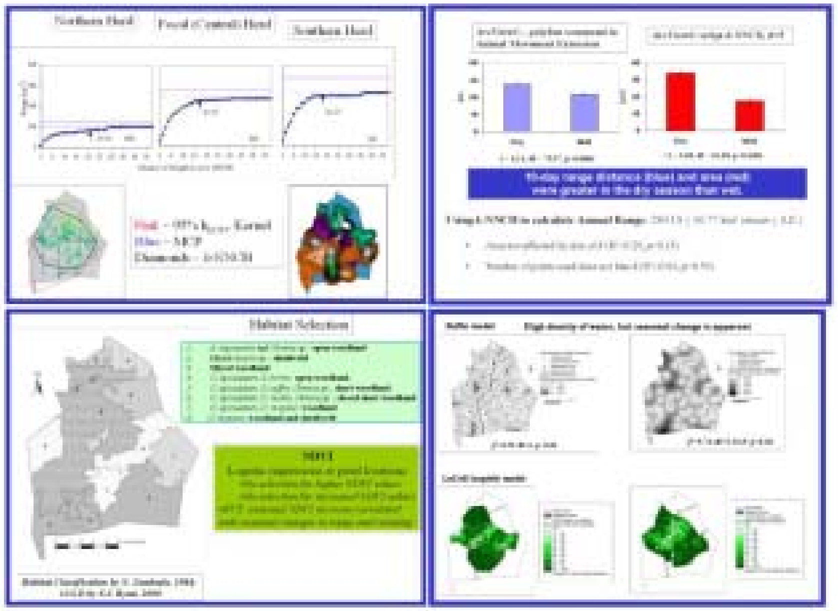
Ecological determinants of birth timing in African Buffalo (*Syncerus caffer*) in the Klaserie Private Nature Reserve, South Africa.

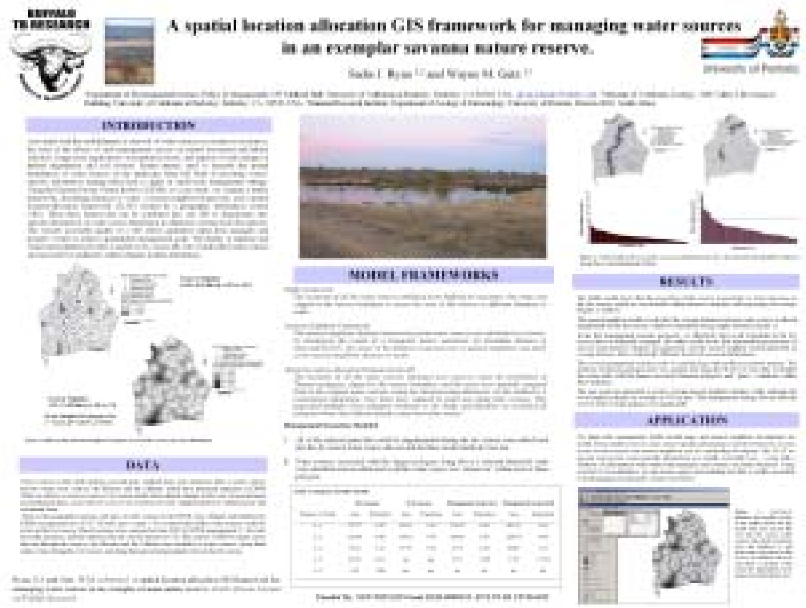
(and final project report)

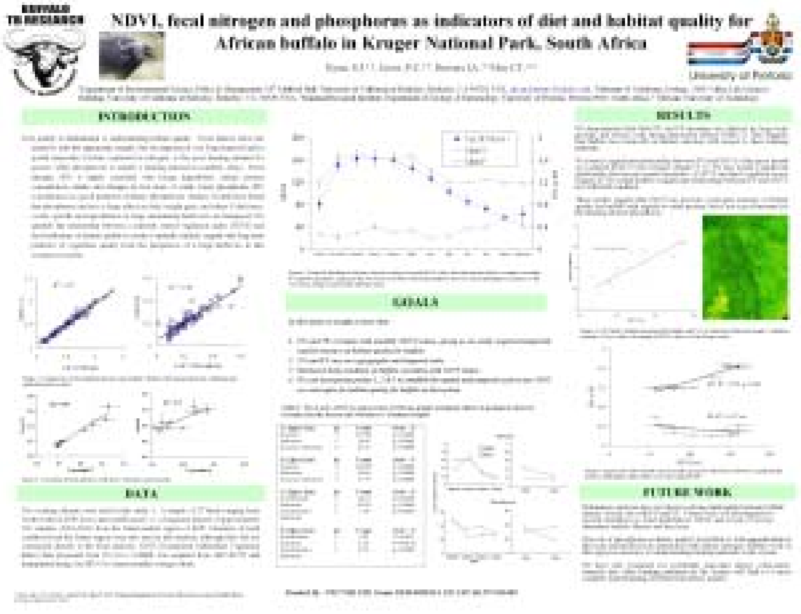
S.J. Ryan[1*2], C. U. Knechtel[3] & W.M. Getz[1,4]

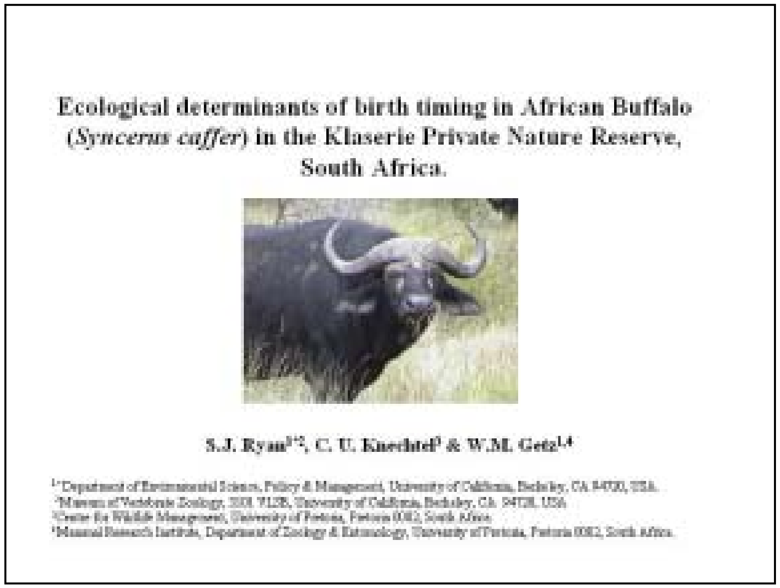
[1*] Department of Environmental Science, Policy & Management, University of California, Berkeley, CA 94720, USA.
[2]Museum of Vertebrate Zoology, 3101 VLSB, University of California, Berkeley, CA 94720, USA
[3]Centre for Wildlife Management, University of Pretoria, Pretoria 0002, South Africa
[4]Mammal Research Institute, Department of Zoology & Entomology, University of Pretoria, Pretoria 0002, South Africa.

Dissertation: Spatial Ecology of African buffalo and their resources in a savanna landscape









Dissertation: Spatial Ecology of African buffalo and their resources in a savanna landscape

Activity patterns of African buffalo *Syncerus caffer* in the Lower Sabie Region, Kruger National Park, South Africa

S.J. Ryan and W. Jordaan

Ryan, S.J. and W. Jordaan. 2005. Activity patterns of African buffalo *Syncerus caffer* in the Lower Sabie Region, Kruger National Park, South Africa. *Koedoe* 48(2): 117–124. Pretoria. ISSN 0075-6458.

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COMMUNITY ECOLOGY

J. V. Redfern · S. J. Ryan · W. M. Getz

Defining herbivore assemblages in the Kruger National Park: a correlative coherence approach

Received: 29 November 2004 / Accepted: 10 August 2005 / Published online: 11 October 2005

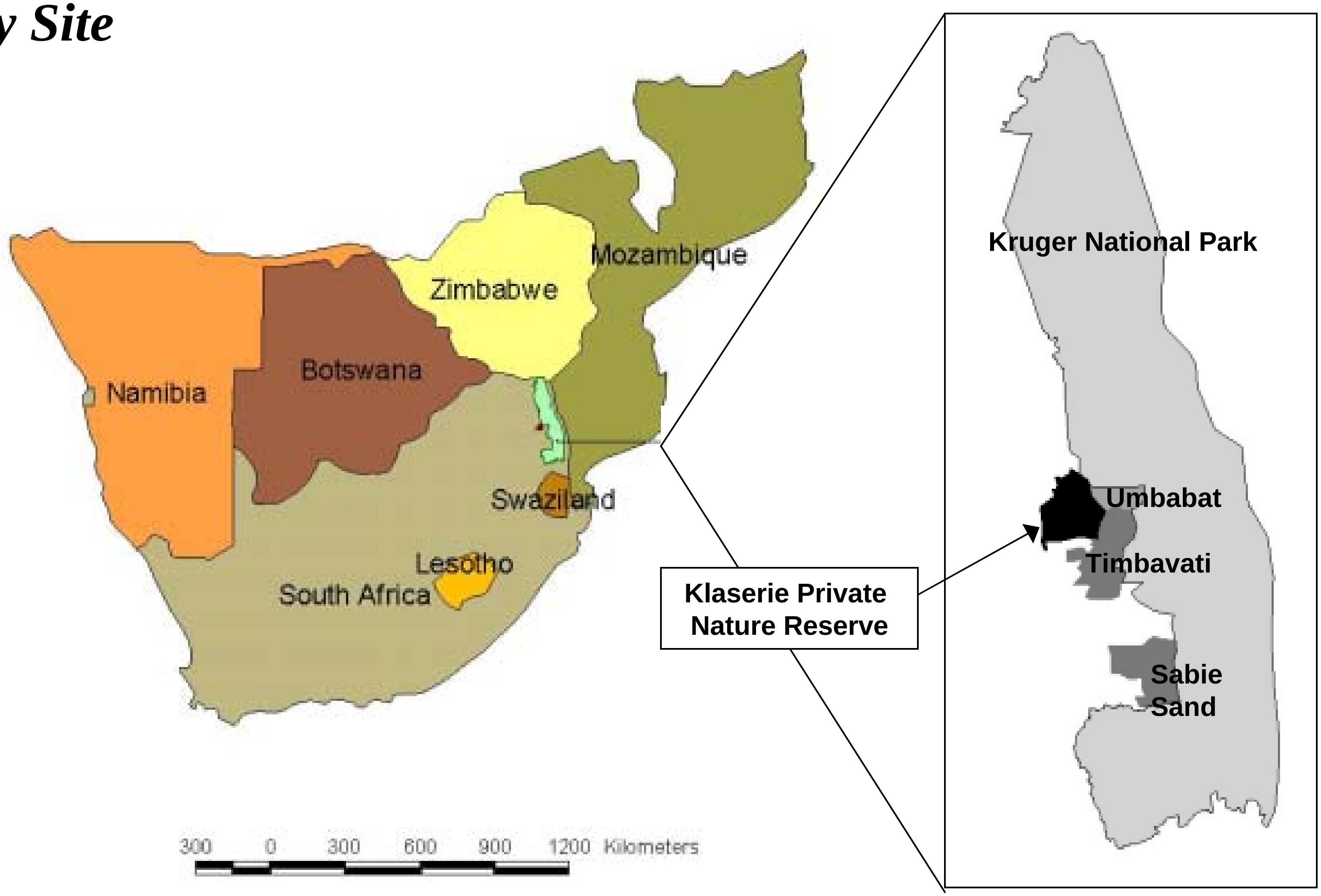
- Demography and association
- Distribution of herd sizes and habitat selection in KNP

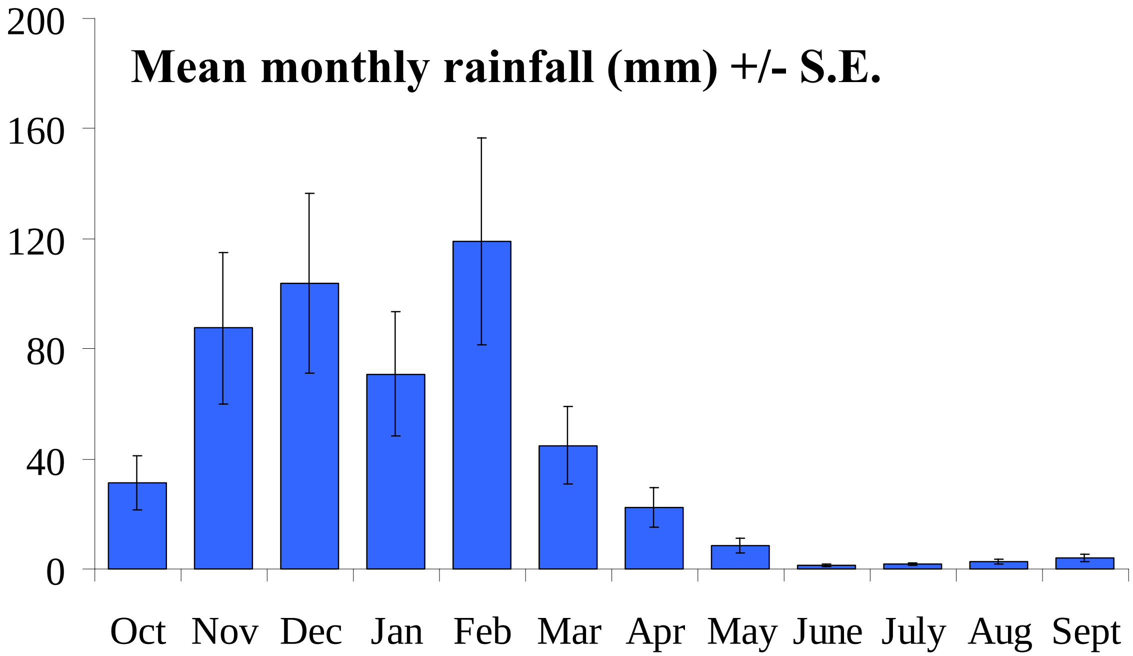
Main questions

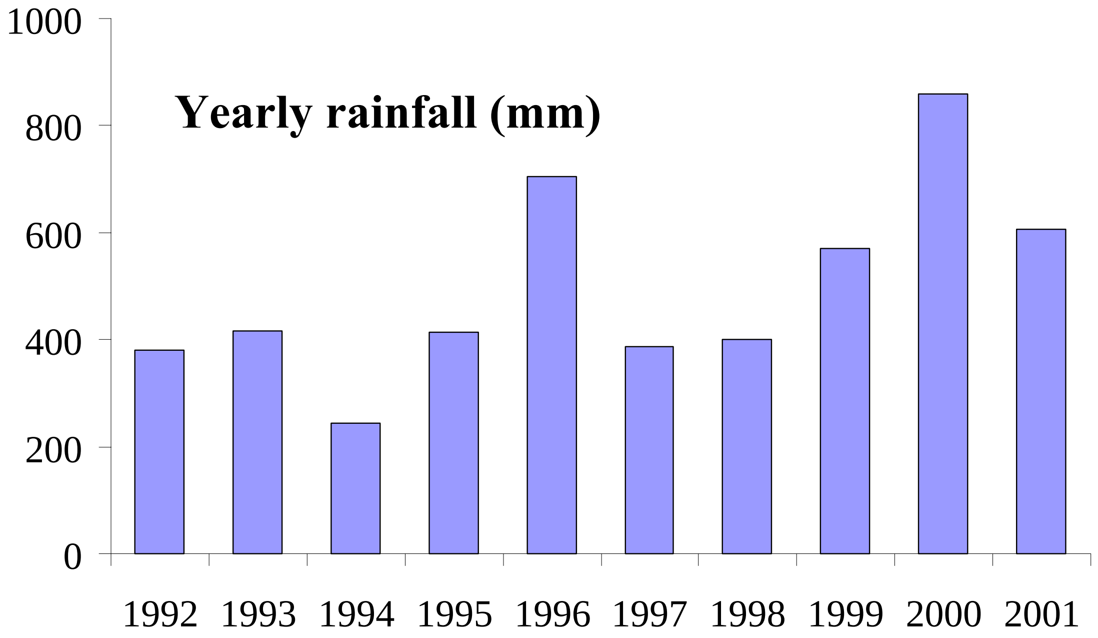
- What is the general pattern of buffalo birth seasons?
  - Are all years identical in pattern?
- What affects the timing/seasonality of births?
  - Can we identify predictive measures of resource influences?

•What are the implications of these findings in the face of larger climatic patterns?

Study Site


Mozambique
Zimbabwe
Botswana
Namibia
Swaziland
Lesotho
South Africa
300 0 300 600 900 1200 Kilometers
Kruger National Park
Umbabat
Timbavati
Klaserie Private Nature Reserve
Sabie Sand


Mean monthly rainfall (mm) +/- S.E.
200
160
120
80
40
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept


Yearly rainfall (mm)
1000
800
600
400
200
0
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001

Data

- Focal herd observation data recorded in notebooks
  - *8 years birthing records of known individuals*
  - *488 events*

  - *Prior studies (Sinclair, 1977; Rutberg, 1987; Sinclair et al., 2000) less data – 49 births over 1.5 years*
  - *Buffalo have 11 month gestation; usually single calf*
  - *Unique opportunity to examine patterns across years, not just within years*

Ungulate Reproductive Strategy

- Birthing synchrony
  - predator swamping hypothesis (Estes, 1976; Sekulic, 1978; Estes and Estes, 1979, e.g.) – Buffalo likely candidates
  - resources are temporally limiting – e.g. snow receding, weather permitting newborns to survive
  - Northern ungulates are more synchronized than tropical (Rutberg, 1987; Gaillard et al., 1993)

- Resource shifts may have severe effects
  - Can lead to lowered birthrates and population decline

- **Effects on mammals less apparent than crop systems but possibly more dramatic (Post, 1999; e.g.)**
  - How much plasticity/adaptability is there?
  - Effects of large climate events – NAO and ENSO?

Ungulate Reproductive Strategy

When should you have babies?

- Prior theory suggests babies occur at **best** food times
  - At or close to biomass peaks *(Sinclair et al. 2000)*
- Small grazers need to eat high quality food
  - high protein content (new growth)
  - Bulk is just indigestible

- Large grazers simply maximize
  - Standing dry season biomass is likely not highly nutritious
- Lactation demands good forage, so do precocious newborns

Formulation of problem

$H_0$1: buffalo birthing will be synchronous, but not extreme, as rainfall seasonality is also not highly synchronous

$H_0 2_a$: We posit that parturition should coincide with best quality food

$H_0 2_b$: We posit that conception should coincide with best quality food

Exploration: Ecological "triggers" for conception

- Synchrony index, comparison with cues
- Cross correlation of births vs. rainfall, NDVI and inferred protein (%N)
- Models of significant time-lags

Analyses

Synchrony of births was quantified using the Evenness Index:

$$\mathbf{J' = (\Sigma\ p_i \log p_i/\log 12)}$$

where p_i is the proportion of births in a month. Evenness ranges from zero to one, from maximum synchrony to no synchrony (Krebs, 1989).

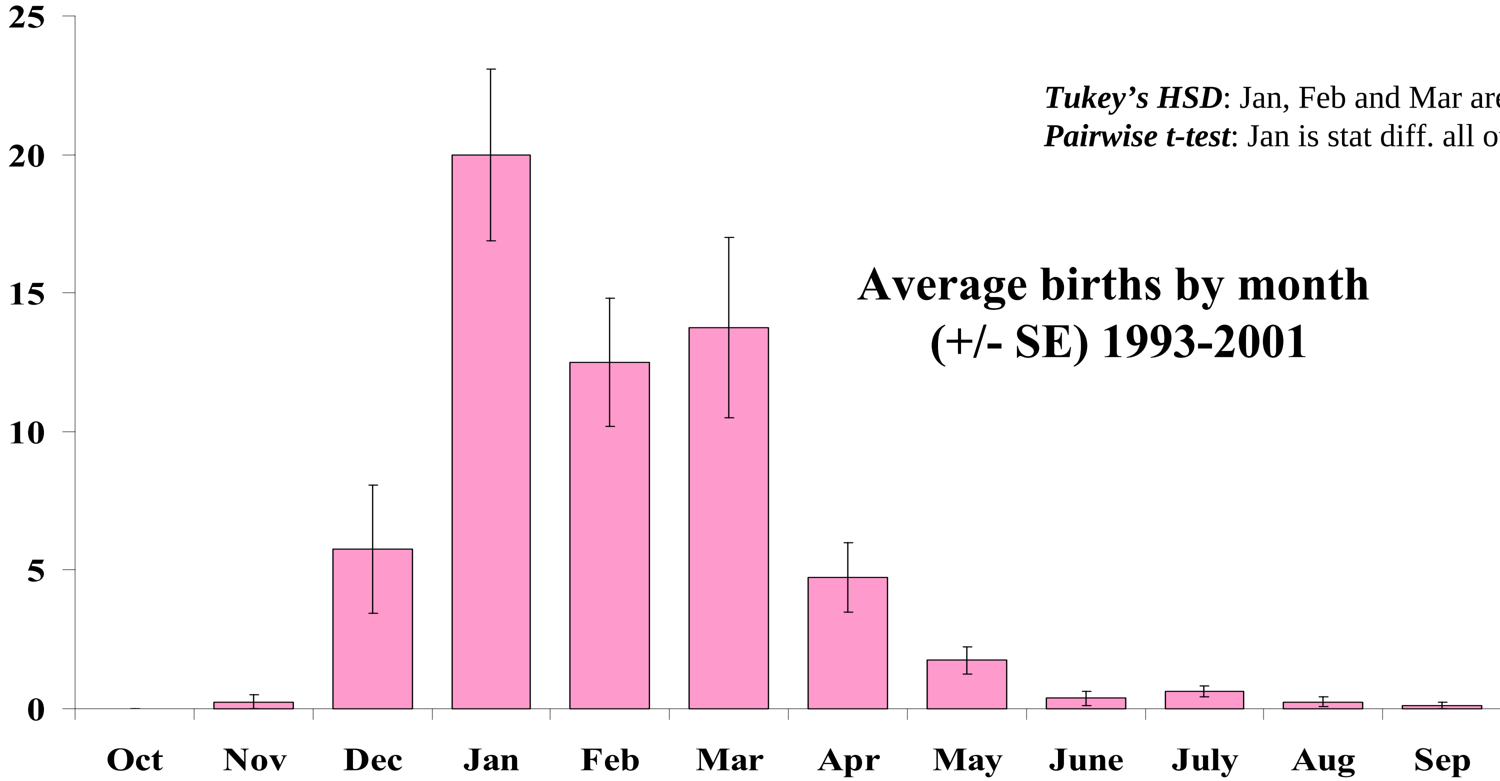
NDVI from NOAA's AVHRR at a 8km^2 resolution was obtained from the Africa Data Dissemination Service (ADDS)

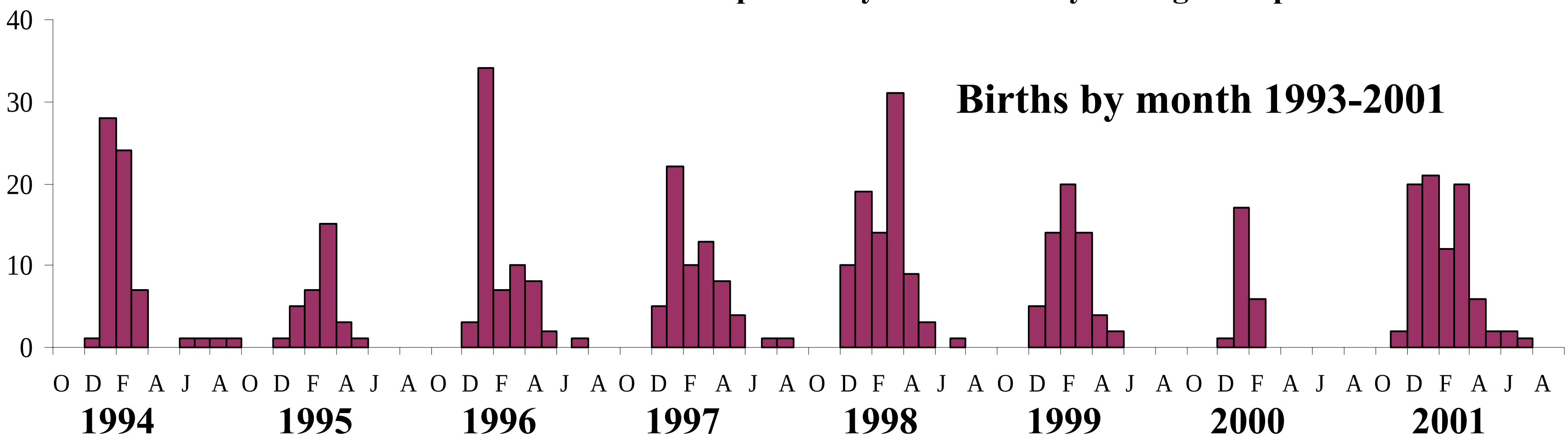
– ArcINFO AML scripts to create monthly average greenness values

Protein content was calculated based on fecal nitrogen analyses from KNP *(diss ch.4)*:

$$\mathbf{N_f = 0.82 + 0.005 * NDVI_{(t-1)}}$$

Patterns of birth events 1993-2001





Synchrony

"Medium" degree of birth synchrony

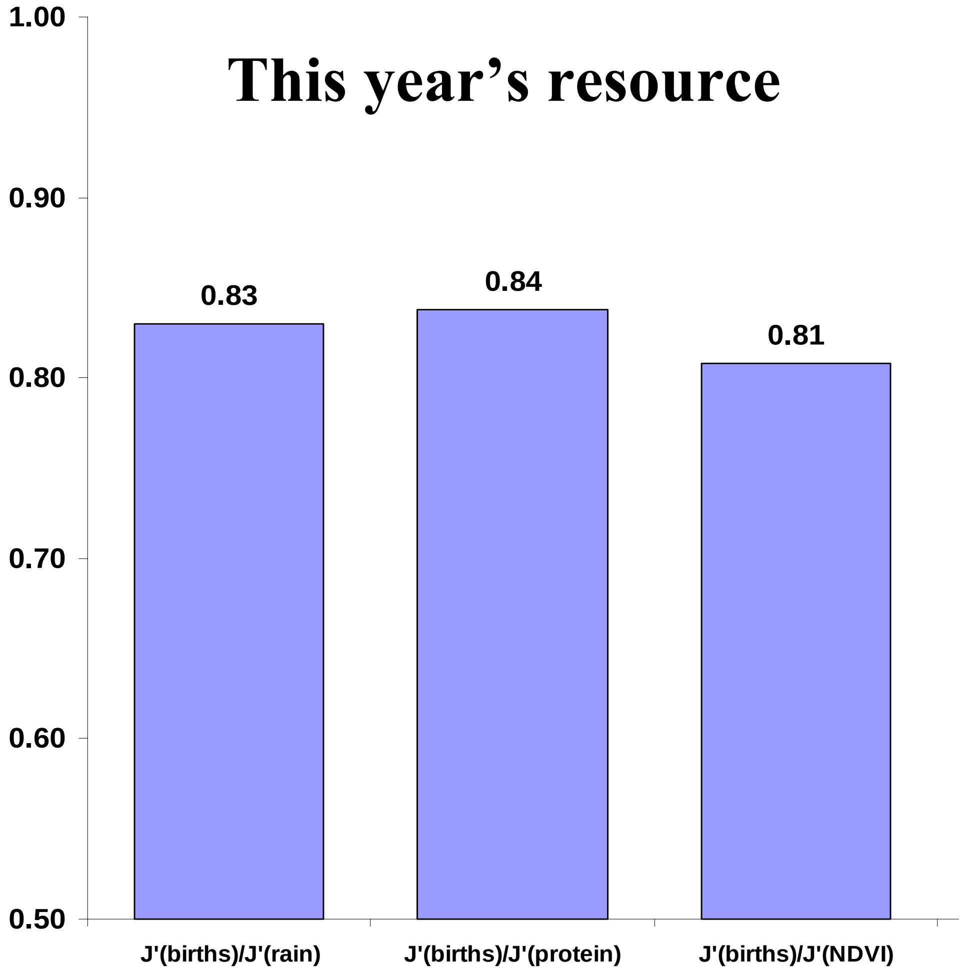
Year	n	J'(births)
1994	64	0.52
1995	32	0.57
1996	65	0.58
1997	64	0.70
1998	87	0.66
1999	59	0.63
2000	24	0.29
2001	86	0.72
Total	480	0.69

J' values of birth synchrony for ungulates in the Serengeti (Sinclair et al., 2000)

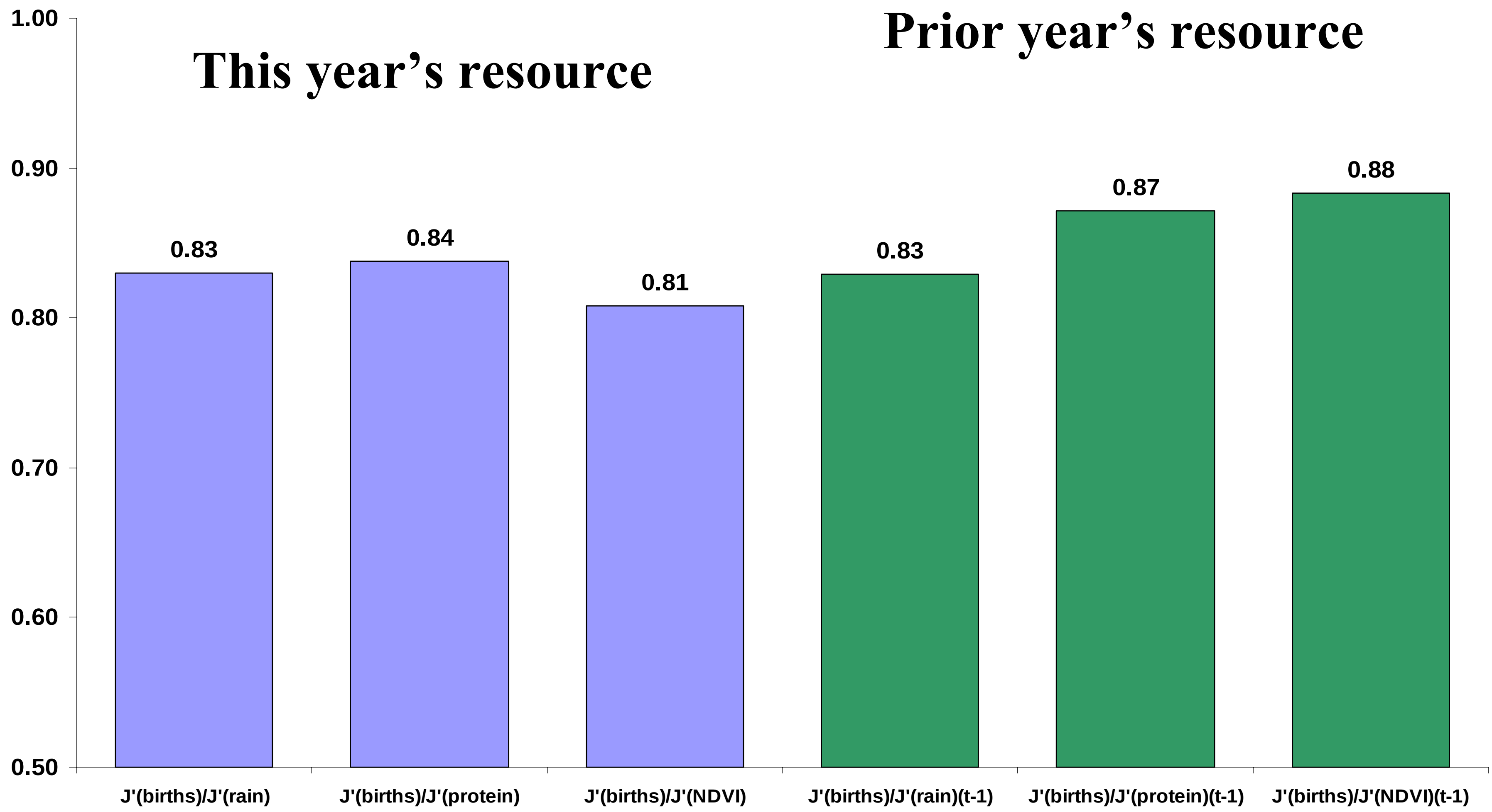
Wildebeest	0.354
Topi	0.515
Warthog	0.629
Dikdik	0.68
Buffalo	0.695
Grant's gazelle	0.771
Giraffe	0.894
Impala	0.894
Oribi	0.933
Waterbuck	0.933
Zebra	0.924
Thompson's gaze	0.924
Kongoni	0.962

Evenness ranges from zero to one, from maximum synchrony to no synchrony

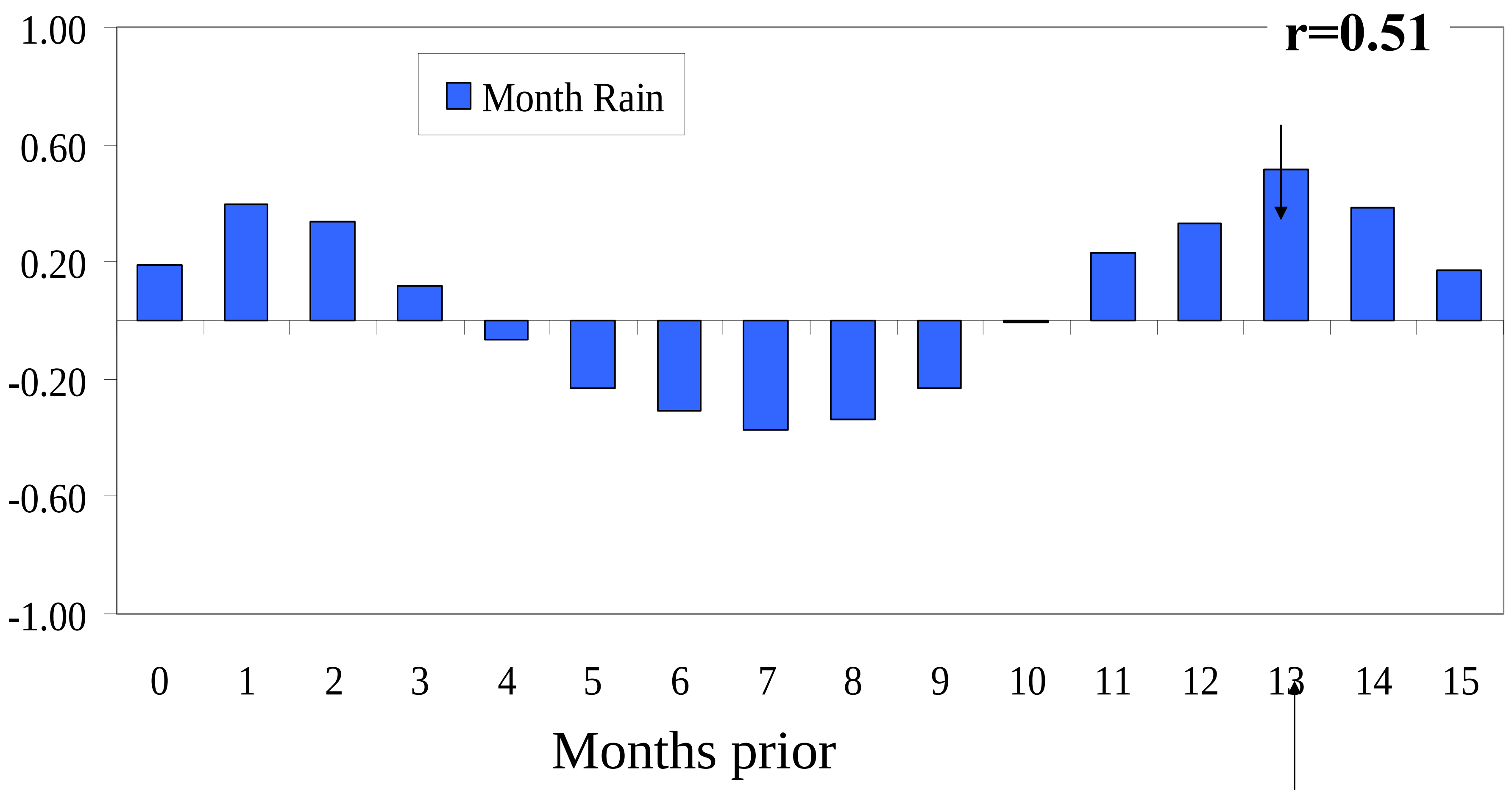
J'/J' comparisons with resources – means, n=8



J'/J' comparisons with resources – means, n=8



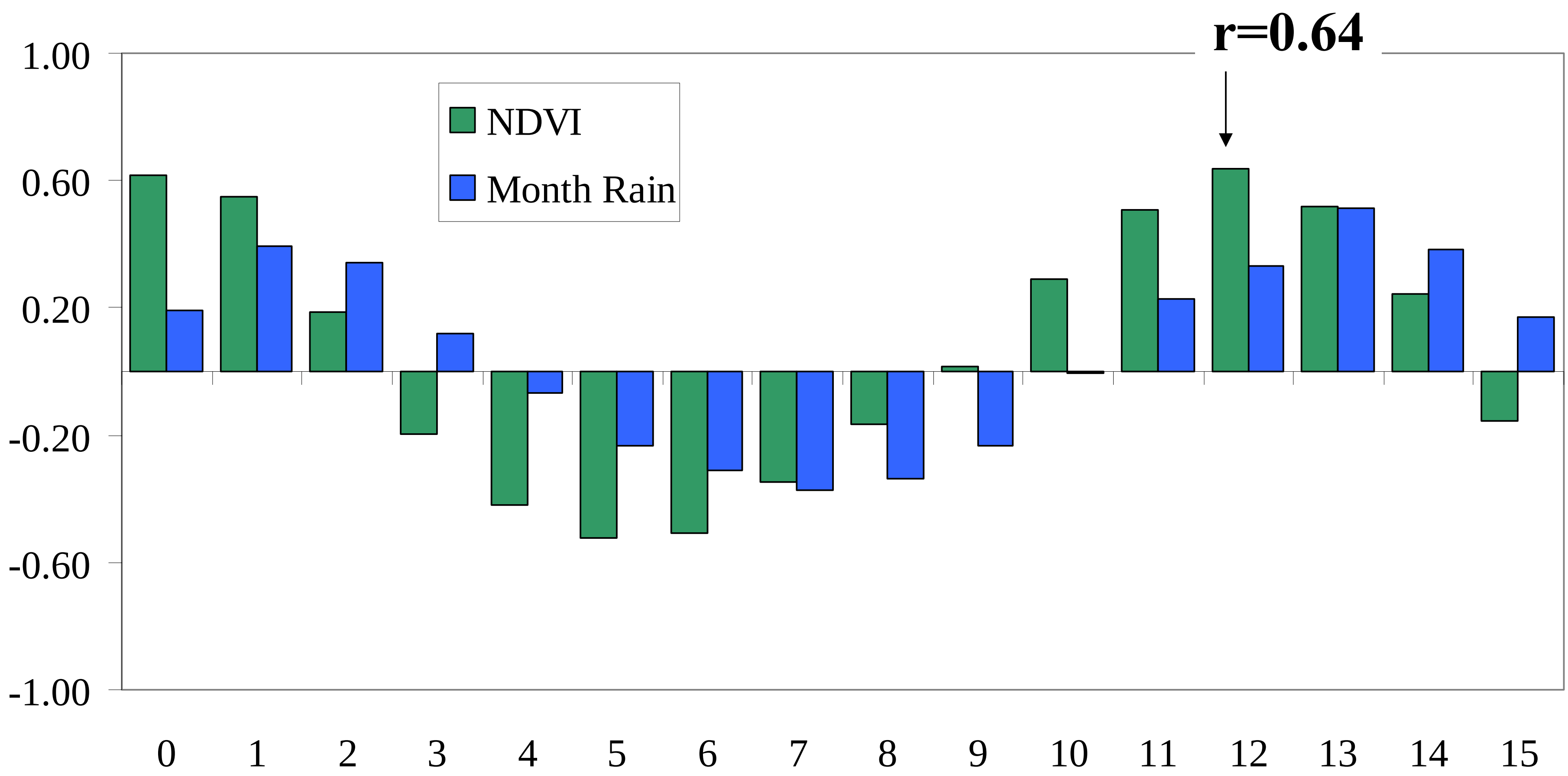
Cross-correlation analysis



A mixed stepwise linear regression (SLR) selected lag 2 and lag13 as best explanatory variables (F=6.35, 24.49; p=0.0134, <0.0001)

lag 13 is the strongest significant parameter $\boldsymbol{y=0.03(rain_{lag\ 2}) + 0.06(rain_{lag\ 13})+1.28}$

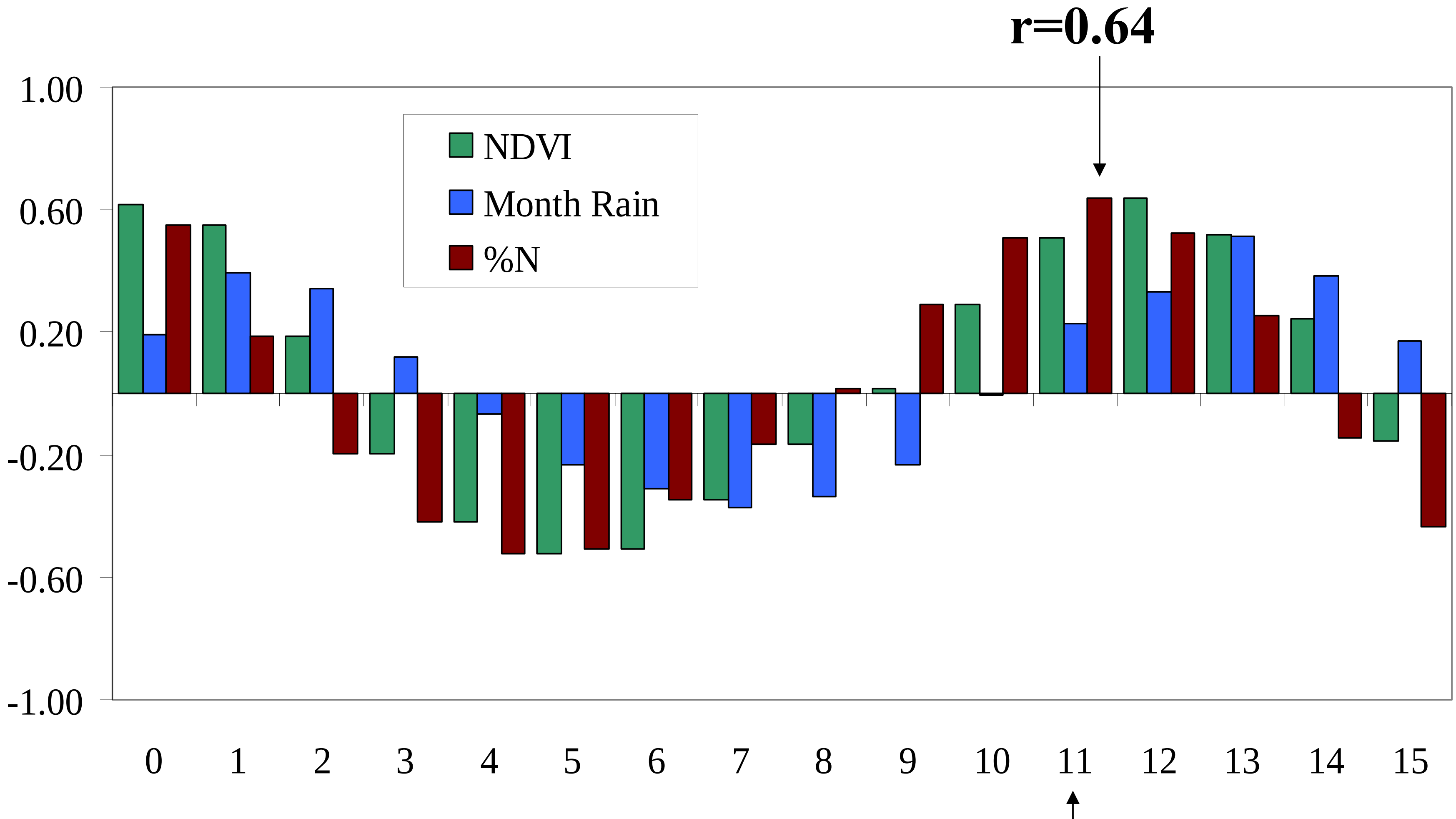
Cross-correlation analysis



A mixed SLR selected lag 1, lag 3 and lag 12 as most explanatory variables (F=17.28, 15.70, 9.54; p<0.0001, 0.0001, 0.0027)

once lag 3 is removed, lag 1 becomes less significant (p=0.02) and lag12 has highest explanatory power $\boldsymbol{y=0.061(NDVI_{lag\ 1}) + 0.121(NDVI_{lag\ 12}) - 14.23}$

Cross-correlation analysis

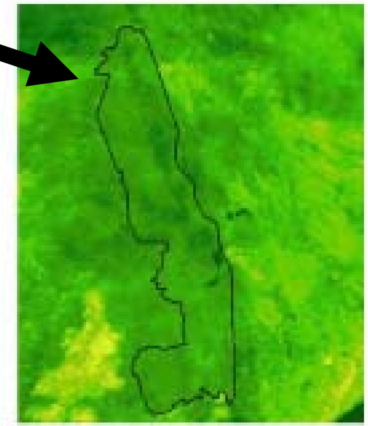


A mixed SLR selected lag 0, lag 2 and lag 11 as most explanatory variables – %N is a fxn of NDVI, so same F_{ratio} and significance, advanced one lag

y=12.26(%N) + 24.30(%N $_{lag\ 11}$***) – 44.20***

[adding ‘year’ to the model – never significant]

Rational sequence of events



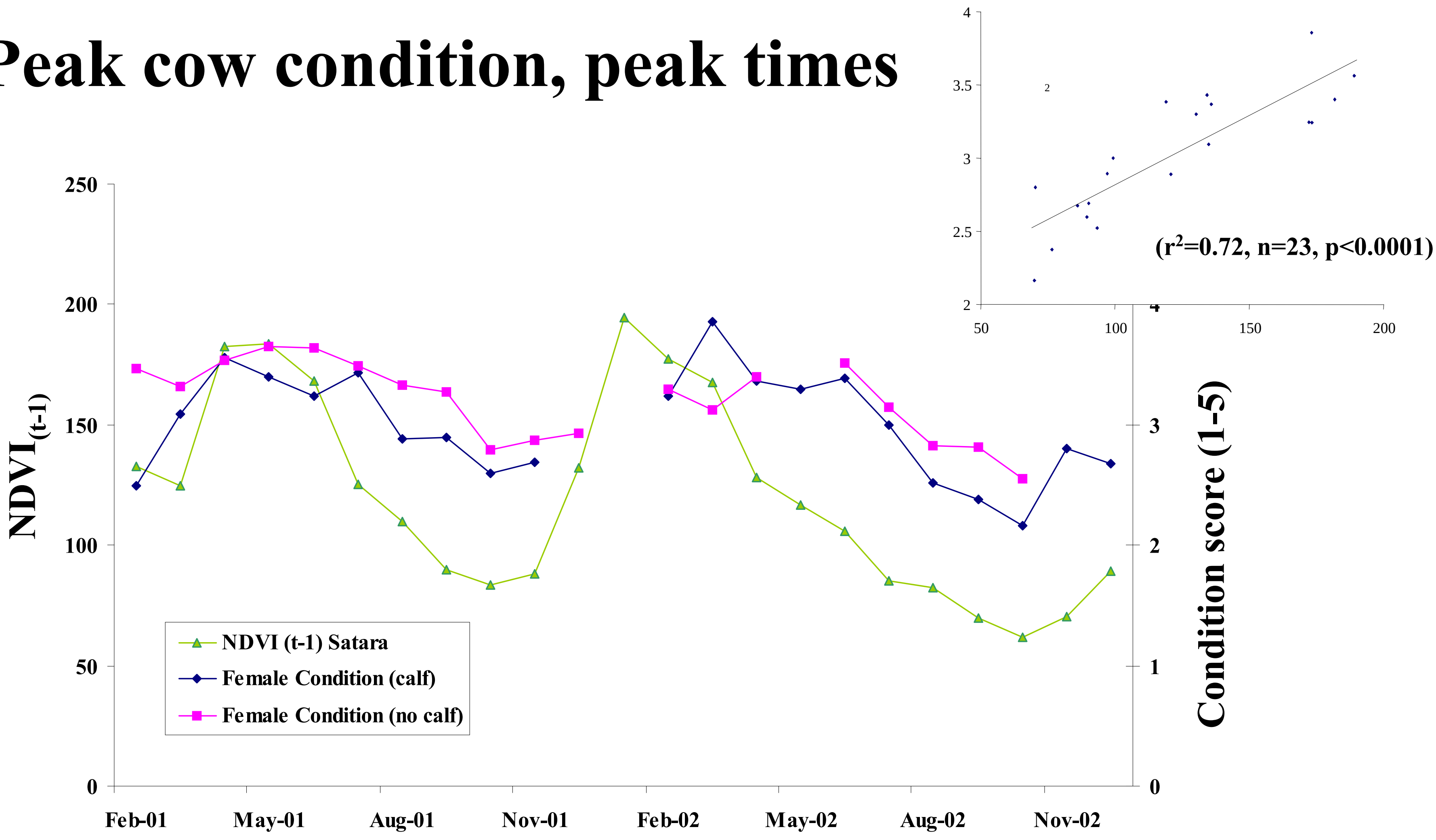
Monthly rainfall – 13 month lag

NDVI – 12 month lag

%N – 11 month lag

This recurs, albeit less significantly, at parturition

Peak cow condition, peak times

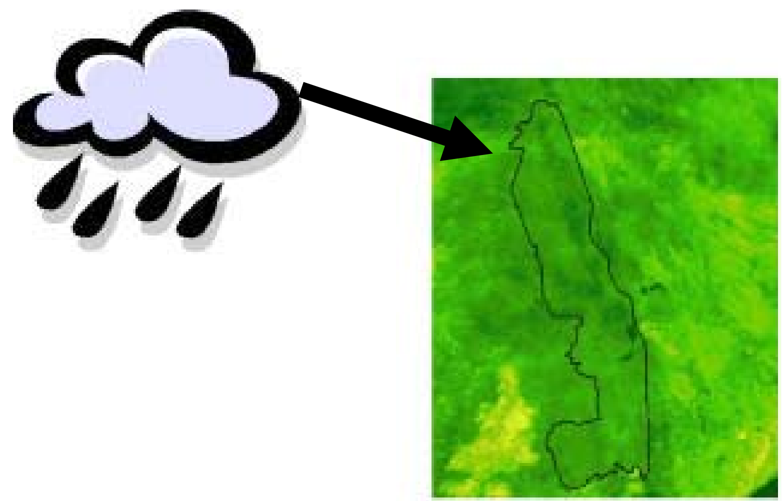


Adaptive strategy or just bad timing?

- *long term evolution of timing parturition to protein peaks with some slippage*

or

- *peak condition and peak conception occur at protein peak*
  - *babies 11 months later*

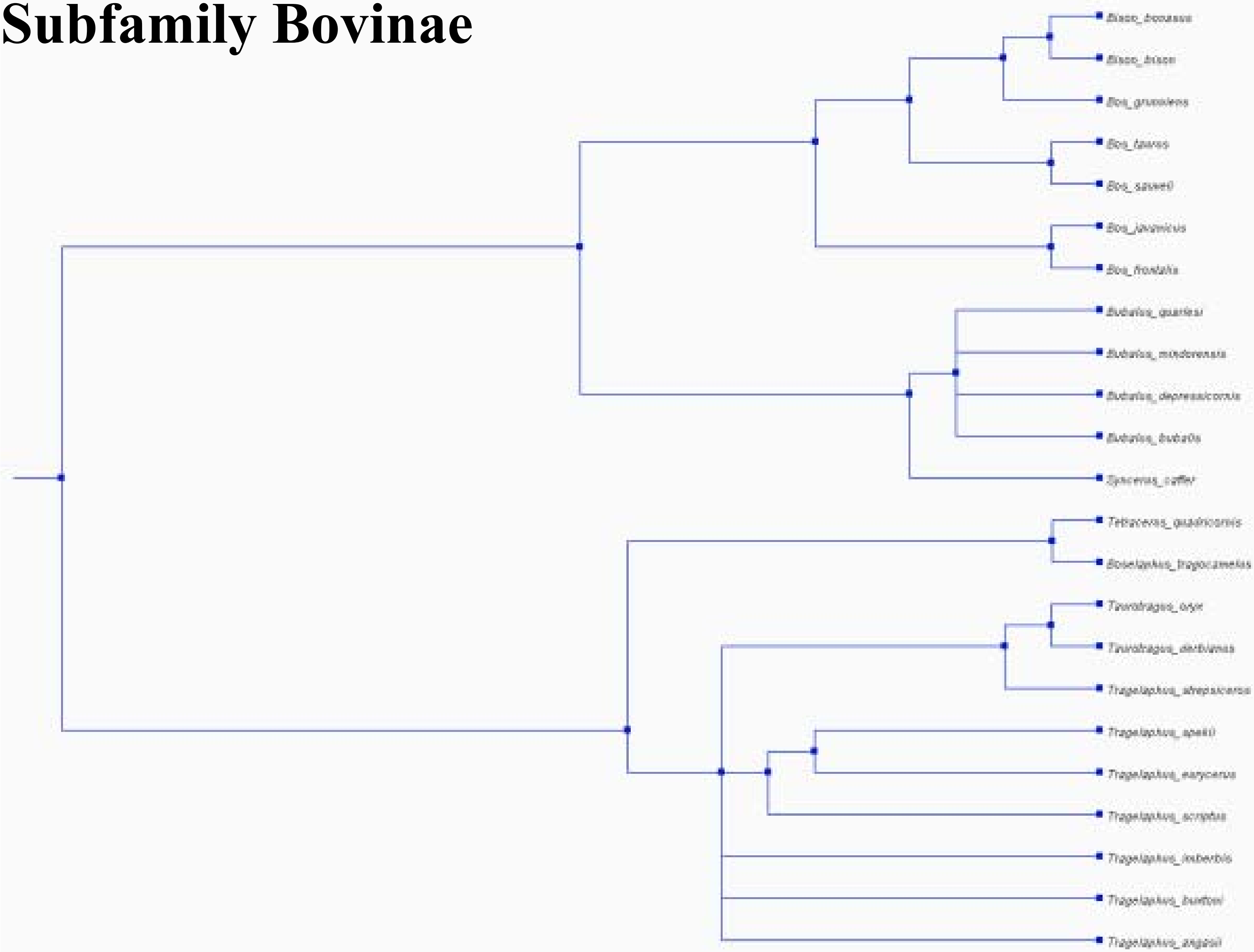


Buffalo don't use calendars, probably ecological cues are more obvious

Is there something different about buffalo gestation?

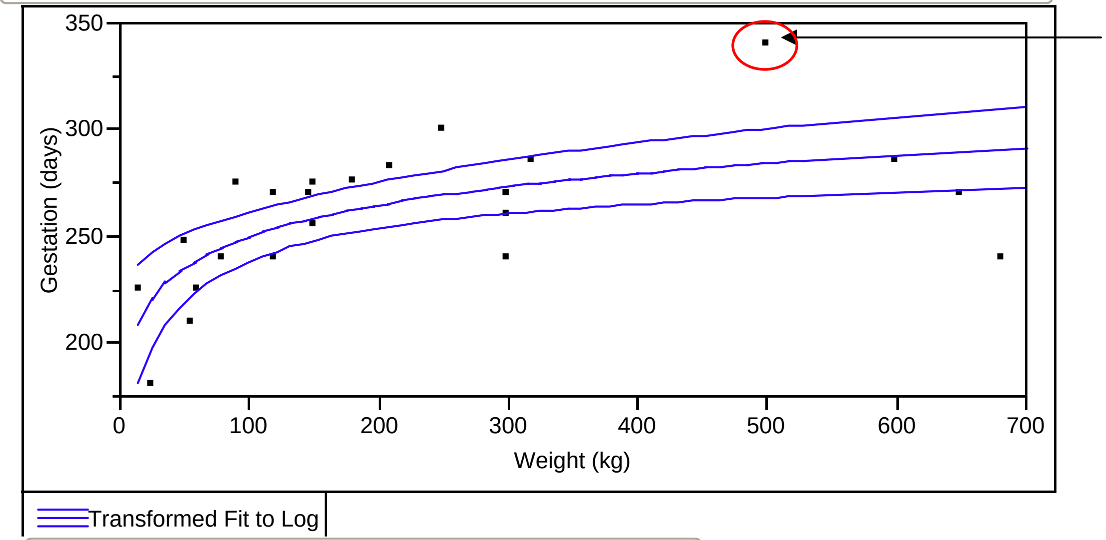
– to the literature!

Subfamily Bovinae



From certarteriodactyl supertree, Price et al., 2005

Bivariate Fit of Gestation (days) By Weight (kg)



Transformed Fit to Log

Gestation (days) = 150.68398 + 21.482705 Log(Weight (kg))

Summary of Fit

RSquare	0.43973
RSquare Adj	0.414263
Root Mean Square Error	24.76361
Mean of Response	259.5833
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	10588.631	10588.6	17.2668
Error	22	13491.203	613.2	Prob > F
C. Total	23	24079.833		0.0004

Parameter Estimates

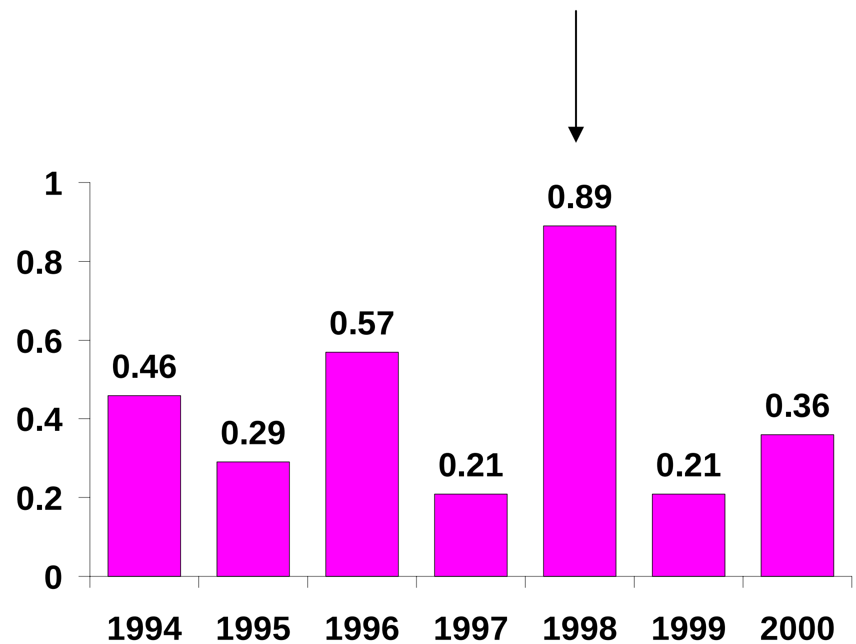
Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	150.68398	26.69017	5.65	<.0001
Log(Weight (kg))	21.482705	5.169911	4.16	0.0004

Buffalo gestation for its weight (500-600 kg)= 284-288 days

Evidence of protracted gestation?

28 well-known mothers over 7 calendar years

Mother ID	1994	1995	1996	1997	1998	1999	2000
Anita	0	1	1	0	1	0	1
Anka	0	0	0	0	1	0	0
Anoa	0	0	0	0	1	1	0
Arkadia	0	1	0	0	1	0	1
Aurora	1	0	0	0	1	1	1
Bjelaja	0	0	0	1	1	0	1
Claudia	1	1	1	0	1	0	0
Diana	1	0	0	1	1	0	1
Dreipunkt	0	1	1	0	1	0	0
Gabane	0	1	0	1	1	1	0
Gabikro	0	0	0	0	0	0	1
Hella	0	0	1	0	1	1	1
Horni	0	0	1	0	1	0	0
Jambila	0	0	1	0	1	0	1
Katanga	0	1	0	0	0	1	1
Liberia	0	0	1	0	1	0	0
Mandy	1	0	1	1	1	0	0
Messina	1	1	0	0	0	0	0
Mitumi	1	0	1	0	1	0	0
Quadri	1	0	1	0	1	0	0
Quiba	0	0	1	1	1	0	0
Rodentia	1	0	1	0	1	0	1
Ruanda	1	0	1	0	1	0	0
Sambia	1	0	1	1	1	0	0
Simone	1	0	1	0	1	0	0
Tailcut I	0	0	1	0	1	1	0
Weike	1	1	0	0	1	0	0
Zianka	1	0	0	0	1	0	0
Total Calves	13	8	16	6	25	6	10



Findings

- Buffalo breeding is unimodal and quite synchronous
  - Moderately peaked resources reflected in birthing pattern
- Buffalo respond to protein content
  - large grazer, semi-arid system
- Conception and parturition coincide with good conditions
  - Potential evidence of protracted gestation
- Further investigations into larger scale anomalies – 1998
- NAO and ENSO show no particular influence at this timespan, but resource shifts might interfere with the evolved timing of 11 month gestation - hard to evolve backward

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