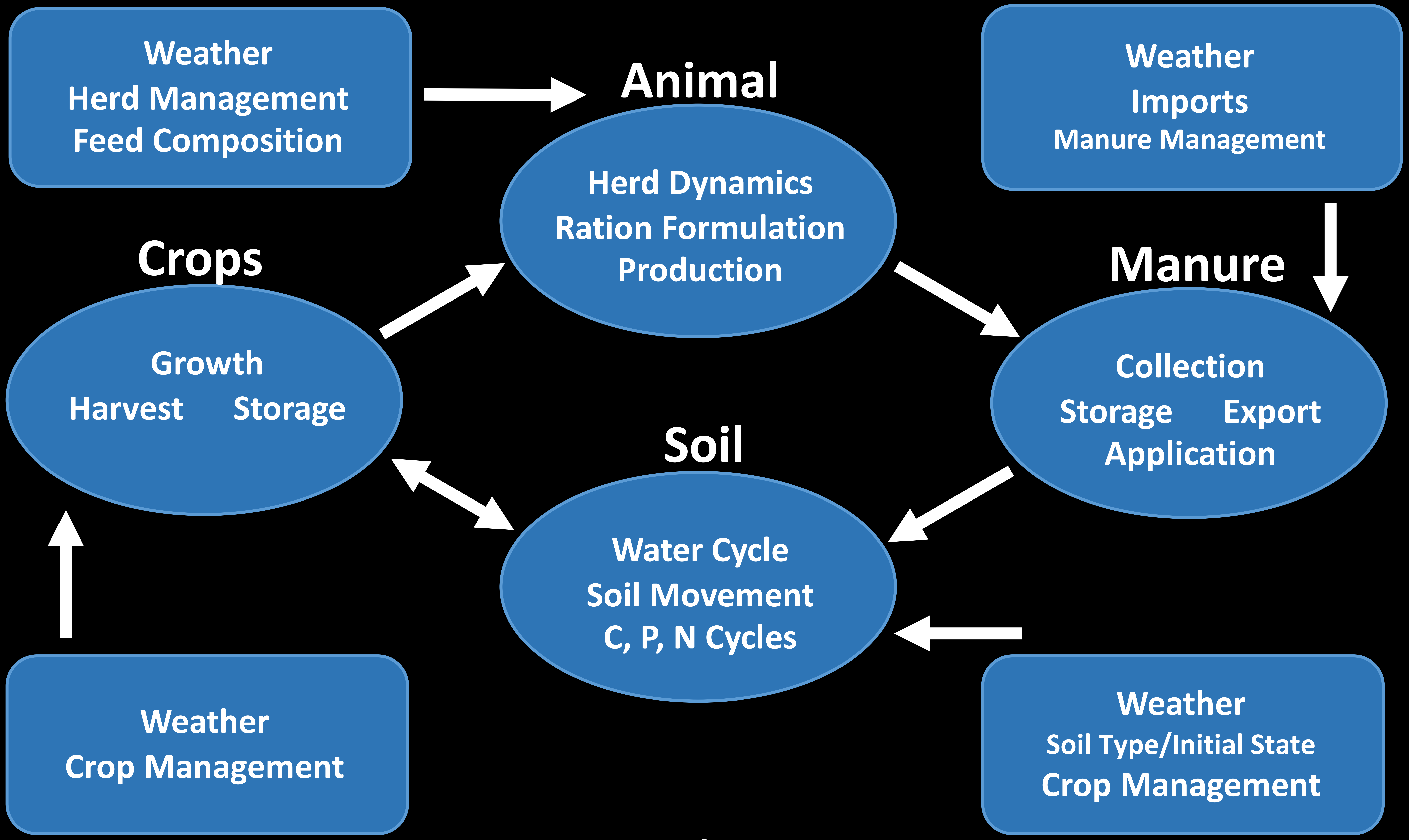
Animal life cycle model of animal module in RuFaS

Summer 2019

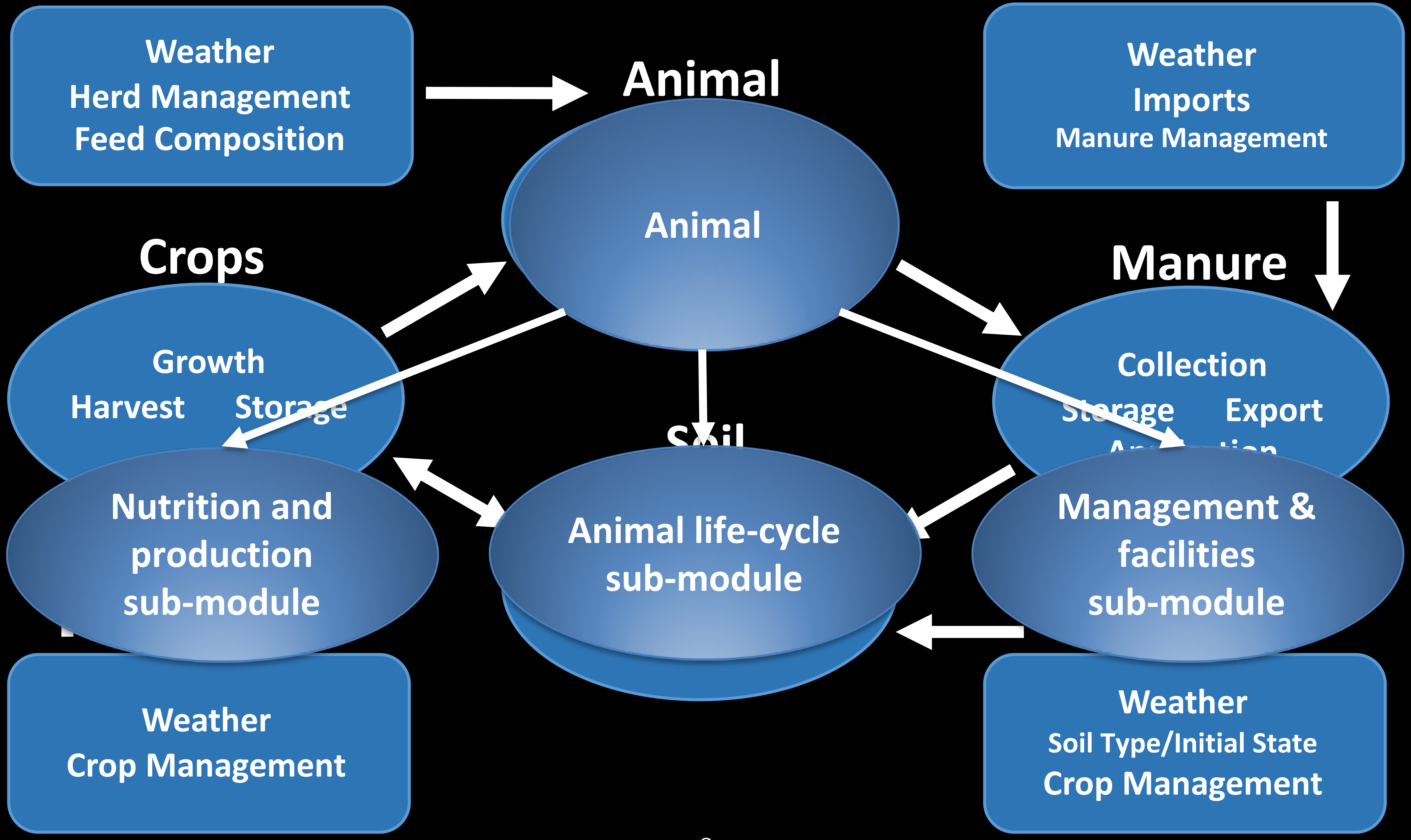
RuFaS model

- Core modules of RuFaS



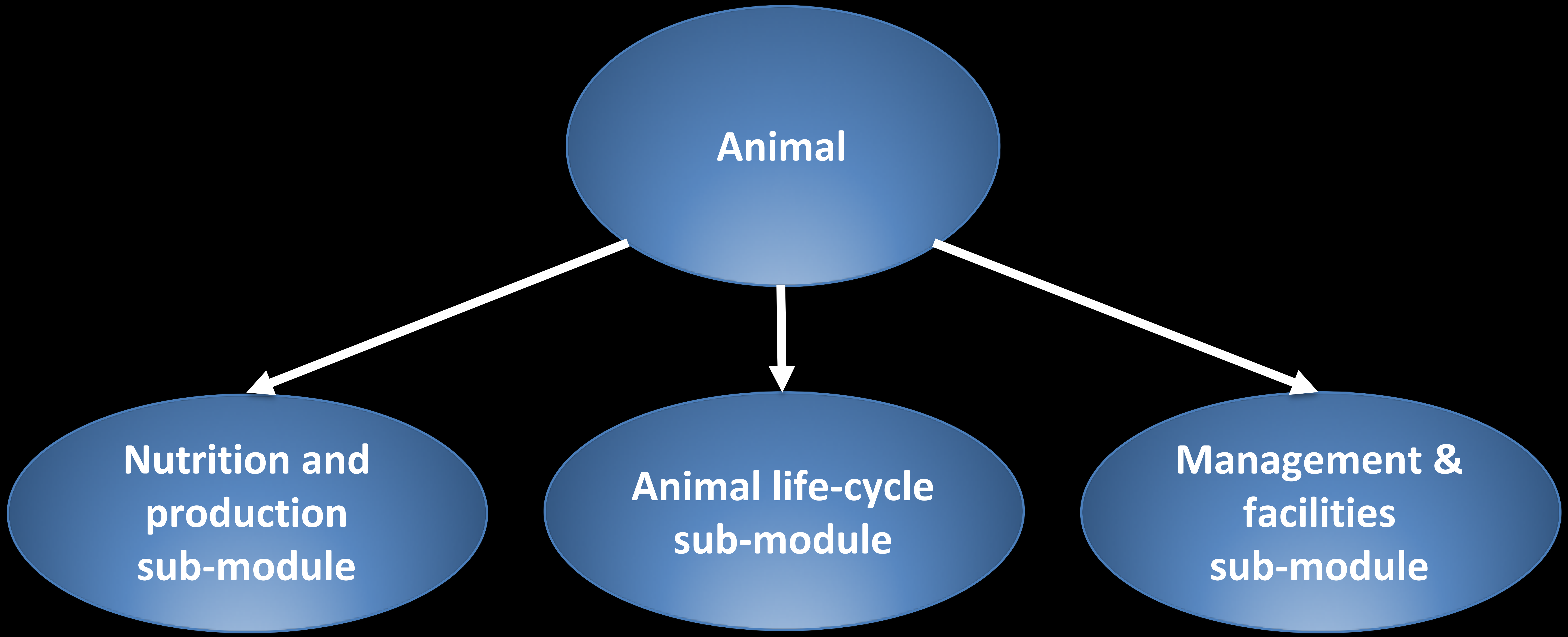
RuFaS model

- Core modules of RuFaS



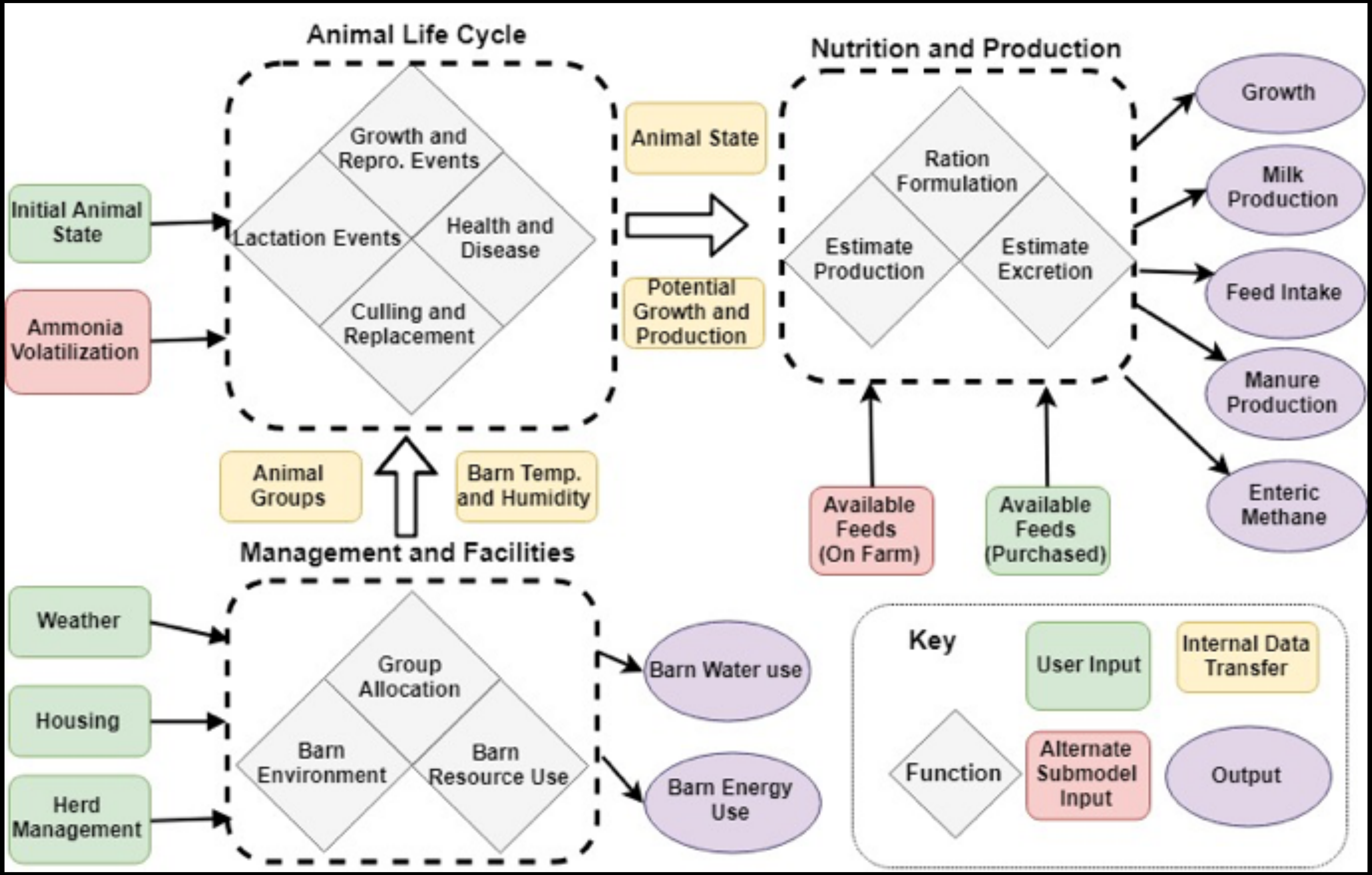
RuFaS model

- Core modules of RuFaS



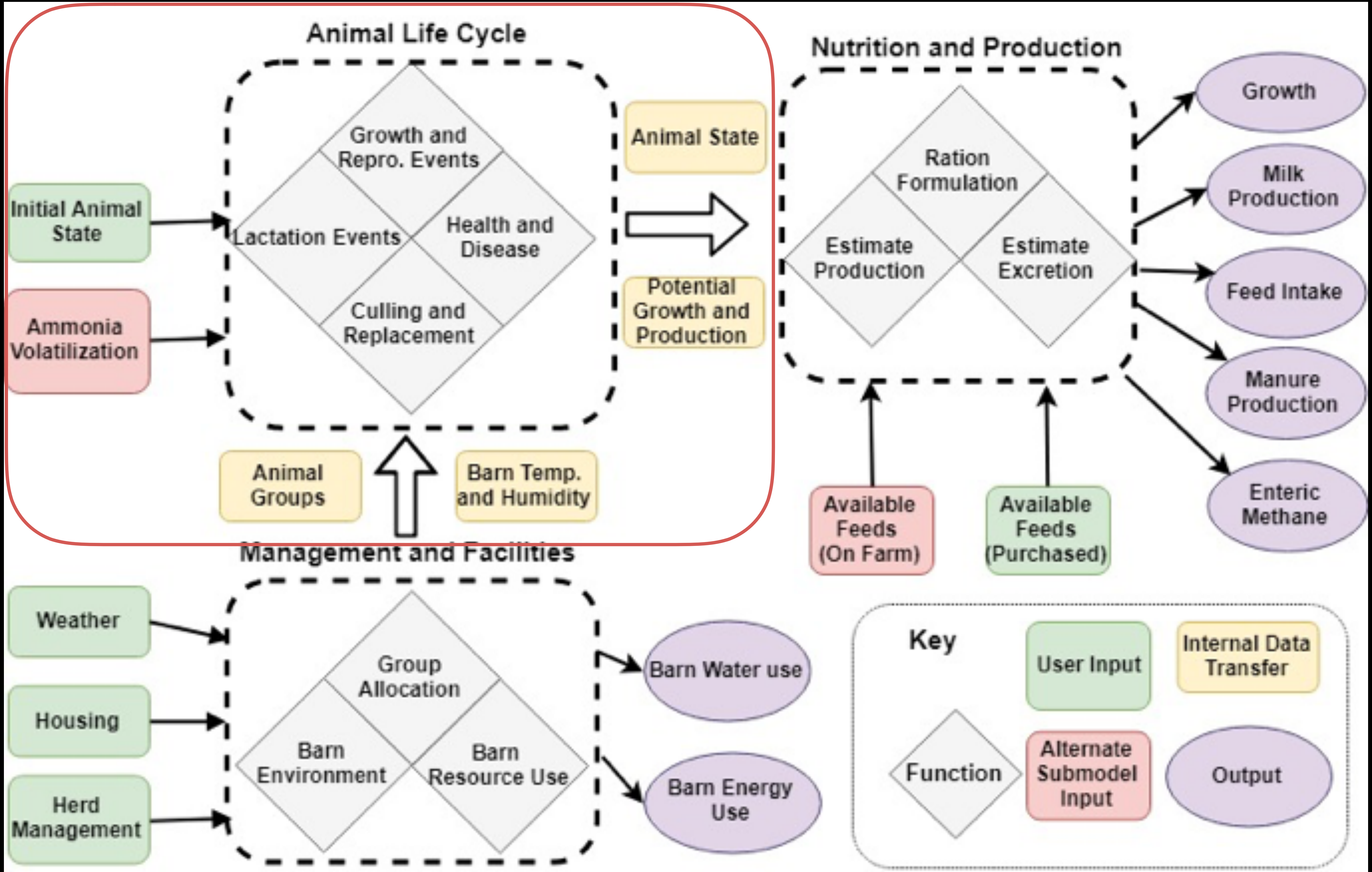
Animal module

- Animal module daily information flow



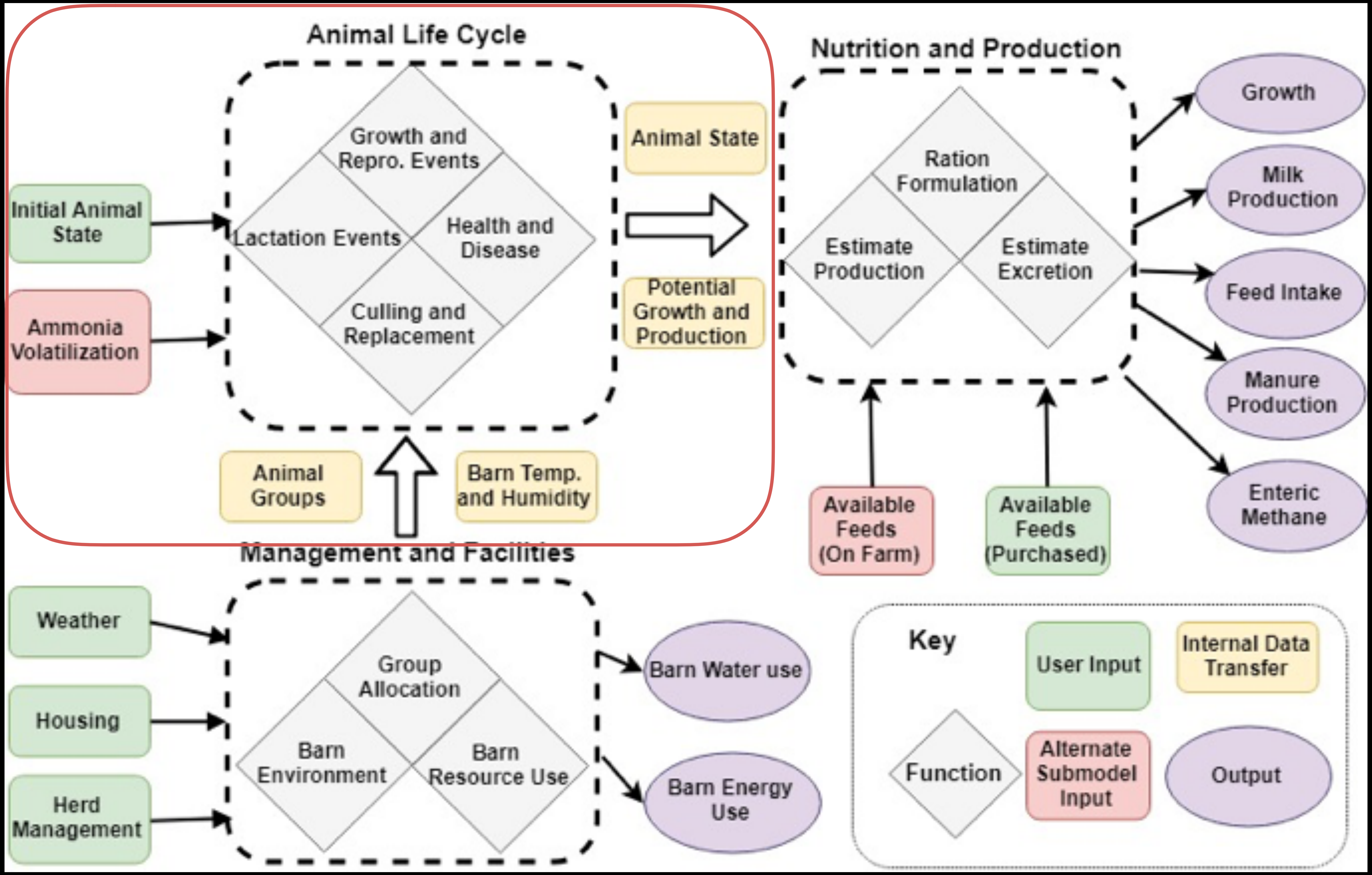
Animal module

- Animal module daily information flow



Animal module

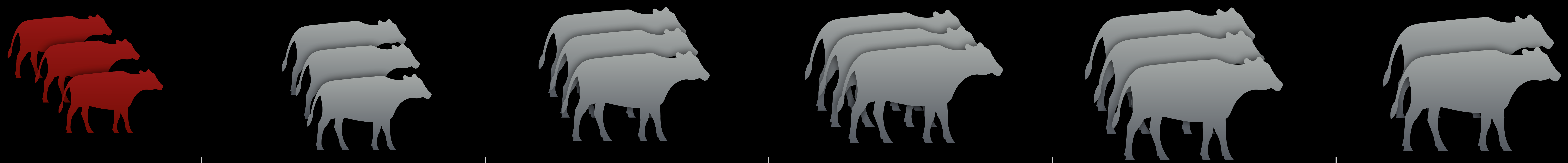
- Animal module daily information flow



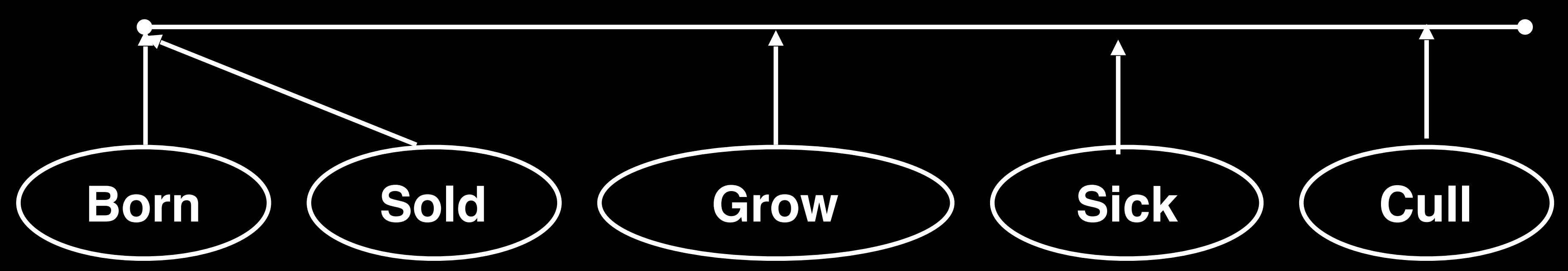
Animal life cycle model

- Monte Carlo stochastic simulation
- Simulate individual animal events from birth until leaving on daily basis
- Herd level distributions are represented when individual animals status accumulates
- Modularized to allow flexibility to mix herd and management decisions
- Build a framework allowing incorporate more factors and findings

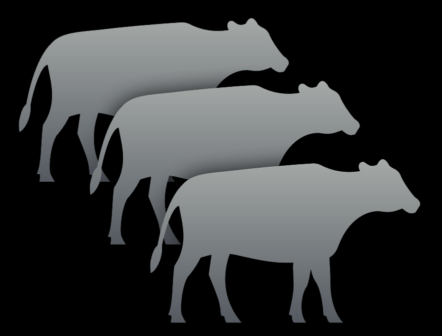
Animal life cycle model



Calves	Heifers I	Heifers II	Heifers III	Cow	Culled
Birth - wean	Wean - breed	Breed - calve	Close to calving	Start lactating	For culling
0 - 60	60 - 400	400 - DIP > 250	- 1st calving	Calved - cull	Culled - sell



- Calves



  - Born, gender assigned according to semen type
  - Sold, as male/ female calf
  - Grow, with initial birth weight and average daily gain
  - Sick, calf specific health issues
  - Cull, leaving the group before wean

Animal life cycle model

Calves	Heifers I	Heifers II	Heifers III	Cow	Culled
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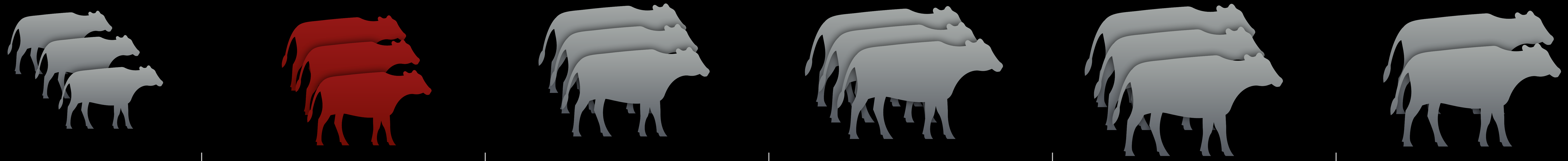
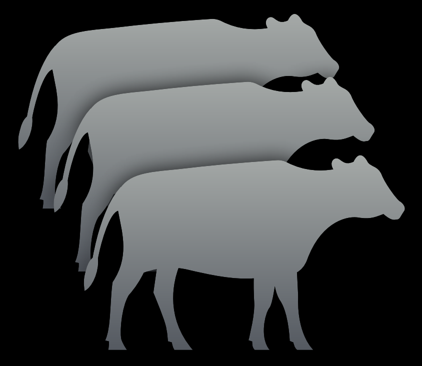


- Heifers I
  - Wean, feed
  - Grow, with ADG
  - Sick
  - Cull, leaving the group before breeding



Animal life cycle model

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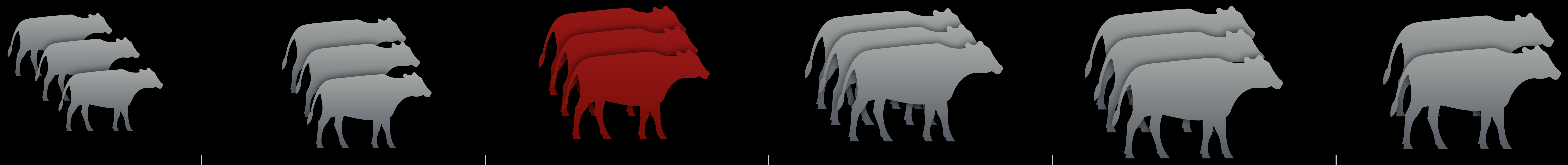
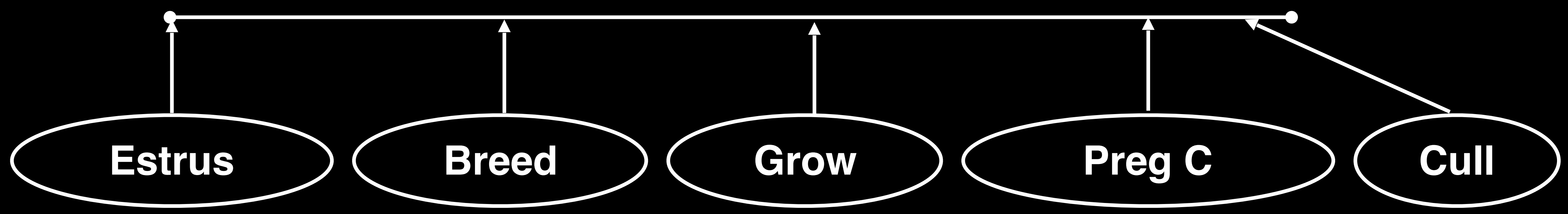
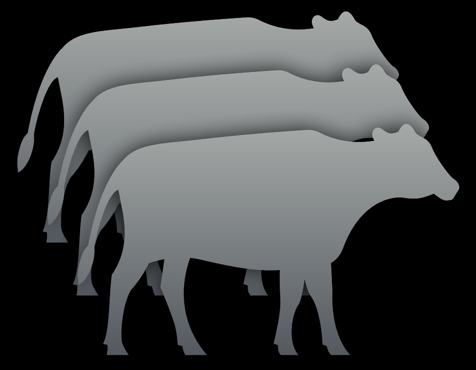
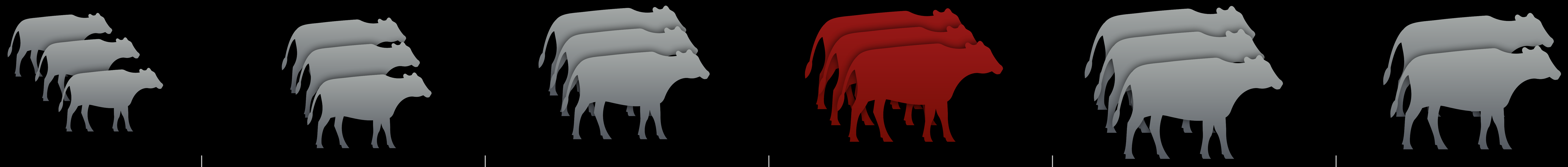






- Heifers II
  - Estrus, if estrus detection involved, estrus ~ N(21,2.5)
  - Breeding, AI after ED and TAI protocols
  - Grow, related to nutrition and pregnancy status
  - Preg checks, three times on day 32, 91, 200 after AI
  - Cull, reproductive failure and health issue

Animal life cycle model



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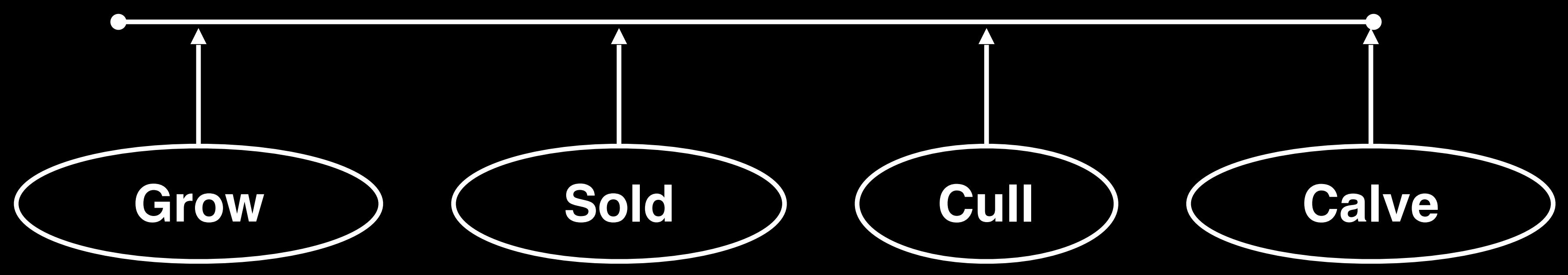

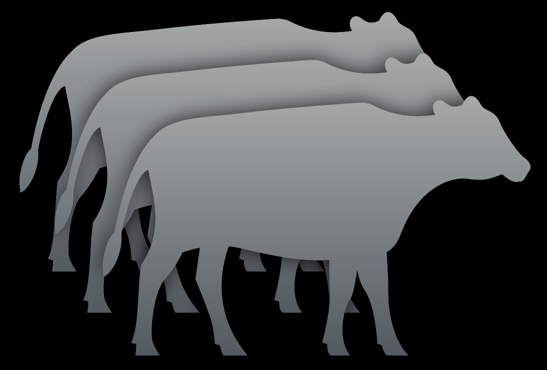

- Heifers III
  - Grow, nutrition needs and supply
  - Sold, as pregnant heifer
  - Cull, leaving the group before enter
  - Calve, at the end of the gestation ~ N(278,6)

Animal life cycle model

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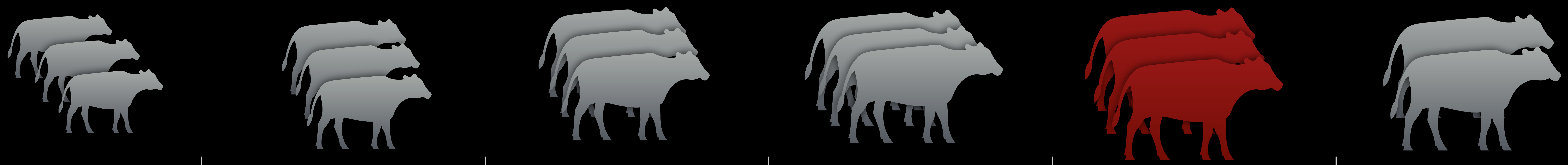

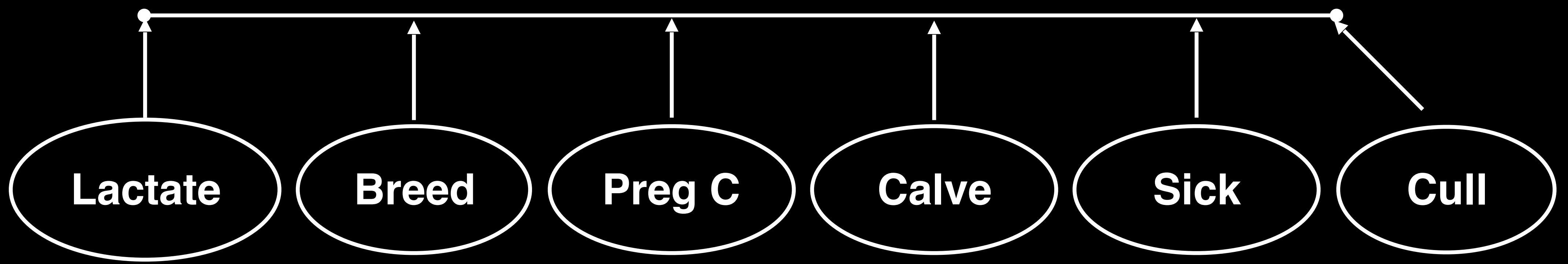

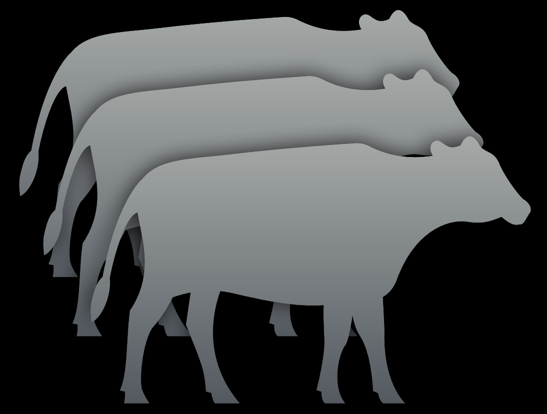

- Cow
  - Lactate, follow the production level specific curve
  - Breed, AI after ED and TAI protocols
  - Preg checks, three times on day 32, 91, 200
  - Calve, at the end of the gestation ~ N(278,6)
  - Sick, calf sensitive illness
  - Cull, leaving the group before wean

Animal life cycle model

Calves	Heifers I	Heifers II	Heifers III	Cow	Culled
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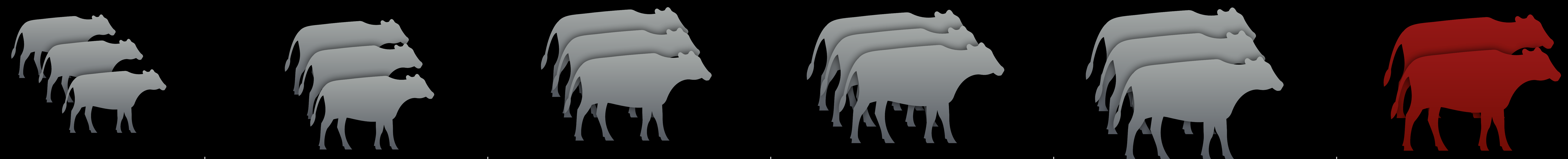
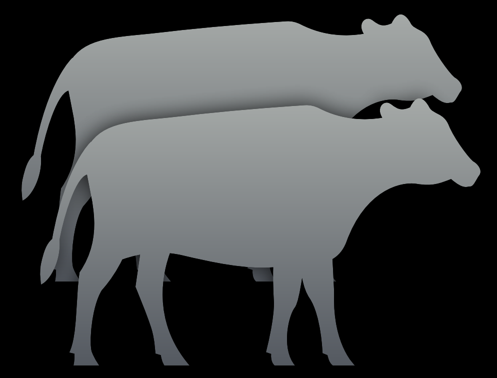
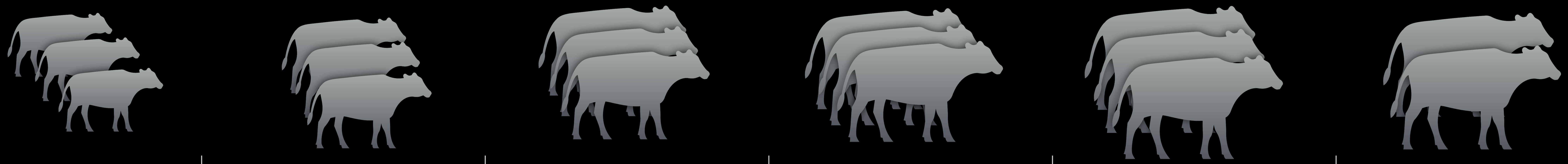




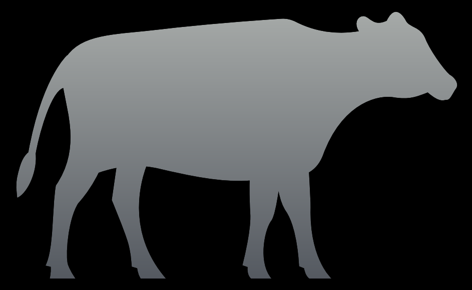
- Culled
  - Maintenance
  - Sold

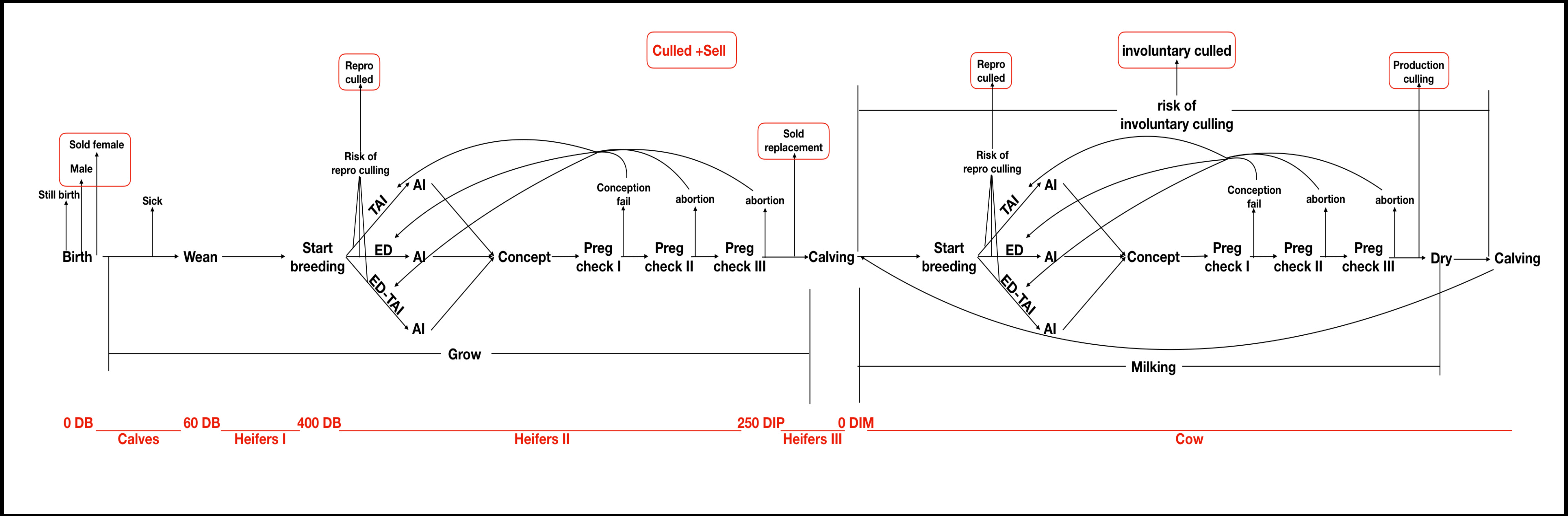
Animal life cycle model

Calves	Heifers I	Heifers II	Heifers III	Cow	Culled
Birth - wean	Wean - breed	Breed - calve	Close to calving	Start lactating	For culling
0 - 60	60 - 400	400 - DIP > 250	- 1st calving	Calved - cull	Culled - sell

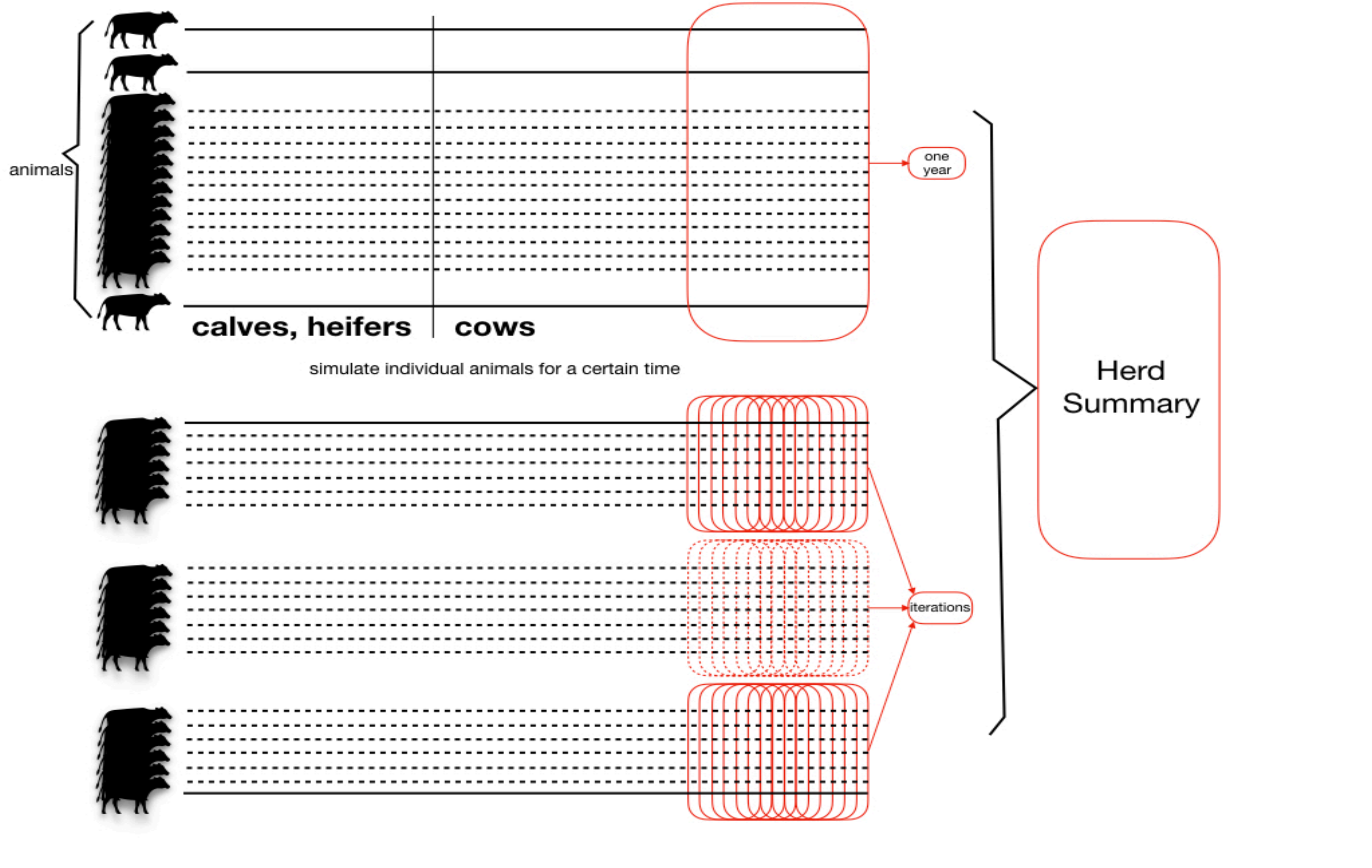


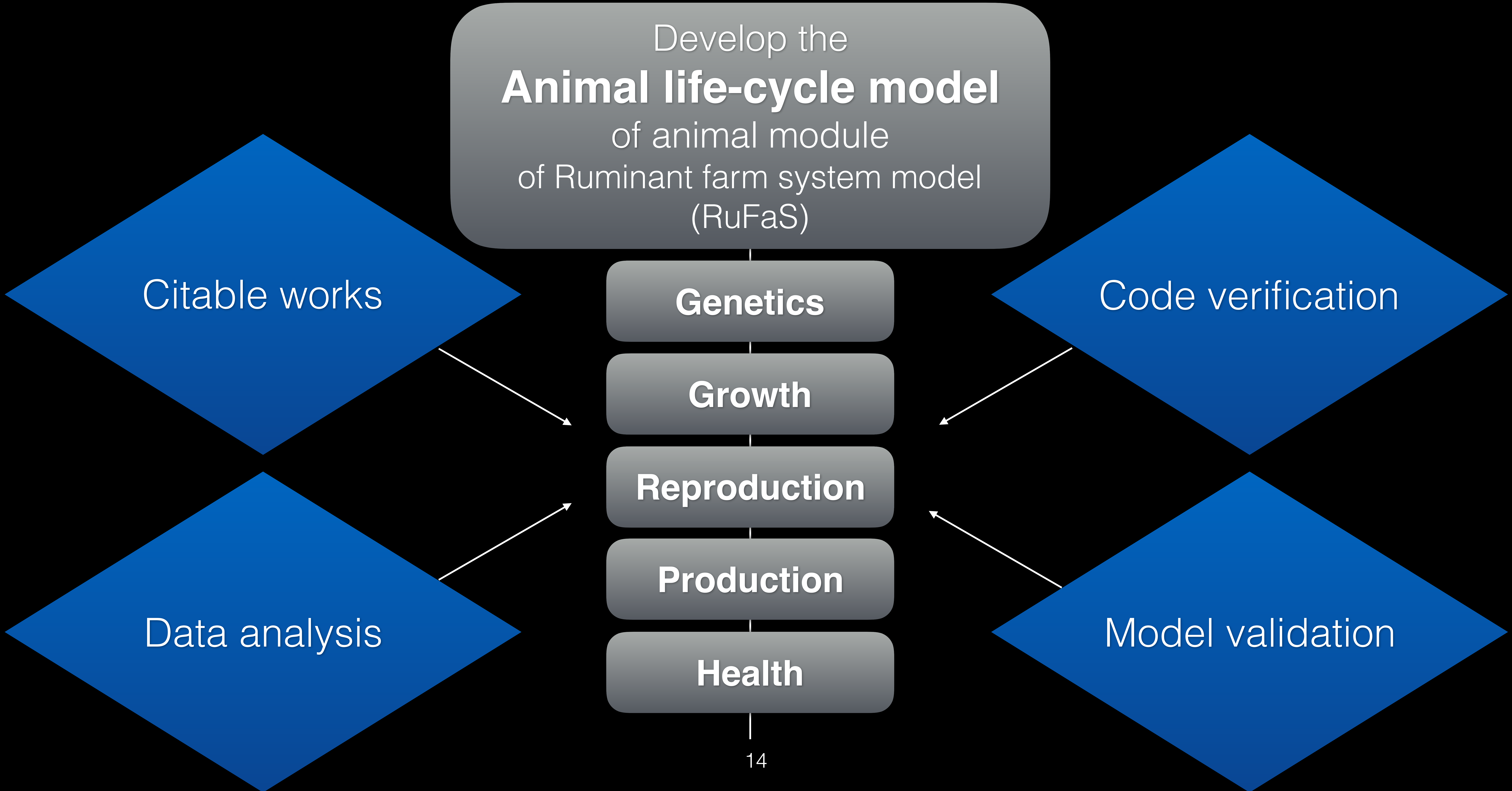
Individual animal life story





Herd simulation and iteration

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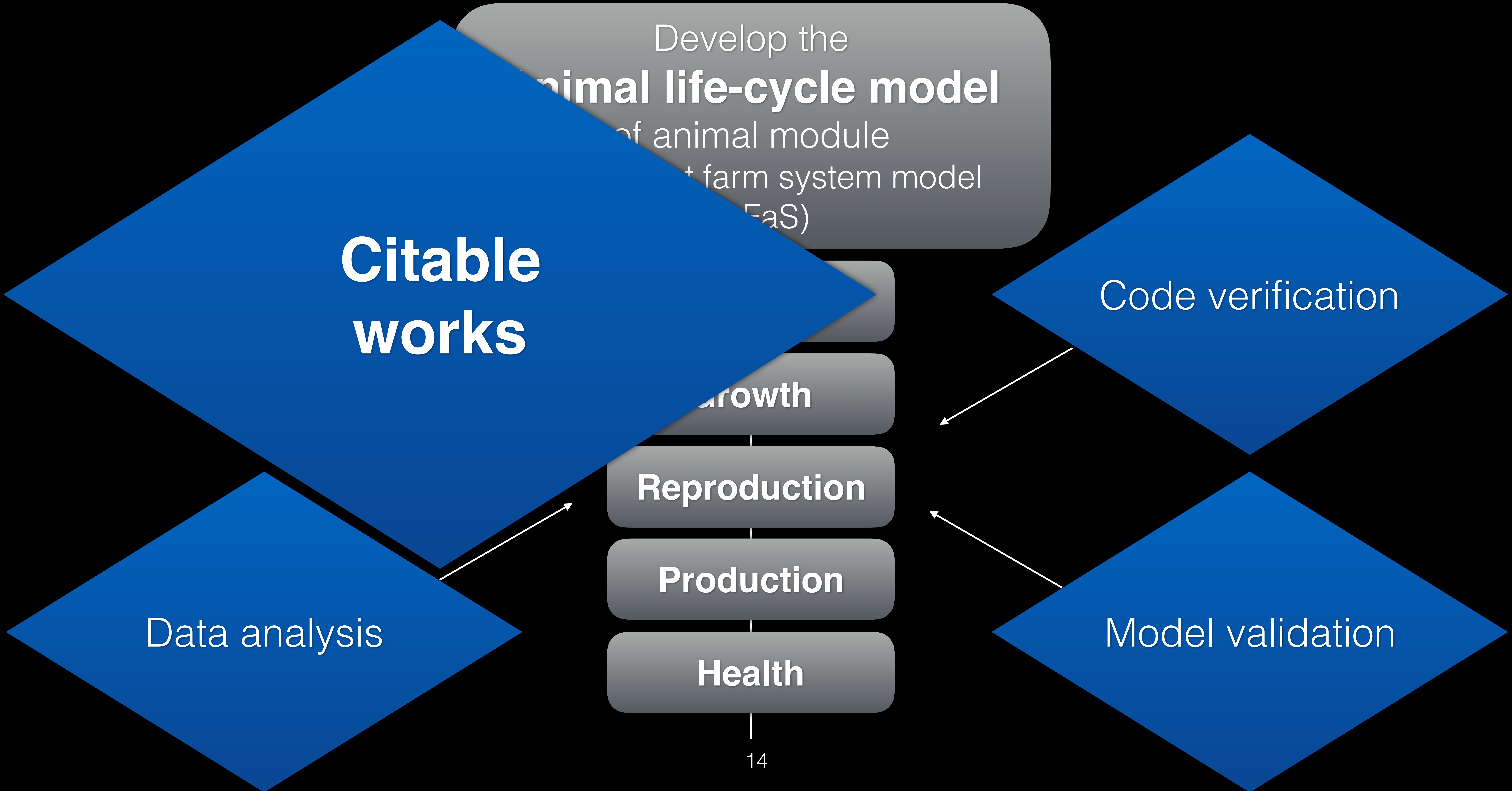
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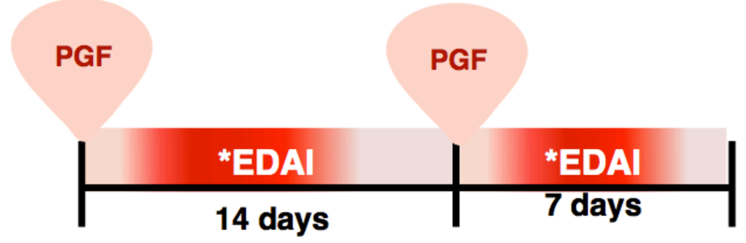
Reproductive Management Strategies for Dairy Heifers

Artificial insemination after detection of estrus

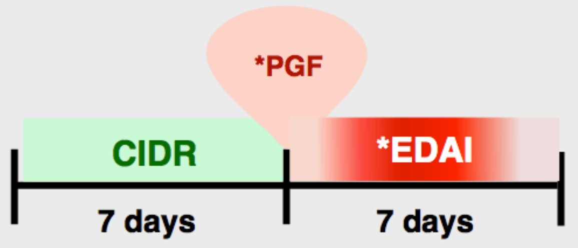
A. Two PGF followed by heat detection



Definitions and comments:

PGF = Prostaglandin $F_{2\alpha}$. ***Intensity of color in EDAI** indicates estrus intensity. Most heifers are in estrus 2-7 days after PGF. Approximately 70% of the heifers will be in estrus in the first 14 days after the first PGF. The remaining heifers should be in estrus after the second PGF. Non-responding heifers might be prepubertal. TAI can be used to provide a breeding opportunity of heifers not detected in estrus

B. CIDR program with PGF at removal



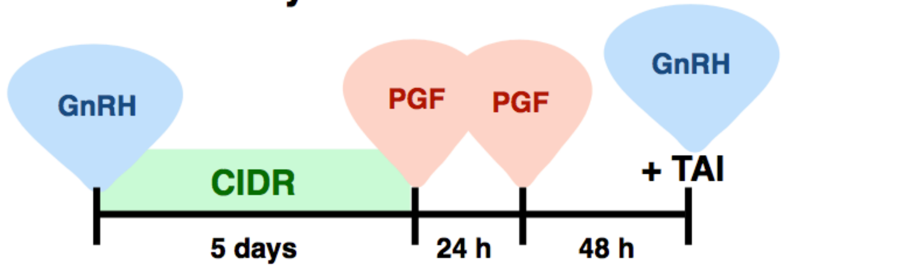
Definitions and comments:

CIDR = Controlled internal drug release. Approximately 70% of heifers should be in estrus during 7 days after the CIDR removal. Non responding heifers may be prepubertal. CIDR-based programs may induce fertile entrees in some prepubertal heifers. ***PGF** can be given on day 6 instead of 7 (One day before CIDR removal) to increase synchrony of estrus in the program

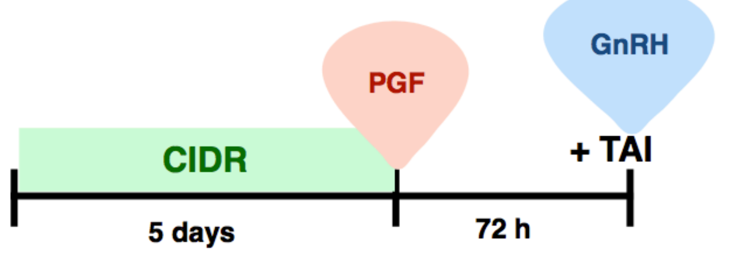
Programs for timed AI

GnRH = Gonadotropin-releasing hormone.
For the timed AI program presented below, the option A yields greater number of pregnancies per insemination than option B

A. 5-d CIDR-Synch with GnRH and 2 PGF



B. 5-d CIDR-Synch without GnRH and 1 PGF



Calendar options

A. Two PGF followed by heat detection

SUN	MON	TUE	WED	THU	FRI	SAT
	PGF	EDAI	EDAI	EDAI	EDAI	EDAI
EDAI	EDAI	EDAI	EDAI	EDAI	EDAI	EDAI
EDAI	PGF	EDAI	EDAI	EDAI	EDAI	EDAI
EDAI	EDAI					

B. CIDR program with PGF at removal

SUN	MON	TUE	WED	THU	FRI	SAT
	CIDR	CIDR	CIDR	CIDR	CIDR	CIDR
CIDR	CIDR PGF	EDAI	EDAI	EDAI	EDAI	EDAI
EDAI	EDAI					

C. 5-d CIDR-Synch with GnRH and 2 PGF

SUN	MON	TUE	WED	THU	FRI	SAT
			CIDR GnRH	CIDR	CIDR	CIDR
CIDR	CIDR PGF	PGF		GnRH TAI		

Note: This reproductive management sheet was assembled by the Dairy Cattle Reproductive Council (DCRC). Programs are intended to promote sustainable food production through sound dairy practices. The DCRC recommends working with a licensed veterinarian for the proper administration of all treatments.

Reproductive Management Strategies for Dairy Cows

Detection of estrus followed by timed AI

For herds with efficient and accurate estrus-detection systems

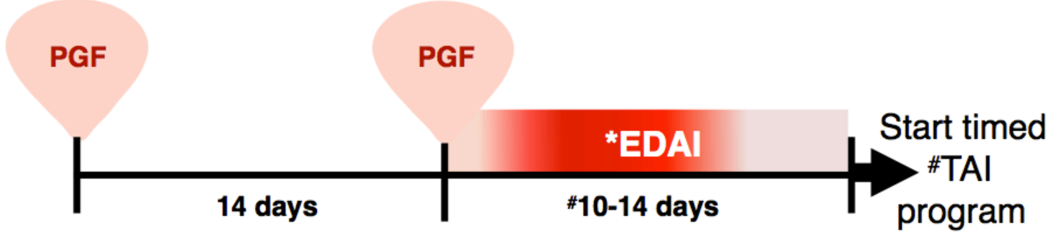
Definitions and comments:

EDAI = Estrous detection followed by AI
***Start** and **stop dates** for EDAI depend on voluntary waiting period **(VWP)** and the reproductive goals of the each herd

Presynchronization methods used before TAI

Used with TAI programs below to increase pregnancy per AI (P/AI). Can be used with or without EDAI

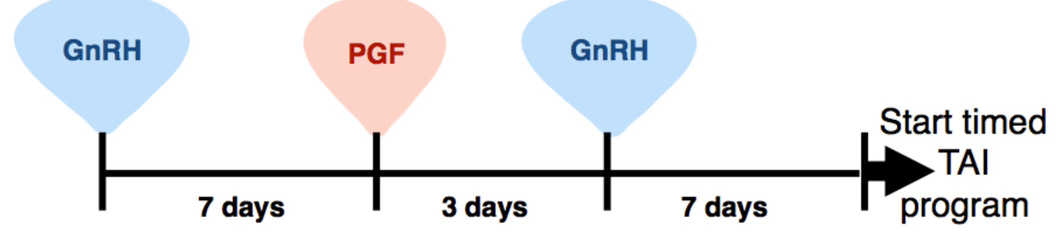
A. "PreSynch" (2xPGF - TAI)



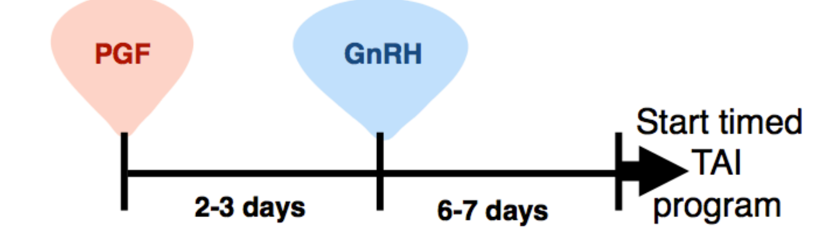
Definitions and comments:

PGF = Prostaglandin $F_{2\alpha}$
GnRH = Gonadotropin-releasing hormone
***Intensity of color in EDAI** denotes period (2-7 days) to expect most cows in estrus; **#TAI** program starting 10-12 days after PGF results in higher fertility

B. "Double OvSynch" (GnRH-PGF-GnRH - TAI)



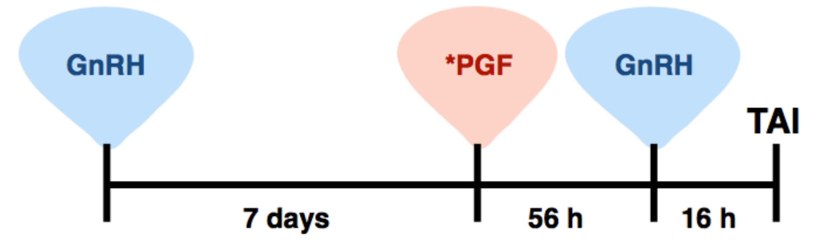
C. "G-6-G" (PGF-GnRH - TAI)



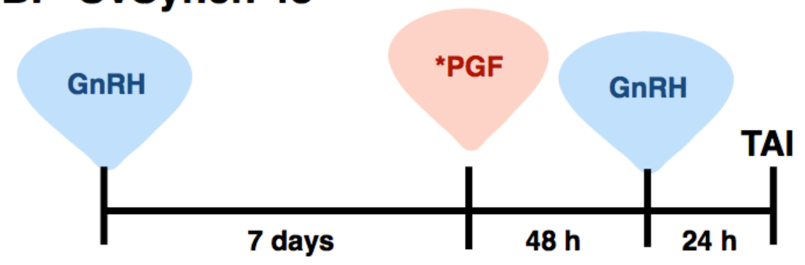
Synchronization methods for TAI

Can be used alone or with presynchronization (see above), and with or without EDAI detection. Presynchronization increases fertility. The use of the CIDR benefits fertility of cows with no CL starting TAI.

A. "OvSynch 56"

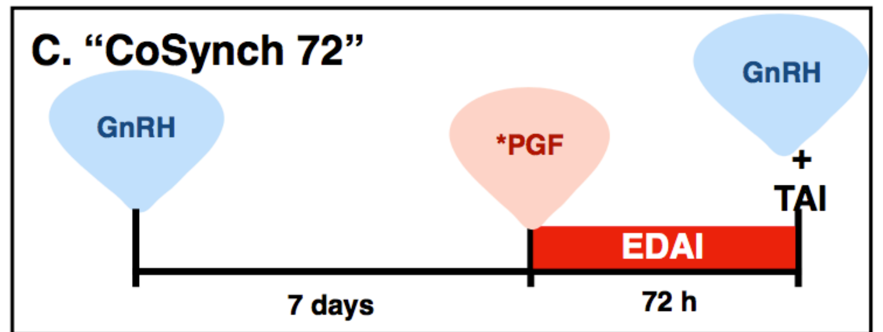


B. "OvSynch 48"

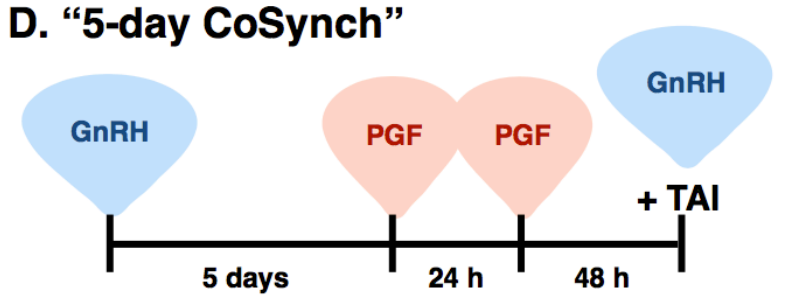


CIDR can be used in any program being inserted at 1st GnRH and removed at PGF

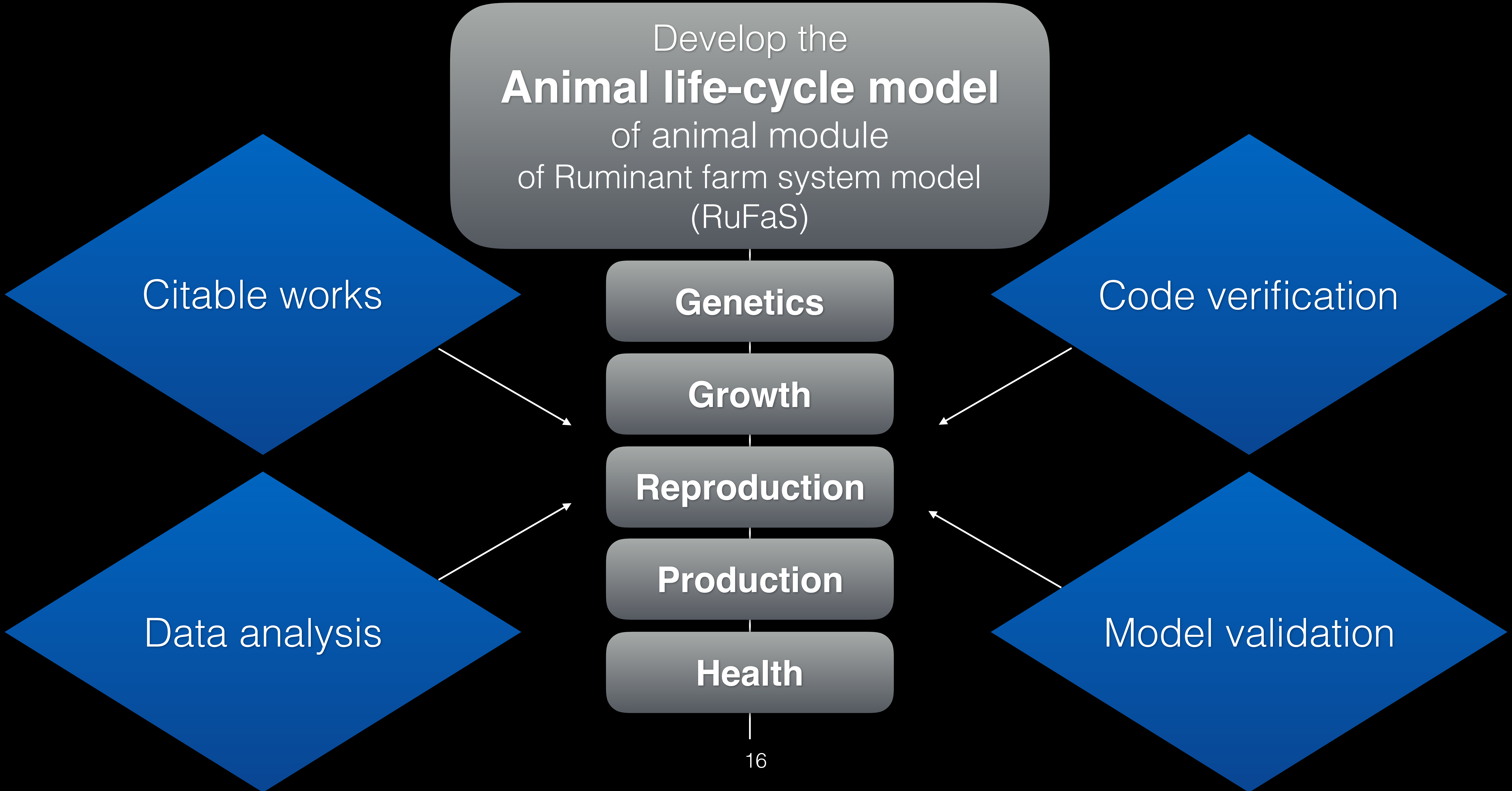
C. "CoSynch 72"



D. "5-day CoSynch"



**A second PGF 24 h after the first PGF improves luteolysis and fertility*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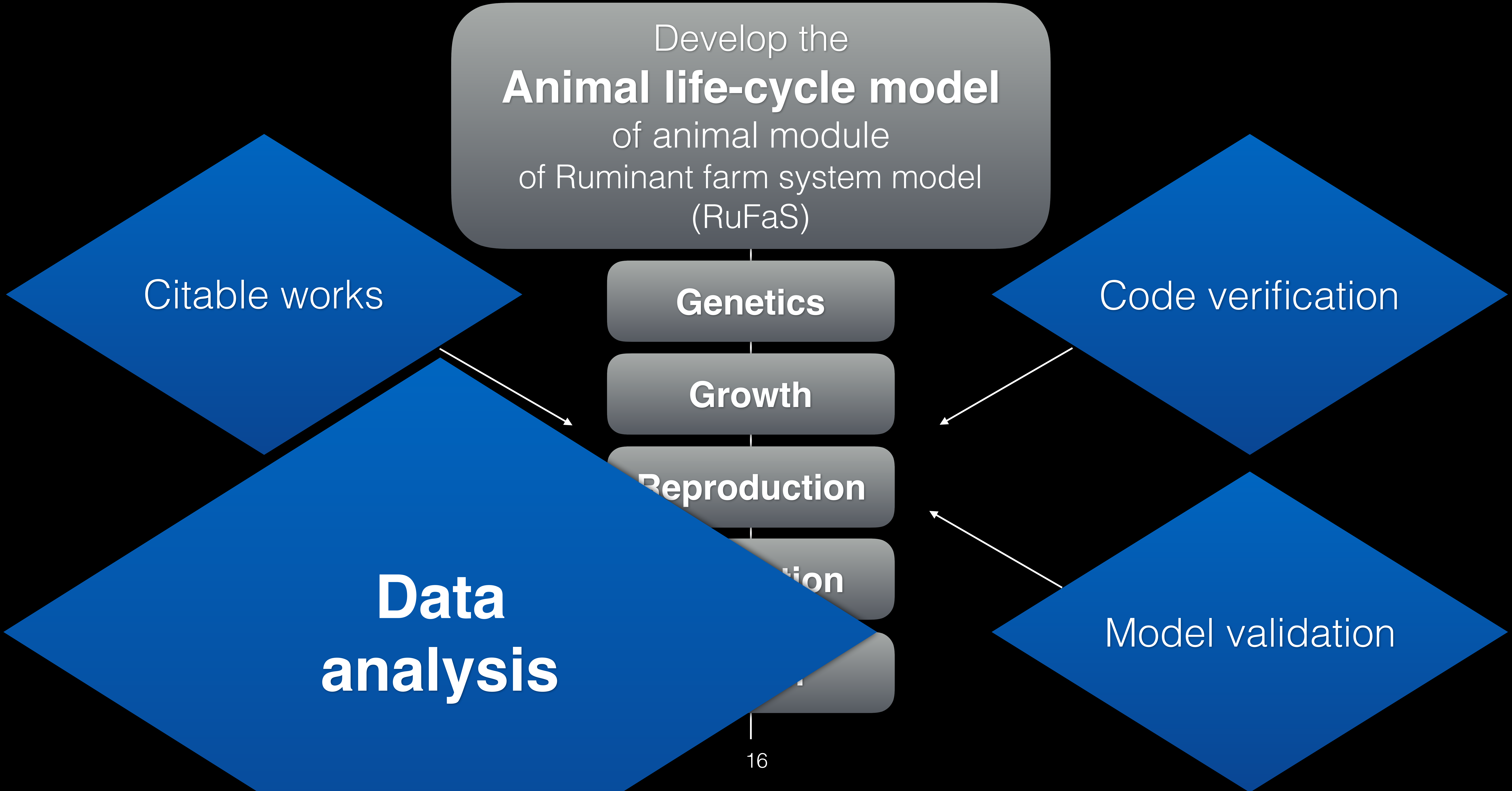
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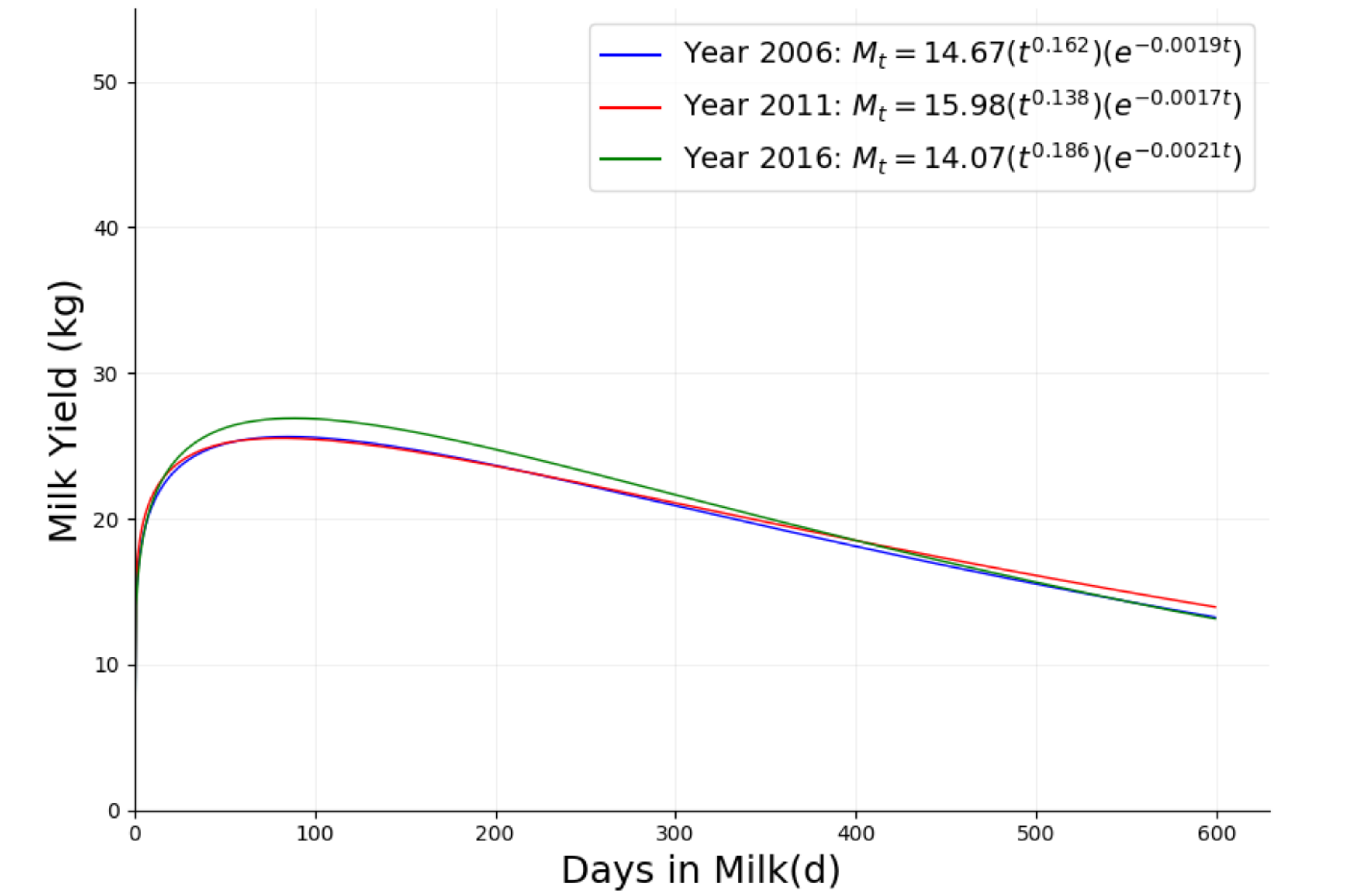
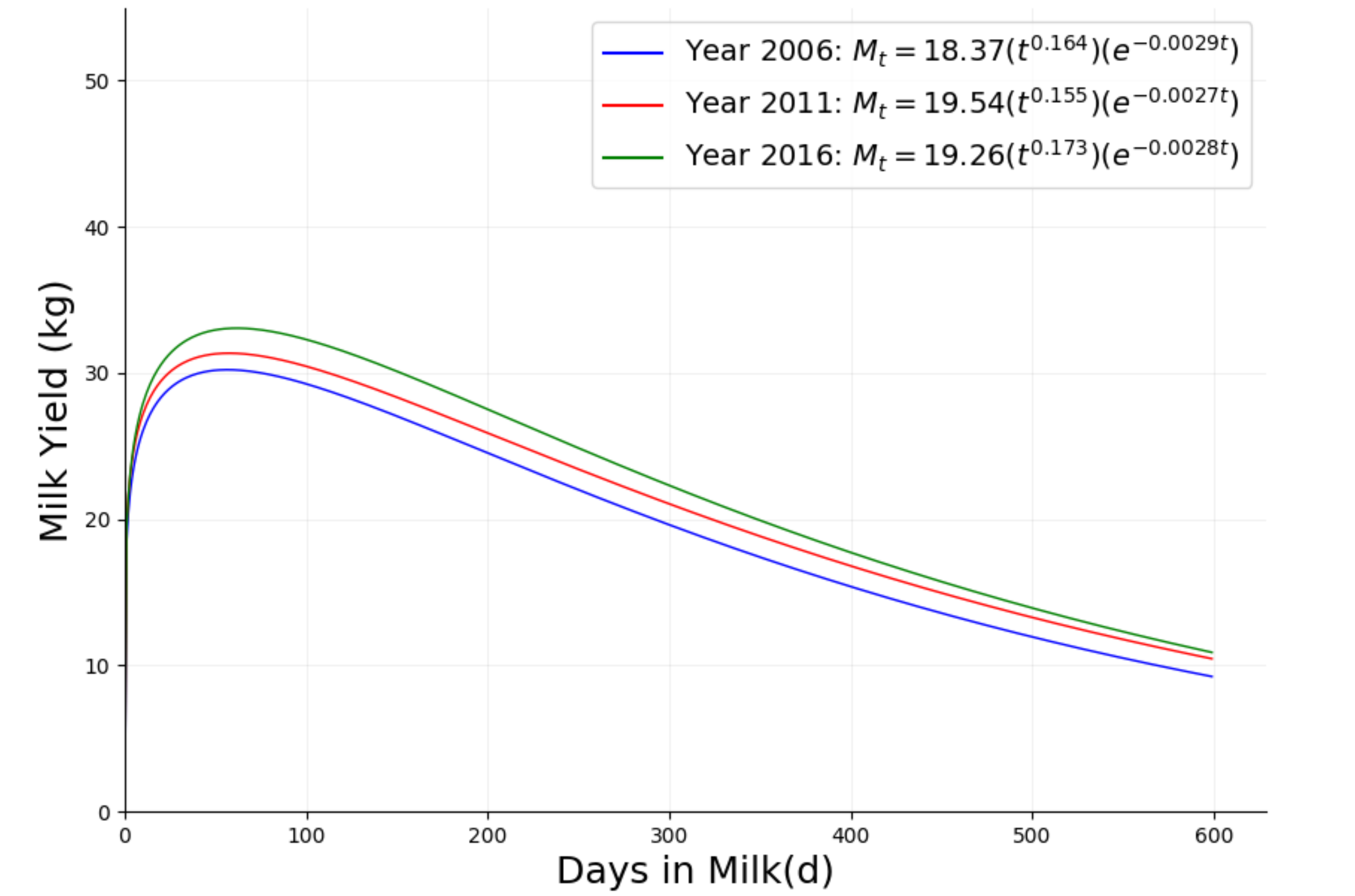
Lactation curve parameters

- Dataset
  - From Council on Dairy Cattle Breeding(CDCB)
- Three goals:
  - Update lactation curve parameters for Holstein and Jersey
  - Investigate production changes along time and regions
  - Find suitable methods to be incorporate in the animal model

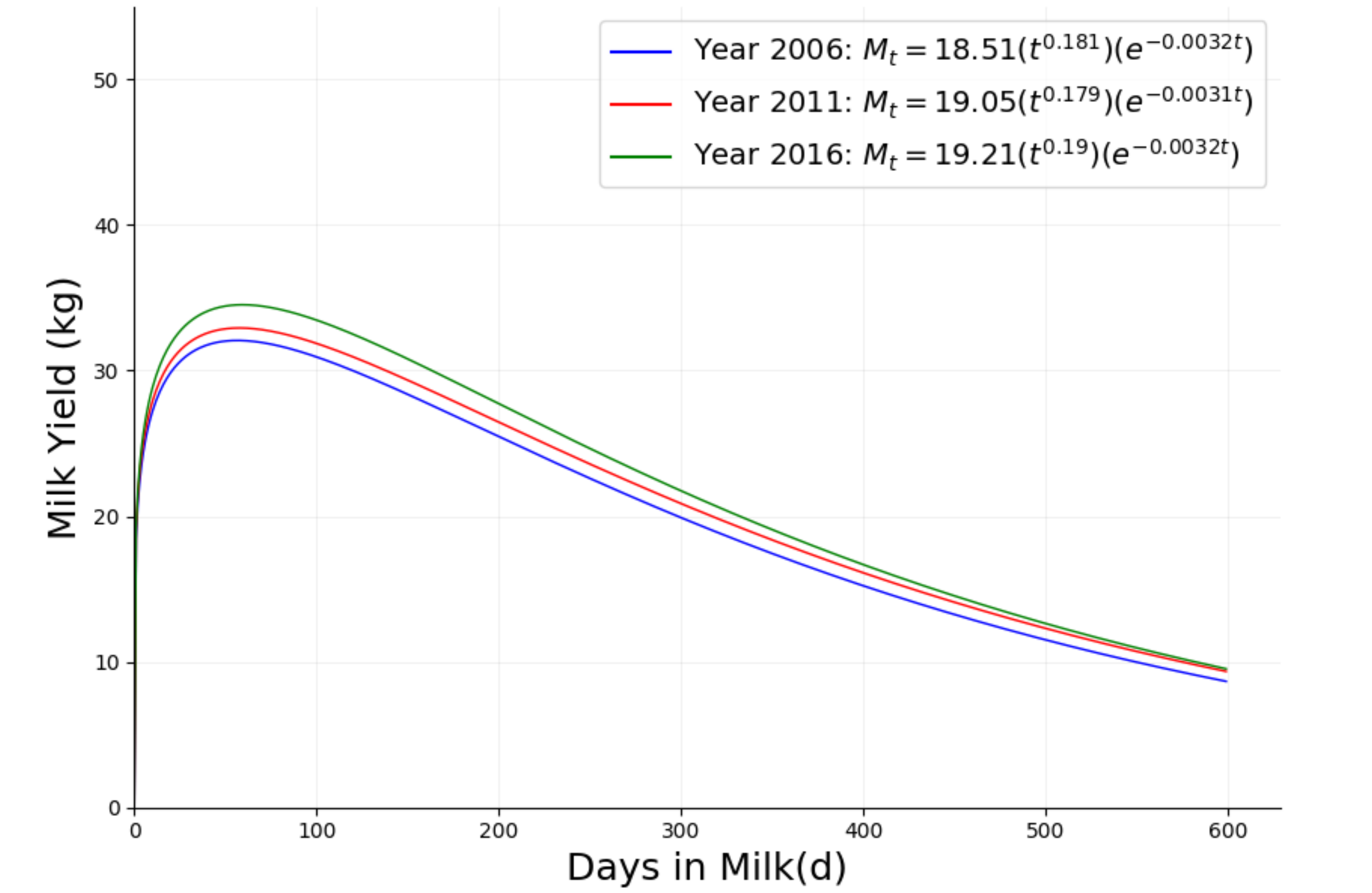
Curves across years



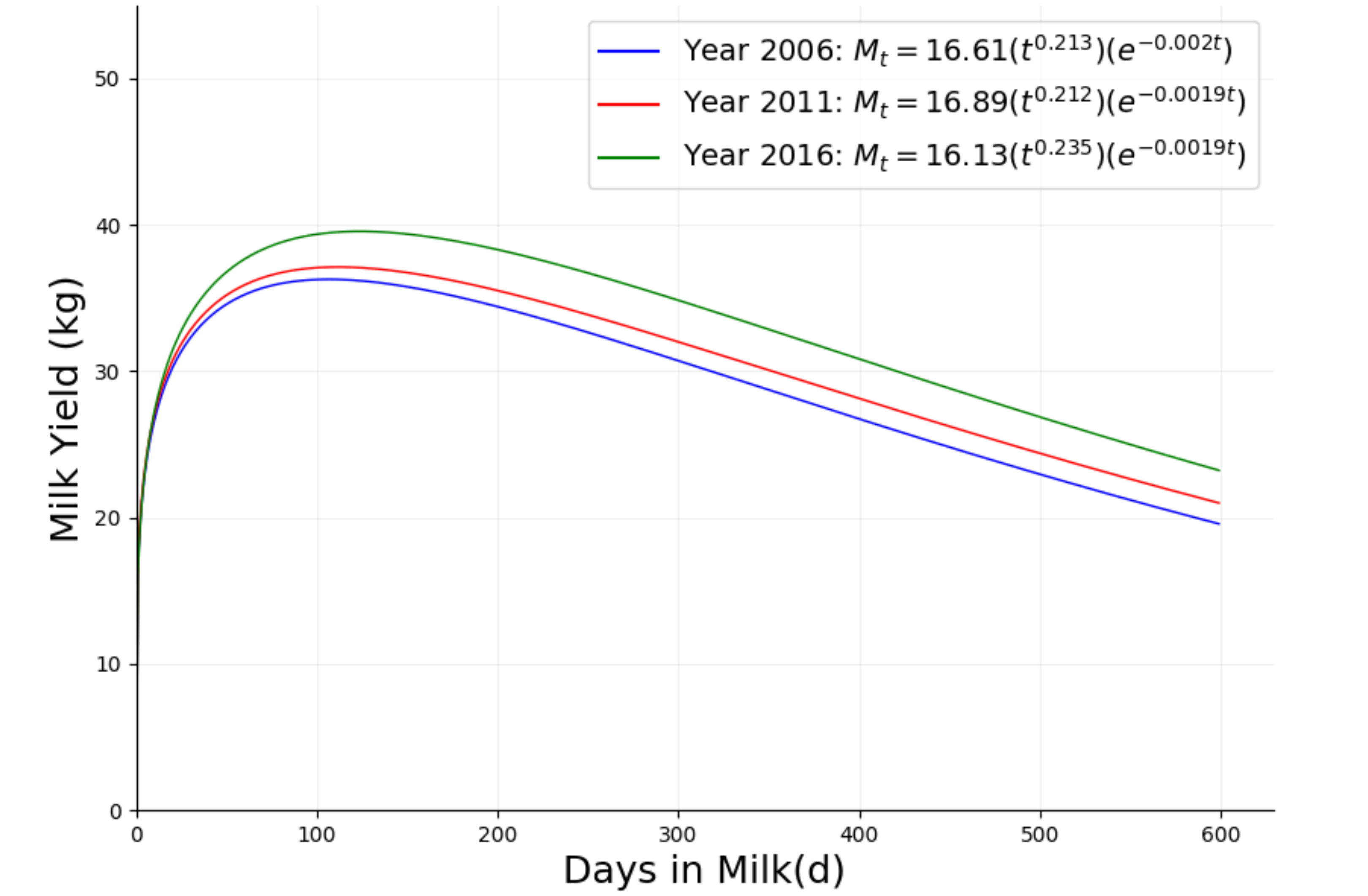
Jersey Lactation 1



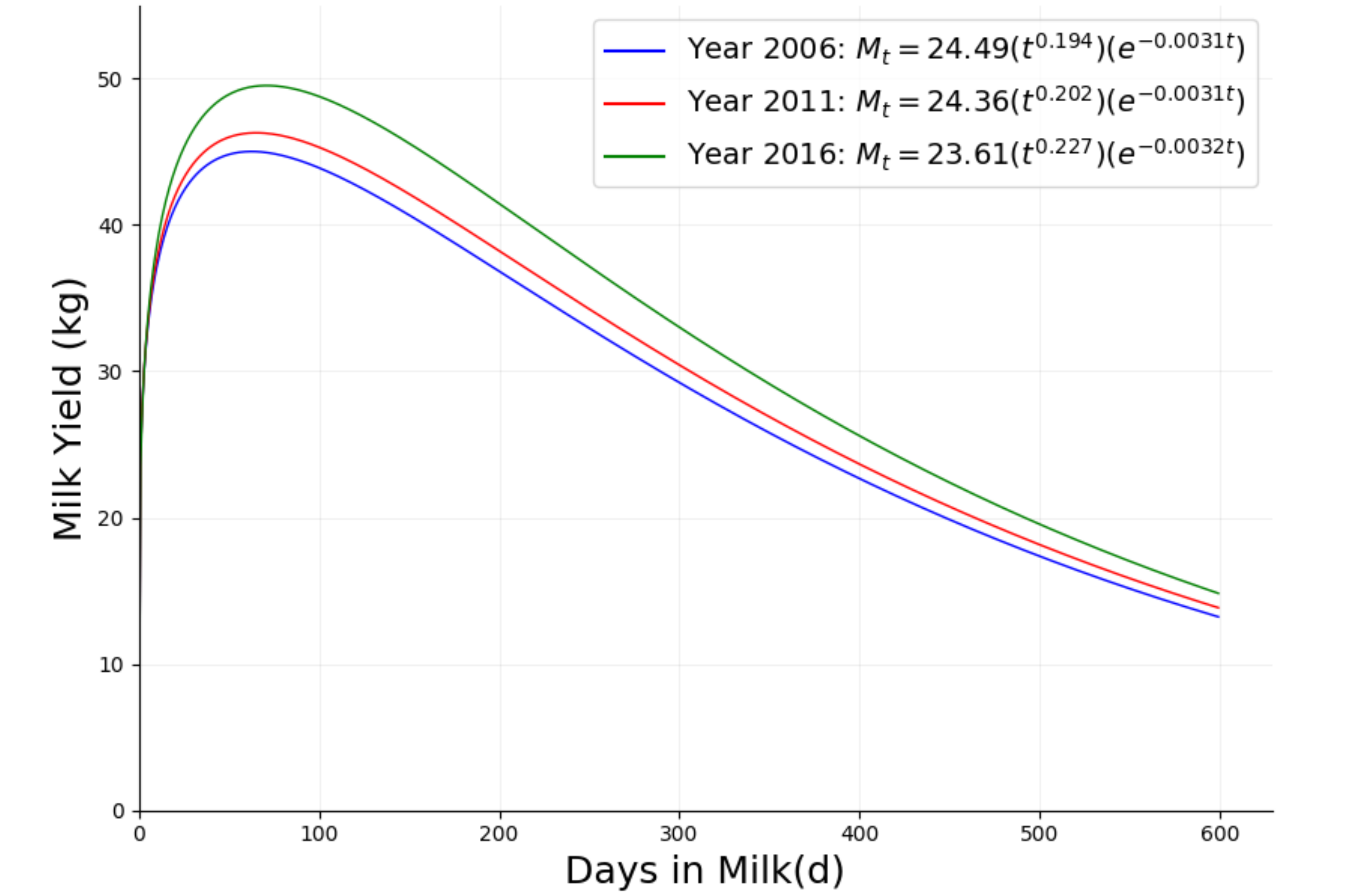
Jersey Lactation 2



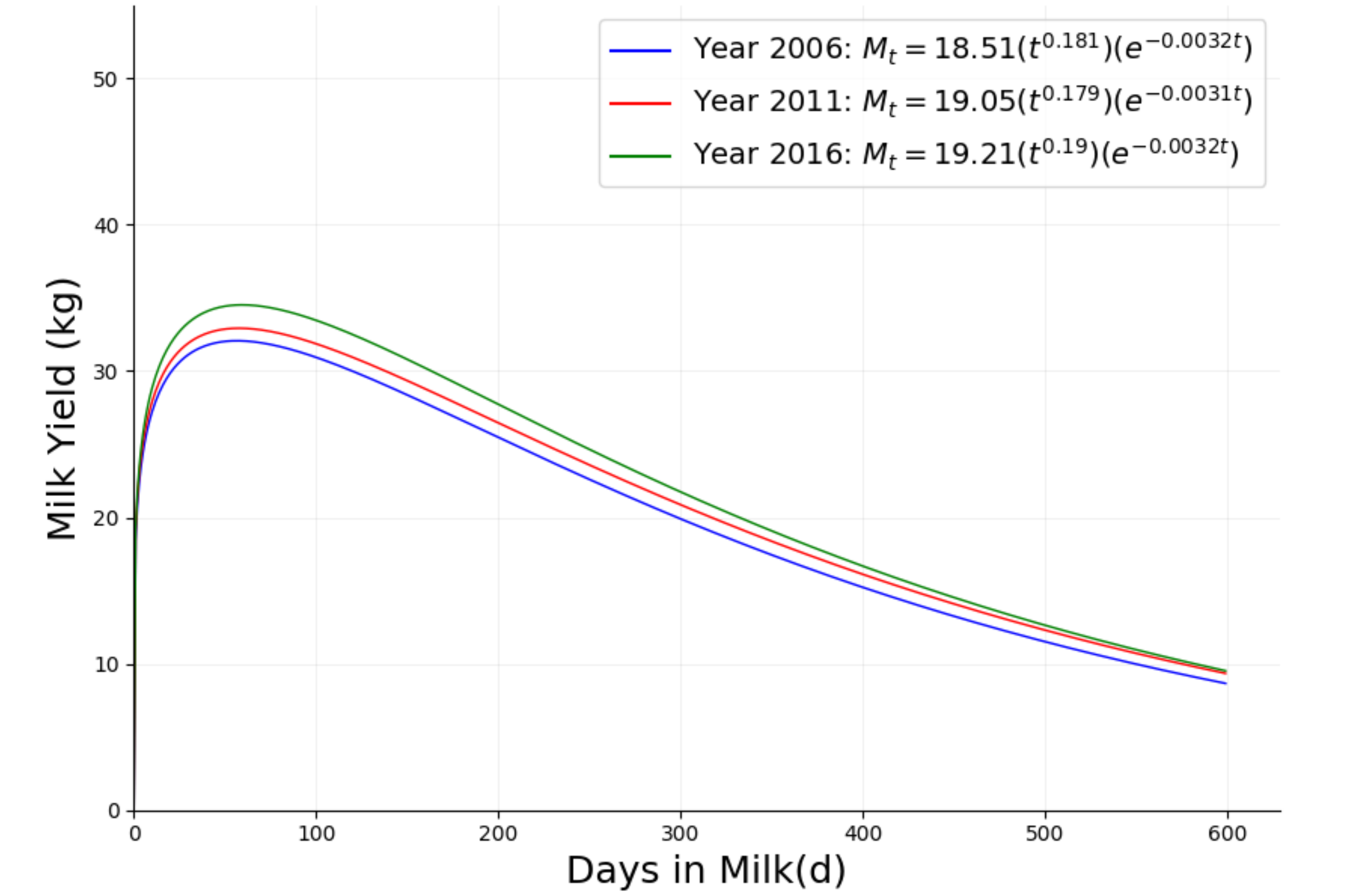
Jersey Lactation >2



Holstein Lactation 1



Holstein Lactation 2

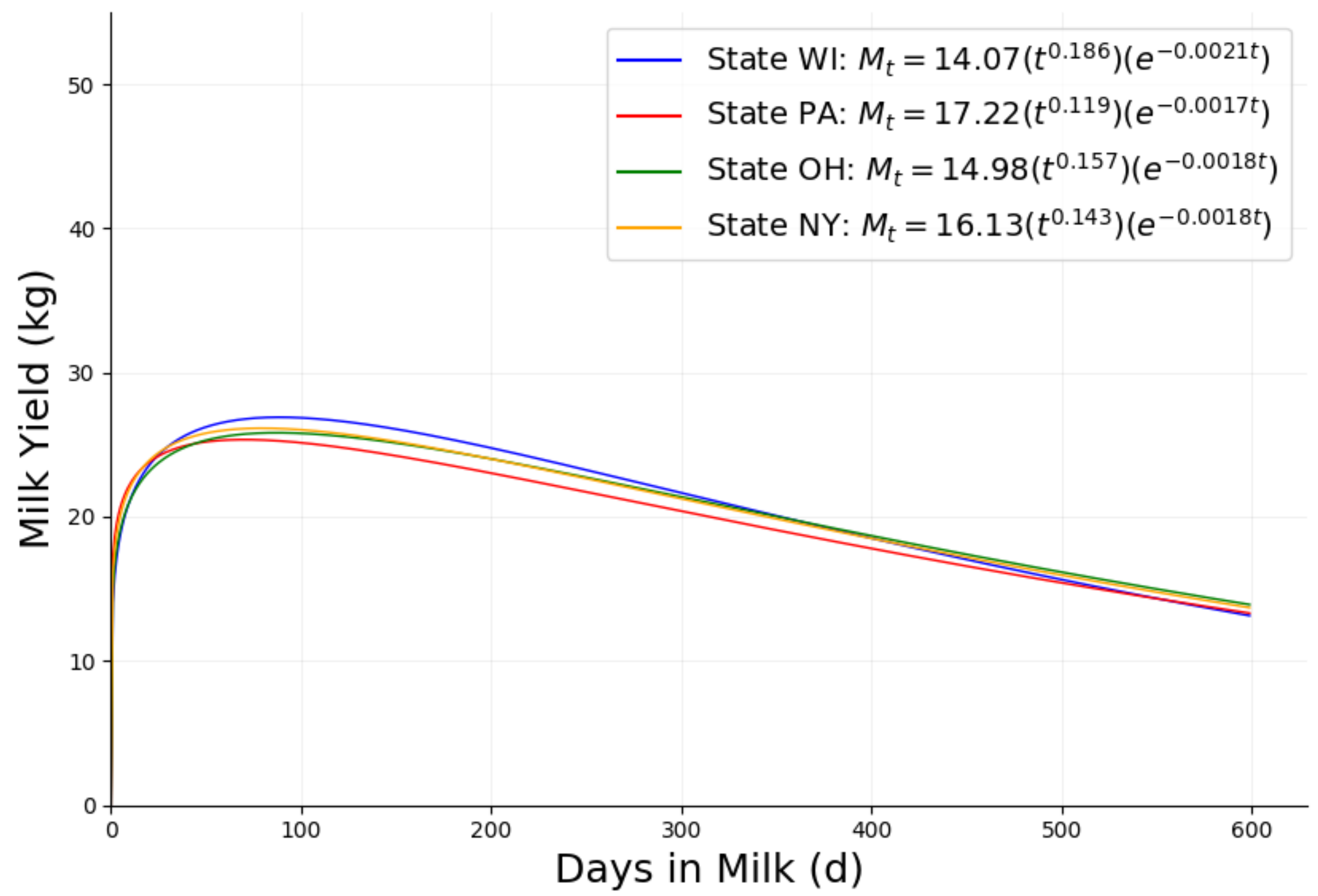


Jersey Lactation >2

Statistical Analysis

		Jersey		Holstein	
Lactation		2006	2011	2006	2011
1st	2011	0.0157	-	<0.001	-
2nd		<0.001	-	<0.001	-
Later		<0.001	-	<0.001	-
1st	2016	<0.001	0.126	<0.001	<0.001
2nd		<0.001	<0.001	<0.001	<0.001
Later		<0.001	<0.001	<0.001	<0.001

Curves across states



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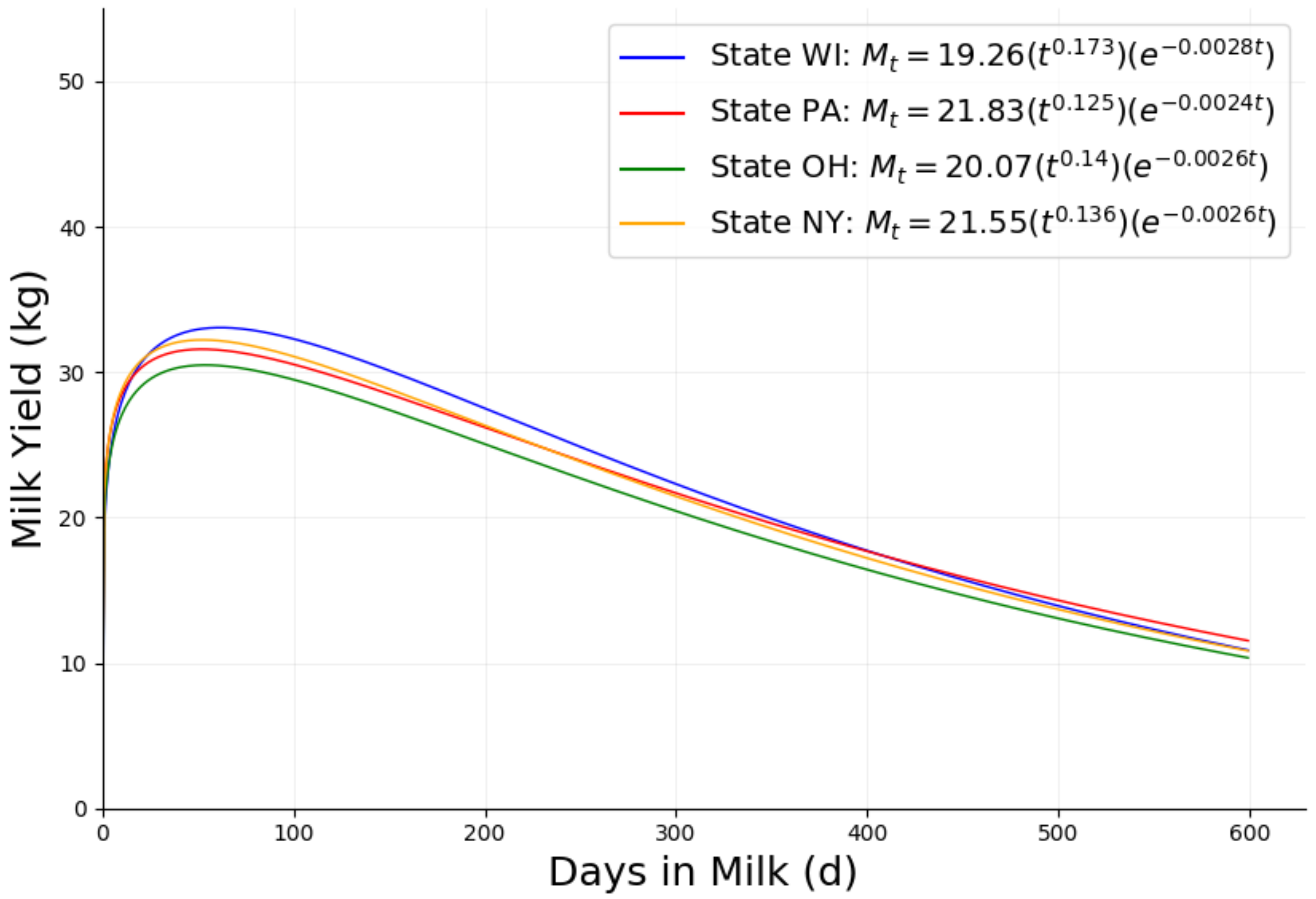
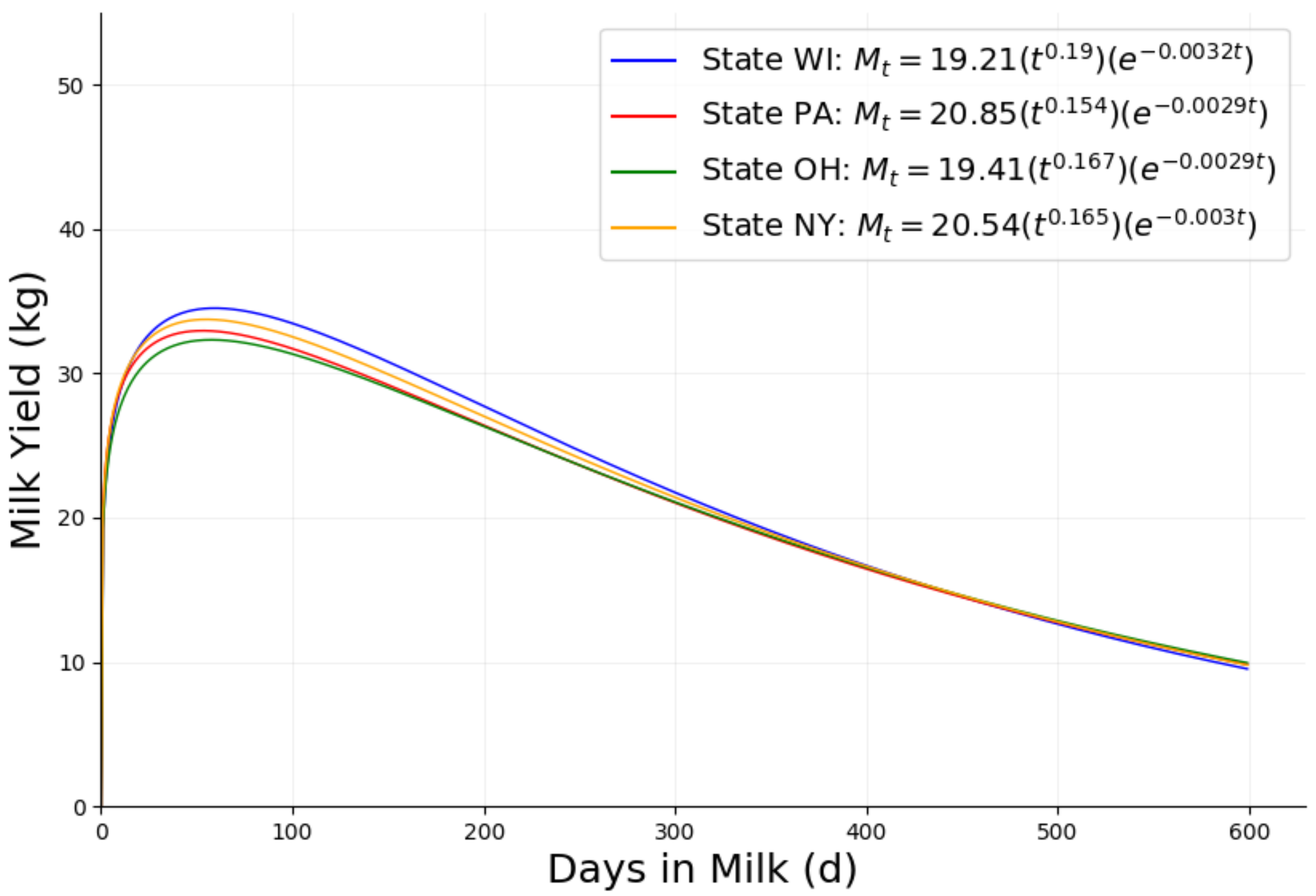
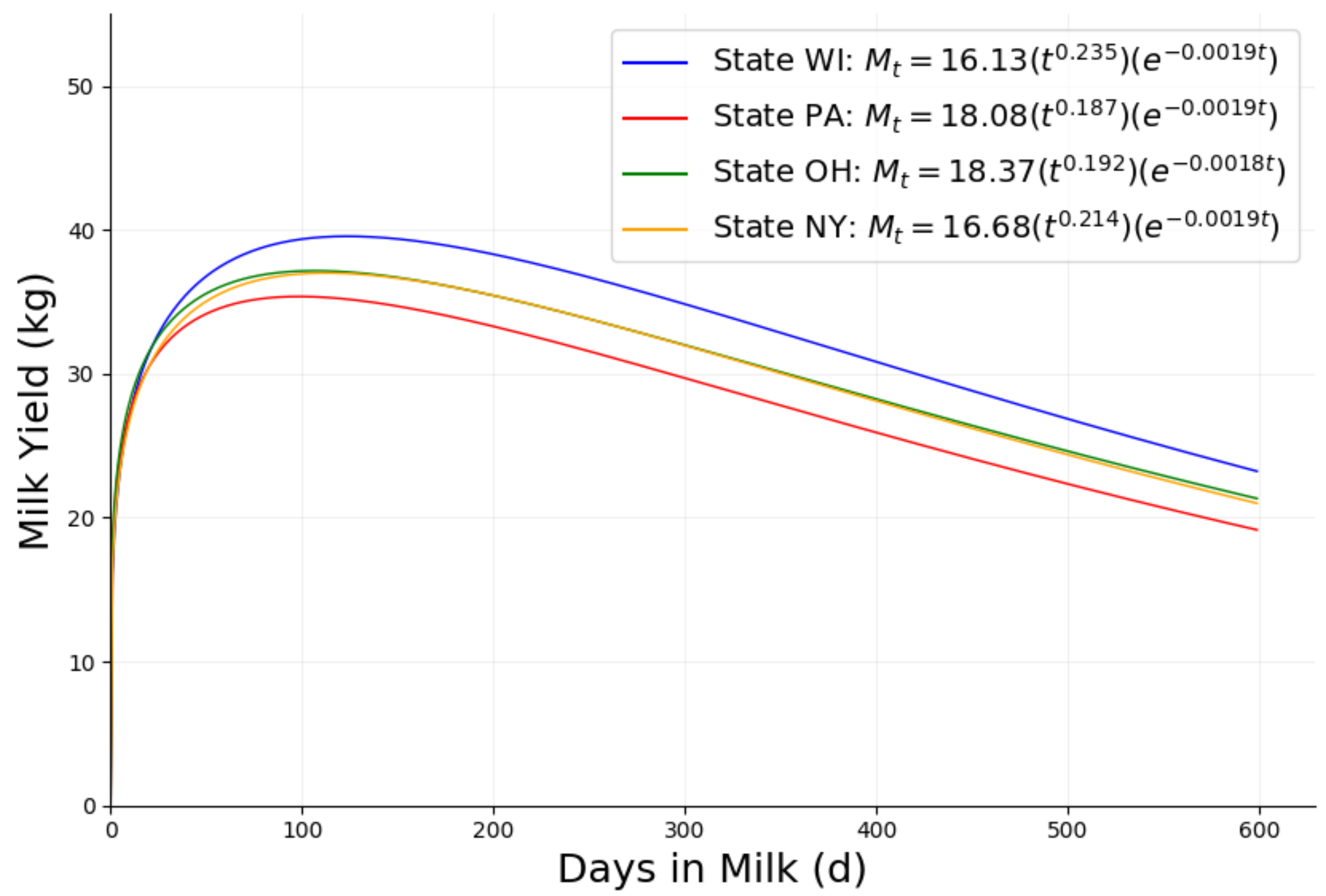


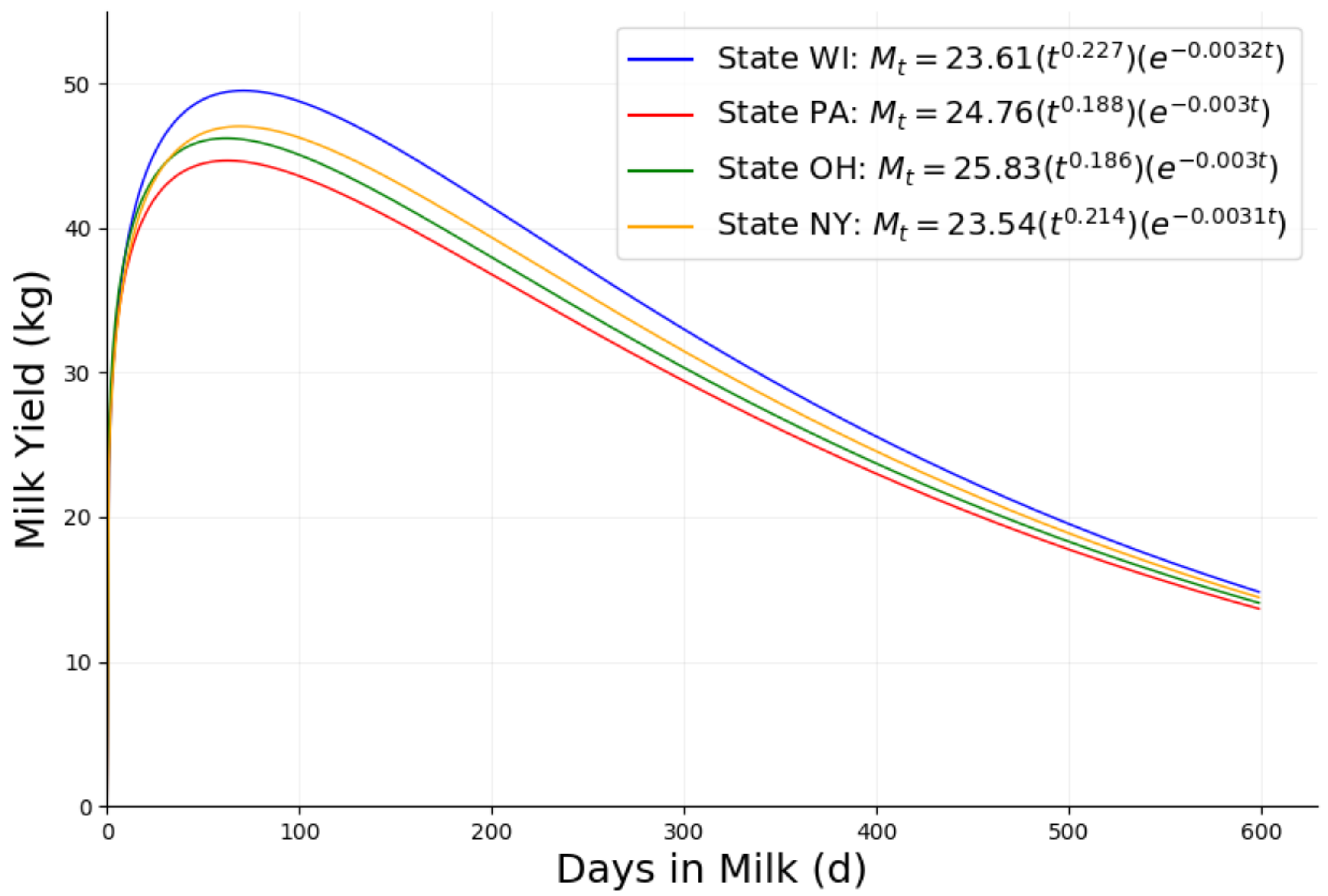
Jersey Lactation 2



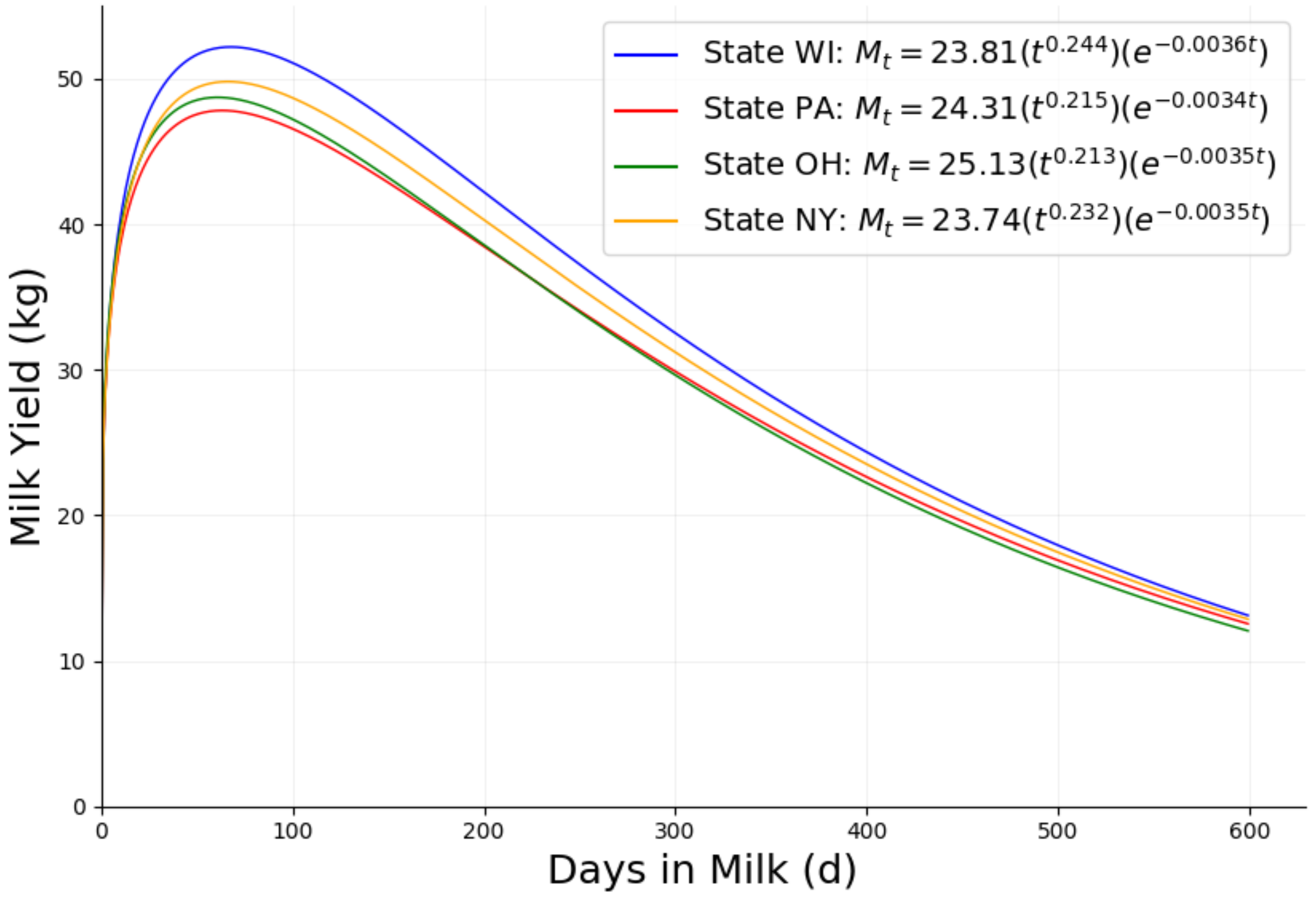
Jersey Lactation >2



Holstein Lactation 1



Holstein Lactation 2



Holstein Lactation >2

Statistical Analysis

		Jersey			Holstein		
Lactation		WI	PA	OH	WI	PA	OH
1st	PA	<0.001	-	-	<0.001	-	-
2nd		<0.001	-	-	<0.001	-	-
Later		<0.001	-	-	<0.001	-	-
1st	OH	<0.001	0.0016	-	<0.001	<0.001	-
2nd		<0.001	<0.001	-	<0.001	<0.001	-
Later		<0.001	0.046	-	<0.001	<0.001	-
1st	NY	0.013	<0.001	0.0369	<0.001	<0.001	0.703
2nd		0.104	0.0011	<0.001	<0.001	<0.001	<0.001
Later		0.059	<0.001	<0.001	<0.001	<0.001	<0.001

Discussion

There are a significant improvement in terms of lactation curve scale in the last 10 years in both breeds. The updating of the lactation curve parameters is necessary.

There are a significant difference in terms of lactation curve scale among different States in 2016. The use of state-specific lactation curve parameters is necessary.

Further analysis could be conducted regards other factors, such as calving season, other lactation models, for instance Dijkstra's model, and milk components curves

Presented in ADSA this year

DEPARTMENT OF DAIRY SCIENCE
University of Wisconsin-Madison

Updating Jersey and Holstein lactation curve parameters for the Rumination Farm System Model (RuFaS)

Cornell University

Manfei Li[1], Victor E. Cabrera[1], Kristan F. Reed[2]

[1]Department of Dairy Science, University of Wisconsin - Madison, Madison, WI 53706; [2]Department of Animal Science, Cornell University, Ithaca, NY

INTRODUCTION

- In the last decade, milk production has risen mostly due to increased genetic potential and management
- A lactation curve is a mathematical function describing the trend of milk yield with days in milk (DIM) during a lactation
  - E.g.: Wood's model ($y = at^{b}e^{-ct}$)
  - Parameter a is the scale factor for initial milk yield, b is rate factor for increase in milk yield to peak, and c is the rate factor for decline in milk yield after peak.
- Lactation curves can be used to predict milk yield daily or over long periods of time but must include parameters that are fit to representative data to achieve an acceptable level of accuracy.
- Most of today's dairy simulation models use lactation curve parameters that were fit many years ago when the models were first introduced.
- To better represent current animal performance in a holistic dairy farm system model, the RuFaS model, we investigated changes in lactation curve parameters across breed, parity, and region.
  - The RuFaS model is a process-based and daily time-step model, using biophysical equations to represent farm processes.
  - Holstein and Jersey are the two breeds have most dairy cows in the U.S. and also in our dataset, and so are the breeds that are included in this study.

OBJECTIVES

- Analyze how much the lactation performance has improved during the last 10 years for Jersey and Holstein breeds in Wisconsin.
- Explore breed-, parity-, and state-specific lactation curve parameters for 2016 in states with large Jersey populations: Pennsylvania, Ohio, and New York.

MATERIALS & METHODS

- Data
  - Provided by the Council on Dairy Cattle Breeding
  - 12.82 million individual lactations, each one containing at least 10 test-day records and calving dates for 47 states and 22 breeds
  - 11.76 million of the lactations belonged to Holstein's, 485.39 thousand to Jersey's, 332.10 thousand to crossbred, 117.56 thousand to Brown Swiss, and 124.95 to other breeds
  - **Table 1**. Number of lactations in the studied States

Number of Lactations	Wisconsin		Pennsylvania		Ohio		New York	
	Jersey	Holstein	Jersey	Holstein	Jersey	Holstein	Jersey	Holstein
Overall	85,250	3,240,000	61,180	1,700,000	46,810	458,460	39,630	1,660,000
2016	7,906	278,923	5,263	124,524	4,377	28,404	2,957	133,587
2011	7,061	249,931						
2006	6,309	215,825						

  - Averaged milk yield every 10 DIM and set the cut-off point at 365 DIM.
- Lactation curve fitting
  - Fitted the averaged data to the Wood's lactation curve function using the least square method in the *lmfit* package in Python to get the curve parameters.
  - The least square method was chosen for this non-linear curve fitting to minimize the variation.

RESULTS

- **Table 2**. Peak time, peak production and accumulated 305-days production of each curve

	2006, WI		2011, WI		2016, WI		2016, PA		2016, OH		2016, NY	
	Holstein	Jersey	Holstein	Jersey	Holstein	Jersey	Holstein	Jersey	Holstein	Jersey	Holstein	Jersey
Peak time (days in milk)	105	83	111	80	117	87	97	71	104	86	111	79
	61	56	65	56	69	59	62	51	61	53	67	52
	60	55	64	57	67	59	61	52	60	56	65	55
Peak production (kg)	36.25	25.53	37.15	25.52	39.20	26.88	35.33	25.39	36.99	25.78	37.07	26.19
	44.86	30.29	46.49	31.33	49.38	32.94	44.72	31.55	46.20	30.53	46.94	32.36
	46.20	32.03	48.54	32.90	52.24	34.53	47.64	32.99	48.87	32.33	49.72	33.84
305-day production (kg)	10,218	7,159	10,525	7,215	11,079	7,506	9,981	7,149	10,496	7,273	10,501	7,373
	11,641	7,894	12,210	8,235	12,944	8,647	11,698	8,432	12,064	8,050	12,329	8,529
	11,792	8,211	12,534	8,503	13,433	8,927	12,207	8,533	12,489	8,422	12,783	8,776

RESULTS

Figure 1. Fitted lactation curves and parameters of Holstein's and Jersey's of Wisconsin from years 2006, 2011, and 2016

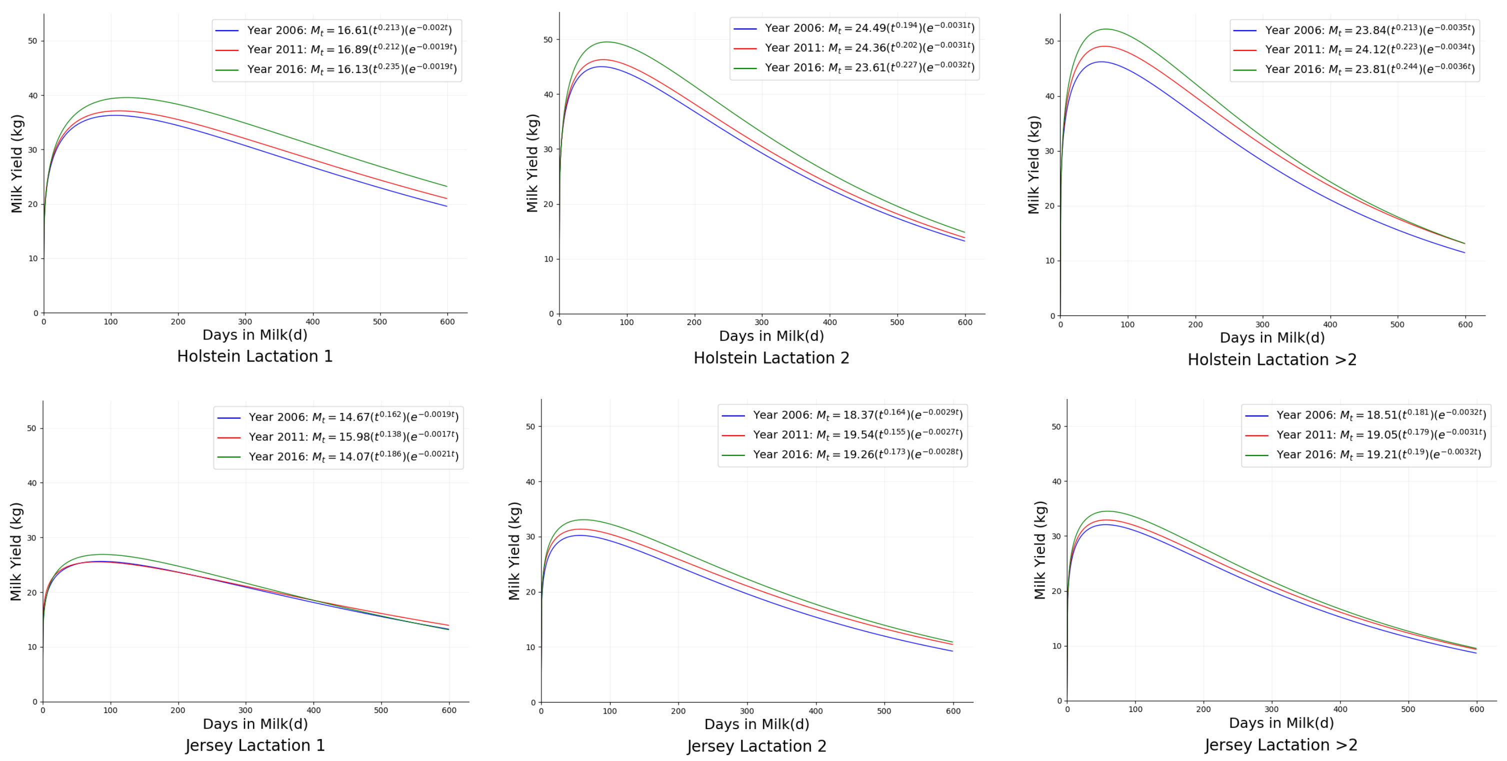
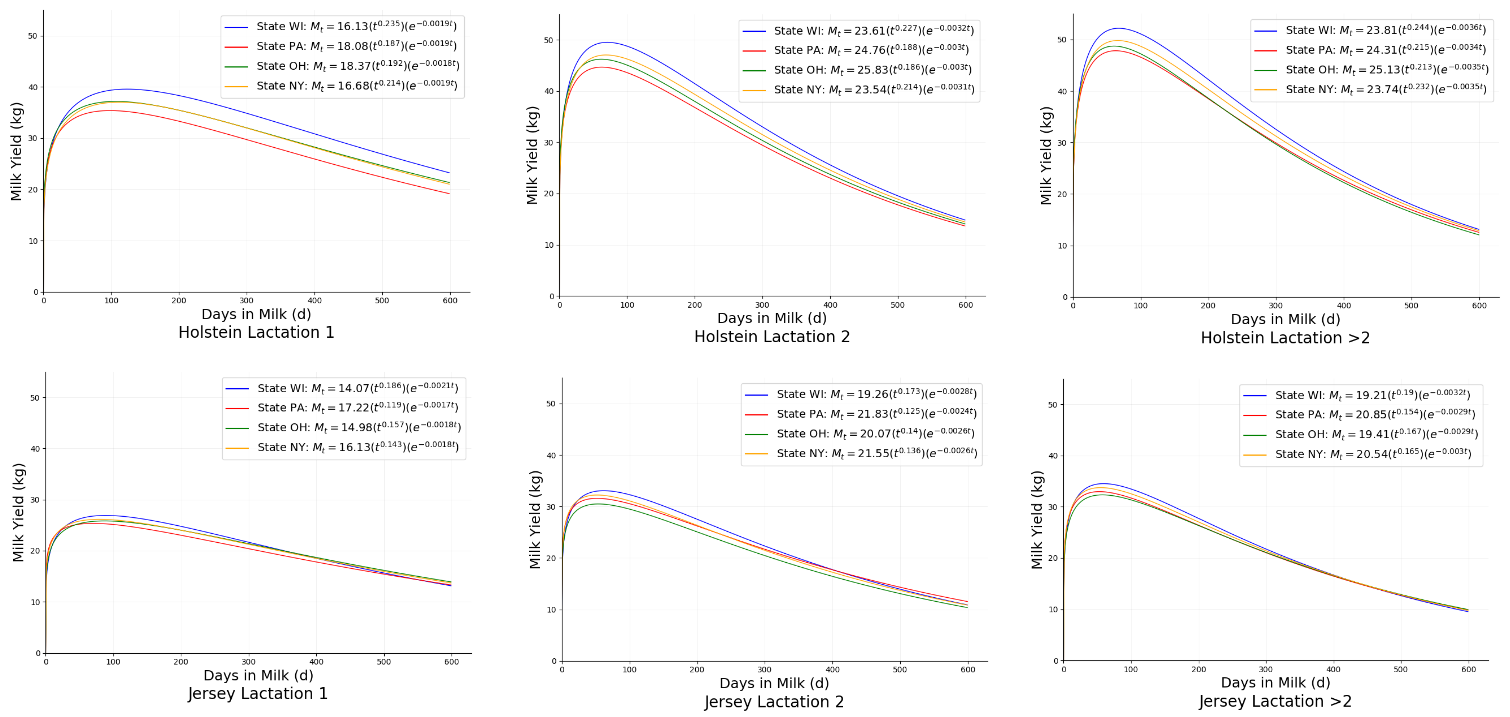


Figure 2. Fitted lactation curves and parameters of Holstein and Jersey from the year 2016 for Wisconsin, Pennsylvania, Ohio, and New York

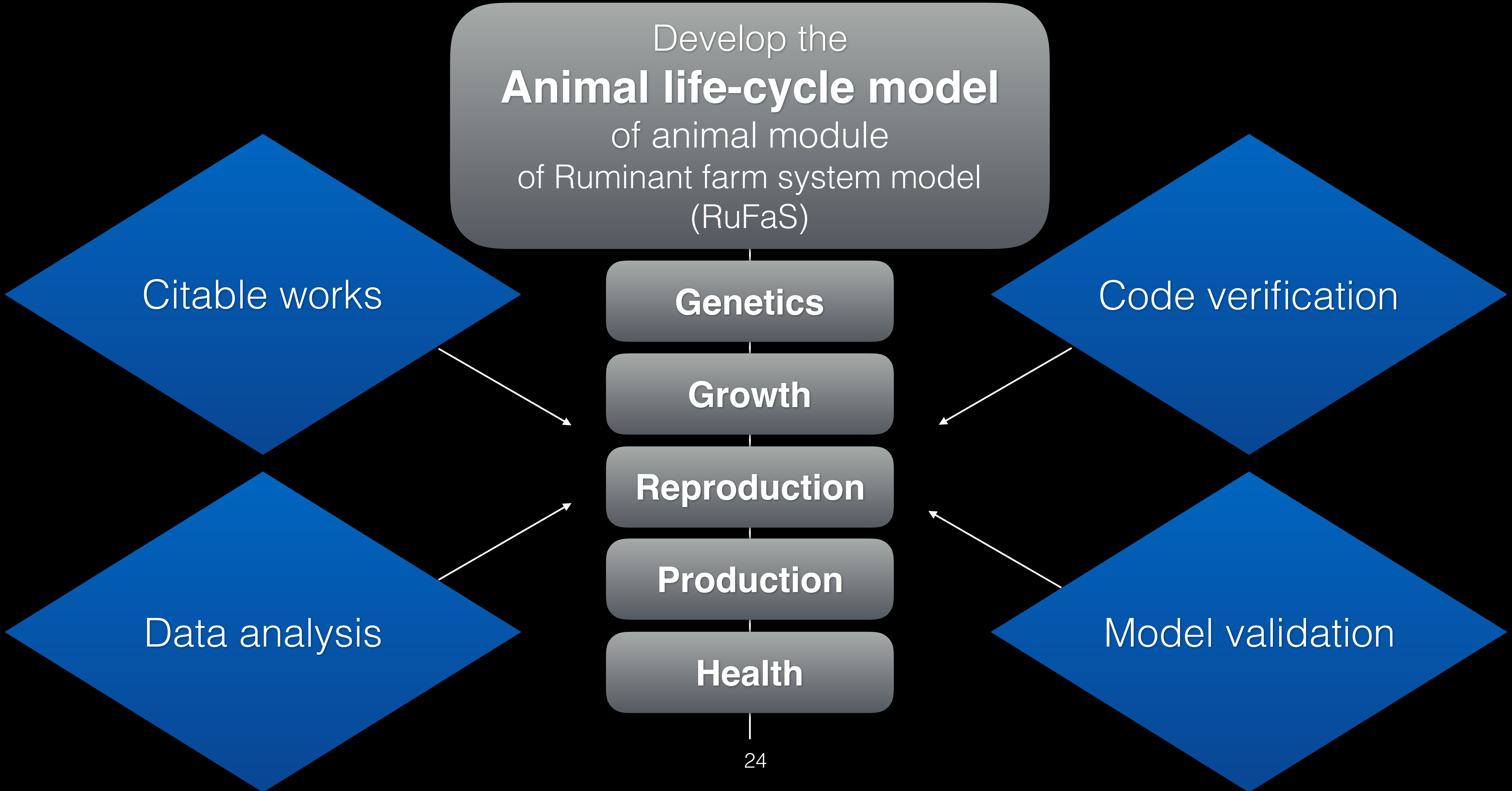


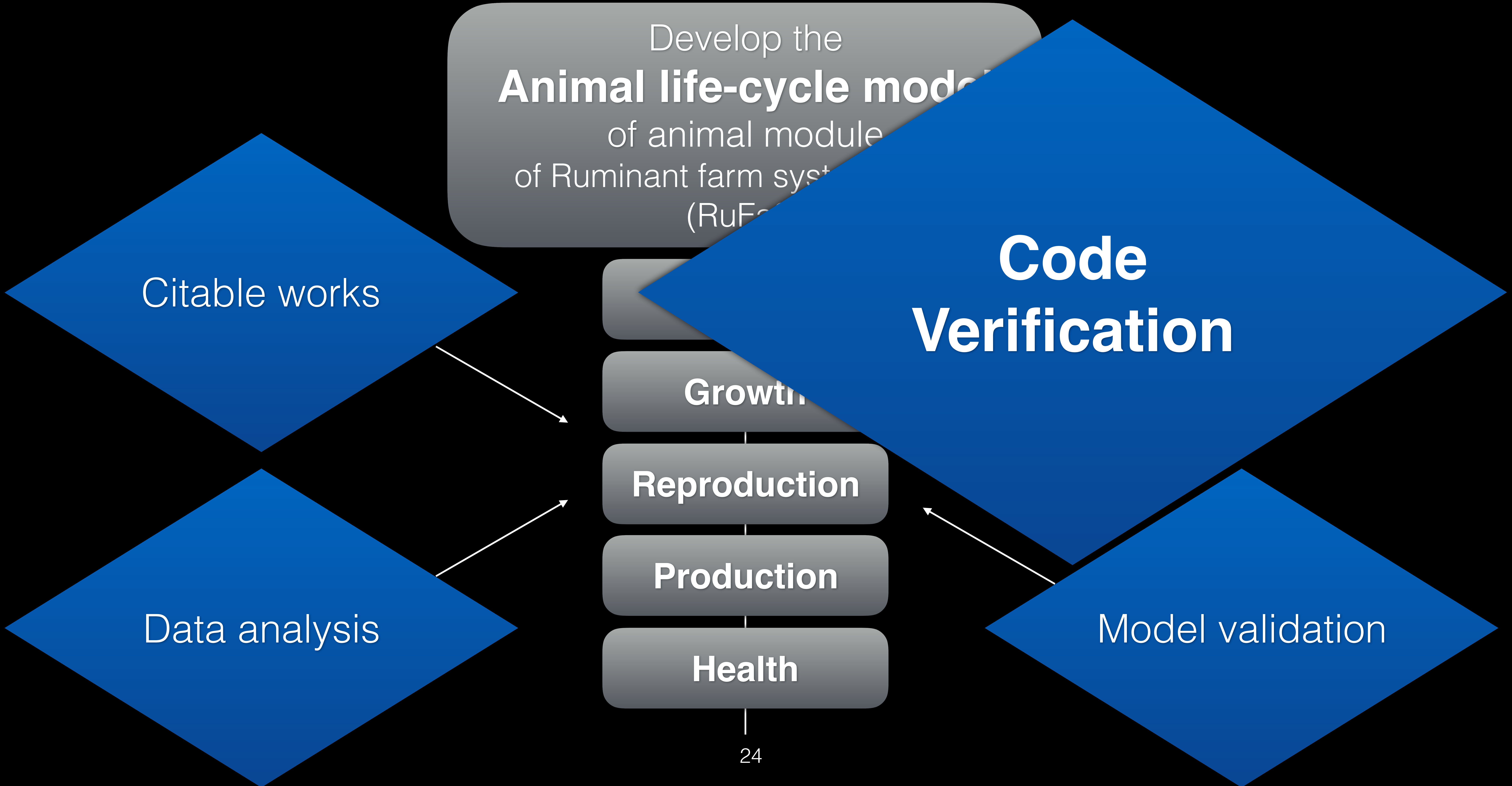
CONCLUSIONS

- Results showed increased 305-d milk yields and postponed and higher lactation peaks in 2016 compared to 2011 and in 2011 compared to 2006 for Jerseys and Holsteins in all parities in Wisconsin.
- Holstein curves had a greater scale of production (a in the Wood's model), a faster rate of increase to peak (b), and a higher rate of decline after the peak (c) than Jersey curves.
- Despite a slower rate to peak, Jersey's curves reached a peak of lactation sooner than Holstein's (27.5 days for 1st lactation and 8.3 days for later lactations).
- Based on our analysis, there is a significant improvement of lactation curves in the last 10 years in both breeds.
- The lactation curves for Wisconsin are significantly higher than the other states in scale factor (a), except for Jersey's in New York in later lactations.
- Some curves are not significantly different from others, such as first lactation Holstein curves between New York and Ohio, all Jersey curves between Wisconsin and New York, later lactation Jersey curves between Pennsylvania and Ohio, and first lactation Jersey curves between Ohio and New York.
- Our results show the necessity of having updated and state-specific lactation curve parameters for milk yield prediction in the Ruminant Farm System model (RuFaS).
- The RuFaS model will incorporate lactation curve parameters as a matrix of inputs according to breed, parity, and state.
- These lactation curves parameters are used to predict milk yields and better inform management decisions allowing sensible reflection of daily production changes caused by diet alterations, pregnancy, or health issues, among others.

ACKNOWLEDGEMENTS

- This work was supported by funding from the American Jersey Association.
- We thank the Council on Dairy Cattle Breeding for sharing the dataset used in this study.


Develop the
Animal life-cycle model
of animal module
of Ruminant farm system model
(RuFaS)
Citable works
Code verification
Genetics
Growth
Reproduction
Production
Health
Data analysis
Model validation

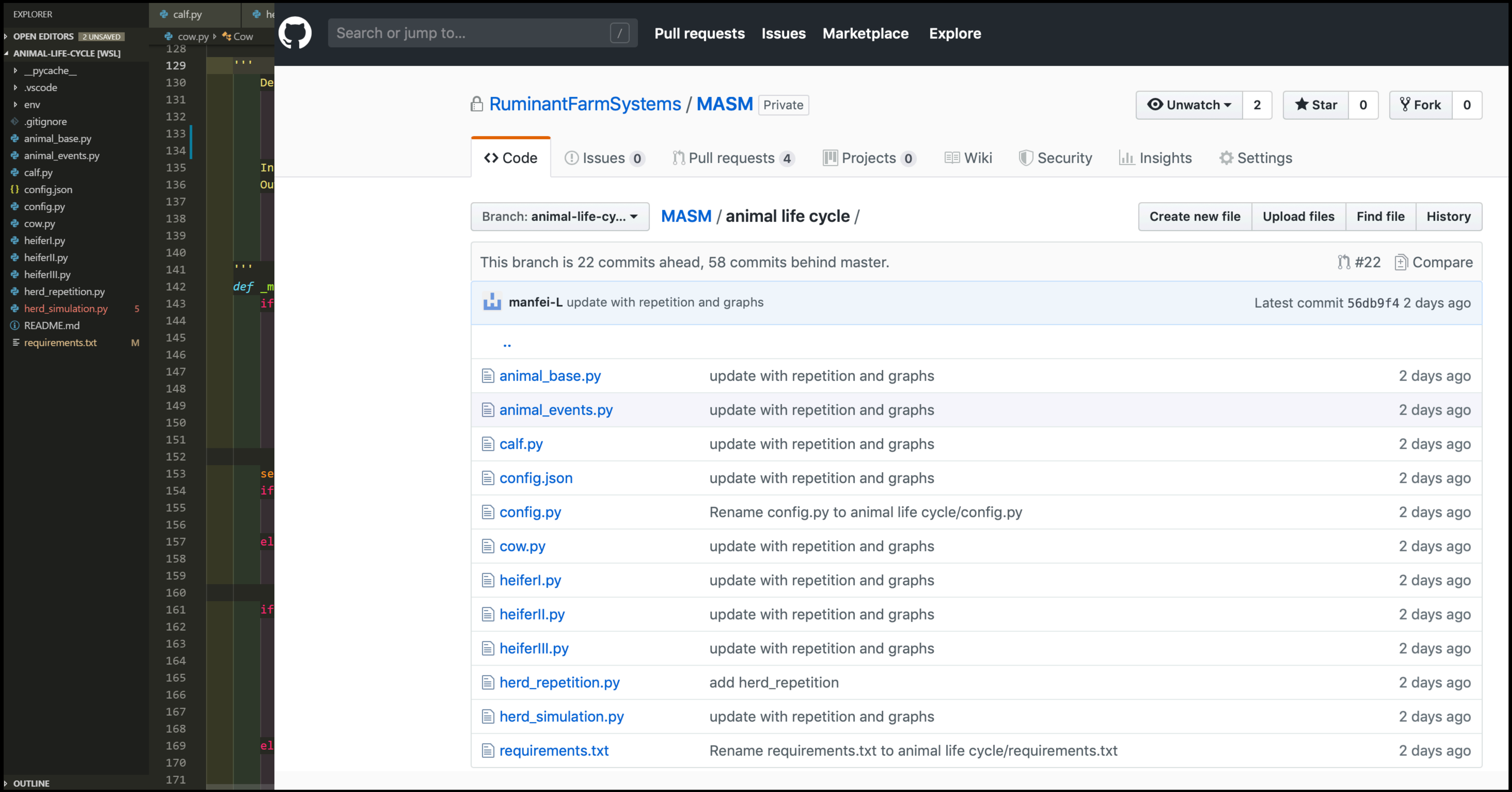

Develop the
Animal life-cycle
of animal module
of Ruminant farm
Citable works
Data analysis
Code
Verification
Reproduction
Production
Health
Model validation

Code sample

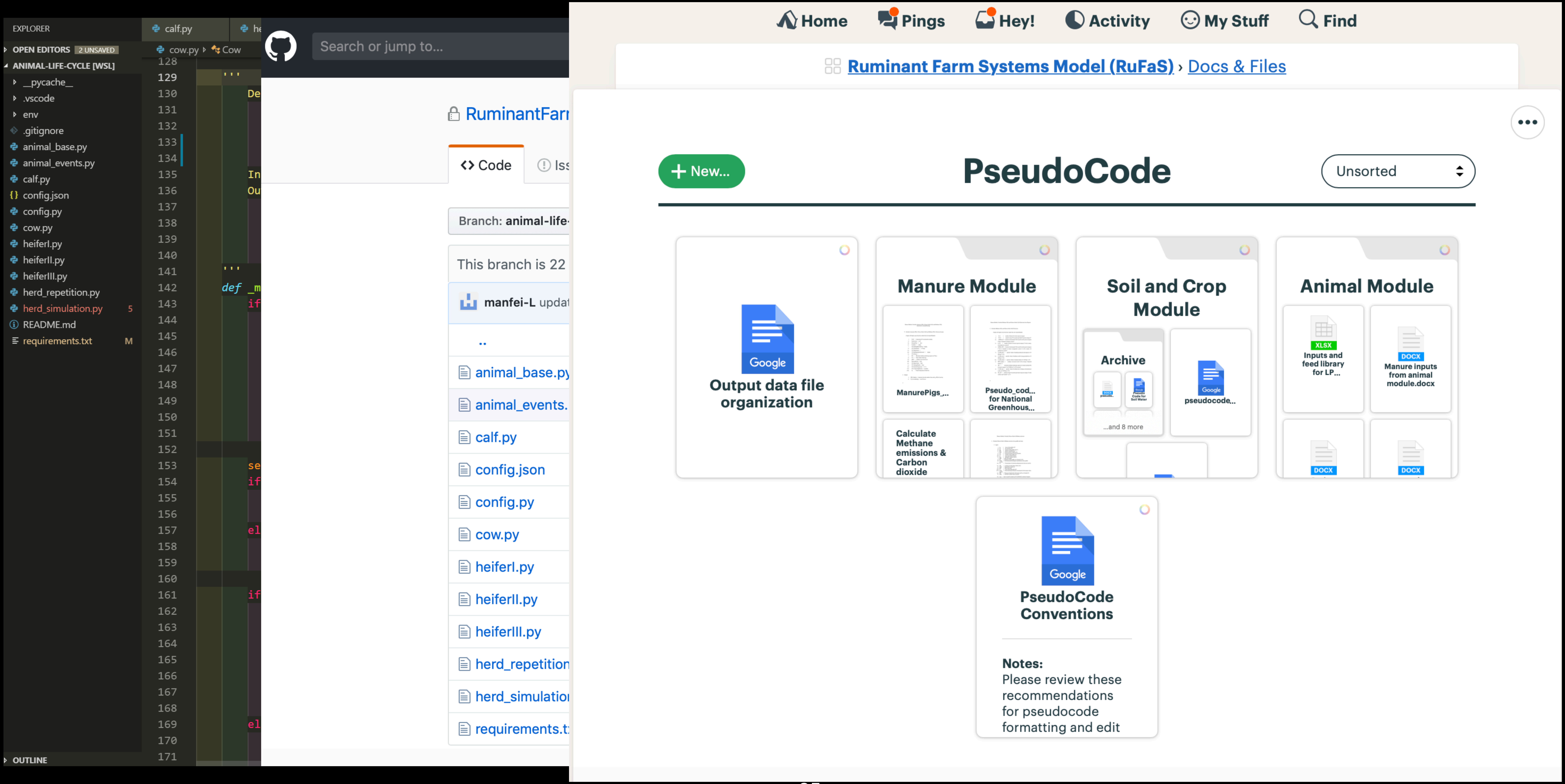
Code sample

```python
'''
    Description:
        update milking status for lactating cows
        start at calving, daily milk production estimated by breed and parity specific lactation curves
        TEMP: fat percent, FCM, body weight during lactation, and dry matter intake are coded here with equations with hard-coded parameters
        just for valid the simulation model indication of the place for future adjustment with ration formulation and ecnomics caculation
    Input:
    Output:
        estimated_daily_milk_produced: estimated daily milk production from the lactation curve
        fat_percent: caculated with days in milk, for temprary use
        daily_fat_correct_milk_production: caculated form estimated milk production and fat percent, for temprary use
        dry_matter_intake: caculated from FCM, days in milk, and body weight, for temprary use
'''
def _milking_update(self):
    if self._days_in_preg == self._gestation_length - config.dry_period:
        self._milking = False
        self._events.add_event(self._days_born, 'dry')
        self._days_in_milk = 0
        self._estimated_daily_milk_produced = 0
        self._estimated_daily_milk_produced_lst.append(self._estimated_daily_milk_produced)
        self._body_weight_lst.append(self._body_weight)
        dry_matter_intake = 12
        return 0, 0, 0, dry_matter_intake

    self._days_in_milk += 1
    if self._breed == 'HO':
        breed_index = 0
        parity_index = 2 if self._calves - 1 > 2 else self._calves - 1
    elif self._breed == 'JE':
        breed_index = 1
        parity_index = 2 if self._calves - 1 > 2 else self._calves - 1

    if config.lactation_curve == 'wood':
        l = self._determine_param_value(config.l[breed_index][parity_index], config.l_std[breed_index][parity_index])
        m = self._determine_param_value(config.m[breed_index][parity_index], config.m_std[breed_index][parity_index])
        n = self._determine_param_value(config.n[breed_index][parity_index], config.n_std[breed_index][parity_index])

        estimated_daily_milk_produced = l * \
            math.pow(self._days_in_milk, m) * \
            math.exp((0 - n) * self._days_in_milk)
    elif config.lactation_curve == 'milkbot':
        estimated_daily_milk_produced = config.a * \
            (1 - math.exp((config.c-self._days_in_milk) / config.b) / 2) * \
```

Code sample


EXPLORER
OPEN EDITORS 2 UNSAVED
ANIMAL-LIFE-CYCLE [WSL]
__pycache__
.vscode
env
.gitignore
animal_base.py
animal_events.py
calf.py
config.json
config.py
cow.py
heiferI.py
heiferII.py
heiferIII.py
herd_repetition.py
herd_simulation.py
README.md
requirements.txt
OUTLINE
calf.py
cow.py › Cow
Search or jump to...
Pull requests
Issues
Marketplace
Explore
RuminantFarmSystems / MASM Private
Unwatch 2
Star 0
Fork 0
Code
Issues 0
Pull requests 4
Projects 0
Wiki
Security
Insights
Settings
Branch: animal-life-cy...
MASM / animal life cycle /
Create new file
Upload files
Find file
History
This branch is 22 commits ahead, 58 commits behind master.
#22
Compare
manfei-L update with repetition and graphs
Latest commit 56db9f4 2 days ago
animal_base.py update with repetition and graphs 2 days ago
animal_events.py update with repetition and graphs 2 days ago
calf.py update with repetition and graphs 2 days ago
config.json update with repetition and graphs 2 days ago
config.py Rename config.py to animal life cycle/config.py 2 days ago
cow.py update with repetition and graphs 2 days ago
heiferI.py update with repetition and graphs 2 days ago
heiferII.py update with repetition and graphs 2 days ago
heiferIII.py update with repetition and graphs 2 days ago
herd_repetition.py add herd_repetition 2 days ago
herd_simulation.py update with repetition and graphs 2 days ago
requirements.txt Rename requirements.txt to animal life cycle/requirements.txt 2 days ago

Code sample



EXPLORER
OPEN EDITORS 2 UNSAVED
ANIMAL-LIFE-CYCLE [WSL]
__pycache__
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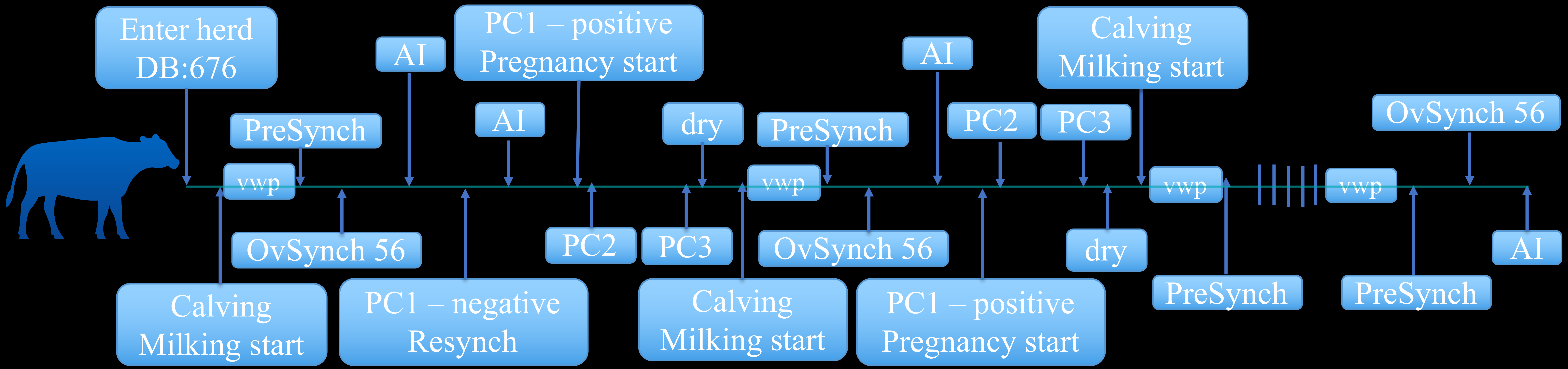
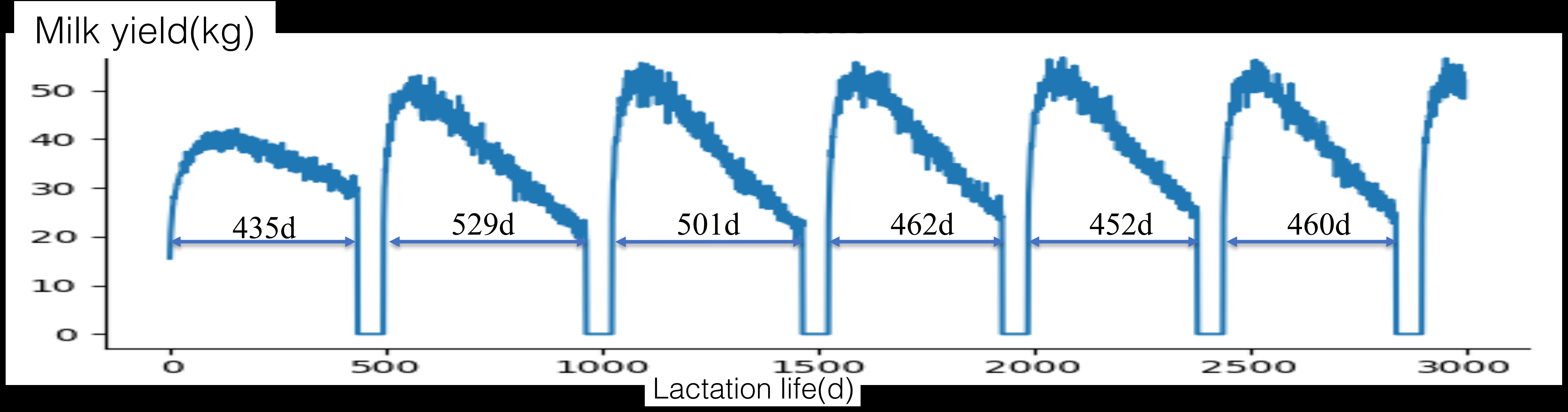
README.md
requirements.txt
OUTLINE
Search or jump to...
RuminantFarı
Code
Branch: animal-life-
This branch is 22
manfei-L updat
Home
Pings
Hey!
Activity
My Stuff
Find
Ruminant Farm Systems Model (RuFaS) › Docs & Files
New...
PseudoCode
Unsorted
Output data file organization
Manure Module
ManurePigs_...
Pseudo_cod... for National Greenhous...
Calculate Methane emissions & Carbon dioxide
Soil and Crop Module
Archive
...and 8 more
pseudocode...
Animal Module
Inputs and feed library for LP...
Manure inputs from animal module.docx
PseudoCode Conventions
Notes:
Please review these recommendations for pseudocode formatting and edit

Output sample - animal

1000 targeted herd size, 3000days, 1 individual:

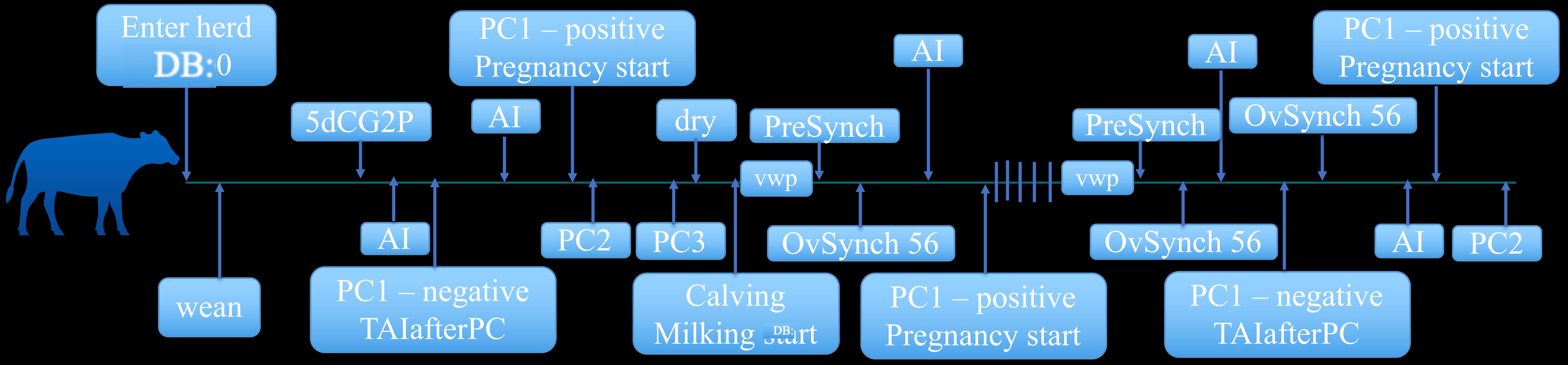


Days Born: 3673; Body Weight: 720.72kg; Repro program: TAI, PreSynch + OvSynch 56 + TAIafterPD
Parity: 7; Curve: Wood’s; Days in milk: 98d; Milk produced: 52.01kg; Days in preg: 0d; Gestation Length: 0d.

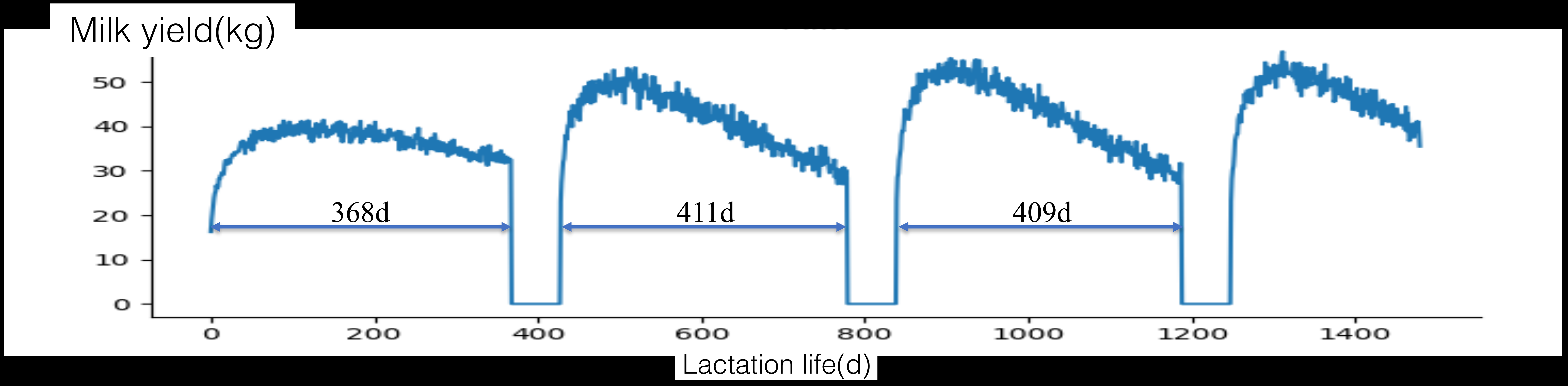


Output sample - animal

1000 targeted herd size, 3000days, 1 individual:

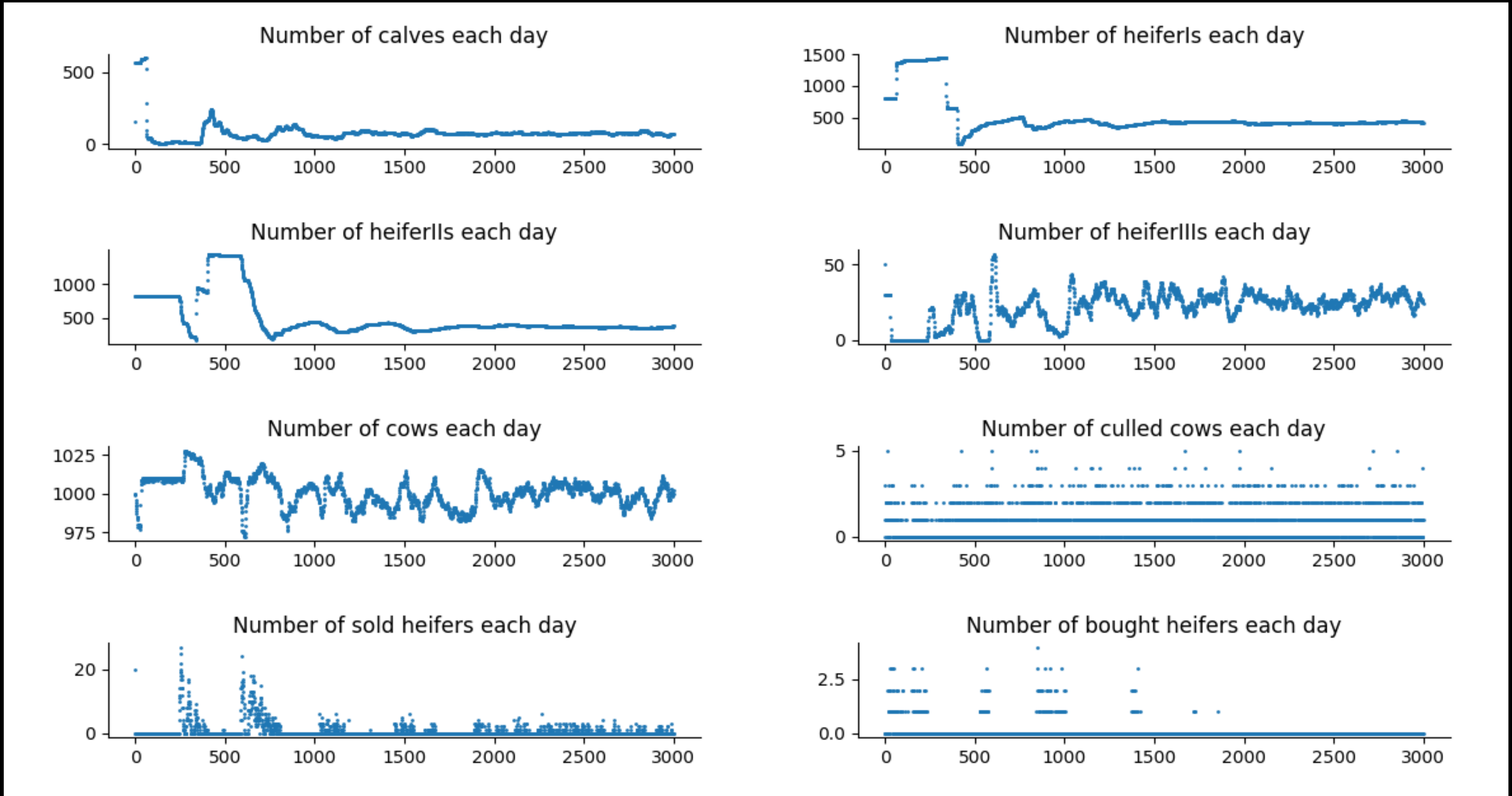


Days Born: 2213; Body Weight: 748.90kg; Repro program: TAI, 5dCG2P+PreSynch+OvSynch56+TAIafterPC
Parity: 4; Curve: Wood's; Days in milk: 232d; Milk produced: 35.44kg; Days in preg: 137d; Gestation Length: 265d.



Output sample - herd

1000 targeted herd size, 3000days, overall:



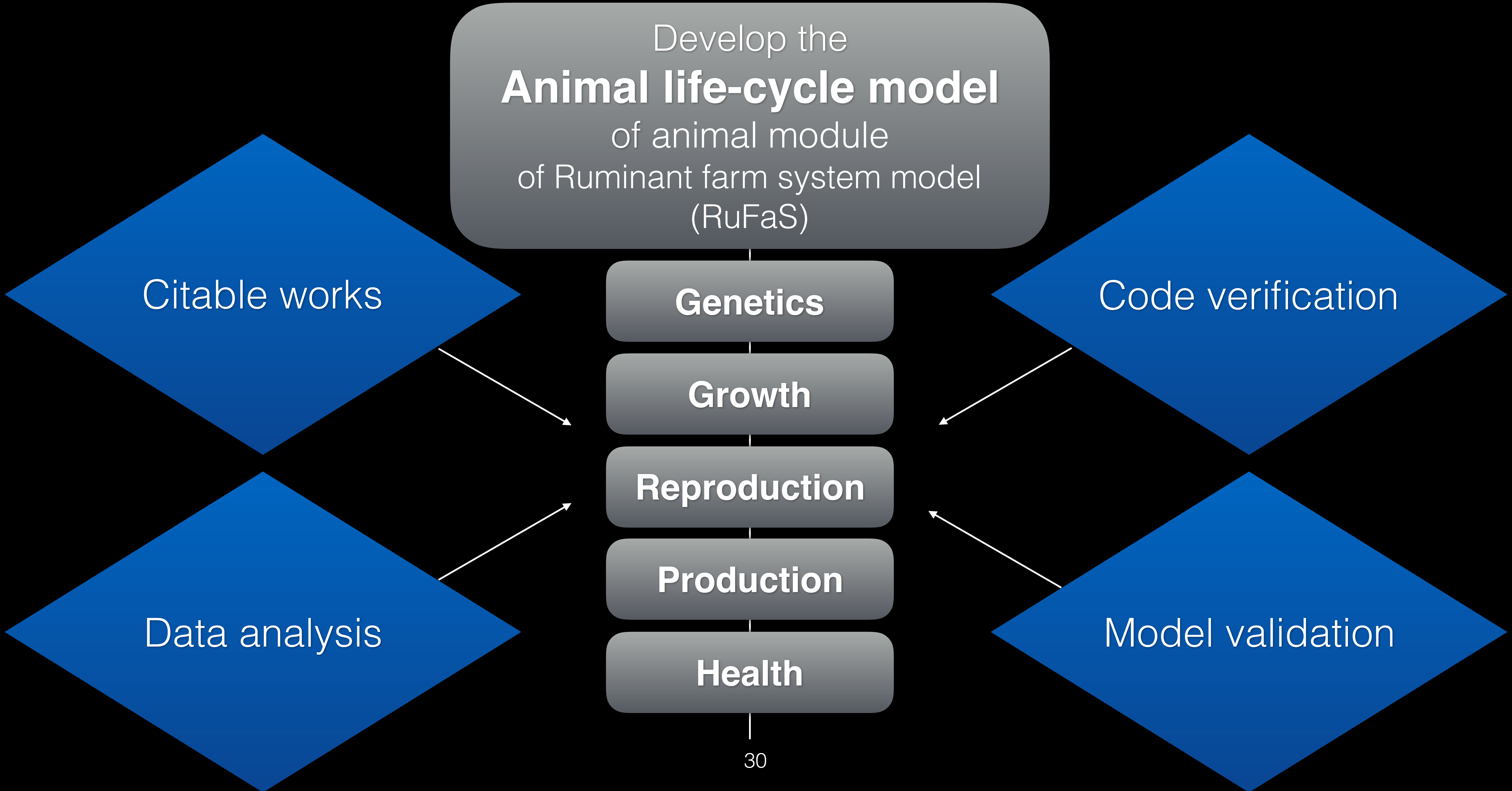
Output sample - herd

100 iterations, 1000 targeted herd size, 3000days:

Herd structure (averaged through 100 iterations) at the end of the simulation									
Calves	HeiferI	HeiferII	HeiferIII	Cows	Cows pregnant	Cows milking	Parity 1	Parity 2	Parity 3
86.8	419.2	351.1	31.5	999.4	635.4	872.8	363.0	239.6	396.8

Herd stats (averaged through 100 iterations) for last 365 days of the simulation							
Feed cost	Fixed cost	Repro cost	Milk income	Slaughter value	Service rate	Conception rate	Pregnancy rate
$/cow/day				$/cow	%		
5.44	2.17	0.15	14.08	481.05	54.91	28.23	26.49

Herd structure (averaged through 100 iterations) at the end of the simulation									
Calves	HeiferI	HeiferII	HeiferIII	Cows	Cows	Cows	Parity 1	Parity 2	Parity 3
86.8	419.2	351.1	31.5	999.4	635.4	872.8	363.0	239.6	396.8


Develop the
Animal life-cycle model
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Genetics
Growth
Reproduction
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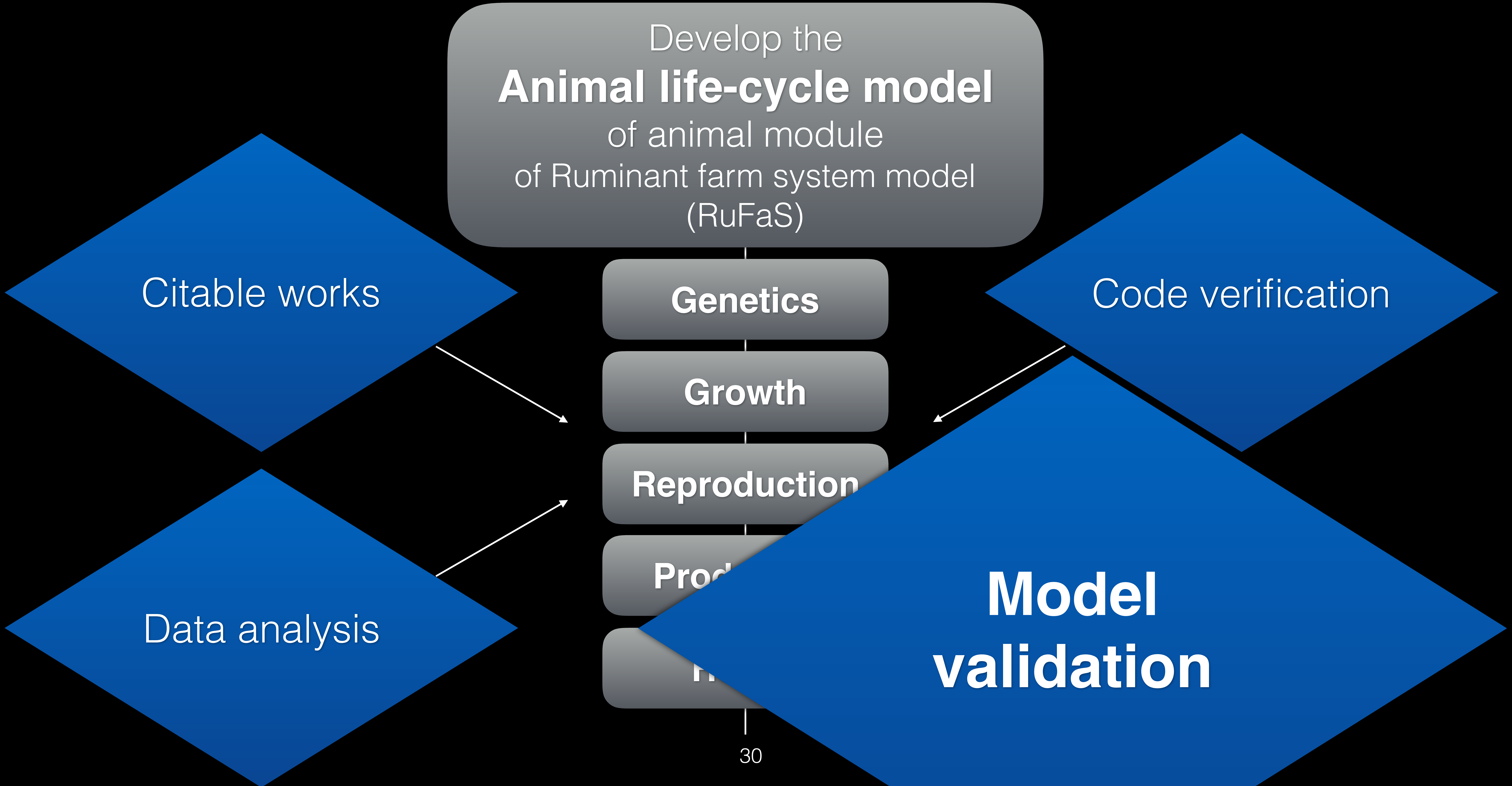
Health
Citable works
Data analysis
Code verification
Model validation



Develop the
Animal life-cycle model
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Citable works
Code verification
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Model
validation

Parallel comparison

The reproductive and economic impact among 6 reproductive programs for lactating dairy cows including a sensitivity analysis of the cost of hormonal treatments

THE UNIVERSITY of WISCONSIN MADISON
DEPARTMENT OF DAIRY SCIENCE University of Wisconsin-Madison
Alessandro Ricci, Manfei Li, Paul M. Fricke, and Victor E. Cabrera
UNIVERSITÀ DEGLI STUDI DI TORINO

Introduction

New advancements in the understanding of the reproductive physiology of dairy cows lead to the development of management strategies and technologies that aim to improve the reproductive performance of dairy herds and to make more profitable reproductive management decisions. Assess the economic impact of those reproductive management decisions is complicated for farmers that tend to perceive the economic impact of synchronization protocols differently than the real ones, therefore misleading their decisions.

This study had 2 primary objectives:

1) To assess the economic impact of using an alternative, more intensive synchronization reproductive programs.
2) To quantify the effect of increasing the price of hormones (GnRH and $PGF_{2\alpha}$) on the profitability of intensive reproductive programs.

Experimental procedures

A reproductive economic analysis simulation model (the UW-Cornell DairyRepro$) was used to compare the economic impact of 6 first TAI reproduction protocols:

- PreSynch-OvSynch with heat detection (ED) before and after first TAI (CR 35%; for ED, SR 60% and CR 30%);
- Presynch-Ovsynch TAI with different CR (35%, 40%, 45%);
- Double-OvSynch+PGF, (CR 50%).

GnRH was set at $2.6 and PGF2α to $2.3 to (US market) and GnRH was set at $6.7 and PGF2α to $5.1 (EU market).

Sensitivity analyses with incremental hormonal prices to find the breakeven point of when high hormonal prices offset the net profit was performed.

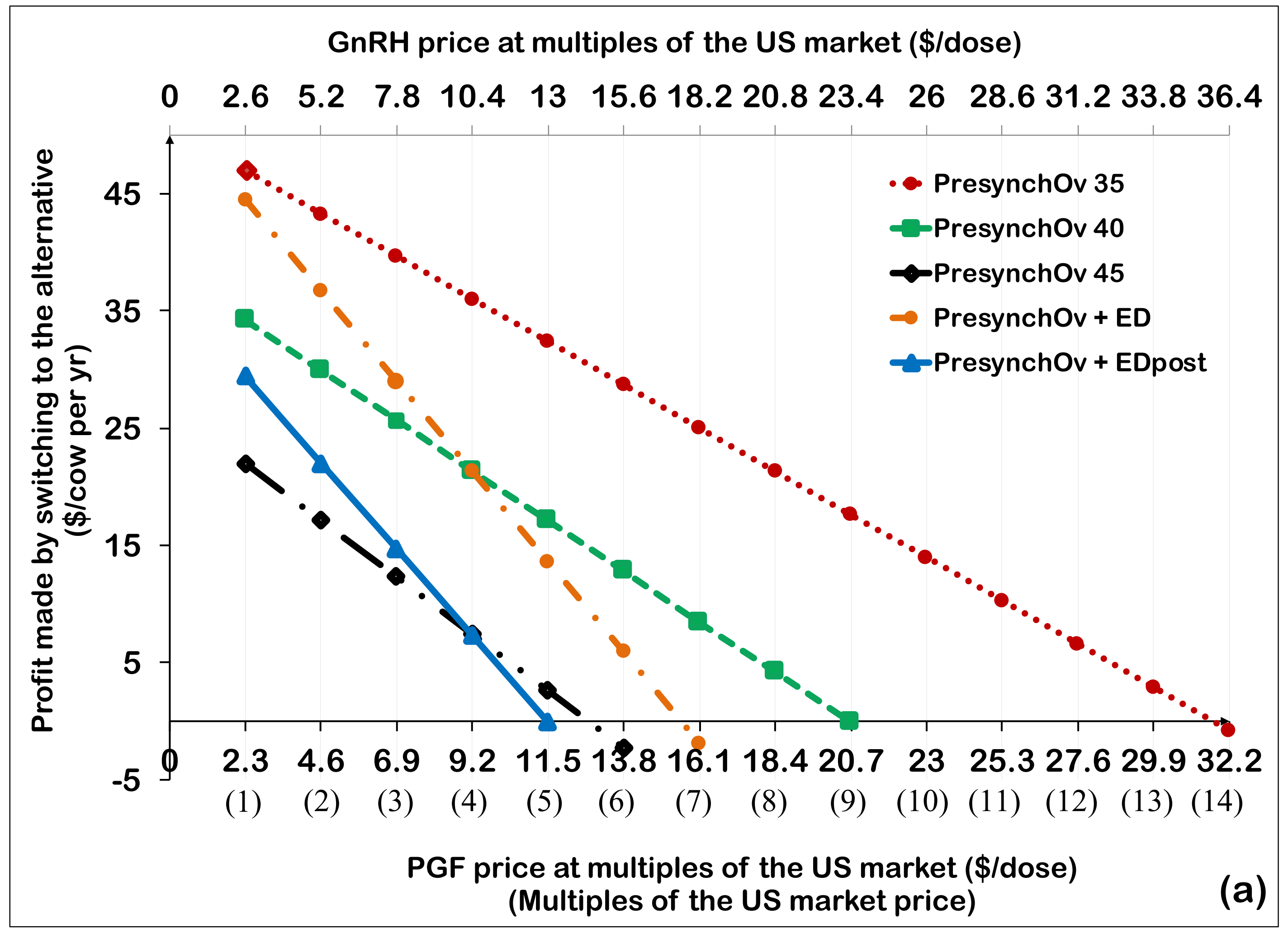
Table 1. Comparison in number of hormonal injections and net profit between different reproductive synchronization programs.

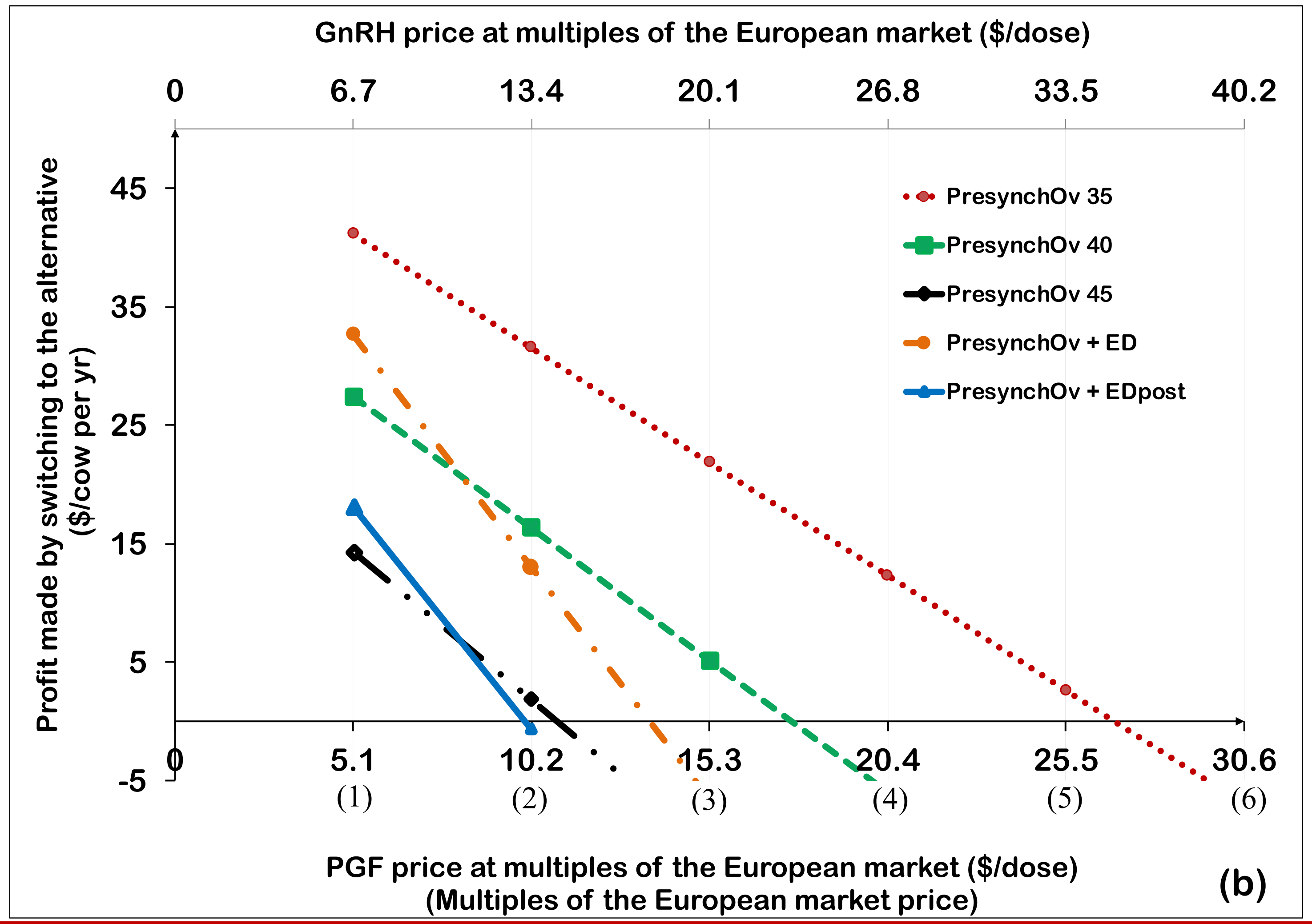
Reproductive Program	CR (%)	Approximated number of injections (#/cow per yr)			Net Profit gain over the baseline ($/cow per yr)	
		Total	GnRH	$PGF_{2\alpha}$	$PGF_{2\alpha}$ at $2.3 and GnRH at $2.6	$PGF_{2\alpha}$ at $5.1 and GnRH at $6.7
PreSynch-OvSynch (baseline)	35	7.8	3.12	4.68	-	-
PreSynch-OvSynch	40	7.6	3.04	4.56	12.7	13.7
PreSynch-OvSynch	45	7.4	2.96	4.44	25	26.7
PreSynch-OvSynch + ED	35 + 30	6.2	2.48	3.72	5.8	8.2
PreSynch-OvSynch + EDpost	35 + 30	6.3	2.52	3.78	17.3	22.8
Double-OvSynch+PGF	50	9.2	5.24	3.96	46.2	32.1

Table 2. The price ($/dose) of GnRH or $PGF_{2\alpha}$ at breakeven profit points (red numbers), when the other price was set constant at European market, when comparing, Presynch-Ovsynch programs against the most intensive synchronization program, The Double-OvSynch+PGF .

Hormones	Price ($/dose) at breakeven point when compared with Double-OvSynch+PGF									
	Presynch-Ovsynch						Presynch-Ovsynch (35% CR) + ED			
	35% CR		40% CR		45% CR		ED		EDpost	
GnRH	32.8	6.7	22.4	6.7	14.2	6.7	19.0	6.7	13.7	6.7
$PGF_{2\alpha}$	5.1	--	5.1	--	5.1	--	5.1	97.0	5.1	63.0

Figure 1 a, b. Sensitive analysis by identifying the breakeven points when the net profit gain by switching the Presynch-Ovsynch protocols to Double-Ovsynch PG2x protocol become negative with multiples of GnRH and PGF market price.

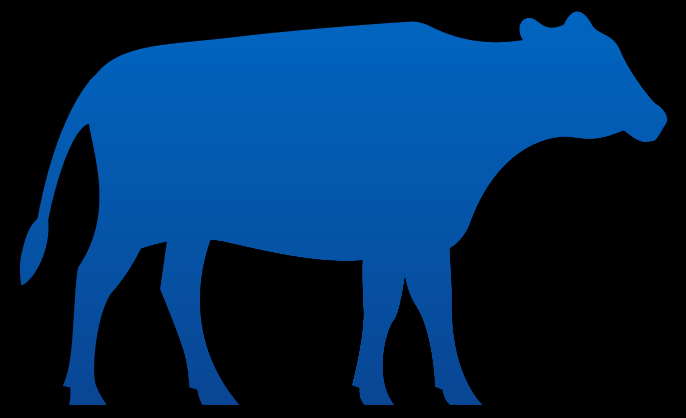




- The PreSynch-OvSynch protocols use fewer injections than the Double-OvSynch+PGF protocol but the latter is more profitable.
- The Double-OvSynch+PGF protocol attained greater profit per cow per yr. than PreSynch-OvSynch protocols with ED and was more profitable than the sole Presynch-Ovsynch.
- ED after the first TAI was more profitable than either using ED, before the first TAI or not using ED.
- The prices of hormones would need to be 5 to 14 times more expensive in US market and 2 to 6 times more expensive in the EU market in order for the Presynch-Ovsynch protocols to have more profit than The Double-OvSynch+PGF protocol.

Conclusion

- Our study shows that more intensive reproductive programs using more hormones, but having substantial better reproductive performance, are more profitable even when hormonal prices are high



Next steps:

Genetics

Diseases

Validation

Challenges:

Dynamic lactation curve

Long run time — need optimization

Validate with real farm data

Thank you!