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Nocturnal distance sampling of a Mediterranean population of fallow deer is consistent with population projections

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Appendix S1. Survey costs

It has been possible carry out many of the analyses reported in the present paper only because an intensive research project on the population of fallow deer living at Castelporziano was conducted. Drive-netting of fallow deer required nearly 2–4 days per capture session and a total of four capture sessions were carried out. To conduct a drive using 1 km of nets, at least 40–80 operators (including at least five field biologists and one wildlife veterinarian), five cross-country vehicles and one minibus were required. Capturing fallow deer fawn required a total of 15 days, three skilled field biologist, 10 helpers, and three cross-country vehicles. Counting fallow deer in spring required 5 days, 40–50 operators (including at least five field biologist), five cross-country vehicles and one minibus, and counting fallow deer at the lek site in autumn required at least 20 days, four field biologist and one cross-country vehicle. Radiotracking required four field biologist and two cross-country vehicles. Still, we considered an average daily cost of €500 for vet, €100 for field assistants (a flat rate including overnight subsistence) involved in capture activities and €0.30 km^{-1} for mileage reimbursement. All upfront, personnel and logistic costs are reported in Tables S1, S2 and S3

Table S1. Summary of costs (€) of the equipment used during the research project carried out on the Fallow deer population of Castelporziano, from 2000 to 2005

Upfront costs	Research project	Nocturnal distance sampling
Ear-tags for adults	200	
Ear-tags for fawns	150	
30 radio-collars for adult	13 500	
50 radio-collars for fawns	15 000	
2 radio receivers	1800	
Antennas, cables and compasses	700	
Capture equipment (e.g. scales, lanyards, net, masks)	450	
Equipment for placement of standing linear nets (e.g. poles, hammers, nails)	190	
1 km of nets	10 230	
10 receivers	900	
10 binoculars 7×42	12 000	
7 telescopes ×20–60	10 500	
10 doses of anaesthetic	350	
Thermal imagery and equipment (e.g. laserrange finder, compass, GPS)		35 000

Table S2. Summary of costs (€ year^{-1}) of the personnel involved in the research project and in the distance-sampling (DS) survey carried out on the Fallow deer population of Castelporziano, from 2000 to 2005

Personnel	Research project	Nocturnal DS
One contract researcher	35 000	
Two grant researchers	44 000	44 000

Table S3. Summary of logistic costs of the activities carried out during the research project on the Fallow deer population of Castelporziano, from 2000 to 2005, using a car cost per km cost of €0.3

Activity	km day^{-1} car^{-1}	Overall travel costs €
Drive-netting (6 cars, 4 days)	100	720
Capture of fawns (3 cars, 15 days)	40	540
Spring counts (6 cars, 6 days)	15	162
Autumn counts (1 car, 20 days)	15	90
Radio-tracking (2 cars, 30 days)	40	720
Nocturnal distance sampling (1 car, 8 days)	125	300

Appendix S2. Population model

$\hat{N}_{y,a}$ = the total population estimated by distance sampling in Season *a* (autumn) of Year *y*;

$h_{y,i}$ = the number of animals in Age/sex class *i*, harvested between November of Year *y* and March of Year *y*+1;

$f_{y,sp,i}$ = the fraction of animals in Age/sex class *i*, in Year *y* and Season *sp* (spring);

$\hat{\rho}$ = the estimated pregnancy rate; and

$\hat{R}_{0,i}$ = the sex proportion at birth.

Since 2001, we used a forward projection of the estimates obtained from distance-sampling surveys. The number of animals on 1 April of Year *y* is given by the equation

$$\hat{N}_{y,sp} = (\hat{N}_{y-1,a} \times \overline{\phi}) - \sum_i h_{y-1,i}\text{ , (1)}$$

where $(\hat{N}_{y-1,a} \times \overline{\phi})$ represents the 'natural' survival (i.e. in the absence of culling), and $\sum_i h_{y-1,i}$ is the total number of harvested animals (we assume additive sources of mortality; Lebreton 2005). The average survival from October to April (weighted for population structure because it was estimated in March) is given by the equation

$$\overline{\phi} = \sum_i \hat{\phi}_i \hat{f}_{y,sp,i}\text{ , (2)}$$

where $\hat{\phi}_i$ is the estimated survival in Age/sex class *i*. It is straightforward to estimate the number of animals in Age/sex class *i* as $n_{y,sp,i} = \hat{N}_{y,sp} \times \hat{f}_{y,sp,i}$. Survivals were scaled to the appropriate time span (3, 4 or 5 months) according to the season considered.

Because between April and June no harvest is carried out and we have no evidence of births, then the population size in June (before birth) is given by

$$\hat{N}_{y,sum} = \sum_i n_{y,sum,i} = \sum_i (n_{y,sp,i} \times \phi_i)\text{ , (3)}$$

where *sum* stands for summer. We assume that the change of age class is on the 1 June. So the number of males and females in autumn is given by $n_{y,a,i} = \phi_i (n_{y,sum,i} + \hat{R}_{0,i} \times n_{y,sum,juv})$. The variable $n_{y,sum,juv}$ represents the number of fawns, being born in year *y*–1, changing age class on the 1 June. Note that because during spring counts, it is difficult to discern the sex of fawns, we assume that the sex ratio of 1-year-old fawns is the same than the birth sex ratio; this holds if survival is the same for the two sexes. The number of newborns surviving until October is

$$n_{y,a,juv} = \hat{\rho} \times n_{y,sum,fem} \times \phi_{y,fawn}\text{ , (4)}$$

where *fem* stands for females. It is, hence, possible to compute the expected frequency of each age/sex class ($\hat{f}_{y,a,i}$) from the $n_{y,a,i}$.

In autumn, we have two estimates of population, the first one, $N^r_{y,a} = \sum_i n_{y,a,i}$, reconstructed and the second one, $\hat{N}_{y,a}$, estimated from distance-sampling survey. Because distance sampling does not allow us to evaluate the population structure, we apply $\hat{f}_{y,a,i}$ to $\hat{N}_{y,a}$.

Confidence limits for demographic parameters

We estimated confidence limits of our population projections by Monte Carlo uncertainty analysis (Caswell 2001). In the Monte Carlo simulations, noise was added to each survival $\hat{\phi}_{y,i}$, $\hat{\phi}_{y,fawn}$, by sampling from β distributions with the estimated means and standard deviations. The β distribution is useful because it is bounded in [0,1], a range appropriate to simulate survivals. Parameters $\hat{f}_{y,sp,i}$, $\hat{\rho}$, $\hat{R}_{0,i}$ were derived by binomial distributions, whereas $\hat{N}_{y,a}$ was log-normally distributed. Log-normal distribution is the choice for population numbers that are only positive. We used 10 000 simulations to evaluate, for each year of study, the precision of our demographic projections for March, June and November. More specifically, our goal is to evaluate model capability to compute $N^r_{y+1,a}$, starting from $\hat{N}_{y,a}$ (estimated by distance sampling).

References

Caswell, H. (2001). 'Matrix Population Models: Construction, Analysis and Interpretation.' (Sinauer and Associates: Sunderland, MA.)

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