Across-highway Connectivity for Mojave Desert Tortoises:

Changes in movement behavioral states are an indirect impact of highways on Mojave desert tortoises (*Gopherus agassizii*)

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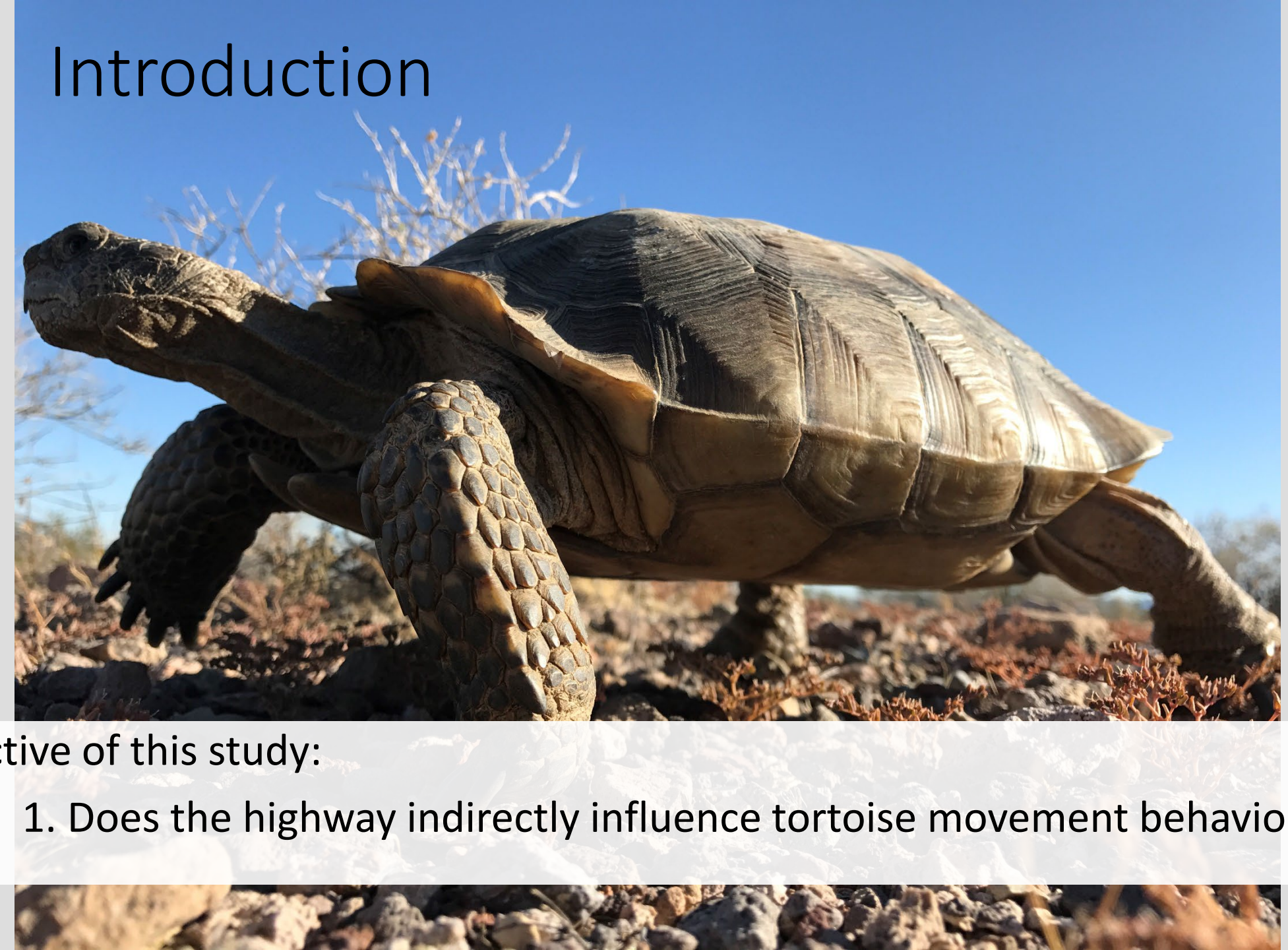
Introduction

- Roads impact wildlife directly (e.g., mortality, habitat loss) and indirectly (e.g., avoidance, spread of invasives).
- For Mojave desert tortoises (*Gopherus agassizii*), direct mortality is well known with widespread preventative road fencing on major highways (Sadoti et al. 2017)
- Culverts are often assumed to alleviate the primary impact of fenced roads: fragmentation

Introduction

- Indirect effects have also been observed, including:
  - Lower abundance near roads (Nafus et al. 2013)
  - Less movement when activity centers near minor roads and barrier fences (Sadoti et al. 2017)
  - Higher movement near fenced roads (Peaden et al. 2017)
  - Smaller home ranges near fenced roads (Peaden et al. 2017)
  - Higher extreme carapace temperatures near fenced roads (Peaden et al. 2017)

Introduction



Objective of this study:

1. Does the highway indirectly influence tortoise movement behavior?

Methods

- Captured 15 adult resident tortoises along U.S. Highway 95 during spring and summer of 2021.
- Only searched for and GPS-tagged tortoises within 800 m of existing culverts
- GPS locations recorded every 30 minutes

Methods

- Behavioral states and transitions between:

  Hidden Markov Models (HMM)
- Main goal: use observed location data to predict the underlying behavioral movement state

  (e.g., resting vs. moving)

- *Transition probabilities are crucial*

Methods

- Created best biological model: time of day, temperature, sex

- Added log(distance to highway):
  - Hwy affects steps and/or transition probability
  - Sex interaction?

Results

Best model:

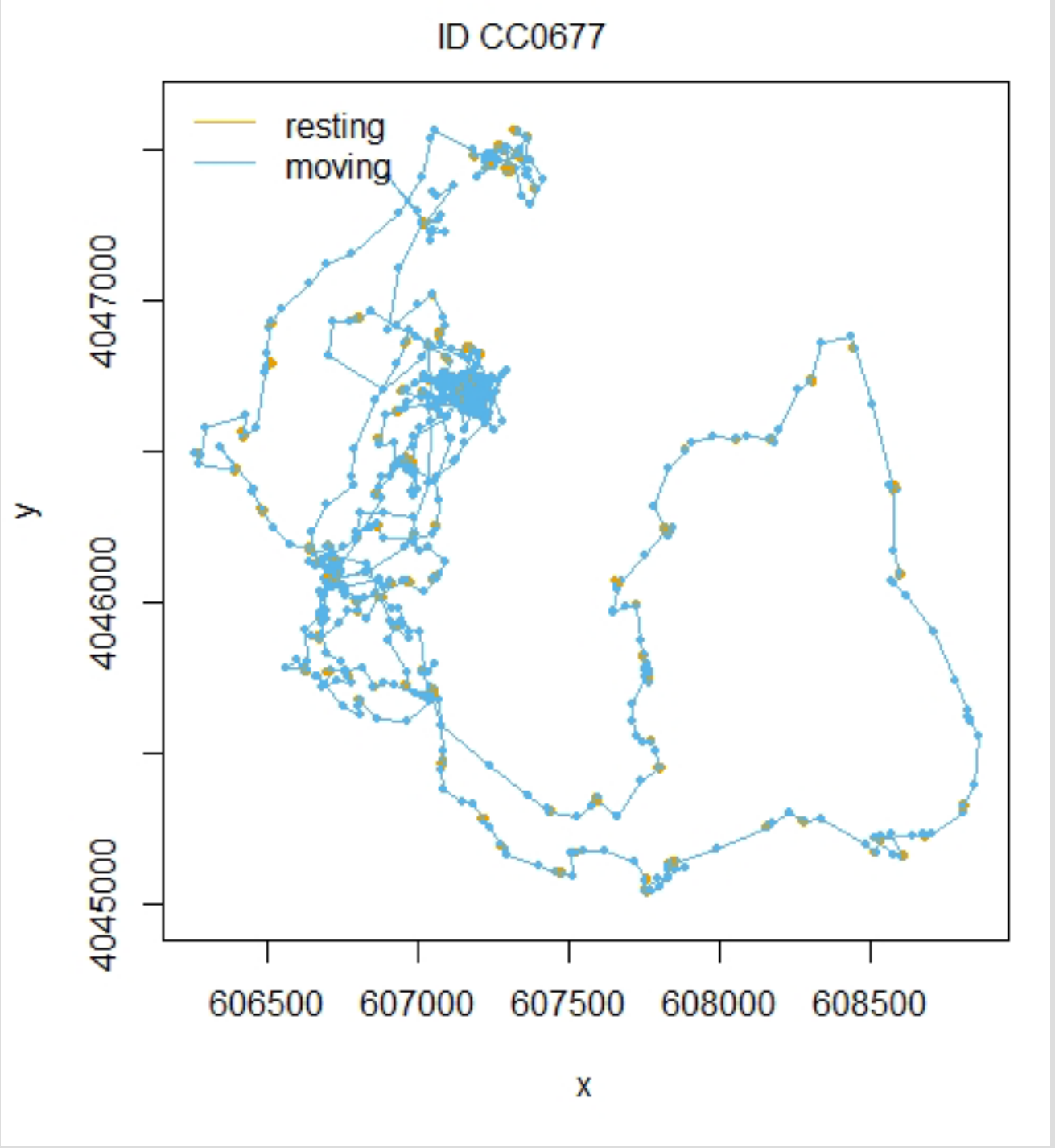
Biological component

Highway component

Steps: Time of day + temp + sex + log(disthwy)*sex

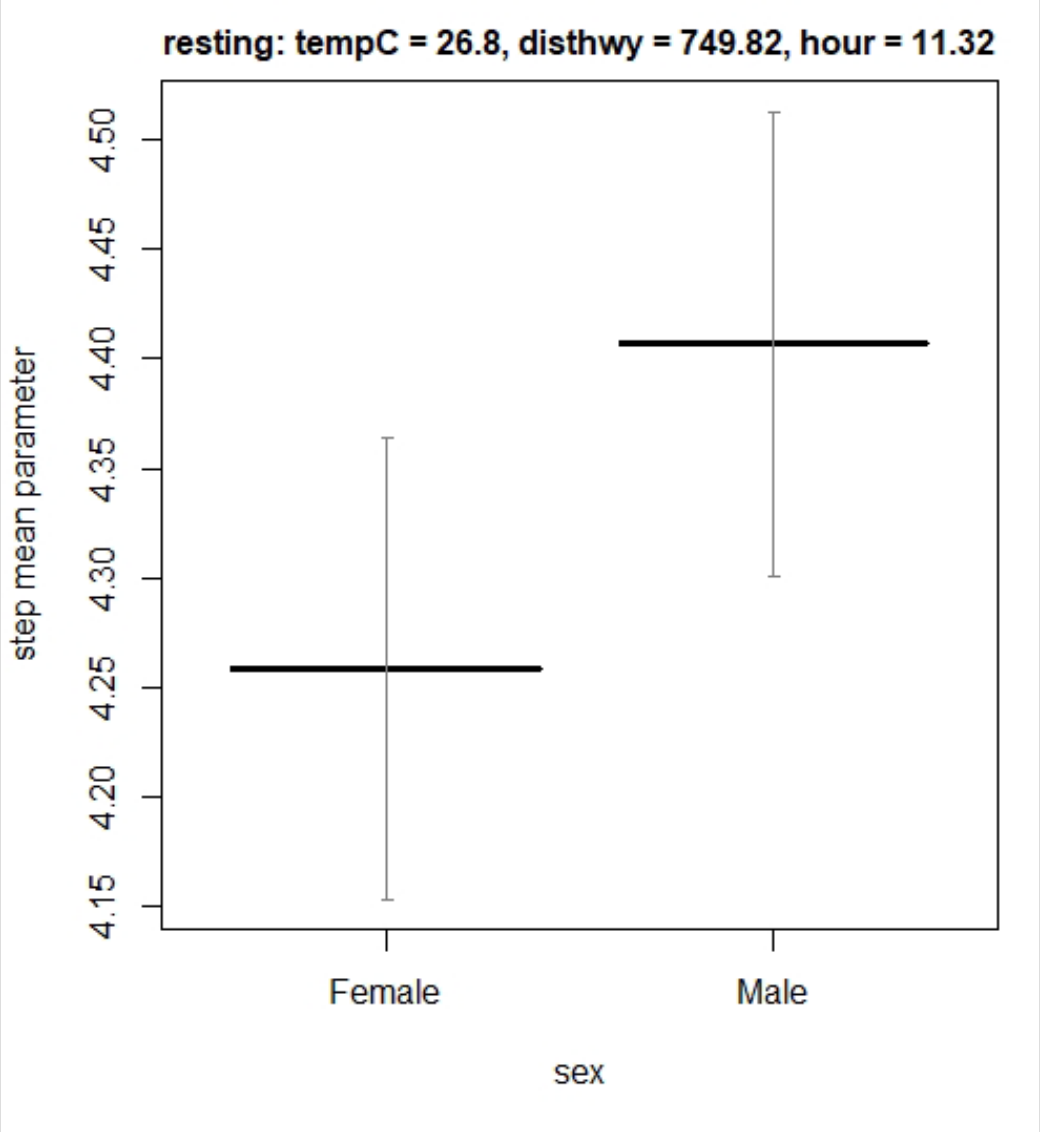
Transition prob.: Time of day + temp + sex + log(disthwy)*sex

Results

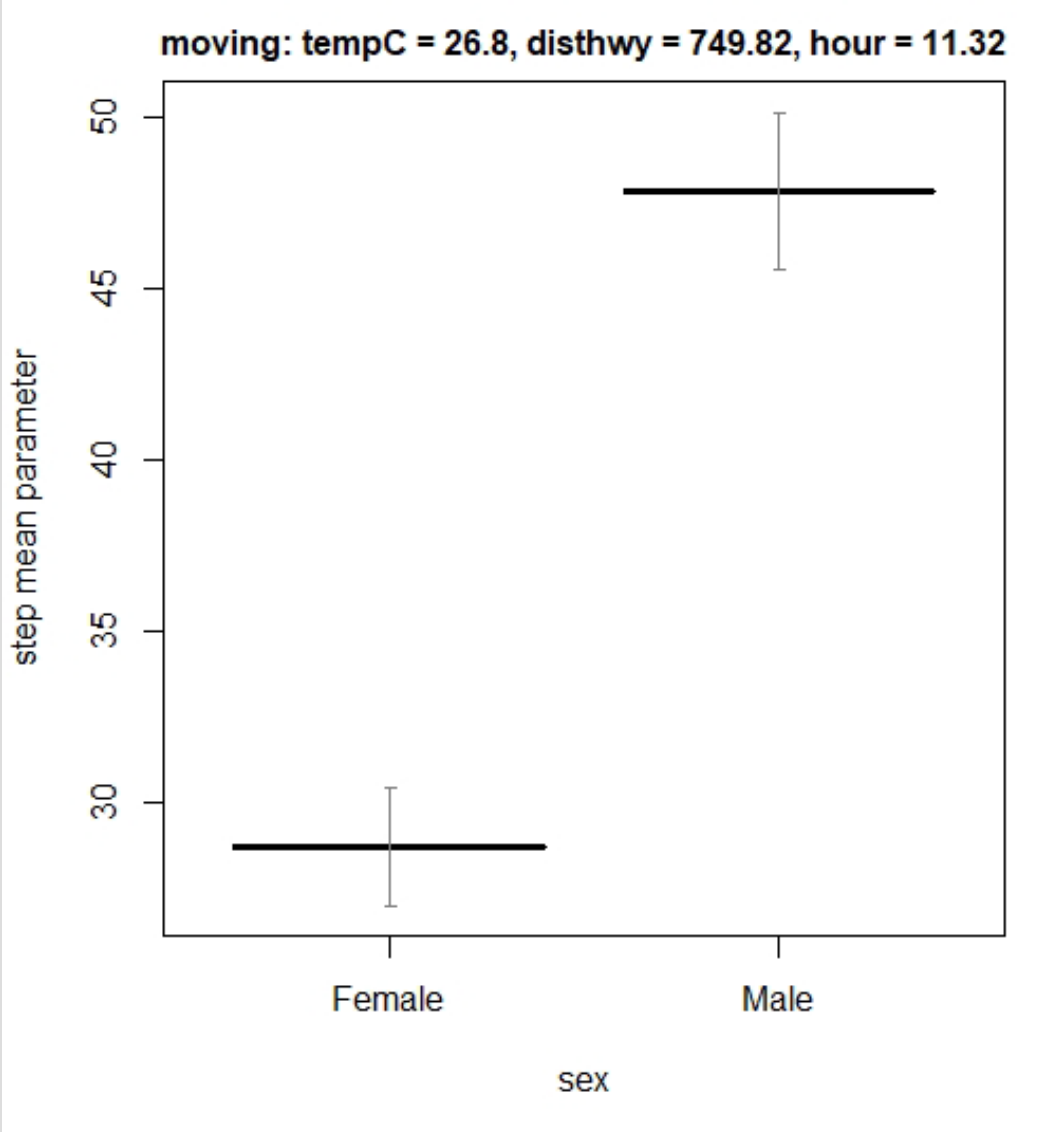

ID CC0677
resting
moving
4047000
4046000
4045000
y
606500
607000
607500
608000
608500
x

Results

Resting state

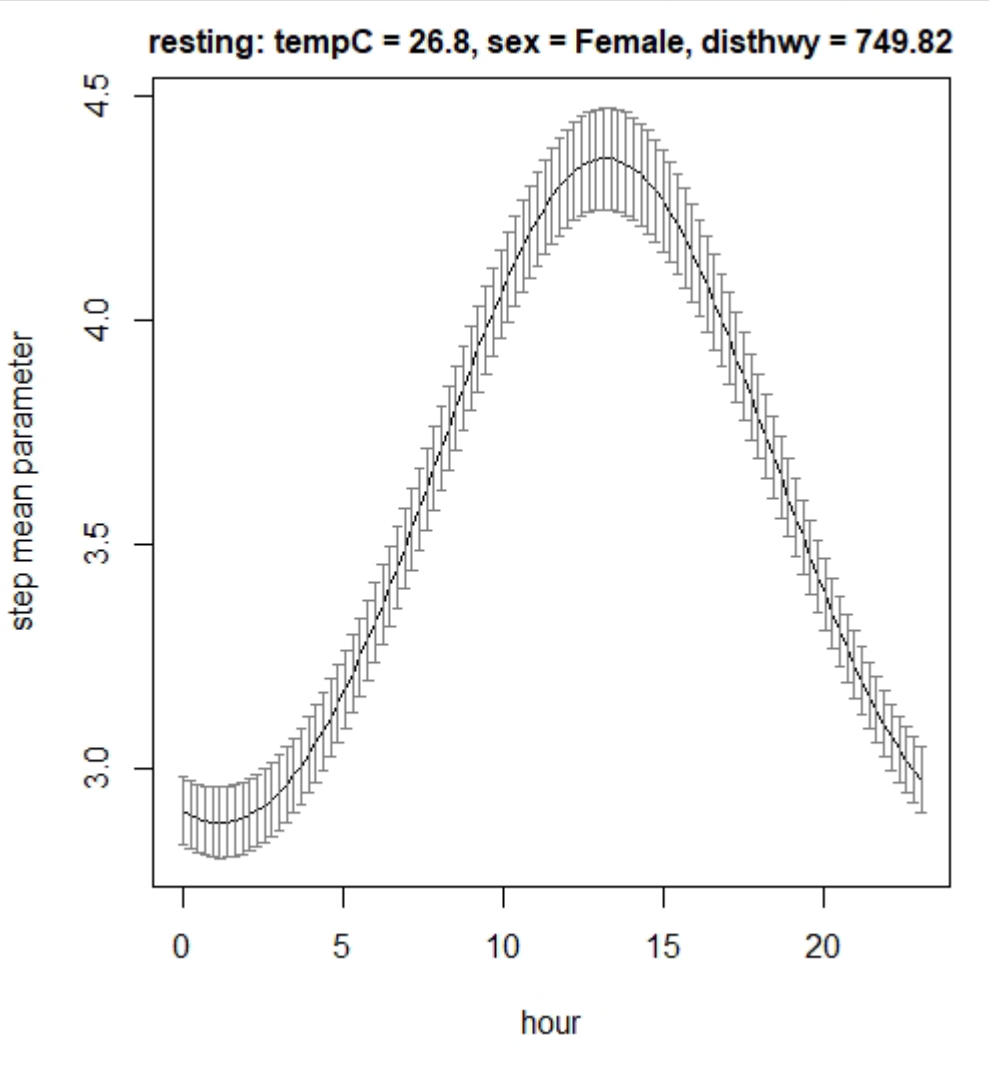


Moving state

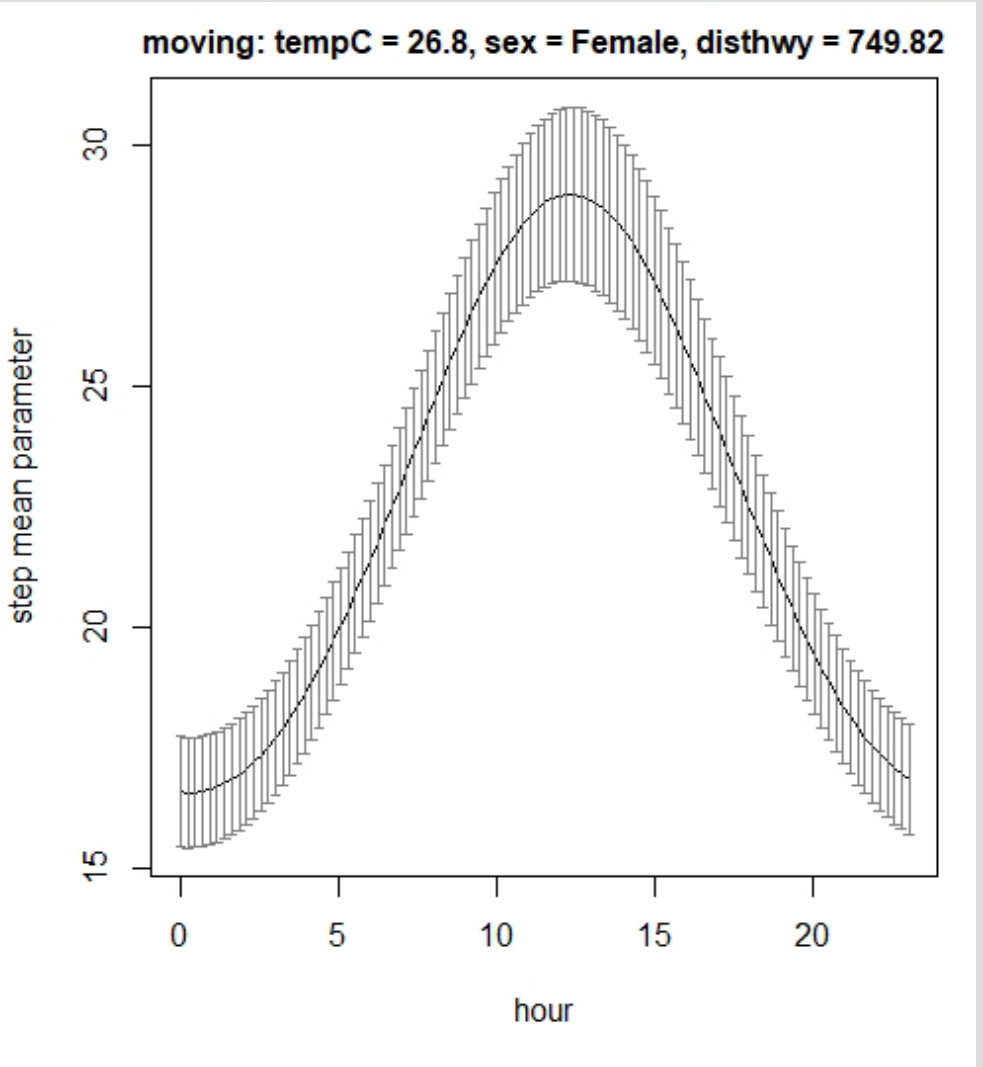


Results

Resting state



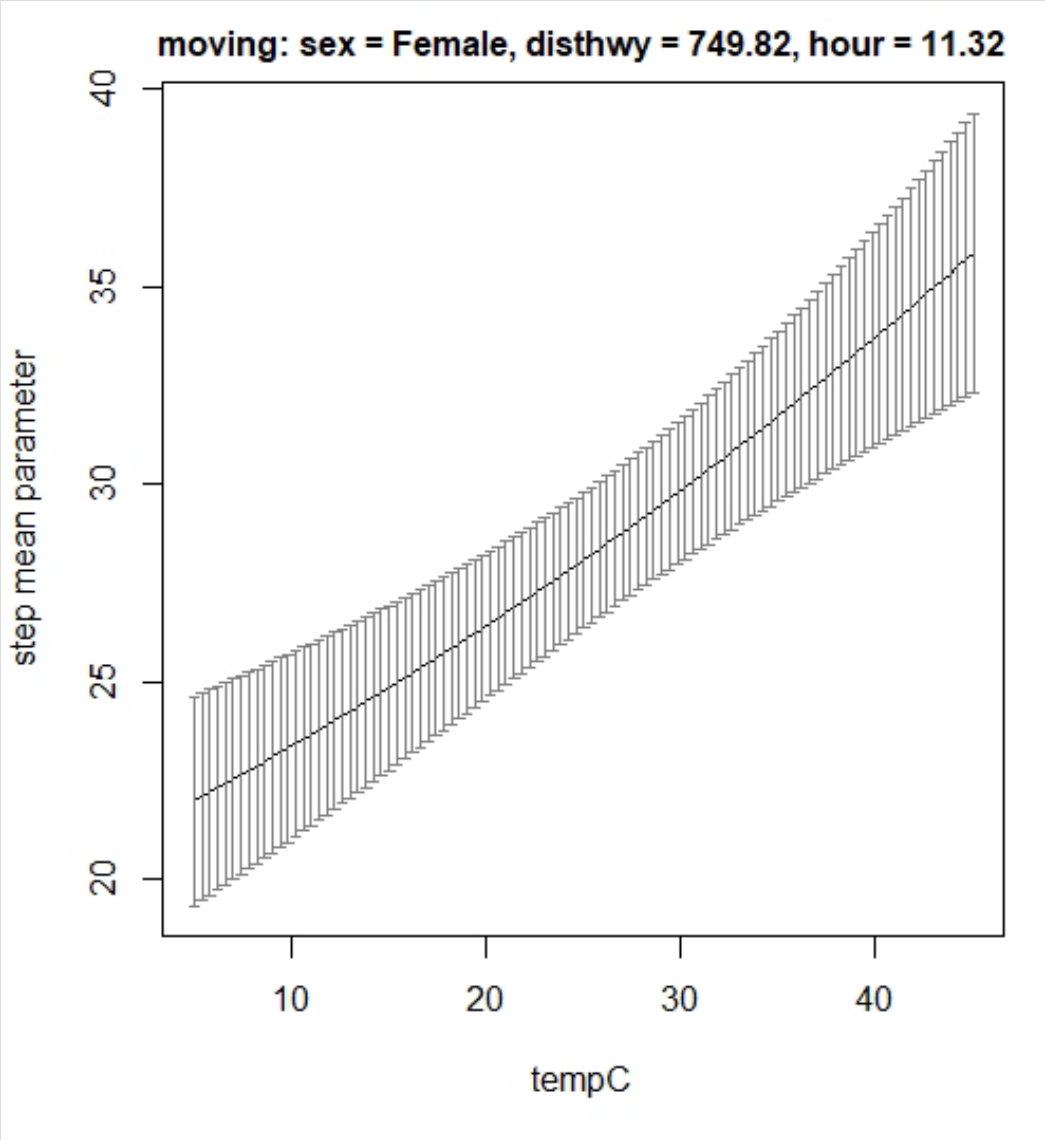
Moving state



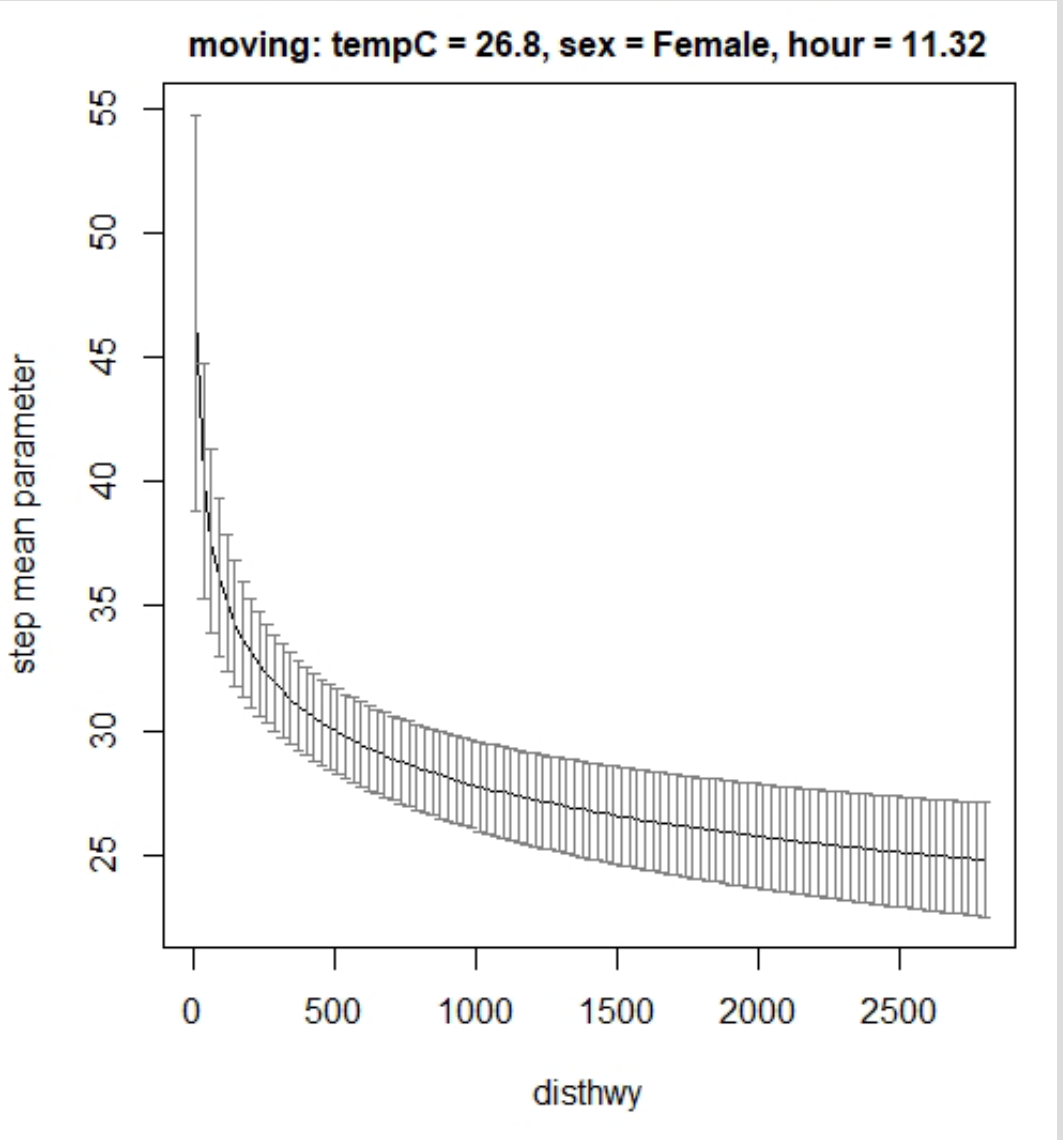
Moving state

Results

Temperature

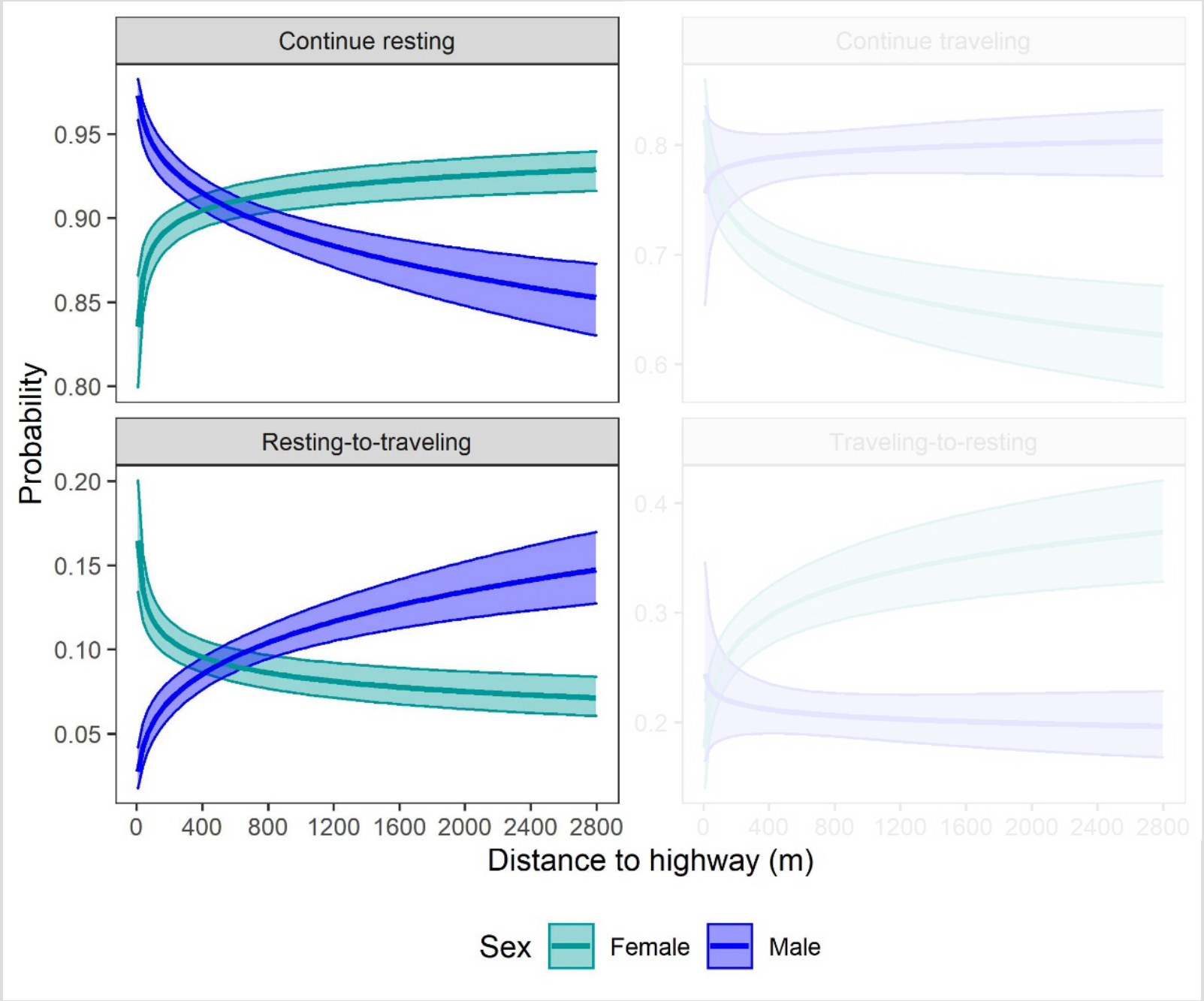


Distance to highway



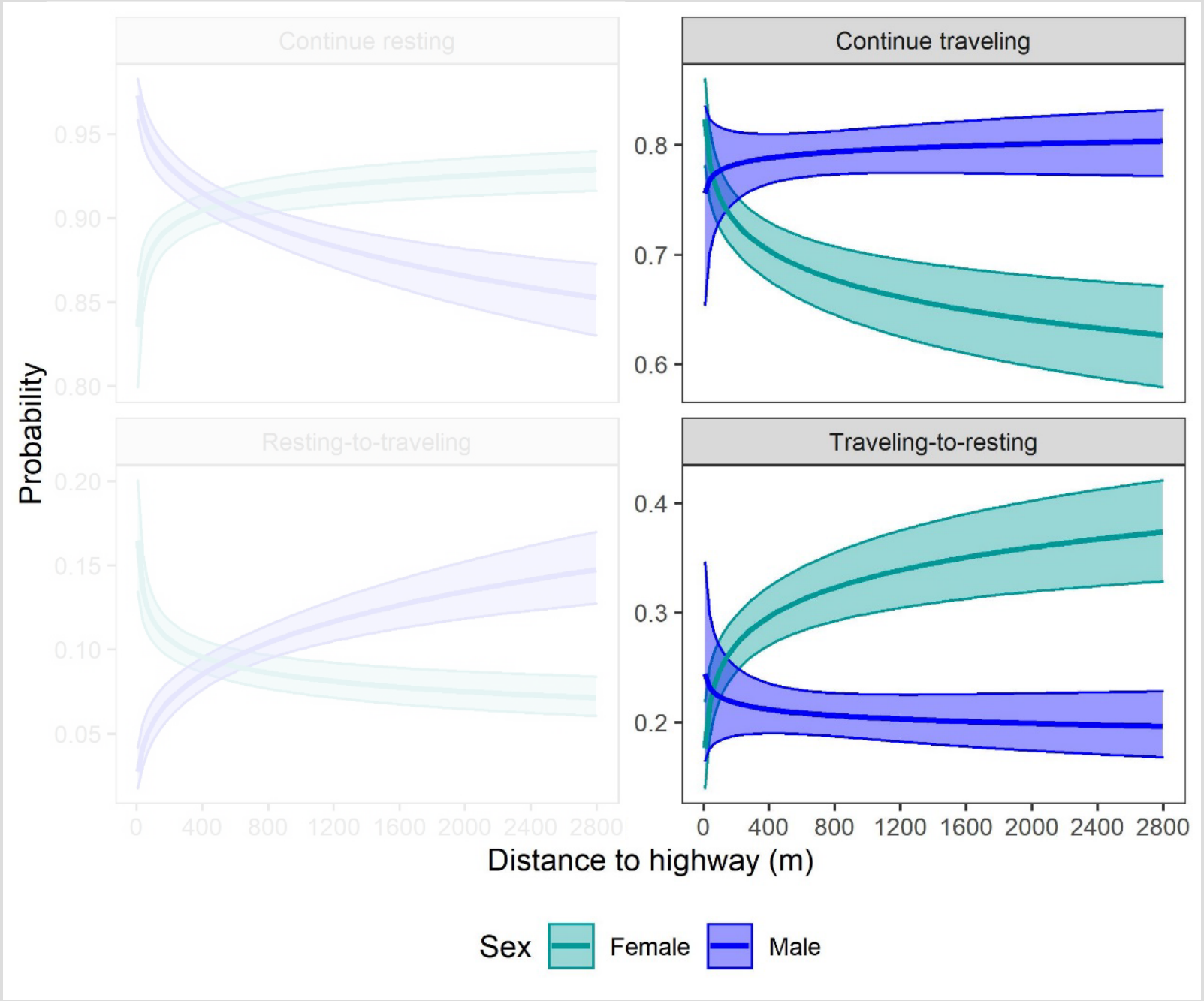
Results

Transition Probabilities



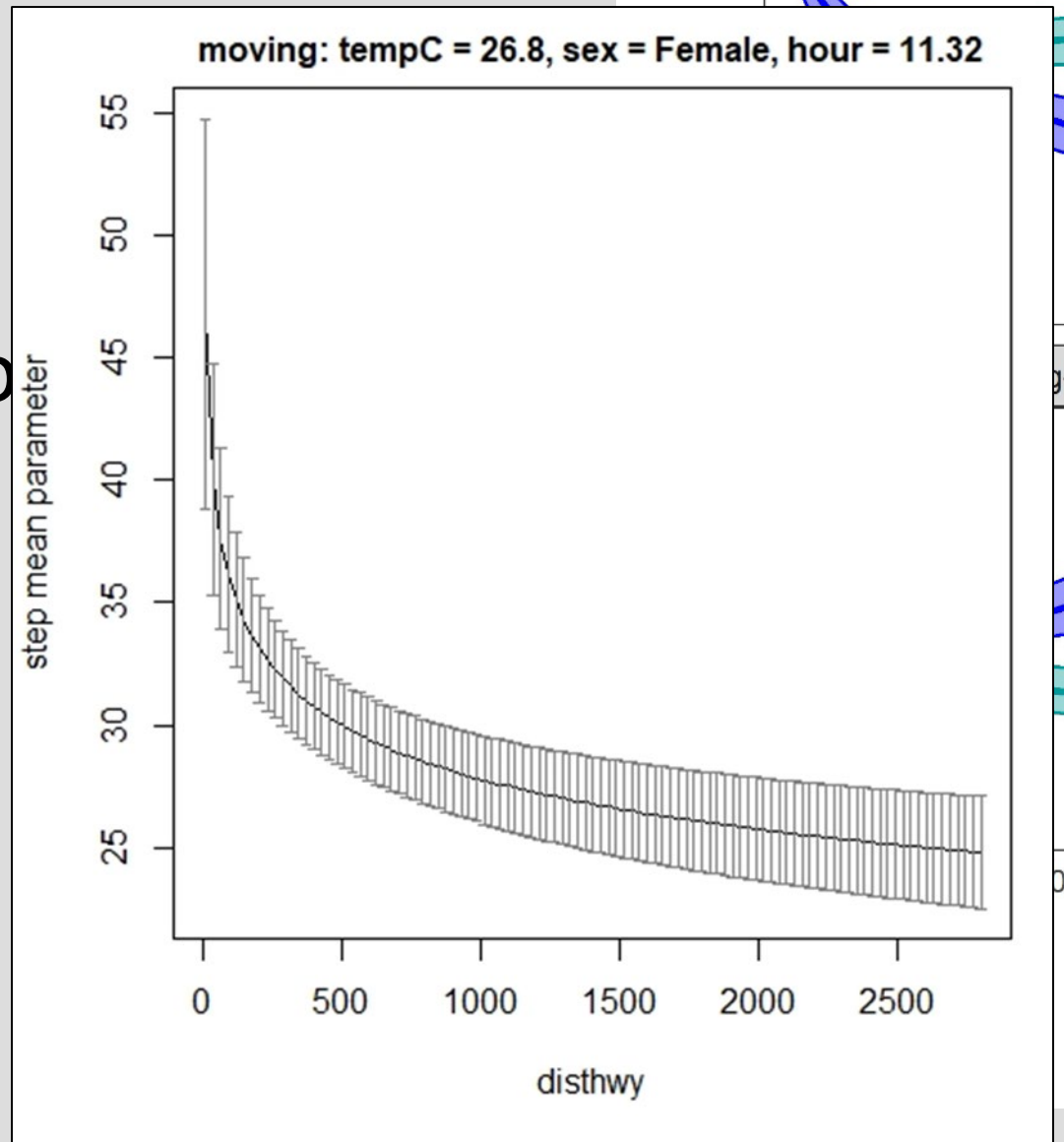
Results

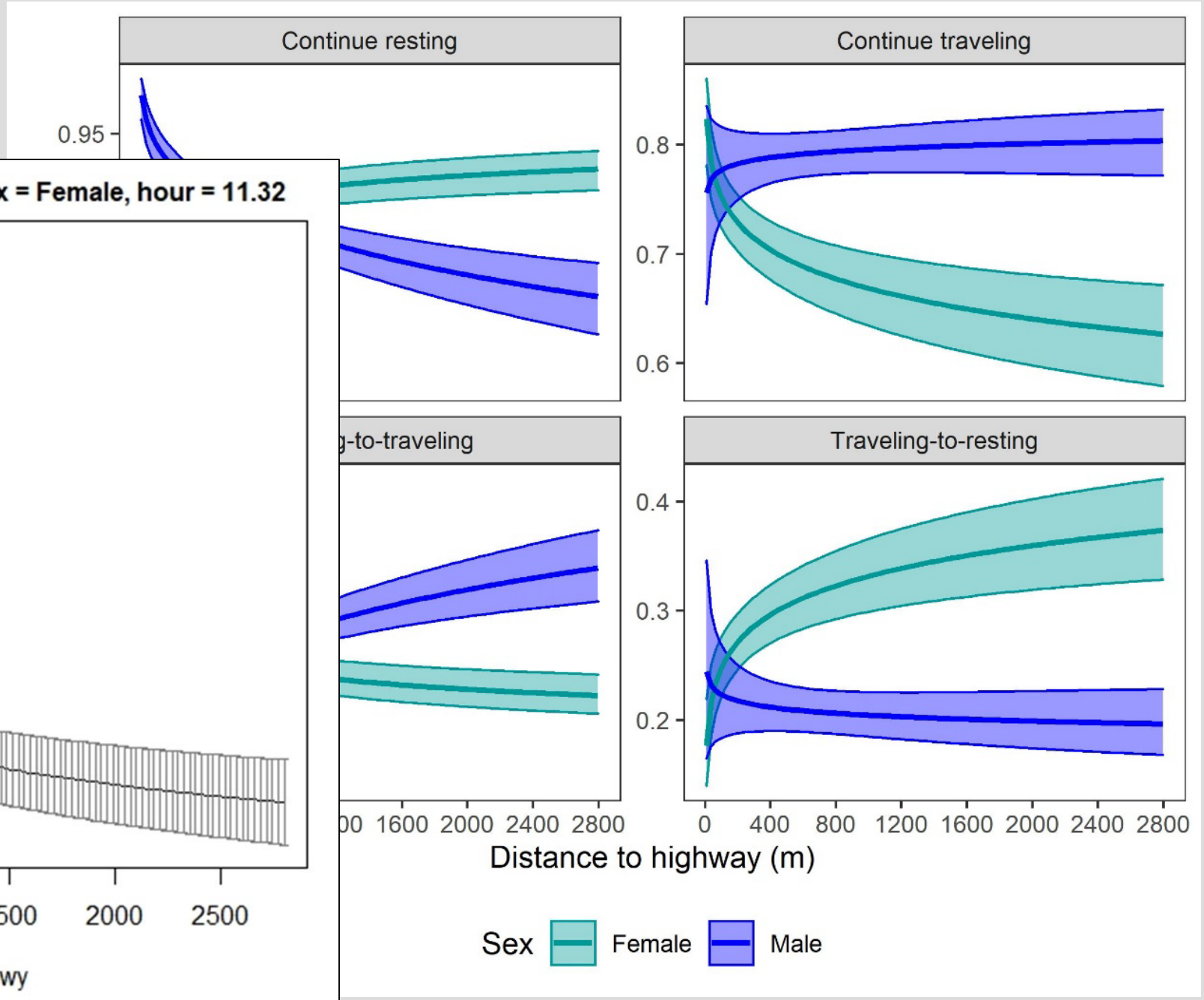
Transition Probabilities



Results

Tra
Pro

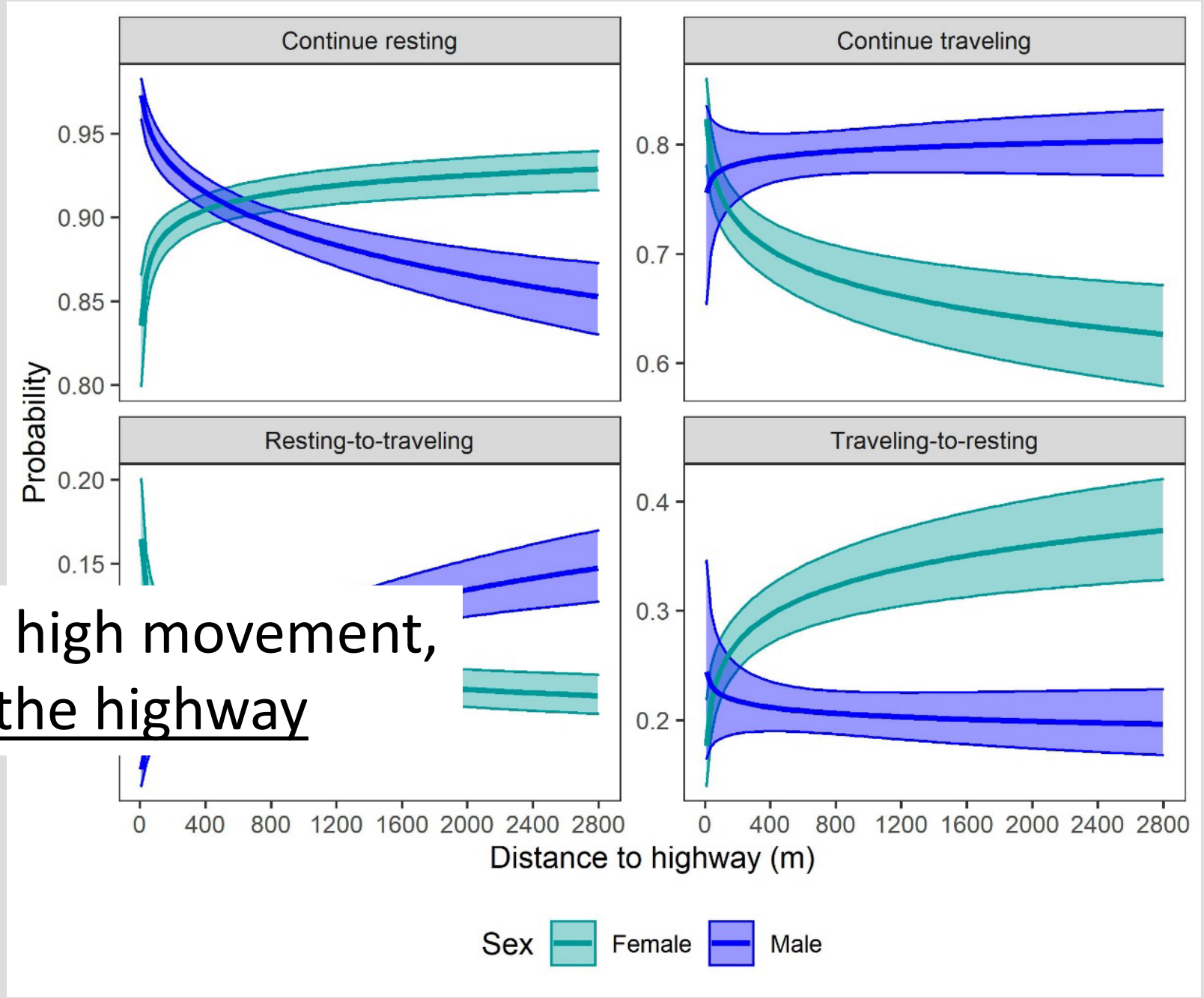




Results

Transition Probabilities

In spite of inducing high movement, no female crossed the highway



Discussion

- Indirect effect of the highway
- Different impacts to males and females

Discussion

- Highway induces females to move significantly more
- Highway induces males to ‘hunker down’

Discussion

Problem for females:

- Higher energetic demand
- Higher water stress for females near highway

Discussion

Is fragmentation the only impact of the highway? *No*

Do culverts ameloriate behavioral impact? *No*

Thank you!

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