

**A “rare” mating system in a weird bat:
What lek breeding by New Zealand’s
Mystacina tuberculata suggests about the
mating behaviour of temperate bats**



Cory Toth, PhD Candidate

**School of Biological Sciences, University of
Auckland**

**Stuart Parsons, Gregory Holwell,
and Todd Dennis**



Lek Breeding

- **Males** aggregate and produce sexual displays for visiting **females**
- **Females** receive no resources, **males** provide no parental care
- **Female** selection based entirely on **male** displays



Lek Abundance



148 species
1.5%

(Jiguet et al. 2000)



14 species
0.08%

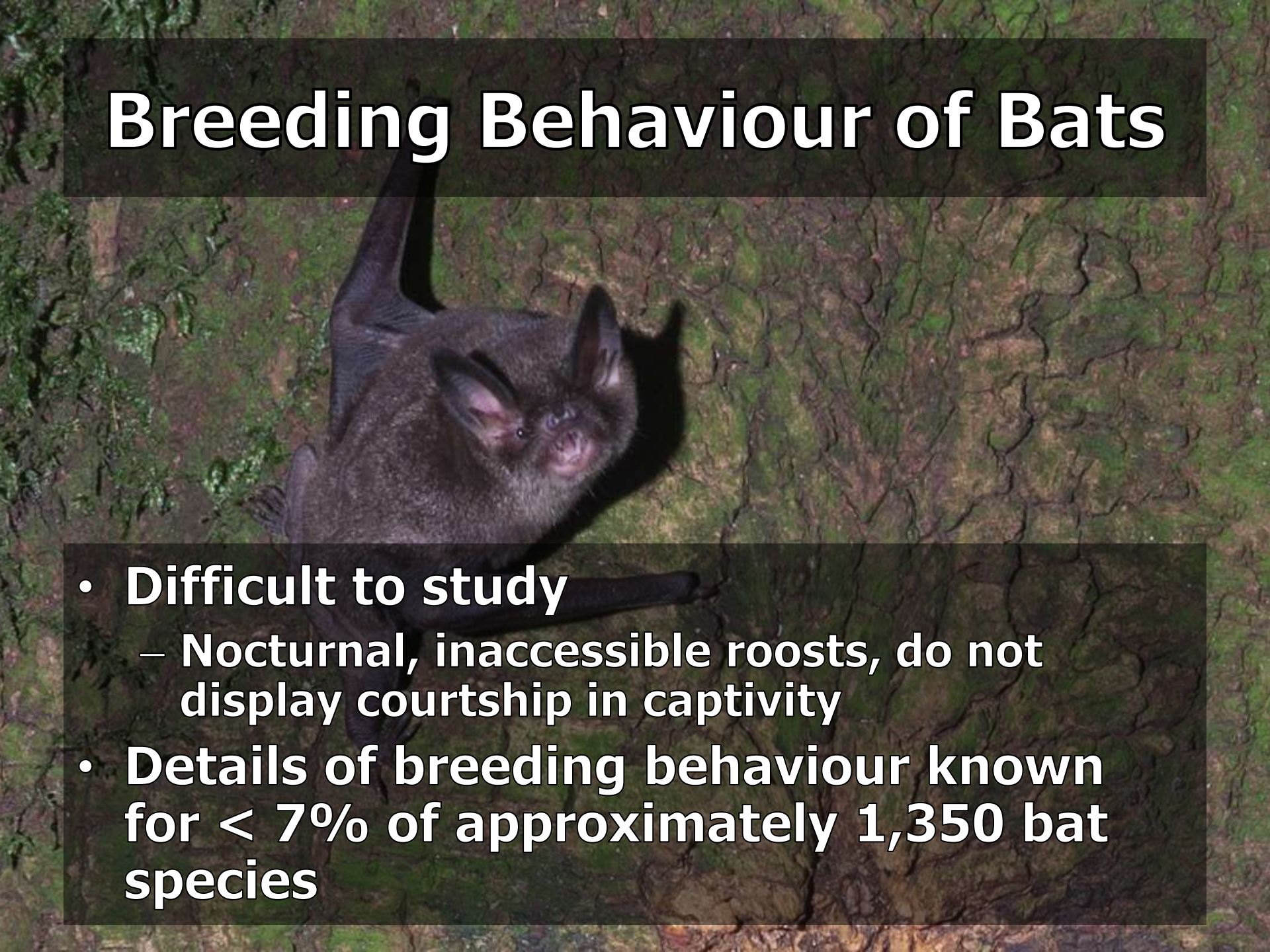
(Hypsigena et al. 1977)

Lekking Prerequisites

- **Males** are emancipated from parental care
- **Females** have the ability to discriminate between **males**
- High mobility for both **males** and **females**



Breeding Behaviour of Bats

- 
- A photograph of a bat clinging to a tree trunk. The bat is dark-colored with large, prominent ears and is positioned upside down. The tree bark is covered in green moss and has a deeply cracked texture.
- **Difficult to study**
    - Nocturnal, inaccessible roosts, do not display courtship in captivity
  - **Details of breeding behaviour known for < 7% of approximately 1,350 bat species**

The Lesser Short-tailed Bat (*Mystacina tuberculata*)



Singing Roost



Mystacina may provide an ideal system to study breeding behaviour in a bat

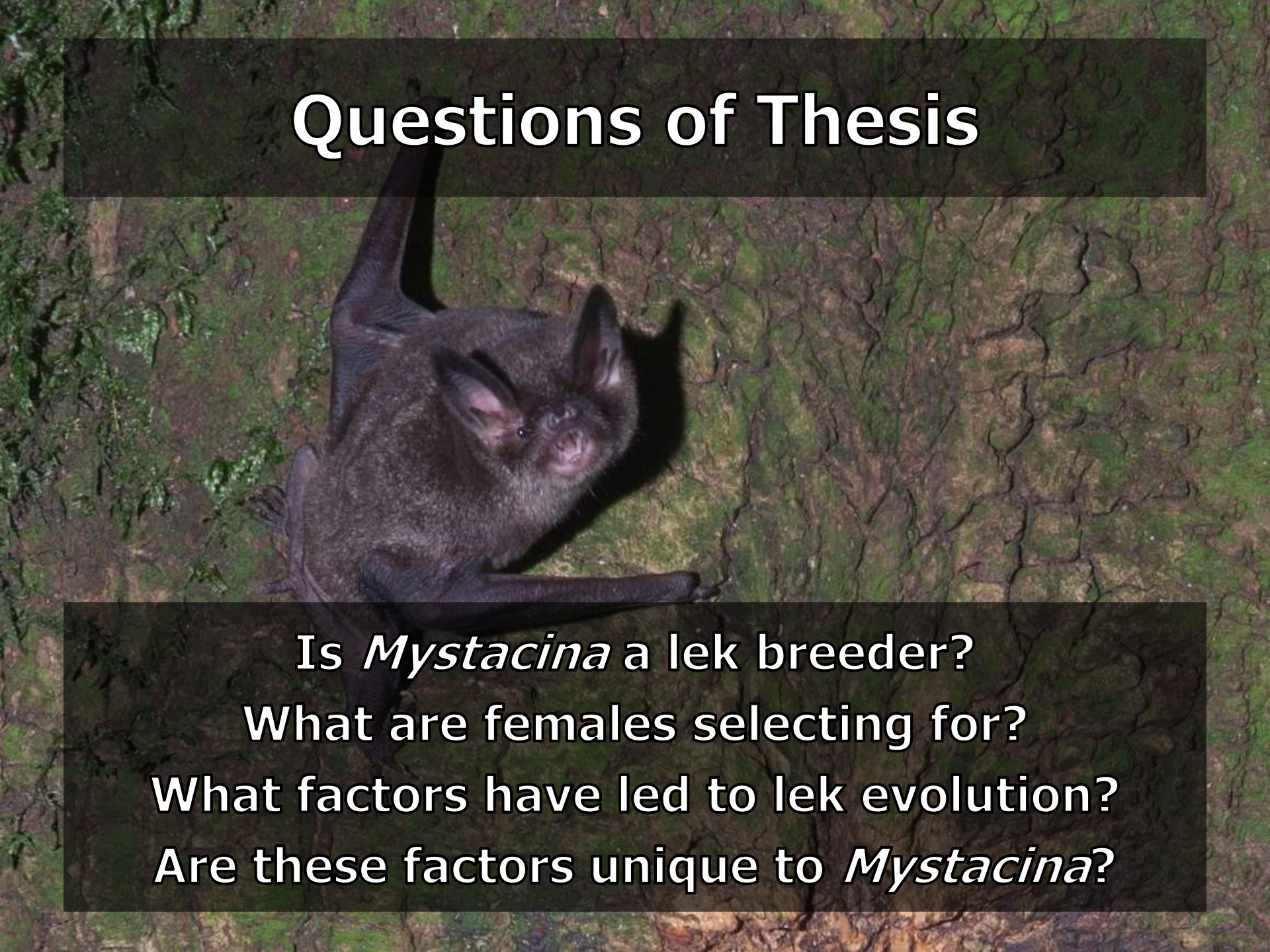




By studying the breeding
behaviour of *Mystacina* we can...

- Determine what factors have led to the adoption of lek breeding (if they are lek breeders)
  - May provide insight into other lek-breeding bats
- Use *Mystacina* as a model organism to study sexual selection in a bat
- Design meaning conservation strategies

Questions of Thesis



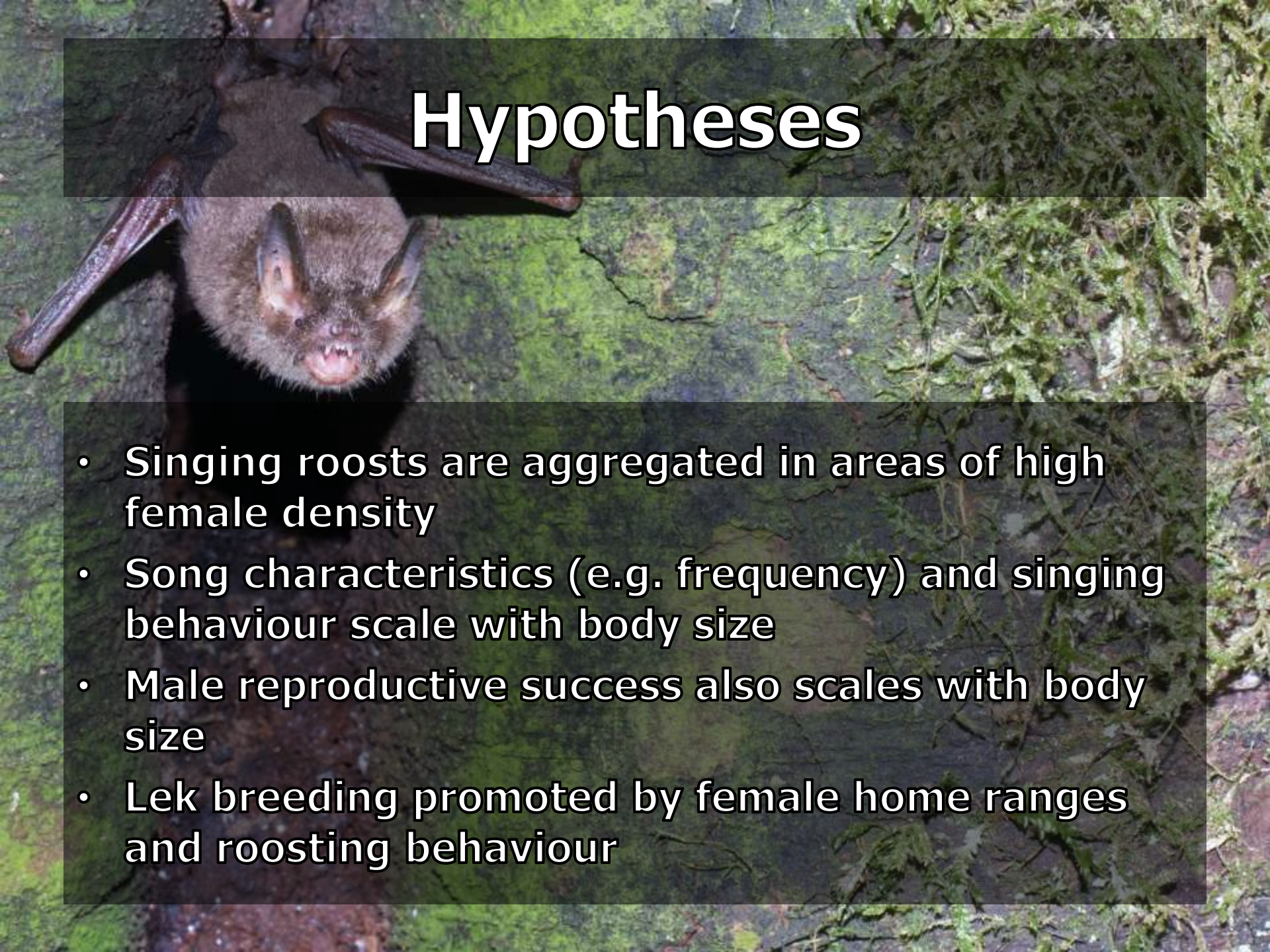
Is *Mystacina* a lek breeder?

What are females selecting for?

What factors have led to lek evolution?

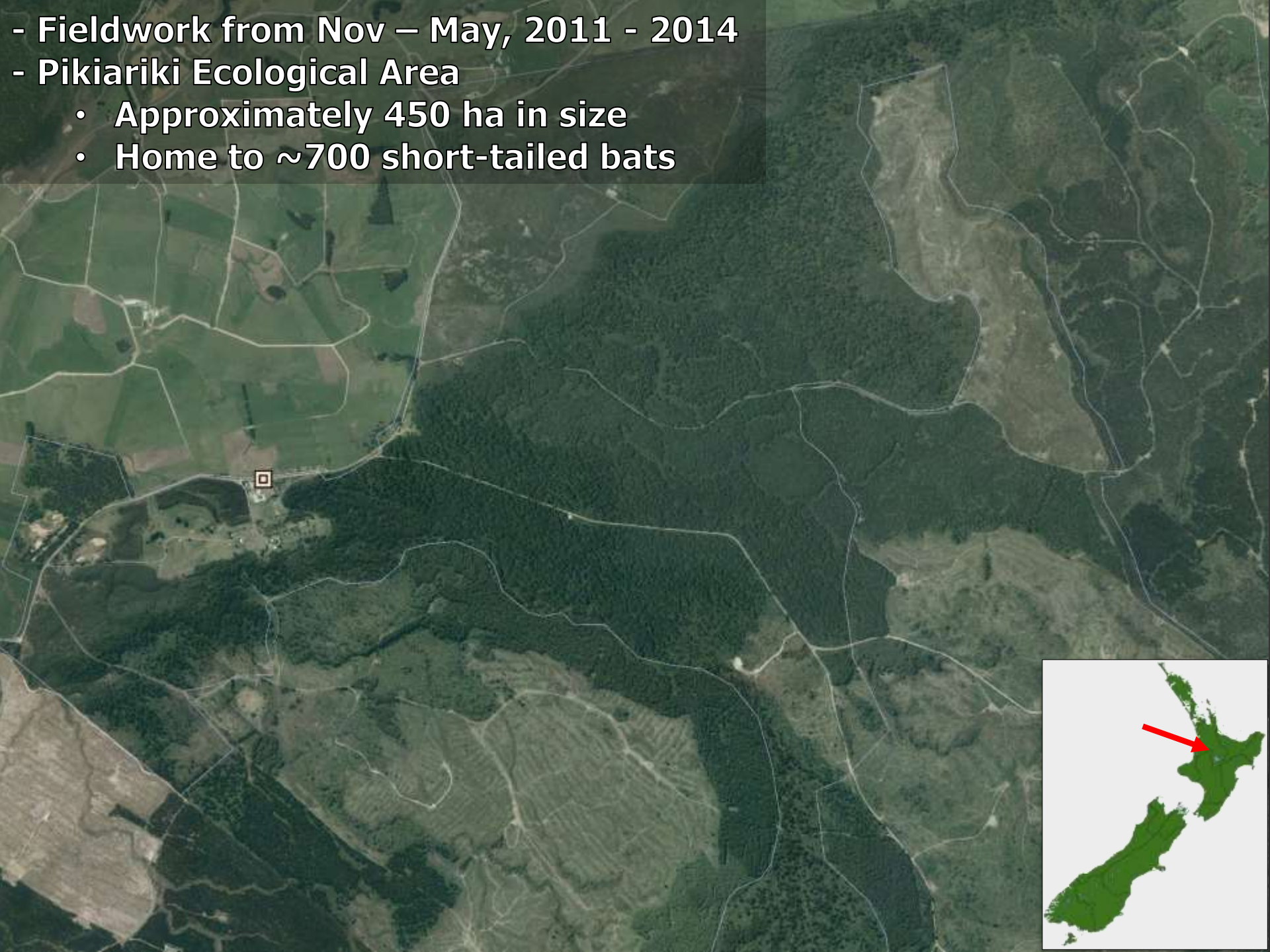
Are these factors unique to *Mystacina*?

Hypotheses

A photograph of a bat, likely a species of vespertilionid, with its mouth open, revealing its teeth. The bat is positioned in the upper left quadrant of the frame. The background is a dark, textured surface covered in green moss or lichen. The word "Hypotheses" is written in large, white, bold letters across the top of the image.

- Singing roosts are aggregated in areas of high female density
- Song characteristics (e.g. frequency) and singing behaviour scale with body size
- Male reproductive success also scales with body size
- Lek breeding promoted by female home ranges and roosting behaviour

- Fieldwork from Nov – May, 2011 - 2014
- Pikiariki Ecological Area
  - Approximately 450 ha in size
  - Home to ~700 short-tailed bats







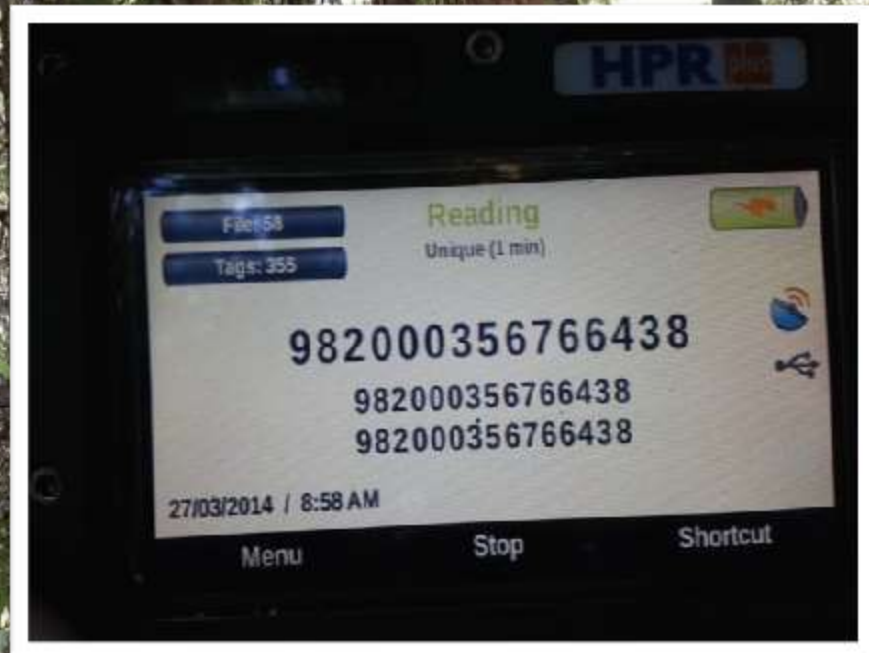


- PIT-tags used to ID individuals
- 711 bats PIT-tagged between 2012-2014
  - 254 adult males, 240 adult females, 217 volant juveniles, and a few humans



- Forearm length used as a proxy of body size
- Punch biopsies of wing tissue collected for genetic/paternity analyses
  - 175 adult males, 158 juveniles (76 males, 82 females)
  - 11 microsatellite loci developed

- 12 singing roosts filmed (3 nights per roost) in 2014
- > 400 hours of total footage
- 20 PIT-tagged males



Singing roosts originally believed to be solitary, but approximately half of studied singing roosts are “timeshares”

- 2–5 resident males take “shifts” singing**
- Same males each night, never overlap**

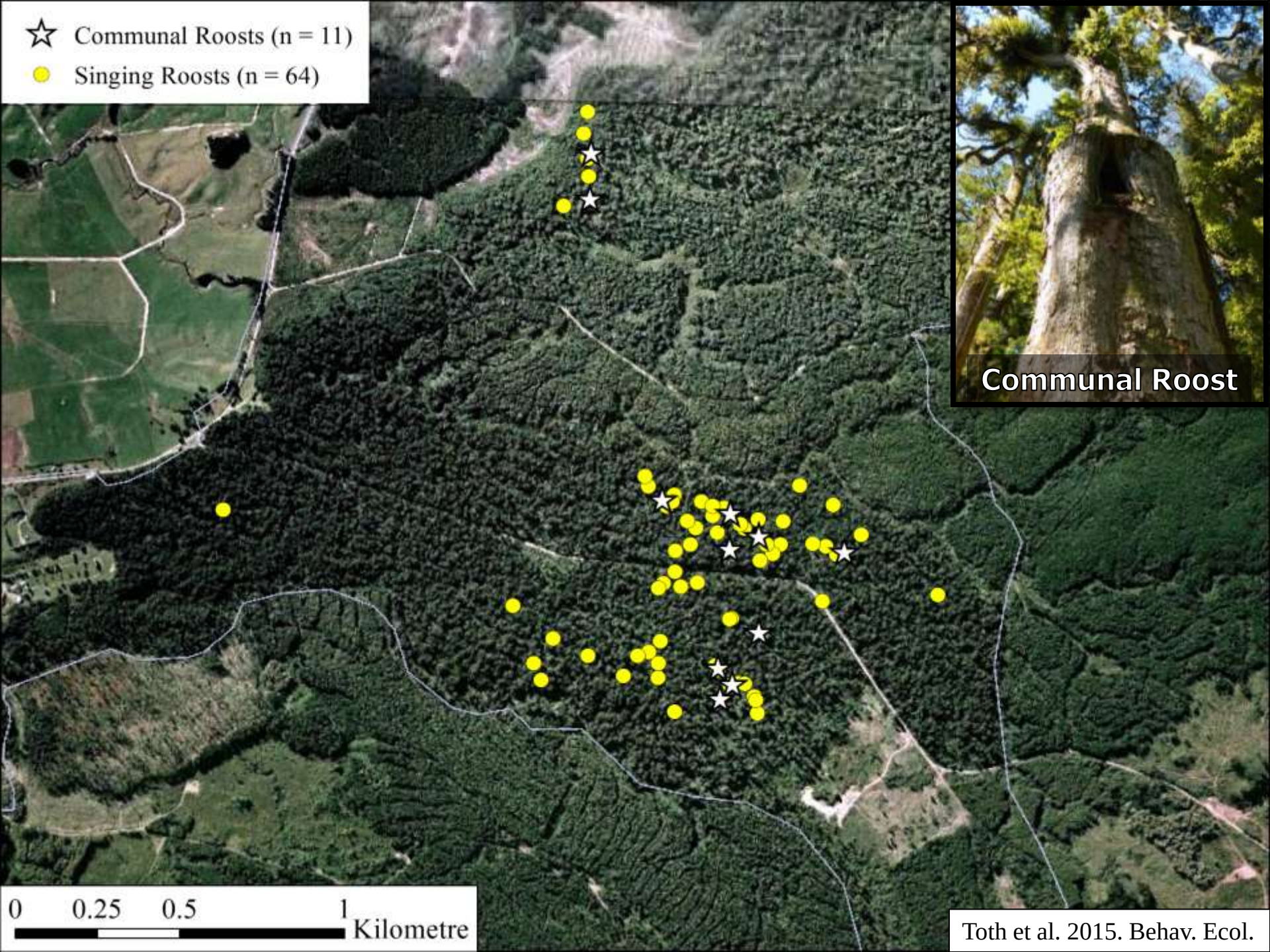


Are they lek breeders?



☆ Communal Roosts (n = 11)

● Singing Roosts (n = 64)



Communal Roost

0 0.25 0.5 1 Kilometre

Toth et al. 2015. Behav. Ecol.

Females Receive No Resources



No nuptial gifts
**14+ hours of recorded
male/female interactions at
singing roosts**



No access as day roosts
**Nine females radio-tracked
over 41 days – none roosted
in singing roosts**

Females Select Males

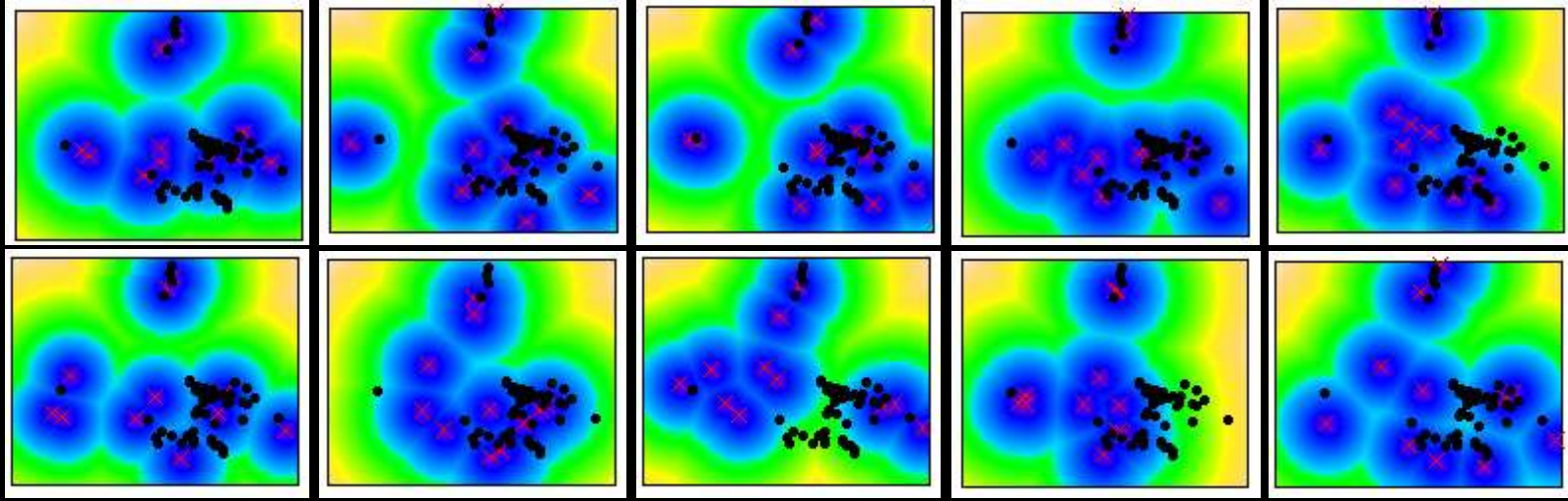
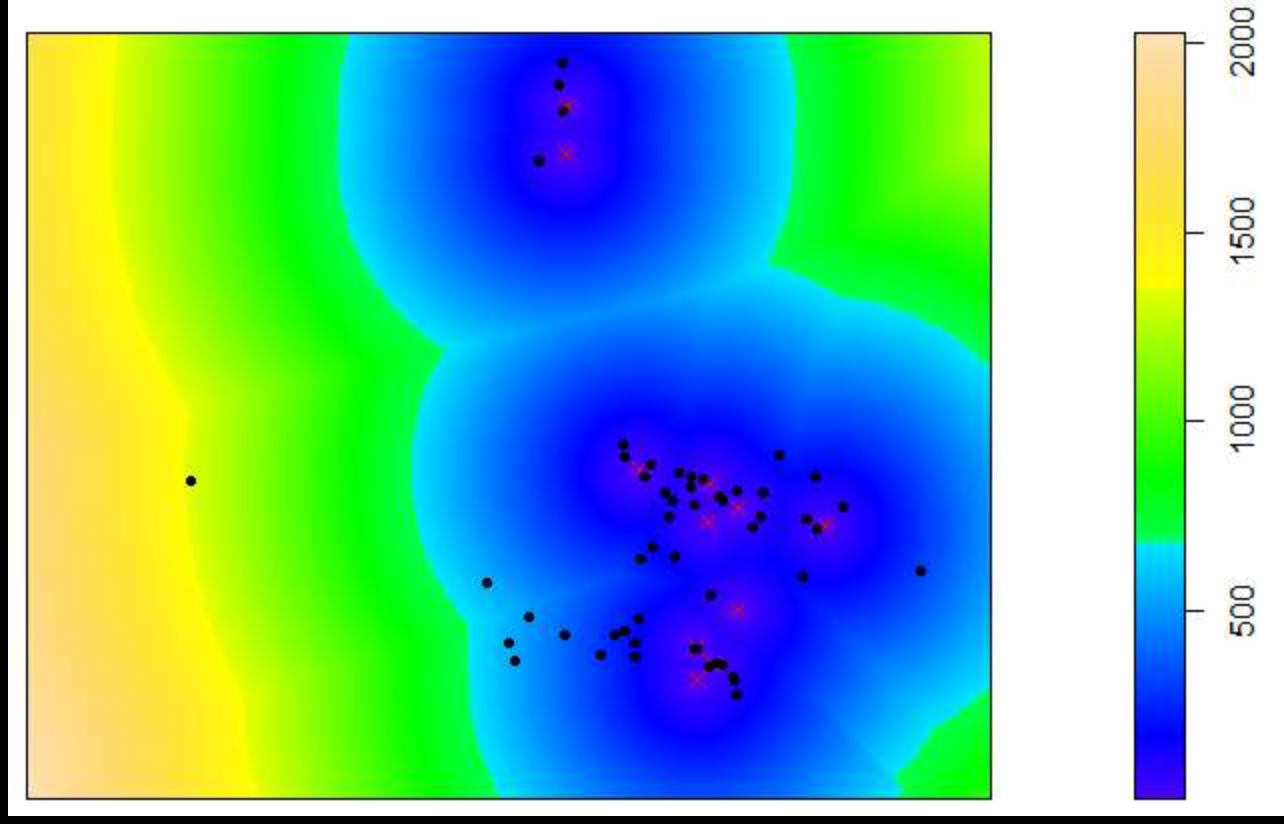


What promotes lek breeding?



The Importance of Communal Roosts

- A **spatial logistic regression** was used to determine if **communal roosts** explained the location of **singing roosts**
  - In basic terms: are you more likely to find a singing roost the **closer** you get to a communal roost?
  - Tested predictive ability of **actual** locations of communal roosts vs. **randomly-generated** communal roosts



Model	ΔAIC	Weight
Actual Locations	0.0	1.0
Random 2	63.9	<0.001
Random 3	67.9	<0.001
Random 7	70.4	<0.001
Random 1	70.9	<0.001
Random 4	75.6	<0.001
Random 6	80.8	<0.001
Random 10	103.5	<0.001
Random 5	105.6	<0.001
Random 9	126.1	<0.001
Random 8	140.9	<0.001
Null	142.1	<0.001

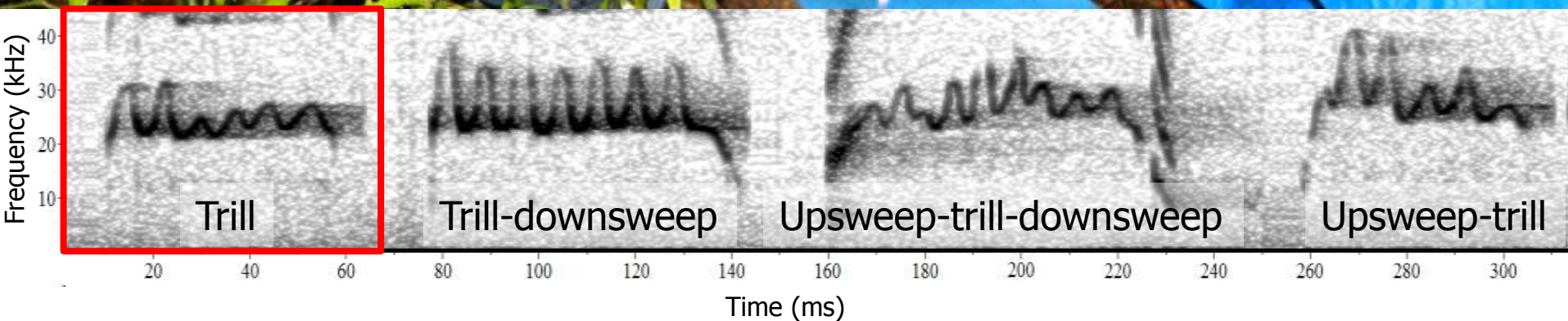
A horizontal scale bar with tick marks at 0, 1, 2, and 4. The word "Kilometres" is written to the right of the 4 mark.

Source: EAF, Digital Data
 Corresponding, Average

Male singing behaviour and female selection



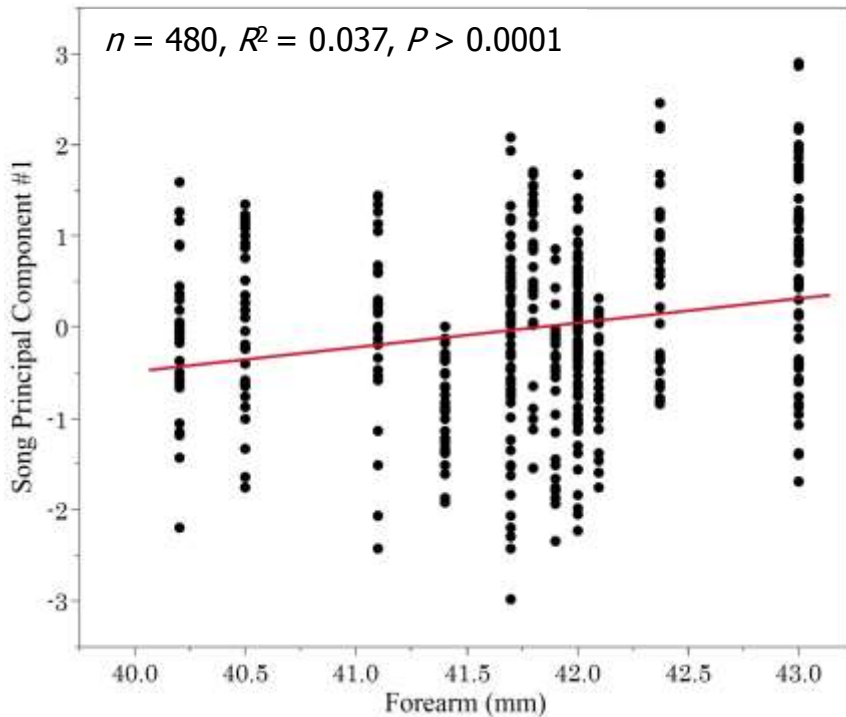
- Songs of 16 PIT-tagged males recorded
  - 5 minutes of continuous singing per male
- >25,700 individual songs annotated
- 52 unique song types produced in total
  - 28.6 ± 3.9 song types/male, range: 21 – 35



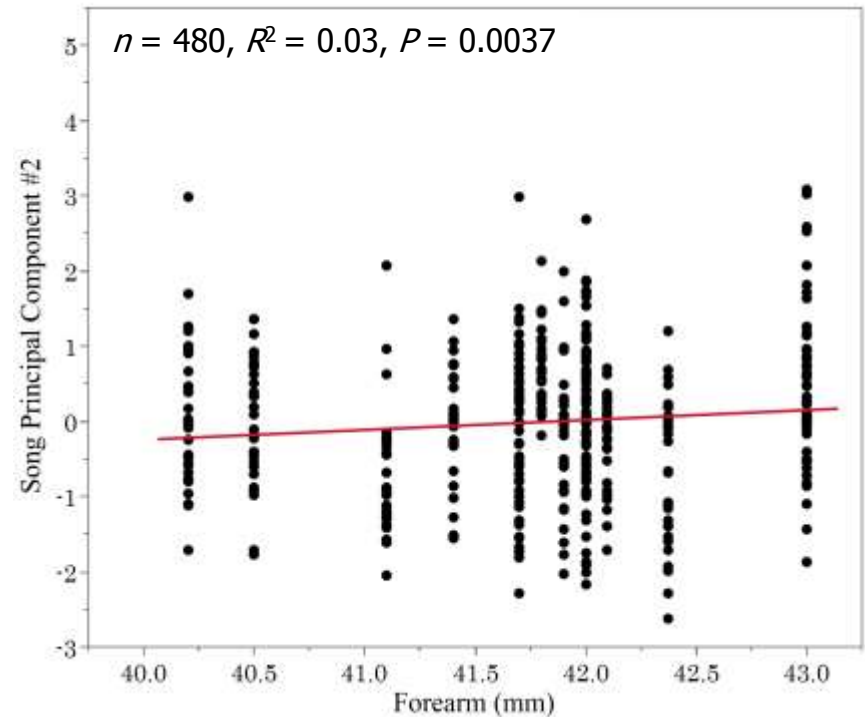
Trill frequency vs forearm length

30 trills from each individual, principal component analysis used to combine frequency characteristics

Principal Component #1
(Described by high freq., delta freq.)



Principal Component #2
(Described by low freq., centre freq., peak freq.)

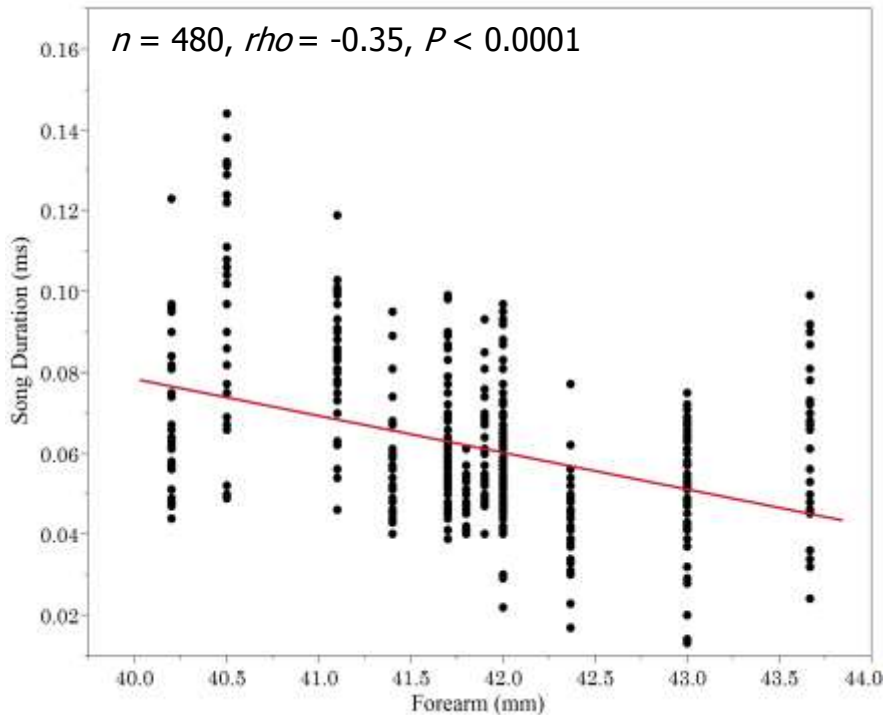


Result: Frequency parameters of all four major song types scale either positively (trills, upswing-trill-downsweeps) or negatively (trill-downsweeps, upswing-trills) with forearm length. Only second example of size-pitch allometry in a mammal.

Song output vs forearm length

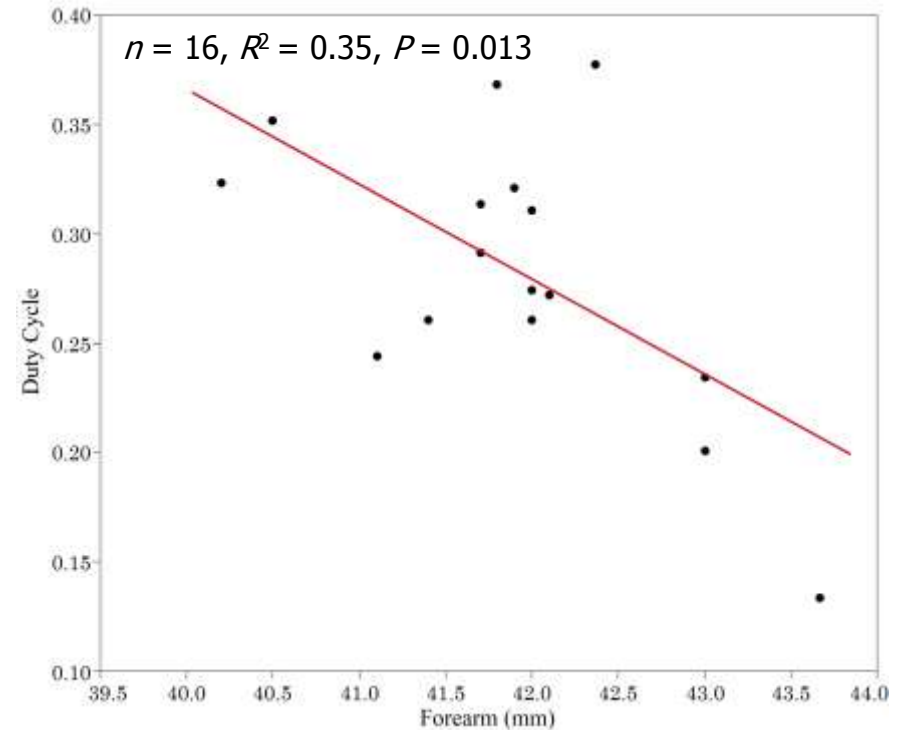
Song output indices

Duration of Trill



Duty Cycle

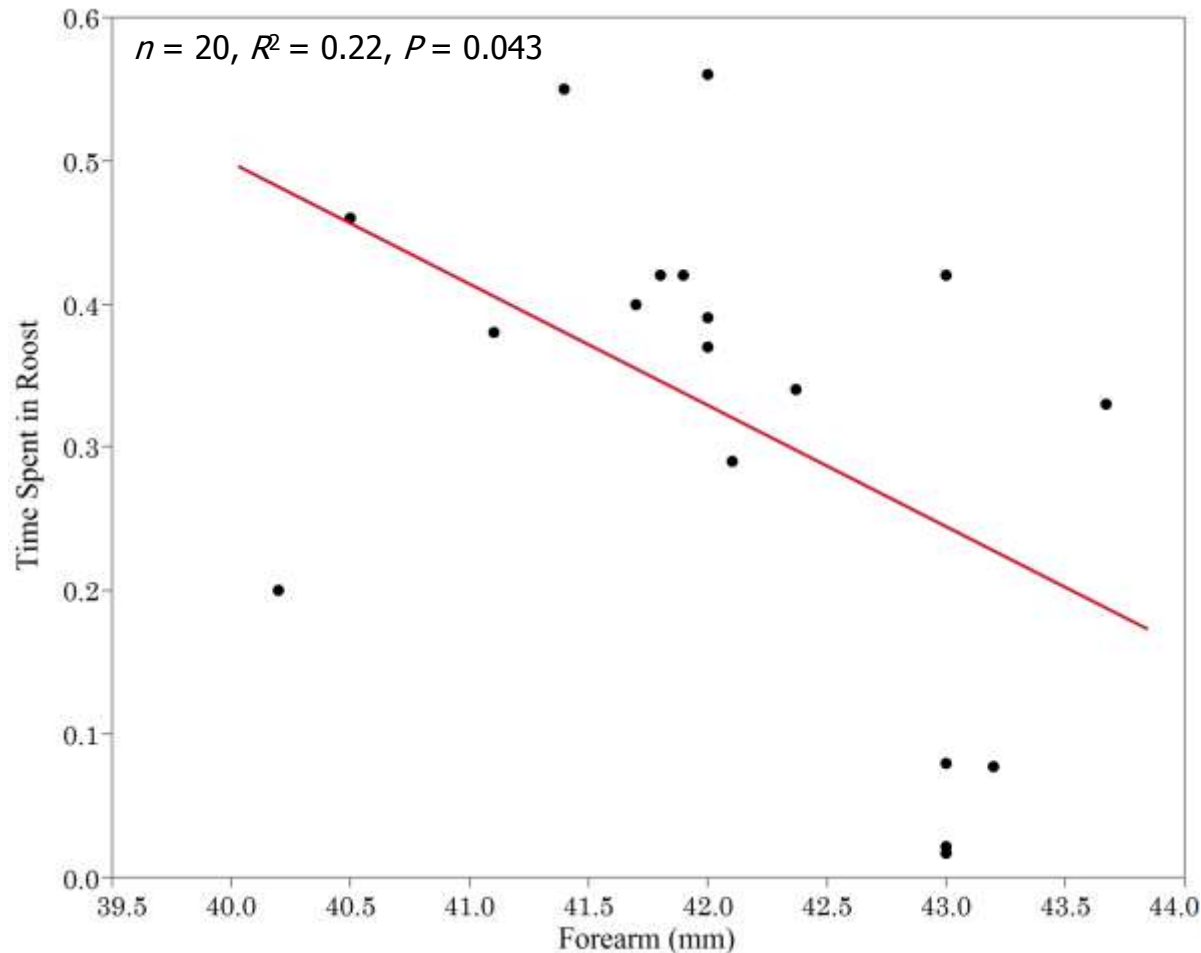
(Sum total of all song lengths/total recording length)



Result: Smaller males have higher song outputs – longer songs in all four song types, as well as higher duty cycles.

Roost occupancy vs forearm length

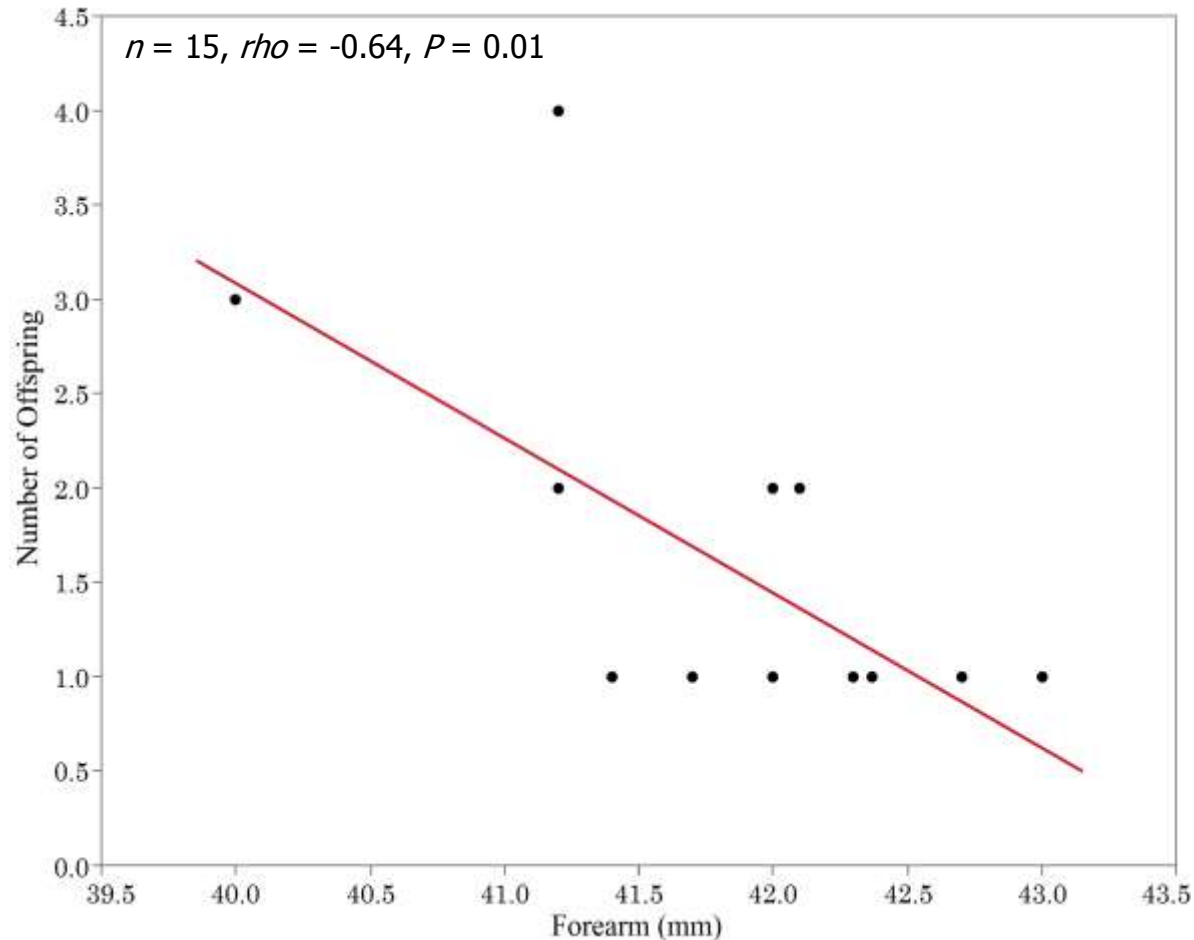
From video footage: proportion of the night spent within the singing roost (time in roost/night length)



Result: Smaller males spend more time singing

Number of offspring vs forearm length

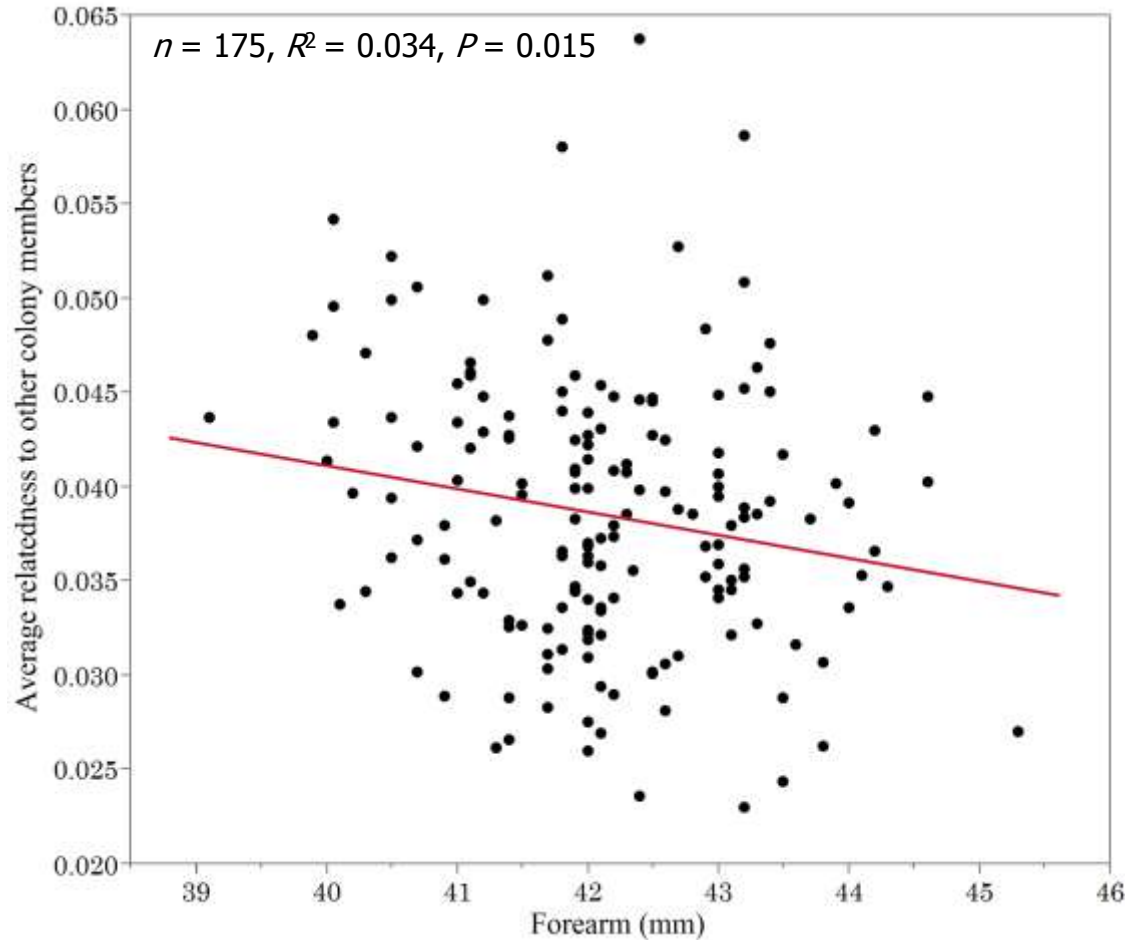
Assigned 24 offspring to 15 males (1-4 offspring/male) using the software COLONY



Result: Smaller males sired more offspring

Average relatedness vs forearm length

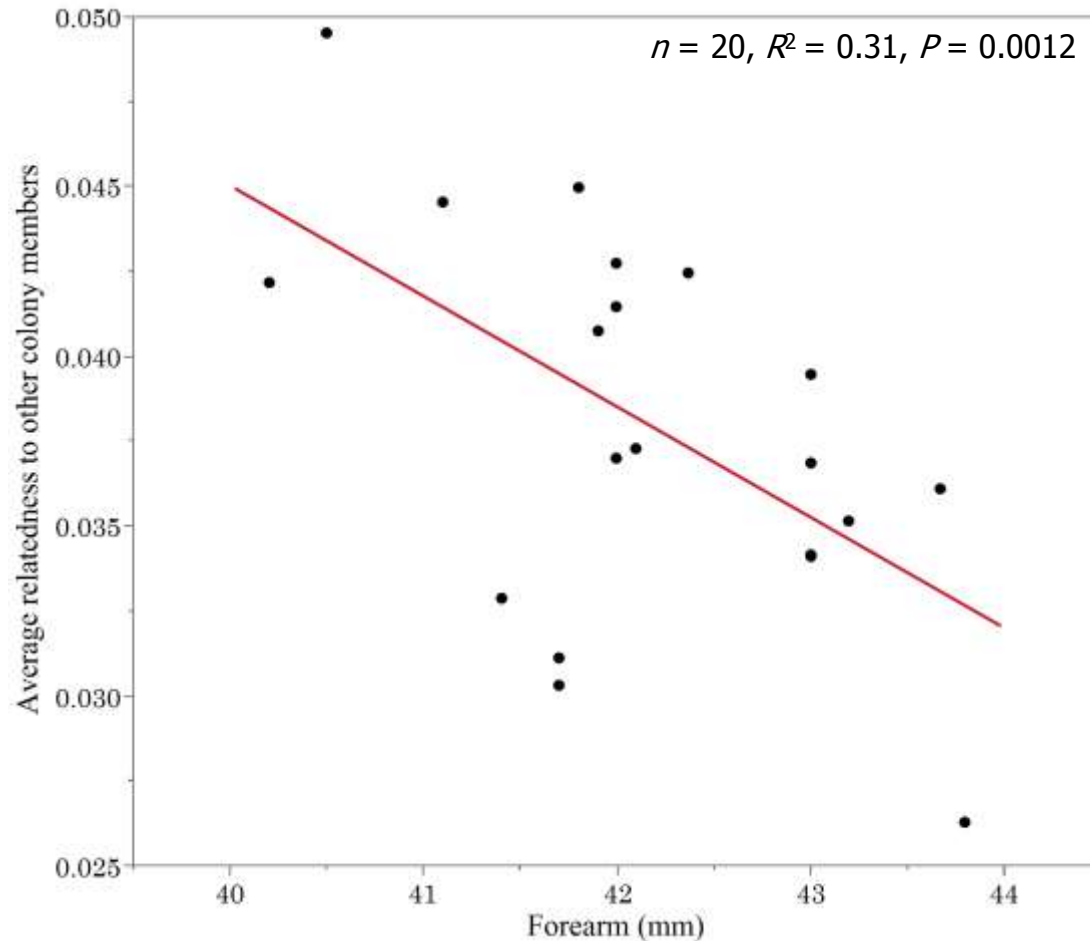
Triadic likelihood estimator values calculated for every male to all other genotyped individuals, then averaged
More-successful males should have more relatives (i.e. higher relatedness score)



Result: Overall, smaller males have more relatives within the colony

Average relatedness vs forearm length

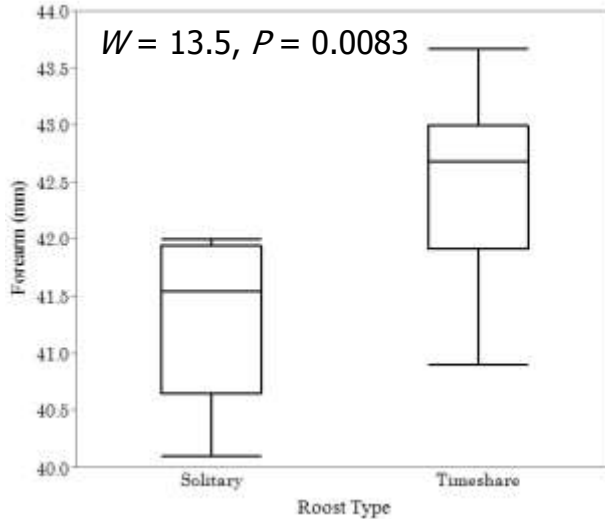
Average triadic likelihood estimator values for 20 singing males



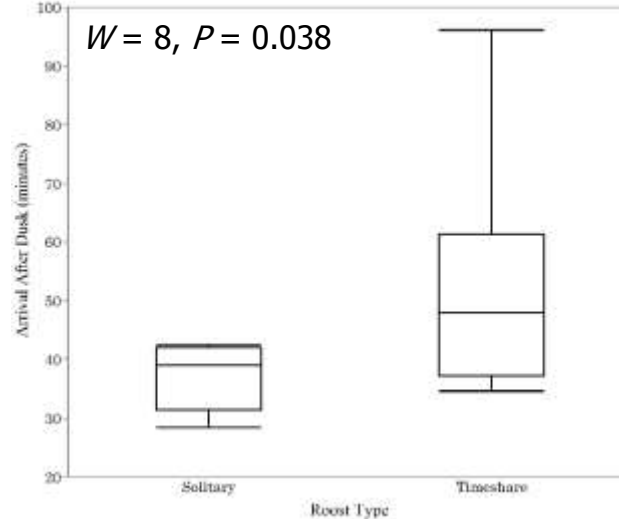
Result: Amongst singing males, smaller males have more relatives within the colony

Timeshare vs Solitary Males

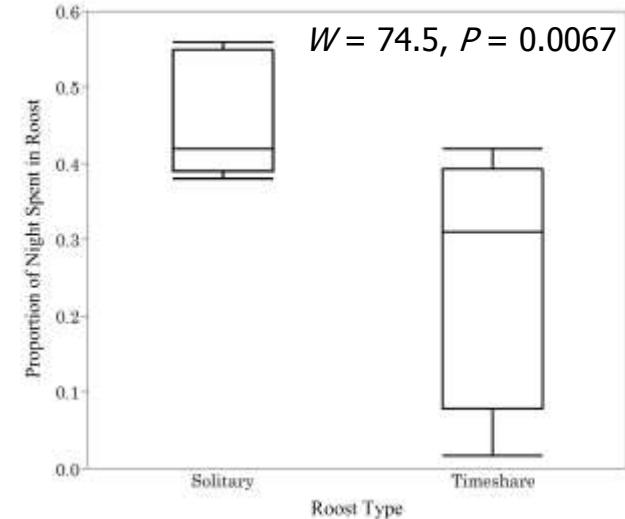
Forearm Length



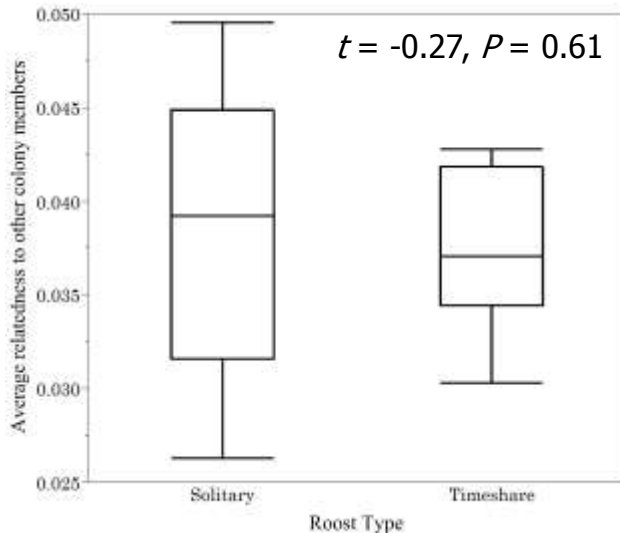
Arrival After Dusk



Time Spent in Roost



Average Relatedness



Result: Solitary males are smaller, arrive to their roosts sooner, and spend more time in the singing roost nightly than timeshare males.

Both groups equally successful. Timesharing is an alternative strategy to boost reproductive success for males that would be less successful otherwise?

Smaller Males May Have More **Energy**



Morrison et al. (2001)



Hakkarainen and Korpimäki (1991)

- **Singing may be less energetically demanding for smaller males**
- **Smaller males may save energy during flying/foraging**

What We Know

- *Mystacina* is a lek breeder
- Lekking likely adopted due to high female densities around communal roosts
- Male song frequency and singing behaviour are honest indicators of male size
- Smaller males appear to be preferred as mates
- Larger males form timeshares to increase success(?)

Yet to be Determined

- Why do small males sing more?
- How do timeshare males recover reproductive success?

Conservation Impacts

Translocated populations:

- Increased risk of inbreeding depression in small populations
- Release sites will need to be checked for suitable singing roosts
- Juveniles may require songs of adults to be played for them(?)

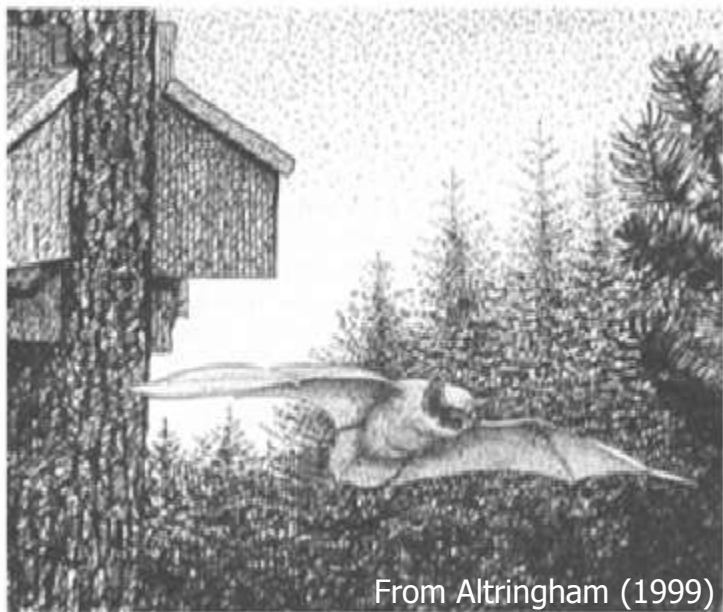
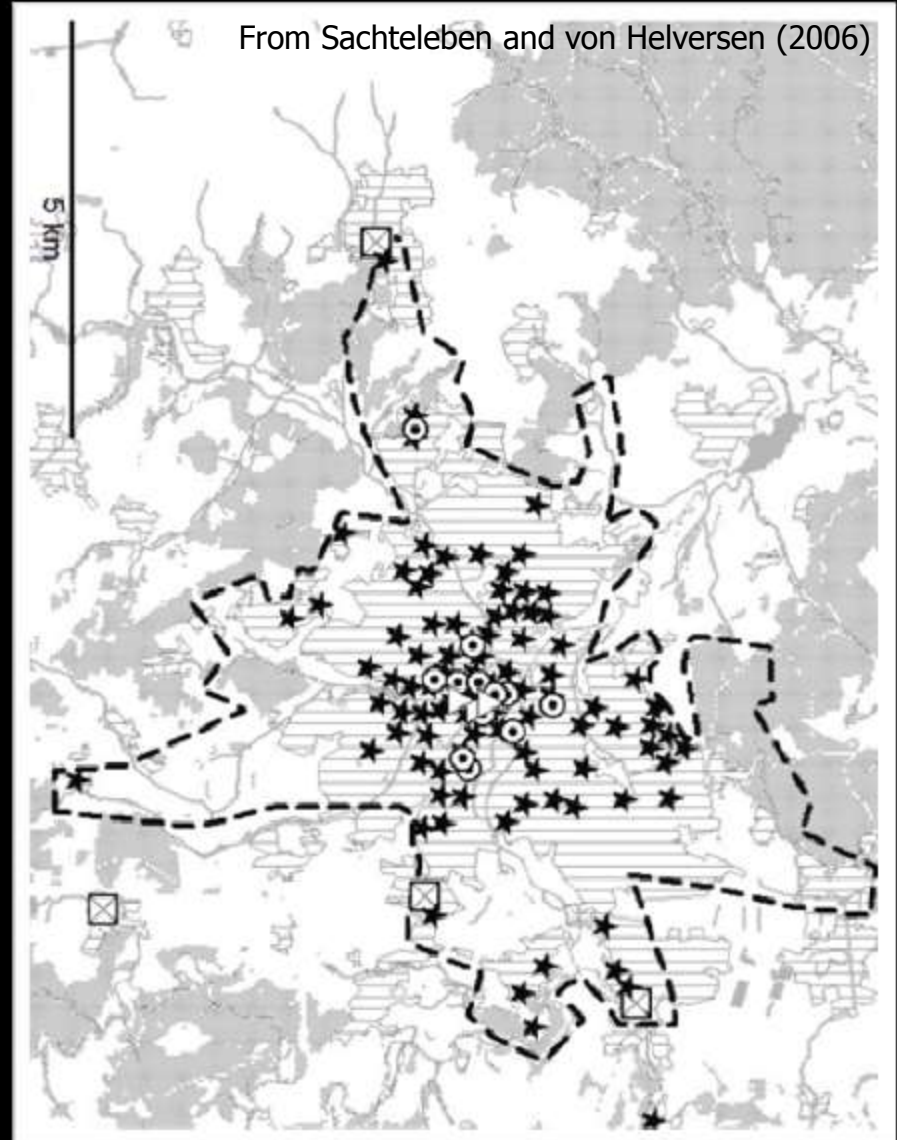
Where Are the **Lekking Bats**?

Conditions imposed by **temperate climates** may promote lek-like behaviour

- Large home ranges and communal roosting sites
- Swarming behaviour



Where Are the **Lekking Bats**?



No Batman is an Island

- Various assistance: Stuart Parsons, Greg Holwell, Todd Dennis, Shane Lavery, Anna Santure, and the staff of the Pureora DOC Fieldbase
- Camera equipment: Dave Pattermore
- Funding: Australasian Society for the Study of Animal Behaviour, Australasian Bat Society, Bat Conservation International, American Society of Mammalogists, and the University of Auckland
- Background photos by David Mudge

BAT CONSERVATION
INTERNATIONAL



Email:
tothcorya@gmail.com