Large mammals facing climate change

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Gertrud Riemerschmid


Riemerschmid G (1943) The amount of **solar radiation** and its absorption on the hairy coat of **cattle** under South African and European conditions. *J S Afr Vet Assoc* 14:121-141

## CO₂ emission (g per year per $GDP)

<table>
<thead>
<tr>
<th>Country</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>1230</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>960</td>
</tr>
<tr>
<td>Namibia</td>
<td>290</td>
</tr>
<tr>
<td>USA</td>
<td>360</td>
</tr>
<tr>
<td>Australia</td>
<td>320</td>
</tr>
<tr>
<td>New Zealand</td>
<td>220</td>
</tr>
<tr>
<td>UK</td>
<td>200</td>
</tr>
</tbody>
</table>

Calculated from World Bank data
Government coal subsidies: G20 countries

<table>
<thead>
<tr>
<th>Rank order</th>
<th>GDP (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>$13.4 \times 10^{12}$</td>
</tr>
<tr>
<td>India</td>
<td>$2.7 \times 10^{12}$</td>
</tr>
<tr>
<td>Japan</td>
<td>$4.8 \times 10^{12}$</td>
</tr>
<tr>
<td>South Africa</td>
<td>$0.4 \times 10^{12}$</td>
</tr>
</tbody>
</table>

2018 data

Daily Maverick 1 July 2019 and International Monetary Fund
Hotspots for $SO_2$ emissions

NASA/Greenpeace 2019
Days per year reaching 35°C

Bramble Cay mosaic-tailed rat (*Melomys rubicola*)

first mammal species wiped out by human-induced climate change
Plant toxins get more toxic as temperature increases

**Figure 4.** Proportion of woodrats remaining in the trial (persistence) while ingesting a controlled dose of creosote (0.36 g resin per day) at three temperatures (cool, solid line; room, grey dashed line; warm, dotted line).

Change in average annual rainfall (mm) and in Keetch-Byram drought index: 2071-2100 vs 1961-1990

Larger mammals are more vulnerable to global warming

McCain and King *Global Change Biology*, 2014
Late Pleistocene extinction of large mammals

Late Pleistocene
126 000 to 11 700 years ago


(Log mass (g)

Number of species

North America

Australia

Africa

South America

1000 kg)
Hunting is the biggest threat to large herbivores

Ripple et al. Science Advances, 2015
About one-quarter of all mammals are in danger of extinction, and more than half of all mammal populations are in decline.

Davidson et al. *PNAS*, 2009

The status of large-bodied species, particularly those above 100 kg (including many iconic taxa), deteriorated significantly more than small-bodied species (below 10 kg).

Di Marco et al. *Conservation Biology*, 2014
Under mid-range climate change scenarios for 2050, South Africa may lose 69% of its mammals if dispersal is limited

Thomas et al. *Nature*, 2004

25-40% of a representative sample of 277 African mammalian species is likely to be critically endangered or extinct by 2080

1. Die out
2. Move
3. Stay put
1. Die out
2. Move
3. Stay put
1. Die out
2. **Move**
3. Stay put
Migrations of large terrestrial herbivores

Anthropogenic land fragmentation prevents movement
Emigrate to a suitable environment?

Host switching

“Parasites are resource specialists with restricted host ranges, yet shifts onto relatively unrelated hosts are common”

Hoberg and Brooks *Philosophical Transactions of the Royal Society*, 2015

Saegerman et al. http://www.cdc.gov/EID/content/14/4/539-G1.htm
1. Die out
2. Move
3. Stay put
The “stay-put” options

• **Adaptation**: genetic adjustment occurring by natural selection, and increasing fitness
How many generations between now and 2050?
Microevolution

Soay sheep

Maloney et al. *Biology Letters*, 2009
Tasmanian devil facial tumour disease
How many generations between now and 2050?
The “stay-put” options

- **Acclimatization**: phenotypic adjustment in the natural habitat, to chronic change
Do animals have latent physiological talents that will help them cope with climate change?

- Free-living animals
- Avoid artefacts caused by human presence
- Long-term field studies
- Identified individual animals
- Characterize microclimates
- Responses of healthy and sick animals
Do animals have latent physiological talents that will help them cope with climate change?

- Free-living animals
- Avoid artefacts caused by human presence
- Long-term field studies
- Identified individual animals
- Characterize microclimates
- Responses of healthy and sick animals

“Biologging”
Year in the thermal life of a springbok

Fuller et al. *Journal of Experimental Biology*, 2005
Mean annual maximum air temperature, 1985-2004

Predicted days per year above those maxima, 2050-2069

Horton et al. *Current Climate Change Reports*, 2016
Arabian oryx in Saudi Arabia
low 24h amplitude of body temperature (homeothermy)

high 24h amplitude of body temperature (heterothermy)
Maintenance of a low amplitude of body temperature (homeothermy) requires energy and water.
Activity (counts)

Time of day

0:00 6:00 12:00 18:00 24:00

warm, wet 34°C 24 mm

Hetem et al. Zoology, 2012
<table>
<thead>
<tr>
<th>Time of day</th>
<th>Activity (counts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00 - 6:00</td>
<td>Warm, wet 34°C 24 mm</td>
</tr>
<tr>
<td>6:00 - 12:00</td>
<td>Hot, dry 40°C 0 mm</td>
</tr>
<tr>
<td>12:00 - 18:00</td>
<td></td>
</tr>
<tr>
<td>18:00 - 24:00</td>
<td></td>
</tr>
</tbody>
</table>

Hetem et al. Zoology, 2012
Moving grazing to the night?
• Cool microclimate selection
• Reduced diurnal activity
• Increased amplitude of body temperature rhythm
• Water conservation by selective brain cooling
Artiodactyls have physiological means of saving water, which they currently don’t need to use fully in most habitats.

Perissodactyls have to be near drinking water.
Ripple et al. Science Advances, 2015
Projected meat and milk consumption
(as % of 1980 consumption in the developed world)

<table>
<thead>
<tr>
<th>Year</th>
<th>Developed Meat</th>
<th>Developed Milk</th>
<th>Developing Meat</th>
<th>Developing Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>100</td>
<td>100</td>
<td>55</td>
<td>50</td>
</tr>
<tr>
<td>2015</td>
<td>130</td>
<td>120</td>
<td>210</td>
<td>140</td>
</tr>
<tr>
<td>2050</td>
<td>150</td>
<td>130</td>
<td>380</td>
<td>260</td>
</tr>
</tbody>
</table>

Calculated from Table 1 of Thornton P K *Philosophical Transactions of the Royal Society B*, 2010
“Greenhouse gas emissions from ruminant meat production are significant. Reductions in global ruminant numbers could make a substantial contribution to climate change mitigation goals and yield important social and environmental co-benefits”

William J Ripple and colleagues
USA, Scotland, Germany, Australia

Ripple et al. Nature Climate Change, 2014
Agricultural contributions to greenhouse gas emissions

(as % of anthropogenic sources, with primary source and expectation of change by 2030)

Carbon dioxide 15 (land use change, stable or decreasing)

Methane 49 (ruminants and rice, 60% increase in livestock output)

Nitrous oxide 66 (livestock manure, 35-60% increase)
Central Namib sand sea

Near Birdsville, Australia
<table>
<thead>
<tr>
<th>Protein Source</th>
<th>Litres of Water Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>3700</td>
</tr>
<tr>
<td>Mutton</td>
<td>1900</td>
</tr>
<tr>
<td>Pork</td>
<td>600</td>
</tr>
<tr>
<td>Milk</td>
<td>700-1900</td>
</tr>
</tbody>
</table>

Nardone et al. *Livestock Science*, 2010
In USA beef consumption is declining

2010 meat consumption 280g per person per day
But there is a livestock surge in Africa
Projected changes in cereal productivity in Africa due to climate change – current climate to 2080

Not suitable for cereal crops

50% decrease

Davis C “Climate change and vulnerability” 2011
The future for Africa

“African economies are heavily dependent on agriculture. The industry employs 65% of Africa’s labour force and accounts for 32% of the continent’s overall GDP”
“African economies are heavily dependent on agriculture. The industry employs 65% of Africa’s labour force and accounts for 32% of the continent’s overall GDP”

How much does agriculture contribute to South Africa’s GDP?
## Agriculture value add (%GDP)

<table>
<thead>
<tr>
<th>Country</th>
<th>2010</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mozambique</td>
<td>29.7</td>
<td>29.0</td>
</tr>
<tr>
<td>Namibia</td>
<td>9.3</td>
<td>6.1</td>
</tr>
<tr>
<td><strong>South Africa</strong></td>
<td>2.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Zambia</td>
<td>10.5</td>
<td>9.6</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>14.5</td>
<td>12.0</td>
</tr>
<tr>
<td>Australia</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>New Zealand</td>
<td>7.2</td>
<td>-</td>
</tr>
<tr>
<td>UK</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>USA</td>
<td>1.2</td>
<td>-</td>
</tr>
</tbody>
</table>
Ambient heat load compromises reproduction by causing:

- Failure of conception (male and female effects)
- Teratogenesis
- Intrauterine growth retardation
- Failure of lactation
From: Hafez (1968). Adaptation of domestic animals
Figure 1. The curvilinear relationship between maximum temperature and conception rate based upon first services grouped according to temperature on the day of breeding.
Are goats the future?

Thornton *Philosophical Transactions of the Royal Society B*, 2010
“Globally, cow milk represents 85% of world production”

But

“it is most probable that more people in the world drink milk or consume dairy products from goats than from any other animal”

Silanikove and Koluman (Darcan) Small Ruminant Research, 2015
SHARE OF WORLD PRODUCTION
AANDEEL IN WÊRELD PRODUUKSIE
Effects of desertification on the body temperature, activity and water turnover of Angora goats

R.S. Hetem a,*, B.A. de Witt a, L.G. Fick a, A. Fuller a, S.K. Maloney b, a, L.C.R. Meyer a, D. Mitchell a, G.I.H. Kerley c
Per 30g of protein produced, do feedlots or pastoralists contribute more greenhouse gases?
Funders:
National Research Foundation (SA),
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Oppenheimer Memorial Trust,
Carnegie Corporation,
Claude Leon Foundation,
START/PACOM,
Tswalu Foundation,
University of the Witwatersrand,
University of Western Australia,
University of Pretoria.

Sir Arnold Theiler Memorial Lecture
Faculty of Veterinary Science
University of Pretoria
Peak rates of increase

- Maize: 1985
- Rice: 1988
- Wild fish: 1988
- Meat: 1996
- Milk: 2004
- Wheat: 2004
- Poultry: 2006

No peak rate yet for:
- Coal
- Oil
- Gas

Air temperature thresholds for economic loss

Cow in milk 21°C
Dry cow 24°C
Beef cattle 25°C
Shorn sheep 29°C
Dry sow 30°C