

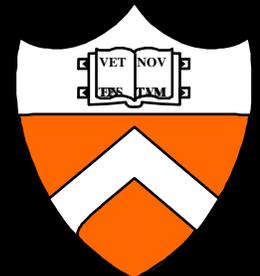


Population Control of 'Wild' Horses: Pros and Cons of Adoption and Immunocontraception

Daniel I. Rubenstein

Department of Ecology and Evolutionary Biology

Princeton University



Team mates and funders

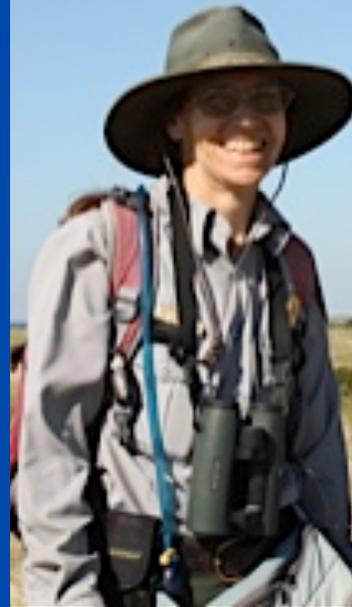
Cassandra Nunez



Jessa Madosky



Sue Stuska



Carolyn Mason



National Science



Foundation



Princeton University



Aims



- 1) Review history of management on Shackleford Banks, NC
- 2) Illustrate the outcome of co-management and dual strategies
- 3) Explore the unintended consequences of these strategies and what it means for future management

Managing Shackleford Banks Feral Horses



How best to manage a population without harming a fragile frontline ecosystem?

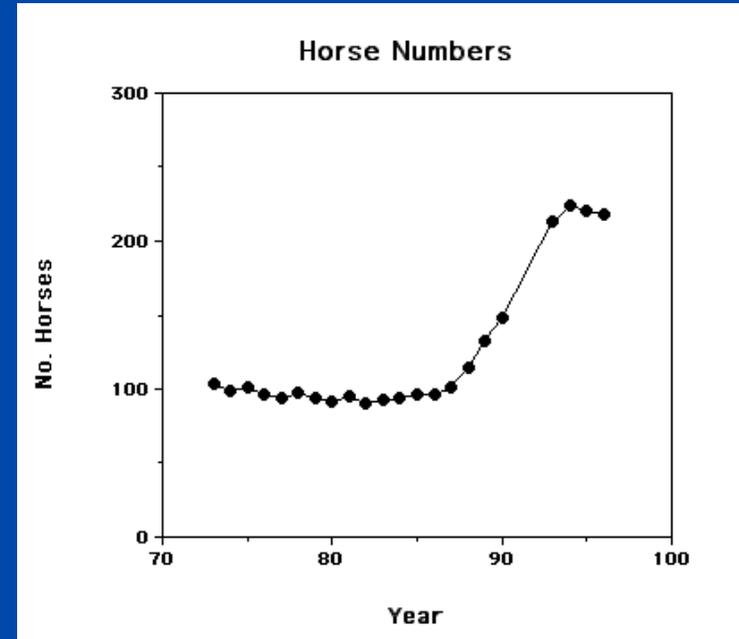
History & Options

Background

- Horses shipwrecked on island in 1565
- Lived with people until 1899
- Horses, cows, sheep & goats roamed the island

Options

- 1) Eliminate all the horses
- 2) Do nothing
- 3) Manage to maximize protection of ecosystem
- 4) Manage to sustain the evolutionary potential of the horse population (*under constraint: $N = 100?$*)



Model Characteristics

Forecast

- Numbers
- Effective Population Size

$$N_e = \frac{4 N_m N_f}{N_m + N_f}$$

Population projection model

$$\begin{bmatrix} I \\ J \\ A \end{bmatrix}_{t+1} = \begin{bmatrix} 0 & \alpha Ff(N_t) & Ff(N_t) \\ Sf(N)_t & 0 & 0 \\ 0 & Sf(N_t) & Sf(N_t) \end{bmatrix} \bullet \begin{bmatrix} I \\ J \\ A \end{bmatrix}_t$$

- Behavioral & ecological details make models realistic

Natural Factors

- Rainfall ---> Production
- Density - Dependence [$f(N_t)$]
 - \bar{x} — age 1st reproduction
 - F — fecundity
 - S — annual survival

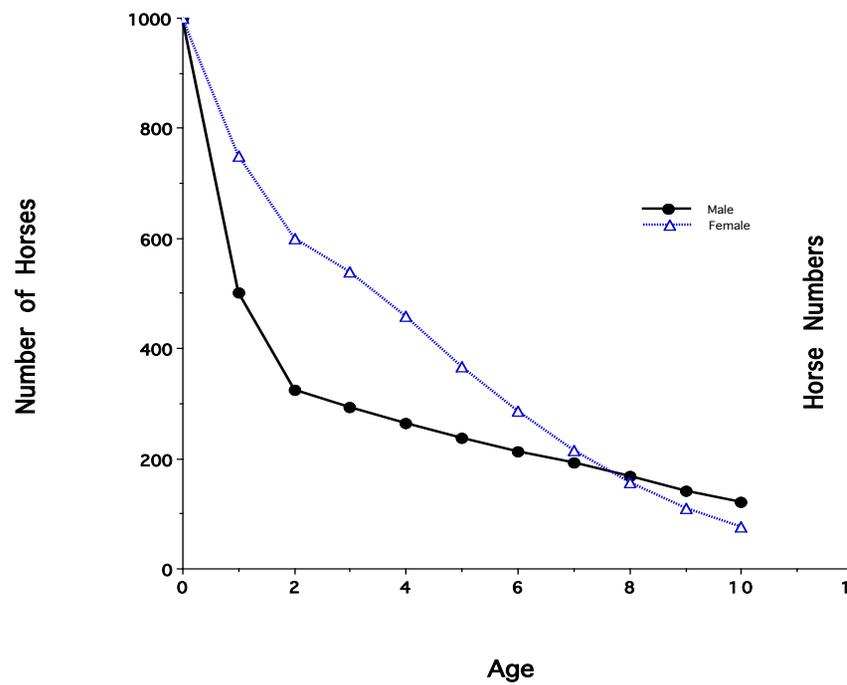
Anthropogenic Factors

- Fertility Control
 - (-) fecundity
 - (+) survival
- Harvesting
 - (-) N_t

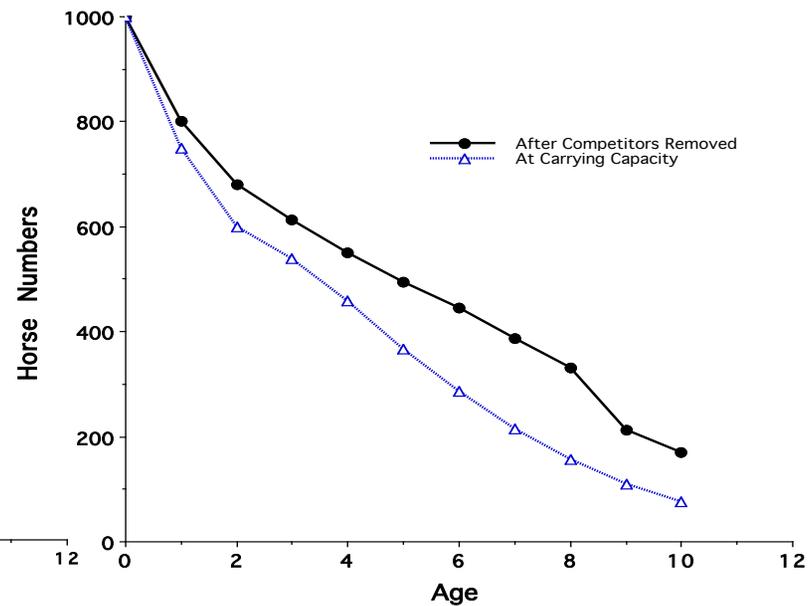
- Models guide human decision-making!

Key Observations

Sex Difference in Survival



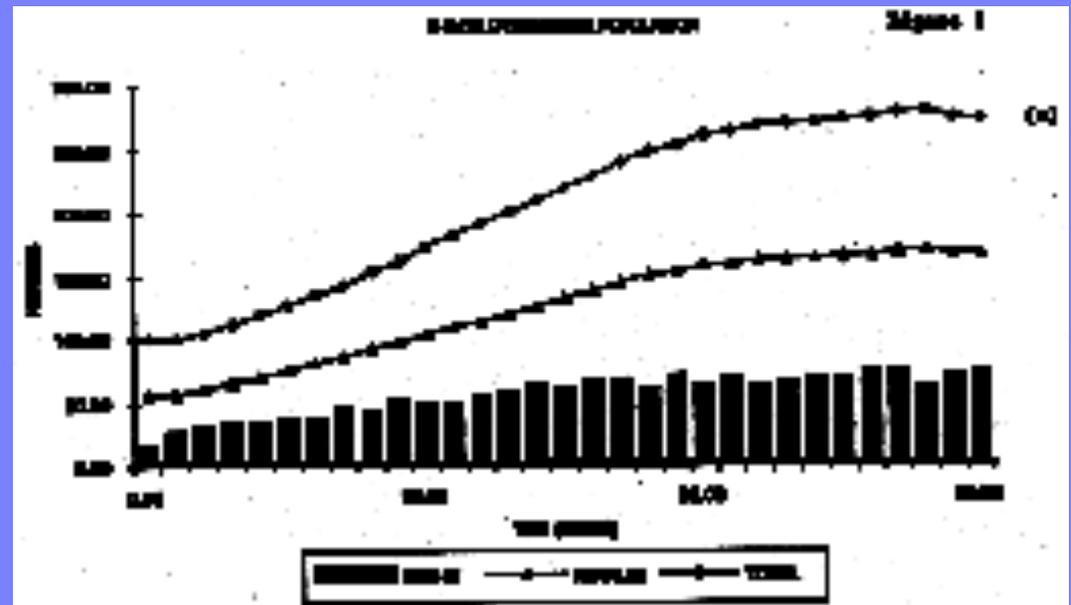
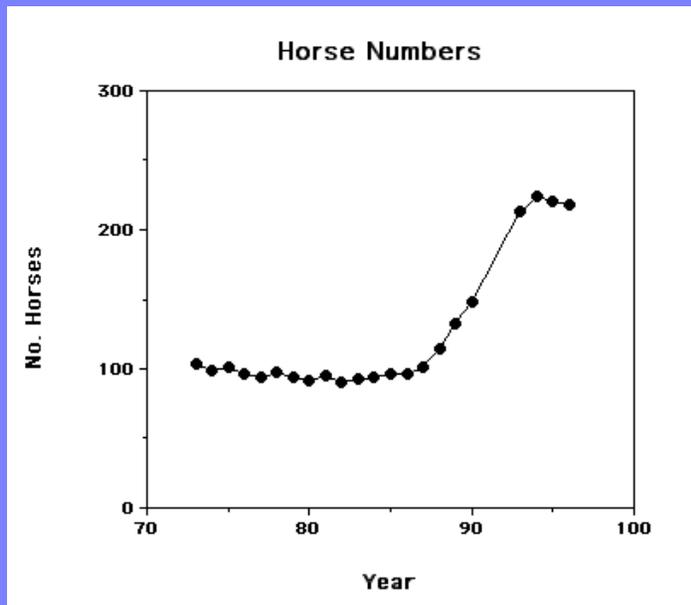
Density Dependence on Horse Survival



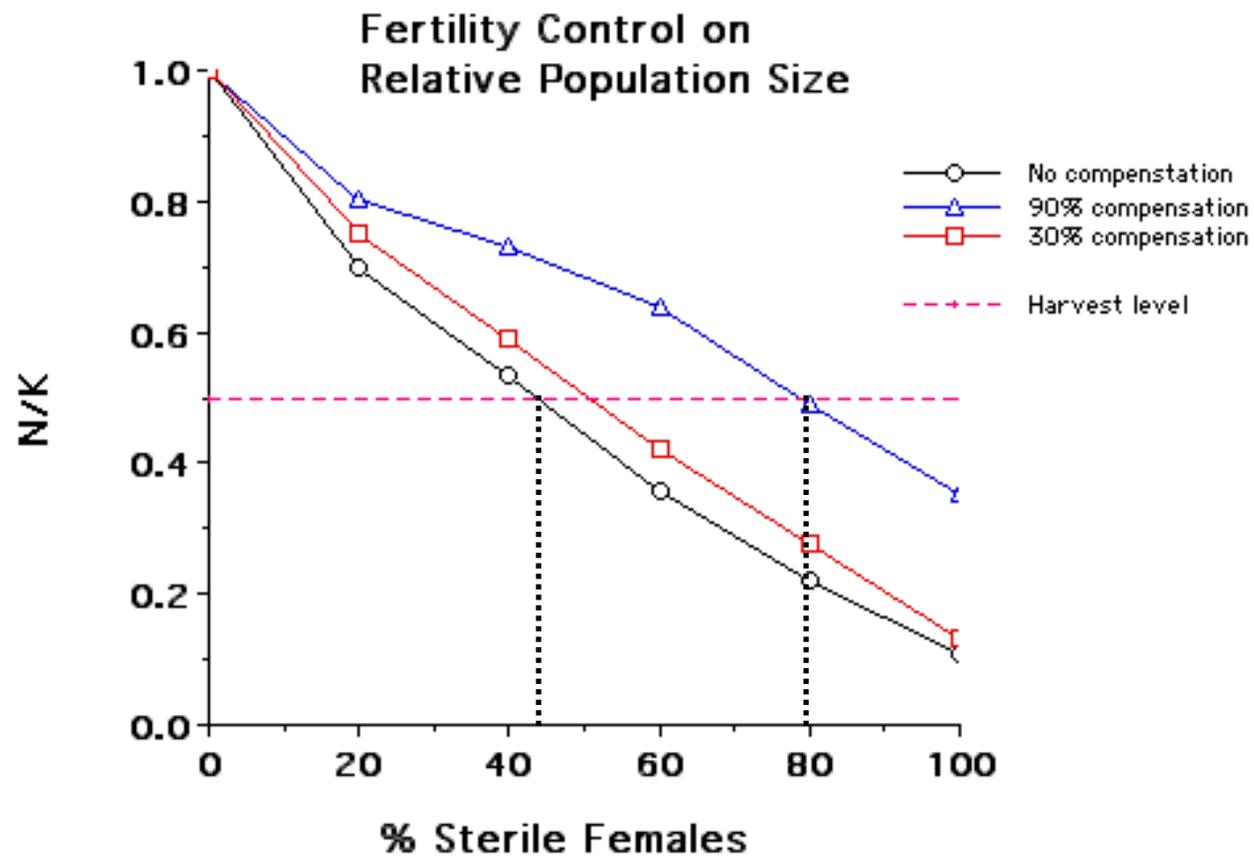
Critically important for tuning the model

Model forecasts: Numbers

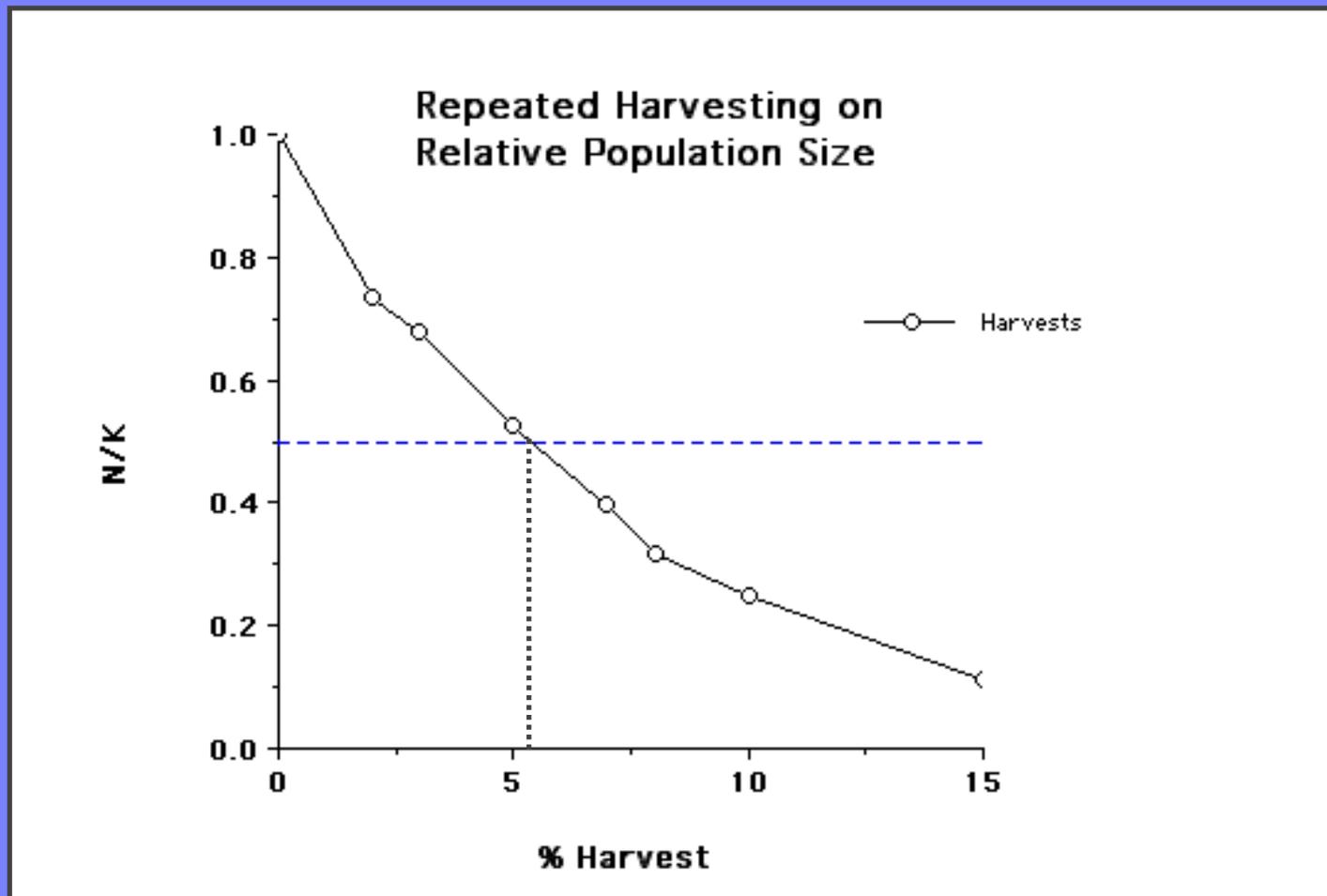
SHACKLEFORD HORSE POPULATION



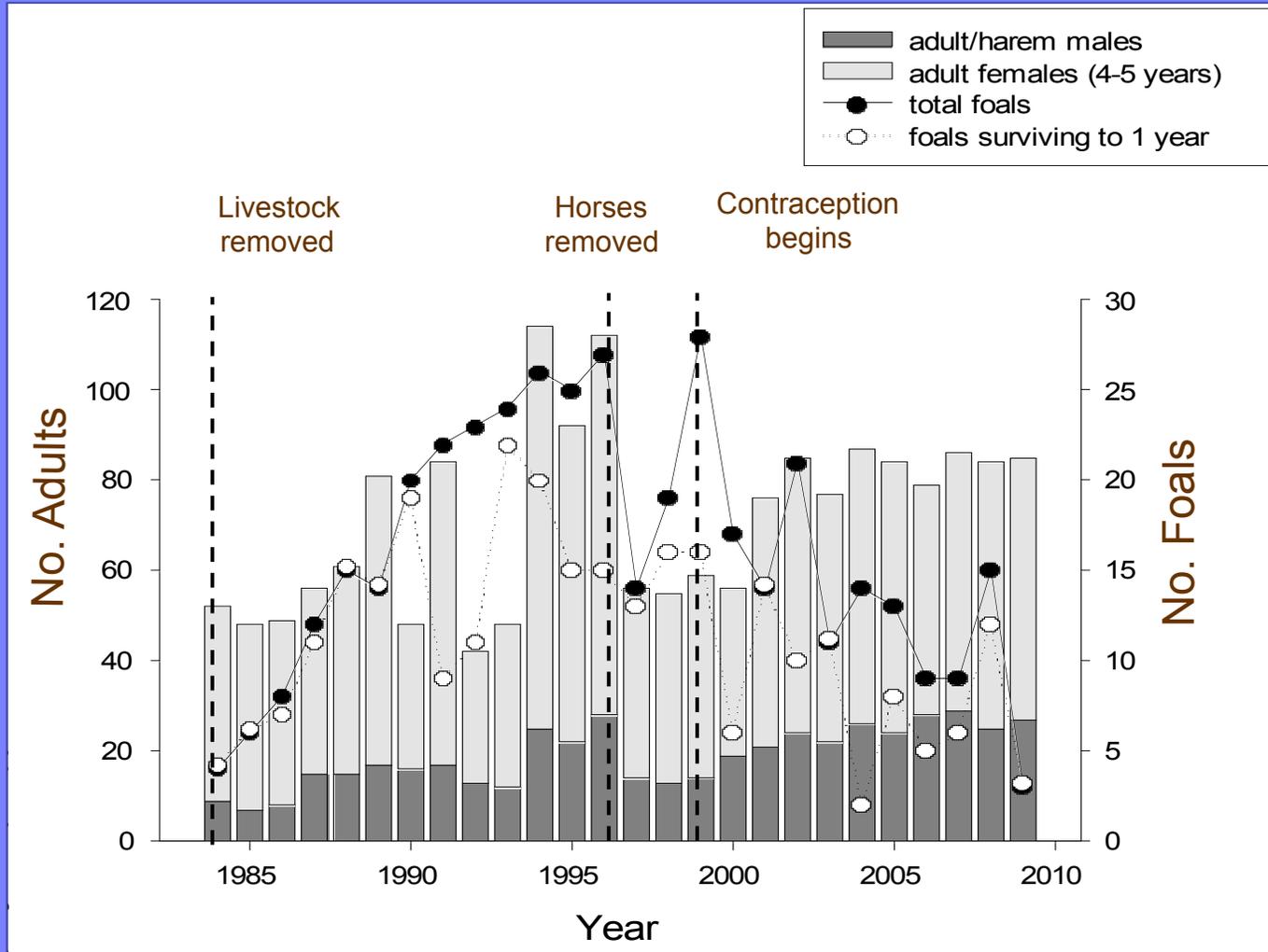
Model forecasts: Fertility control



Model forecasts: Removals



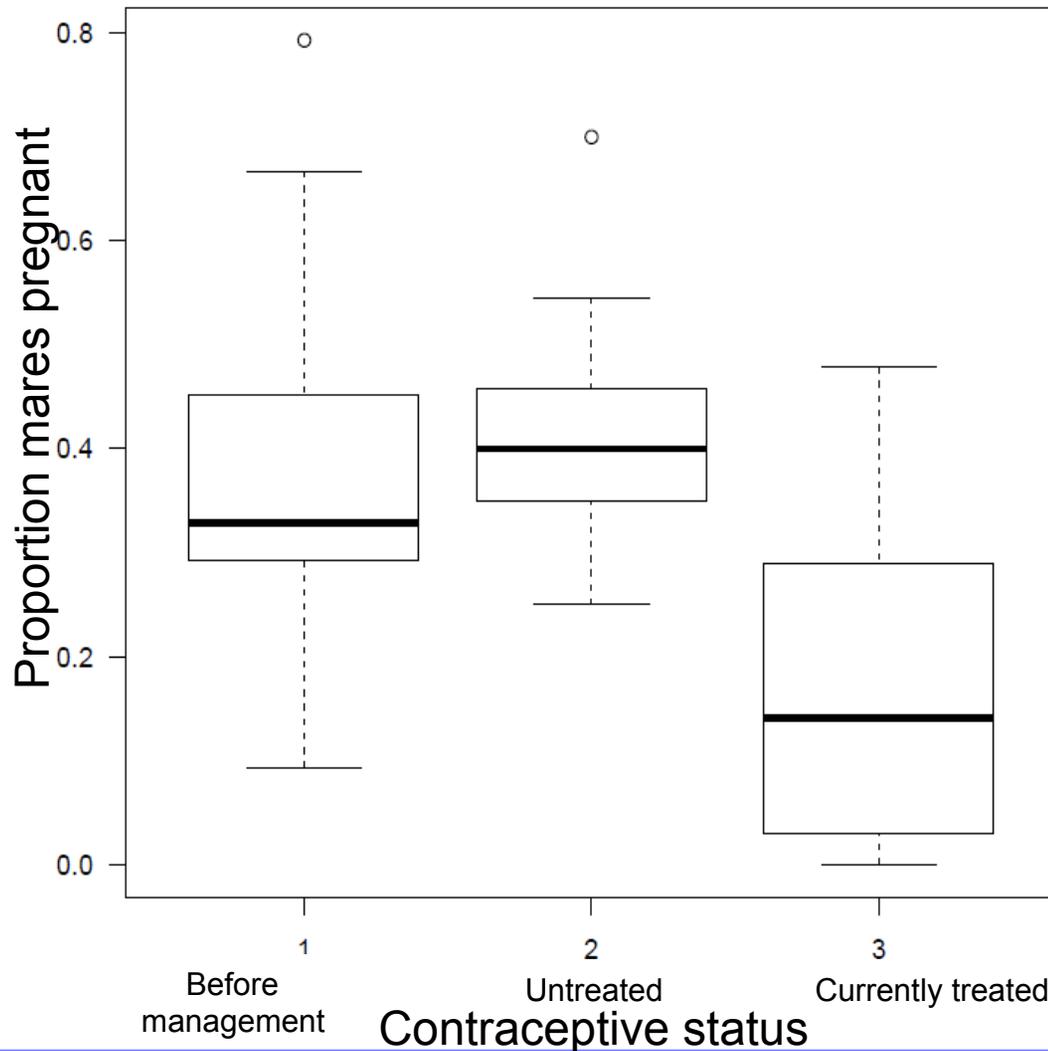
10 Years On: Successful Control



Major outcomes

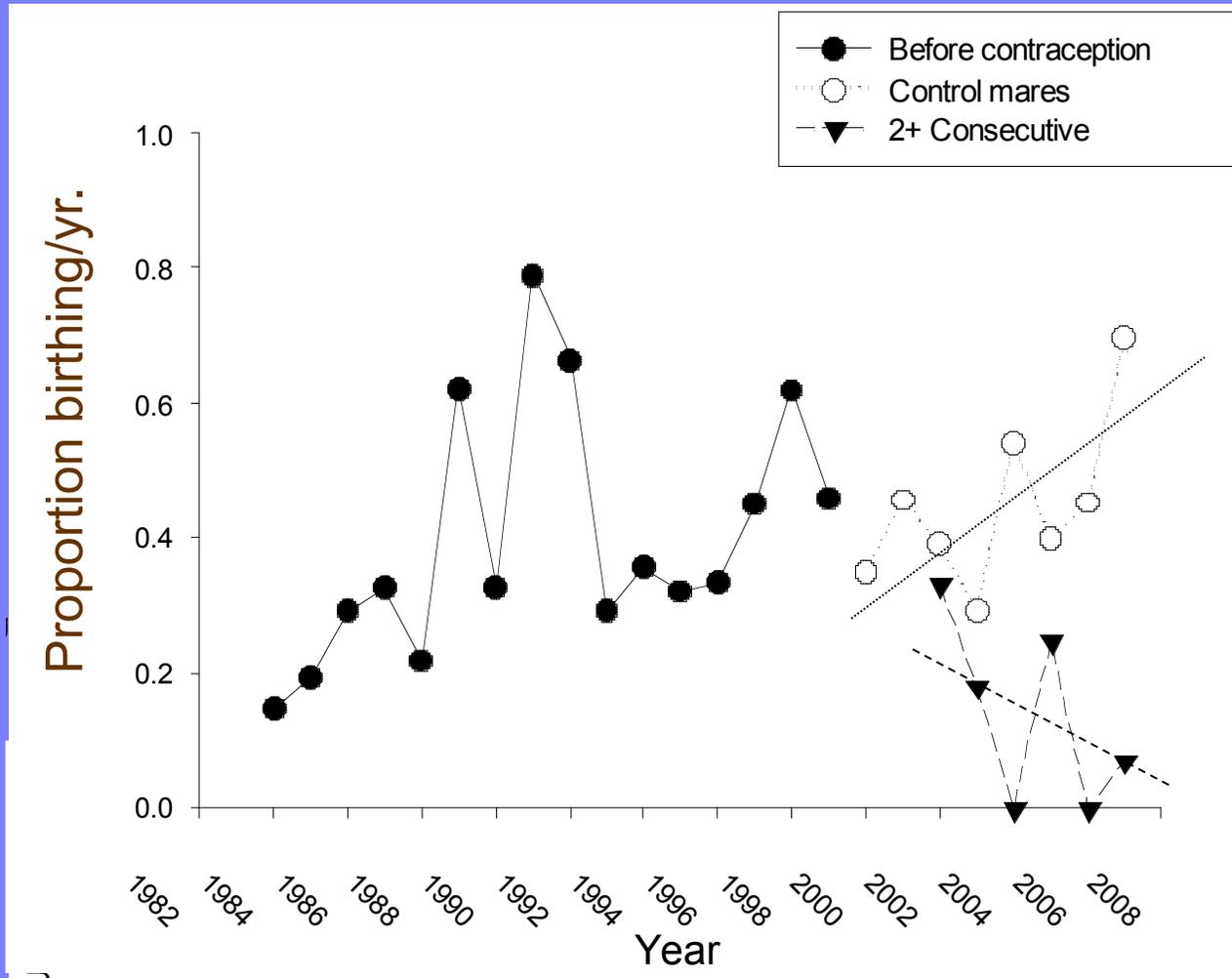
- 1) Population stabilizes
- 2) Birth rate declines

Success: Females giving birth declines



1. Controls breeding normally
2. Contraception very effective

Unintended Consequences: 1. Contraception



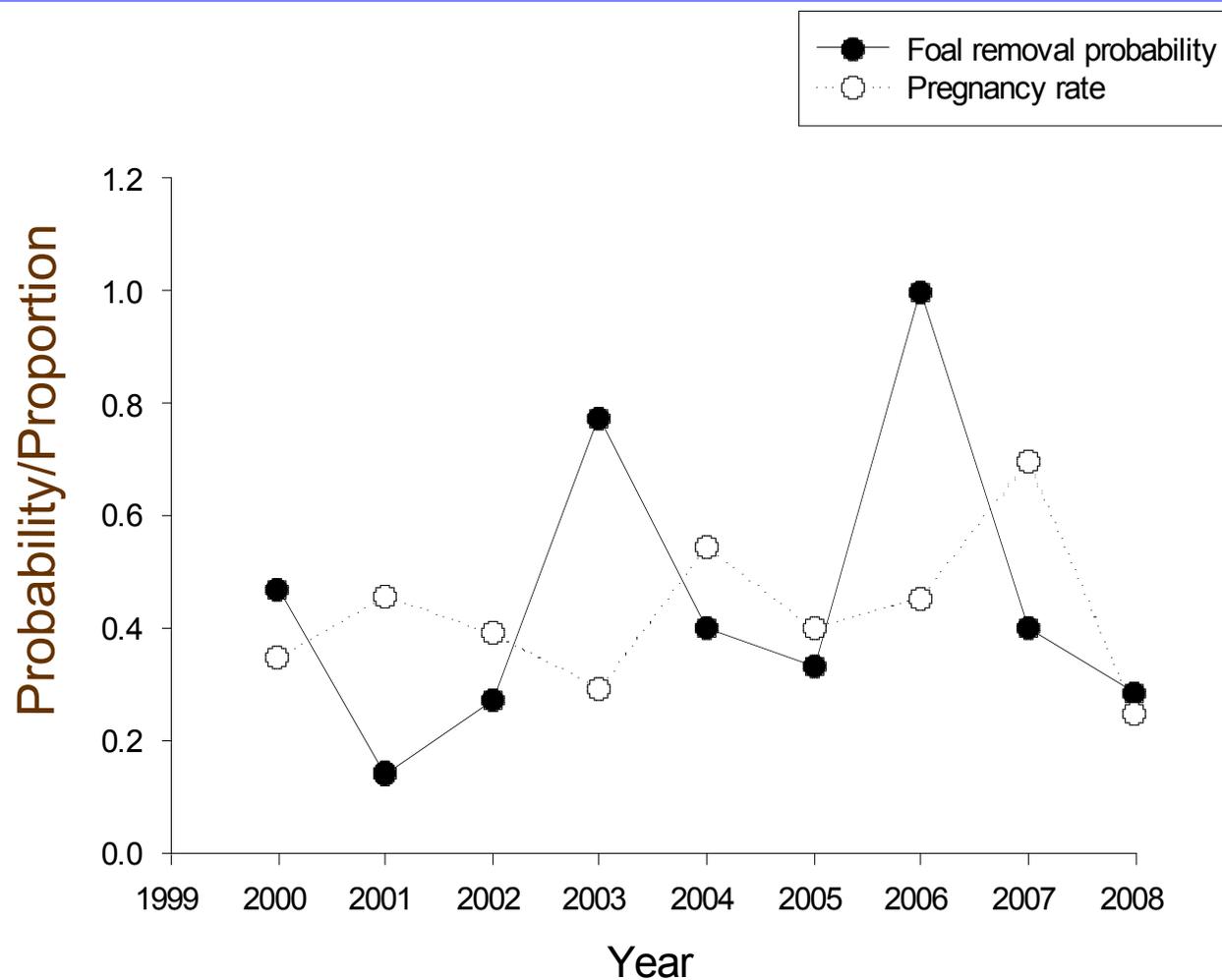
Surprising dynamics

'Control' females show increasing birth rate

Contracepted show decreasing birth rate

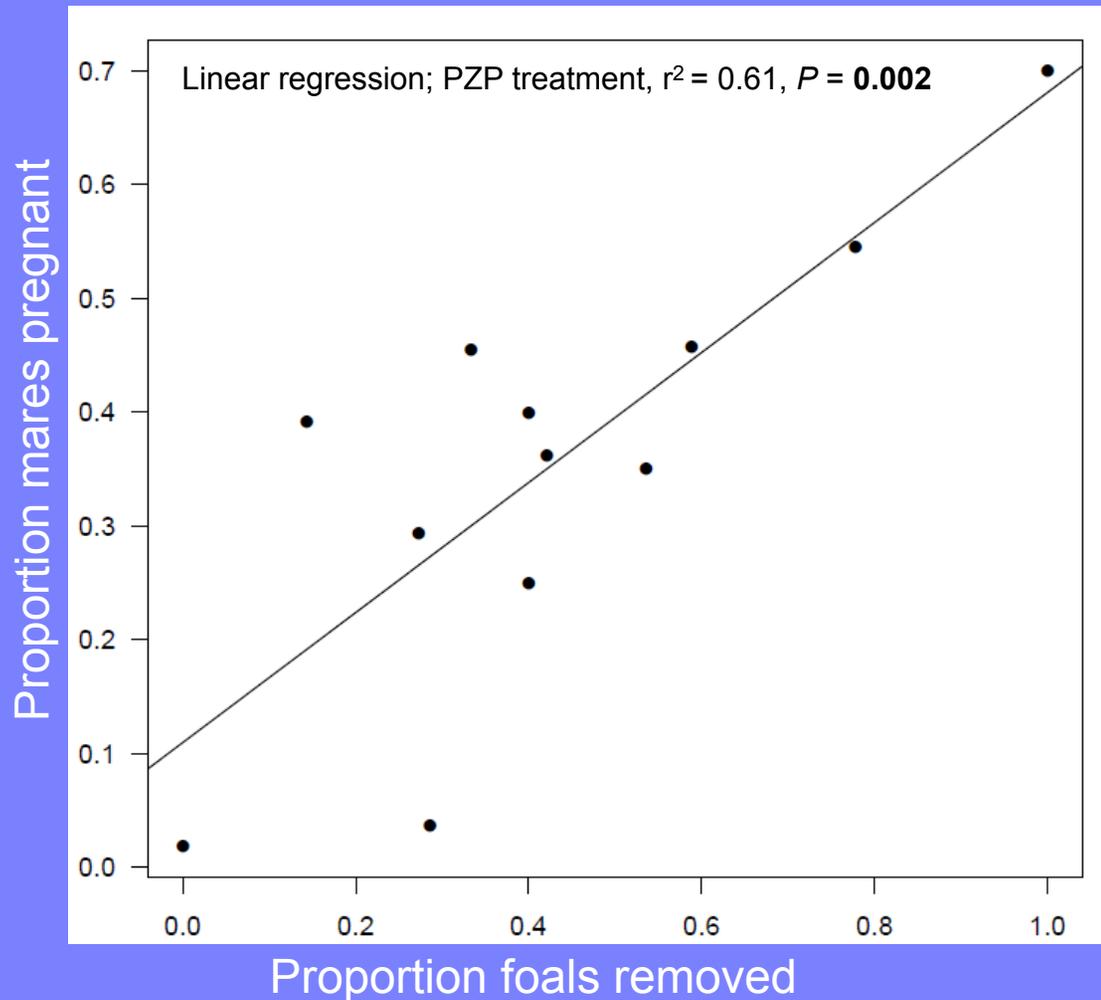
- *Permanent damage*
- *End of controls*

2. Removals



Rapid birth pulses
after pulsed
removals

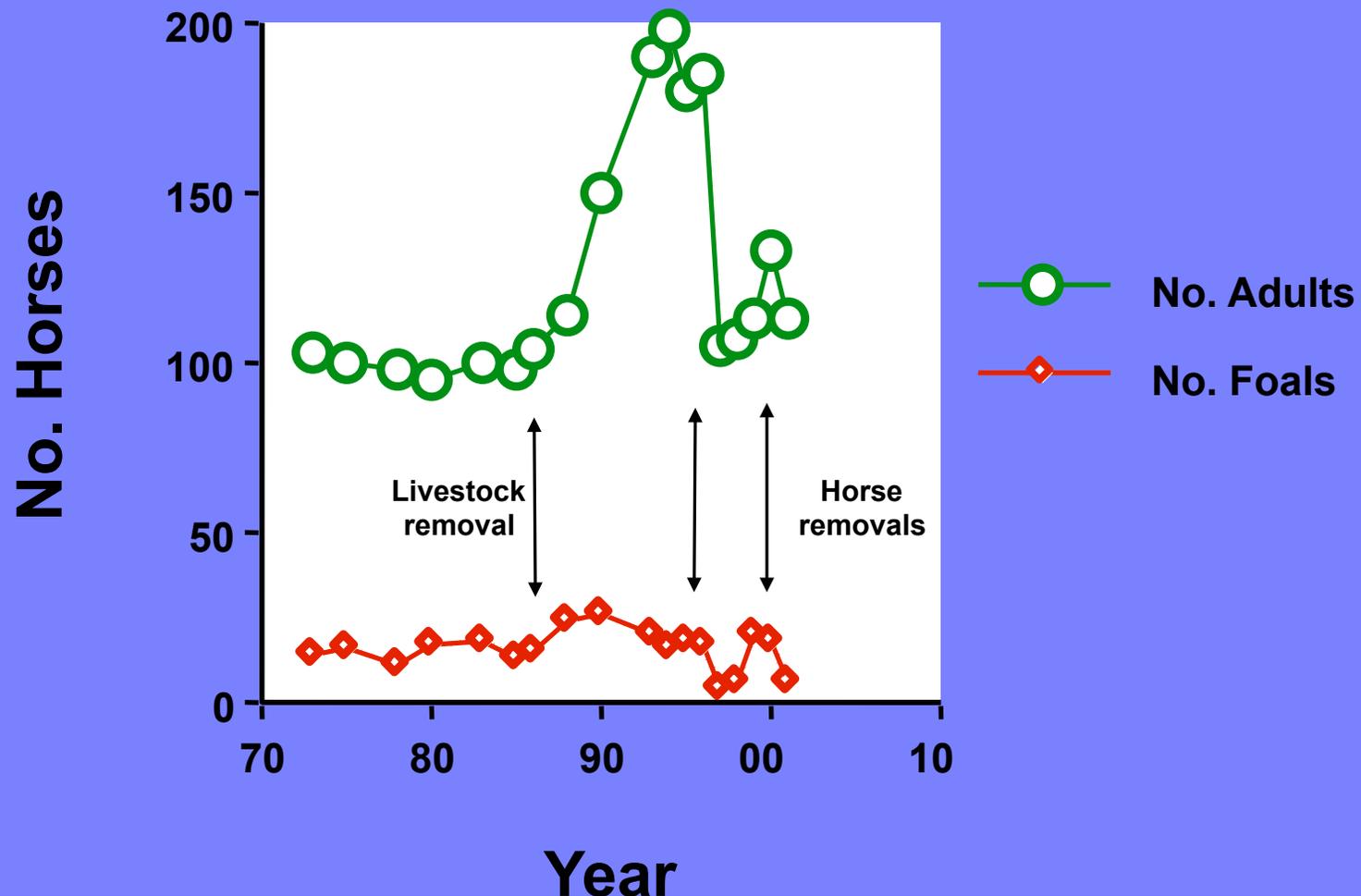
Aggregated Pattern



Makes it difficult to care for removed horses

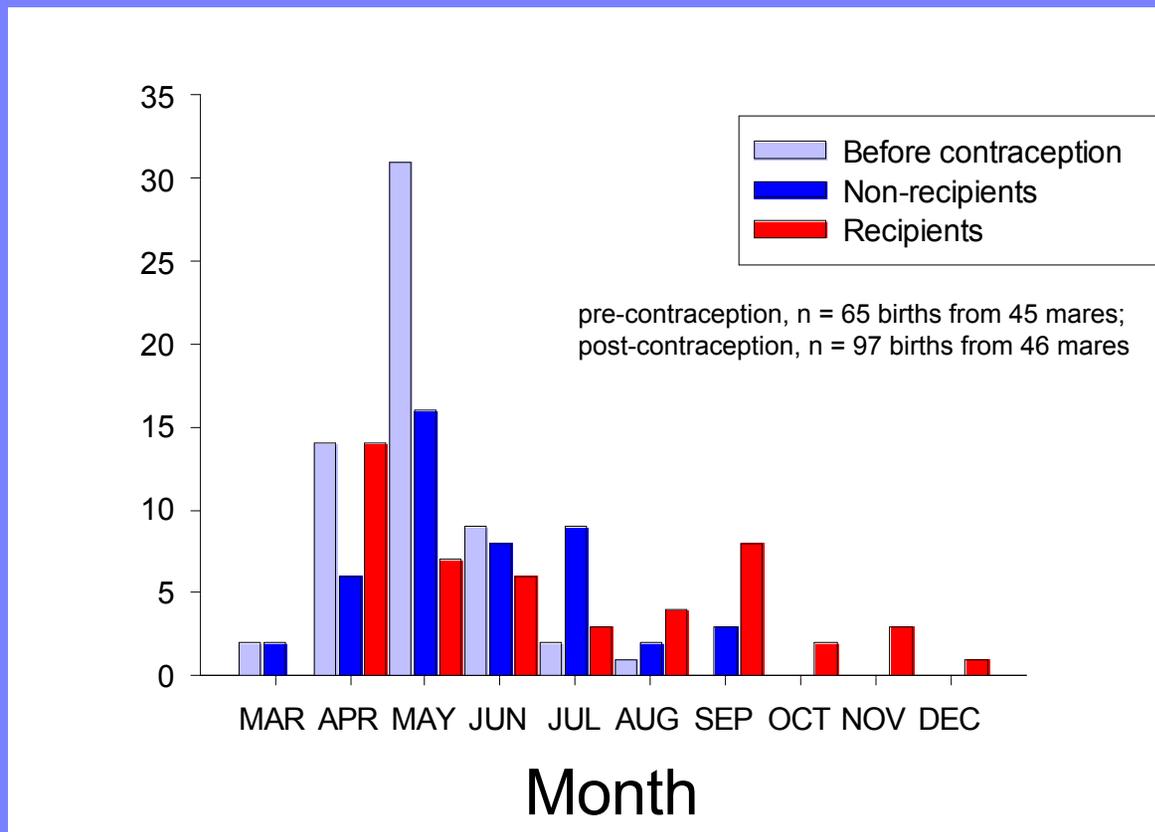
'Knock on Effect' on Demography

Variable density dependence....



3. Birth date

- Gestation lasts 11-12 months
- Conception can be reliably determined from foals' birth dates
- Birth dates of foals born before and after contraception management



Breeding season extended

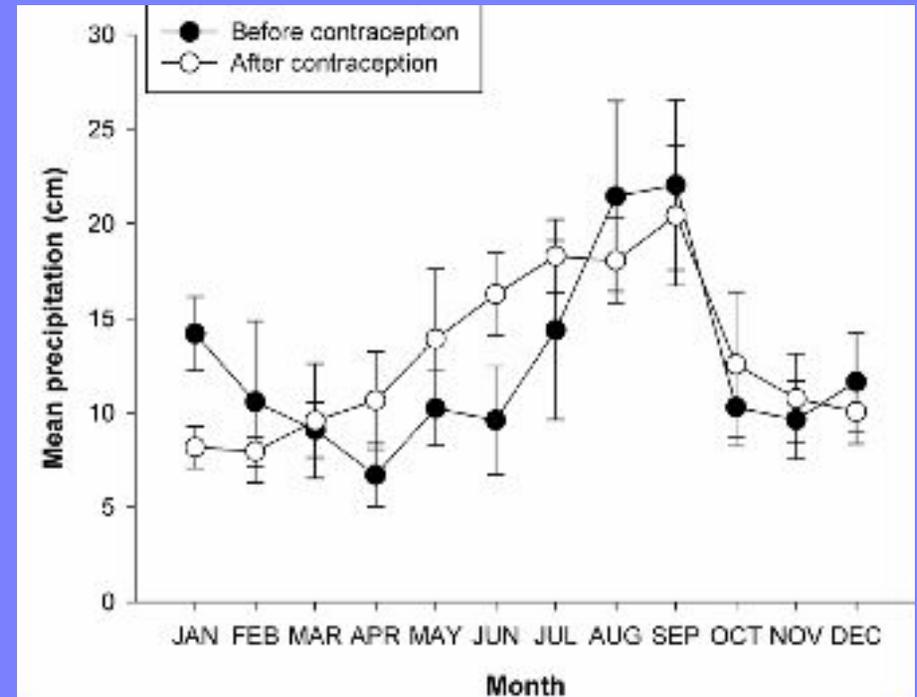
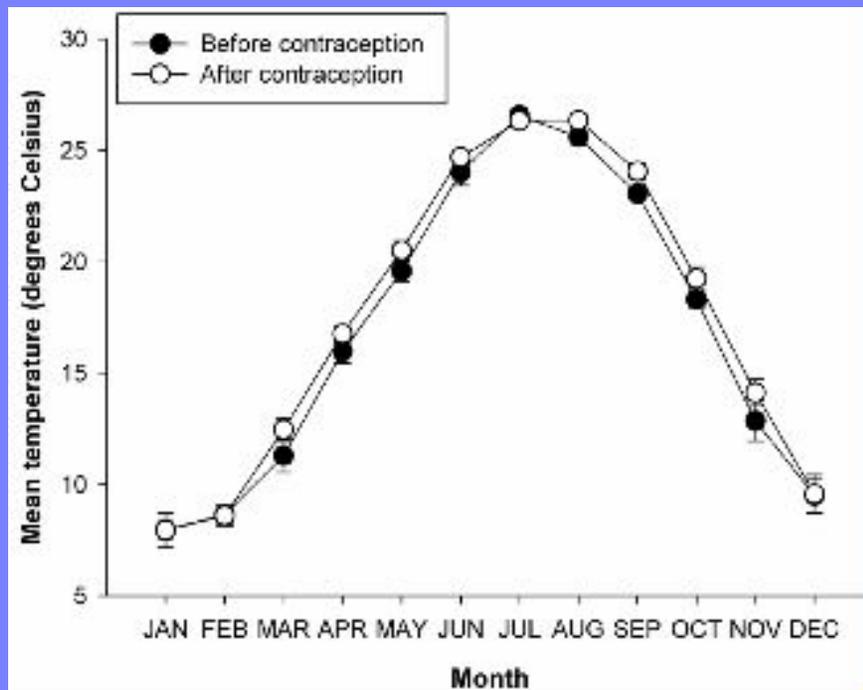
- Births during winter
- No 'off season' for recovery

Generalized Linear Model; $r^2 = 0.21$, $P < 0.001$;
recipients: estimate = 1.98, SE = 0.36, $t = 5.51$, $P < 0.001$;
non-recipients: estimate = 1.07, SE = 0.26, $t = 4.20$, $P = 0.001$

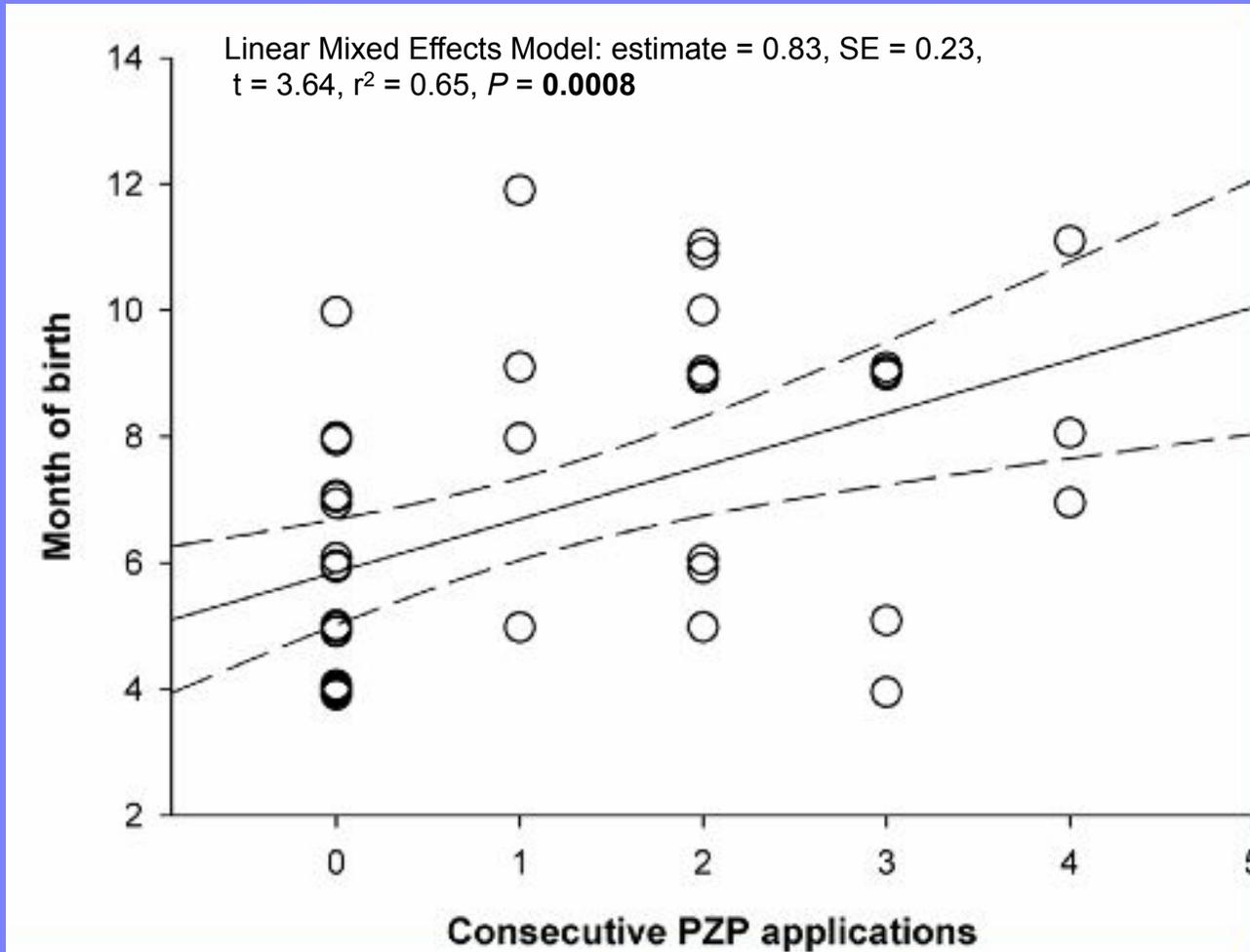
Nuñez, C.M.V., J.S. Adelman, and D.I. Rubenstein. 2010. PLoS ONE.

Weather matters...

Recent conditions more favorable

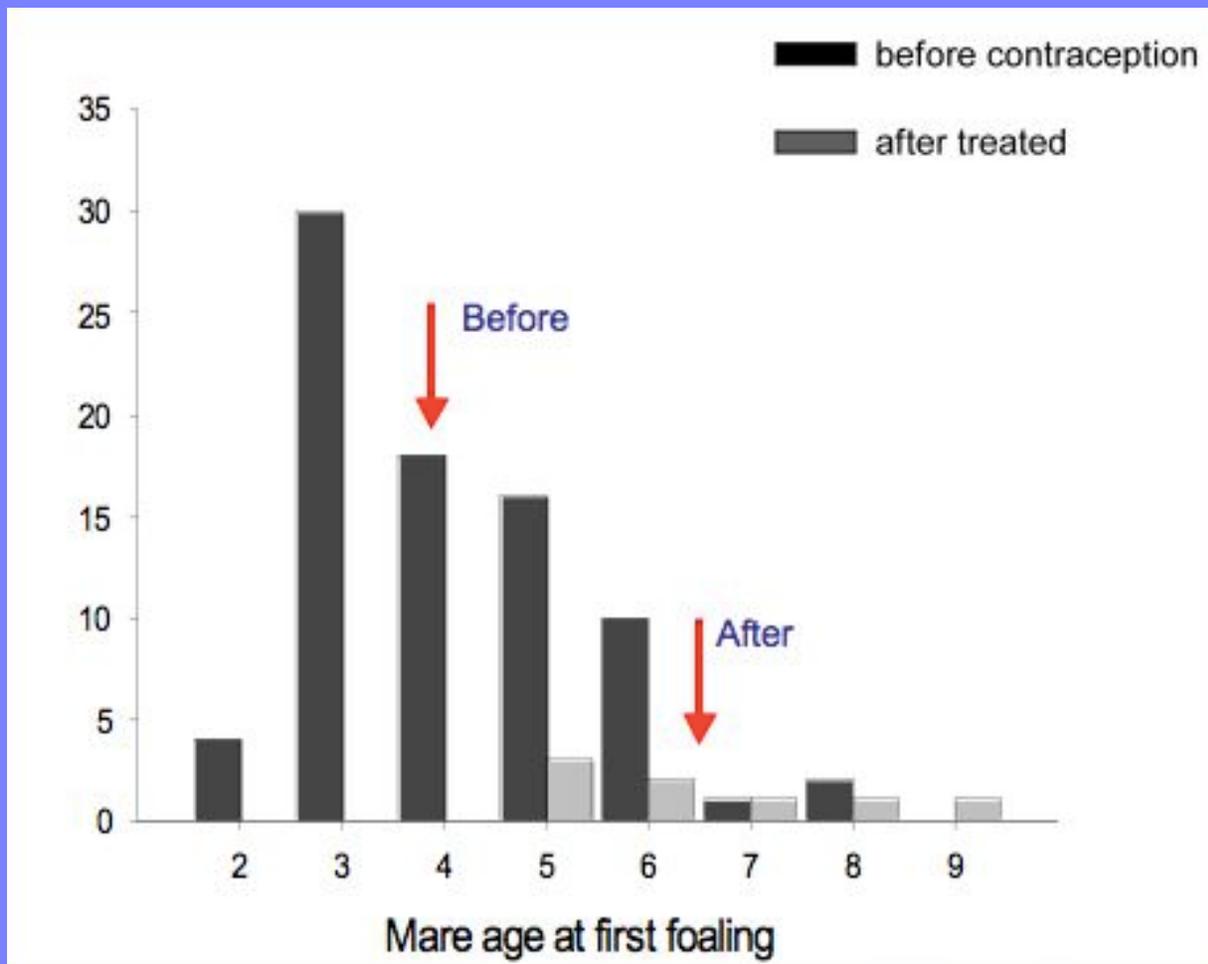


...so does repeated immunocontraception



- repeated PZP delays average birthday
- consecutive PZP does so even more

4. Maturity



Maturity delayed

Before contraception
Mean age = 4.0 yrs.

After contraception
Mean age = 6.4 yrs.

- *Naturally slows
population growth*

- *But is it natural?*

What about behavior?

Primer on Equid Social Systems

Living Equids

Social System

Plains Zebras

Mountain Zebras

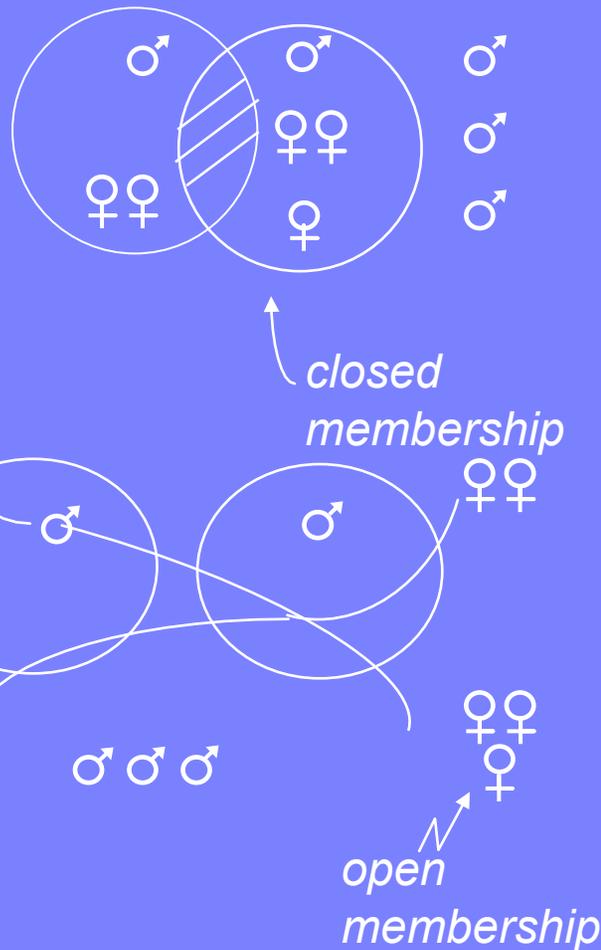
Wild Horses

Feral Domestic Horses

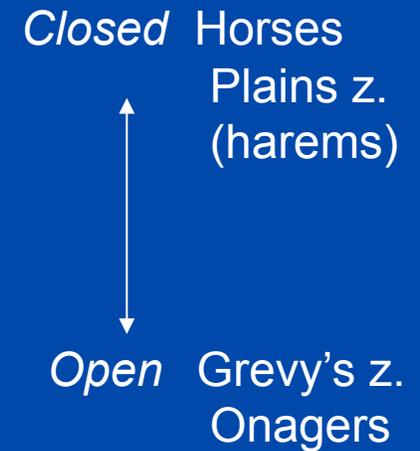
Grevy's Zebras

Asiatic Wild Asses

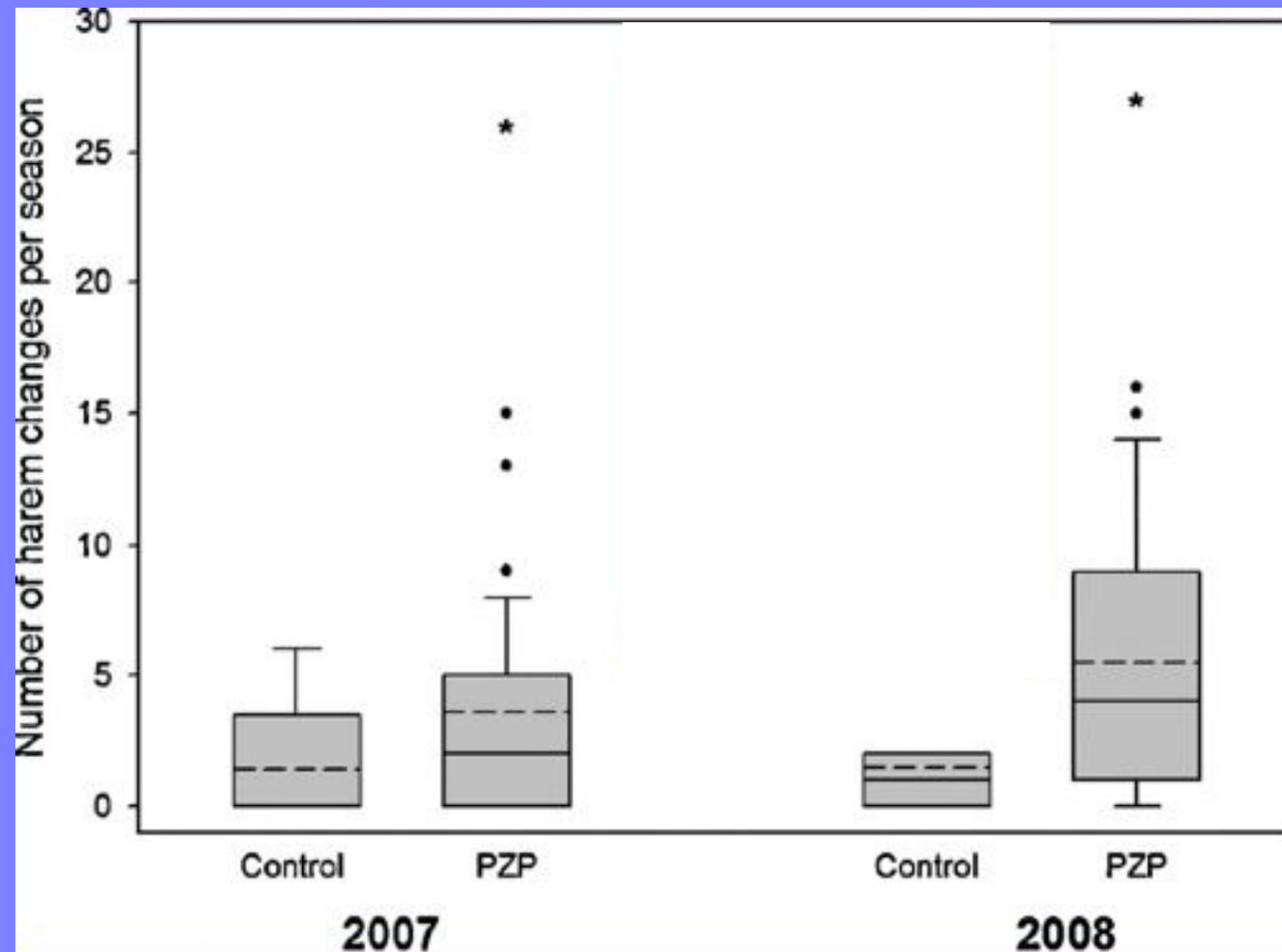
African Wild Asses



- 2 Social Systems



5. Stability



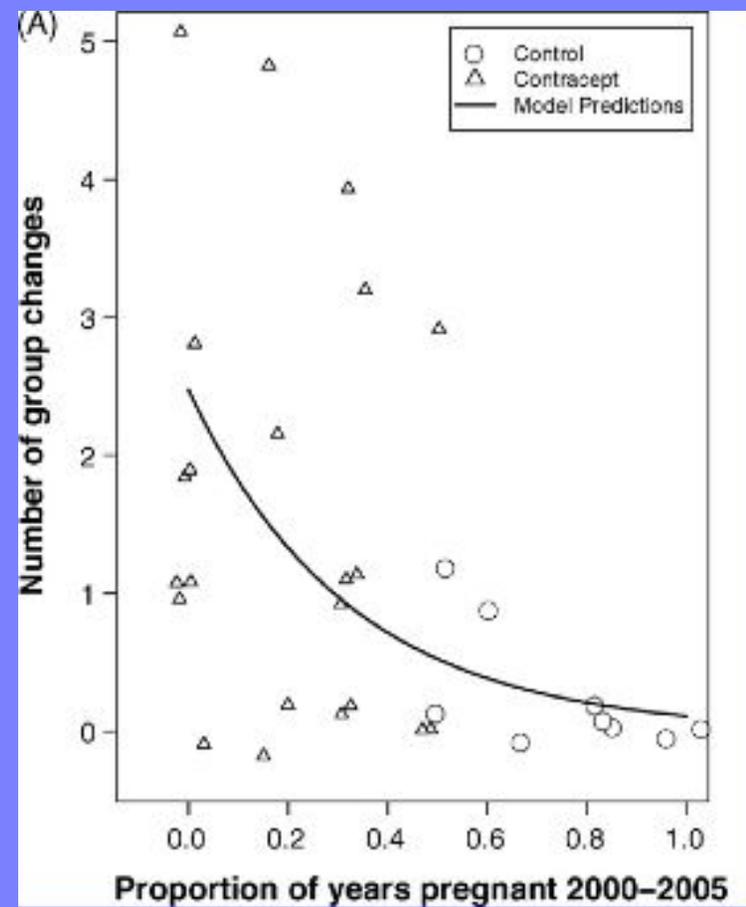
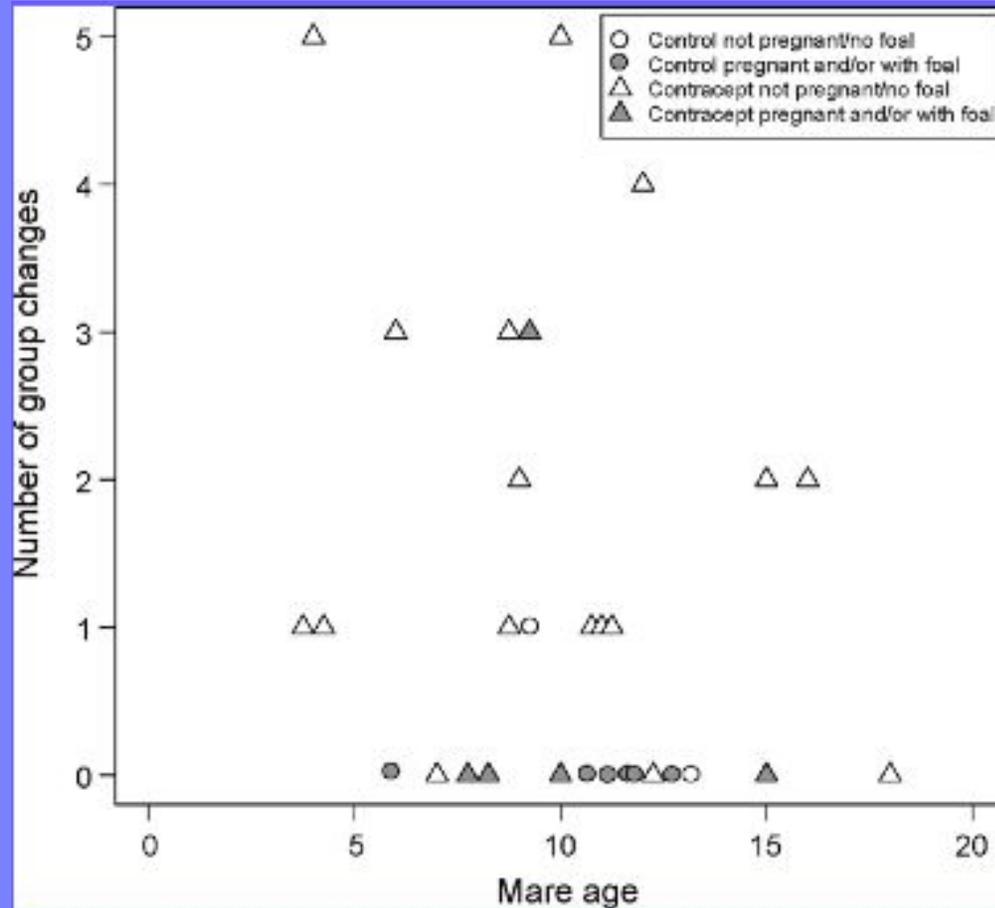
1) PZP treated females change groups more often

2) 2007: $P = 0.037$
2008: $P = 0.016$

3) Social instability increased from historical 10% to ~ 70%

4) Females w/out foals move more

Factors influencing female group changes



Nuñez, Adelman, Mason, Rubenstein (2009)
Applied Animal Behaviour Science

Consequences of female movements

1) When females change groups inter-individual spacing changes

Spacing increases

Spacing decreases

Harem size increase
Harem size decrease

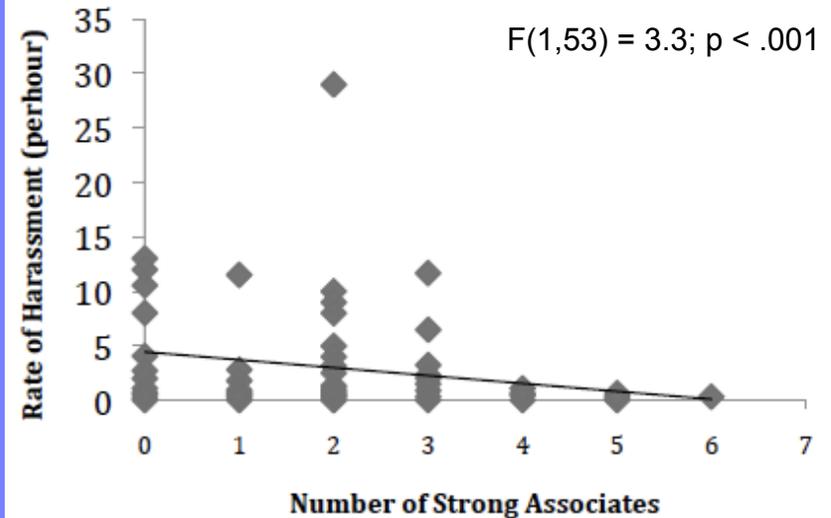
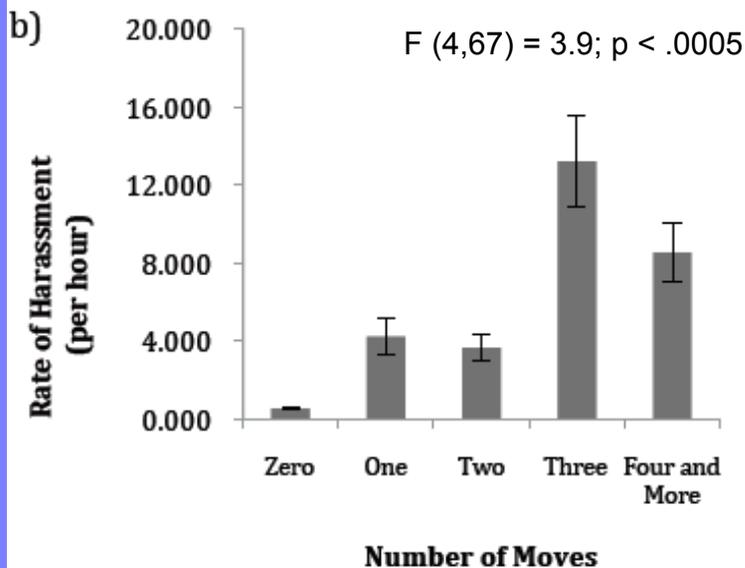
15
4

5
20

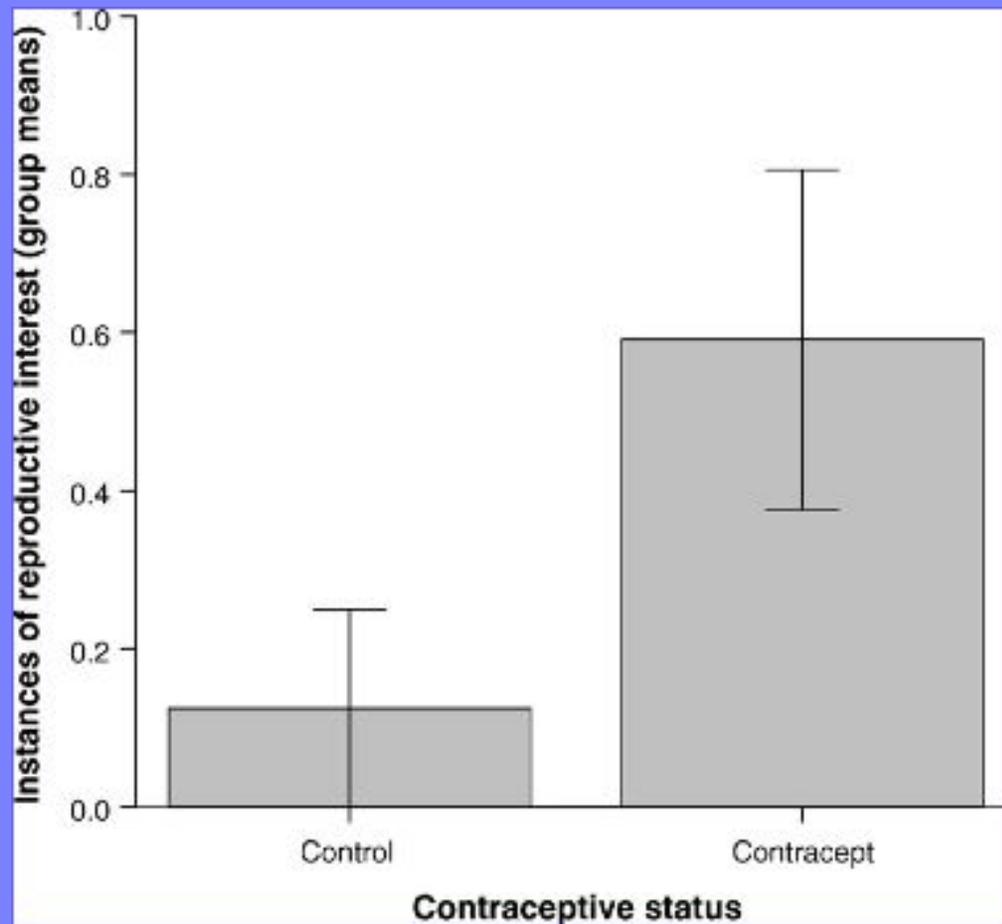
$chi^2 = 15.1; p < .0001$

2) Females that move are harassed more than those that do not

3) Harassment declines as number of many close & strong associates increases



Heightened male interest...



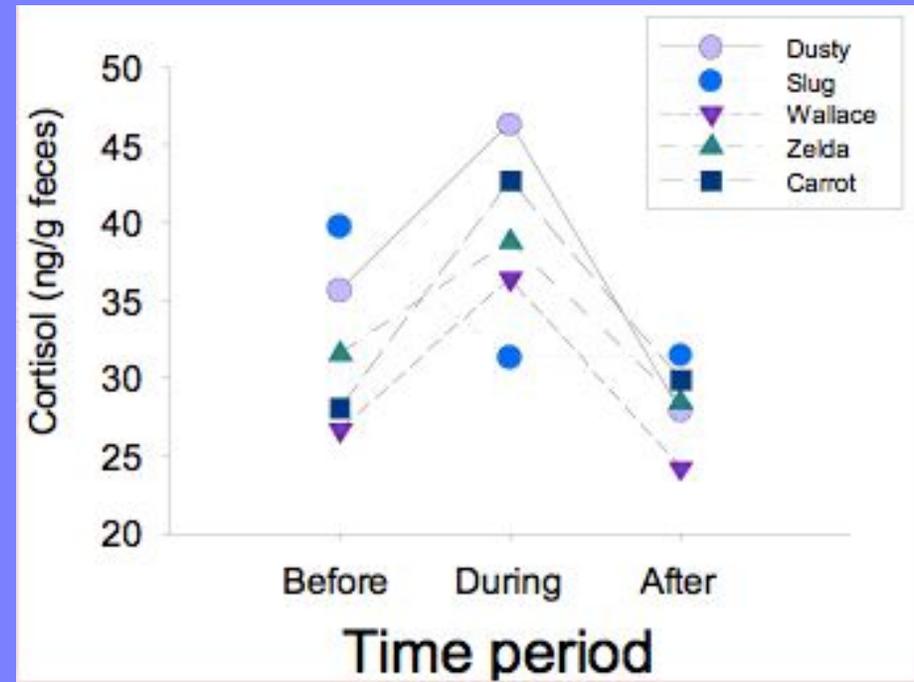
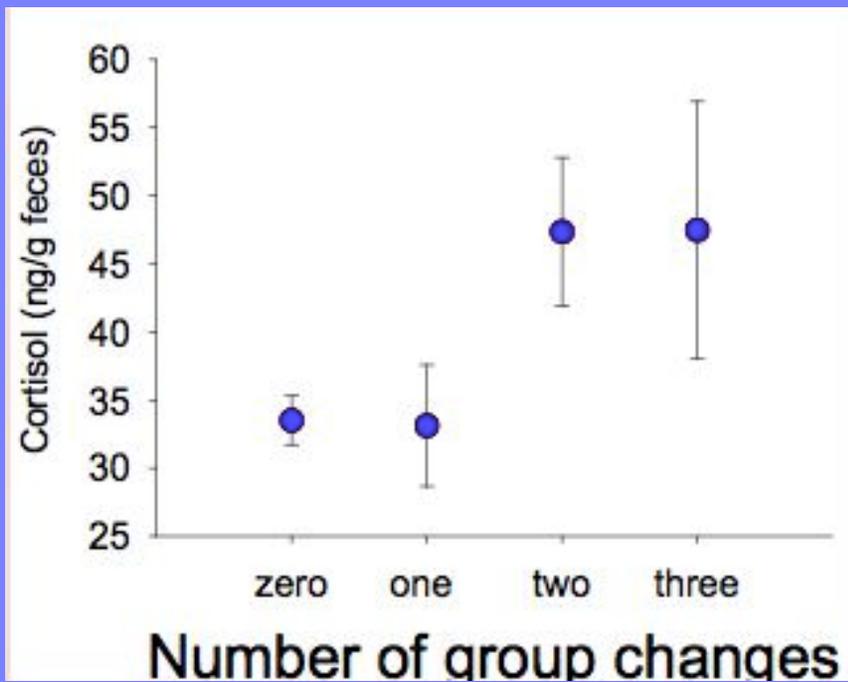
Contracepted females continue to cycle, attracting male attention...

... even during non-breeding season

Núñez, Adelman, Mason, Rubenstein (2009)
Applied Animal Behaviour Science

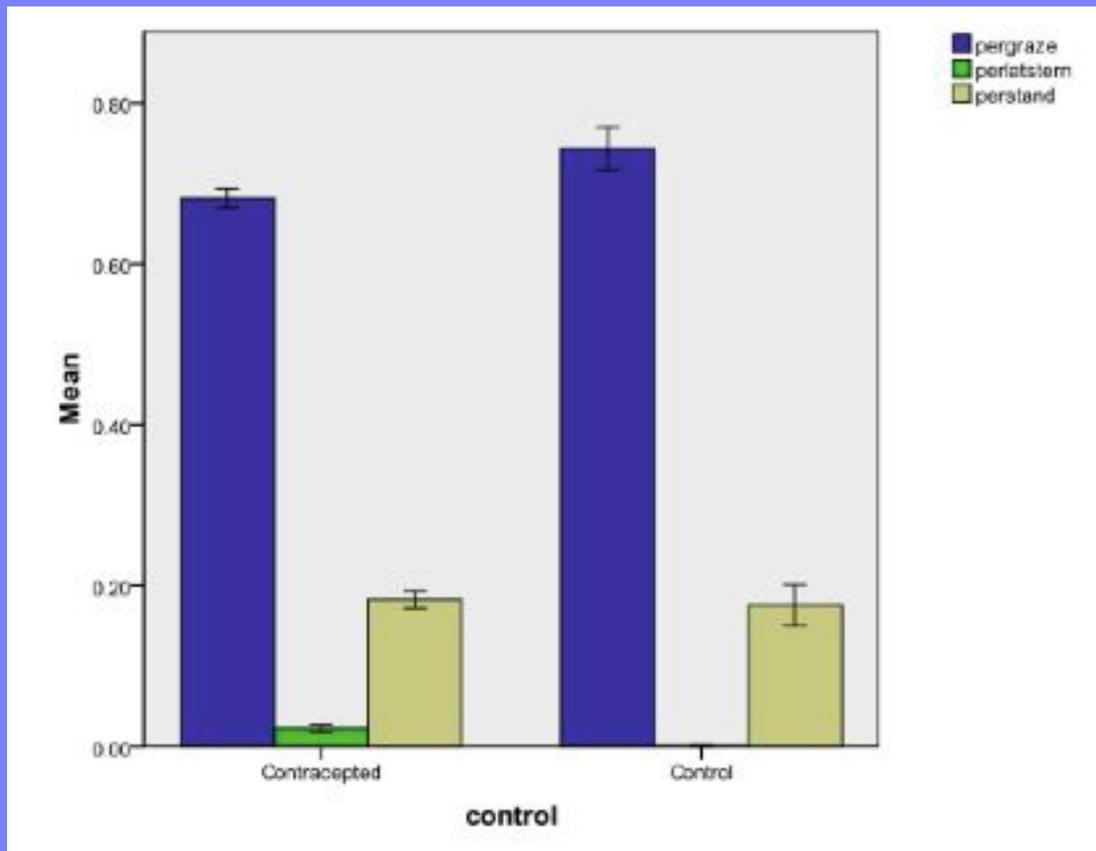
...Increases stress

Cortisol levels



Instability leads to stress

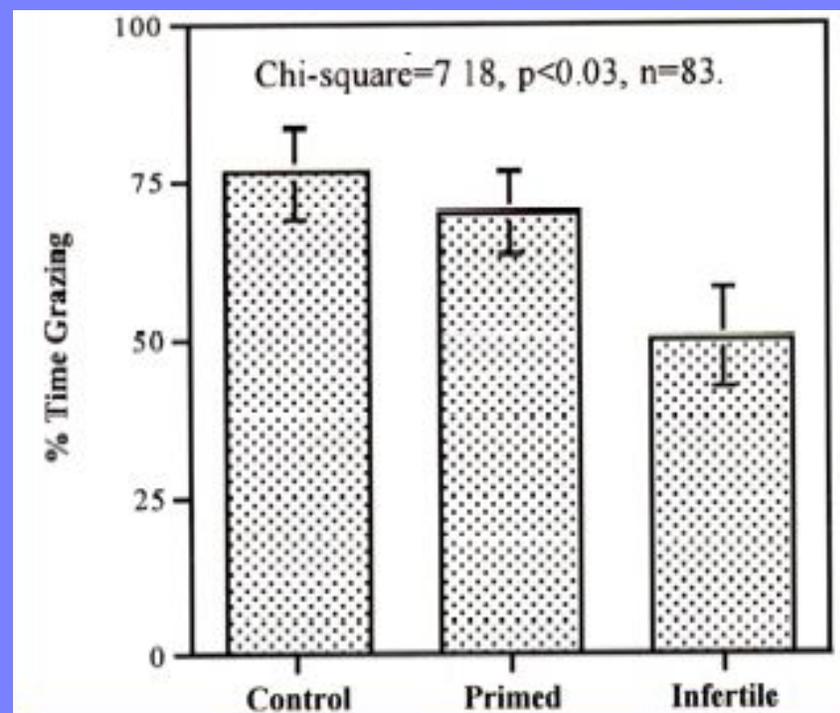
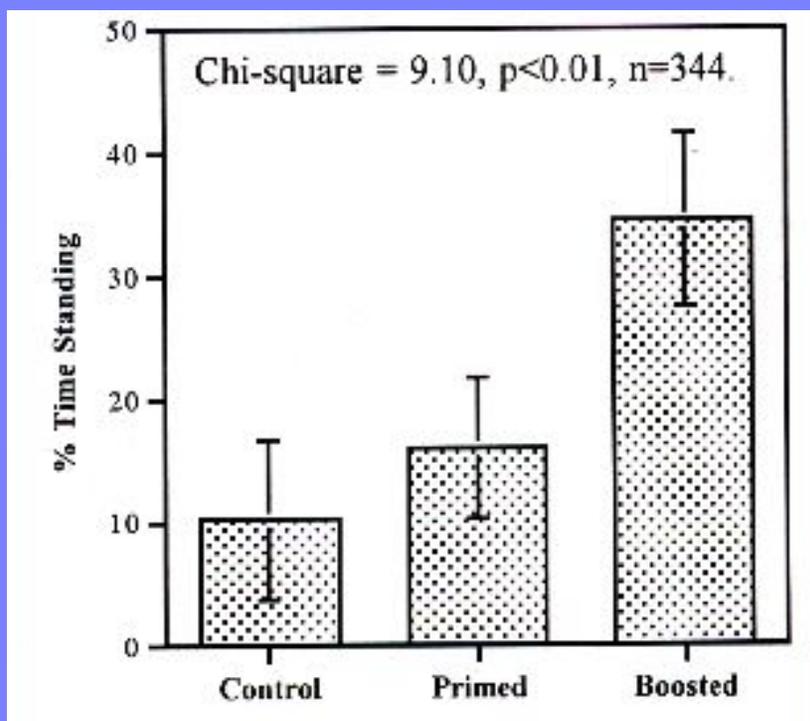
6. Time Budgets



Adult contracepted females
feed less & rests more

Time budgets for the young...

Time budgets for primiparous females...



...mounting an immune response appears to be costly

Should we care
About unintended consequences?



Photo by Cassandra Nuñez

Is the glass half full or half empty?

Why balancing these two strategies matters...

1. Immunocontraception & removals are both effective alone
2. But they work better if together -- they mitigate each other's problems
3. The problems are real:
 - a) removals and adoptions come in pulses & are difficult to arrange and costly to maintain
 - b) successful reduction in population size *increases* the number of desirable horses that can be removed
 - c) PZP increases the age of first reproduction, limiting the pool of females that can be contracepted
 - d) Limiting this pool increases the likelihood of having to repeatedly contracept the same individuals
 - e) Contracepting the same females can sterilize them and increase the average birthday, pushing births into the winter
 - f) Breeding in the winter limits recovery time during harshest time of year
 - g) This adds to the stress caused by PZP induced changes in behavior
 - contracepted females move more & are harassed more
 - contracepted females feed less
 - both behavioral changes lower condition, health & presumably fertility

Because d, e, f & g negatively impact individuals while facilitating management, is the glass half full or half empty?