

Supplementary materials for Le Gouar, Dubois et al. Demographic parameters of sexes in an elusive insect: implications for monitoring methods

Appendix S1: Pictures of habitat types, elytra marked individuals and radio equipped individuals.



Figure 1: *Malus* hollow tree in Orne



Figure 2: *Castanea* hollow tree in Sarthe



Figure 3: Marking of an individual on the elytra with a drill

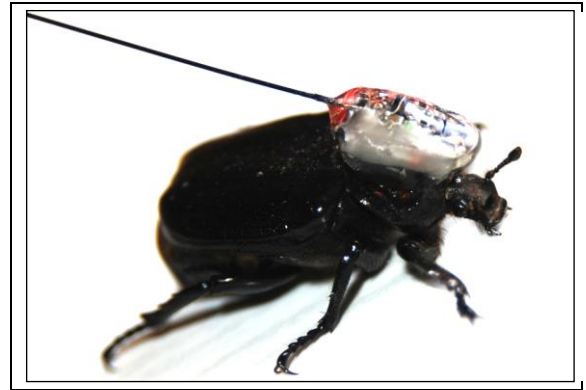


Figure 4: Transmitter-equipped individual

Appendix S2: Goodness-of-fit testing and \hat{c} estimates

We assessed the fit of our data set to the assumptions inherent to Mark Release Recapture models. Different potential sources of heterogeneity (i.e. transient and trap dependence) in survival and recapture parameters were first investigated using the Cormack-Jolly-Seber (CJS) model (live recapture only) with the program U-CARE (Choquet *et al.*, 2003). The overall fit of models using both live recapture and dead recovery was also examined by using the Median \hat{c} approach proposed in program MARK (White and Burnham, 1999). This approach allowed to compute the variance inflation factor, \hat{c} , which was used to scale the deviance of all subsequent models and to inflate parameter variances (Burnham *et al.*, 1987). \hat{c} values were computed using time dependent models for all data set.

For all the three data set (“sex effect”, “region and year for male”, “region and year for female”), we found that *O. eremita* data met assumption on survival homogeneity under the CJS model ($\Phi_i p_i$) (Global test for “sex effect” data set: $\chi^2 = 66.4$, $df = 68$, $P = 0.53$; Global test for “region and year for male” data set: $\chi^2 = 62.4$, $df = 168$, $P = 1$; Global test for “region and year for female” data: $\chi^2 = 6.3$, $df = 15$, $P = 0.97$). Moreover, test for transient and trap dependence were not significant for all groups ($P > 0.15$ for TEST 3SR and TEST 2CT).

For Live Recapture Dead Recoveries data, using the less constrained model as the general starting model we obtained a \hat{c} value equal to 0.98 +/- 0.2 for “sex effect” data set, 1.2 +/- 0.004 and 1.12 +/- 0.03 for “region and year effect” data sets for males and females. We thus used $\hat{c} = 1$, and computed all subsequent QAIC_c values for models.

References

Burnham KP, Anderson DR, White GC, Brownie C, Pollock KII (1987) Design and analysis methods for fish survival experiments based on release-recapture. Monograph 5.

American Fisheries Society, Bethesda, Maryland.

Choquet R, Reboulet AM, Pradel R, Gimenez O, Lebreton, JD (2003) User's manual for U-CARE. Mimeographed document, CEFE/CNRS, Montpellier.

White GC, Burnham KP (1999) Program MARK: survival estimation from populations of marked animals. *Bird Study* 46:120-139

Table S3: List of models run when testing the sex effect. Np: number of parameters. *S*: survival rate, *p*: recapture rate, *r*: recovery rate, *F*: fidelity rate. For each parameter, the effects are taking into account sequentially. c: constant, t: time within year, a2: age effect with one estimate for after the first recapture a1 and one estimate from the second recapture to the end of monitoring a2, sx: testing sex effect, M: parameters for males, F: parameters for females. The best model selected for each step of the sequential selection is in bold, the best final model is shaded in grey.

Model number	<i>S</i>	<i>p</i>	<i>r</i>	<i>F</i>	Np	QAIC_c	ΔQAIC_c
1	t×sx	t×sx	t×sx	t×sx	129	2534.4	189.3
2	t×sx	t×sx	t×sx	c×sx	99	2462.6	117.5
3	t×sx	t×sx	t×sx	a2×sx	101	2462.0	116.9
4	t×sx	t×sx	t×sx	t	113	2491.8	146.7
5	t×sx	t×sx	t×sx	c	98	2457.4	112.3
6	t×sx	t×sx	t×sx	a2	99	2451.6	106.5
7	t×sx	t×sx	c×sx	a2	69	2415.7	70.6
8	t×sx	t×sx	a2×sx	a2	70	2417.1	72.0
9	t×sx	t×sx	t	a2	86	2421.2	76.1
10	t×sx	t×sx	c	a2	68	2415.4	70.3
11	t×sx	t×sx	a2	a2	69	2417.7	72.6
12	t×sx	c×sx	c	a2	38	2383.0	38.0
13	t×sx	a2×sx	c	a2	40	2382.5	37.4
14	t×sx	t	c	a2	52	2432.8	87.7
15	t×sx	c	c	a2	37	2426.2	81.1
16	t×sx	a2	c	a2	38	2426.7	81.6
17	c×sx	a2×sx	c	a2	9	2355.5	10.4
18	a2×sx	a2×sx	c	a2	11	2355.1	10.0
19	t	a2×sx	c	a2	23	2362.3	17.2
20	c	a2×sx	c	a2	8	2353.5	8.4
21	a2	a2×sx	c	a2	9	2352.6	7.6
22	a2	a2F cM	c	a2	8	2345.1	0.0
23	c	a2F cM	c	a2	7	2346.0	1.0
24	a2×sx	a2F cM	c	a2	10	2347.7	2.7
25	a1c a2×sx	a2F cM	c	a2	9	2355.7	10.7

Table S4: List of model run when testing region and year effects on demographic

parameters. c: constant, a2: age effect with one estimate for after the first capture and one estimate from after first capture to the end of monitoring, reg: testing region effect, year: testing year effect, O: parameter for Orne study site, S: parameter for Sarthe study site, Np: number of parameters. The best selected model is shaded in grey. Bold models are all the models considered for model averaging.

Model n°	S	p	r	F	QAIC _c	Np	Δ QAIC _c	QAIC _c Weights
1	a2	a2F cM	c	a2	2345.06	8	10.0	0.002
2	a2	a2F cM	c	a2 reg	2345.67	9	10.6	0.002
3	a2	a2F cM	c	a2 O×c S×year	2355.40	17	20.32	0
4	a2	a2F cM	c	a2 O×year S×c	2347.43	17	12.35	0.001
5	a2	a2F cM	c	a2 year×reg	2356.16	26	21.08	0
6	a2	a2F cM	c	a2 year	2353.02	16	17.94	0
7	a2	a2F cM	c reg	a2	2345.03	9	9.95	0.002
8	a2	a2F cM	c S×year O×c	a2	2342.02	13	6.94	0.01
9	a2	a2F cM	c O×year S×c	a2	2344.33	13	9.26	0.003
10	a2	a2F cM	c reg×year	a2	2341.41	17	6.33	0.013
11	a2	a2F cM	c year	a2	2344.11	12	9.03	0.003
12	a2	[a2F, cM] reg	c reg×year	a2	2335.08	20	0	0.307
13	a2	[a2F, cM] S×year O×c	c reg×year	a2	2338.41	32	3.33	0.058
14	a2	[a2F, cM] O×year S×c	c reg×year	a2	2342.61	32	7.53	0.007
15	a2	[a2F, cM] reg×year	c reg×year	a2	2346.92	44	11.84	0.001
16	a2	[a2F, cM]×year	c reg×year	a2	2358.91	29	23.83	0
17	a2	[a2F reg], cM×c	c reg×year	a2	2339.78	19	4.70	0.029
18	a2	a2F c, [cM reg]	c reg×year	a2	2336.68	18	1.60	0.138
19	a2	[a2F O×year S×c], cM c	c reg×year	a2	2346.04	27	10.96	0.001
20	a2	[a2F S×year O×c], cM c	c reg×year	a2	2340.82	27	5.74	0.017
21	a2	a2F c, [cM O×year S×c]	c reg×year	a2	2337.75	22	2.67	0.081
22	a2	a2F c, [cM S×year O×c]	c reg×year	a2	2338.77	22	3.69	0.049
23	a2	[a2F year], cM	c reg×year	a2	2356.5	25	21.42	0
24	a2	a2F c, [cM year]	c reg×year	a2	2343.64	21	8.56	0.004
25	a2 reg	[a2F, cM] reg	c reg×year	a2	2337.36	22	2.28	0.098
26	a2 S×year O×c	[a2F, cM] reg	c reg×year	a2	2345.17	30	10.09	0.002
27	a2 O×year S×c	[a2F, cM] reg	c reg×year	a2	2336.35	30	1.28	0.162
28	a2 year×reg	[a2F, cM] reg	c reg×year	a2	2344.85	38	9.77	0.002
29	a2 year	[a2F, cM] reg	c reg×year	a2	2343.15	28	8.07	0.005

Table S5: List of models for population size estimates. c: constant, sex: testing sex effect, tree: testing tree species effect, year: testing year effect, np: number of parameters.

Region	Model	n° λ	N	np	AIC_c	Δ AIC_c	AIC_c Weights
<i>Sarthe</i>							
	1	year	sex×year×tree	28	1069.69	0.0	0.9084
	2	sex	sex×year×tree	25	1074.28	4.6	0.0915
	3	year	tree×year	19	1087.77	18.1	0.0001
	4	year	sex×tree	13	1102.18	32.5	0
	5	sex×tree	sex×year×tree	27	3624.48	2554.8	0
	6	tree	sex×year×tree	25	3826.24	2756.6	0
	7	sex×year×tree	sex×year×tree	42	3834.67	2764.9	0
	8	year	sex	11	4135.12	3065.4	0
	9	c	sex×year×tree	24	4249.67	3179.9	0
	10	tree×year	sex×year×tree	33	4535.12	3465.4	0
	11	year	year	14	4566.88	3497.2	0
	12	year	sex×year	19	6124.17	5054.5	0
	13	year	c	10	6429.37	5359.7	0
	14	year	tree	11	6958.83	5889.1	0
	15	sex×year	sex×year×tree	33	7455.44	6385.7	0
<i>Orne</i>							
	1	sex×year×tree	sex×tree	31	3398.06	0.0	1
	2	sex×year×tree	tree	29	3451.49	53.4	0
	3	sex×year×tree	year×sex	37	9723.46	6325.4	0
	4	sex×year×tree	sex×tree	31	12177.44	8779.4	0
	5	sex×year×tree	year×tree	37	14298.18	10900.1	0
	6	sex×year×tree	c	28	18836.45	15438.4	0
	7	sex×year×tree	year	32	47864.19	44466.1	0
	8	sex×year×tree	sex	29	54237.49	50839.4	0

Table S6: List of models with individual covariates

ely-length: linear relationship with individual length of the right elytra; mass: linear relationship with the mass of individuals; BCI: linear relationship with the individual body condition index (see materials and methods for calculation); c: no linear relationship with individual covariates, ²: second order relationship with individual covariates.

model	Survival			Probability of capture		
	First occasion after first capture	Long term - female	Long term - male	Male	First occasion after first capture - female	Long term - female
1	ely-length	c	c	c	c	c
2	c	ely-length	c	c	c	c
3	c	c	ely-length	c	c	c
4	c	c	c	ely-length	c	c
5	c	c	c	c	ely-length	c
6	c	c	c	c	c	ely-length
7	ely-length	ely-length	c	c	c	c
8	ely-length	c	ely-length	c	c	c
9	c	ely-length	ely-length	c	c	c
10	ely-length	ely-length	ely-length	c	c	c
11	c	c	c	ely-length	ely-length	c
12	c	c	c	ely-length	c	ely-length
13	c	c	c	c	ely-length	ely-length
14	c	c	c	ely-length	ely-length	ely-length
15	ely-length	ely-length	ely-length	ely-length	ely-length	ely-length
16	ely-length	ely-length	ely-length	ely-length	c	c
17	ely-length	ely-length	ely-length	c	ely-length	c
18	ely-length	ely-length	ely-length	c	c	ely-length
19	ely-length	ely-length	ely-length	ely-length	ely-length	c
20	ely-length	ely-length	ely-length	ely-length	c	ely-length
21	ely-length	ely-length	ely-length	c	ely-length	ely-length
22	ely-length	c	c	ely-length	ely-length	ely-length
23	c	ely-length	c	ely-length	ely-length	ely-length
24	c	c	ely-length	ely-length	ely-length	ely-length
25	ely-length	ely-length	c	ely-length	ely-length	ely-length

26	ely-length	c	ely-length	ely-length	ely-length	ely-length
27	c	ely-length	ely-length	ely-length	ely-length	ely-length
28	mass	c	c	c	c	c
29	c	mass	c	c	c	c
30	c	c	mass	c	c	c
31	c	c	c	mass	c	c
32	c	c	c	c	mass	c
33	c	c	c	c	c	mass
34	mass	mass	c	c	c	c
35	mass	c	mass	c	c	c
36	c	mass	mass	c	c	c
37	mass	mass	mass	c	c	c
38	c	c	c	mass	mass	c
39	c	c	c	mass	c	mass
40	c	c	c	c	mass	mass
41	c	c	c	mass	mass	mass
42	mass	mass	mass	mass	mass	mass
43	mass	mass	mass	mass	c	c
44	mass	mass	mass	c	mass	c
45	mass	mass	mass	c	c	mass
46	mass	mass	mass	mass	mass	c
47	mass	mass	mass	mass	c	mass
48	mass	mass	mass	c	mass	mass
49	mass	c	c	mass	mass	mass
50	c	mass	c	mass	mass	mass
51	c	c	mass	mass	mass	mass
52	mass	mass	c	mass	mass	mass
53	mass	c	mass	mass	mass	mass
54	c	mass	mass	mass	mass	mass
55	BCI	c	c	c	c	c
56	c	BCI	c	c	c	c
57	c	c	BCI	c	c	c
58	c	c	c	BCI	c	c
59	c	c	c	c	BCI	c
60	c	c	c	c	c	BCI
61	BCI	BCI	c	c	c	c
62	BCI	c	BCI	c	c	c

63	c	BCI	BCI	c	c	c
64	BCI	BCI	BCI	c	c	c
65	c	c	c	BCI	BCI	c
66	c	c	c	BCI	c	BCI
67	c	c	c	c	BCI	BCI
68	c	c	c	BCI	BCI	BCI
69	BCI	BCI	BCI	BCI	BCI	BCI
70	BCI	BCI	BCI	BCI	c	c
71	BCI	BCI	BCI	c	BCI	c
72	BCI	BCI	BCI	c	c	BCI
73	BCI	BCI	BCI	BCI	BCI	c
74	BCI	BCI	BCI	BCI	c	BCI
75	BCI	BCI	BCI	c	BCI	BCI
76	BCI	c	c	BCI	BCI	BCI
77	c	BCI	c	BCI	BCI	BCI
78	c	c	BCI	BCI	BCI	BCI
79	BCI	BCI	c	BCI	BCI	BCI
80	BCI	c	BCI	BCI	BCI	BCI
81	c	BCI	BCI	BCI	BCI	BCI
82	ely-length	mass	BCI	ely-length	mass	BCI
83	BCI	ely-length	mass	BCI	ely-length	mass
84	mass	BCI	ely-length	mass	BCI	ely-length
85	mass	ely-length	BCI	ely-length	mass	BCI
86	BCI	mass	ely-length	BCI	ely-length	mass
87	ely-length	BCI	mass	mass	BCI	ely-length
88	ely-length	mass	BCI	c	c	c
89	BCI	ely-length	mass	c	c	c
90	mass	BCI	ely-length	c	c	c
91	mass	ely-length	BCI	c	c	c
92	BCI	mass	ely-length	c	c	c
93	ely-length	BCI	mass	c	c	c
94	c	c	c	ely-length	mass	BCI
95	c	c	c	BCI	ely-length	mass
96	c	c	c	mass	BCI	ely-length
97	c	c	c	ely-length	mass	BCI
98	c	c	c	BCI	ely-length	mass
99	c	c	c	mass	BCI	ely-length

100	ely-length	mass	BCI	ely-length	c	c
101	BCI	ely-length	mass	BCI	c	c
102	mass	BCI	ely-length	mass	c	c
103	mass	ely-length	BCI	ely-length	c	c
104	BCI	mass	ely-length	BCI	c	c
105	ely-length	BCI	mass	mass	c	c
106	ely-length	mass	BCI	c	mass	BCI
107	BCI	ely-length	mass	c	ely-length	mass
108	mass	BCI	ely-length	c	BCI	ely-length
109	mass	ely-length	BCI	c	mass	BCI
110	BCI	mass	ely-length	c	ely-length	mass
111	ely-length	BCI	mass	c	BCI	ely-length
112	mass ²	BCI	ely-length	mass	c	c
113	mass	BCI ²	ely-length	mass	c	c
114	mass	BCI	ely-length ²	mass	c	c
115	mass	BCI	ely-length	mass ²	c	c

Table S7: First 6 best models including covariates on sex specific survival and probability of recapture. The three models testing effect of each covariate on male and female survival rates and probability of capture and the model without covariate are presented at the bottom of the table. Structure of model follow the structure of best model selected when testing for sex effect (see table 2). c: constant, a1,2: age effect with one estimate for after the first capture a1 and one estimate from after first capture to the end of monitoring a2, W: mass of individuals (g), LE: length of elytra (mm), BCI: body condition index, M: parameters for males, F: parameters for females, Np: number of parameters.

Models	QAIC _c	ΔQAIC _c	Np
$S_{a1 \times W}, SM_{a2 \times LE}, SF_{a2 \times BCI}, pM_{c \times W}, pF_{a1,2}, r_{a1,2}, F_c$	1062.40		12
$S_{a1 \times W}, SM_{a2 \times LE}, SF_{a2}, pM_{c \times W}, pF_{a1,2}, r_{a1,2}, F_c$	1064.35	1.94	11
$S_{a1 \times W}, SM_{a2 \times LE}, SF_{a2 \times W}, pM_{c \times W}, pF_{a1,2}, r_{a1,2}, F_c$	1064.76	2.36	12
$S_{a1 \times W}, SM_{a2 \times LE}, SF_{a2 \times LE}, pM_{c \times W}, pF_{a1,2}, r_{a1,2}, F_c$	1066.37	3.97	12
$S_{a1 \times W}, SM_{a2 \times W}, SF_{a2 \times W}, pM_{c \times W}, pF_{a1,2}, r_{a1,2}, F_c$	1067.44	5.04	12
$S_{a1 \times W}, SM_{a2 \times LE}, SF_{a2 \times BCI}, pM_{c \times BCI}, pF_{a1,2}, r_{a1,2}, F_c$	1067.75	5.35	12
$S_{a1 \times W}, SM_{a2 \times W}, SF_{a2 \times W}, pM_{c \times W}, pF_{a1,2 \times W}, r_{a1,2}, F_c$	1071.09	8.69	14
$S_{a1 \times LE}, SM_{a2 \times LE}, SF_{a2 \times LE}, pM_{c \times LE}, pF_{a1,2 \times LE}, r_{a1,2}, F_c$	1080.58	18.18	14
$S_{a1 \times BCI}, SM_{a2 \times BCI}, SF_{a2 \times BCI}, pM_{c \times BCI}, pF_{a1,2 \times BCI}, r_{a1,2}, F_c$	1089.15	26.75	14
$S_{a1}, SM_{a2}, SF_{a2}, pM_c, pF_{a1,2}, r_{a1,2}, F_c$	1092.14	29.74	8