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NEWS RELEASE
Arid conditions stimulate plant trait diversity – UP part of worldwide study that offers hope for biodiversity conservation

A species from the genus Drosanthemum, growing in a lightly grazed site near Graaff Reinet

PRETORIA - The University of Pretoria (UP) has been part of a groundbreaking international study to understand how plants found in drylands have adapted to these extreme habitats. The results of this large-scale study, which involved 120 scientists from 27 countries, were recently published in scientific journal Nature and have significant implications for protecting biodiversity as the planet warms and regions become drier.

For eight years, teams collected samples from several hundred selected dryland plots across six continents, enabling the analysis of more than 1 300 sets of observations of over 300 plant species, a first on this scale. The study shows that plants in arid zones adopt various survival strategies and that, surprisingly, this diversity increases with aridity levels. The isolation of plants in more arid zones appears to have reduced competition between species, allowing them to express a diversity of forms and functions that is globally unique, displaying double the diversity found in more temperate zones.

UP researchers contributed datasets from South African drylands, with sampling being carried out in the vicinities

of Graaff Reinet and Prince Albert in the central Karoo, and around Lichtenburg in the North-West province.

"These sites provided unique data as South Africa's drylands are particularly rich in plant species compared with many of the other sites included in the study," said Professor Peter le Roux of UP's Department of Plant and Soil Sciences who was involved in the study. "South Africa is very arid, with 85% of the country defined as drylands. We typically think of the Karoo and the Kalahari as being arid, but actually, most of the rest of the country is also a dryland, including large portions of our grasslands and savannas. Despite this, these drylands feature exceptionally diverse flora, including the Succulent Karoo, a biome along the West Coast that usually receives less than 200mm of rain annually yet hosts more than 6 000 plant species. Many of these aren't found anywhere else on Earth."

Drylands are defined as tropical and temperate zones with an aridity value below 0.65, meaning they have the potential to lose much more moisture than they receive via rainfall. They cover 45% of Earth's terrestrial area and are home to a third of the global human population. They include sub-humid, semi-arid, arid and hyper-arid ecosystems such as the Mediterranean landscape, steppes, savannas and deserts.

Earth is home to a diversity of plants with highly varied forms and functions. This extraordinary morphological, physiological and biochemical diversity determines how plants adapt and respond to ongoing global changes, with significant consequences for the functioning of ecosystems. Yet, 90% of current knowledge on the functional diversity of plants concerns only agricultural ecosystems and temperate zones.

By contrast, drylands are under-represented in the data. These important zones are now directly threatened by increases in aridity, grazing pressure and desertification. How plants respond to such pressures needs to be understood to more accurately predict how these fragile ecosystems will respond in terms of their biodiversity and functioning. This worldwide investigation of the functional diversity of plants in arid zones was carried out to meet this urgent need.

According to Prof Le Roux, the latest assessment of the threat status of South Africa's flora – the Red List of South African Plants, completed by the South African National Biodiversity Institute earlier this year – highlights how climate change is a growing threat to biodiversity. For example, 12% of recently assessed species were considered to be affected by climate change, including several tree aloe species that are characteristic of the very arid Nama Karoo and Desert biomes.

"Understanding the ecology of our dryland ecosystems is critical for how we manage and conserve these arid environments, as most of our country lives in, and relies on, drylands," Prof Le Roux says.

Conducting the study

This massive study was coordinated by three scientists from the French National Research Institute for Agriculture, Food and Environment; the French National Centre for Scientific Research; and the King Abdullah University of Science and Technology in Saudi Arabia respectively. All the scientists involved in the study processed samples from the 301 plant species found across 326 representative plots from all continents (other than Antarctica) to characterise the functional diversity of the zones, generating a total of 1 347 full sets of trait observations for analysis. Particular attention was paid to the characterisation of the plant elementome, that is, the diversity of chemical elements and trace elements (such as nitrogen, phosphorus, calcium, magnesium and zinc) found in plants. These often unrecorded traits can exert a strong influence on how plants function. Overall, the study involved more than 130 000 individual plant trait measurements.

A key hypothesis at the start of the study had been that aridity would reduce the diversity of plants, leaving only those species capable of tolerating extreme water scarcity and heat stress. However, the scientists found the

opposite to be the case in the most arid rangelands of the planet, where plants instead exhibit a wide range of individual strategies. For example, some plants have developed high calcium levels, strengthening cell walls as a protection against desiccation; others contain high concentrations of salt, reducing transpiration. Although fewer species are observed at local scale than in other regions of the planet (in temperate or tropical zones), plants in arid zones display an extraordinary diversity of forms, sizes and functioning – double that in more temperate climatic zones.

This increase in trait diversity occurs abruptly at the point where rainfall volumes drop below the annual threshold of 400mm. This is also the threshold for a pronounced decline in plant cover and the appearance of large areas of bare soil. To explain this phenomenon, the study's authors suggest that the loss of plant cover leads to 'plant loneliness syndrome', where increased isolation and reduced competition for resources allow for high degrees of trait uniqueness and functional diversity that are globally exceptional. This diversity could equally reflect complex evolutionary histories dating back to the initial colonisation of terrestrial habitats by plants more than 500 million years ago, when these habitats presented extreme conditions for living organisms.

The study sheds new light on our understanding of plant architecture, plant adaptation to extreme habitats, historical plant colonisation of terrestrial environments and the capacity of plants to respond to current global changes.

"This project has provided remarkable insights into functional diversity in understudied deserts," says Prof Thulani Makhalanyane of UP who was also part of the study. "The unprecedented scale and collaboration with such a large multidisciplinary team has been excellent for our team."

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Media enquiries can be directed to Mr Sashlin Girraj - Public Relations & Events Manager

Email: sashlin.girraj@up.ac.za | Cell: +27(0)72 447 3784

ABOUT THE UNIVERSITY OF PRETORIA

The University of Pretoria (UP) is one of the largest contact and residential universities in South Africa, with its administration offices located on its Hatfield Campus in Pretoria. This 115-year-old institution is also one of the largest producers of research in South Africa.

Spread over seven campuses, it has nine faculties and a business school, the Gordon Institute of Business Science (GIBS). It is the only university in the country with a Faculty of Veterinary Science, which is ranked the best in Africa. UP has 120 academic departments and 92 centres and institutes, accommodating more than 56 000 students and offering about 1 100 study programmes. It has the most academic staff with PhDs (70%), NRF-rated researchers (613).

The 2024 Times Higher Education subject rankings placed UP first in South Africa in the fields of Law, Veterinary Science, Accounting and Finance; Agriculture and Forestry and Electrical and Electronic Engineering. Quacquarelli Symonds (QS) ranked the University among the top five in Africa, as part of their 2024 World University Rankings (WUR). UP was the only South African university featured in the 2023 World University Rankings for Innovation (WURI), falling within in the 101-200 range of innovative universities.

For more information, please go to www.up.ac.za