Modelling flying-fox heat stress vulnerability

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Affiliations: ¹School of BioSciences, The University of Melbourne; ²Hawkesbury Institute for the Environment, Western Sydney University
Understanding how extreme heat events affect the heat budget of Australian flying-foxes (*Pteropus* spp.): roles of physiology, morphology and behaviour

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Australia adds new colour to temperature maps as heat soars

Forecast temperatures are so extreme that the Bureau of Meteorology has had to add a new colour to its scale. It is a sign of things to come.

Record-breaking temperatures prompt BOM to launch heatwave service early

The Bureau of Meteorology has brought forward the annual launch of its online heatwave service after months of record-breaking temperatures.

The service normally runs from November 1 to the end of March.

National heatwave project director John Nairn said the bureau had noticed increasing heat episodes in northern Australia and parts of the east coast, prompting it to bring the service forward by three weeks.

He said starting the service early was unusual.

"It won't happen every year. On occasion, particularly if you have sections of the country being affected by drought, it is likely that we will see some earlier heat events," he said.
Solution: Predict beforehand when and where flying-fox heat stress events may occur
**Assumption:** Heat stress related die-off events occur in flying-foxes when the air temperature is **42°C or above**

(Welbergen *et al* 2008)
Flying-fox heat stress forecaster

- Weather data from the Bureau of Meteorology (ACCESS-R NWP system)
- Occupied camp data from the National Flying-fox Monitoring Program

Current temperature forecasts for southeastern Australia

Heat stress alert status

HIGH

When this reads ‘HIGH’, temperatures >42°C are likely in flying-fox camps in SE Australia in the next three days.

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Heat Stress

- Environment / Weather
  - Solar radiation
  - Wind speed
  - Relative humidity
- Microclimate
  - Foliage cover
- Temperature of surrounding surfaces
- Animal's morphology
  - Fur length
  - Shape / Posture
- Animal's physiology
  - Body temperature
  - Metabolic rate
- Animal's behaviour
  - Salivating
  - Wing-fanning

- Temperature of surrounding surfaces
Heat Stress

Environmental Conditions
- Air temperature
- Relative humidity
- Wind speed
- Solar radiation
- Foliage cover

Animal Characteristics
- Body temperature
- Metabolic rate
- Fur length
- Shape / Posture

Panting
- Wing-fanning

Temperature of surrounding surfaces
Biophysical Model
Mathematical validation of physical properties

Environmental conditions
Animal Characteristics

Simulate biological system
Predict influences of biological and physical factors on biological system
**Environmental Conditions**
- Air temperature
- Relative humidity
- Wind speed
- Solar radiation
- Foliage cover
- Temperature of surrounding surfaces

**Animal Characteristics**
- Salivating
- Panting
- Wing-fanning
- Body temperature
- Metabolic rate
- Fur length
- Shape / Posture

*Heat Stress*
Environmental Conditions

- Air temperature
- Relative humidity
- Wind speed
- Solar radiation

Weather

Microhabitat conditions

- Foliage cover
- Temperature of surrounding surfaces

Animal Characteristics

- Salivating
- Panting
- Wing-fanning
- Body temperature
- Metabolic rate
- Fur length
- Shape / Posture
Weather: Australian Bureau of Meteorology databases

Air temperature

Relative humidity

Wind speed and direction
Microhabitat

Hygrochron - iButtons

Thermal Camera

iButton holders

Weather Station
Morphology

- Length and width of body
- Thickness of hair
- Fur length and depth

Illustration: Elia Pirtle
Thermophysicsology

Controlled ambient temperature and humidity inside incubator

Measure oxygen consumption, water loss and body temperature
Thermoregulatory behaviours

Wing-fanning

Shade-seeking

Panting

Salivation

Photo credit: Justin Welbergen
Death...
Biophysical Model

Microclimate Model

Animal Model

Environmental Conditions

Animal Characteristics

Biophysical Model
Main model outputs

NicheMapper / NicheMapR

- Body temperature
- Skin temperature
- Metabolic rate
- Water loss rate
Benefits of a biophysical model

- More accurate predictions
- Identify more vulnerable groups (species, sexes, ages)
- Identify driving forces of heat stress
- Changes in distribution
- Climate change effects
Flying-fox heat stress forecaster

Current temperature forecasts for southeastern Australia

Sunday, 12 Feb 01 PM

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Acknowledgements

- Holsworth Wildlife Research Endowment
- NESP Threatened Species Recovery Hub
- Bureau of Meteorology – Kamal Puri
- National Flying-fox Monitoring Program
- Melbourne Museum
- Australian Museum
- Royal Botanic Gardens Sydney
- Yarra Bend Park - Parks Victoria & DEWLP
- David Karoly and Pallavi Govekar
- John Martin
- Natalie Briscoe
- Numerous volunteers
Questions?