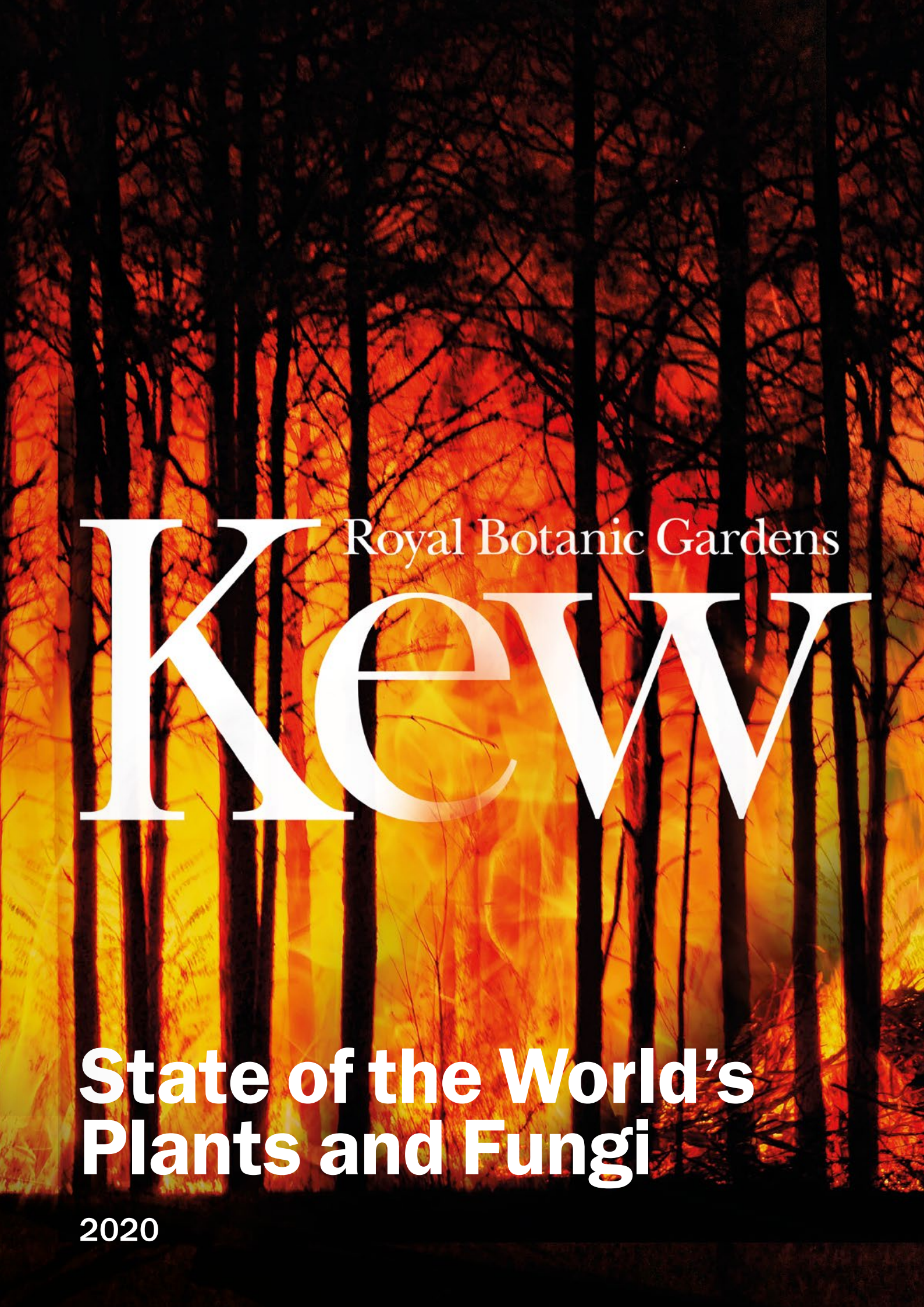
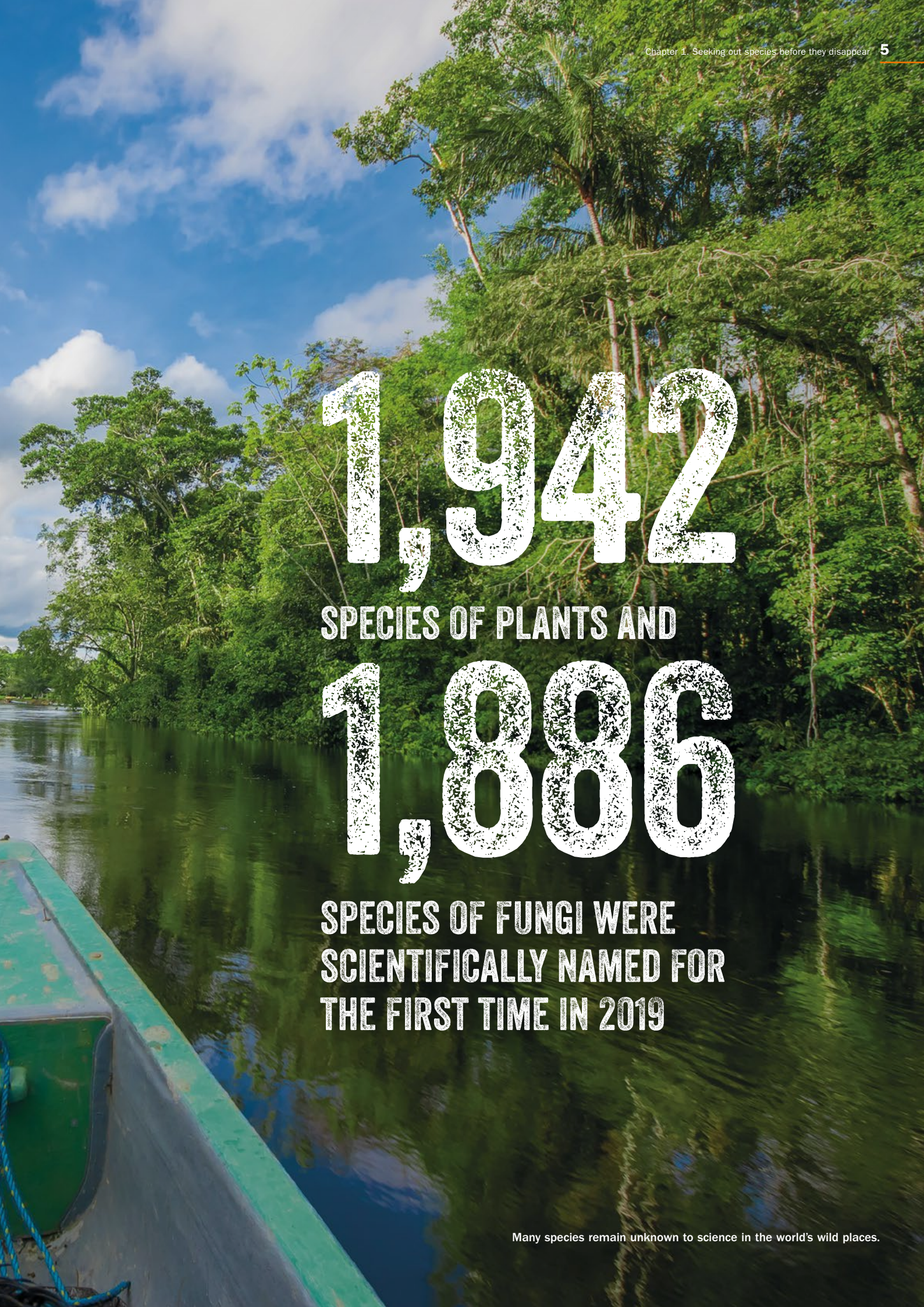


State of the World's Plants and Fungi

2020

SEEKING OUT SPECIES BEFORE THEY DISAPPEAR

In this chapter, we find out: how exploration and detective work are revealing thousands of new species to science every year; which novel plants and fungi could yield new foods, timber and medicines; how a newly described fungus could help us save the banana; and why it took 160 years to name the bears' breeches *Barleria deserticola.*



1,942

SPECIES OF PLANTS AND

1,886

SPECIES OF FUNGI WERE SCIENTIFICALLY NAMED FOR THE FIRST TIME IN 2019

Many species remain unknown to science in the world's wild places.


Barleria deserticola


Galanthus bursanus

A small selection of the species named for the first time in 2019.

Naming *Barleria deserticola* was far from straightforward. First collected in Angola 160 years ago, it was not encountered again by a botanist until 2009. It took another decade to publish the scientific name and description.

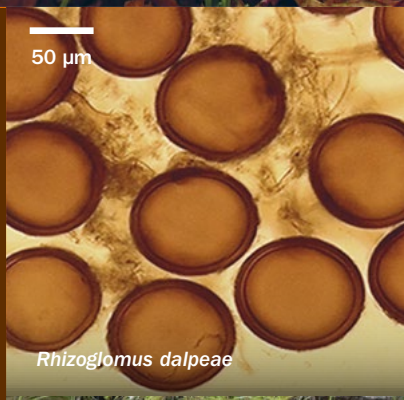
The snowdrop *Galanthus bursanus*, from north-west Turkey, was identified as a new species after a Ukrainian researcher spotted it in a holiday photo.

Scientists encountered *Rhizoglomus dalpeae* on an inselberg in Benin, West Africa.

Gladiolus mariae is only known to grow on two mountains in Guinea. The Kew scientist who encountered it in the wild named it after his wife.

The name of the fungus *Lecanora solaris* refers to the bright yellow 'sunny' colour of the fungus.

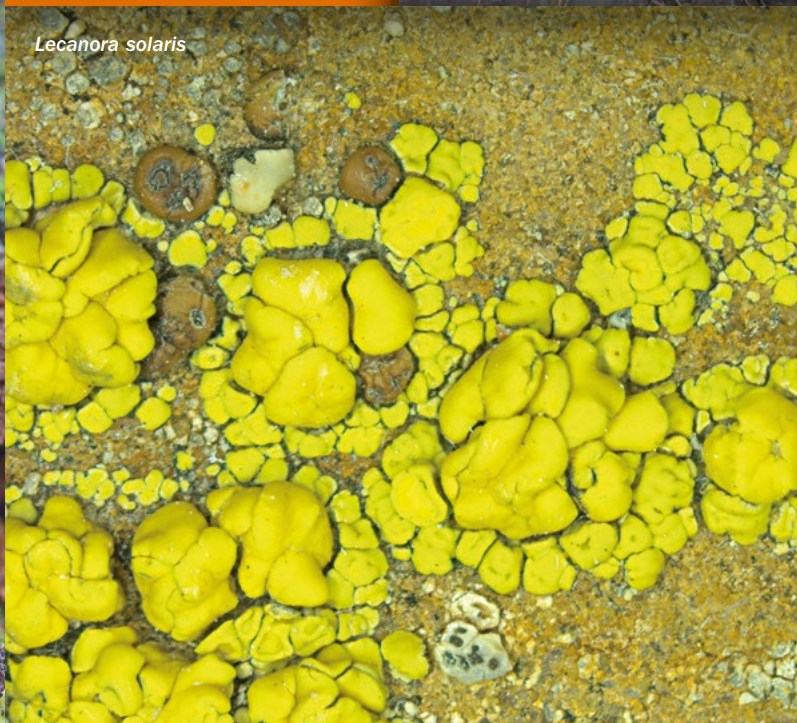
Cordyceps jakajanicola is a newly named fungal parasite of cicadas.



Rhizoglomus dalpeae


Gladiolus mariae

Cordyceps jakajanicola


Lecanora solaris

SCIENTISTS ARE CONSTANTLY ENCOUNTERING AND NAMING SPECIES OF PLANTS AND FUNGI THAT ARE NEW TO SCIENCE, MANY OF WHICH ARE ALREADY THREATENED. WITH BIODIVERSITY LOSS GATHERING PACE, WE NEED TO STEP UP THIS VITAL WORK OR RISK THE EXTINCTION OF MANY POTENTIALLY VALUABLE SPECIES.

Every year, as scientists explore the world's ecosystems, search herbaria and fungaria, sequence organisms' DNA and, increasingly, browse social media, they come across species of plants and fungi that have not been scientifically described. In 2019, botanists registered 1,942 newly named species of vascular plants on the International Plant Names Index (mainly flowering plants, ferns and gymnosperms). And mycologists recorded 1,886 novel fungi on the equivalent Index Fungorum.

Current threats to global biodiversity, from climate change, logging and land-use change, make the task of cataloguing species a race against time. Often, by the time a new species has been described and named, it is facing extinction. This means species that might be valuable as foods, medicines or fibres – or that play important roles in ecosystems, such as by helping to circulate nutrients – are disappearing before we've even had a chance to explore their characteristics.

"People often think that every species has been located and classified but it's not the case," says Dr Martin Cheek, Senior Research Leader on the Africa and Madagascar team at Kew. "There are still vast numbers of species on this planet that we know nothing about and don't even have names for. So that's the job we do in the Identification and Naming department at Kew. Once we have identified a species, the next step is to find out what its potential uses are, and whether it's a priority for conservation."

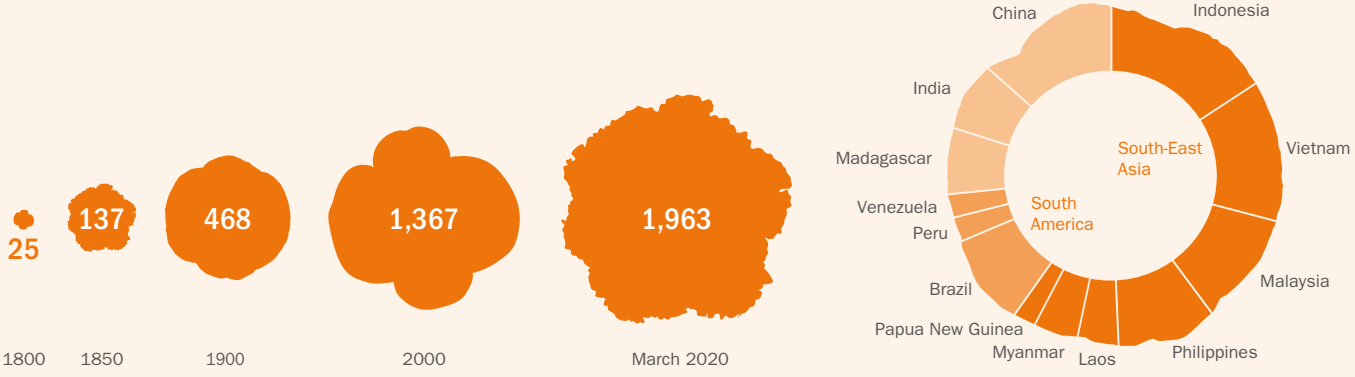
IDENTITY PARADE

Many of the plants described in 2019 have the potential to provide new drinks or foods. From China and mainland South-East Asia came 30 previously unnamed species of *Camellia*, the genus to which tea (*Camellia sinensis*) and many ornamental flowering shrubs belong. Meanwhile, six species of *Allium*, the genus that includes garlic, onions, leeks and chives, were encountered for the first time by scientists in Turkey, and ten undescribed spinach relatives from the genus *Chenopodium* came to light in California, USA. Brazil yielded two wild relatives of cassava *(Manihot esculenta)* that were previously unknown to science, as well as wild relatives of yams (*Dioscorea*) and sweet potatoes (*Ipomoea*).

"The manihots have the potential to be really important for future-proofing the cassava crop, which is a staple food for some 800 million people worldwide," says Dr Cheek.

FIGURE 1: Increase in the number of known species of *Begonia* since 1800

The rate at which new species of *Begonia* are being scientifically described has increased rapidly over the last two centuries. Between 2014 and 2019, an average of 60 new species of *Begonia* were published per year, making it one of the fastest-expanding genera. The pie chart shows where the 46 species of *Begonia* named in 2019 come from, mainly South-East Asia.



New begonias coming to our gardens soon?

Begonias are much-loved garden plants in the UK, but did you know they originate in tropical climes? The genus *Begonia* occurs throughout the tropics, with species mostly growing in undisturbed cloud and montane forests. Some are epiphytes (they grow on other plants, often trees), while others favour shady rock faces or waterfalls. To date (March 2020) 1,963 species have been named but botanists expect this figure to exceed 2,000 by the end of 2020. Some of these new species may one day make it into our gardens.

"The genes present in the newly named species might, for example, be useful in helping to make the current crop pest- or disease-resistant, or to enable it to grow in other habitats with different rainfall or soil fertility patterns."

Potential new medicines were also among the plants new to science. *Eryngium arenosum*, encountered by scientists in Texas, USA, comes from a genus containing plants used to treat inflammation, high blood sugar and scorpion stings; *Artemisia baxoiensis*, pinpointed in Tibet, is closely related to the antimalarial *Artemisia annua*; and three previously undescribed species, located far apart in Italy, Poland and on a Mexican Pacific island, are from the *Oenothera* genus. Also known as evening primrose, *Oenothera* species produce gamma linoleic acids used to treat systemic sclerosis, eczema and psoriasis.

The revelation to science of the tree *Cedrela domatifolia*, from the mahogany family (Meliaceae), might provide us with a new source of timber. And eight newly described species from the palm genus *Calamus*, found in South-East Asia and India, could, like their close relatives, supply rattan of value to the multibillion-dollar cane furniture trade. Meanwhile horticulturists are likely to be excited by 28 newly named species of tree fern, 46 novel *Begonia* species (see Figure 1) and the spectacular red-flowered *Gladiolus mariae*. Scientists encountered the gladiolus on an isolated mountain in Guinea, West Africa.

The fungal kingdom yielded species new to science, too: from mycorrhizal fungi that form mutualistic relationships with plants, to plant pathogens, animal-associated fungi and lichens. Among the mycorrhizal fungi, 51 came from the family containing milkcaps and brittlegills (Russulaceae). Mushrooms in this family form associations with plants that range from giant *Lithocarpus* trees in South-East Asia to dwarf willows (*Salix arctica*) in the Arctic. A further 37 species were newly described across 15 genera of the Boletaceae. These include eight species of the genus *Strobilomyces*, from which the edible 'old man in the woods' mushroom hails.

One of the most important fungus namings of 2019 was that of the species *Fusarium odoratissimum,* responsible for Panama disease of the Cavendish banana. This fungus had previously only been recognised as one of several *Fusarium oxysporum* strains, or genetic variants. The species began to spread in Cavendish plantations across Asia in the 1990s, later arriving in Africa, the Indian subcontinent and the Middle East. It is now also gaining ground in South America. Some 116 million tonnes of bananas are grown every year, with Cavendish accounting for 40–50% of global production.

"*Fusarium odoratissimum* did not have an official name before, and there had been no proper study of the species limits within the complex," explains Dr Tuula Niskanen, Research Leader in Mycology at Kew. "However, several species have now been identified, and finally we have a name for the one that is currently threatening the global production of the Cavendish banana. That means we now have a better way to communicate information about this disease and target research. It's good to know our enemies, because once we know them, we can find better ways to control them."

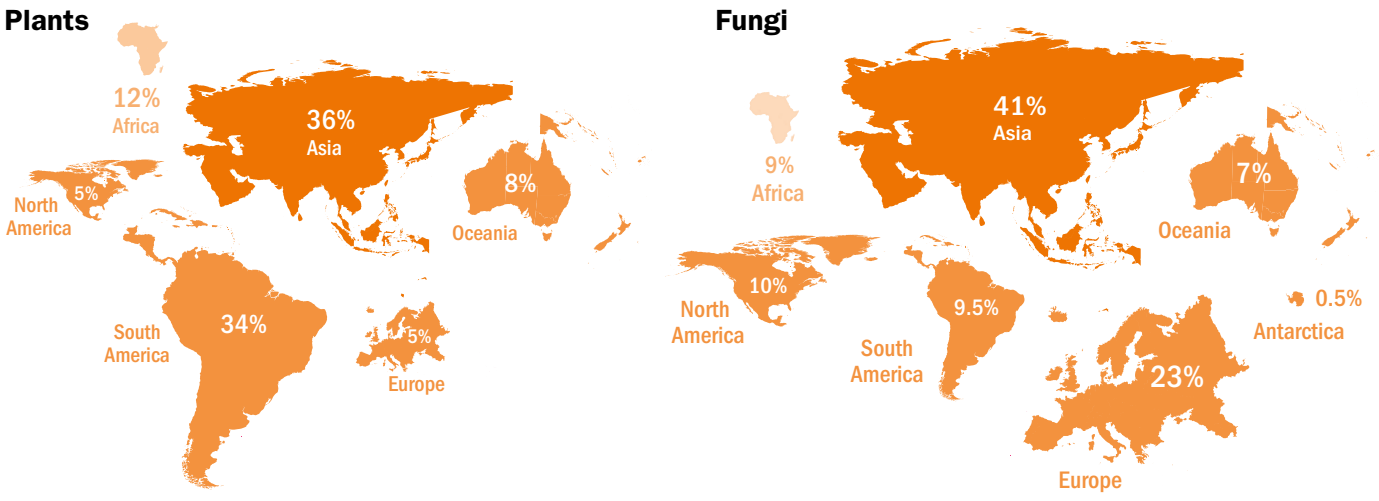
Some fungi live in symbiotic associations with photosynthetic partners (algae, cyanobacteria, or both) forming lichens. In 2019, more than 200 species of 'lichenised' fungi from 37 families and 87 genera were named scientifically. Mycologists came across them in all kinds of environments, from high-altitude tea plantations in Sri Lanka to Ecuador's Galapagos Islands and dry tropical forests in Mexico. Demonstrating the value of citizen science to taxonomy, *Allographa kamojangensis* was only identified from Indonesia after a photo of it was posted on the Facebook group 'Lichens Connecting People'.

REVEALING BIODIVERSITY

Current rates of new plant descriptions are likely to continue. The World Checklist of Vascular Plants, the most comprehensive and regularly updated species list of its kind, records around 350,000 accepted species, of which 325,000 are flowering plants. Ten years ago, scientists thought that the vast majority of flowering plants had been described and named. But the subsequent stream of species revealed to science suggests there are many more to find, as do the experiences of botanists undertaking fieldwork in the tropics today.

FIGURE 2: The proportion of species from each continent named as new to science in 2019

The relative size of the continents reflects the number of species named from each. There were no plants named from Antarctica.



When it comes to fungi, we have even more left to catalogue. Currently, 148,000 species have been identified, primarily in the Ascomycota and Basidiomycota phyla. But scientists believe that more than 90% of species remain unknown to science. They estimate that there are between 2.2 to 3.8 million species on Earth. The main reason we know so little about fungi is because they lead very cryptic lifestyles. Whereas almost all plants are visible above ground, fungi often remain concealed.

"The study of fungi is mainly based on their spore-bearing structures, including the mushrooms that we see above ground, and many species only produce them at certain times of the year," explains Dr Niskanen. "Some species don't even produce them every year – perhaps only every ten years – and some species don't produce them at all. The species we know best are those that produce mushrooms. Those that don't produce any visible spore-bearing structures are thus the least known so far."

HOTSPOTS FOR UNNAMED SPECIES

Between the 1990s and 2018, three countries consistently yielded the highest numbers of newly described species of plants: Brazil, China and Australia. However, in 2019, Australia (with 86 newly described species) was knocked out of the top three by both Colombia (121) and Ecuador (91). Brazil retained the number one spot (216), which it has held since 2008. Every year, 200 or more new species are described from Brazil, equating to 10% of the global total. China took second place (195) in 2019.

The dominance of Brazil, China and Australia is likely connected to the fact that all have rich treasure troves of biodiversity and large numbers of professional taxonomists. On the other hand, the Democratic Republic of Congo yielded only seven new species descriptions, despite being tropical Africa's largest country and home to many species-rich habitats. This likely reflects the lack of taxonomists, scientific infrastructure and security, as well as periodic hazards such as outbreaks of the Ebola virus.

Northern temperate and boreal countries yield very few novel plants these days, being far less diverse than the tropics and having been very well surveyed over the years. When it comes to fungi, however, species that are new to science can still be found almost anywhere, their locations reflecting areas with the most research activity. In 2019, most newly named species of fungi came from Asia (41%) and Europe (23%), with nine from the UK. At the other end of the scale, Antarctica yielded 0.5% of the fungal scientific novelties (see Figure 2).

WE CAN'T ASSESS HOW THREATENED A SPECIES IS UNTIL WE KNOW IT EXISTS. THIS MAKES LOCATING, DESCRIBING AND NAMING SPECIES A CRITICAL TASK

Describing and naming a new species to science can take time. For plants, the vast majority are described using morphology alone, in other words, on the basis of their flowers, fruits, leaves and other parts. First, a scientist has to collect a specimen of a plant suspected as being unknown to science to deposit in a herbarium; then they must compare it to reference specimens of similar species to ensure the find has not, in fact, already been described. Finally, they have to choose a name and publish its characteristics in the scientific literature. This process can be protracted – *Barleria deserticola* was first collected 160 years ago, but only encountered again in 2009 and not given a formal scientific name until 2019.

Advances in DNA technology have helped to speed up the naming of species in recent years, particularly for fungi. Unlike for plants, a single DNA marker known as the 'internal transcribed spacer', or ITS, is often able to distinguish many fungi to species level. The new techniques have also revealed many species new to science from environmental samples, for example from soils. However, one of the problems associated with DNA-based methods of description is that for a fungus to be officially named by the scientific community as a new species, it is customary to have a reference specimen in a fungarium. "The idea is to have something that is physical so people can go back and do more studies of the species if needed," says Dr Niskanen. "However, for fungi that don't, for example, produce mushrooms, or can't be cultivated, you don't really have anything you can put in a fungarium. An alternative could be storing a soil or DNA sample that would contain the genome of the species."

SAFEGUARDING SPECIES

The United Nations' Sustainable Development Goal 15 calls for the protection of terrestrial ecosystems and halting of biodiversity loss. Programmes to conserve species identified as threatened through extinction risk assessments (such as those of the International Union for Conservation of Nature Red List of Threatened Species) provide a route to achieving this. However, we can't assess how threatened a species is until we know it exists. This makes locating, describing and naming species a critical task if we are to conserve plants and fungi for future generations.

This chapter is based on the following scientific paper published in *Plants, People, Planet*, where you can find more information and references: Cheek et al. (2020). New scientific discoveries: Plants and fungi. *Plants, People, Planet* 2(5). DOI: https://doi.org/10.1002/ppp3.10148

Read Chapter 2 to learn how our understanding of extinction is changing and how this is informing conservation efforts.