USA; Nate Pope, then an ecology PhD student at University of Texas with a strong interest in statistics, who crucially designed our sampling protocol and developed methods to analyse our results; and Arnold Frisby, now nursery curator and lecturer at the University of Pretoria. Ian Medeiros and Nate Pope had been Nishanta Rajakaruna's undergraduate research students and Arnold Frisby was Stefan Siebert's MSc student.

Our target proved exceptionally challenging. Identifying lichens in the field is notoriously difficult, even in well-studied areas. No field guides or identification keys have yet been produced for South African lichen, leaving us working in almost completely unknown lichen populations with no reference material to orientate us.

Was that whitish-grey crust the same as this other whitish-grey crust, or was it something different? We ended up collecting a lot of specimens, though that was another challenge. To make recording possible, we had to position our quadrats on flat surfaces – but serpentinite can be very hard rock and trying to chip a piece of rock off a flat surface without ending up with something other than a small boulder or crumbs is not easy!

MORE DISCOVERIES

A week of this gruelling fieldwork left us needing a break so we headed off to Buffelskloof Nature Reserve, about 150 kilometres away near Mashishing (formerly Lydenburg). John and Sandie Burrows were excellent hosts and not ones to let their visitors sit around admiring the view – and so a hike into the kloof was arranged.

Here we made the biggest discovery of our entire expedition so far. At the base of the Calodendron Falls, a lichen was collected that superficially

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IAN MEDEIROS

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(Above left to right): Ian Medeiros and Alan Fryday record species in a quadrat. (Top right) The team: Ian Medeiros, Stefan Siebert, Nate Pope, Arnold Frisby, Nishanta Rajakaruna and Alan Fryday. (Right) Ian Medeiros takes a hammer to the hard greenstone rock near Barberton to collect a lichen specimen.

resembled *Rhizocarpon lavatum*, a northern hemisphere species that grows in a similar habitat.

A few weeks later, however, back in the lab and under the microscope, it clearly was not *R. lavatum*. The whole microscopic structure of the species was unusual. The spores had cell walls that made a pattern like brickwork (muriform) and were coloured – very different from the colourless spores of *R. lavatum*.

Ian Medeiros produced the specimen's genetic sequence and showed that it was not a *Rhizocarpon* at all. In fact, it was not even part of the Rhizocarpaceae family or the order of Rhizocarpales. It was on its own on a long branch length, sister to a group containing the type species of *Buellia* in the Caliciales!

This was exciting stuff and could cause a rethink of Caliciales taxonomy. Most Caliciales species have coloured spores with just one horizontal cell wall. Only in the distantly related genus *Diplotomma* do cell walls appear in a brickwork pattern. The structure housing the spores (ascus) was also different from the rest of the Caliciales and the cellular structure of the vegetative body (thallus) was very unusual.

Our specimen clearly represented an independent lineage and should be described as a new genus. But if our new species was systematically close to the type species of *Buellia* but physically very different, what did that mean for other species lumped into *Buellia* that were molecularly more distant but physically much more similar to the type species of our new genus?

We named the new genus *Burrowsia* in honour of our hosts, with the specific epithet *cataractae*, referring to its habitat at the base of a waterfall. So *Burrowsia cataractae* really is an exceptional find for South Africa and the first genus of lichenised fungi to be described from the country for almost three decades!

'Fungi that have learnt to farm'

Until recently, lichenologists were reasonably happy with the classic definition of a lichen – a fungus and a green alga (chlorophyte) or the different blue-green alga (cyanobacterium) living together in a mutually beneficial symbiosis. The alga provides energy through photosynthesis and the fungus provides a structural framework for the symbiosis to survive. The fungus seems to gain a lot more from the relationship than the alga so lichens have been described as 'fungi that have learnt to farm'.

But now we know that much more is going on. There is a third partner present, a microscopic yeast (another fungus related to the more familiar cap mushrooms) plus an assortment of bacteria, amoeba and other micro-organisms. Lichens are, in fact, more mini-ecosystems than species and are sometimes referred to as microbiomes. Taxonomically, however, the name of a lichen still refers only to the fungus.

ALAN FRYDAY

Lichens on a boulder overlooking Blyde River Canyon, Mpumalanga.

NORTHERN CAPE

After completing our work on Mpumalanga serpentinites, we headed to Griqualand West in the Northern Cape because, to the best of our knowledge, it had never previously been visited by a lichenologist. Once there, it was easy to see why – it was difficult to find any lichens!

However, local people helped us visit some fascinating areas that we would never have found on our own – a beautiful area of escarpment-edge dolomite, an impressive dolomite kloof and a banded ironstone koppie. Again, we collected numerous lichens, some of which we could only guess as to which genus they belonged.

All these collections are currently being curated and studied in the herbarium of Michigan State University (on a long-term loan from South Africa's North-West University). Some have been loaned out to international experts in the relevant groups but the current coronavirus pandemic has slowed down this process.

More new species, or even genera, are expected from these collections. There is also so much more that needs to be done with South African's lichens, such as documenting their distribution and understanding the role that lichens play in various ecosystems. Exciting discoveries are out there waiting for anyone with the inclination to seek out and understand these elusive but endlessly fascinating organisms.

Alan Fryday (fryday@msu.edu), a research associate in plant biology at Michigan State University, has been studying lichens professionally for more than 30 years and recently published an updated list of lichens reported from South Africa. Stefan Siebert (stefan.siebert@nwu.ac.za) is a professor of botany with an interest in geobotany at North-West University, South Africa. Nishanta Rajakaruna (nrajakar@calpoly.edu) is a professor of plant biology at California Polytechnic State University and an extraordinary professor at North-West University, whose research focuses on the diversity, ecology and evolution of plants, lichens, and microbes found on harsh soils.

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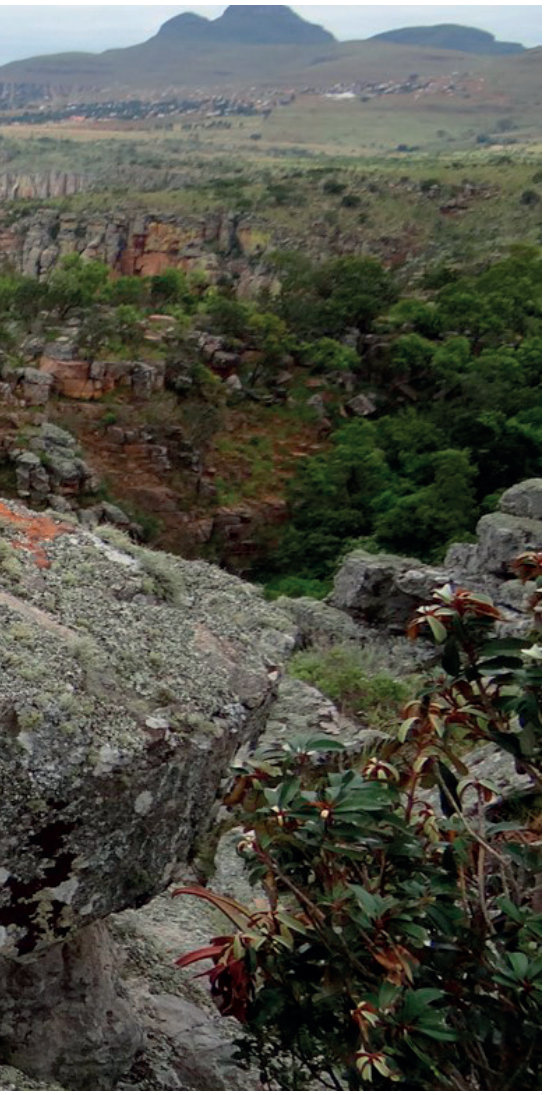

JOHN BURROWS

Ian Medeiros collects lichens at Calodendron Falls in Buffelskloof Nature Reserve, where the team made the expedition's biggest discovery.

Discovering SA lichens

There have been just two peaks of interest in South African lichens over the past 150 years. The first was around the end of the 19th century, spurred on by the Victorian passion for natural history. Unfortunately, with no resident lichenologist, South African collectors sent their lichen collections to European experts – mainly Ernst Stizenberger (1827-1895) in Zurich and Anton Zahlbruckner (1860-1938) in Vienna. Many new species were described but most have not been reported since.

In 1950, as part of her monumental catalogue of southern African fungi, Ethel Doidge, a specialist in mycology and plant pathology, reported nearly 1 200 species of lichen. Her work and a series of visits to South Africa by Swedish lichenologist Ove Almborn (1914-1992) starting in 1953 created a second peak of interest.

Over the next 40 years, Almborn revised several South African lichen genera but the South African lichen flora that he hoped to produce was never finished. Between 1985 and 1994, Franklin Brusse of the Botanical Research Institute (now SANBI) published a series of papers describing numerous new South African lichen species and genera.

NISHANTA RAJAKARUNA

Collecting lichens can be precarious – Alan Fryday dangles on a rock near Barberton.