DEB 2023

AmP Parameter Estimation

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ΠΑΝΕΠΙΣΤΗΜΙΟ ΚΡΗΤΗΣ

UNIVERSITY OF CRETE

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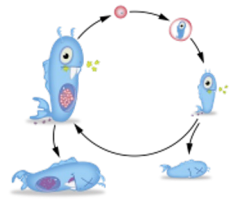
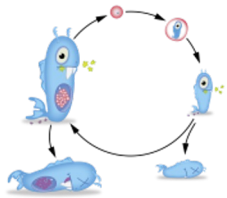
deb2023.sciencesconf.org



Lecture outline

- Parameter estimation
  - Estimation criteria
  - Loss functions
  - Numerical implementation
  - Pseudo-data
- Estimation of a new species
  - AmPeps-Guided example
  - Prepare the 4 source files
  - Customize option for running the estimation procedure
  - Estimate parameters
- Evaluation of estimation



Abstract World

Model

prediction

estimation

Organism data

Real World

State Variables

V, E, E_R

Core Primary Parameters

$\dot{v}, [\dot{p}_M], \{\dot{p}_{Am}\}, [E_G], \kappa, \ldots$

Auxiliary Parameters

$\delta_M, \mu_E, \omega_E, d_V, \ldots$

Mapping Functions

$$L_m = \frac{\kappa\{\dot{p}_{Am}\}}{[\dot{p}_M]} \qquad [E_m] = \frac{\{\dot{p}_{Am}\}}{\dot{v}}$$

$$L_{wm} = \frac{L_m}{\delta_M} \qquad W_m = d_V L_m^3 (1 + f w) \qquad w = \frac{[E_m] w_E}{d_V \mu_E}$$

$$W_w = d_V V + (E + E_R)\frac{w_E}{\mu_E}$$

W_m maximum dry mass (g)

L_{Wm} maximum body length (cm)

...

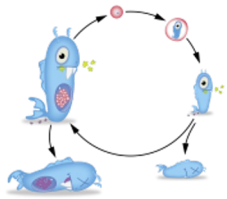
Zero-variate Observations

t (time, days)	W_W (weight, g)
t_1	$W_W(t_1)$
t_2	$W_W(t_2)$
t_3	$W_W(t_3)$
...	

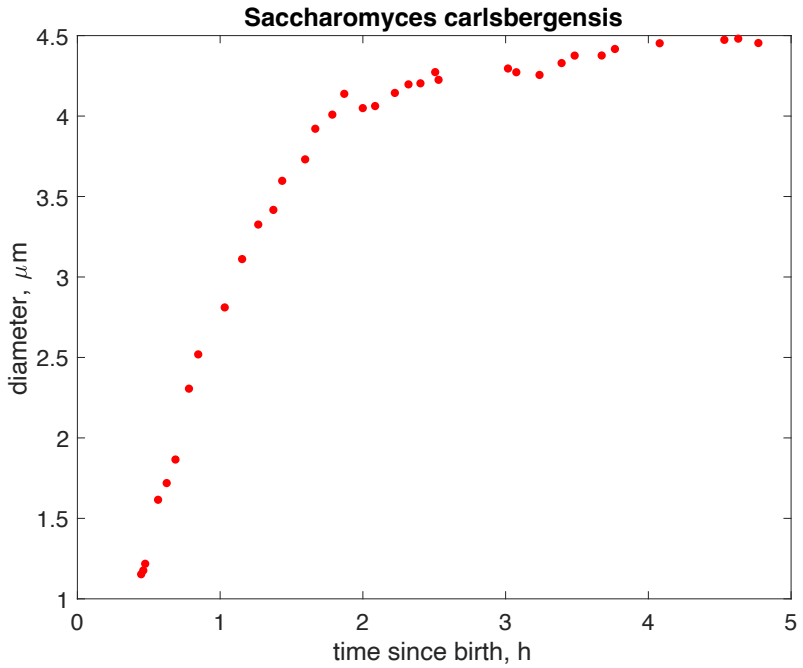
Uni-variate Observations

Lika et al. (2011) J. Sea Research **22**:270-277
doi.org/10.1016/j.seares.2011.07.010

Parameter estimation



- Data
  - time-length
- Model using von Bertalanffy equation
  - L_b: length at birth
  - L_∞: ultimate length
  - r_B: VB growth rate
- Estimate L_b, L_∞, r_B in VB equation



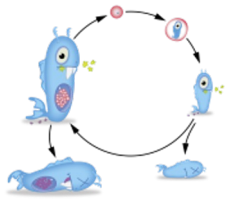
Von Bertalanffy equation

$$L(a) = L_\infty - (L_\infty - L_b)\exp\{-\dot{r}_B a\}$$

Compound parameters

$$L_\infty = f\frac{\kappa\{\dot{p}_{Am}\}}{[\dot{p}_M]}, \quad \dot{r}_B = \frac{[\dot{p}_M]}{3([E_G] + f\kappa[E_m])}$$

Parameter estimation



- Estimate L_b, L_∞, r_B in VB

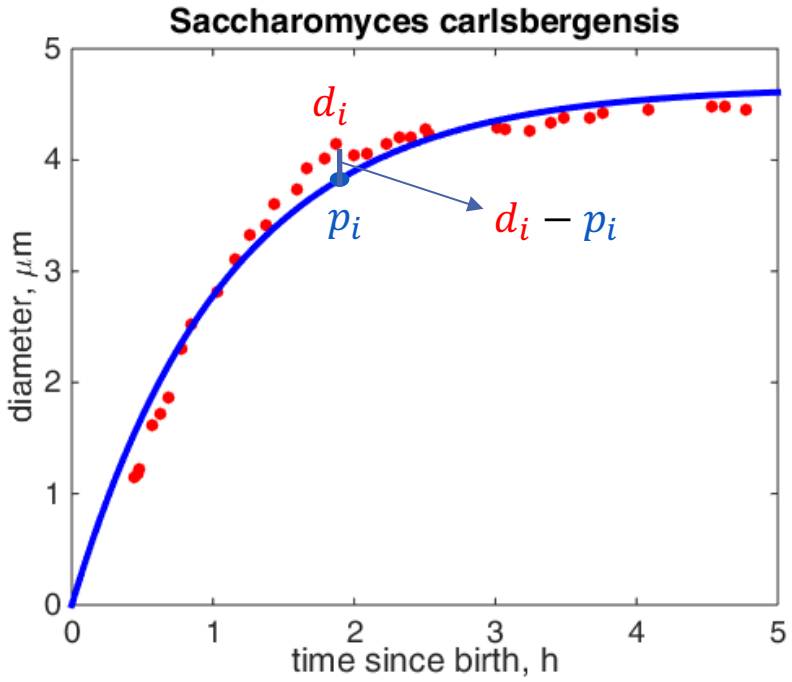
- Estimation criteria

  Simple non-linear regression

  Minimization of the sum of squared deviations between data d_j and predictions p_j

  Loss function

$$F = \sum_{j=1}^{n} (d_j - p_j)^2$$



Von Bertalanffy equation

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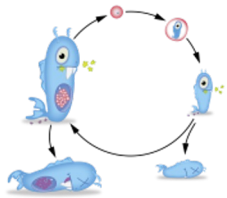
AmP Parameter estimation

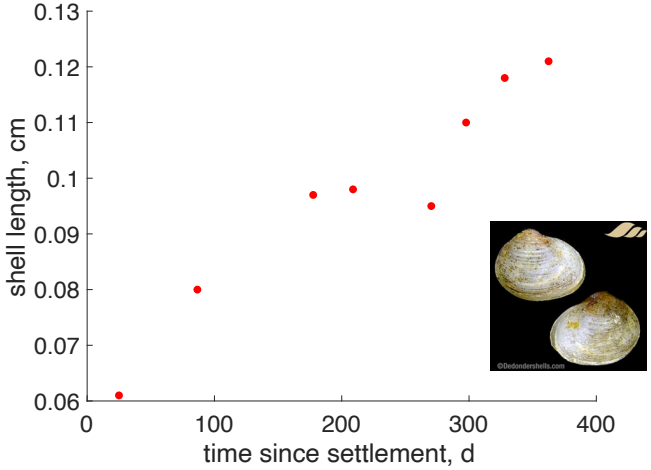


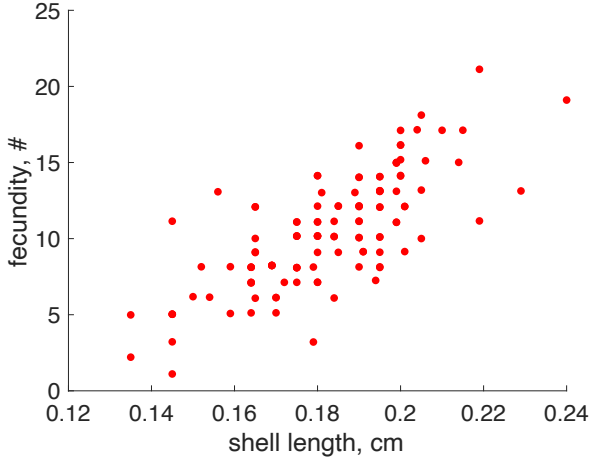
- Data
  - time-length
  - Length-fecundity
  - age at birth
- Fitting multiple models, which share parameters, to multiple data sets, which may differ in dimensions, in a single parameter estimation.
- Estimation criteria

  Minimization of a weighted sum of squared deviations between data and predictions

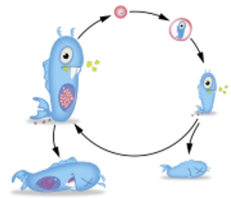
Data for *Lasaea rubra*

Age at birth $a_b = 60\ d$





Data from Grath & Foighil (1986) *Ophelia*, 25(3):209--219



Estimation Criteria

Minimization of a weighted sum of squared deviations between data d_{ij} and predictions p_{ij}

$$F = \sum_{i=1}^{n} \sum_{j=1}^{n_i} w_{ij} \left(d_{ij} - p_{ij} \right)^2$$

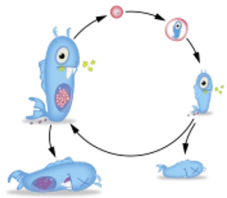
The weight coefficients w_{ij} account for

differences in units of the various data: $\dim(w_{ij}) = \dim(d_{ij}^{-2})$

the certainty of the individual data-sets/points

Marques et al. (2019) *J Sea Research*, **143**: 48-56 doi.org/10.1016/j.seares.2018.07.004

DEB Video: Point parameter estimation



Loss functions

$$F_{re} = \sum_{i=1}^{n} \sum_{j=1}^{n_i} \frac{w_{ij}^0}{n_i} \frac{(d_{ij} - p_{ij})^2}{d_i^2}$$

non-symmetric

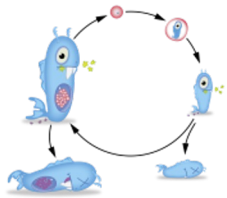
$$F_{sb} = \sum_{i=1}^{n} \sum_{j=1}^{n_i} \frac{w_{ij}^0}{n_i} \frac{(d_{ij} - p_{ij})^2}{d_i^2 + p_i^2}$$

symmetric bounded

---

means $\quad d_i = \frac{1}{n_i} \sum_{j=1}^{n_i} d_{ij} \qquad p_i = \frac{1}{n_i} \sum_{j=1}^{n_i} p_{ij}$

Numerical implementation



Nelder-Mead method

A simplex method for finding a parameter set that minimizes the loss function F

For 2 parameters, a simplex is a triangle (1+No. of free parameters)

The function is evaluated at the vertices of the simplex

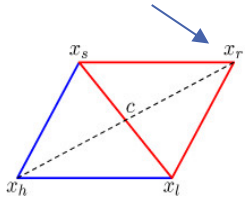
The worst vertex x_h , where F is largest, is rejected and replaced with a new vertex x_C obtained via a sequence of transformations (reflect, expand or contract) or shrink the triangle towards the best.

The process generates a sequence of triangles (different shapes), for which the function values at the vertices get smaller and smaller.

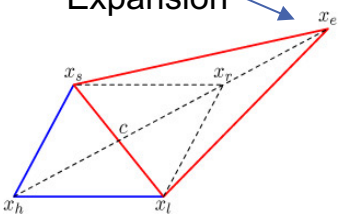
The size of the triangles is reduced and the coordinates of the minimum point are found.

Stopping rules

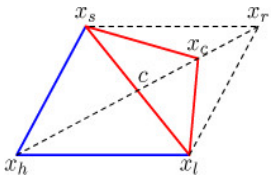
Reflection



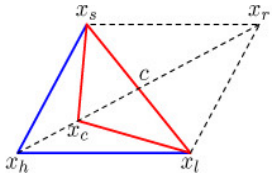
Expansion



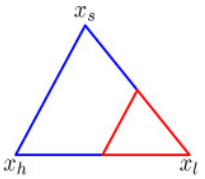
Contraction outside

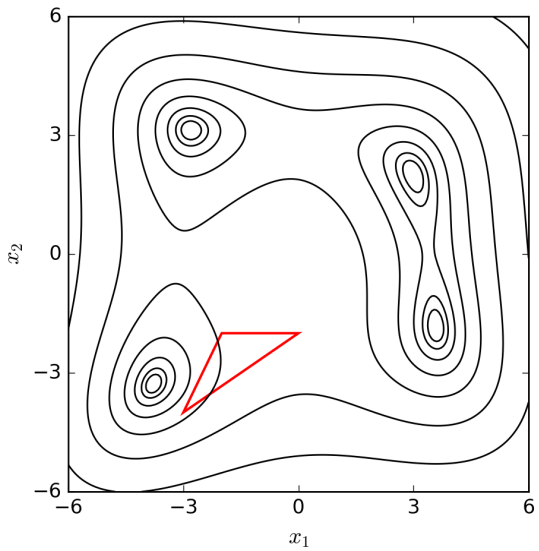


Contraction inside

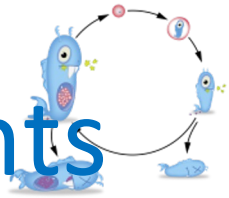


Shrinking





The N-M method with constraints



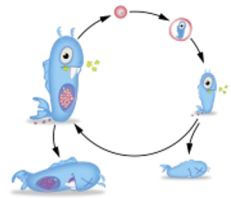
During the NM procedure the parameter combinations are filtered to constrain them within the boundaries of the parameter space

Default constraints:

- all parameters must be positive.
- κ_G, κ, κ_R must be < 1
- maturity levels must increase (e.g., $E_H^b < E_H^j < E_H^p$)
- constraint for reaching birth
- constraint for reaching puberty

MATLAB functions
debtool/lib/pet/filter_dmod.m
dmod : typified model (std, abj, etc)

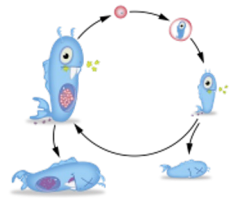
Pseudo-data



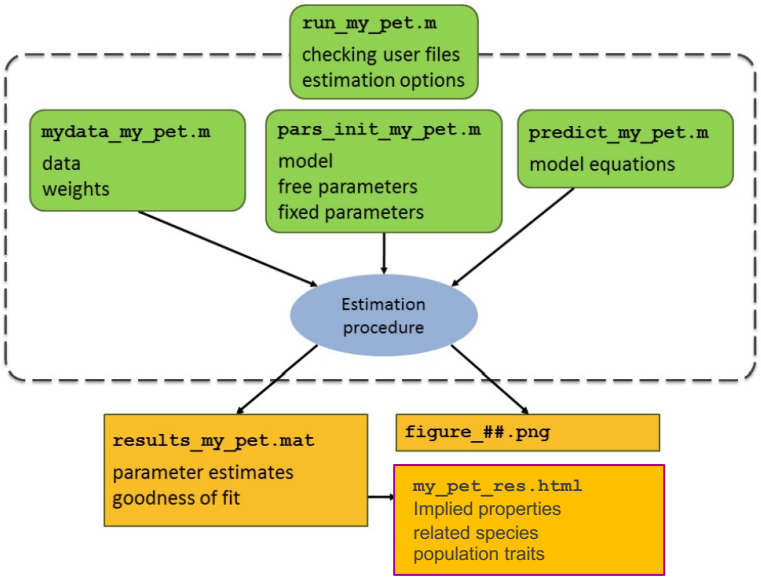
- Define the area of the parameter space where the parameter values are reasonable
- Decrease non-identifiability of parameters
- Small weight coefficients to prevent pseudo-data playing a major role when real data determine parameters well.

- Set of zero-variate data for the generalized animal
- Species-specific parameters and parameters that depend on max body size should not be used as pseudo-data

$\dot{v}$	0.02	cm d^{-1}	energy conductance
κ	0.80	-	allocation fraction to soma
κ_R	0.95	-	reproduction efficiency
$[\dot{p}_M]$	18	$d^{-1}cm^{-3}$	volume-spec. som. maint. costs
$\dot{k}_J$	0.002	d^{-1}	maturity maint. rate coefficient
κ_G	0.80	-	growth efficiency



Code structure
Input-Output files



mydata_my_pet

- Sets metaData (classification, eco-codes, links, references etc)
- Sets the data (real data, pseudo data, auxiliary data)
- Sets weight coefficients

predict_my_pet

- Computes the predictions for the data sets in mydata-file given parameter values

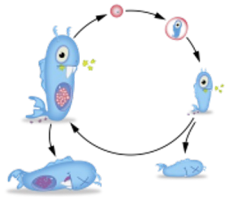
pars_init_my_pet

- Sets the model
- Sets the initial parameter values to start the estimation procedure

run_my_pet

- Checks the user's files
- Sets the estimation options
- Runs the estimation procedure

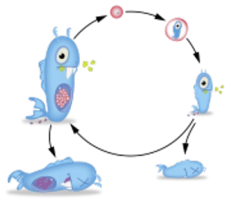
Our pet



British Sea Fishing

Phylum:	Chordata
Class:	Chondrichthyes
Order:	Squaliformes
Family:	Squalidae
Scientific name:	Squalus acanthias
English name:	Spurdog

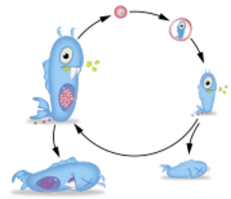
Data for *Squalus acanthias*



code	value	unit	label	temp °C	bibkey*
ab	690	d	age at birth	9	JoneGeen1977
tp	2190	d	time since birth at puberty	9	Avsa2001
am	29200	d	life span	9	Steh2007
Lb	24	cm	total length at birth	-	JoneGeen1977
Lp	72	cm	total length at puberty	-	Avsa2001
Li	136	cm	ultimate total length	-	Avsa2001
Ww0	35	g	wet weight at start (egg)	-	YigiIsme2013
Wwp	950	g	wet weight at puberty	-	Avsa2001
Wwi	9900	g	ultimate wet weight	-	Avsa2001
Ri	0.019	#/d	maximum reprod rate	9	Avsa2001

* Full citation in the appendix

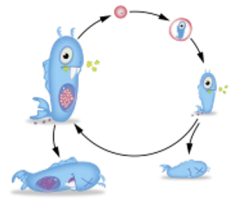
ecoCodes



climate	MB, MC	subtropical: average surface temp (SST) >15 °C, < 25 °C temperate: average surface temp (SST) >5 °C, < 15 °C
ecozone	MAN, MAm, MAS	Atlantic ocean, N; Mediterranean Sea; Atlantic ocean, S
habitat	0iMcd	marine coastal demersal
embryo	Mv	(ovo)viviparous, born in marine water
migrate	Mo	oceanodromous: live and migrate wholly in the sea
food	biCi, biCvf	living invertebrates (Ci) and living vertebrates (Cvf) from birth to ultimate size (bi)
gender	D	dioecy (either male or female, also called gonochoric)
reprod	O	homogamy (no alternating generations, fertilisation obligatory)

Read and watch the video about ecoCodes AmP Ecology coding

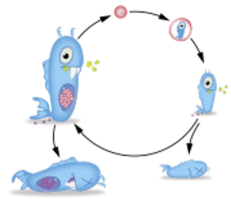
AmP entry prepare system



The AmPeps writes the 4-source files

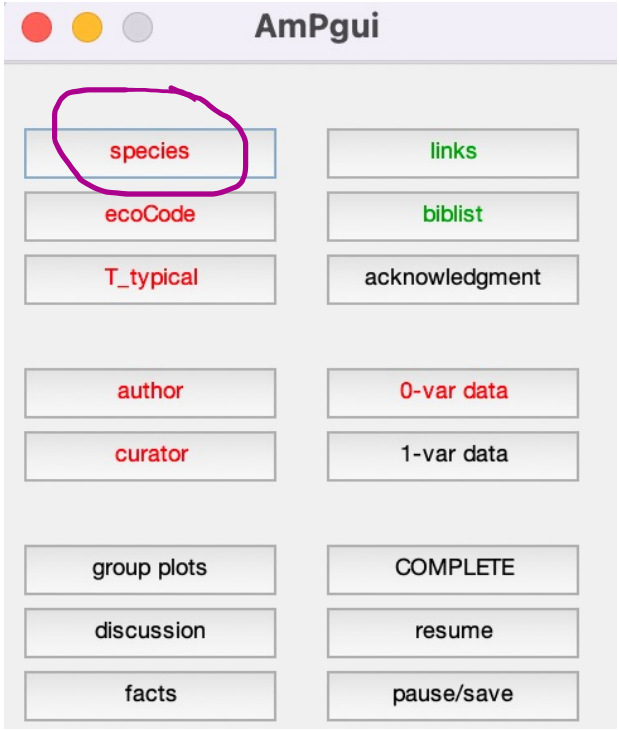
- if the species exists in AmP collection
  - it loads the files from the web which can be post-edited
- if the species does not exist in AmP collection
  - it searches first the AmP (genus, family, etc) and then the CoL for the classification
  - if it cannot be found you can proceed with hand-filling

Work on the AmPeps[1]

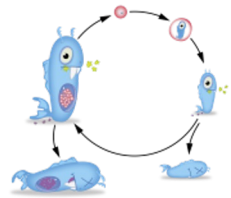


Follow the steps:

1. Create an empty folder
2. cd in Matlab to that folder
3. type `AmPeps` in the Matlab command window
4. Click on “species” in the AmPgui



Work on the AmPeps^2

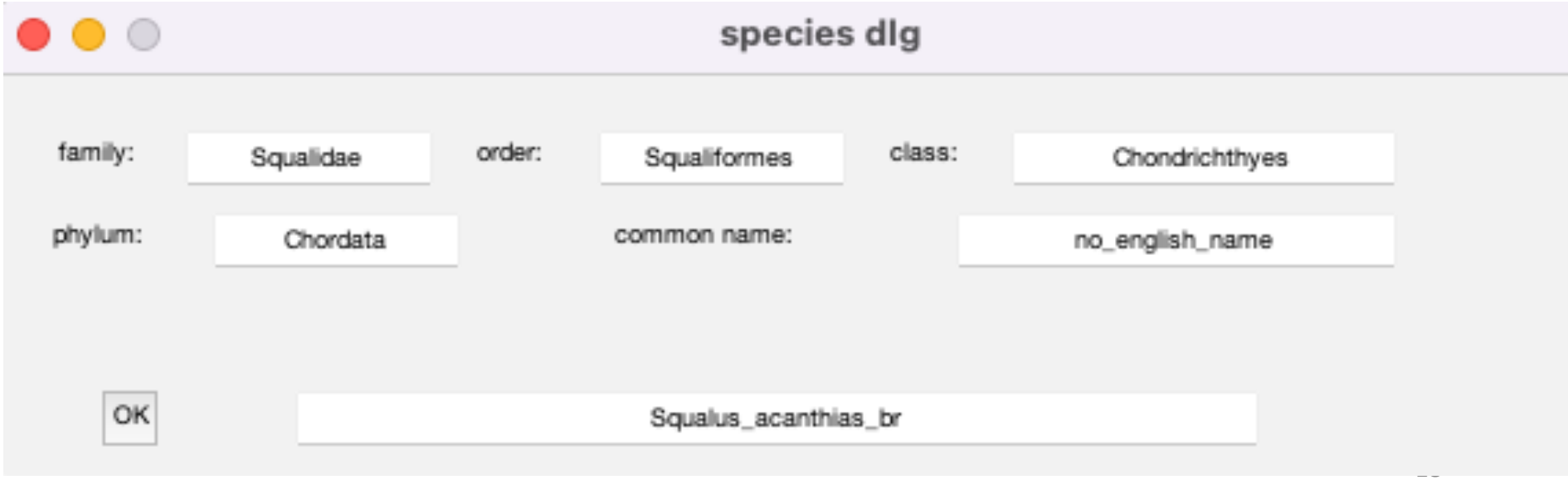


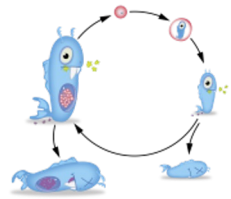
Follow the steps:

5. In the “species dlg” give the name **Squalus_acanthias_br** and press “enter” twice

   Note: Squalus acanthias is in AmP collection

6. Proceed with hand-filling the classification (click on “OK”)
7. Continue with filling the rest of information (click on “OK”)

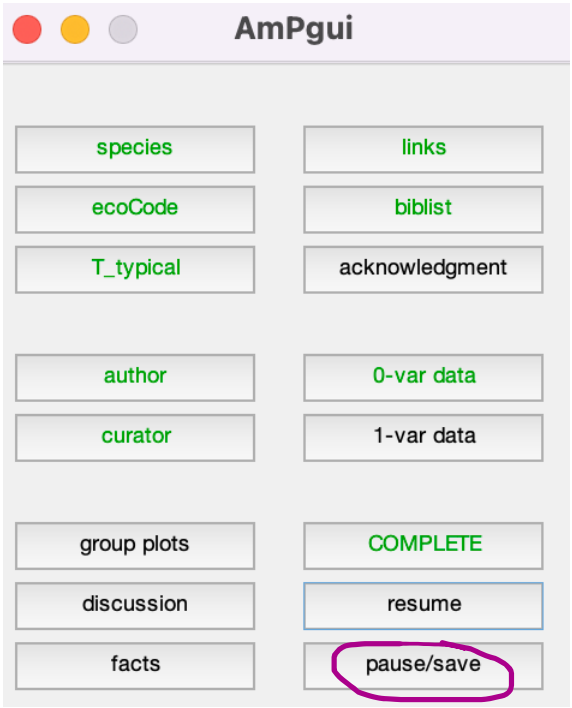


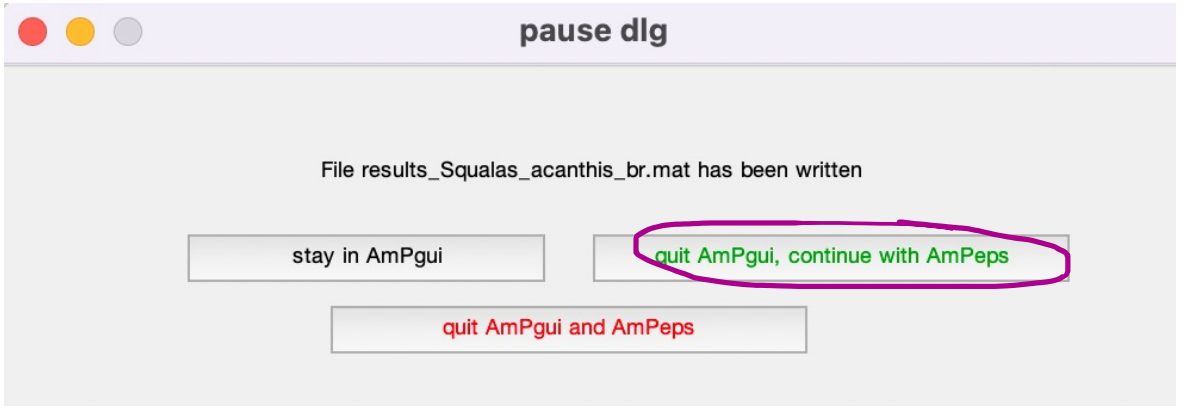


Work on the AmPeps^3

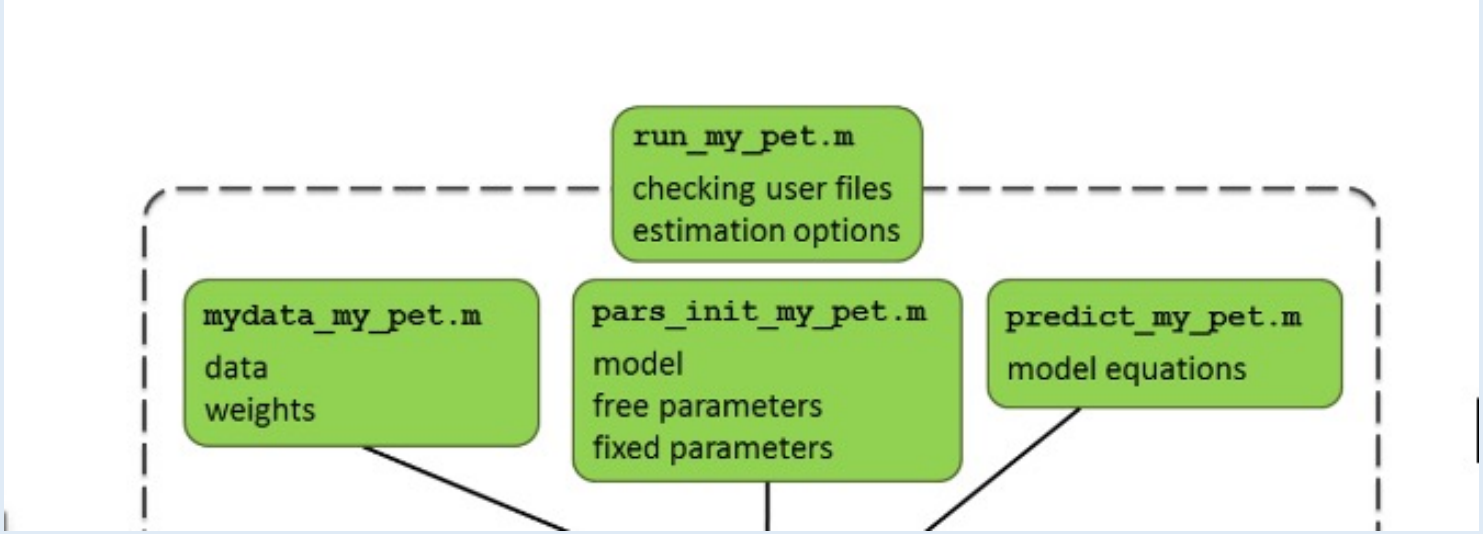
8. Fill in the ecoCodes, T_typical, author, curator, 0-var data, biblist …

9. Click on “pause/save” in the AmPgui
10. Click on “quit AmPgui, continue with AmPeps” in the pause dlg

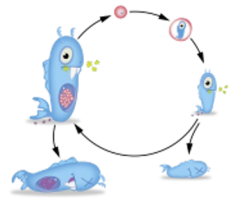




AmPeps-create the 4-source files



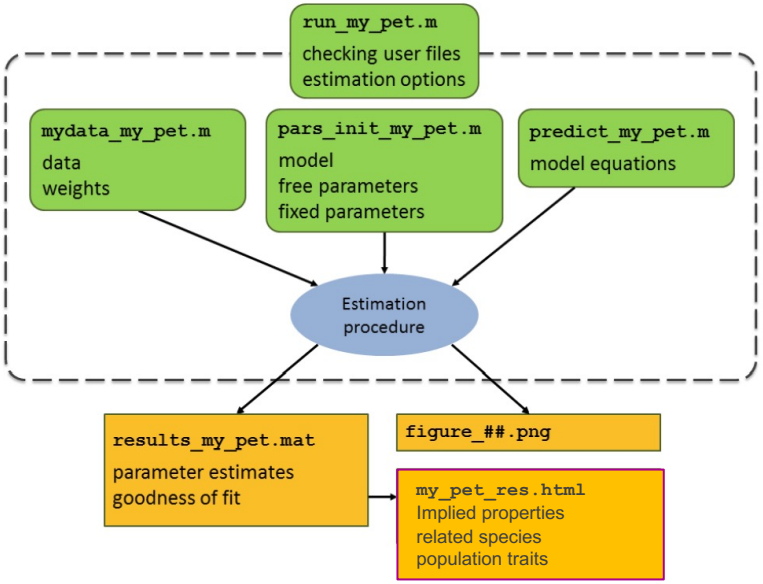
15 min

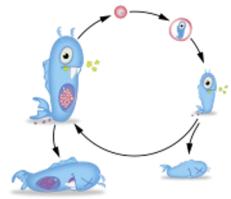


run-file

Set estimation options and run the estimation procedure

```
close all;
global pets

pets = {'Squalus_acanthias'};
check_my_pet(pets);

estim_options('default');
estim_options('max_step_number', 5e2);
estim_options('max_fun_evals', 5e3);


estim_options('pars_init_method', 2);
estim_options('results_output', 3);
estim_options('method', 'no');

estim_pars;
```





run-file

Different options to get initial parameter values for parameter estimation, specified with

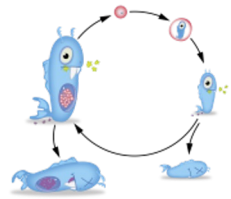
```
estim_option('pars_init_method', n)
```

where

n=1 - read initial estimates from .mat file (for continuation)

n=2 - read initial estimates from pars_init-file (default)

With the DEBtool function `mat2pars_init` you can copy the values from the `results_my_pet.mat` file to `pars_init_my_pet.m`



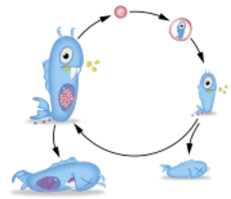
run-file

Many options to output the results

```
estim_option('results_output', n)
```

n	Description
0	only saves data to .mat (no printing to html or screen and no figures) - use this for (automatic) continuations
1, -1	no saving to .mat file, prints results to html (1) or screen (-1), shows figures but does not save them
2, -2	saves to .mat file, prints results to html (2) or screen (-2), shows figures but does not save them
3, -3	like 2 (or -2), but also prints graphs to .png files (default is 3)
4, -4	like 3 (or -3), but also prints html with implied traits
5, -5	like 4 (or -4), but includes related species in the implied traits
6	like 5, but also prints html with population traits

Estimation



Activate the estimation method

```
estim_options('method', 'nm');
```

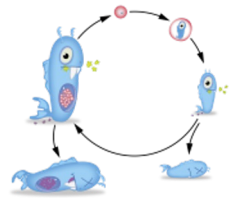
Save results in .mat file by setting

```
estim_options('results_output', 2 or -2);
```

Run

```
run_my_pet
```

Estimation



>> run_Squalus_acanthias

step 1 ssq 1.339-1.604 initial

step 10 ssq 1.2488-1.3711 reflect

step 20 ssq 1.0901-1.2488 reflect

step 30 ssq 0.99753-1.1191 reflect

step 40 ssq 0.82861-1.022 expand

.

.

step 440 ssq 0.11305-0.11312 reflect

step 450 ssq 0.11295-0.11308 expand

step 460 ssq 0.11295-0.11304 reflect

step 470 ssq 0.11288-0.11296 reflect

step 480 ssq 0.11281-0.11291 expand

step 490 ssq 0.11245-0.11276 reflect

step 500 ssq 0.11219-0.11255 expand

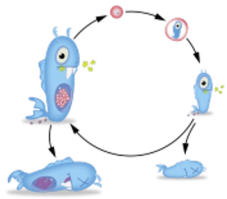
No convergences with 500 steps

min value of loss function

max value of loss function

$$F_{sb} = \sum_{i=1}^{n} \sum_{j=1}^{n_i} \frac{w_{ij}^0}{n_i} \frac{\left(d_{ij} - p_{ij}\right)^2}{d_i^2 + p_i^2}$$

my_pet_res.html report



Squalus acanthias br

COMPLETE = 2.2; MRE = 0.107; SMAE = 0.103; SMSE = 0.016

Data & predictions

data	prd	RE	symbol	units	description
690	601.2	0.1287	ab	d	age at birth
2190	2900	0.3244	tp	d	time since birth at puberty
2.92e+04	2.893e+04	0.009154	am	d	life span
24	22.64	0.05663	Lb	cm	length at birth
72	67.12	0.06773	Lp	cm	length at puberty
136	154.2	0.1339	Li	cm	ultimate length
35	39.94	0.1413	Ww0	g	initial wet weight
950	824.2	0.1324	Wwp	g	wet weight at puberty
9900	9993	0.009429	Wwi	g	ultimate wet weight
0.019	0.0203	0.06837	Ri	#/d	ultimate reproduction rate
0.02	0.04244	1.122	psd.v	cm/d	energy conductance
0.8	0.8144	0.01802	psd.kap	-	allocation fraction to soma
0.95	0.95	0	psd.kap_R	-	reproduction efficiency
18	12.23	0.3203	psd.p_M	J/d.cm^3	vol-spec som maint
0.002	0.002	0	psd.k_J	1/d	maturity maint rate coefficient
0.8	0.8106	0.01326	psd.kap_G	-	growth efficiency

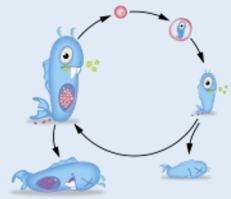
std parameters at 20.0°C

symbol	units	value	free	description
T_ref	K	293.1	0	Reference temperature
T_A	K	8000	0	Arrhenius temperature
z	-	16.41	1	zoom factor
F_m	l/d.cm^2	6.5	0	{F_M}, max spec searching rate
kap_X	-	0.8	0	digestion efficiency of food to reserve
kap_P	-	0.1	0	faecation efficiency of food to faeces
v	cm/d	0.04244	1	energy conductance
kap	-	0.8144	1	allocation fraction to soma
kap_R	-	0.95	0	reproduction efficiency
p_M	J/d.cm^3	12.23	1	[p_M], vol-spec somatic maint
p_T	J/d.cm^2	0	0	{p_T}, surf-spec somatic maint
k_J	1/d	0.002	0	maturity maint rate coefficient
E_G	J/cm^3	5162	1	[E_G], spec cost for structure
E_Hb	J	1.682e+04	1	maturity at birth
E_Hp	J	4.674e+05	1	maturity at puberty
h_a	1/d^2	1.658e-09	1	Weibull aging acceleration
s_G	-	0.0001	0	Gompertz stress coefficient
del_M	-	0.1064	1	shape coefficient
f	-	1	0	scaled functional response for 0-var data
t_0	d	0	0	time at start of development

maximum length $L_m = \frac{\kappa\{\dot{p}_{Am}\}}{[\dot{p}_M]}$

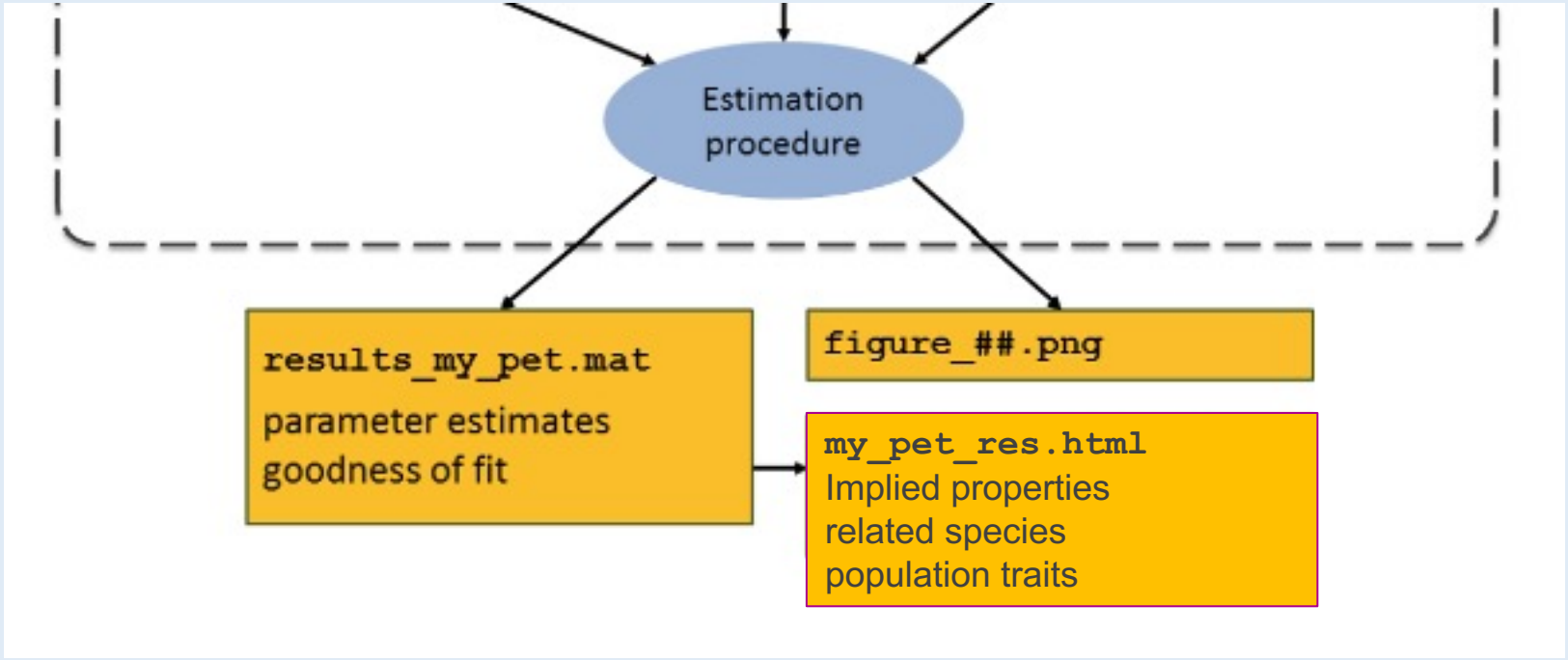
zoom factor $z = \frac{L_m}{L_m^{\mathrm{ref}}}$ $L_m^{\mathrm{ref}} = 1\,\mathrm{cm}$

Estimation – “1 continuation”



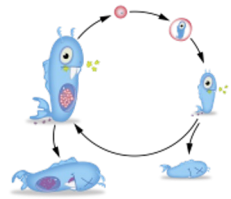
Continue the estimation procedure;
read parameter values from the .mat file by setting

```
estim_options('pars_init_method', 1);
```



5 min

my_pet_res.html report



Results after 1 continuation

Squalus acanthias br

COMPLETE = 2.2; MRE = 0.057; SMAE = 0.056; SMSE = 0.004

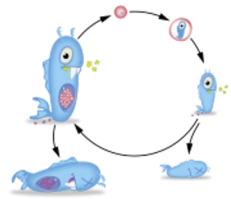
Data & predictions

data	prd	RE	symbol	units	description
690	674.4	0.02257	ab	d	age at birth
2190	2444	0.116	tp	d	time since birth at puberty
2.92e+04	2.792e+04	0.04384	am	d	life span
24	22.62	0.05751	Lb	cm	length at birth
72	69.06	0.04088	Lp	cm	length at puberty
136	150.6	0.1071	Li	cm	ultimate length
35	38.21	0.09165	Ww0	g	initial wet weight
950	921.7	0.02977	Wwp	g	wet weight at puberty
9900	9554	0.03492	Wwi	g	ultimate wet weight
0.019	0.01958	0.03067	Ri	#/d	ultimate reproduction rate
0.02	0.02641	0.3204	psd.v	cm/d	energy conductance
0.8	0.8515	0.06439	psd.kap	-	allocation fraction to soma
0.95	0.95	0	psd.kap_R	-	reproduction efficiency
18	33.75	0.8752	psd.p_M	J/d.cm^3	vol-spec som maint
0.002	0.002	0	psd.k_J	1/d	maturity maint rate coefficient
0.8	0.8006	0.0007406	psd.kap_G	-	growth efficiency

std parameters at 20.0°C

symbol	units	value	free	description
T_ref	K	293.1	0	Reference temperature
T_A	K	8000	0	Arrhenius temperature
z	-	12.38	1	zoom factor
F_m	l/d.cm^2	6.5	0	{F_M}, max spec searching rate
kap_X	-	0.8	0	digestion efficiency of food to reserve
kap_P	-	0.1	0	faecation efficiency of food to faeces
v	cm/d	0.02641	1	energy conductance
kap	-	0.8515	1	allocation fraction to soma
kap_R	-	0.95	0	reproduction efficiency
p_M	J/d.cm^3	33.75	1	[p_M], vol-spec somatic maint
p_T	J/d.cm^2	0	0	{p_T}, surf-spec somatic maint
k_J	1/d	0.002	0	maturity maint rate coefficient
E_G	J/cm^3	5226	1	[E_G], spec cost for structure
E_Hb	J	7434	1	maturity at birth
E_Hp	J	3.304e+05	1	maturity at puberty
h_a	1/d^2	2.238e-09	1	Weibull aging acceleration
s_G	-	0.0001	0	Gompertz stress coefficient
del_M	-	0.08221	1	shape coefficient
f	-	1	0	scaled functional response for 0-var data
t_0	d	0	0	time at start of development

my_pet_res.html report



Squalus acanthias br

COMPLETE = 2.2; MRE = 0.052; SMAE = 0.051; SMSE = 0.004

Results after 2 continuations

Data & predictions

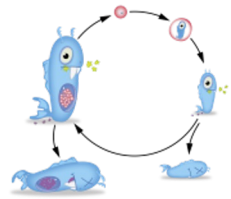
data	prd	RE	symbol	units	description
690	659.7	0.04391	ab	d	age at birth
2190	2463	0.1247	tp	d	time since birth at puberty
2.92e+04	2.92e+04	1.615e-06	am	d	life span
24	22.43	0.06553	Lb	cm	length at birth
72	68.71	0.04569	Lp	cm	length at puberty
136	152.7	0.1224	Li	cm	ultimate length
35	36.87	0.0534	Ww0	g	initial wet weight
950	897.6	0.05513	Wwp	g	wet weight at puberty
9900	9843	0.005752	Wwi	g	ultimate wet weight
0.019	0.01901	0.0005791	Ri	#/d	ultimate reproduction rate
0.02	0.02819	0.4093	psd.v	cm/d	energy conductance
0.8	0.8612	0.07645	psd.kap	-	allocation fraction to soma
0.95	0.95	0	psd.kap_R	-	reproduction efficiency
18	28.89	0.6048	psd.p_M	J/d.cm^3	vol-spec som maint
0.002	0.002	0	psd.k_J	1/d	maturity maint rate coefficient
0.8	0.8017	0.002171	psd.kap_G	-	growth efficiency

```
step 450 ssq 0.037021-0.037021 reflect
step 460 ssq 0.037021-0.037021 contract inside
step 470 ssq 0.037021-0.037021 reflect
step 480 ssq 0.037021-0.037021 contract inside
step 490 ssq 0.037021-0.037021 reflect
step 500 ssq 0.037021-0.037021 contract inside
No convergences with 500 steps
```

std parameters at 20.0°C

symbol	units	value	free	description
T_ref	K	293.1	0	Reference temperature
T_A	K	8000	0	Arrhenius temperature
z	-	13.09	1	zoom factor
F_m	l/d.cm^2	6.5	0	{F_M}, max spec searching rate
kap_X	-	0.8	0	digestion efficiency of food to reserve
kap_P	-	0.1	0	faecation efficiency of food to faeces
v	cm/d	0.02819	1	energy conductance
kap	-	0.8612	1	allocation fraction to soma
kap_R	-	0.95	0	reproduction efficiency
p_M	J/d.cm^3	28.89	1	[p_M], vol-spec somatic maint
p_T	J/d.cm^2	0	0	{p_T}, surf-spec somatic maint
k_J	1/d	0.002	0	maturity maint rate coefficient
E_G	J/cm^3	5219	1	[E_G], spec cost for structure
E_Hb	J	7252	1	maturity at birth
E_Hp	J	3.065e+05	1	maturity at puberty
h_a	1/d^2	1.938e-09	1	Weibull aging acceleration
s_G	-	0.0001	0	Gompertz stress coefficient
del_M	-	0.08577	1	shape coefficient
f	-	1	0	scaled functional response for 0-var data
t_0	d	0	0	time at start of development

my_pet_res.html report



Squalus acanthias br

COMPLETE = 2.2; MRE = 0.052; SMAE = 0.051; SMSE = 0.004

Results after 3 continuations

Data & predictions

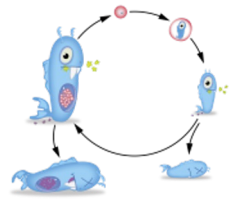
data	prd	RE	symbol	units	description
690	659.7	0.04391	ab	d	age at birth
2190	2463	0.1247	tp	d	time since birth at puberty
2.92e+04	2.92e+04	2.736e-09	am	d	life span
24	22.43	0.06554	Lb	cm	length at birth
72	68.71	0.0457	Lp	cm	length at puberty
136	152.7	0.1224	Li	cm	ultimate length
35	36.87	0.0534	Ww0	g	initial wet weight
950	897.6	0.05513	Wwp	g	wet weight at puberty
9900	9843	0.005724	Wwi	g	ultimate wet weight
0.019	0.01901	0.0005675	Ri	#/d	ultimate reproduction rate
0.02	0.02819	0.4093	psd.v	cm/d	energy conductance
0.8	0.8612	0.07646	psd.kap	-	allocation fraction to soma
0.95	0.95	0	psd.kap_R	-	reproduction efficiency
18	28.89	0.6048	psd.p_M	J/d.cm^3	vol-spec som maint
0.002	0.002	0	psd.k_J	1/d	maturity maint rate coefficient
0.8	0.8017	0.002171	psd.kap_G	-	growth efficiency

std parameters at 20.0°C

symbol	units	value	free	description
T_ref	K	293.1	0	Reference temperature
T_A	K	8000	0	Arrhenius temperature
z	-	13.09	1	zoom factor
F_m	l/d.cm^2	6.5	0	{F_M}, max spec searching rate
kap_X	-	0.8	0	digestion efficiency of food to reserve
kap_P	-	0.1	0	faecation efficiency of food to faeces
v	cm/d	0.02819	1	energy conductance
kap	-	0.8612	1	allocation fraction to soma
kap_R	-	0.95	0	reproduction efficiency
p_M	J/d.cm^3	28.89	1	[p_M], vol-spec somatic maint
p_T	J/d.cm^2	0	0	{p_T}, surf-spec somatic maint
k_J	1/d	0.002	0	maturity maint rate coefficient
E_G	J/cm^3	5219	1	[E_G], spec cost for structure
E_Hb	J	7251	1	maturity at birth
E_Hp	J	3.065e+05	1	maturity at puberty
h_a	1/d^2	1.938e-09	1	Weibull aging acceleration
s_G	-	0.0001	0	Gompertz stress coefficient
del_M	-	0.08577	1	shape coefficient
f	-	1	0	scaled functional response for 0-var data
t_0	d	0	0	time at start of development

```
step 310 ssq 0.037021-0.037021 reflect
step 320 ssq 0.037021-0.037021 reflect
step 330 ssq 0.037021-0.037021 reflect
step 340 ssq 0.037021-0.037021 reflect
step 350 ssq 0.037021-0.037021 reflect
step 360 ssq 0.037021-0.037021 contract inside
Successful convergence
```

Convergence



If goodness of fit / parameters estimates do not change considerably and convergence has not been reached, you can change the stopping rules.

- increase the “max step number” (default 500 steps), e.g.

```
estim_options('max_step_number', 5e3);
```

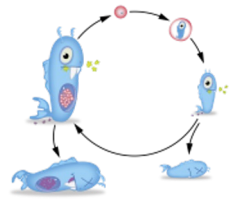
- decrease “tol_simplex”, tolerance for how close the simplex points must be together to call them the same (default 1e-4), e.g.

```
estim_options('tol_simplex', 1e-6);
```

- decrease “tol_fun”, tolerance for how close the loss-function values must be together to call them the same (default 1e-4), e.g.

```
estim_options('tol_fun', 1e-6);
```

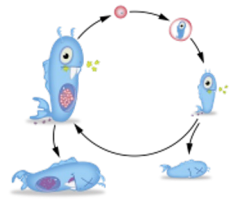
After estimation…[1]



- Check goodness of fit
  the MRE (mean relative error) $[0,\infty)$
  SMSE (Symmetric Mean Squared Error) [0,1]

- Prioritize biological and physical realism over goodness of fit when checking the implied properties.

After estimation…[2]



Overwriting the pars_init-file

With the DEBtool function `mat2pars_init` you can copy the values from the `results_my_pet.mat` file to `pars_init_my_pet.m`

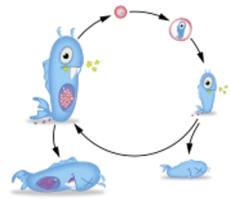
Compute implied properties to judge credibility and consistency for the resulting parameter combination

Run with `estim_options('results', 4 or -4);`

Compare parameters and implied properties with those of related species

Run with `estim_options('results', 5 or -5);`

`estim_options('results', 4 or -4)`



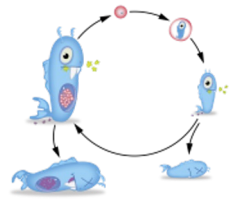
my_pet_res.html report

Search for symbol .. | Search for units .. | Search for label .. | Short/Medium/Long/Pars

Squalus acanthias br **date: 2023/05/17**

symbol	units	value	°C	func resp	description
model	-	std	NA	NA	typified model
T_typical	°C	9	NA	NA	typical body temperature
T_A	K	8000	NA	NA	Arrhenius temperature
z	-	12.3786	NA	NA	zoom factor
F_m	l/d.cm^2	6.5	20	NA	{F_M}, max spec searching rate
kap_X	-	0.8	NA	NA	digestion efficiency of food to reserve
kap_P	-	0.1	NA	NA	faecation efficiency of food to faeces
v	cm/d	0.0264078	20	NA	energy conductance
kap	-	0.851508	NA	NA	allocation fraction to soma
kap_R	-	0.95	NA	NA	reproduction efficiency
p_M	J/d.cm^3	33.7541	20	NA	[p_M], vol-spec somatic maint
p_T	J/d.cm^2	0	20	NA	{p_T}, surf-spec somatic maint
k_J	1/d	0.002	20	NA	maturity maint rate coefficient
E_G	J/cm^3	5226.25	NA	NA	[E_G], spec cost for structure
E_Hb	J	7433.98	NA	NA	maturity at birth
E_Hp	J	330417	NA	NA	maturity at puberty
h_a	1/d^2	2.23766e-09	20	NA	Weibull aging acceleration
s_G	-	0.0001	NA	NA	Gompertz stress coefficient
d_X	g/cm^3	0.2	NA	NA	specific density of food
d_V	g/cm^3	0.2	NA	NA	specific density of structure
d_E	g/cm^3	0.2	NA	NA	specific density of reserve
d_P	g/cm^3	0.2	NA	NA	specific density of faeces
mu_X	J/ mol	525000	NA	NA	chemical potential of food

my_pet_res.html report

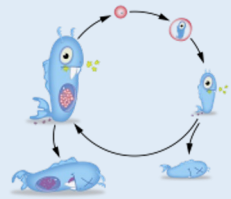


`estim_options('results', 5 or -5)`

Search for symbol .. | Search for units .. | Search for label .. | Short/Medium/Long/Pars

		Squalus acanthias br		Squalus acanthias		Squalus blainville		Squalus megalops		Squalus mitsukurii		Squalus montalbani		date: 2023/05/17; allStat version: 2023/05/05	
symbol	**units**	**value**	**°C**	**value**	**°C**	**value**	**°C**	**value**	**°C**	**value**	**°C**	**value**	**°C**	**func resp**	**description**
model	-	std	NA	std	NA	std	NA	std	NA	std	NA	std	NA	NA	typified model
T_typical	°C	9	NA	9	NA	17	NA	17	NA	11.4	NA	8.6	NA	NA	typical body temperature
T_A	K	8000	NA	8000	NA	8000	NA	8000	NA	8000	NA	8000	NA	NA	Arrhenius temperature
z	-	12.3786	NA	13.7987	NA	13.6352	NA	11.2679	NA	9.6266	NA	10.8042	NA	NA	zoom factor
F_m	l/d.cm^2	6.5	20	6.5	20	6.5	20	6.5	20	6.5	20	6.5	20	NA	{F_M}, max spec searching rate
kap_X	-	0.8	NA	0.8	NA	0.8	NA	0.8	NA	0.8	NA	0.8	NA	NA	digestion efficiency of food to reserve
kap_P	-	0.1	NA	0.1	NA	0.1	NA	0.1	NA	0.1	NA	0.1	NA	NA	faecation efficiency of food to faeces
v	cm/d	0.0264078	20	0.02774	20	0.019742	20	0.016708	20	0.019848	20	0.031509	20	NA	energy conductance
kap	-	0.851508	NA	0.84851	NA	0.95567	NA	0.86487	NA	0.61767	NA	0.46762	NA	NA	allocation fraction to soma
kap_R	-	0.95	NA	0.95	NA	0.95	NA	0.95	NA	0.95	NA	0.95	NA	NA	reproduction efficiency
p_M	J/d.cm^3	33.7541	20	34.3632	20	17.8897	20	14.7524	20	16.7614	20	14.3482	20	NA	[p_M], vol-spec somatic maint
p_T	J/d.cm^2	0	20	0	20	0	20	0	20	0	20	0	20	NA	{p_T}, surf-spec somatic maint
k_J	1/d	0.002	20	0.002	20	0.002	20	0.00088621	20	0.002	20	0.002	20	NA	maturity maint rate coefficient
E_G	J/cm^3	5226.25	NA	5212.32	NA	5230.35	NA	5237.8	NA	5231.86	NA	5239.74	NA	NA	[E_G], spec cost for structure
E_Hb	J	7433.98	NA	7096	NA	3350	NA	25570	NA	31910	NA	65450	NA	NA	maturity at birth
E_Hp	J	330417	NA	300600	NA	98700	NA	505300	NA	972200	NA	3.965e+06	NA	NA	maturity at puberty
h_a	1/d^2	2.23766e-09	20	2.076e-09	20	4.186e-08	20	4.256e-09	20	2.875e-08	20	3.771e-08	20	NA	Weibull aging acceleration
s_G	-	0.0001	NA	0.0001	NA	0.0001	NA	0.0001	NA	0.0001	NA	0.0001	NA	NA	Gompertz stress coefficient

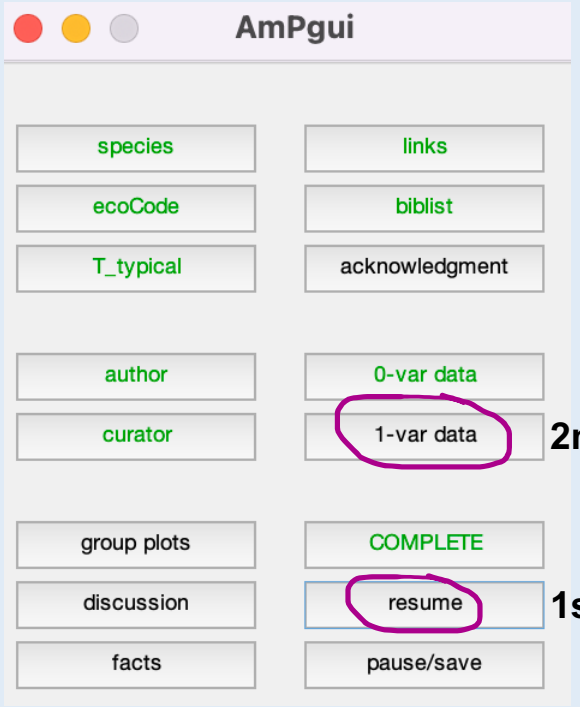
Add a uni-variate dataset



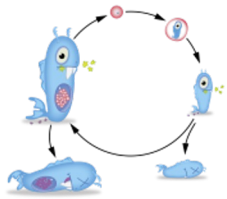
Follow the steps:

1. In your working folder type `AmPeps` in the Matlab command window
2. Click on “resume” in the AmPgui
3. Add the 1-var data
4. Redo estimation
5. Check changes in the goodness of fit

10 min



my_pet_res.html report



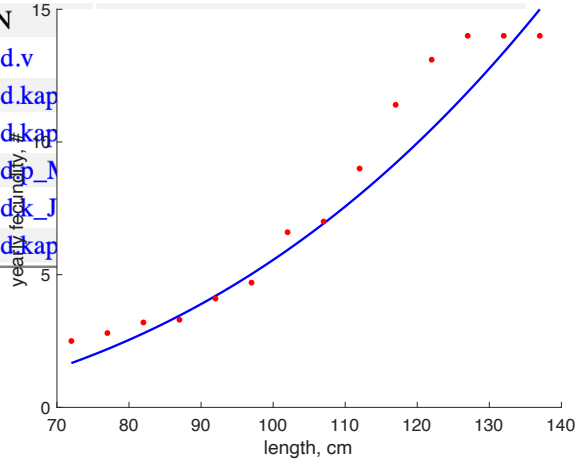
Results after 3 continuations

Squalus acanthias br

COMPLETE = 2.2; MRE = 0.067; SMAE = 0.071; SMSE = 0.009

Data & predictions

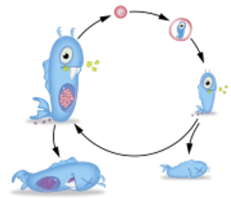
data	prd	RE	symbol	units	description
690	683.7	0.009167	ab	d	age at birth
2190	2252	0.02852	tp	d	time since birth at puberty
2.92e+04	2.921e+04	0.0002346	am	d	life span
24	20	0.1667	Lb	cm	length at birth
72	61.95	0.1396	Lp	cm	length at puberty
136	131.9	0.02992	Li	cm	ultimate length
35	37.11	0.06018	Ww0	g	initial wet weight
950	960.1	0.01061	Wwp	g	wet weight at puberty
9900	9274	0.06321	Wwi	g	ultimate wet weight
0.019	0.02122	0.1169	Ri	#/d	ultimate reproduction rate
see figure		0.1157	LN		
0.02	0.01912	0.04404	psd.v		
0.8	0.8537	0.0671	psd.kap		
0.95	0.95	0	psd.kap		
18	83.15	3.62	psd.p_M		
0.002	0.002	0	psd.k_J		
0.8	0.802	0.002477	psd.kap		



std parameters at 20.0°C

symbol	units	value	free	description
T_ref	K	293.1	0	Reference temperature
T_A	K	8000	0	Arrhenius temperature
z	-	9.349	1	zoom factor
F_m	l/d.cm^2	6.5	0	{F_M}, max spec searching rate
kap_X	-	0.8	0	digestion efficiency of food to reserve
kap_P	-	0.1	0	faecation efficiency of food to faeces
v	cm/d	0.01912	1	energy conductance
kap	-	0.8537	1	allocation fraction to soma
kap_R	-	0.95	0	reproduction efficiency
p_M	J/d.cm^3	83.15	1	[p_M], vol-spec somatic maint
p_T	J/d.cm^2	0	0	{p_T}, surf-spec somatic maint
k_J	1/d	0.002	0	maturity maint rate coefficient
E_G	J/cm^3	5217	1	[E_G], spec cost for structure
E_Hb	J	4613	1	maturity at birth
E_Hp	J	2.959e+05	1	maturity at puberty
h_a	1/d^2	2.039e-09	1	Weibull aging acceleration
s_G	-	0.0001	0	Gompertz stress coefficient
del_M	-	0.07086	1	shape coefficient
f	-	1	0	scaled functional response for 0-var data
f_LN	-	0.3706	1	scaled functional response for LN data
t_0	d	0	0	time at start of development

Appendix



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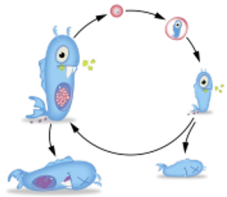

Thank you for your attention!!!

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