INSECTS · NAVIGATION & ECOLOGY

Dung Beetles: Steering by the Milky Way

How a beetle with a ball of dung uses the sun, the moon, the wind and the Milky Way to roll in a straight line — and why the bush depends on it.

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> Watch a dung beetle at work on an elephant dropping and you'll see it shape a ball, climb on top, spin around, then roll away — backwards — in a dead-straight line. Over the last two decades, researchers working in South Africa have shown that this small beetle is one of the most sophisticated navigators in the insect world.

01 Three ways to deal with dung

Not every dung beetle rolls a ball. Of the more than 8,000 known dung beetle species, only about 600 roll dung balls. Scientists group them by what they do with the dung:

ROLLERS · TELECOPRIDS

Roll it away

Cut a portion of dung from the pile, roll it some distance away and then bury it. These are the beetles of the famous ball.

TUNNELLERS · PARACOPRIDS

Dig straight down

Build their nests at the end of tunnels dug under the dung, pulling dung down into the soil.

DWELLERS · ENDOCOPRIDS

Live in it

Make a nest chamber within, or immediately under, the dung pat itself.

KLEPTOPARASITES

Steal it

Use dung that other beetles have already buried.

02 Why roll a ball at all?

Rollers propel their balls with their **hind legs, moving backwards with their heads pointed at the ground**. A fresh dung pile is a crowded, competitive place. Rolling beetles grab their share and head off in a **straight line away from the pile**, because circling back risks having the ball stolen by rivals. A straight line is the quickest way out of the scrum.

The ball is food, but it can also be a nursery. Beetles bury a ball, lay an egg in it, and the larva then eats the ball from the inside out. As Wits University's Marcus Byrne puts it, the ball is *"a vehicle that the adult beetles use to get their genes into the next generation."*

In some species, a male and female roll a brood ball together. A 2024 study of *Sisyphus* beetles, including the southern African *Sisyphus fasciculatus*, found the male steers while the female mainly helps lift the ball over obstacles — and that teamwork makes transport more efficient where the ground is cluttered with fallen plant material.

03 A compass in the sky

To hold a straight line, a rolling beetle needs a fixed reference. Research led by Lund University (Sweden) with Wits University and the University of Pretoria has shown that dung beetles switch between several cues depending on the time of day:

DAY

The sun

When the sun is low or at medium height, beetles steer by it. Move the sun's apparent position 180° and they turn 180°.

MIDDAY

The wind

When the sun is more than **75°** above the horizon, or it is cloudy, they switch to wind direction — and back to the sun once it drops again.

Dacke et al. 2019, PNAS

DUSK & MOONLIGHT

Polarised light

The sky's pattern of polarised light — from the setting sun, and even from the moon.

Dacke et al. 2003, Nature

MOONLESS NIGHT

The Milky Way

The glowing band of the Milky Way, used as a whole rather than individual stars.

Dacke et al. 2013, Current Biology

POLARISED MOONLIGHT (2003)

On moonlit nights, the dung beetle *Scarabaeus zambesianus* rolled its balls in straight lines away from the dung pile; on moonless nights it did not. When researchers hid the moon and placed a polarising filter over the beetles, rotating the filter so the light pattern appeared to turn 90° made the beetles turn by close to 90°. It was the first known case of an animal using the polarisation of moonlight to orient — a remarkable feat, since moonlight's polarisation is far dimmer than sunlight's.

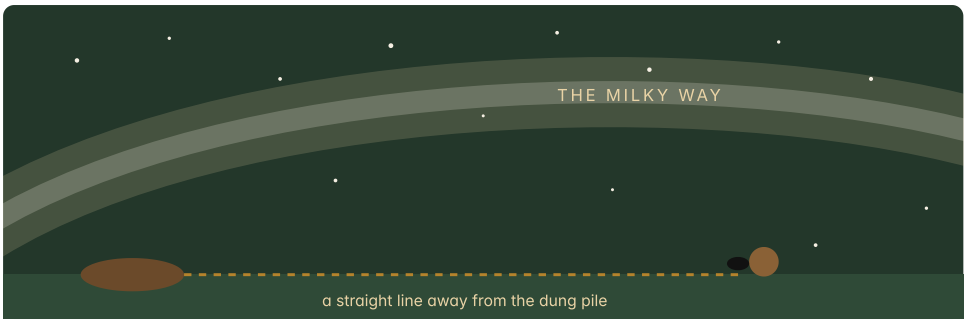
THE MILKY WAY (2013)

Many beetles still managed straight paths on clear, *moonless* nights. So the team tested the stars:

- Under a starlit sky, *Scarabaeus satyrus* kept straight paths. Under overcast skies, it lost the ability.
- Beetles fitted with tiny **cardboard caps** that blocked their view of the sky wandered far off course; beetles with clear plastic caps rolled normally.
- In the **Johannesburg Planetarium**, beetles oriented as well under the Milky Way alone as under the full starry sky. With only 18 bright "stars" and no Milky Way, they strayed and took more than 50% longer.

A FIRST IN THE ANIMAL KINGDOM

This was the first convincing evidence of an insect using the starry sky, and the first documented use of the Milky Way for orientation by any animal.



On moonless nights, ball-rolling beetles use the light of the Milky Way band to keep a straight course away from the competition at the dung pile.

04 The dung beetle “dance”

Before setting off, a rolling beetle often climbs onto its ball and **spins around on top**. A 2012 study found this “dance” also happens mid-journey — especially when a beetle loses control of its ball or loses contact with it, after the ball is knocked off course, or when the visual cues around it change. The researchers concluded the dance is a visual check: the beetle takes a bearing from the sky, sets its direction, and uses the dance to get back on course after a disturbance.

05 The ball as a portable cool spot

Midday sand in southern Africa can be scorching, and a rolling beetle is in constant contact with it. A 2012 study found that:

- Beetles on hot soil climbed onto their balls **almost seven times as often** as beetles on cooler ground, with climbing peaking in the midday sun.
- The moist dung ball stays cooler than the sand through evaporation, so standing on it gives the beetle’s legs a break.
- When researchers fitted beetles with tiny **silicone “boots”** on their front legs, the booted beetles climbed their balls less often — evidence that hot legs drive the climbing.

The authors described the dung ball as a *mobile thermal refuge*.

06 Small but astonishingly strong

Up to 50×

PUSHING POWER

Ball-rolling beetles push dung balls up to 50 times their own body weight.

1,141×

BILLED AS THE STRONGEST INSECT

A male *Onthophagus taurus* (a tunnelling dung beetle) resisted a pull of about 1,141 times its body weight — measured as the force needed to drag it out of its tunnel. That is like a 70 kg person holding on against roughly 80 tonnes.

In *O. taurus*, horned males fight rivals inside tunnels beneath dung pats. Smaller, hornless males don’t fight; instead they have much larger testes for their size and appear to sneak matings while rivals are distracted.

07 Why the bush needs dung beetles

By burying and breaking up dung, dung beetles provide a range of ecological services documented in the scientific literature:

SOIL

Nutrient cycling & fertility

Dung pulled underground returns nutrients to the soil, where plants can take them up.

SOIL

Aeration & water

Tunnelling mixes and aerates the soil ("bioturbation") and improves soil structure and water infiltration.

PLANTS

Secondary seed dispersal

Seeds in dung are moved and buried along with it.

HEALTH

Fly & parasite control

Breaking up and burying dung helps control pest flies and intestinal parasites of grazing animals.

AT THE DUNG PILE — HOW TO SAY IT

"This little beetle is pushing a ball many times its own weight — backwards, with its back legs — and it's going in a perfectly straight line so that no one steals it. In the day it steers by the sun. At midday, when the sun is too high to be useful, it switches to the wind. And on a dark night with no moon, it uses the Milky Way. Scientists proved that in a planetarium in Johannesburg. It was the first animal ever shown to navigate by our galaxy."

IF IT CLIMBS ON ITS BALL AND SPINS

"Watch — that's its dance. It's taking a bearing from the sky before setting off again. And if the sand is hot, it's also cooling its feet on the ball."

08 Key terms

Telecoprid	A "roller": a dung beetle that rolls a portion of dung away from the source before burying it.
Paracoprid	A "tunneller": nests at the end of tunnels dug under the dung.
Endocoprid	A "dweller": nests within or immediately under the dung pat.
Brood ball	A buried ball of dung in which an egg is laid; the larva feeds on it from the inside.
Polarised light	Light whose waves vibrate mainly in one plane. Sunlight and moonlight scattered in the sky create a polarisation pattern many insects can see.
Bioturbation	The mixing and reworking of soil by living organisms.

In summary

- Dung beetles roll, tunnel, dwell in or steal dung; rollers head off in a **straight line** to escape competition.
- Their compass changes through the day: **sun**, **wind** when the sun is above 75°, **polarised light** at dusk and by moonlight, and the **Milky Way** on moonless nights.
- The "dance" on top of the ball is a visual orientation check.
- The moist ball doubles as a **portable cool spot** on hot sand.
- By burying dung they recycle nutrients, aerate soil, spread seeds and help control flies and parasites.

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