Systematic data evidence reveals: Plant water stress causes Namibia's fairy circles

Author: Dr. Stephan Getzin, University of Göttingen

The mysterious fairy circles of the Namib are known since the 1970s. Many explanations exist, but with regard to the causal mechanism, many theories lack even the most basic data evidence. For example, the sand termite theory proposes that foraging on the roots of freshly germinated grasses would kill the *Stipagrostis* seedlings within fairy circles. However, field evidence based on root measurements and systematic replicates has never been shown. Likewise, the *Euphorbia* hypothesis is not supported by plausible data evidence.

Ten years after the First Fairy Circle Symposium, modern research on fairy circles should be strictly based on quantitative data evidence and measurements, instead of anecdotal observations. Here, I summarize my ten years of fieldwork and present data-driven facts that strongly underpin the plant self-organization theory:

1) The grasses in fairy circles die within the first 10-20 days after rainfall. Hence, the processes which cause or maintain fairy circles, happen within the first three weeks.
2) 500 grasses were excavated in and around the fairy circles in the southern, central and northern Namib. If the last rain was only 3-5 weeks ago, the dead grasses in the circles were 100% undamaged. Their roots were as long as those of the vital matrix grasses outside the circles. No sand termites were found near the dead grasses, nor could termite feeding explain roots of equal length. The grasses did not die due to termite foraging.
3) The root length of those dead grasses in fairy circles averaged 10 cm throughout the Namib. Consequently, the small grasses in this topsoil cannot utilize the multiple times higher soil-moisture content, which only exists at lower depths between 20-100 cm. Two to three weeks after rainfall, moisture in the topsoil was below the permanent wilting point of 2%. The topsoil acts as a "death zone" for the grasses, where they dry out.
4) Continuous measurements of soil moisture over years show that the surrounding grasses suck the water out of the fairy circle after rainfall. This competition for water explains the fairy circles and why the dying seedlings cannot further develop roots being long enough to reach the higher soil moisture under the dry topsoil.
5) The soil-water content at 20 cm depth was above 8% during the first 20 days after several grass-triggering rainfall events in 2021 and 2022. This enables a high hydraulic conductivity and long-distance water diffusion towards the surrounding grasses, which also have long enough roots to utilize the water at 20 cm depth and below.
6) Hundreds of soil-moisture measurements during the rainy season reveal that the topsoil in the fairy circle is significantly drier than in the matrix. This prevents the survival of seedlings and thereby maintains the underground water source for the surrounding grasses. The same results were found for related but smaller circular grass and forb rings in the Namib, indicating a universal adaptation to drought stress.
7) Among all the explanations hypothesized, only plant self-organization can explain the extremely regular, spatially periodic patterns of the fairy circles.