

Biophysical Field Methods in the Namib Desert



Gobabeb

10 - 26 February 2020



**Adaptation to a harsh environment:
the Namib desert. An international
field workshop**

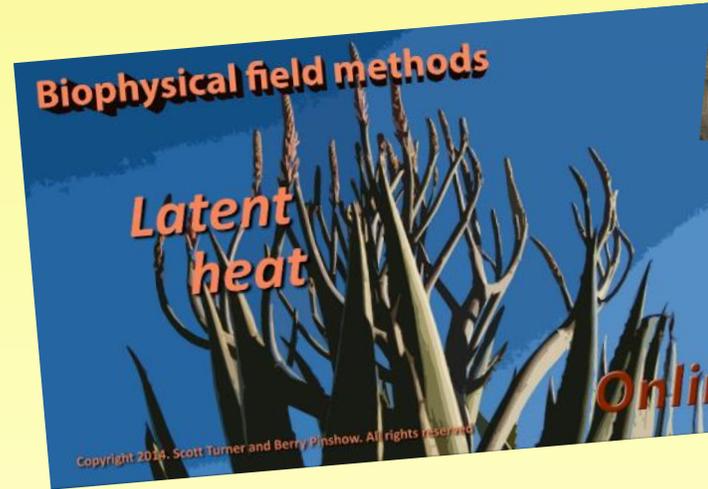


Gobabeb Namib Research Institute, 10-26 February 2020
Ben-Gurion University of the Negev

Before the course ...

Prior to leaving for Namibia, students from Israel, Namibia, and South Africa take Biophysical Field Methods, an eight-week online course together to reach a common background level.

Biophysical Ecology in the Namib is the second part of a hybrid online / field course in the biophysics of adaptation to harsh environments.



Off to Namibia ...

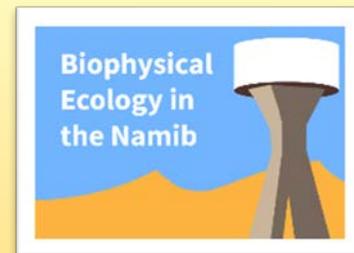
Once students complete Biophysical Field Methods, it's off to Namibia.

For the Israeli students it's a long international flight to Walvis Bay!

Thức Nguyen and Ben Poodiack on the way.



Arrival in Walvis Bay!



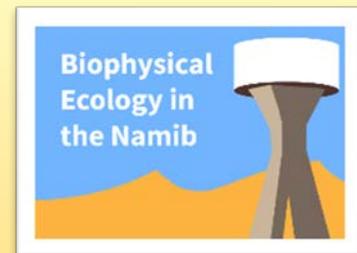
Day 1. Settling in at Gobabeb

Students settle in to their accommodation



Gal Lupovitch

The day ends with a meal in the Gobabeb dining hall



Day 2. Orientation

In the morning, Dr Eugene Marais takes everyone on a walk through the desert habitats around Gobabeb

On the dune crest



In the riparian corridor of the Kuiseb River

On a !nara hummock



Day 2. Orientation

We also took a bit of time to learn about the instrumentation we will be using.

Prof Scott Turner talks about operative temperature thermometers



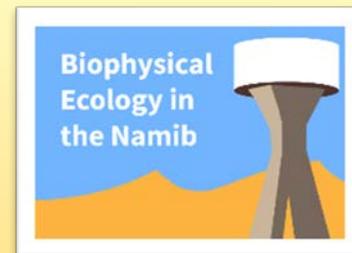
Prof Berry Pinshow describes a psychrometer



Dr Dilia Kool demonstrates the micro-lysimeter ...



... and a meteorological shield for a thermocouple



Days 3-5: Field work

We divided up into three groups, for three days of hands-on field work

One problem studied was about desert beetles that are almost always black.

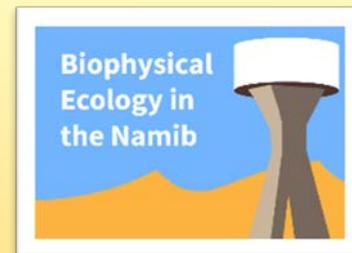
You would expect beetles inhabiting a hot sunny environment to be white!

But, they're black!

Why?



One group implanted fine thermocouples into black desert beetles to measure their operative temperatures in the sun



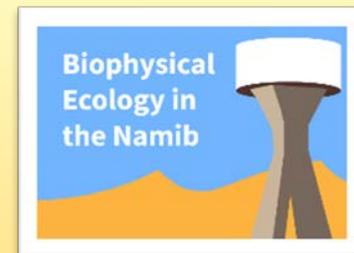
Days 3-5: Field work

A second question addressed was about the indigenous !nara plant (*Acanthosicyos horridus*).

The !nara lives in the dunes in an extremely dry desert, but uses a lot of water. Where does it get water from?

Does the water come from dew and fog?

We set out micro-lysimeters around a !nara thicket to measure air-borne water deposition in dune sands.



Days 3-5: Field work

The third group posed a question about thermal buffering.

We used operative temperature thermometers (made of painted ping-pong balls) to measure how their temperature responds when environmental temperature suddenly changes.

One ball was filled with water and had had high thermal capacity, while the other was empty and had low thermal capacity.



Days 3-5: Field work

Each afternoon, we analyzed and discussed the data gathered in the morning.



There was also time to let our hair down.



Day 6: Data analysis workshop

After three days of field work, we got down to making sense of the data.



We discussed our own data and how to make sense of them.

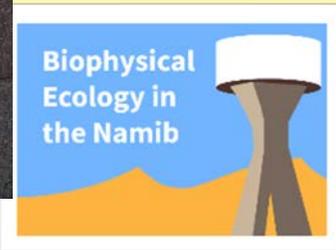
We had a sundown discussion about what science is ...

... and what science isn't

We had a charrette of posters at Gobabeb, to evaluate what makes a good (and what makes an ineffective) poster



We worked up draft slides to see what worked and what didn't



Day 7: Namib day trip

On the 7th day, we travelled to the Atlantic ocean, visiting lichen fields, geological formations and local cultural sites.

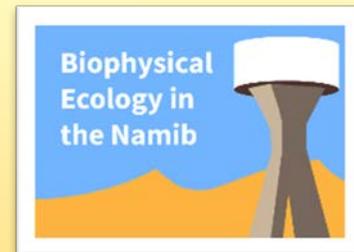


Arriving at the Walvis Bay lagoon

... watched the flamingoes ...

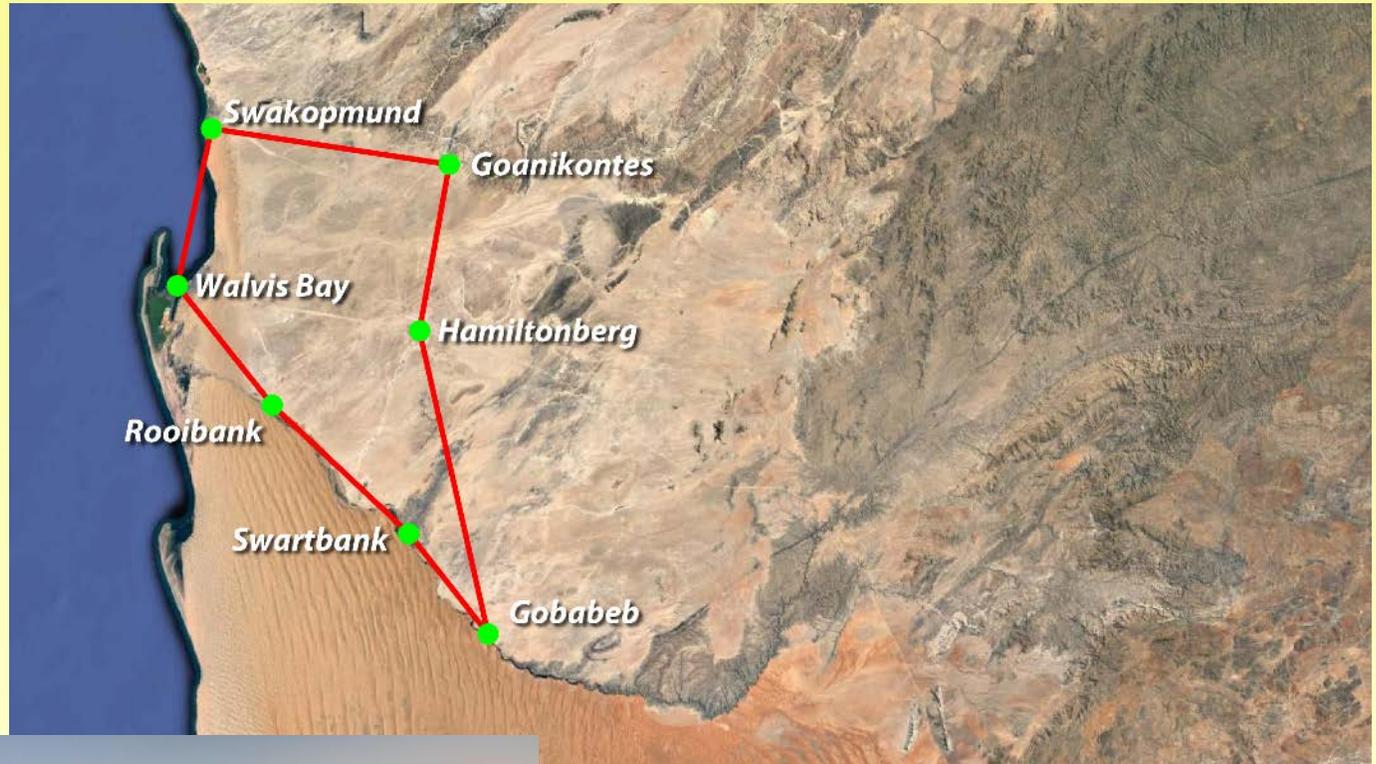


... and had lunch.



Day 7: Namib day trip

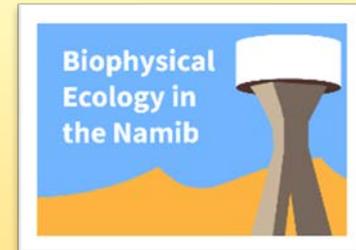
In the afternoon we
... looked over the “moonscape” of
Goanikontes on the Swakop River ...



... checked out some
Welwitschia ...



... enjoyed
sundowners looking
in vain for *Lithops*
plants at the
Hamiltonberg ...



Days 8-10: Field work

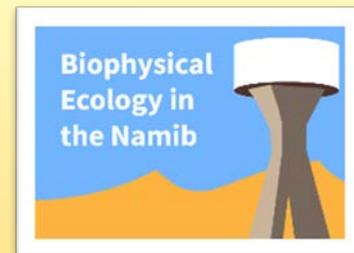
How fast does a beetle have to run across a hot stretch of sand?

We measured how fast beetles run

Black Namib beetles are often seen running across hot sands. How do they avoid overheating?

One way is to run fast!

We measured temperatures along a transect between two Inara hummocks



Days 8-10: Field work

Just how hot *do* beetles get?

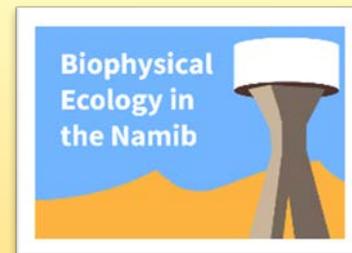
We measured body temperatures of beetles walking across sand ...



This involved some pretty close work



... we also used an infrared thermometer to measure beetle surface temperature



Days 8-10: Field work

Do !nara hummocks actually capture fog?

Fog comes in overnight ...



It looks like they do (sort of)



!Nara hummocks capture fog water (and so does everywhere else) ...

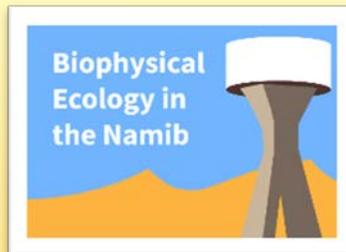
... but !nara hummocks retain the water longer



... taking overnight measurements of water capture.



... so we spent the night at a !nara hummock ...

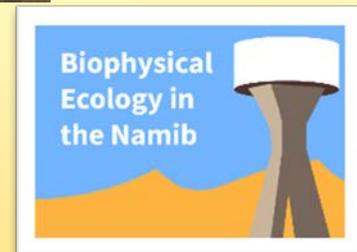


Day 12: Data analysis workshop (2)

After the second three days of field work, we learned new methods of data analysis.

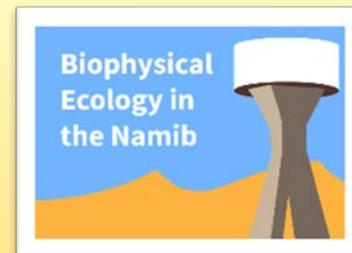
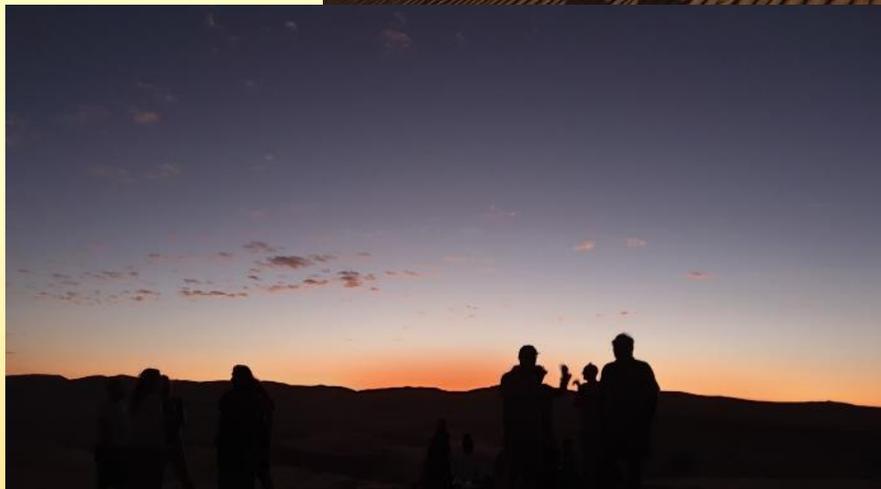
Finally, we discussed the data as a group ...

... and broke into smaller groups to analyze and interpret our data



Days 13-14: Overnight trip into the dune sea

After an intense bout of intellectual work, it was time for an overnight outing into the dune sea.



Days 13-14: Overnight trip into the dune sea

We enjoyed each others' company ...



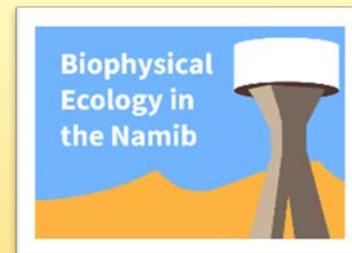
... cooked a nice meal ...



... and woke up to a rare cloudy morning.



... saw interesting nocturnal creatures ...



Day 15. Poster workup

Then we set about making our own, preparing posters describing our findings..

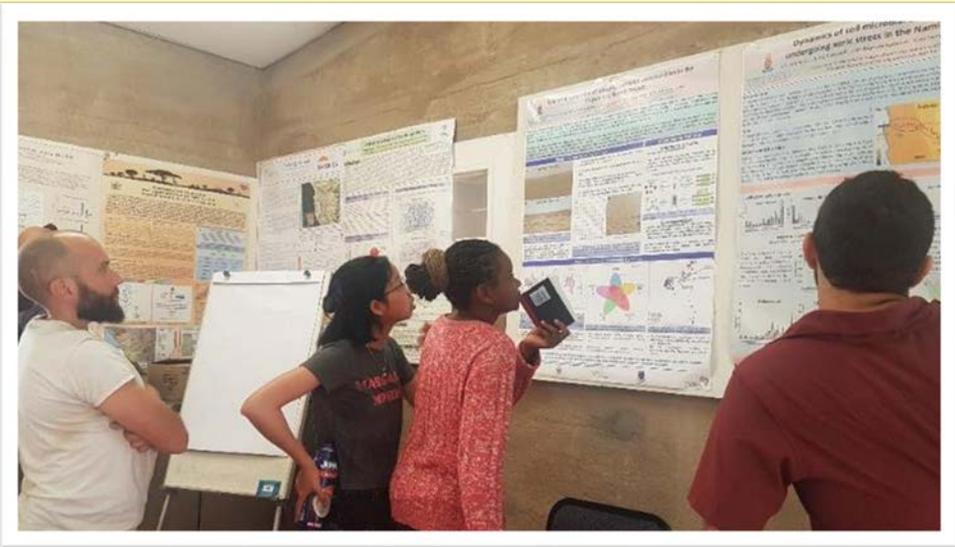


First we had a poster design charette, learning from the work of others (left).

We thought, and worked, together ...



... and critiqued each other's work



... and alone ...



Day 16. Poster presentations

Then it was time to tell the Gobabeb staff what we had been doing

Dr Gillian Maggs-Kölling
(Director of Gobabeb
Namib Research Institute)
welcomed us

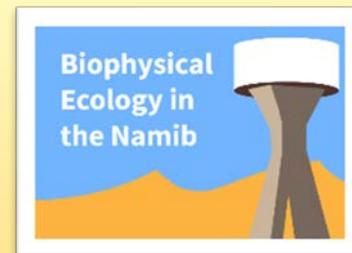
The entire Gobabeb staff attended



Prof Nurit
Agam added
her welcome



Prof Berry
Pinshow
opened the
session



Day 16. Poster presentations

The "Black Desert Beetle Paradox" solved!

Ariel Drabkin



Ella Agra



Nata Ndilenga



Thức Nguyen



אוניברסיטת בן-גוריון
Ben-Gurion University
of the Negev

GOBABEB
NAMIB RESEARCH INSTITUTE

תל אביב
TEL AVIV
UNIVERSITY

An end to the "black desert beetle paradox"

Ella Agra¹, Ariel Drabkin², Natanuel Ndilenga³ and Thuc Nguyen¹
¹Ben-Gurion University of the Negev, Israel, ²Tel-Aviv University, Israel, ³Gobabeb Namib Research Institute.

Introduction

Why would a beetle in a hot sunny desert be black in color? This has been a paradoxical question for many years because being black would make the beetle very hot.

On the other hand, black coloration is apparently common in desert animals. Crows, for example, have black feathers, but they have a mechanism to deal with the heat.

Think I'm too hot because I'm black?

Not at all, I have a secret: My black plumage is an insulating layer that allows wind to dissipate most heat absorbed at my surface, so I'm cool!

Do black beetles have the same mechanism?

1 I also have an insulating layer of air. It's between my elytra (wing covers) and my body.

2 Perhaps the wind blows heat away from MY body as well!

3 Perhaps black color keeps my body temperature low, just like the crow.

Radiation → Convection

1 Beetle, you said you have an insulating layer. Then, we predict your body temperature will be lower than surface temperature of your elytra.

Surface temperature

Body temperature

Thermal camera

Data logger

You can see from the graph below that there is a time delay between my body temperature and my surface temperature. My insulating layer works!

Temperature (°C)

Time (min)

• Body temperature
• Surface temperature

2 Beetle, is it true that your body size and posture affect your operative temperature (T_e)?

T_e prone > T_e stiling T_e large > T_e small

Well, when stiling, I'm more affected by convection. So, my T_e should be lower than when I'm prone.

But, body size does not have any significant effect on my T_e .

3 Beetle, you have an insulating layer and your heat budgets are easily affected by convection. So it must take time for you to heat up. What's your time constant*?

Heating $\tau = 6.91$ min

Cooling $\tau = 3.62$ min

*The time constant (τ) indicates the time for a beetle's body temperature to approach the T_e .

$\tau = R \times C$

C - Thermal capacitance of the beetle

R - Resistance to heat flux

1+2=3

The τ for heating is longer than for cooling i.e. it's much easier for me to cool down than to heat up.

The (1) insulating layer and (2) convection effect together combine to allow black beetles to (3) keep cool in hot sunny deserts.

Black coloration does not matter that much to a beetle's body temperature, so let "the paradox" sleep!



Day 16. Poster presentations

!Nara hummocks help retain water for a longer period



Rorie Duncan



Yaniv Shmuel



Ailly Nabwandja



Gal Lupovitch

MEMBER OF THE UNIVERSITY OF CAPE TOWN

UNIVERSITY OF THE NEGEV

Water under arrest

UNIVERSITY OF CAPE TOWN

Can the !Nara (*Acanthosicyos horridus*) hummock take atmospheric water into custody? For how long can it imprison this water? And will the water be able to escape?

Rorie Duncan¹, Gal Lupovitch², Ailly Nabwandja³, and Yaniv Shmuel⁴
¹University of Cape Town; ²Ben Gurion University of the Negev; ³Namibia University of Science and Technology; ⁴The Interuniversity for Marine Science.

In the hyper-arid Namib desert, the !Nara (*Acanthosicyos horridus*) plant thrives. How is this possible? Can it be that fog plays a role?

How did we examine this?

Hi. I am a microlysimeter. I am filled with soil, representing the surrounding soil. My mass will increase when water accumulates in my soil and decrease when water evaporates. We were put in various locations around the !Nara hummock

After a fog event, water accumulates during the night, even two days later.

Day	Water accumulation (mm)	Relative humidity (Mean and s.d)
Day 0...	~0.05	74±18.5%
Day 1	~0.12	83±7.3%
Day 2	~0.09	72±9.1%

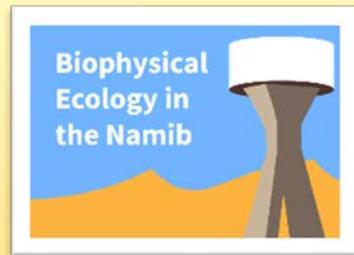
During the day, water evaporates.

Time of day	Water evaporation (mm)
6:00	~189.68
7:00	~189.65
8:00	~189.64
9:00	~189.62
10:00	~189.58
11:00	~189.57
12:00	~189.53

Water is accumulating in the hummock when there is fog, but also when there isn't fog. Can the !Nara hummock capture other types of water? Dew? Water vapor?

Water is accumulating in the hummock soil at night. Is it possible that the !Nara hummock's structure itself plays a role in the accumulation of water?

Acknowledgements:
 This study was part of the 2020 class in Biophysical Ecology in the Namib. Our work was supported in part by a generous grant from the Sillans Foundation in Israel, and with additional support from Gobabeb, Namib Research Foundation



Day 16. Poster presentations

Beetles can use thermal inertia to cross hot sands without overheating, but only if they run really fast.





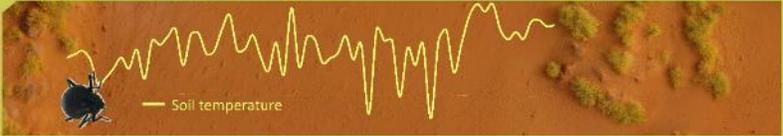
Lost in Transition?

Paulina Fendinat¹, Sarah Leduc², Sagi Liran², Ben Poodiack²
¹Namibia University of Science and Technology, ²Ben-Gurion University of the Negev, Israel.



The ecology of the transient state

What happens to a beetle's body temperature while crossing a hot stretch of sand?

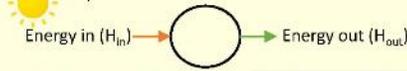


As the beetle runs, it passes through a complex field of varying temperature (yellow trace). How much will its body temperature rise or fall as it runs? Should it run fast or slow? *How should we even think about it?*

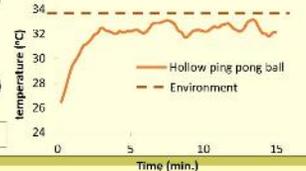
We use three tools:

Operative temperature: For example, a hollow ping pong ball placed in the sun reaches its operative temperature when it's in equilibrium with the environment.

The operative temperature of an object is its temperature once it reaches equilibrium with the environment.

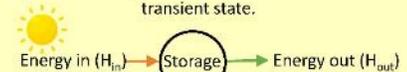


At equilibrium (the steady state), the energy budget is zero $0 = H_{in} + H_{out}$

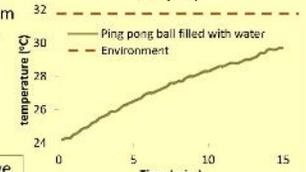


Thermal capacity: Organisms are made largely of water which can store heat energy. This heat storage is quantified as the thermal capacity.

A water-filled ping pong ball filled will reach its equilibrium temperature slowly as heat is stored within. This is the transient state.



In the transient state, its energy budget is **not zero** $0 = H_{in} + H_{out} + storage$



Time constant: In the transient state, a body will approach its equilibrium temperature at a specific rate. This is quantified by the time constant, τ .

A body with large thermal capacity (like the water filled ping pong ball) has a longer time constant a body with small thermal capacity (like the hollow ping pong ball).

The time constant, τ , is the product of the thermal capacity, C , and the resistance to heat flux, R , across the body's outer boundary.

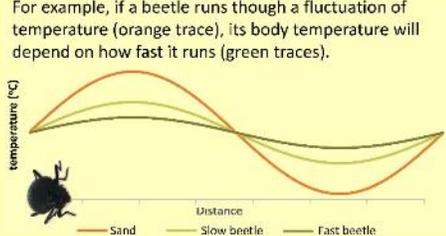
$\tau = RC$



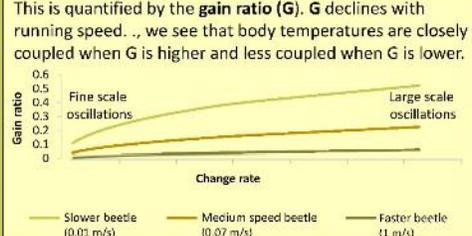
Now we can apply these concepts to our original question.
 We used the operative temperature, thermal capacity, and the time constant of desert beetles to model what would happen if a beetle ran across hot sand.

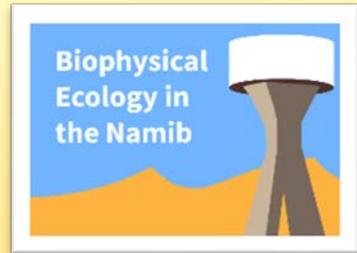
When the beetle runs faster, its body temperature is less coupled with the sand temperature it encounters (yellow trace above). If it runs fast enough, it will not overheat.

For example, if a beetle runs through a fluctuation of temperature (orange trace), its body temperature will depend on how fast it runs (green traces).



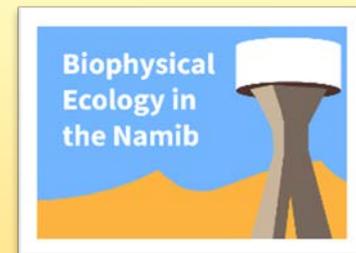
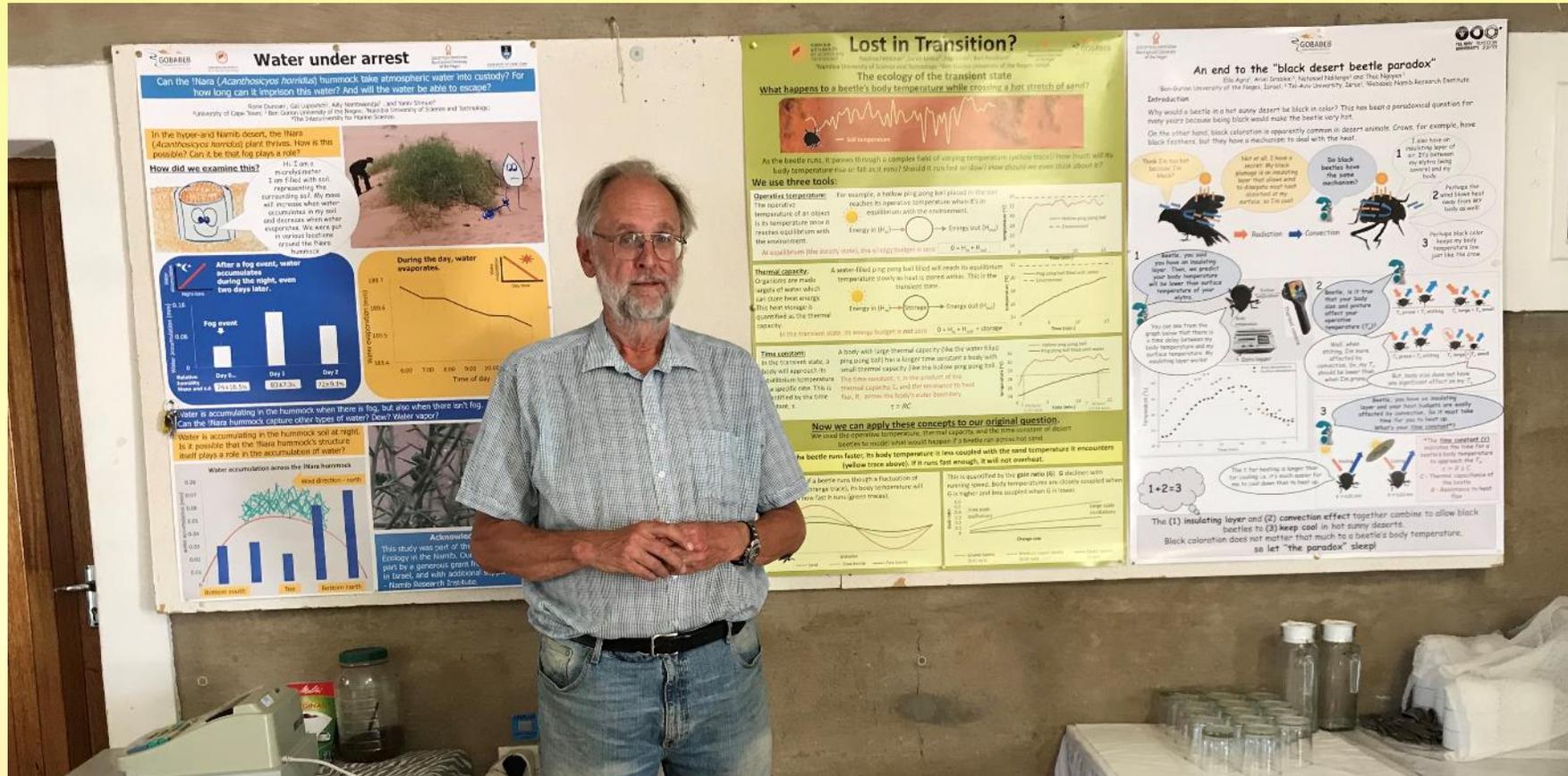
This is quantified by the **gain ratio (G)**. **G** declines with running speed. . . we see that body temperatures are closely coupled when **G** is higher and less coupled when **G** is lower.





Day 16. Poster presentations

The posters are now on display in the dining hall at Gobabeb, for all to see.

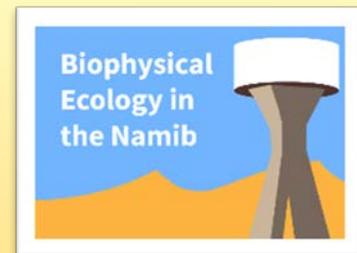


Day 16. We celebrate

Our last night at Gobabeb. We enjoy a good meal ...



... and good libations

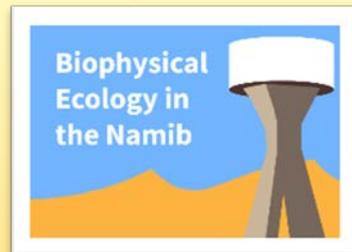


Day 17. Departure

It was back in the bus from Gobabeb to Walvis Bay, where it all began.



We had a lot of fun,
and learned a lot!



Biophysical Field Methods. Class of 2020

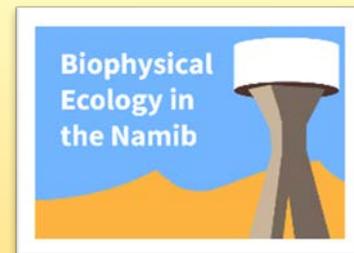
Thức
Nguyen
& Yaniv
Shmuel



Natanael Ndilenga



Ella Agra & Liran Sagi



Biophysical Field Methods. Class of 2020

Ariel Drabkin

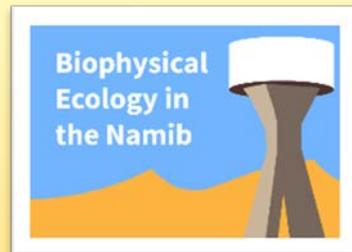


Ben Poodiack



Rorie Duncan

Gal Lupovitch



Biophysical Field Methods. Class of 2020



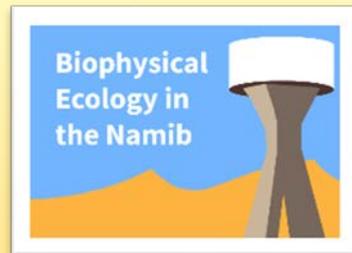
Ailly Nambwandja



Sarah Leduc



Paulina Fendinat



Biophysical Field Methods. Leaders



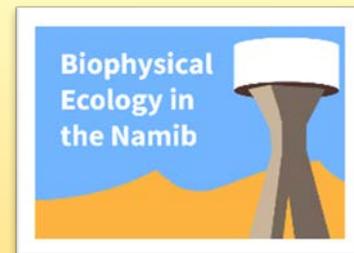
Berry Pinshow, Scott Turner, Eugene Marais



Nurit Agam



Gillian Maggs-Kölling, Nurit Agam



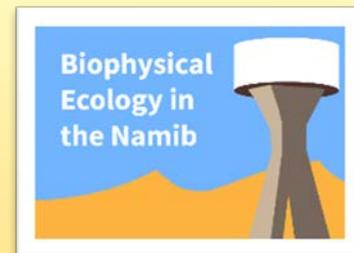
Biophysical Field Methods. Leaders



Dilia Kool



Stuart Summerfield, Scott Turner



Biophysical Ecology in the Namib 2020

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UNISA – University of South Africa

NUST - Namibia University of Science and Technology

UCT – University of Cape Town

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Photo credits: Ella Agra, Ariel Drabkin, Scott Turner