Determinants of the temporal dynamics of the ruminant movement network of Senegal

- Presented by: Alexis Delabouglise
- Authors: Katherin Michelle Garcia Garcia, Andrea Apolloni, Mbargou Lo, Ibrahima Diallo, Etienne Chevanne, Fabrizio Rosso, Alexis Delabouglise

- ModStatSAP 2023, 19 September 2023, Montpellier, France

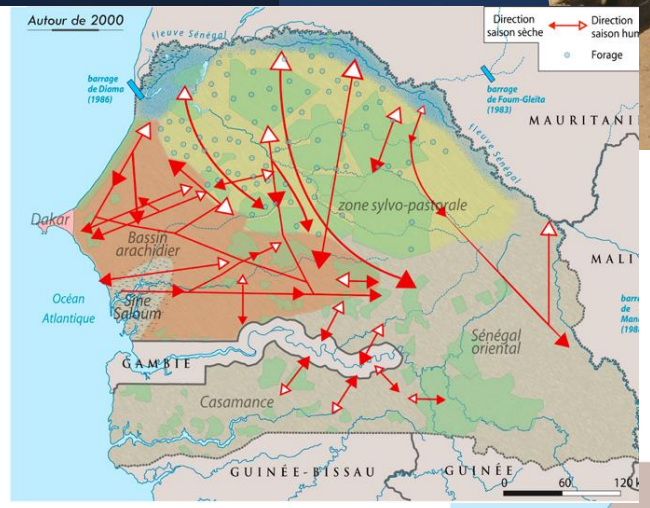
Introduction : mobility of domestic ruminants in Senegal

Mobility of ruminant herds : transmission of transboundary diseases (FMD, PPR, FVR)

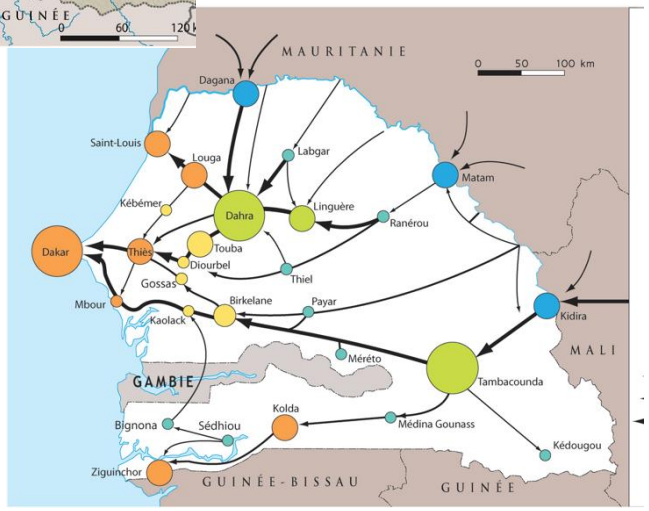
Farmers use transhumance to optimize the use of the limited environmental resources

Commercial trade of live animals on long distance

Importance of forecasting variations in the patterns of ruminant movements



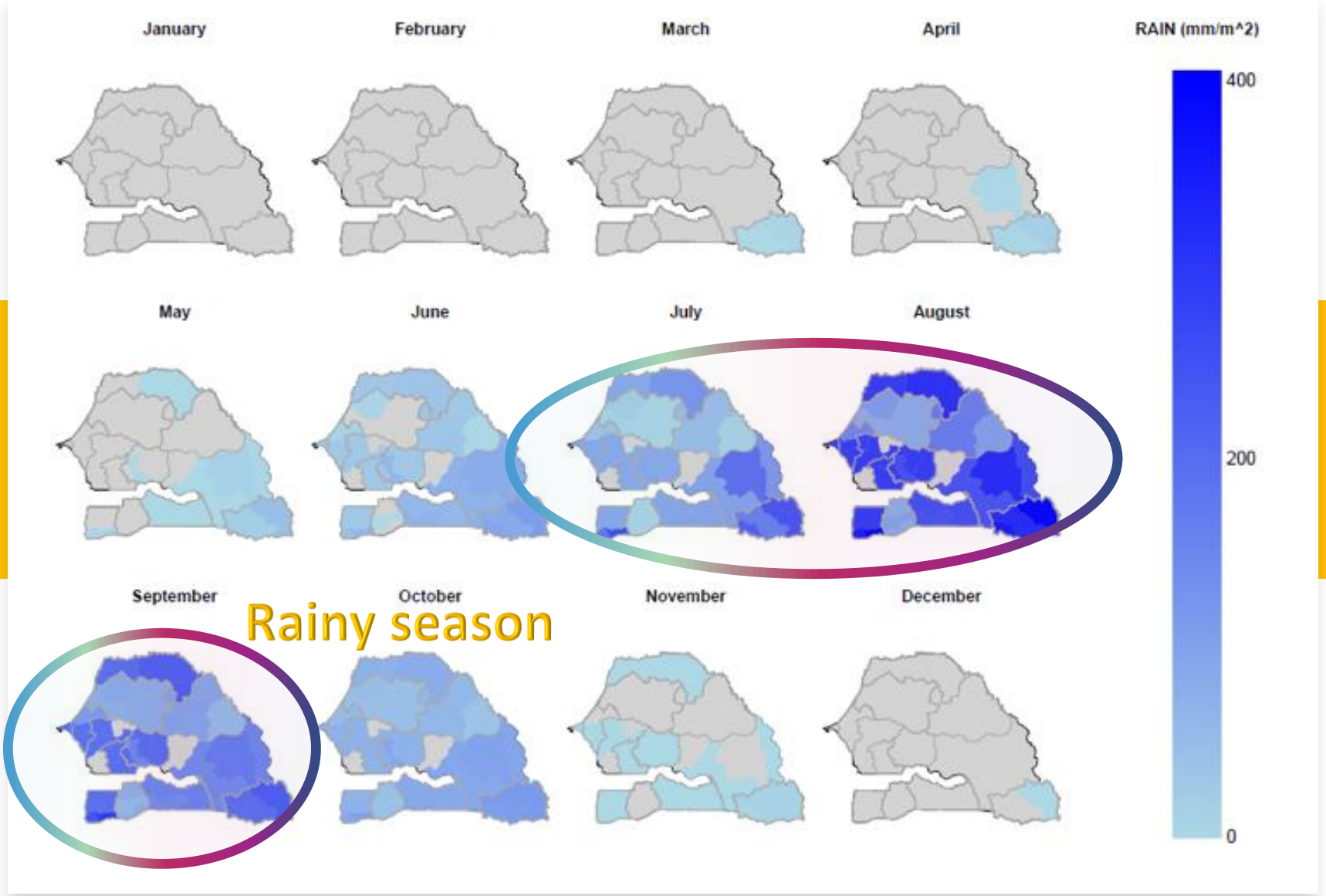
Transhumance axes (Cesaro, Magrin, & Ninot, 2010)



Trade routes and livestock markets (Cesaro, Magrin, & Ninot, 2010)

Hypothesis

Temporal variations of mobility patterns can be predicted on the basis of religious calendar and environmental and economic indicators



Data on rainfall

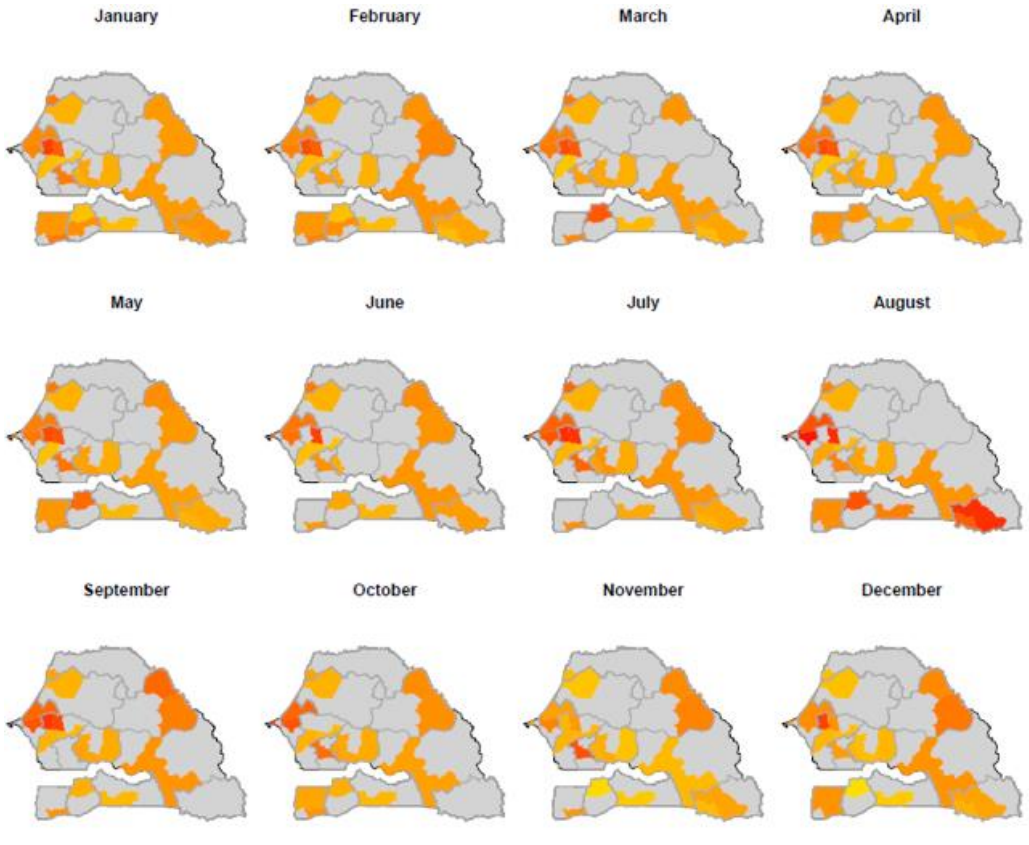
GPCC (Global Precipitation Climatology Center)

Data on vegetation – biomass production per surface unit per day

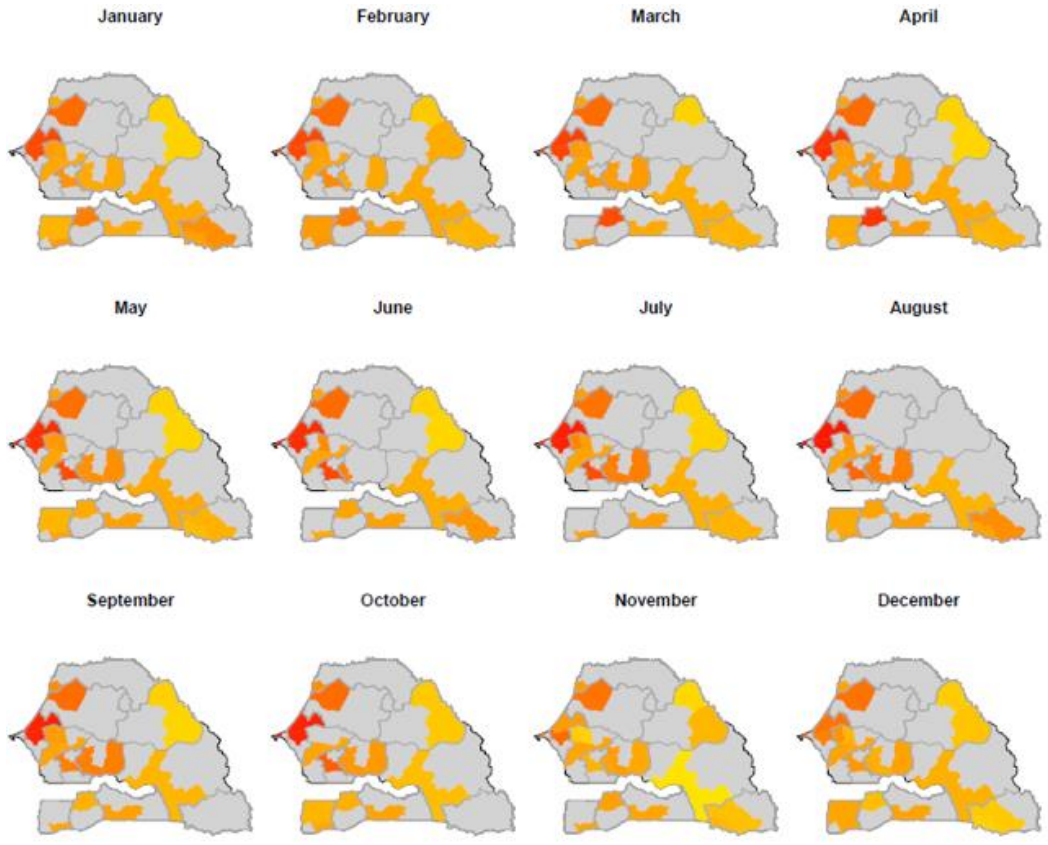
Copernicus Global Land Service : indicator of dry matter production (DMP)

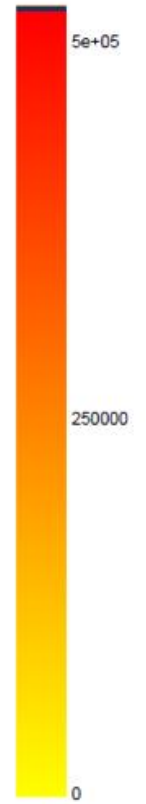
Method: price data collected in livestock markets of Senegal by WFP

Small ruminants



Bovine

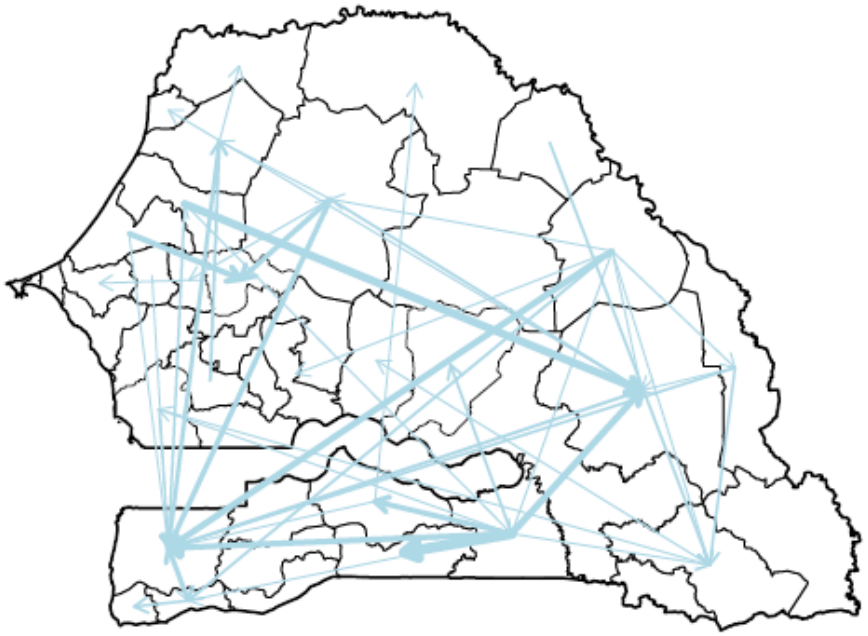


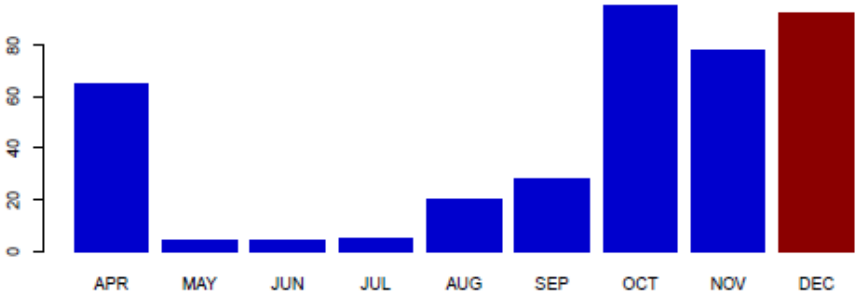


Provided by the VAM office (Vulnerability Analysis and Mapping) of the WFP (World Food Program), 2021.

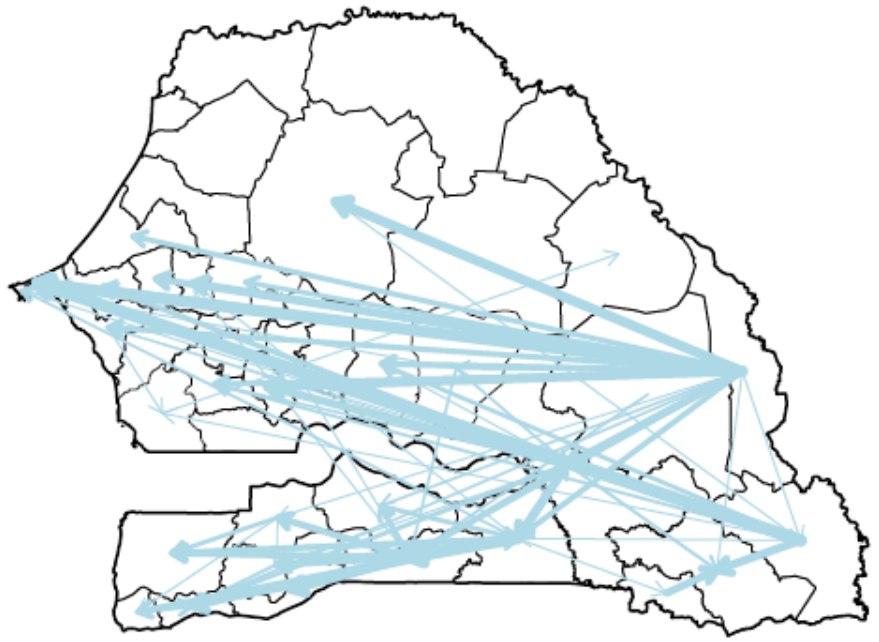
Animal mobility data obtained from the copies of the sanitary permits collected by the Senegalese veterinary services

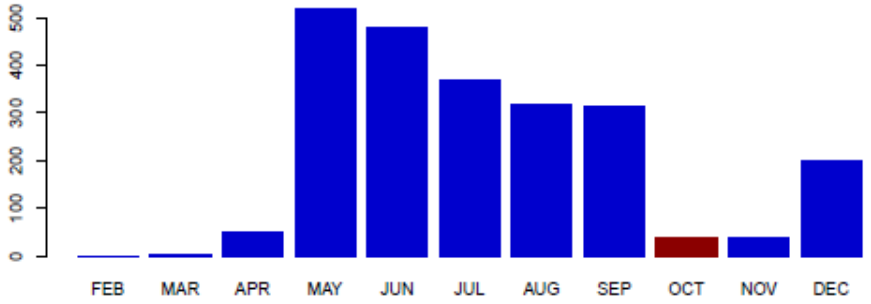
Bovine 2014





Bovine 2019





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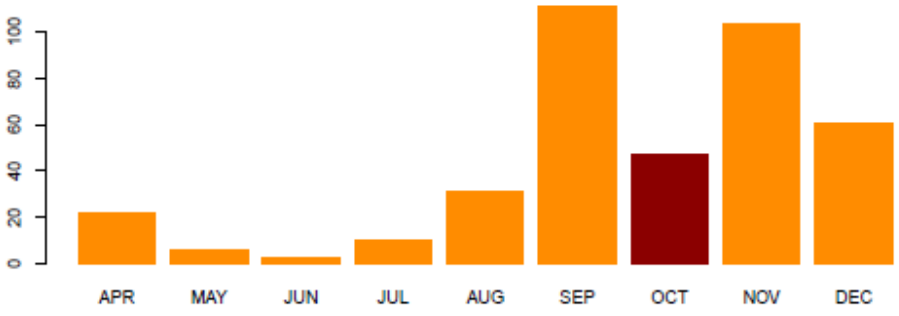
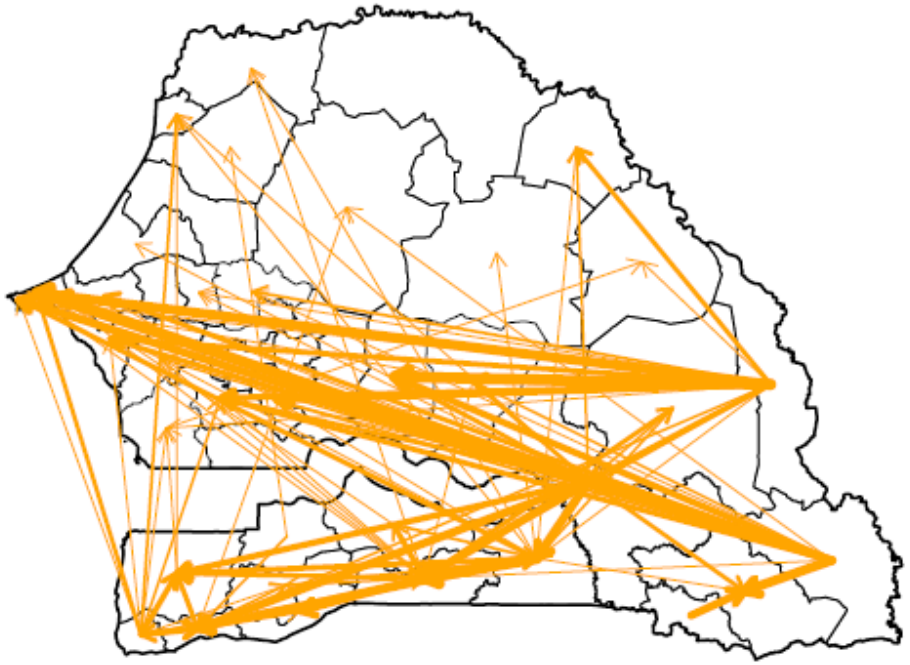
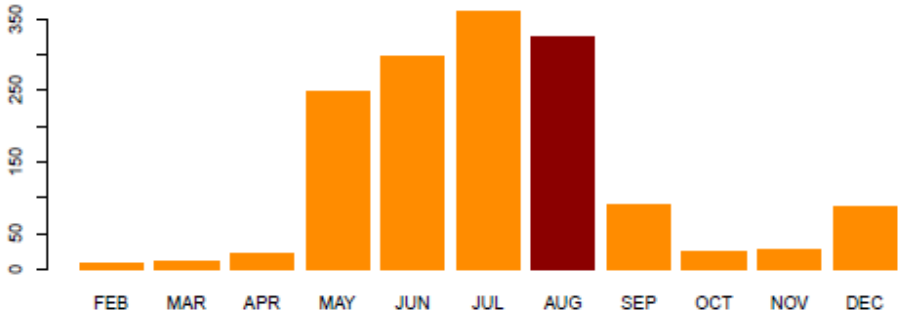
Small ruminants 2014



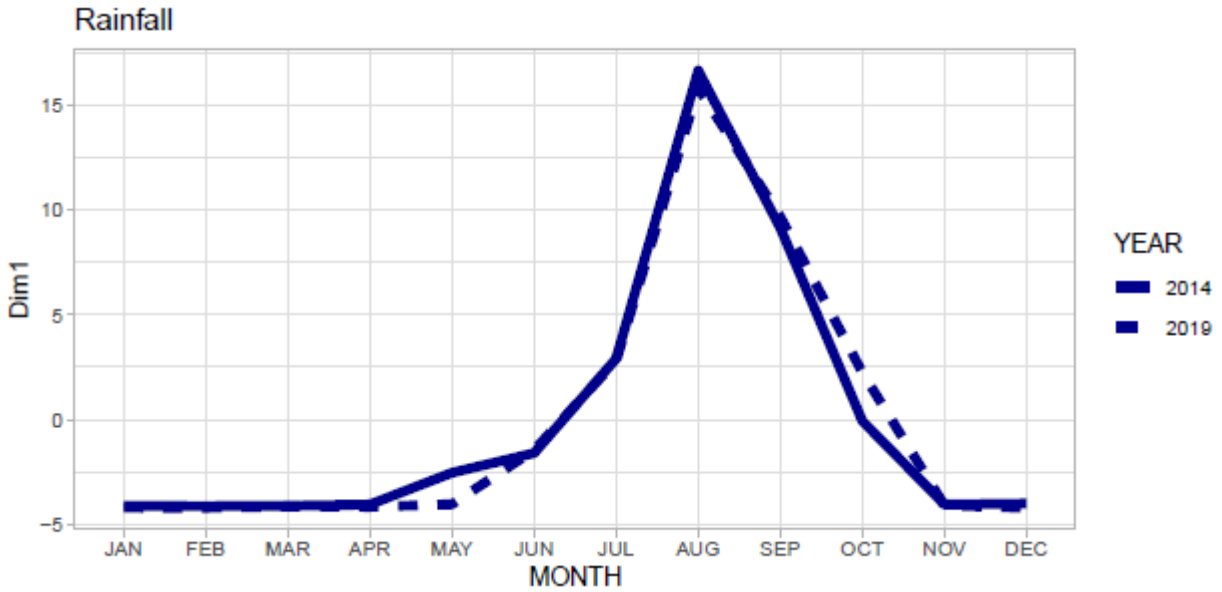
Small ruminants 2019

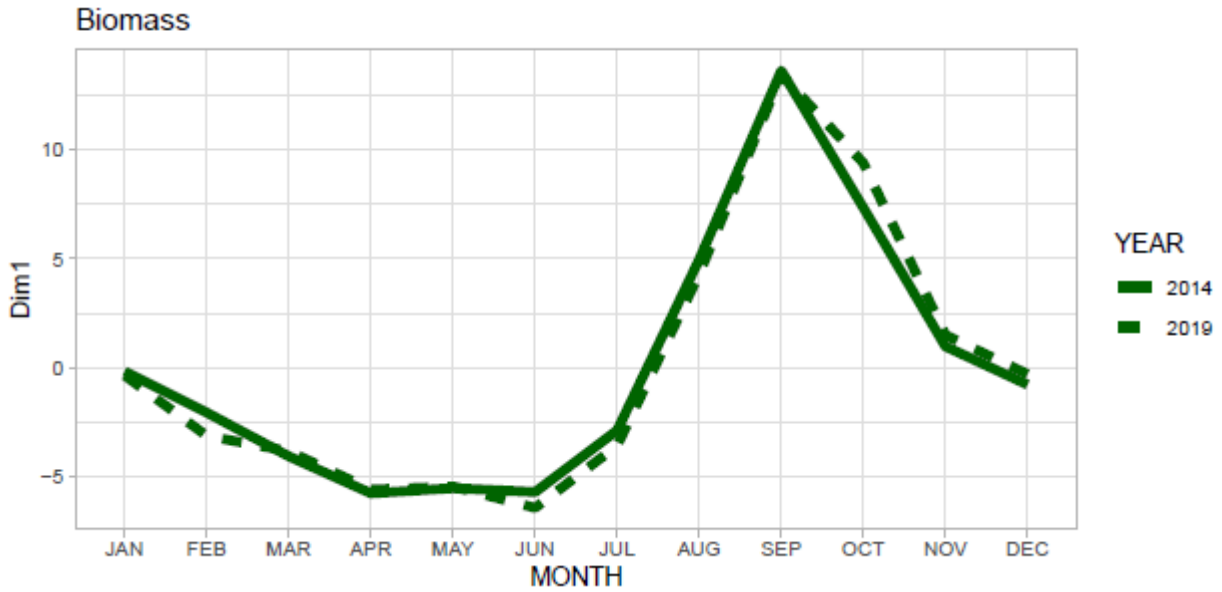




Principal component analysis: rainfall and biomass production

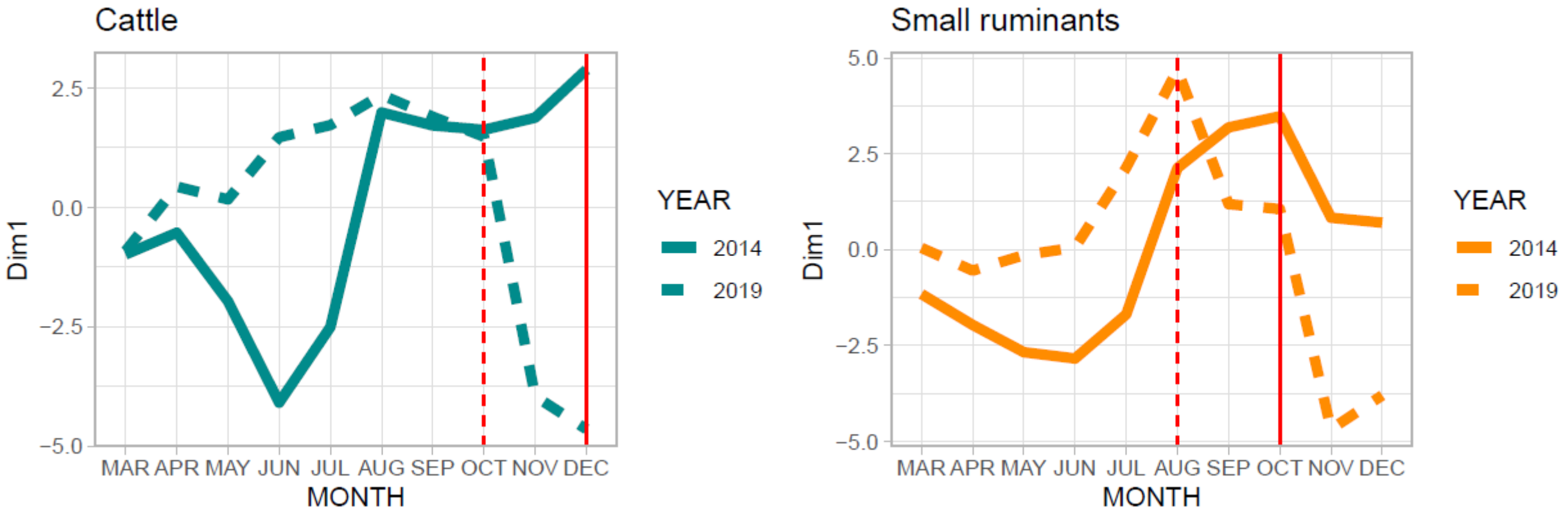
First dimension: >75% of variance explained





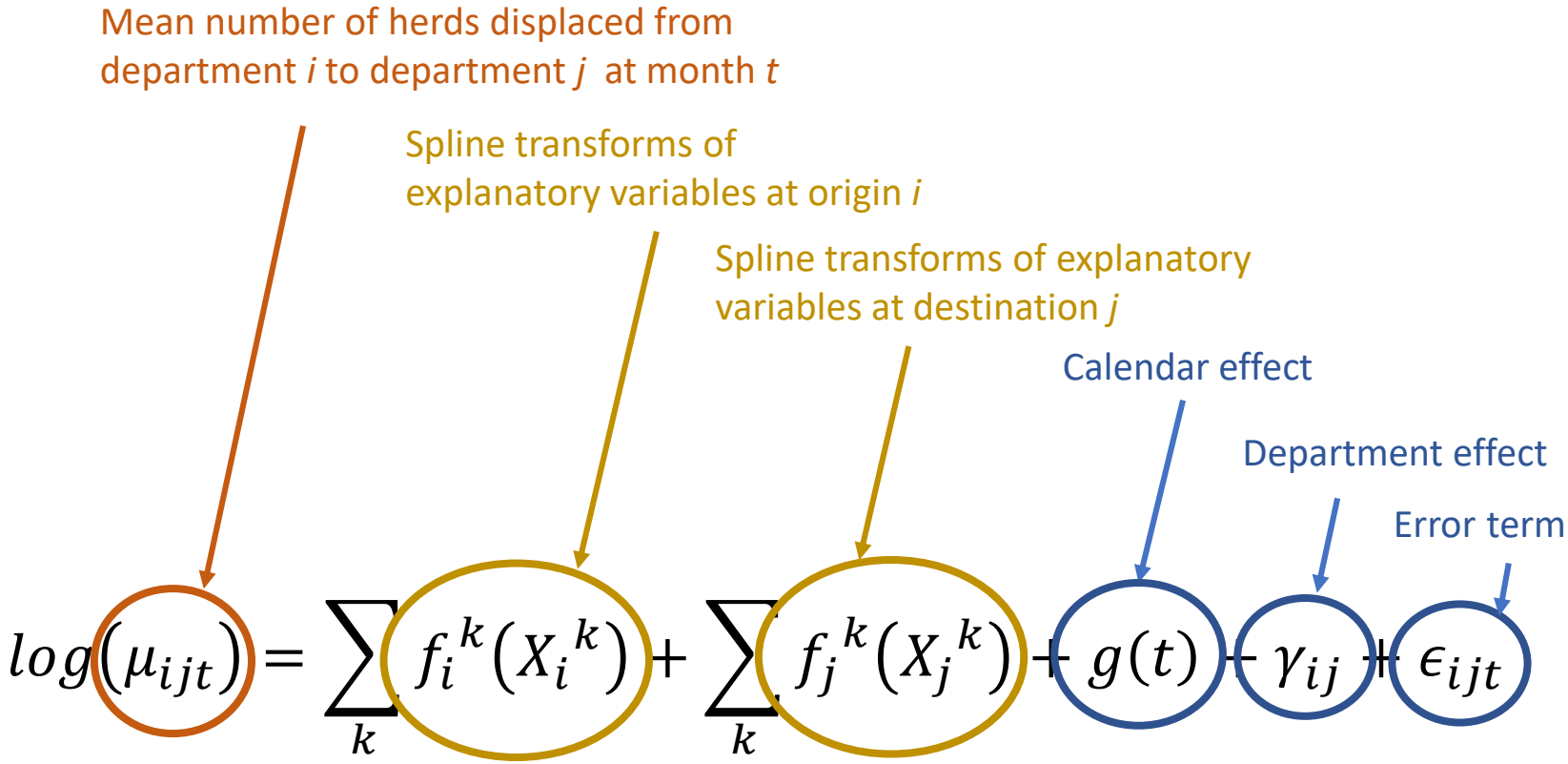
Principal component analysis: market sale prices

First dimension: >40% of variance explained



METHOD

Generalized additive model (GAM)

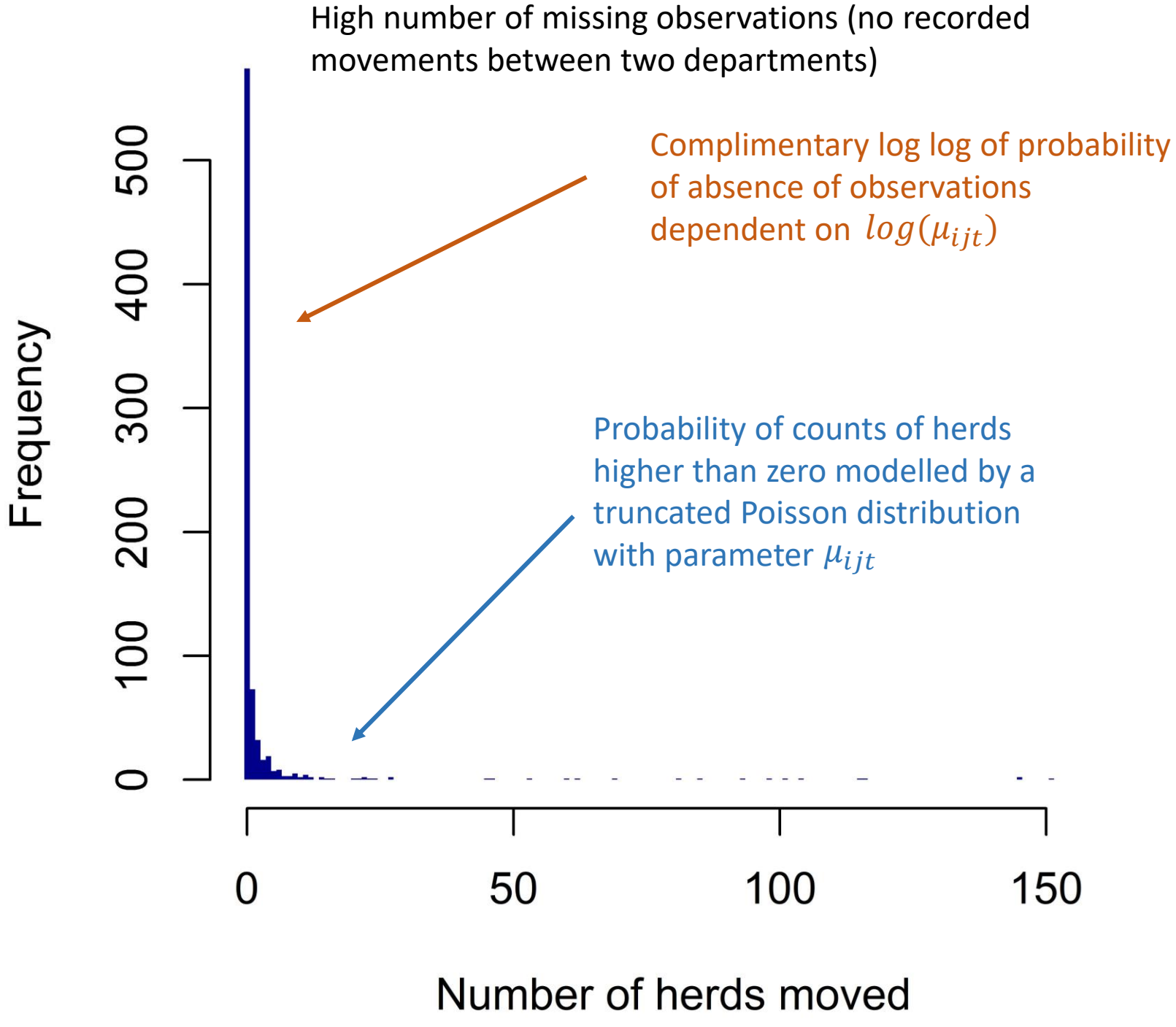


Predictive variables (*k*):

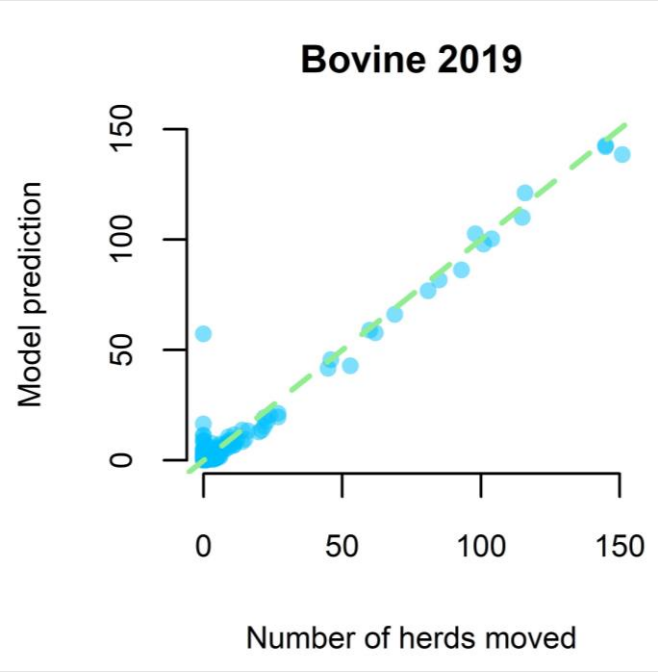
- Department average rainfall on the previous month (*t-1*)
- Difference between department average rainfall on current *(t)* and previous month (*t-1*)
- Department average biomass production on the previous month (*t-1*)
- Difference between department average biomass production on current *(t)* and previous month (*t-1*)
- Regional average market price on the previous month (*t-1*)
- Difference between regional average market price on current *(t)* and previous month (*t-1*)

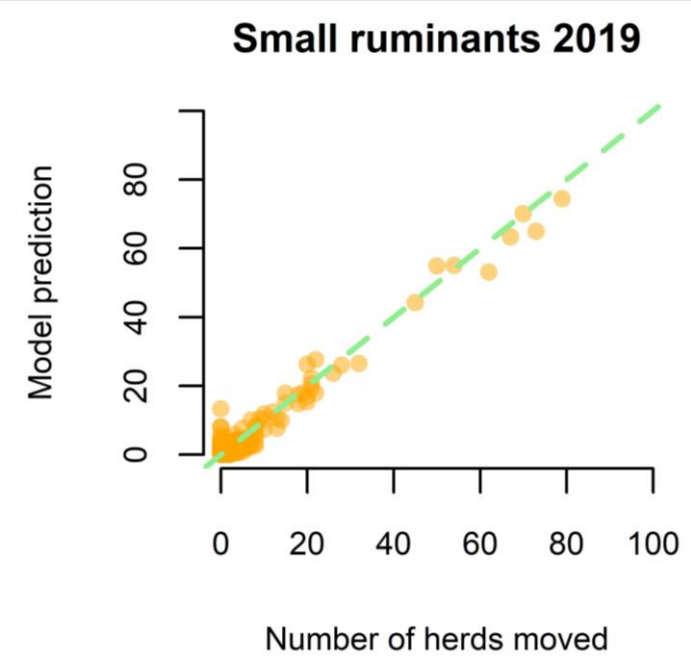
METHOD

Hurdle Poisson regression



Results of the generalized additive hurdle model





BOVINES:

- 777 observations
- 203 observations with at least one registered herd movement
- 93.8% explained deviance

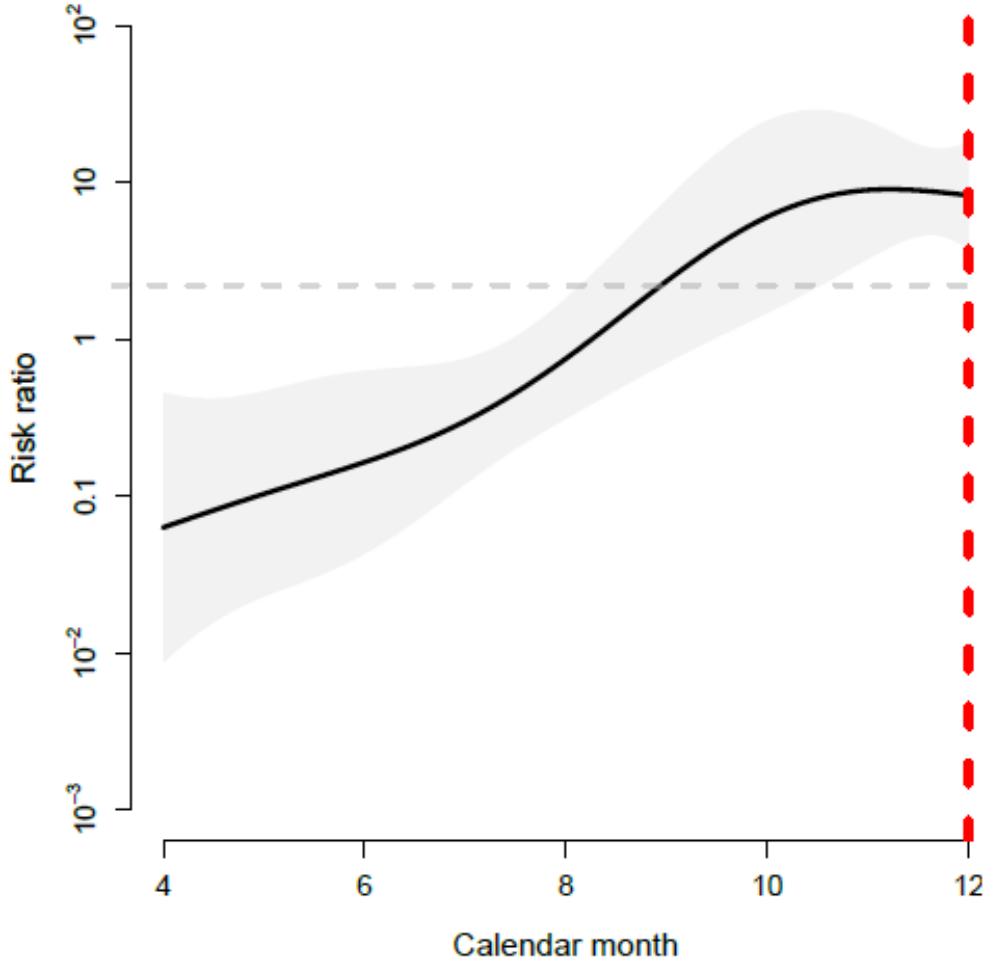
SMALL RUMINANTS:

- 1051 observations
- 239 observations with at least one registered herd movement
- 89.6% explained deviance

Effect of calendar month on herd movements: cattle

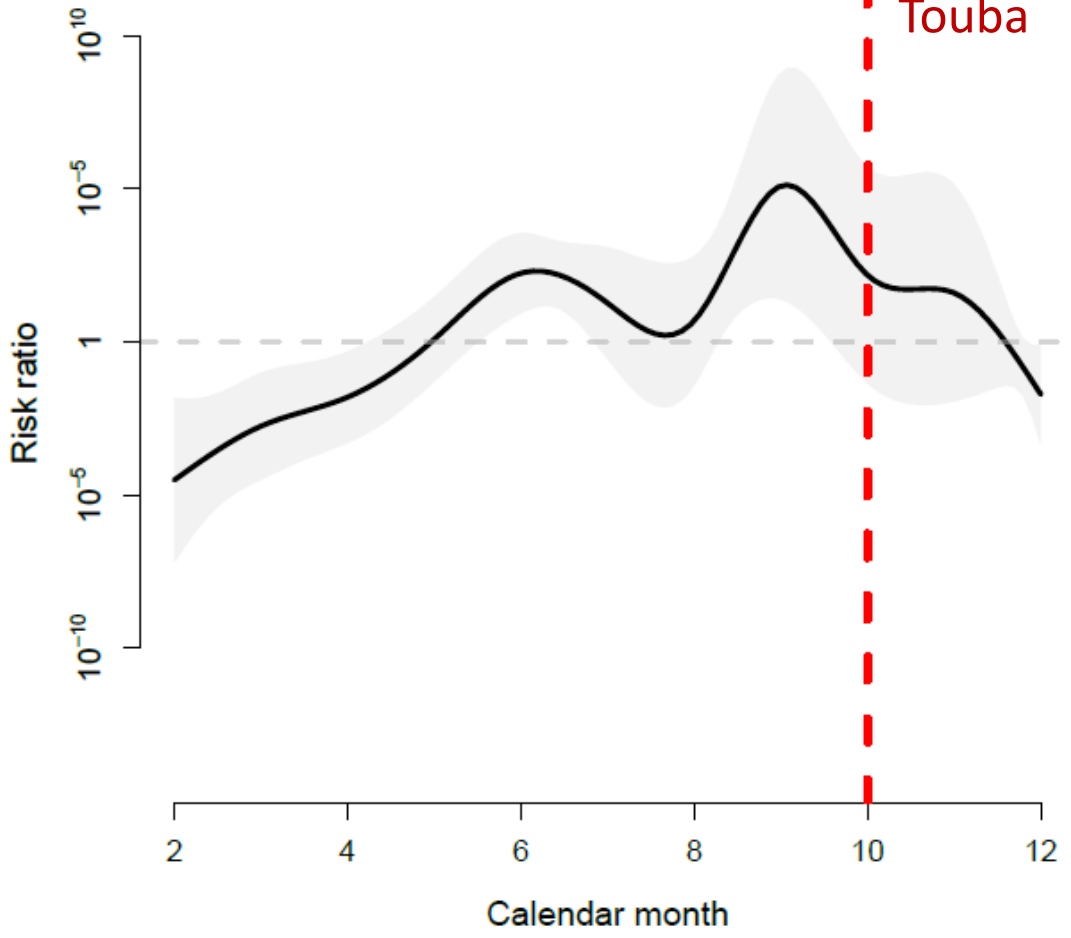
2014

Magal de Touba



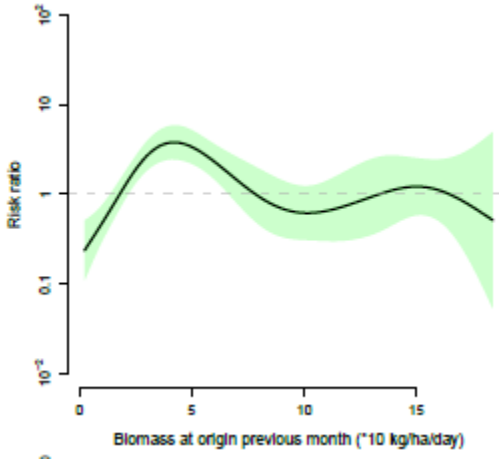
2019

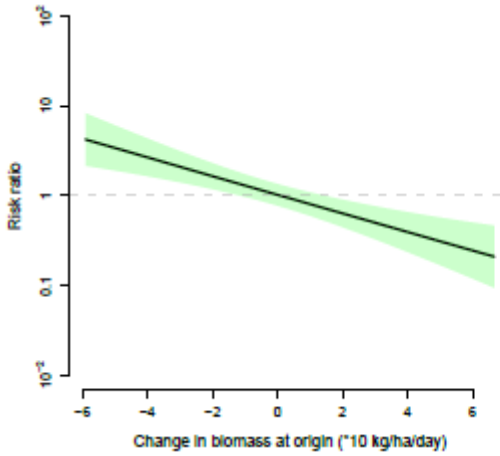
Magal de Touba

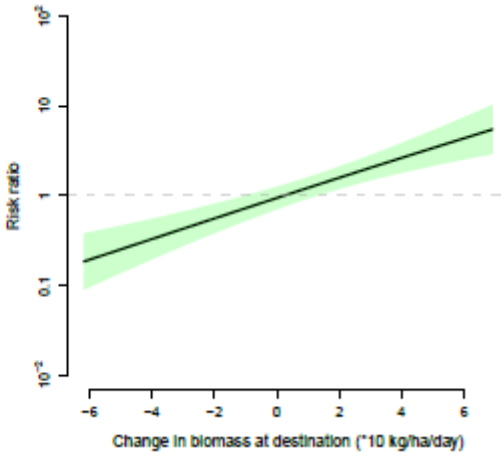


Effect of biomass production: small ruminants

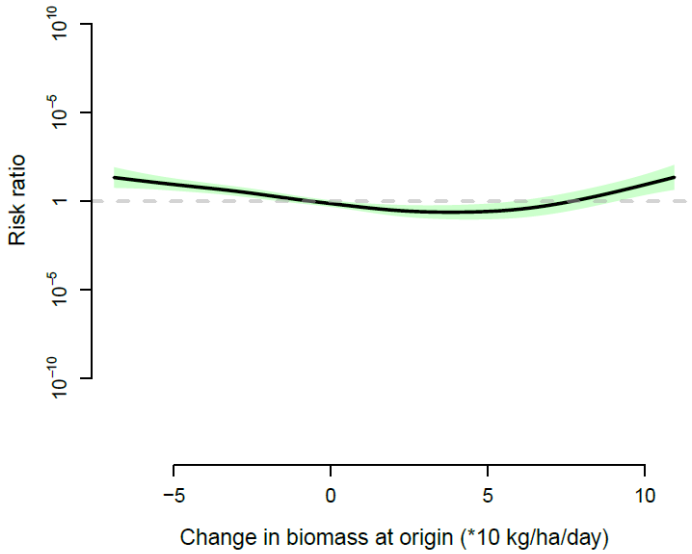
2014







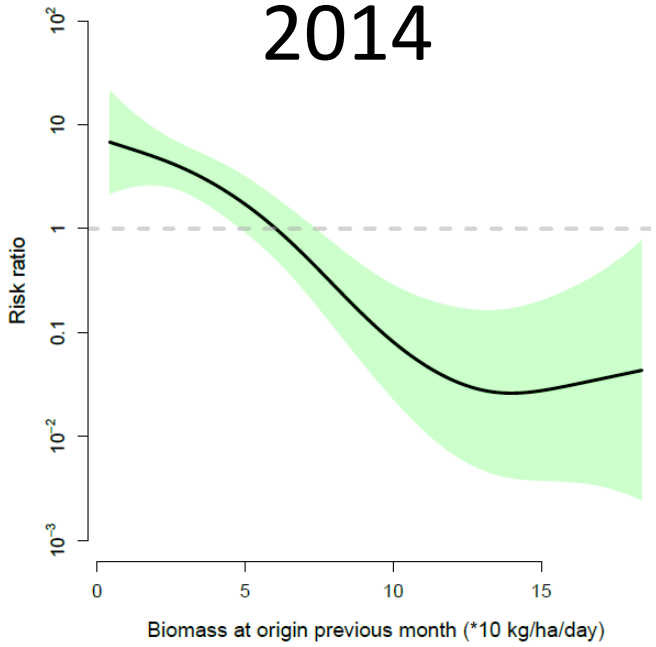
2019



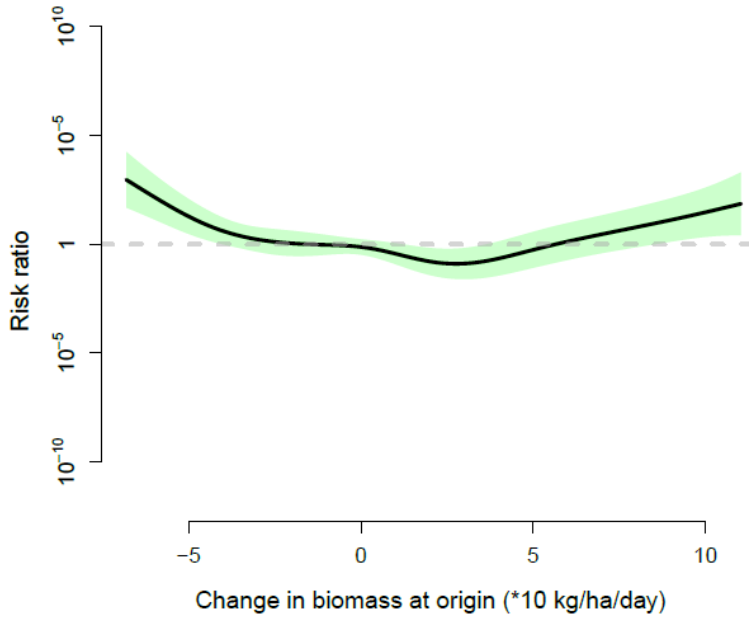
- 2014: Movements of ruminants increase when biomass production declines at the place of origin or increases at the place of destination (small ruminants)
- 2019: Movements of ruminants stimulated by changes in biomass production at the department of origin (either increase or decrease)
- Herders more likely to depart when (1) grass in limited availability to feed animals or (2) crop fields are fully grown to avoid damages to fields and conflicts with crop farmers

Effect of biomass production: cattle

2014



2019



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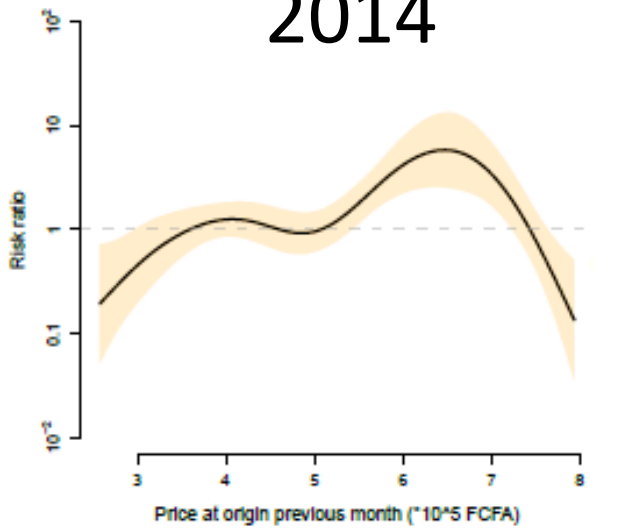
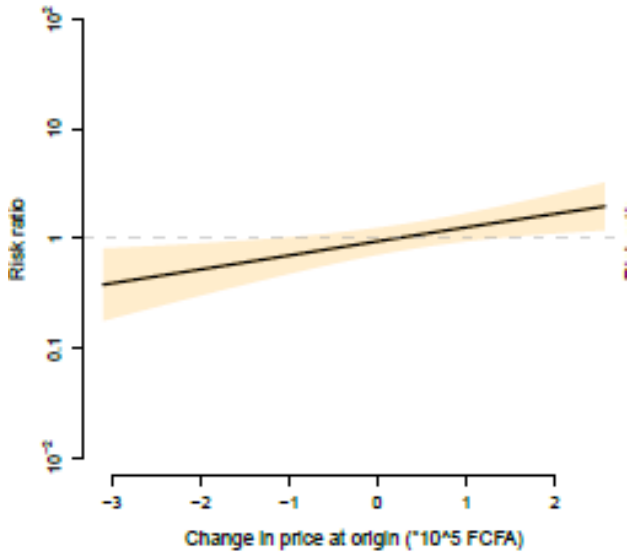
Effect of market price: small ruminants

2014





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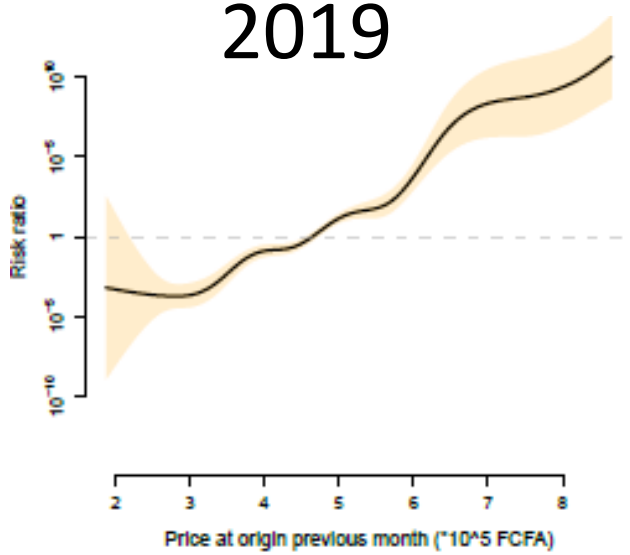
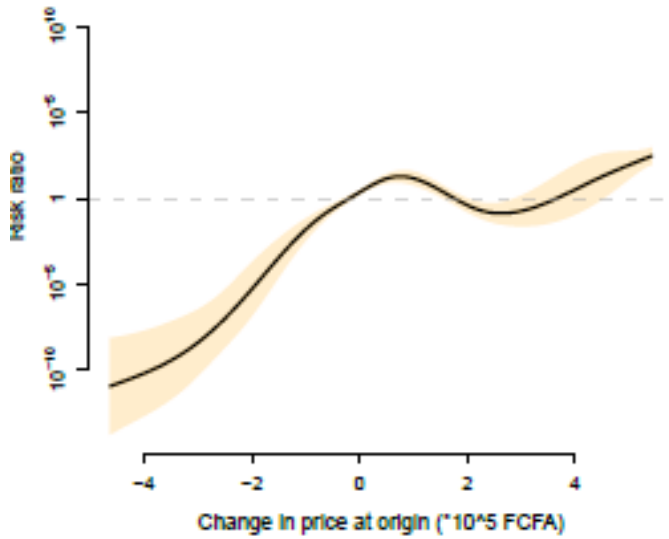
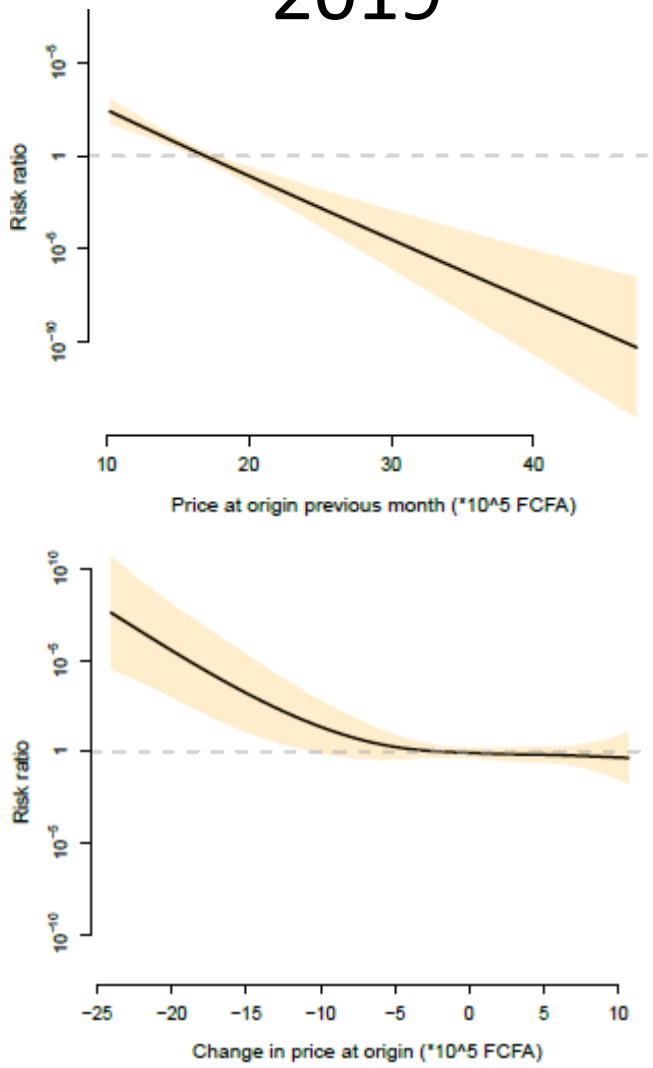




- The effect of prices at destination is unsignificant for bovines, very low for small ruminants
- For small ruminants : higher likelihood of departure if the department of origin has a high market price or an increased market price
- For bovines in 2019: low market prices at origin tend to incentivize a higher frequency of departure

Effect of market price: cattle

2019



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Discussion

- Main observations
  - Strong predictive power of the hurdle poisson GAM model
  - Evidences for:
    - Consistent effect of
      - Religious festivals for cattle (Magal de Touba)
      - Market price at origin for small ruminants
    - Mobility partly driven by rainfall and biomass, mostly at the place of origin but with differences between 2014 and 2019 data
    - Complex effect of market price at origin : economic rational differs across livestock systems (cattle and small ruminants)
- Limits
  - Sanitary permits: incomplete dataset, very limited data in the northern part of the country for 2019
  - Monthly data on market prices: mainly available in the biggest markets, aggregated at regional level
  - No distinction between transhumant and commercial movements

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Environmental and economic determinants of temporal dynamics of the ruminant movement network of Senegal

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