# Opportunities to improve resilience and health traits in dairy breeding programs

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# Acknowledgement





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# Importance of resilience and health

- Trouble-free cows
- Cows that need less labour
- Cows that need less antibiotics
- Cows that are adapted to disturbances
    - Climate change
    - More variation in feed quality

# Requirements genetic improvement

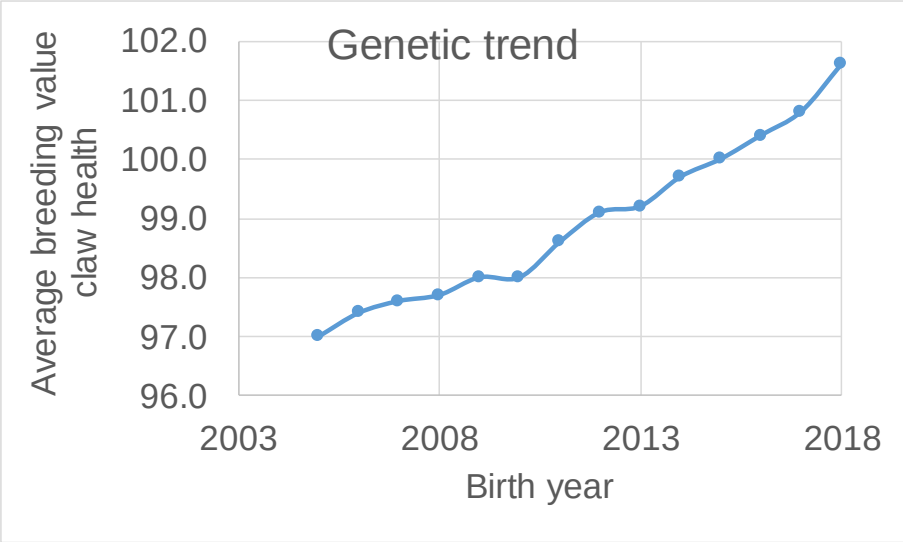
| Trait | Bull A | Bull B |
|---|---|---|
| EBV subclinical mastitis | 108 | 88 |
| Incidence subclinical mastitis | 41 | 58 |
| EBV somatic cell count | 107 | 90 |
| Average somatic cell count | 77,000 | 139,000 |

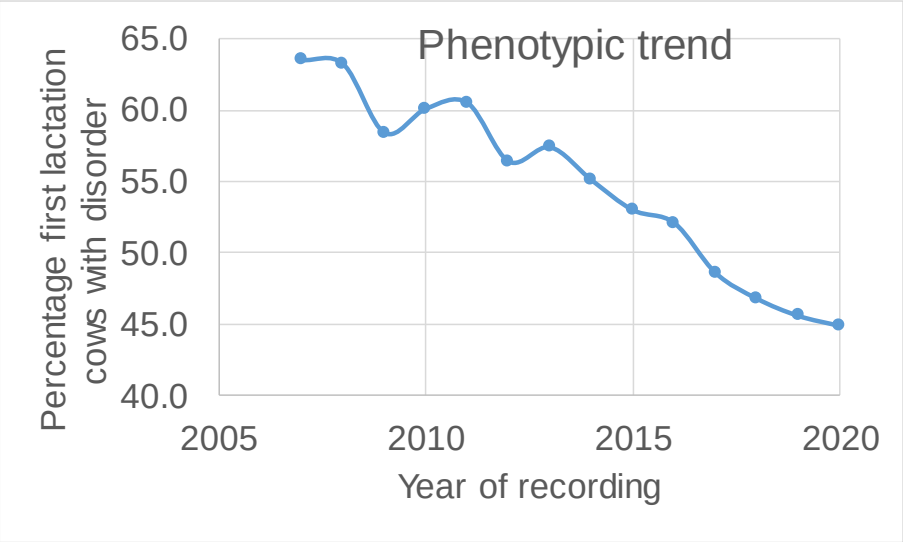
# Requirements genetic improvement

$$\Delta G = \frac{\sum(i * r * \sigma_a)}{\sum L}$$

- Trait has genetic variation (= $\sigma_a$)
- The trait can be recorded at large scale (accuracy = $r$)
    - Large reference population for genomic selection
- Trait is included in selection index (selection intensity = $i$)
- Genomic selection lowers generation interval (= $L$)

# Genetic trend claw health The Netherlands




- A positive genetic trend for claw health
- Decrease in percentage of cows with claw disorders

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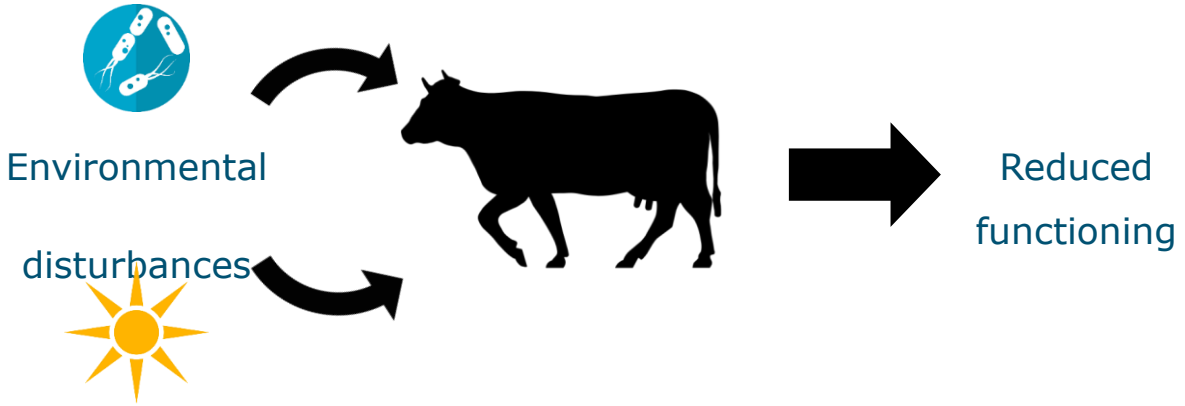
# Defining resilience indicators, genetic analysis and validation

# Resilience in dairy cattle




The ability to be minimally affected by disturbances

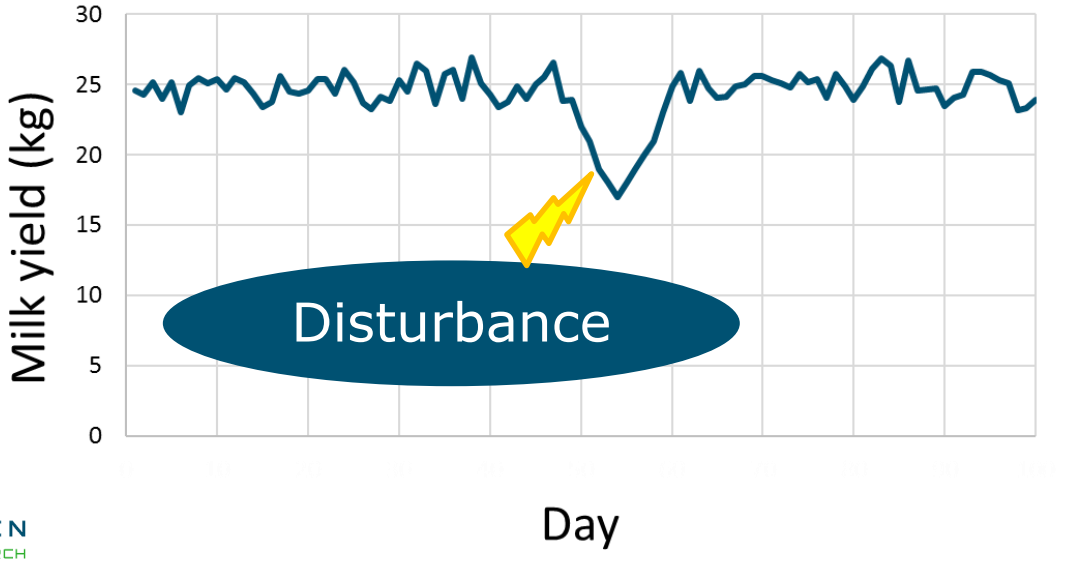
**AND/OR**

to quickly recover

# Project aim PhD Marieke Poppe

- To develop resilience indicator traits that can assist in genetic selection to improve resilience in dairy cattle
  - … using daily milk yield records

Why?

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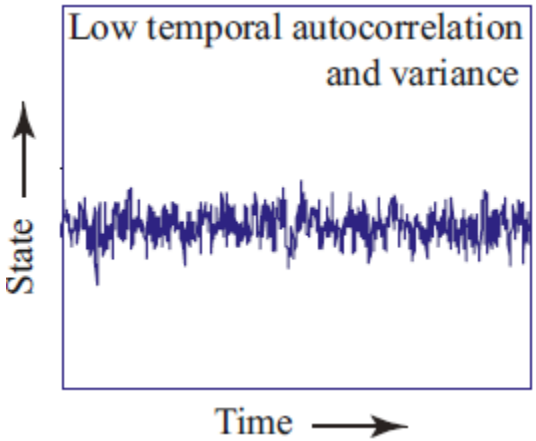
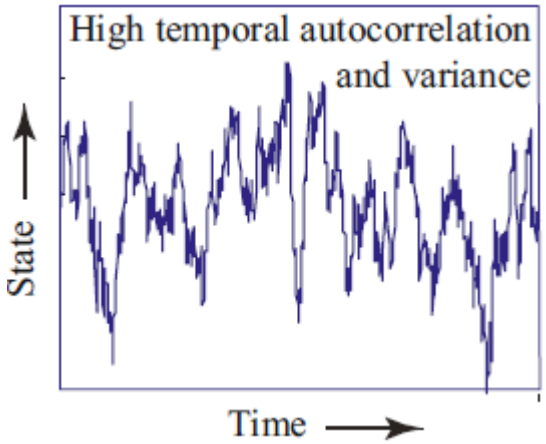
# Developing resilience indicators

- Resilience theory Marten Scheffer
  - Longitudinal data series
  - Systems with high variance and high autocorrelation are prone to a critical transition, e.g. from healthy to sick

Scheffer et al. 2018 Quantifying resilience of humans and other animals. PNAS. 115:11883-11890



# Application to daily milk yield data

Steps:

1. Calculate variance and autocorrelation based on daily milk yield
2. Genetic analysis
3. Validation

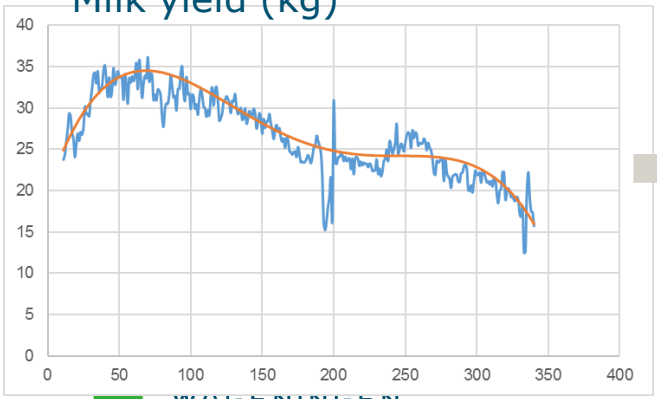


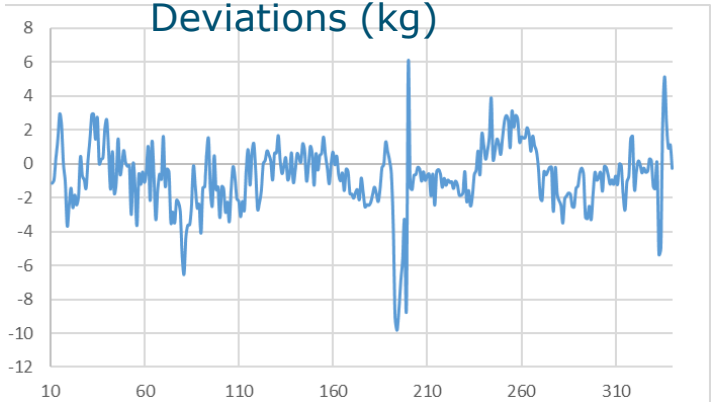
Poppe et al. 2020; J. Dairy Sci. 103:1667-1684

# Calculate resilience indicators

- 200,000 first lactation cows
- Automatic milking system
- Fit quantile regression curve
- Calculate ln-transformed variance and autocorrelation of deviations

Milk yield (kg)

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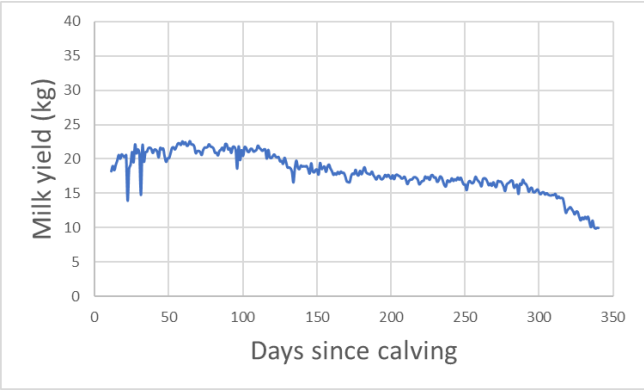
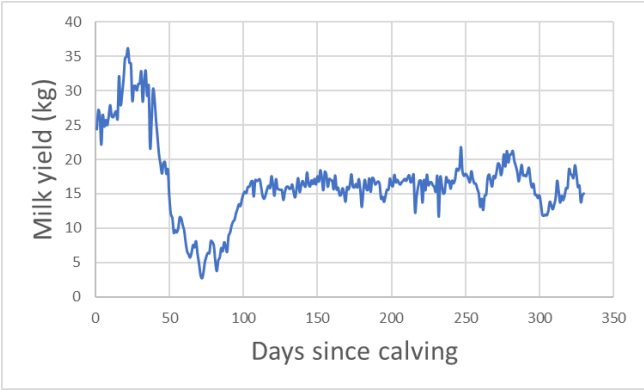
Poppe et al. 2020; J. Dairy Sci. 103:1667-1684

# Resilience indicators examples




Low variance
&
low autocorrelation

***Resilient (?)***




High variance
&
high autocorrelation

***Not resilient (?)***

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# Genetic analysis:

## are the resilience indicators heritable?

$$Resilience\ indicator = \mu + AFC + LL + HYS + animal + e$$

$AFC$ = age at first calving
$LL$ = lactation length
$HYS$ = herd*year*season

| | $h^2$ (SE) | $r_g$ with milk yield (SE) |
|---|---|---|
| Variance | 0.21 (0.009) | 0.79 (0.02) |
| Autocorrelation | 0.09 (0.006) | 0.16 (0.04) |



Poppe et al. 2020; J. Dairy Sci. 103:1667-1684

# Validation:

## do the indicators contain info about resilience?

- No golden standard
- 2 different validation methods

# Validation method 1

- Assumption: resilient cows are healthy and live long
- Genetic correlations with health traits and longevity
    - MACE method
    - Adjusted for mean milk yield

| | Udder health | Claw health | Ketosis resistance | Longevity |
|---|---|---|---|---|
| Variance | -0.32 | -0.04 | -0.33 | -0.34 |
| Autocorrelation | -0.19 | -0.01 | -0.10 | -0.03 |



Poppe et al. 2020; J. Dairy Sci. 103:1667-1684

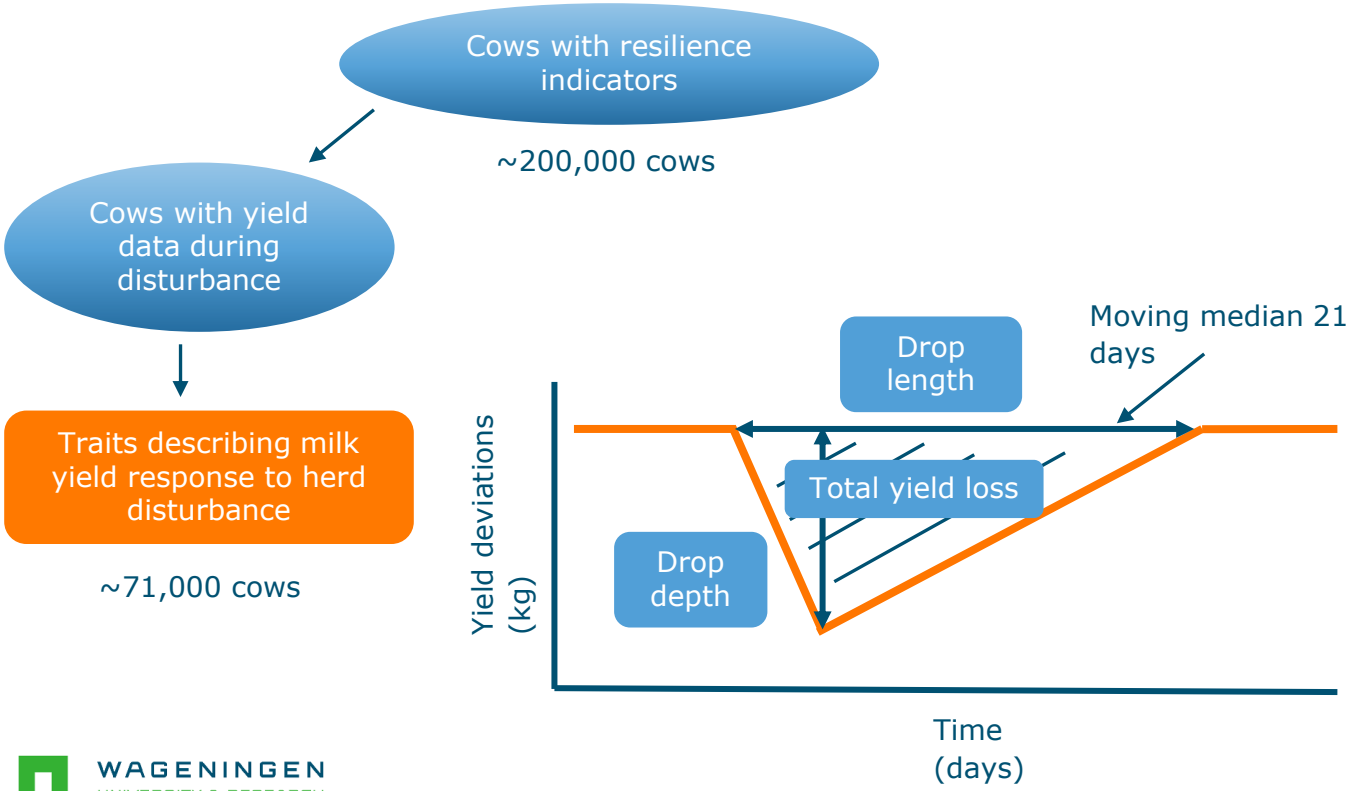
# Validation method 2

- Health traits and longevity ≠ resilience
- Cows with good EBV for resilience indicators → low yield response to actual disturbances and quick recovery?
- Actual disturbance: Unknown disturbance affecting herd milk yield



Poppe et al. 2021; J. Dairy Sci. 104:8094-8106

# Validation method 2

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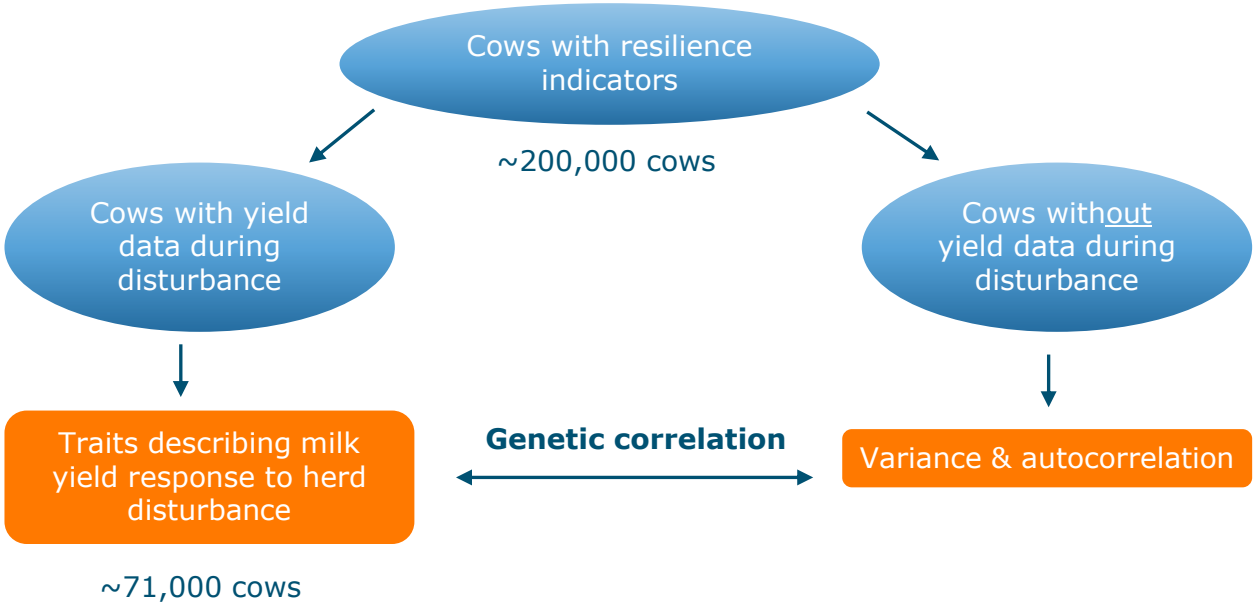
Poppe et al. 2021; J. Dairy Sci. 104:8094-8106

# Validation method 2

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Poppe et al. 2021; J. Dairy Sci. 104:8094-8106

# Results validation method 2

Genetic correlations between resilience indicators and 'response traits'

| | Variance | Variance partial | Autocorrelation |
|---|---|---|---|
| **Depth drop** | 0.93 (0.04) | 0.82 | -0.13 (0.12) |
| **Length drop** | -0.001 (0.29) | -0.18 | 0.97 (0.35) |
| **Total yield loss** | 0.90 (0.05) | 0.74 | -0.01 (0.13) |



Poppe et al. 2021; J. Dairy Sci. 104:8094-8106

# Genetic improvement resilience

# Economic value resilience

- Resilient cows need less labor
  - Less treatments
  - Less attentions either from sensors or human eye

- € 19 per genetic sd of ln variance
  - (10 minutes per alert, 5% alerts/day, € 15/hour)



Berghof et al. 2019 Frontiers in Genetics 9:692

# Dairy cattle breeding program

- Simplified breeding goal:
  - Milk yield (30%)
  - Udder health (20%),
  - Longevity (30%)
  - Lower variance (= higher resilience) (20%)

- Genomic selection scheme



Berghof et al. 2019 Frontiers in Genetics 9:692

# Dairy cattle breeding program

| Trait | Change when including resilience in index |
|---|---|
| **Milk production** | −6.3% |
| **Longevity** | 1.4% |
| **Udder health** | 1.0% |
| **Resilience** | 102.6% |
| **Breeding goal** | 3.0% |
| **Alert probability** | −8.4% |



Berghof et al. 2019 Frontiers in Genetics 9:692

# Conclusion

- Variance and autocorrelation can be used as resilience indicator:
  - Good heritabilities and genetic variation
  - Variance: related to milk loss, ketosis, udder health, longevity
  - Autocorrelation: related to recovery, udder health, ketosis

- Outlook: big data offer opportunities to breed for improved resilience

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