Oikos

o18983
Ergon, T., Ergon, R., Begon, M., Telfer, S. and Lambin, X. 2011. Delayed density-dependent onset of spring reproduction in a fluctuating population of field voles. – Oikos 120: 934–940.

Appendix 1

MATLAB code used to estimate density dependence in the paper. The code makes use of the 'ewtls' function by Markovsky et al. (2005) at <ftp://ftp.esat.kuleuven.ac.be/pub/SISTA/markovsky/reports/02-48c.m>

```
function [a,b,nll,ex,out] = EWTLSrandom(Xvar,Xfix,seX,seY,Y,b0)
% Fits a linear regression model by EWTLS (fixed effects) and maximum
% likelihood (random component). Elementwise (observationwise)
% variation in the precision in both x and y values are allowed
% (assumed given and must be supplied). The random residual component
% is fitted as an exponential of a linear model.
% Note that the random residual component is part of the weights in
% the EWTLS.
%
% Input:
% Xvar = model matrix for v0 (= between site variance).
% Xfix = model matrix for E[Y] at a mean site.
% seX = standard errors of the X-values (same dimensions as Xfix - typically zero for
intercept).
% seY = standard error of the Y-values.
% Y = response variable (dependent variable).
% b0 = starting values of the random effects parameters.
%
% Output:
% a = fixed effects parameters (from final EWTLS fit).
% b = log-link parameters for the model of v0.
% [nll,ex,out] = negative log-likelihood, exit flag and output from
% 'fminsearch'.

[b,nll,ex,out] = fminsearch(@nllEWTLSrandom, b0, [], Xvar, Xfix, seX, seY, Y);

% Retreiving the fixed parameters from the final fit:
v0 = exp(Xvar*b);
vtot = seY.^2+v0;
s = [seX, sqrt(vtot)];
a = ewtls(Xfix, Y, s);

function f = nllEWTLSrandom(b,Xvar,Xfix,seX,seY,Y)
% Negative log-likelihood of EWTLS fit with an exponential random
% residual component

% Fitting EWTLS
```

```
v0 = exp(Xvar*b); % Between site variance
vtot = seY.^2+v0; % Total residual variance
s = [seX, sqrt(vtot)];
a = ewtls(Xfix, Y, s); % from
%ftp://ftp.esat.kuleuven.ac.be/pub/SISTA/markovsky/reports/02-48c.m

% Computing the negative log-likelihood
dy = Y - Xfix*a;
f = -sum(-log(sqrt(vtot)) - dy.^2./(2.*vtot));
```