

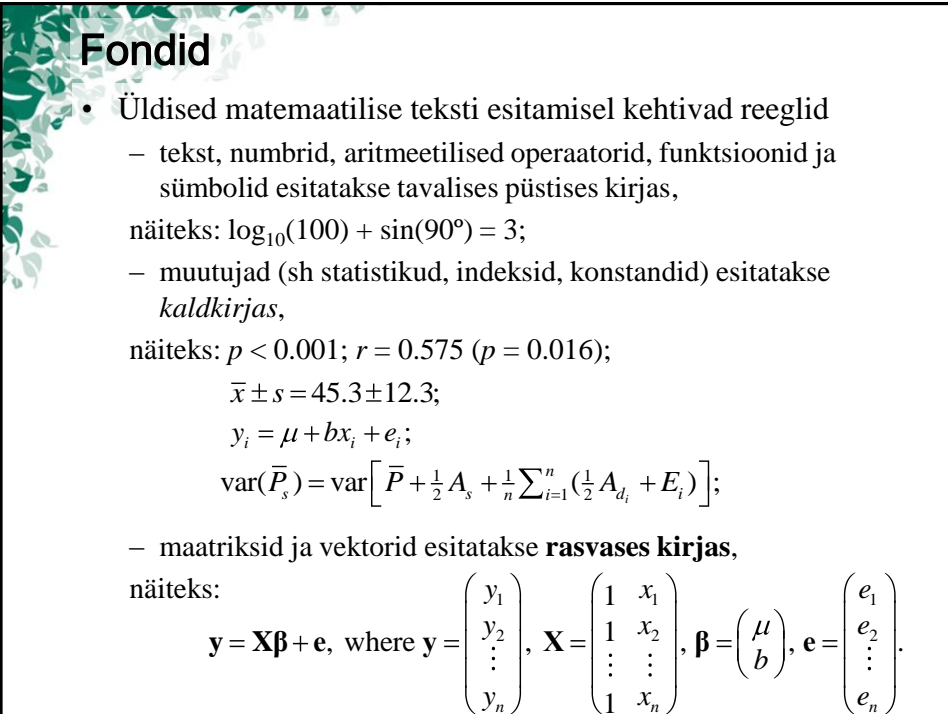
Matemaatiline statistika ja modelleerimine

Analüüsitulemuste esitamisest

(matemaatikute vaatepunktist, mis ei pruugi alati ühtida mittematemaatilistes
ajakirjades aegade jooksul välja kujunenud traditsioonidega)

EMÜ doktorikool
DK.0007

Tanel Kaart



Fondid

- Üldised matemaatilise teksti esitamisel kehtivad reeglid
 - tekst, numbrid, aritmeetilised operaatorid, funktsioonid ja sümbolid esitatakse tavalises püstises kirjas,
näiteks: $\log_{10}(100) + \sin(90^\circ) = 3$;
 - muutujad (sh statistikud, indeksid, konstandid) esitatakse *kaldkirjas*,
näiteks: $p < 0.001$; $r = 0.575$ ($p = 0.016$);
 $\bar{x} \pm s = 45.3 \pm 12.3$;
 $y_i = \mu + bx_i + e_i$;
 $\text{var}(\bar{P}_s) = \text{var}\left[\bar{P} + \frac{1}{2}A_s + \frac{1}{n}\sum_{i=1}^n\left(\frac{1}{2}A_{d_i} + E_i\right)\right]$;
 - maatriksid ja vektorid esitatakse **rasvases kirjas**,
näiteks: $\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{e}$, where $\mathbf{y} = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix}$, $\mathbf{X} = \begin{pmatrix} 1 & x_1 \\ 1 & x_2 \\ \vdots & \vdots \\ 1 & x_n \end{pmatrix}$, $\boldsymbol{\beta} = \begin{pmatrix} \mu \\ b \end{pmatrix}$, $\mathbf{e} = \begin{pmatrix} e_1 \\ e_2 \\ \vdots \\ e_n \end{pmatrix}$.

Mõningad lisasoovitused

- Kasuta tildet (~) tähistamaks ligikaudset võrdust.
- Arvud (≤ 99) lause alguses kirjutatakse sõnadega. Üheksakümneüheksast suuremate arvude puhul on soovitatav kirjutada lause ümber, vältimaks selle arvuga algamist.
- Teksti see esitatakse arvud kuni üheksani enamasti sõnadega: üks, kaks, kolm, ..., üheksa, 10, 11, 12...
Erand: 2-meetrine mõõdulint; 3 miljonit.
- Arvu ja ühiku vahele käib tühik: näiteks, 75 kg.
Erand: 75%.
- Märkus: 0.32, mitte .32.
- Tuhandelite eraldajana kasutatakse inglise keelses tekstis tavaliselt koma (,) enam kui neljakohaliste arvude korral: 143; 2,461 või 2461; 21,278; 1,409,000...

Kümnenndkohtade arv

- Sobiv kümnenndkohtade arv:
 - kirjeldavatel statistikutel (keskmine) tavaliselt üks kümnenndkoht enam, kui mõõtmistäpsus,
 - standardhälbel (standardveal) tavaliselt üks kümnenndkoht enam kui keskmisel,
 - korrelatsioonikordajal kaks kümnenndkohta,
 - protsentidel kaks tüvenumbrit;
 - näiteks: 73 ± 5.2 ; $r = 0.45$; $r = 0.08$; 16%; 1.3%; 0.013%.

		Number of observations	Mean	Standard deviation	T-test (p-value)
Sex	Filly	132	334,4	11,4	0,478
	Colt	131	335,2	9,1	
Foaling time	Spring	182	338,1	9,8	<0,0001
	Autumn	81	327,2	6,9	
Breed	Estonian	23	326,1	11,5	<0,0001
	Tori	240	335,6	9,8	

Kümnendkohtade arv

- Kui olulisuse tõenäosuse (p -väärtuse) esitamine on sobilikum usalduspiiride esitamisest, siis tuleks ära tuua täpne p -väärtus ühe või kahe informatiivse kümnendkohaga ($p < 0.1$ korral) või kahe kümnendkohaga ($p > 0.10$ korral).
- Kui $p < 0.001$ (mõnikord ka $p < 0.0001$), siis täpset väärtust ei esitata.
- Näiteks:
 - $p = 0.03$ või $p = 0.032$, aga mitte $p = 0.0324786$ või $p < 0.05$;
 - $p = 0.007$ või $p = 0.0072$, aga mitte $p = 0.0072213$;
 - $p < 0.001$ või $p < 0.0001$, aga mitte $p = 0.000043$;
 - $p = 0.09$, $p = 0.74$, aga mitte $p > 0.05$.

Materjal ja meetodika

Materjali ja meetodika kirjutamisel võiks eneselt küsida:

- **Kas suudab keegi teine üksnes selles osas kirjas oleva alusel**
 - teostada sama eksperimendi sama tulemusega või
 - koguda (kasvõi teoreetiliselt) sama struktuuriga andmestiku ja kasutada samu matemaatilisi meetodeid või mudeleid?

Kirjas peavad olema

- uurimisobjektid (lehm või laut või farm või ...; piirkond või põld/katselapp või taim või ...),
- protseduur (eksperimendi disain, andmete kogumise kirjeldus),
- statistika (andmetöötlus).

Materjal ja metoodika

- Uuringu ala
- Andmete kogumine

2. Materials and Methods

2.1. Study Area and Sites

Xiangxi River, a sixth-order river, originating from the Shennongjia Forest Region, is an important tributary of the Yangtze River, China. It has a length of 94 km, with a catchment area of 3,059 km², and a natural fall of 1540 m from the headwaters to its confluence with the Yangtze River at Xiangxi River Mouth. Therefore, many small hydropower stations were built within the watershed. When water discharge is low, from October to June, the flow regime of this river is changed by the

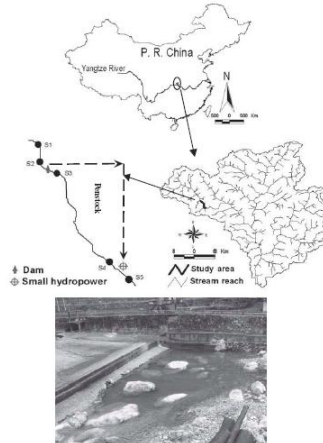


Figure 1. The location of Xiangxi River in China (top), the small hydropower plant and the sampling sites in Xiangxi River (middle) and the picture of S3 (bottom).

Materjal ja metoodika

- Uuringu ala
- Andmete kogumine

population dynamics.

In the present paper we analyse the role of temperature changes in the population dynamics of lake smelt *Osmerus eperlanus eperlanus* m. *spirinchus* Pallas, a key species in the fish community of Lake Peipsi. Lake smelt is a freshwater dwarf form of European smelt *Osmerus eperlanus* (L.) (Kuderskij & Fedorova, 1977; Pihu, 2003) and is a small-sized, slender, shoaling fish with a characteristic cucumber smell (Quigley et al., 2004). In Lake Peipsi, lake smelt has historically been among the most important commercial fish species in terms of catch size (Pihu & Kangur, 2001). Due to their intermediate trophic position as a consumer of plankton and as a prey for higher predators, lake smelt has the potential to introduce

Materials and methods

Study area

Lake Peipsi is situated on the border of Estonia and Russia (Fig. 1). Its surface area is 3,555 km², mean depth 7.1 m and maximum depth 15.3 m (Jaani, 2001a) and its altitude is 30 m above sea level. The volume of the whole lake is 25 km³ and the residence time of water is about 2 years. The only outflow is through the Narva River into the Gulf of Finland. Natural water level fluctuations have shown an overall range of 3.04 m over the last 80 years, with an average annual range of 1.15 m (Jaani, 1996). L. Peipsi is situated in the northern region of the temperate zone with variable



Fig. 1 Location of Lake Peipsi

Materjal ja metoodika

- **Experiment based study** – more attention on the experimental design and less on statistical methods
 - Experimental design
 - Sample size calculations
 - Experiment description
 - Don't assume that the reader knows what you did, even when "the reader" is your instructor.
 - Instead of writing:
First pour agar into six petri plates. Then inoculate the plates with the bacteria. Then put the plates into the incubator . . .
 - Simply describe how the experiment was done:
Six petri plates were prepared with agar and inoculated with the bacteria. The plates were incubated for ten hours.
 - Deviations from initial experimental design.

Materjal ja metoodika

- **Experiment based study**
 - Statistical analysis – as a rule a standard statistical methods (t-test, ANOVA, correlation and regression analysis, chi-square test, ...)
 - Probability level
 - Error measure (standard deviation, standard error)

 - Example:
An unpaired, two-tailed Student's t-test was used to compare the frequency of between males and females. $P < 0.05$ was considered significant and variability was measured with standard error of the mean (*S.E.M.*).

Materjal ja meetodika

- **Model based study** – more attention on the statistical methods
 - Standard statistical methods don't need additional explanations.
 - More specific methods and complex models need extra explanations and references.

Principal component analysis (PCA) was applied to the landscape elements and the bumblebee species found (Table 4). The results of PCA are interpreted using scatters of the site scores connected with group centroids (star plot), and via correlation circles. The effect of the grouping factor was estimated using the multivariate randomisation test (Manly, 1995) with

1000 permutations. The influence of landscape structure on the bumblebee community was studied with co-inertia analysis (Dolédec and Chessel, 1994). This is a two-table ordination method that facilitates the establishment of connections between tables with data domains that contain the same or even different number of variables. This method combines various standard single-table ordination methods such as principal component analysis and correspondence analysis. Dolédec and Chessel (1994) give a detailed description of the co-inertia analysis in their studies.

Materjal ja meetodika

Data analysis

The analysis of the data comprised three major steps. Firstly, we calculated the community-wide characteristics of clonal growth (Table 2). For each plot, we calculated the weighted average of each clonal growth parameter (M_{pj}) as:

$$M_{pj} = \sum a_i p_{ij} \quad (2)$$

Here a_i is the cover (ranging from 0 to 1) for the species i in the plot and p_{ij} is the value of the j -th clonal growth parameter for the species i .

We measured the difference in extent of clonal mobility among the coexisting species with the coefficient of variation of the medians of rhizome increment for all species in one plot. The coefficient of variation was chosen as it is an estimate of variance independent of the value of the sample mean. To correct also for a possible bias associated with the differences in sample size, we used the following correction (Sokal and Rohlf, 1995):

$$CV_{\text{increment}} = (1 + 1/4n)(\text{St.Dev}_{\text{increment}} \times 100/M_{\text{increment}}) \quad (3)$$

Here $CV_{\text{increment}}$ stands for the corrected coefficient of variation for median rhizome increment per plot, n is sample size, $\text{St.Dev}_{\text{increment}}$ is the standard deviation of rhizome increment for one plot, and $M_{\text{increment}}$ is the mean of the rhizome increments for all species found in a plot.

Secondly, we estimated the effect of environmental conditions on the averages of clonal growth parameters, species density, and ramet density as well as the general differences between the communities in average clonal growth. To test for the general relationships between different environmental variables and vegetation characters (incl. community-wide parameters of clonal growth), we built a squared correlation matrix with the Pearson's r and probabilities of error (p -level). To correct for the mass effect we employed the Bonferroni type correction with the Dunn-Šidák method (Sokal and Rohlf, 1995) and obtained the critical p -level (experimentwise error rate) using the following equation:

$$p_{\text{critical}} = 1 - (1 - 0.05)^{1/k} \quad (4)$$

Materjal ja meetoodika

mowing frequency once a year. The following model was tested:

Results were evaluated statistically using a general linear mixed model assuming a first-order autoregressive variance structure of repeated measurements from the individual cows (SAS Inst. Inc. 2006). In order to estimate the effects of different factors on the milk coagulation, compositional parameters, the following models were used:

$$y_{ijkmo} = \mu + \text{parity}_i + \text{lactmonth}_j + \alpha\beta\kappa_Cn_k + \beta_Lg_l + a_o + p_{e_f} + \varepsilon_{ijkmo}$$

where: y_{ijkmo} = milk coagulation (log RCT, E₃₀), production (daily milk yield) or compositional trait (milk fat and protein contents), μ = general mean, parity_i = fixed effect of parity class i ($i = 1$ to 4), lactmonth_j = fixed effect of month of lactation j ($j = 1$ to 11), $\alpha\beta\kappa_Cn_k$ = fixed effect of aggregate α_{s1} -, β - and κ -Cn genotypes k ($k = 1$ to 15), β_Lg_l = fixed effect of β -Lg genotype l , ($l = 1$ to 3); a_o = random additive genetic effect of animal o , $N(0, A\sigma_o^2)$; p_{e_f} = random permanent environmental effect of farm f ; $N(0, I\sigma_{pe}^2)$; ε = random residual effect with spatial power covariance structure, $N(0, R)$.

$$= \mu + a_1HABITAT + a_2L + a_3L^2 + a_4B + a_5B^2 + a_6LB \quad (5)$$

es a dependent variable (species density, ramet density and averages of clonal growth parameters), μ is the intercept, L stands for mowing frequency, B is biomass, and a_1 - a_6 are the coefficients. E was included in the model as a random factor. The factors L and B were included in $HABITAT$, while the factors $SITE$ and $HABITAT$ were included in E . Type 3 test of fixed effects was used with the iterated Maximum Likelihood (REML) procedure to estimate the variance components. To test for the dependence of the variables on mowing frequency and different mowing regimes within one community type, as well as for the differences in the average values of the variables between community types, we used the statement ESTIMATE. In order to calculate the differences in the least squares means, however, as similar results they are not presented here.

Statistika tarkvara

- The well-known commercially-available statistics software like SAS, SPSS, R, Minitab, Genstat, Statistica need no further reference, although it is helpful to provide the version number, as these packages are constantly being updated and features change.
- The more specific software needs reference.

241–280, 281–320 and 321–365 days within the year). Regression analyses were carried out with SAS System, Release 8.2, SAS Institute Inc., 1996, using GLM procedure. For studying effect of water temperature and water level on the smelt

Computations and graphical displays of the co-inertia analysis were obtained using the ADE-4 package (Thiolouse et al., 1997).

Kirjeldav statistika

TABLE I. Values of rainbow trout blood chemistry values ($n = 45$)

	Mean \pm s.e.	Median	Skewness (mean \pm s.e.)	Kurtosis (mean \pm s.d.)	CV (%)	95% CI (lower-upper)
Glucose (mg dl ⁻¹)	108.11 \pm 9.98	98.00	0.62 \pm 0.35	-0.21 \pm 0.70	61.91	88.00-128.22
Urea* (mg dl ⁻¹)	4.36 \pm 0.24	4.00	1.21 \pm 0.35	2.24 \pm 0.70	36.35	3.88-4.83
Creatinine* (mg dl ⁻¹)	0.29 \pm 0.01	0.29	1.24 \pm 0.35	3.09 \pm 0.70	23.71	0.27-0.31
Total bilirubin (mg dl ⁻¹)	0.04 \pm 0.00	0.05	0.11 \pm 0.35	-0.55 \pm 0.70	58.02	0.04-0.05
Aspartate aminotransferase (U l ⁻¹)	461.20 \pm 27.62	447.00	0.65 \pm 0.35	0.38 \pm 0.70	40.18	405.53-516.87
Alanine aminotransferase* (U l ⁻¹)	12.87 \pm 1.16	11.00	1.71 \pm 0.35	3.63 \pm 0.70	60.22	10.54-15.19
Alkaline phosphatase* (U l ⁻¹)	179.22 \pm 19.26	131.00	1.92 \pm 0.35	3.84 \pm 0.70	72.10	140.40-218.04
Creatine phosphokinase* (U l ⁻¹)	1265.11 \pm 161.70	894.00	1.21 \pm 0.35	0.73 \pm 0.70	85.74	939.22-1591.00
Lactate dehydrogenase* (U l ⁻¹)	2628.18 \pm 164.75	2399.00	1.53 \pm 0.35	2.62 \pm 0.70	42.05	2296.15-2960.21
Gamma-glutamyl transferase (U l ⁻¹)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Total protein (g dl ⁻¹)	3.59 \pm 0.13	3.74	-0.59 \pm 0.35	0.46 \pm 0.70	24.64	3.32-3.85
Albumin (g dl ⁻¹)	1.38 \pm 0.05	1.40	-0.39 \pm 0.35	0.05 \pm 0.70	25.17	1.27-1.48
Triglycerides (mg dl ⁻¹)	347.51 \pm 23.56	327.00	0.46 \pm 0.35	-0.73 \pm 0.70	45.47	300.04-394.99
Cholesterol (mg dl ⁻¹)	247.38 \pm 10.32	241.00	0.09 \pm 0.35	0.10 \pm 0.70	27.98	226.59-268.17
Ca (mg dl ⁻¹)	12.52 \pm 0.20	12.20	0.55 \pm 0.35	-0.08 \pm 0.70	10.81	12.11-12.93
P (mg dl ⁻¹)	22.66 \pm 1.19	22.50	0.45 \pm 0.35	-0.67 \pm 0.70	35.26	20.26-25.06
Mg (mg dl ⁻¹)	3.85 \pm 0.11	3.82	0.07 \pm 0.35	-0.84 \pm 0.70	15.40	3.63-4.07
Na (mEq l ⁻¹)	154.07 \pm 0.85	155.00	-0.53 \pm 0.35	1.14 \pm 0.70	3.69	152.36-155.78
K (mEq l ⁻¹)	3.45 \pm 0.29	3.25	0.45 \pm 0.35	-0.81 \pm 0.70	52.55	2.87-4.03
Cl ⁻ (mEq l ⁻¹)	128.09 \pm 1.13	130.00	-2.90 \pm 0.35	11.84 \pm 0.70	5.90	125.82-130.36

n.a., not assessable. *Null hypothesis (Kolmogorov-Smirnov test) was rejected.

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Tabelid

- Tabelid võivad asendada tulemuste pikki kirjeldusi.
 - Tabelid ei tohi korrata tekstis või joonistel esitatud informatsiooni ning peavad ideaaljuhul olema täielikult mõistetavad ka ilma artiklita.
 - Ära kasuta tabeli tegemisel TAB-klahvi.
 - Ära kasuta vertikaalseid jooni, selle asemel „mängi“ horisontaalsete joontega (ja vajadusel ka tühjade veergudega).

Table 2. Mean pod and hay yields (t ha⁻¹) of five groundnut cultivars grown at Wad Medani, Sudan in 1984-86.

Cultivar	Pod yield				Hay yield			
	1984	1985	1986	Mean	1984	1985	1986	Mean
Early Bunch	2.47	3.34	2.14	2.65	3.56	2.40	2.61	2.86
Georgia 119-20	1.73	3.38	2.29	2.46	3.50	3.88	2.81	3.39
UF79-1499	1.61	2.05	2.34	2.00	5.23	1.82	3.26	3.44
Apollo	1.47	3.38	1.93	2.26	4.65	3.44	2.81	3.63
MH 383	1.75	3.70	2.14	2.53	4.78	4.58	2.99	4.12
Mean	1.81	3.17	2.17	2.38	4.34	3.22	2.88	3.49
s.e.	0.235	0.223	0.167	0.210	0.571	0.292	0.264	0.373

Tabelid

Line	Number of stallions	Inside lines				Between lines	
		Coancestry coefficient		Inbreeding coefficient		Coancestry coefficient	
		Average	Max	Average	Max	Average	Max
Ahti	7	0,092	0,276	0,012	0,029	0,037	0,161
Eni	4	0,110	0,255	0,004	0,009	0,041	0,163
Raspel	9	0,090	0,287	0,014	0,047	0,040	0,163
Taru	1	0,000	0,000	0,002	0,002	0,026	0,088
Taube	2	0,074	0,074	0,012	0,020	0,028	0,088

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Raspel	9	0,090	0,287	0,014	0,047	0,040	0,163
Taru	1	0,000	0,000	0,002	0,002	0,026	0,088
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Joonised

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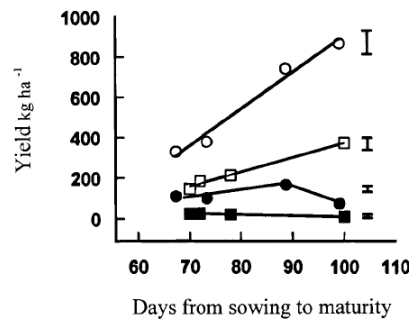
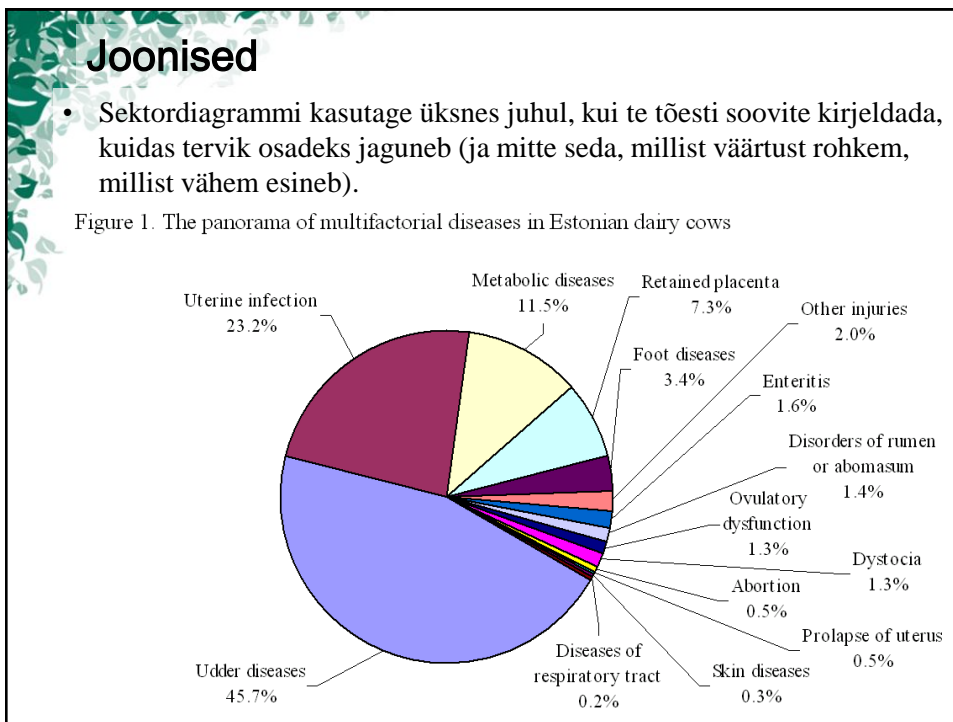


Fig. 2. Relationship between biomass (○●) and seed (□■) yield, and days from sowing to maturity, among four varieties of cowpea grown at Minjibir (open symbols) and Malam Madori (closed symbols) in Nigeria in 1992. Bars are s.e.d. between means. Fitted lines: ○Y = -919(156) + 18.2(1.88)X, r² = 0.98; □Y = -349(42) + 7.2(0.52)X, r² = 0.99; ■Y = 61(3.5) - 0.5(0.04)X, r² = 0.99; ● line fitted by eye.

Joonised

- Sektordiagrammi kasutage üksnes juhul, kui te tõesti soovite kirjeldada, kuidas tervik osadeks jaguneb (ja mitte seda, millist väärtust rohkem, millist vähem esineb).

Figure 1. The panorama of multifactorial diseases in Estonian dairy cows



Korrelatsioonikordajad

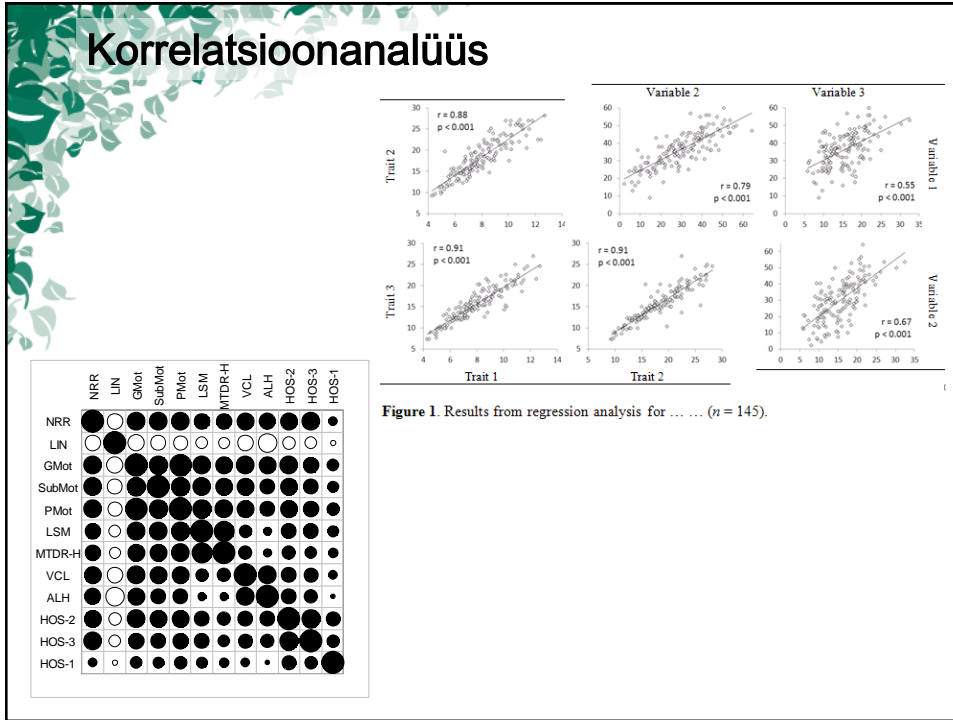
Table 6. Pearson's partial correlation coefficients (r) between studied variables. The effect of 5 partial variables was excluded: light, biomass, their squared effects and combined effect. $CV_{\text{increment}}$ is the estimate of the difference in extent of clonal mobility (coefficient of variation of rhizome increments) in coexisting species. All communities are analysed together, $n = 104$.

	Ramet density	Species density	Ramet life span	Rhizome increment	Branching intensity
Species density	0.44 ***				
Ramet life span	-0.09	-0.04			
Rhizome increment	-0.13	-0.17	0.81 ***		
Branching intensity	0.39 ***	0.23 *	0.34 **	-0.39 ***	
$CV_{\text{increment}}$	-0.26 **	-0.07	0.09	-0.02	-0.30 *

*** - $p < 0.001$; ** - $p < 0.01$; * - $p < 0.05$

Table 6. Pearson's partial correlation coefficients (r) between studied variables. The effect of 5 partial variables was excluded: light, biomass, their squared effects and combined effect. $CV_{\text{increment}}$ is the estimate of the difference in extent of clonal mobility (coefficient of variation of rhizome increments) in coexisting species. All communities are analysed together, $n = 104$. Statistically significant p -levels (p) are in bold script. The critical experimentwise error rate $p_{\text{critical}} = 0.0034$

	Ramet density		Species density		Ramet life span		Rhizome increment		Branching intensity	
	r	p	r	p	r	p	r	p	r	p
Species density	0.44	<.0001								
Ramet life span	-0.09	0.360	-0.04	0.690						
Rhizome increment	-0.13	0.210	-0.17	0.084	0.81	<.0001				
Branching intensity	0.39	<.0001	0.23	0.024	0.34	0.001	-0.39	<.0001		
$CV_{\text{increment}}$	-0.26	0.010	-0.07	0.471	0.09	0.366	-0.02	0.819	-0.30	0.002



Mudelid – parameetrite hinnangud jmt

Table 2. Estimates ±SE of effect of parity on studied traits (zero refers to class of comparison) and percentages of non-coagulated (NCM) and poorly ($E_{30} < 20$ mm) coagulated (NK_{30}) milk samples of all samples in respective parity class.

Trait	Parity				P value
	1	2	3–4	≥5	
Number of samples	125	63	106	40	
Daily milk yield, kg	0 ^a	0.72±1.03 ^{ab}	1.50±0.88 ^b	2.20±1.06 ^b	0.1605
Fat, %	0 ^a	0.50±0.19 ^b	0.31±0.16 ^b	0.19±0.19 ^{ab}	0.0665
Protein, %	0 ^a	0.13±0.09 ^a	0.07±0.08 ^a	0.05±0.09 ^a	0.5461
log RCT	0 ^a	-0.02±0.04 ^{ab}	-0.06±0.03 ^b	-0.02±0.04 ^{ab}	0.2798
¹ E ₃₀ , mm	0 ^{ab}	0.92±2.32 ^a	0.98±1.97 ^a	-3.47±2.31 ^b	0.2321
NCM, %	10.4	6.3	1.9	–	
NK ₃₀ , %	10.4	6.3	5.6	5.0	

¹Estimates of curd firmness of coagulating ($E_{30} > 0$ mm) milk samples
^{a,b}Estimates within row with differing letters in superscript are significantly different (P<0.05)

Table 2. Statistical results for the effect of adding calcium chloride (40% w/w) and water on chemical and functional properties of Mozzarella cheese after 42 d of storage at 4°C.

Source/variable	Model ¹	Contrast		
		Uninjected vs. Calcium	Uninjected vs. Water	Calcium vs. Water
	P<	P<	P<	P<
Calcium	0.001	0.001	NS ²	0.001
Moisture	0.001	0.001	NS	0.001
pH	0.001	0.001	NS	0.001
Weight	0.001	0.001	NS	0.001
Cohesiveness	0.01	0.001	NS	0.001
Hardness	0.05	0.01	NS	0.001
Melting	0.001	0.001	NS	0.001

¹ $Y_{ijk} = \mu + T_j + B_k + e_{ijk} + d_{ijk}$, where Y is the variable of interest, μ is the overall mean, T is the treatment effect, B is the block effect, e is the error term, and d is the subsample effect.
²NS: not significant i.e., $P \geq 0.05$.

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Table 5. Association between milk production, BCS, and BW variables, and SR21¹

Model ²	OR	95% CI	P-value
Model relating milk production variables to likelihood of SR21 n = 2753 R ² = 0.164			
Estimated 200-d milk protein content (g/kg)			
<31.8	1		
31.8 to 33.0	1.20	0.90–1.62	NS
33.1 to 34.4	1.52	1.10–2.09	0.011
>34.4	1.54	1.10–2.14	0.012
Protein-to-fat ratio at herd SBD			
<0.81	1		
0.81 to 0.90	1.34	0.98–1.84	0.066
0.91 to 1.00	1.11	0.80–1.52	NS
>1.00	1.45	1.03–2.05	0.036
Model relating BCS variables to likelihood of SR21 n = 2204 R ² = 0.131			
Average BCS between 60 and 100 d of lactation (BCS units)			
≤2.50	0.59	0.44–0.78	<0.001
2.75 to 3.0	1		
≥3.25	0.90	0.63–1.31	NS
Model relating BW variables to likelihood of SR21 n = 1483 R ² = 0.194			
BW at herd SBD (kg)			
<483	1		
483 to 529	1.33	0.82–2.17	NS
530 to 576	1.20	0.70–2.07	NS
>576	1.90	1.00–3.60	0.048
BW loss from precalving to nadir (kg)			
>131	1		
110 to 131	1.81	1.15–2.86	0.011
88 to 109	1.01	0.65–1.55	NS
<88	1.17	0.72–1.90	NS
BW gain from herd SBD to 90 d thereafter (kg)			
<17	1		
17 to 34	1.08	0.69–1.70	NS
35 to 52	1.64	1.00–2.69	0.052
>52	1.60	0.91–2.82	0.100

¹SR21 = Submission in the first 3 wk of the breeding season, OR = odds ratio, CI = confidence interval, SBD = herd start of breeding date, n = number of cows included in analysis, NS = $P > 0.10$.

²All models were adjusted for herd, calving period, lactation number, proportion of Holstein-Friesian genes, breeding value for milk yield, and degree of calving assistance.

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Relationships Among Milk Yield, Body Condition, Cow Weight, and Reproduction in Spring-Calving Holstein-Friesians

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