Modelling phenotypic variation in monthly weights of Australian beef cows using a random regression model

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Random regression models to describe phenotypic variation in weights of beef cows when age and season are confounded

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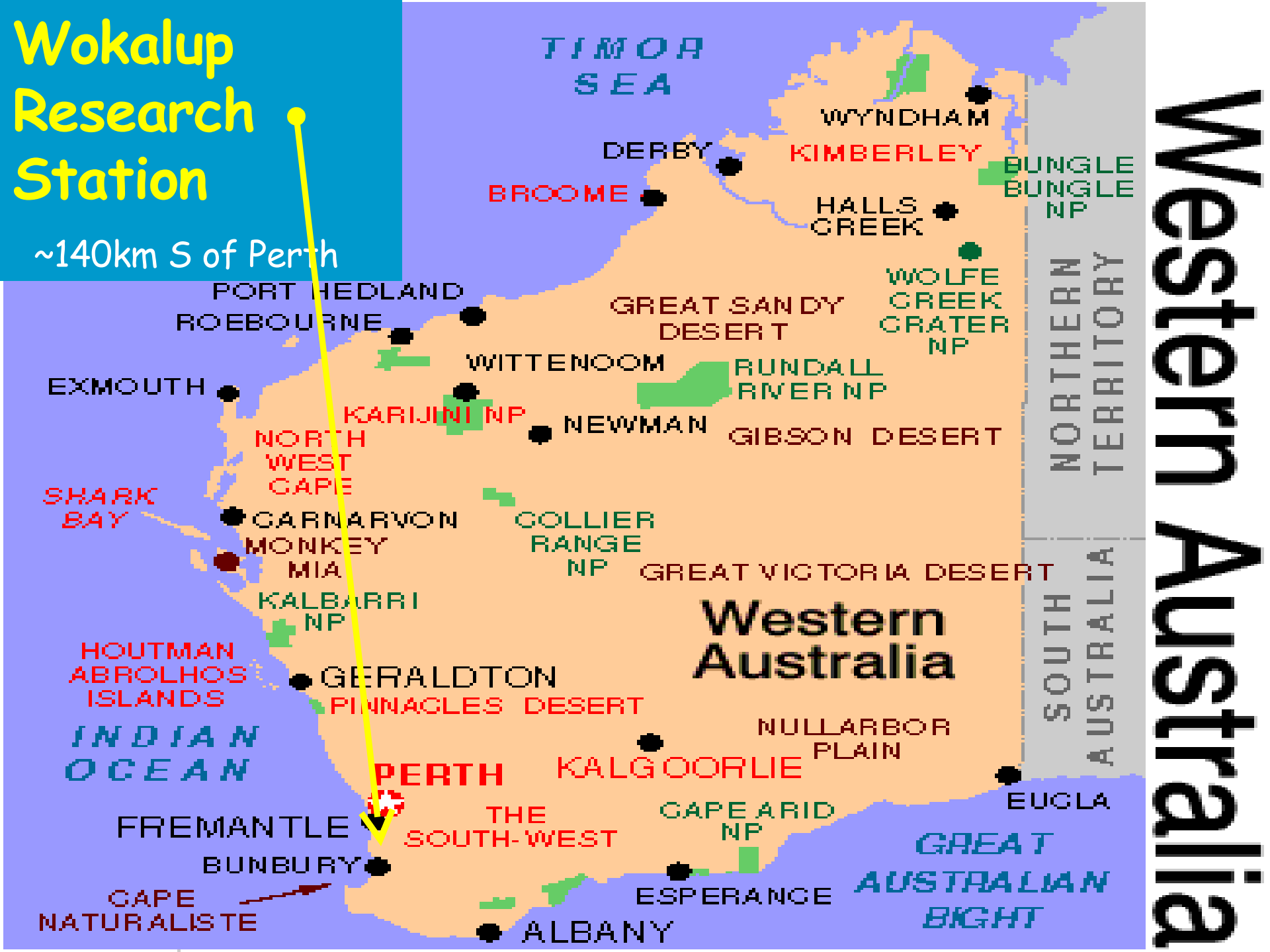
Random Regressions

- Suitable for ‘repeated’ records
  - continuous scale → e.g. time
  - allow for gradual & continual change of trait
- Fit set of random regression coefficients for each animal
  - replace single animal effect
  - description of complete growth curve
- Estimate
  - Covariances(RR coefficients) → Cov.Func.
  - Measurement error variances

Data

- Wokalup selection experiment
  - 2 herds @ 300 cows;
    - Polled Hereford (HEF)
    - Wokalup (WOK) → 4-breed synthetic
  - selection for increased preweaning growth
  - short mating period → most calves born over 8 week period (April/May)
  - monthly weighing of animals
    - 87,516 weights, 1977-1990
- Select records on cows 19-84 months


Wokalup Research Station
~140km S of Perth
TIMOR SEA
WYNDHAM
DERBY
KIMBERLEY
BUNGLE BUNGLE NP
BROOME
HALLS CREEK
WOLFE CREEK CRATER NP
PORT HEDLAND
ROEBOURNE
GREAT SANDY DESERT
WITTENOOM
RUNDALL RIVER NP
EXMOUTH
KARIJINI NP
NEWMAN
GIBSON DESERT
NORTH WEST CAPE
SHARK BAY
CARNARVON
COLLIER RANGE NP
MONKEY MIA
GREAT VICTORIA DESERT
KALBARRI NP
Western Australia
HOUTMAN ABROLHOS ISLANDS
GERALDTON
PINNACLES DESERT
INDIAN OCEAN
NULLARBOR PLAIN
KALGOORLIE
PERTH
EUCLA
FREMANTLE
THE SOUTH-WEST
CAPE ARID NP
GREAT AUSTRALIAN BIGHT
BUNBURY
CAPE NATURALISTE
ESPERANCE
ALBANY
NORTHERN TERRITORY
SOUTH AUSTRALIA
Western Australia

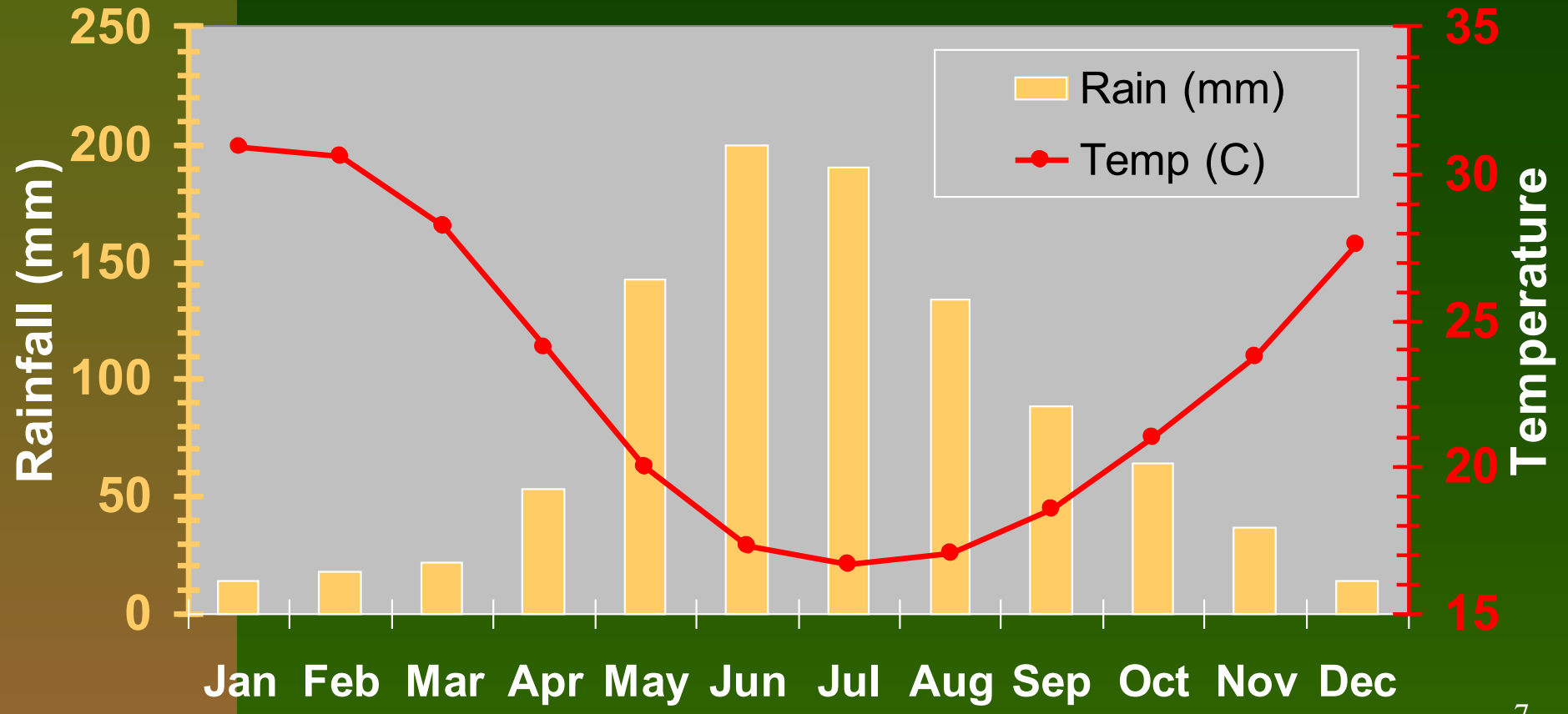

ROCKINGHAM
Peelhurst-Singleton
Mandurah
Jarrahdale
Serpentine
North Dandalup
Boonering Hill
Mt Wells 547
Pinjarra
Dwellingup
Boddington
Cape Bouvard
Harvey Estuary
Peel Inlet
Lake Clifton
Yalgorup National Park
Waroona (A)
Nanga
Mt Keats
Yarloop
Mt Saddleback 574
Harvey
Lake Preston
Benger
Brunswick Junction
Australind
Eaton
Allanson
Darkan
BUNBURY
Picton Junction
Burekup
Dardanup
Boyanup
Collie
Capel
Donnybrook
Dunsborough
Busselton
Vasse
Kirup
Balingup
Jarrahwood
Greenbushes
Boyup Brook
Cowaramup
Margaret River
Witchcliffe
Nannup
Bridgetown
Geographe Bay
Leschenault Inlet
Preston River
Capel River
Margaret River
Darling Range
Williams River
SOUTH WESTERN HIGHWAY
RUSSELL HWY
Wokalup Research Station
~140 km S of Perth

Climate at Wokalup Research station

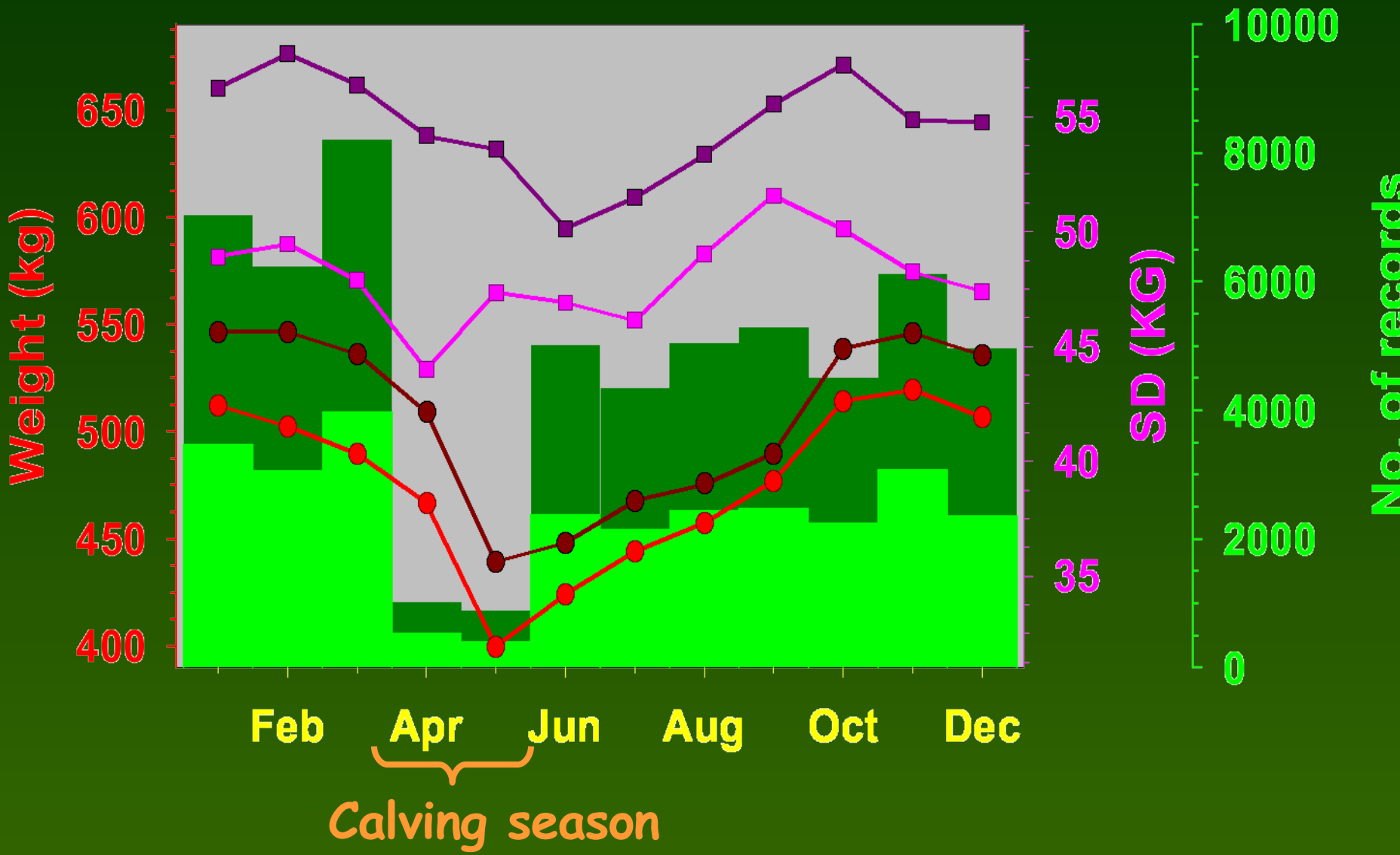
1951-1996

Latitude 33.13 S, Longitude 115.88 E, Elevation 116m

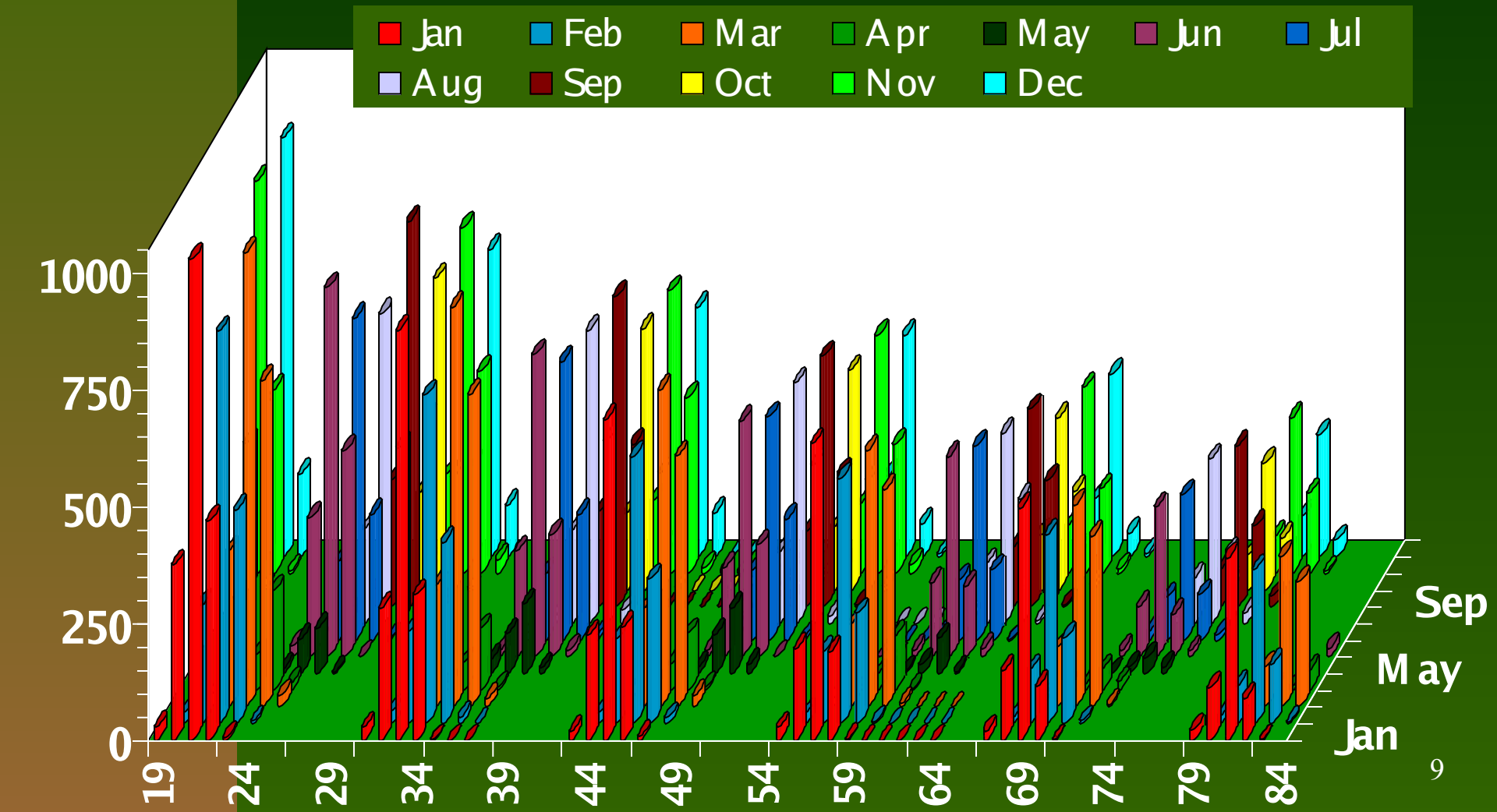
Mean annual rainfall 979 mm



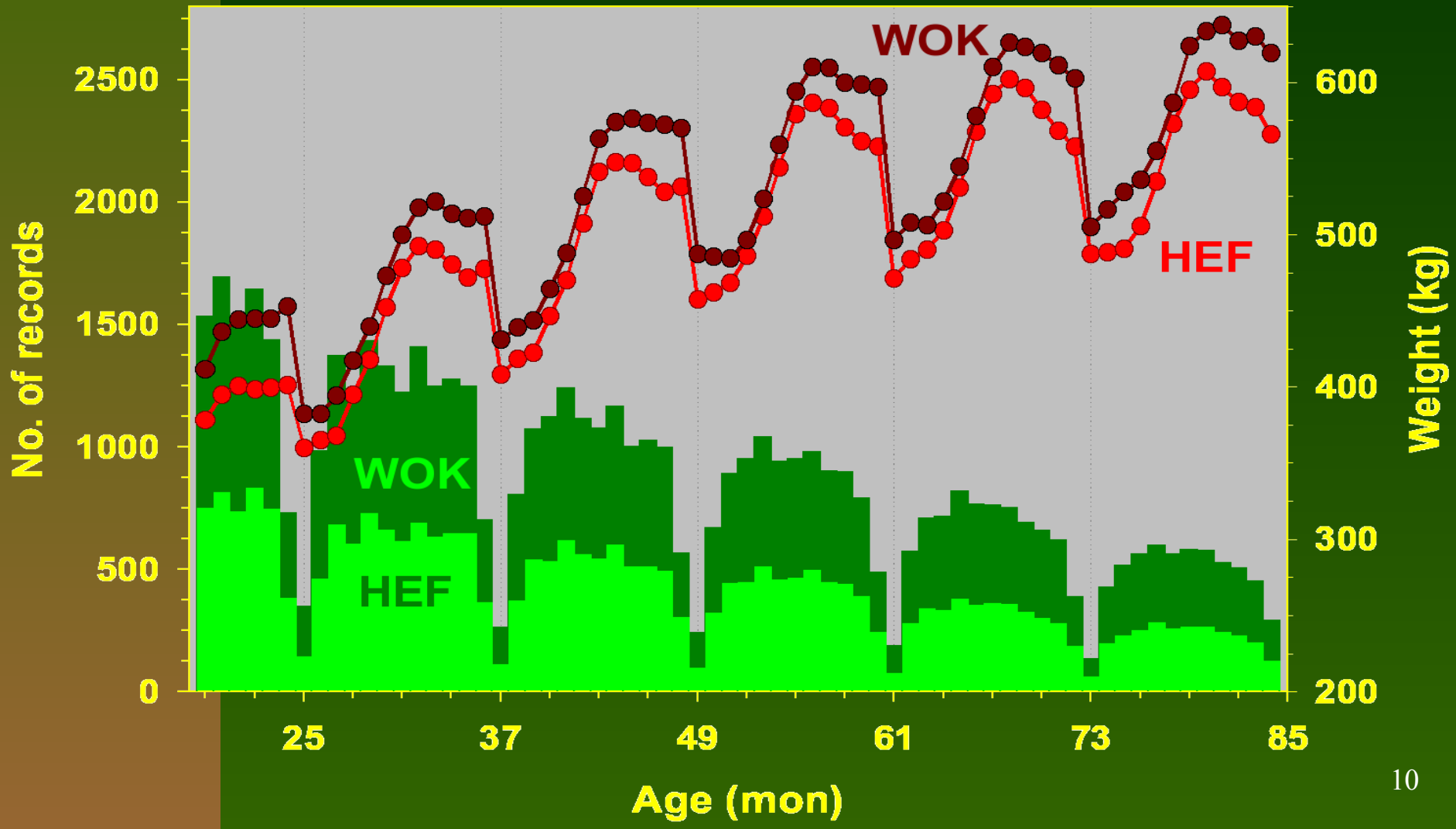
Means & standard deviations : month



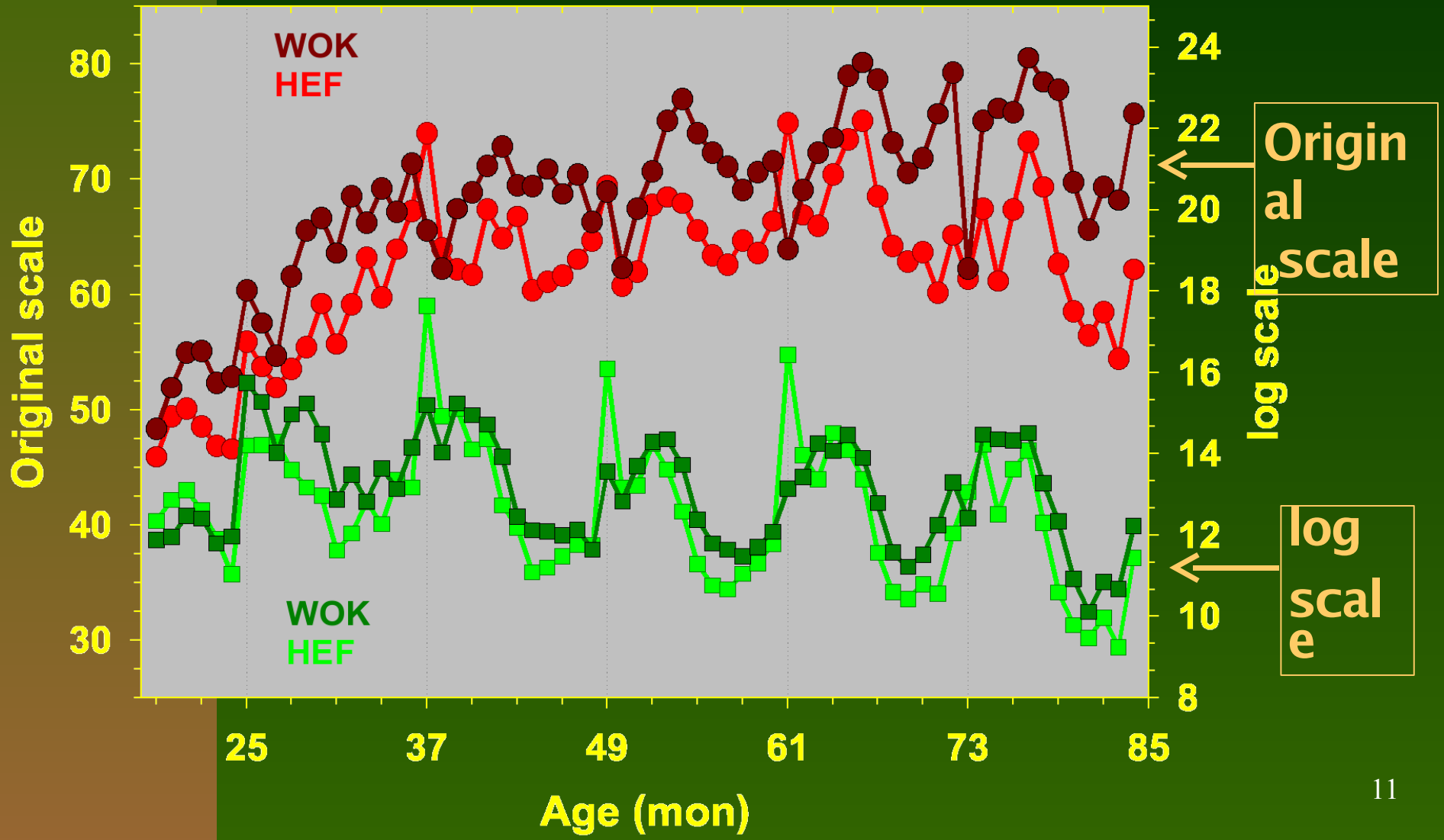
Distribution of ages over months



Means & no.s of records : ages



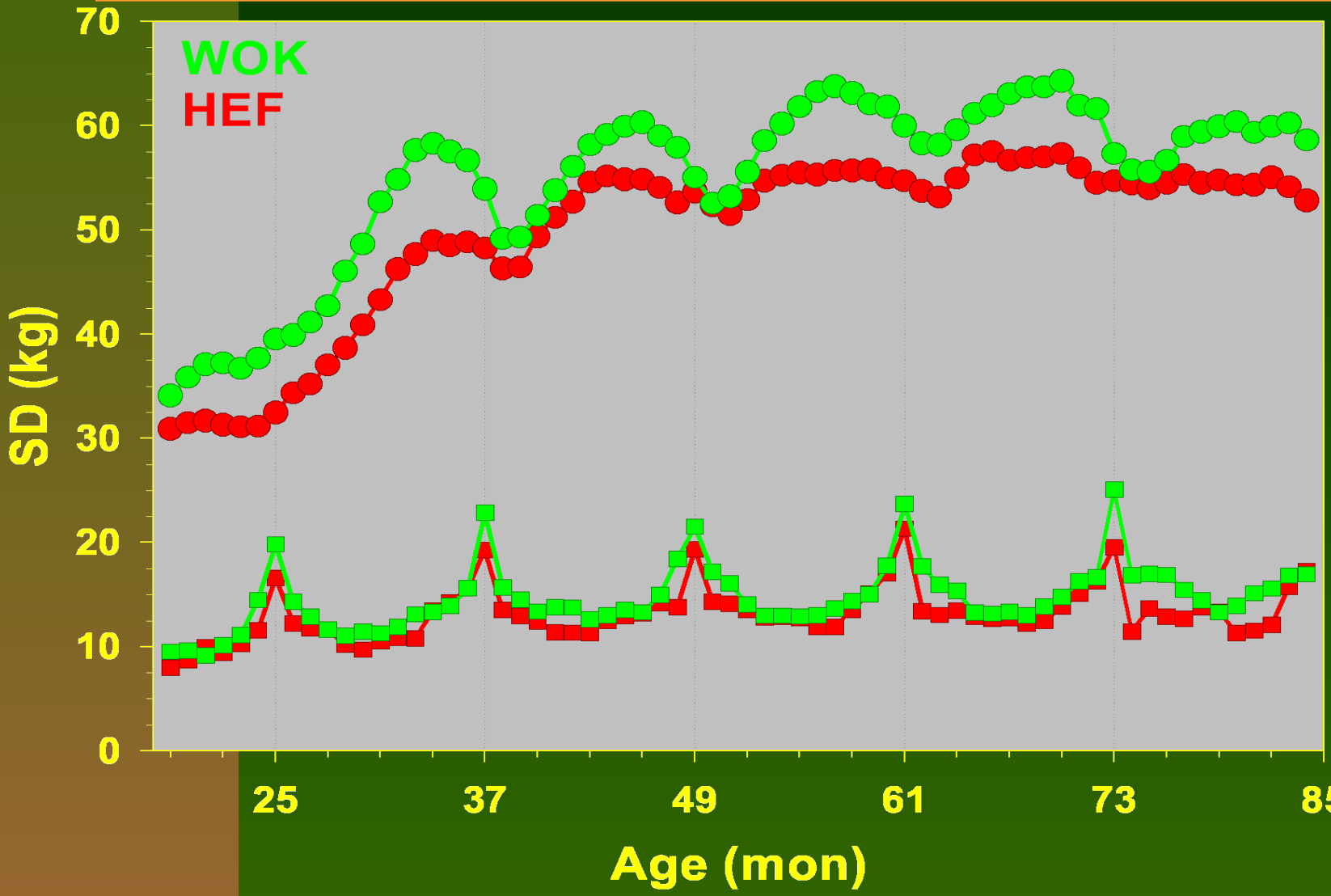
Standard deviations for individual ages



Univariate analyses

- Records for age *i, i=19,84*
  - consider ages *i-1*, *i* and *i+1*
- Model
  - animals, random
  - year-week-paddock classes, fixed
  - age, fixed
- Estimate
  - variance between animals
  - error variance

Estimates : univariate analyses



Between animals

Temporary environment

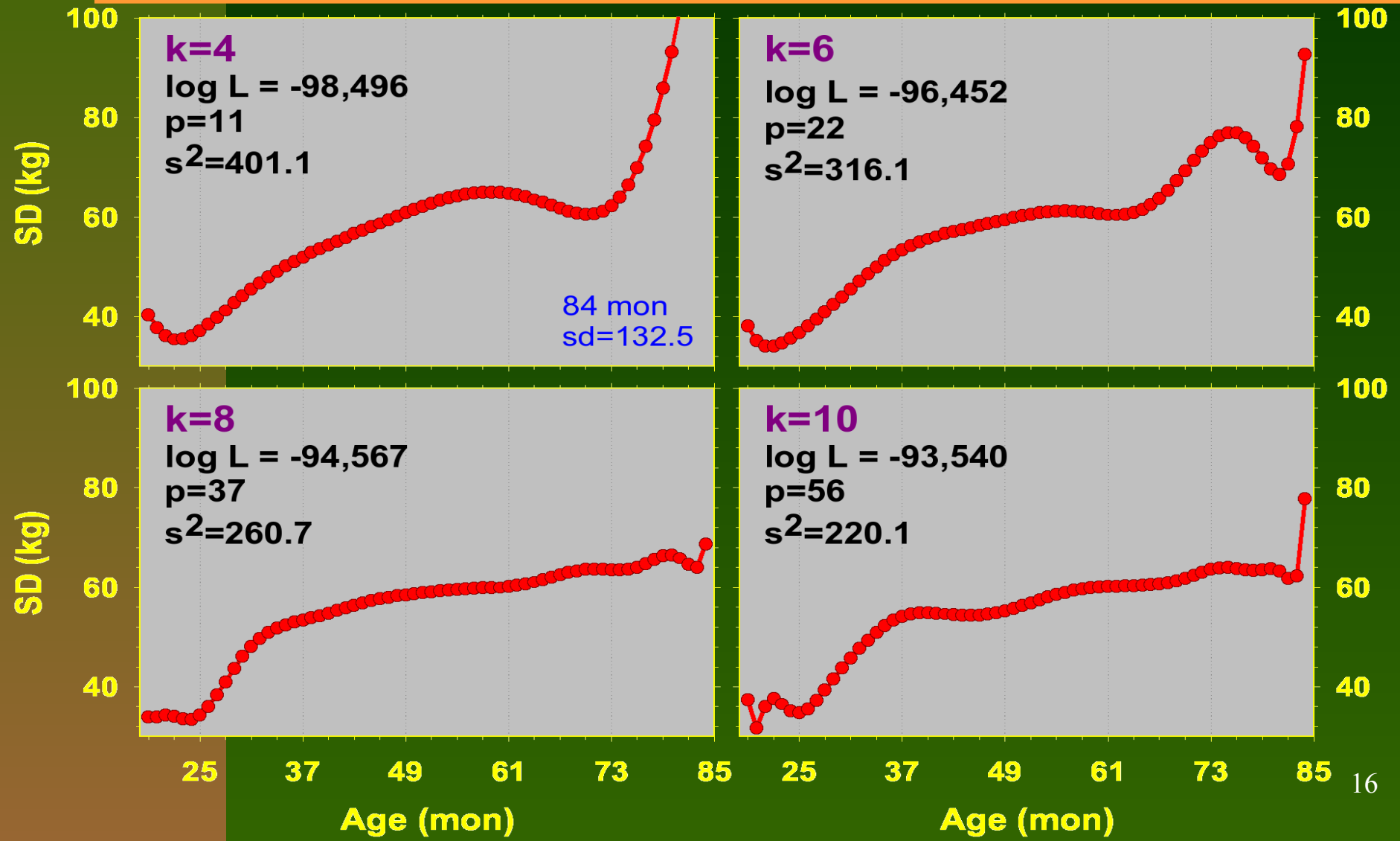
Random Regression Model (RRM)

- Fixed effects :
  - year-week-paddock contemporary group
  - fixed cubic regression on age (k=4)
- Random effects :
  - ***k*** random regression coefficients on orthogonal (Legendre) polynomials of age for each animal
    - Sum of genetic & permanent environm. effects
  - Temporary environmental effects

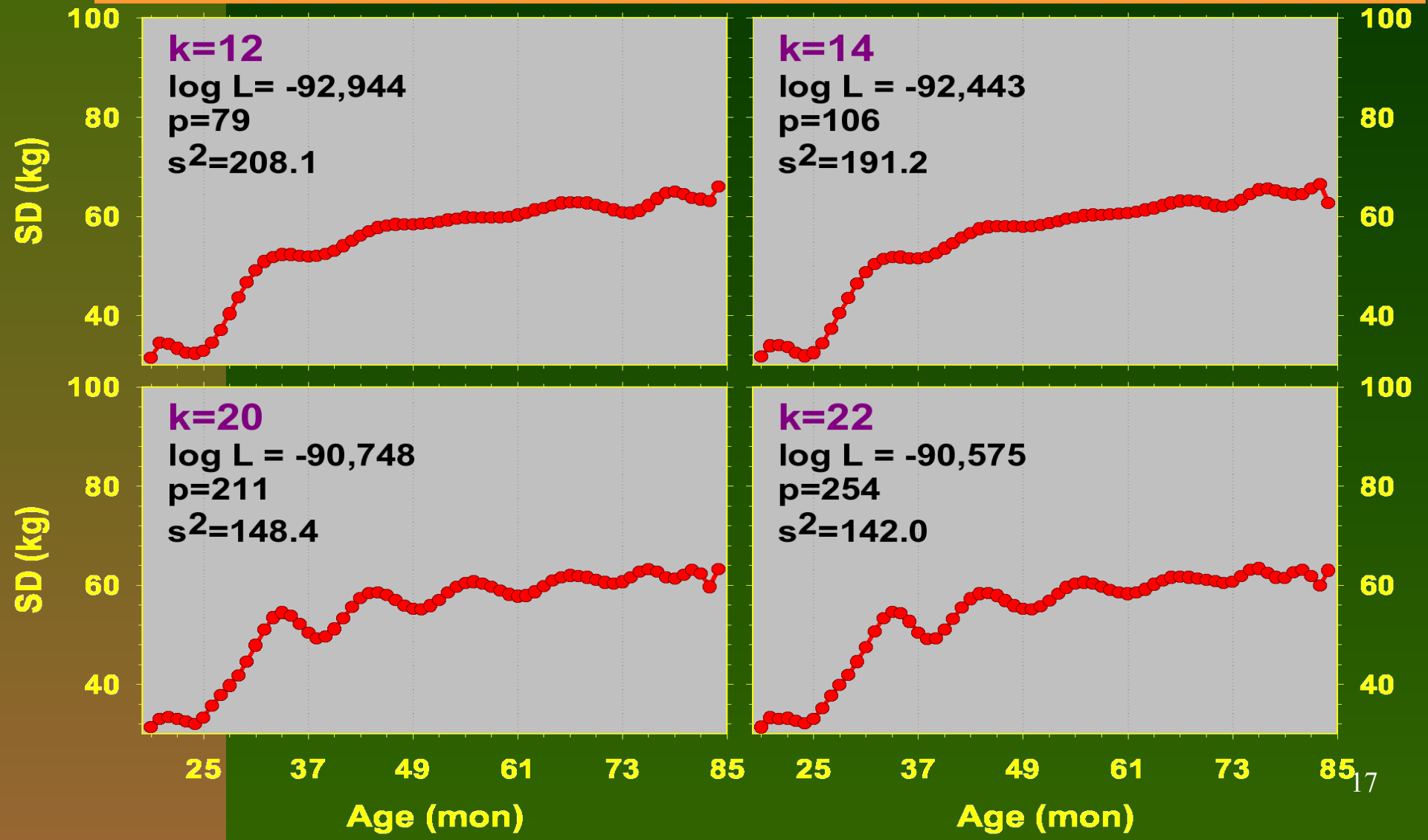
RRM analyses - 2

- Analyses by REML
  - log likelihood (L) → LRT
- Estimate
  - Covariance matrices of RR coefficients
    - k(k+1)/2 parameters
  - Measurement error variances
    - me parameters
- Calculate
  - Covariance functions
  - (Co)Variances for ages in the data

RRM : Standard deviations

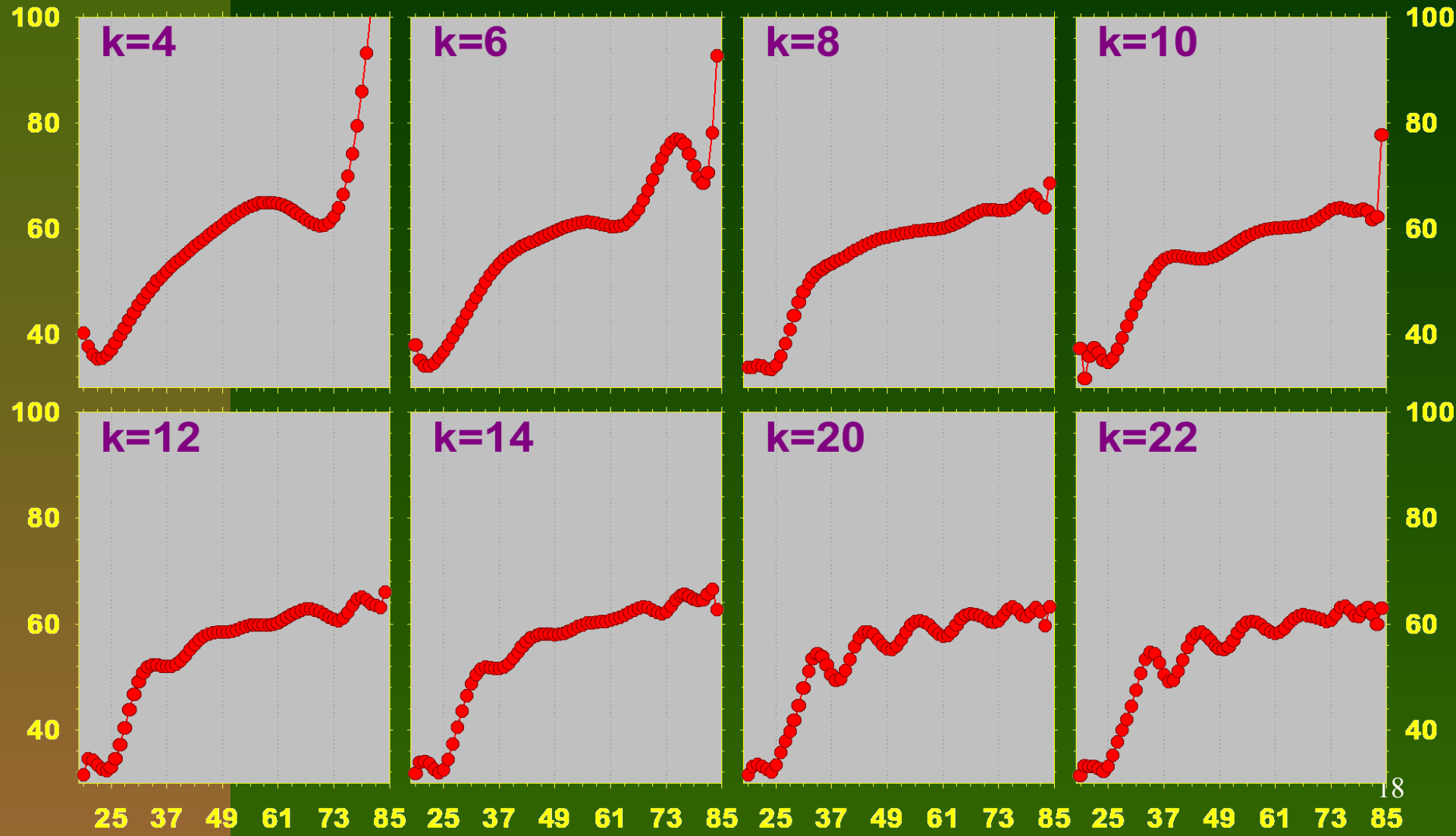


RRM : Standard deviations -2



RRM : Estimates for different k

(Legendre polynomials, me=1, Polled Hereford)



Measurement error variances

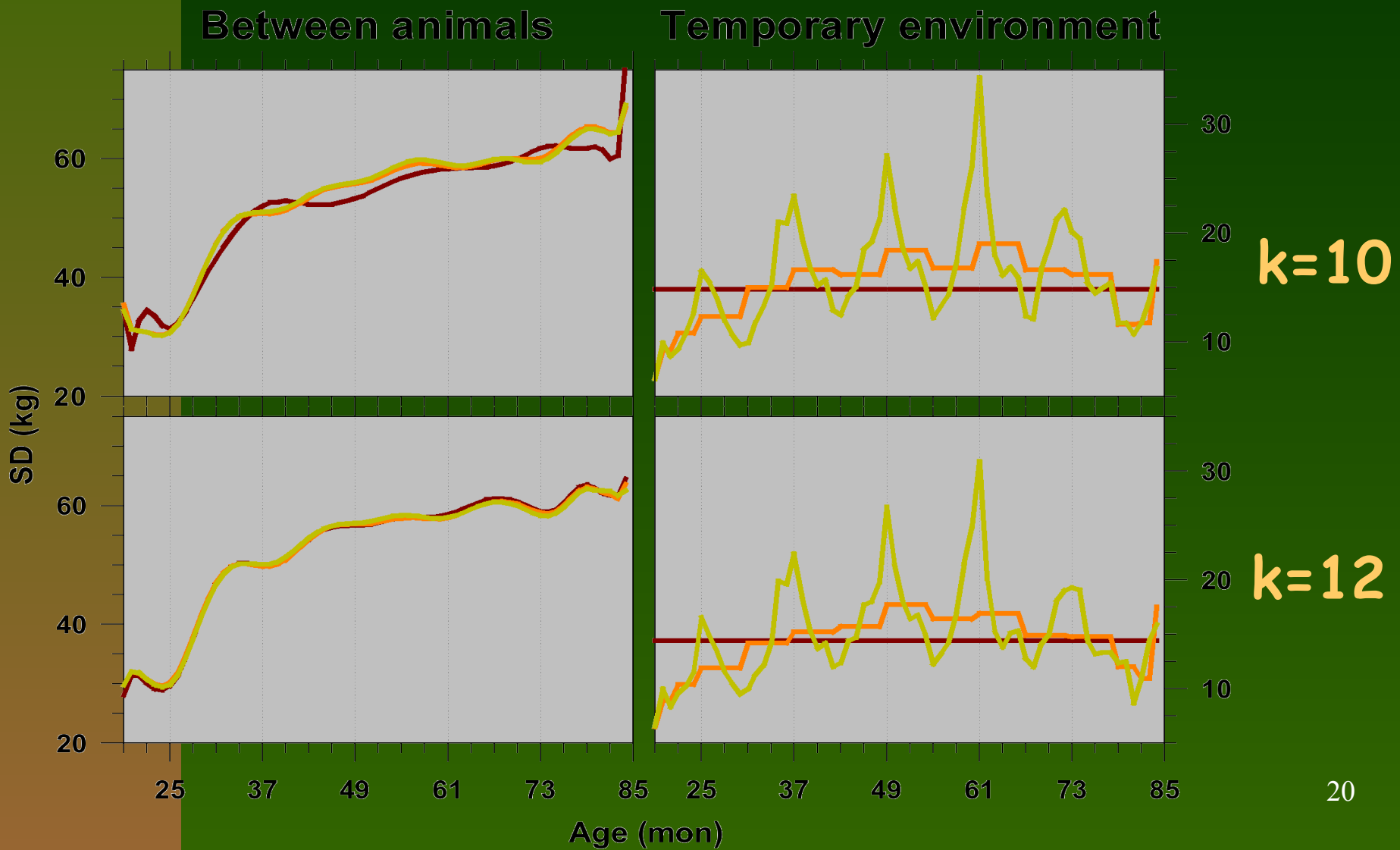
- Reflect temporary environmental variation
- Independently distributed
  - homogeneous → me=1
  - heterogeneous
    - me=15

      6 months intervals + separate σ^2 at extremes
    - me=66

      individual σ^2 for each age

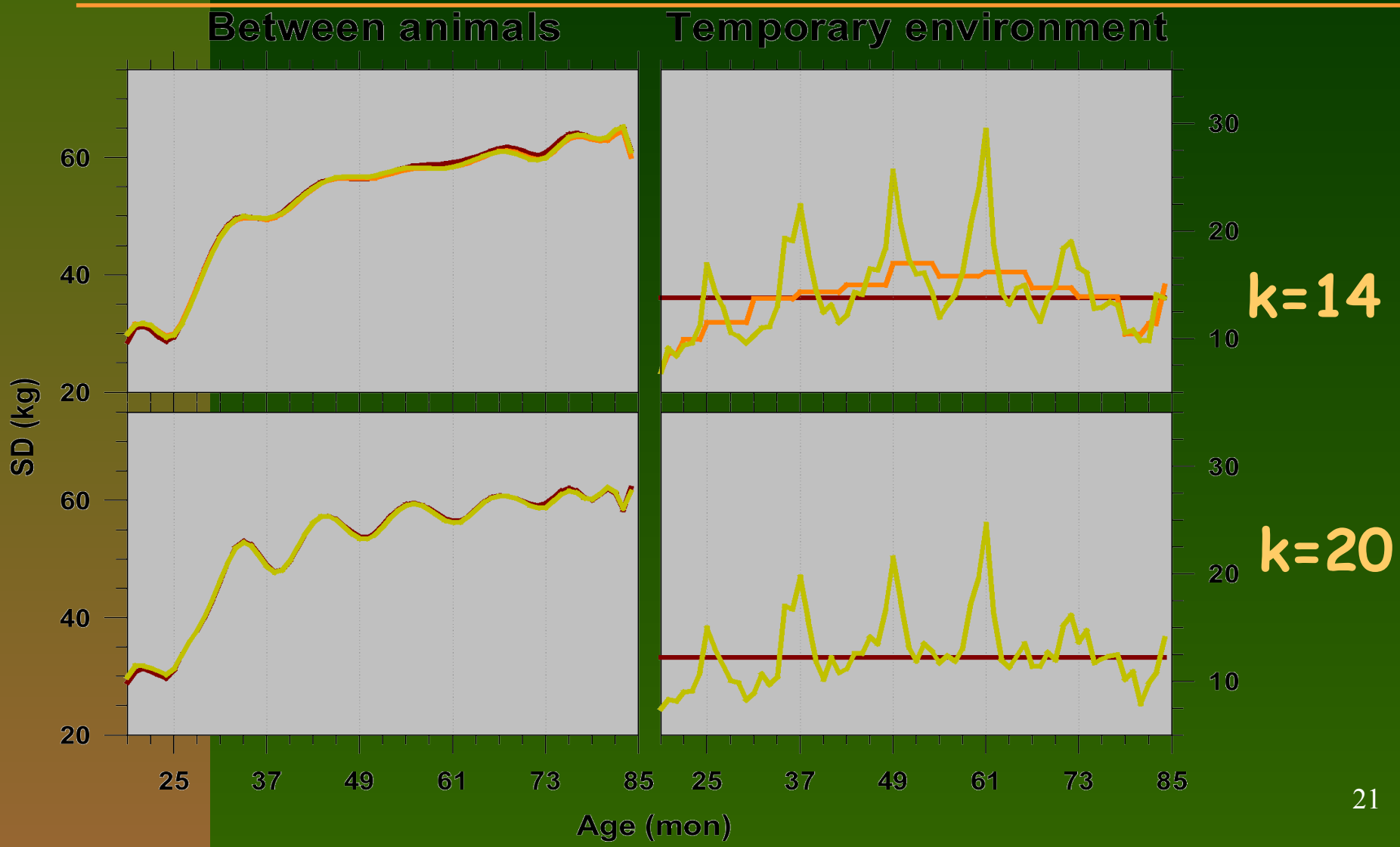
Estimated standard deviations (kg)

(Orthogonal polynomials; Polled Hereford)



Estimated standard deviations (kg)

(Orthogonal polynomials; Polled Hereford)



Results : ME variances

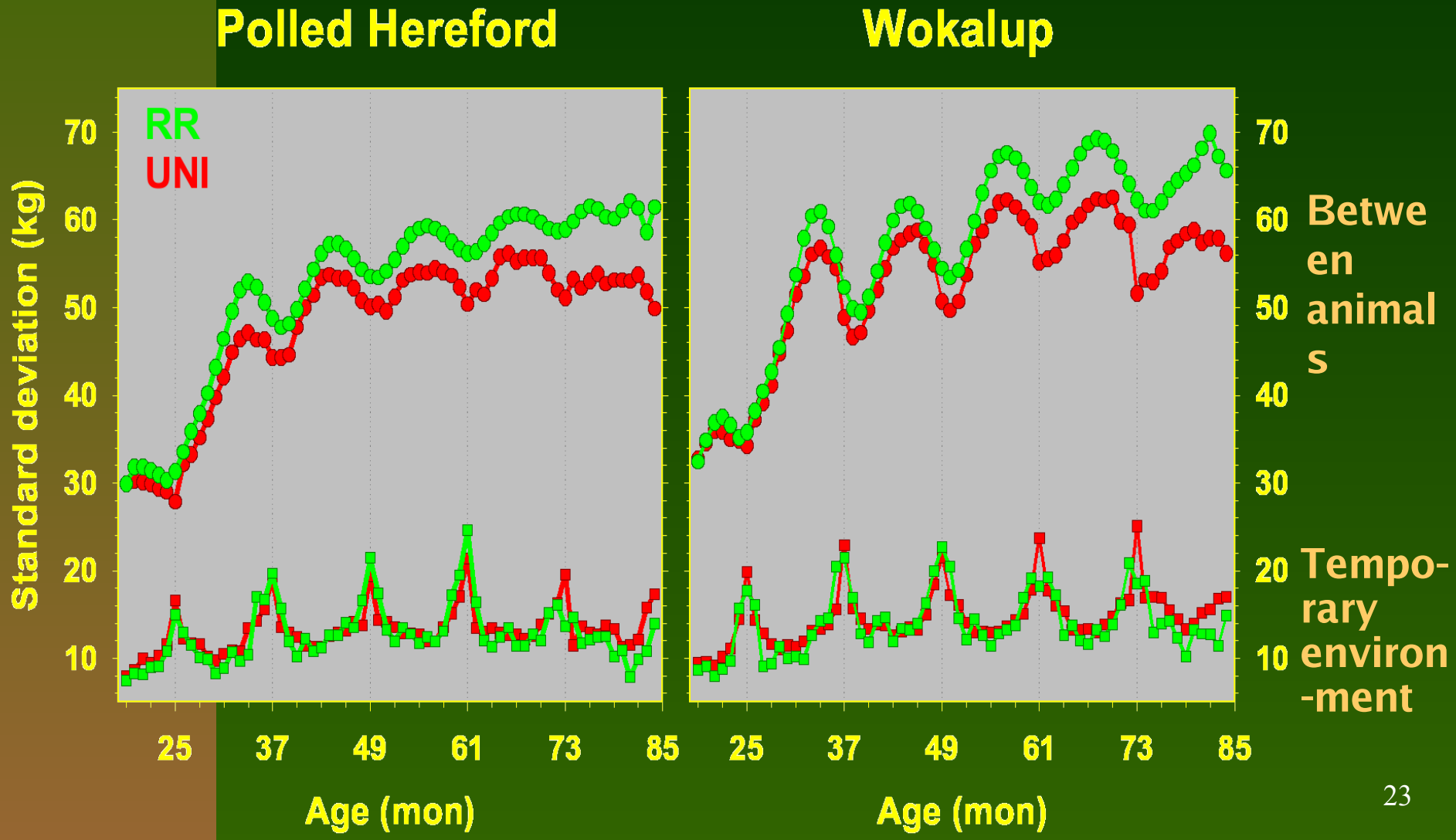
- Heterogeneous measurement error variances model data much better
  - me=1 : log L = -90,747.7
  - me=66 : log L = -90,068.0

  } k=20
- Assumptions have little effect on estimates of between animal variances
  - can compare models assuming homogeneous measurement error variances (me=1)

    provided order of fit is sufficiently large

Univariate *vs.* RRM analyses

(Legendre poly. k=20, me=66)

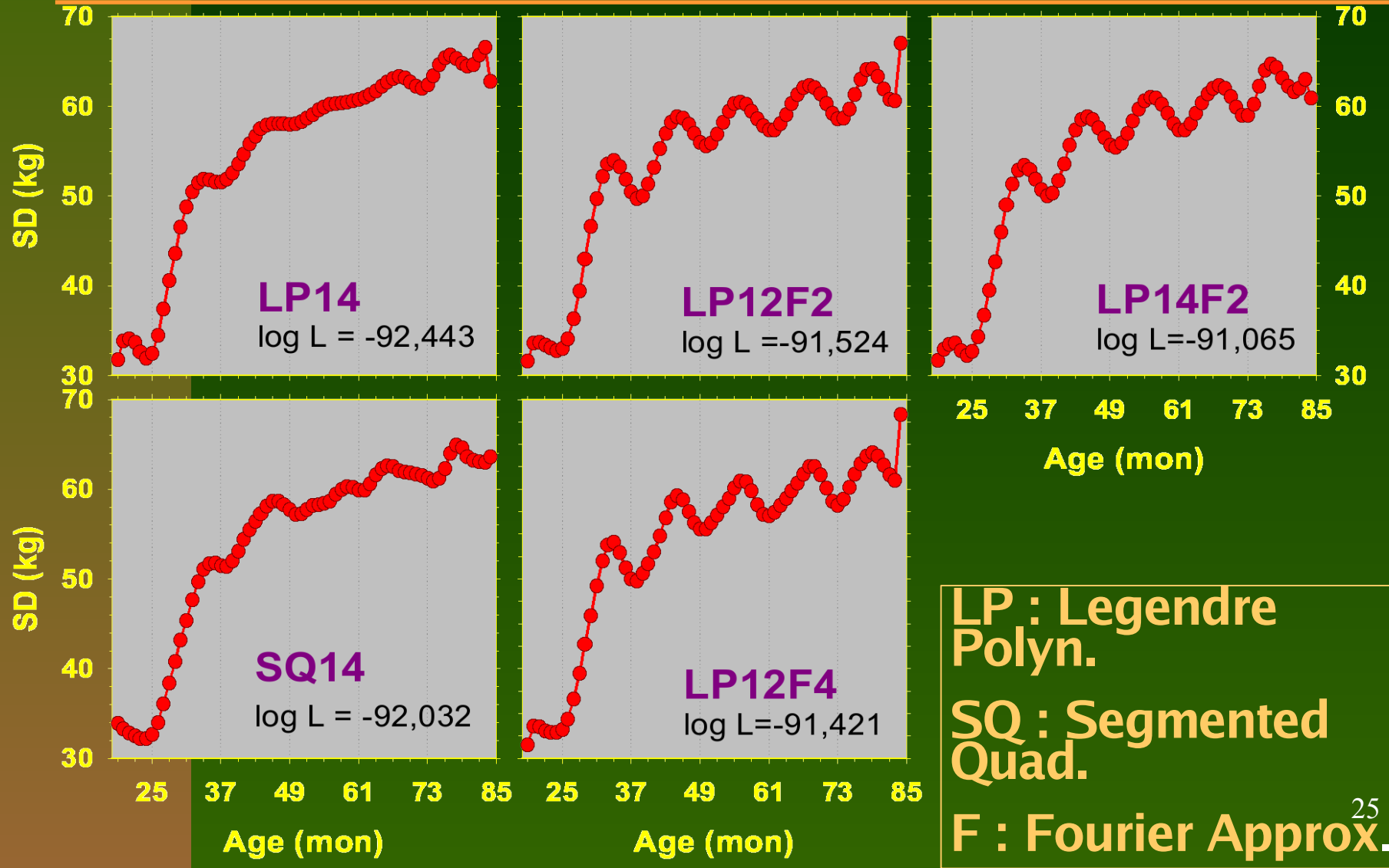


Alternative curves

- Use knowledge about periodicity of changes ➔12 months
- Segmented quadratic polynomials (SQ)
  - Spline function
  - Avoid problems of high powers of age
  - Choose knots carefully
- Fourier series approximation (F)
  - Sum of *sin* and *cos* functions
  - Superimpose on LP to model age trend

RRM : Alternative curves

(Polled Hereford, me=1)



LP : Legendre Polyn.

SQ : Segmented Quad.

F : Fourier Approx.

Conclusions

- RRM capable of modelling complicated patterns of variation in longitudinal data
  - large number of parameters required
  - orthogonal polynomials work (no prior information on pattern of variation)
  - alternative curves using known periodicity yield more parsimonious model
- Future work :
  - Genetic analyses
  - Examine covariances & correlations

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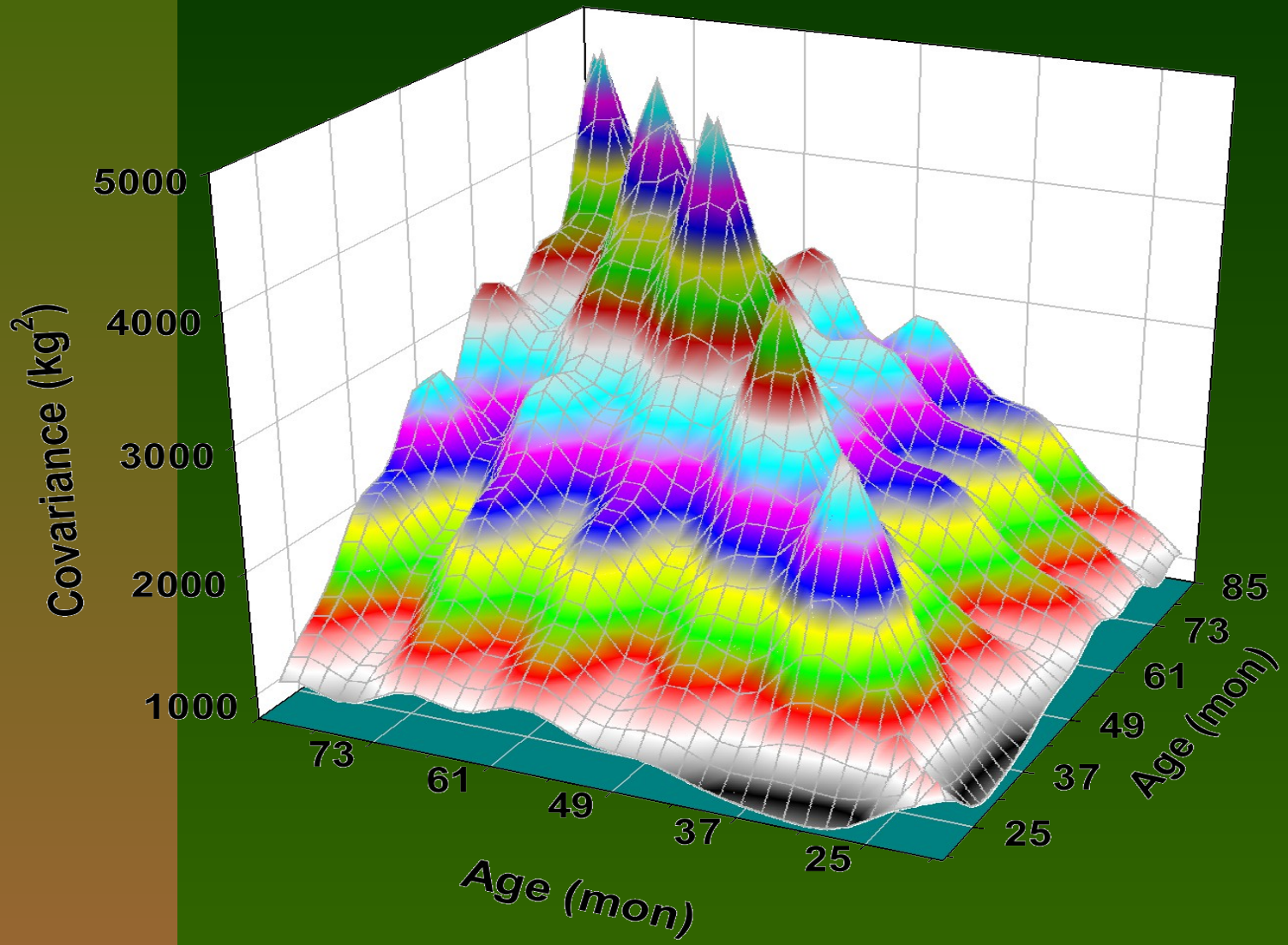
Estimated covariances for ages in data



WOK

SQ13F2

me=1