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## 11. Appendices

**Appendix 1:** (A) & (B) temperature data for Mahazat as-Sayd Reserve from 1995 to March 1998. Temperature data was collected every minute and stored as 15 minute mean values at an automatic weather station located at the Camp (see Fig. 2.2). (C) Rainfall data from January 1997 to March 1998. Rain data was collected automatically at the camp, and read manually in all other sites after every rain event.

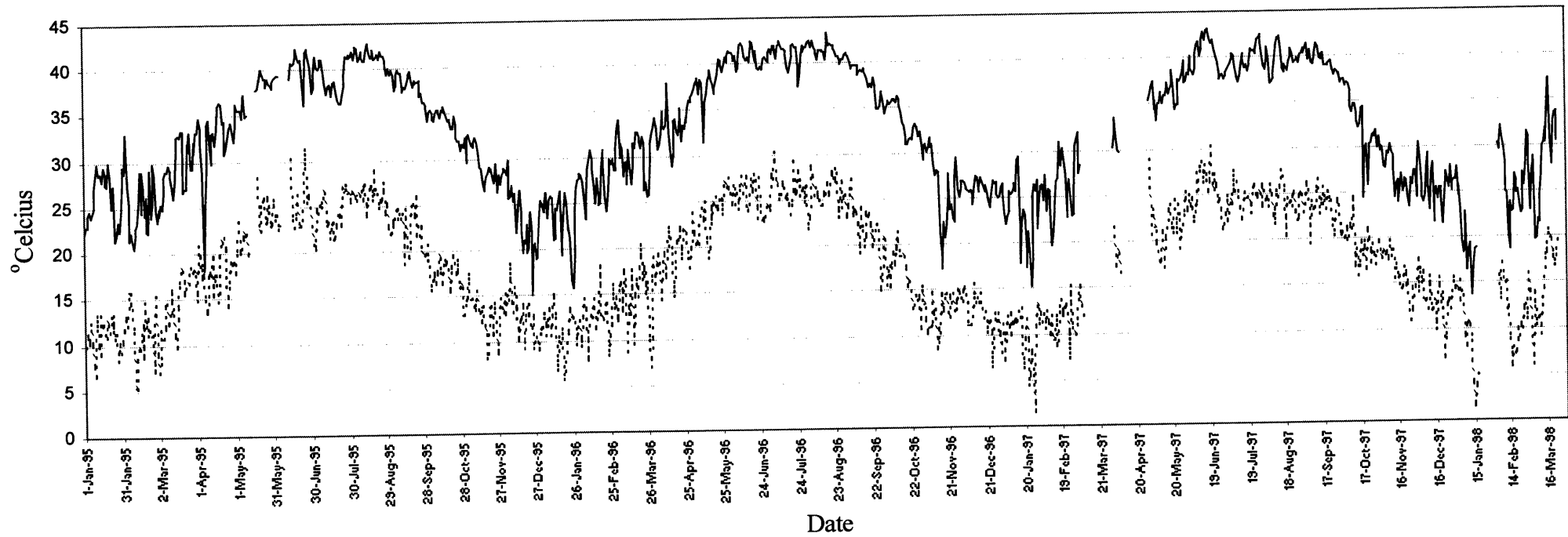
(A)

	Mean monthly temperature (°C)					S.D. of mean monthly temp (°C)				Absolute monthly temperature range (°C)				Mean monthly minimum (°C)				Mean monthly maximum (°C)			
	1995	1996	1997	1998	Mean	1995	1996	1997	1998	1995	1996	1997	1998	1995	1996	1997	1998	1995	1996	1997	1998
Jan	18.2	17.0	16.7	14.4*	16.6	5.2	4.7	5.1	4.9*	6.8-29.9	5.8-27.7	1.6-29.4	1.6-27.7*	10.9	11.0	9.8	9.3	25.9	23.6	23.5	20.2
Feb	18.5	20.3	18.4	19.1	19.1	5.2	5.1	5.0	5.8	5.1-33.0	7.7-30.8	7.3-31.0	5.9-32.2	11.2	12.7	11.2	11.6	25.4	27.6	25.5	26.3
Mar	22.0	22.6	20.7*	21.5*	21.7	5.5	5.6	5.5*	6.2*	8.6-33.5	7.1-34.0	10.0-32.0*	6.0-37.4*	14.8	14.9	12.7	15.0	29.3	30.3	29.2	28.3
Apr	24.8	26.0	24.5*	-	25.1	5.4	4.9	4.6*	-	13.6-36.5	14.4-38.0	16.2-33.6*	-	18.0	19.4	18.4	-	32.4	33.4	31.2	-
May	30.4	31.5	29.3	-	30.4	5.1	5.2	5.1	-	19.8-40.1	18.9-41.5	17.1-39.8	-	23.1	23.8	21.7	-	37.3	38.2	36.4	-
Jun	33.3	33.6	33.3	-	33.4	5.8	5.3	5.4	-	22.6-42.3	22.7-42.4	21.2-43.2	-	24.8	25.4	25.3	-	40.5	40.7	40.3	-
Jul	31.9	33.7	32.7	-	32.8	5.2	5.2	5.3	-	20.4-41.6	23.5-42.5	22.2-42.5	-	24.3	26.2	24.6	-	38.9	41.0	39.7	-
Aug	33.8	33.9	32.4	-	33.4	5.3	5.4	5.3	-	22.0-42.8	22.0-43.4	20.4-42.2	-	25.9	25.7	24.2	-	41.4	41.4	39.7	-
Sep	31.0	30.8	32.2	-	31.3	5.5	6.0	5.5	-	18.7-40.0	15.1-41.2	19.5-41.4	-	22.5	21.9	23.5	-	38.4	38.4	39.6	-
Oct	26.2	25.6	26.4	-	26.2	6.0	6.2	5.3	-	13.0-35.7	10.7-36.4	15.9-37.6	-	17.4	16.5	19.2	-	34.1	33.7	33.0	-
Nov	21.4	19.3	21.1	-	20.8	5.8	5.2	5.1	-	8.2-32.6	8.5-31.7	10.9-30.3	-	13.0	12.6	16.1	-	29.4	26.3	27.1	-
Dec	17.7	18.8	19.4	-	18.6	4.5	4.7	4.5	-	9.1-29.9	6.5-27.5	6.8-30.4	-	12.8	12.1	13.3	-	23.5	26.0	25.8	-

\* data missing for periods 8-31 March 1997, 7 – 30 April 1997, 17 January – 2 February 1998 and 25 - 30 March 1998. Data from manual rain gauge was used to replace missing data

(B)

Figure A1.1: Minimum (dotted line) and maximum (solid line) temperature summary (30 minute means plotted) for the Camp at Mahazat as-Sayd Reserve from January 1995 to March 1998. Missing data as for Appendix 1(A).





(C) Rainfall data, for Mahazat as-Sayd Reserve from January 1997 to March 1998. Rain data was collected automatically at the camp, and read manually in all other sites after every rain event. Rain gauge codes are WJ = White Jabal (Shafaf al Abiadh), BJ = Black Jabal (Shafaf al Asmar), N = north, E = east (see Fig. 2.2), other gauge labels are arbitrary.

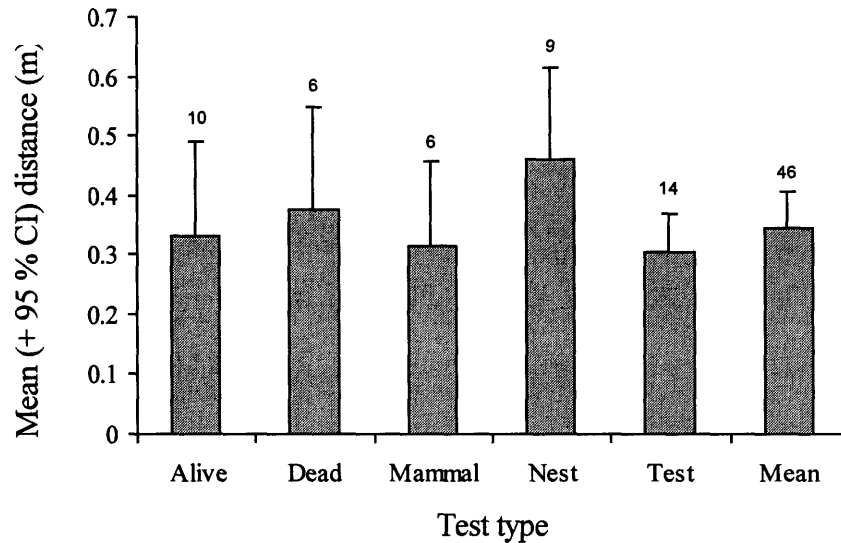
	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	E	BJ	WJ	N	Camp
UTM X	204.567	197.921	195.539	194.289	173.630	176.696	176.971	141.100	153.691	154.736	155.832	162.718	208.867	187.317	188.499	197.646	182.127
UTM Y	2485.924	2475.351	2468.665	2456.084	2471.354	2457.926	2447.574	2461.941	2476.420	2468.646	2458.239	2451.221	2465.423	2443.411	2460.984	2481.282	2452.695
Jan 1997	0.0	0.0	0.0	0.0	0.0	nd	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8
Feb 1997	0.0	0.0	0.0	0.0	0.0	nd	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mar 1997	12.0	8.0	20.0	21.1	17.0	nd	31	25.5	14.1	10.0	19.0	23.0	43.3	33.7	28.5	22.9	33.0
Apr 1997	6.8	8.8	12.1	4.8	15.2	10.0	8.2	5.5	0.1	5.0	3.4	10.5	9.6	5.9	2.8	14.3	6.4
May 1997	0.1	0.5	3.0	2.2	0.0	21.5	0.9	5.4	1.9	0.0	0.8	4.7	6.4	0.0	0.9	0.0	4.4
Jun 1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jul 1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aug 1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sep 1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oct 1997	2.6	2	6.7	16.3	14.6	25.4	12.5	19.3	24.6	36.3	15.0	13.7	5.9	26.1	10.1	2.8	14.7
Nov 1997	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	51
Dec 1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jan 1998	28	28	22.5	20	13	15	17.5	37	53.5	30.0	29.5	15.0	23.5	20.0	15.5	21.5	17.5
Feb 1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mar 1998	51.5	51	43	43.5	42	47	41	30	32.0	43.0	35.0	43.0	55.0	61.6	52.3	4.5	42.8
Total	101	98.3	107.3	107.9	101.8	118.9	111.1	122.7	126.2	124.3	102.7	109.9	143.7	147.3	110.1	66.0	118.8
Mean	6.7	6.6	7.2	7.2	7.3	7.9	6.9	9.4	9.0	9.6	6.4	6.9	11.1	8.7	6.5	4.4	7.0
S.D.	13.5	13.3	11.1	11.1	11.1	11.9	10.3	10.1	12.0	14.3	9.4	10.4	12.0	11.7	11.2	6.6	9.1

## **Appendix 2: Analyses and discussion of errors in locating houbara**

There were two sources of error in recording ground-based locations: From the GPS units and vehicle to bird offset. Manufacturer claimed field precision of these GPS units (not differentially corrected) was 50 – 100 m “GPSE” (GPS Error). My positional error (PE) was normally 20 – 50 m. Therefore maximum ranges for total location error on the ground were 70 – 150 m: the lower bound being 50 m (GPSE) + 20 m (PE) and the upper bound being 100 m (GPSE) + 50 m (PE).

Aerial GPS locations were recorded on a Trimble GPS unit, with GPSE of up to 30 m. My positional error was more difficult to immediately quantify because houbara cannot be seen from the air to confirm their location. There are three types of aerial error that influenced my ability to detect the location of houbara accurately on the ground. These are GPSE, observer reaction time, and precision. Location of houbara by air requires a co-ordinated approach between the pilot and observer. Errors occur because (a) fine scale movements in the flight path of the plane are difficult to communicate between observer and pilot and achieve (because of e.g., cross-wind conditions), (b) signal location depends on the balance of signal strength on opposing sides of the aircraft and is therefore subjective, and (c) there is a potential delay in response time between flying over the transmitter location and fixing its position by GPS.

I tested precision (my ability to locate the exact location of the transmitter) many times throughout the course of the study using three methods. First, aerial locations do not allow identification of dead houbara, so on the same day, or within one day of flights I drove to sites indicated by aerial locations, confirmed that the houbara was alive and recorded the location of the bird using the vehicle mounted GPS. Second, dead houbara, female houbara on nests, and diurnal burrow dwelling radio-tagged ratels and sand cats (tagged as part of another study) were fixed points that enabled an independent check of precision by comparison of locations derived from aerial searches with those determined during follow-up ground checks. Third, in a blind test, I located from the air 14 transmitters placed at sites in the reserve by another worker. Mean distance between aerial and ground locations for all groups combined was 345 m ( $\pm 95\%$  C.I. = 286 – 404 m; Fig. A2.1), and for only the test transmitters was 304 m  $\pm$  66 m. Difference between Garmin and Trimble GPS units placed on the same spot on the ground was 41 m, within the approximate range of GPSE of both units. No GPS locations were differentially corrected. Where ground and aerial locations were recorded on the same day I used the ground location in analyses.



**Figure A2.1:** Mean  $\pm$  95 % C.I. distance between aerial GPS positions and actual ground GPS locations for five different groups of signals and for their average. Positions were gathered during specific tests of flight accuracy, or during the course of routine surveys. Numbers above bars are N values. Test types are described in the text.

Many studies report home range results, but aside from satellite telemetry studies where errors can be hundreds of kilometres for poor quality locations, few studies report error in describing locations. My error was up to 100m for ground locations and a mean of 304m for aerial locations on test transmitters. These errors are unlikely to change the significance of most of my results for three reasons. First, the scale of houbara movements is very large. Home range areas (70 % BNE) were more than 11 km<sup>2</sup>, and adding 100 – 300m to the most outlying locations adds proportionally little area to the overall range area. Second, vegetation sites favoured by houbara are often small patches of only a few hectares in size (Combreau & Smith 1997), separated by several hundred metres of open ground. Thus, regular movements of houbara between patches were several times larger than the error in locating locations. Third, I collected over 7000 locations in total, and even when sub-sampling, used more than 4800 locations in this study. I was most interested here in the comparison between individuals and seasons, and because errors should be random over all locations, it is unlikely any individuals or seasons had a higher level of location error than did others. Differentially correcting data will remove most of the GPS error, but removing observer error from aerial locations would be difficult without greatly increasing the number of flights to reduce location variability. What is more critical is that observers repeatedly measure error variability to show that the degree of error remains constant over time.

My measures of distance between successive locations are likely to be most affected by location error, because errors from both successive locations are confounding. At worst, any of the successive distances reported here might be as much as two times the aerial or ground location error (i.e. 200 – 600+ m). However, I consider that even this level of error makes little difference to the biological significance of my results on comparisons of distances moved (see Fig. 6.6) because successive distances moved by houbara (mean range 2.2 – 7.4 km) and variation between all individuals in all seasons (95 % confidence limits of 930 – 2400 m) were both large and variable.

**Appendix 4:** Details of (A) all 152 houbara released in Mahazat as-Sayd Reserve from 1995 to 1997, and (B) 21 adult houbara followed in this study that were released by Combreau & Smith (1998). Ten birds that either died or were injured before they were due to be released are excluded.

(A)

NWRC ring	Ring number	Transmitter frequency	Year hatched	Sex	Hatch date	Date moved to reserve	Group number	Release date	Age at release	Date left enclosure	Fate	End date (23 March 1998 if alive)	Days from release until death	Age at death	Cause of death
re02	H000248	5260	1995	m	20-Feb-95	13-May-95	95_1	28-May-95	97	31-May-95	alive	23-Mar-98	-	-	-
re08	H000249	5486	1995	f	8-Mar-95	13-May-95	95_1	28-May-95	81	31-May-95	missing	12-Jul-95	-	-	-
re06	H000246	5634	1995	m	14-Mar-95	13-May-95	95_1	28-May-95	75	30-May-95	missing	17-Jan-96	-	-	-
re10	H000247	5372	1995	m	16-Mar-95	13-May-95	95_1	28-May-95	73	7-Jun-95	missing	3-Nov-96	-	-	-
re20	H000532	5590	1995	f	31-Mar-95	23-May-95	95_2	5-Jun-95	66	16-Jul-95	alive	23-Mar-98	-	-	-
re19	H000531	5617	1995	?	26-Mar-95	23-May-95	95_2	5-Jun-95	71	27-Jun-95	dead	27-Jun-95	22	93	Predation, unknown, in reserve
re17	H000533	5569	1995	f	28-Mar-95	23-May-95	95_2	5-Jun-95	69	17-Jun-95	dead	10-Jul-95	35	104	Predation, unknown, in reserve
re33	H000520	5217	1995	?	28-Mar-95	27-May-95	95_2	5-Jun-95	69	3-Oct-95	dead	8-Oct-95	124	194	Predation, unknown, in reserve
re30	H000528	5009	1995	?	29-Mar-95	27-May-95	95_2	5-Jun-95	68	-	dead	2-Aug-95	77	126	Not predation, inside enclosure
re31	H000526	5042	1995	m	28-Mar-95	27-May-95	95_2	5-Jun-95	69	4-Oct-95	missing	11-Jul-96	-	-	-
re18	H000529	5751	1995	m	1-Apr-95	23-May-95	95_2	5-Jun-95	65	31-Aug-95	missing	20-Feb-96	-	-	-
re23	H000527	5458	1995	?	3-Apr-95	27-May-95	95_2	5-Jun-95	63	17-Jun-95	missing	21-Mar-96	-	-	-
re36	H000537	5717	1995	?	15-Apr-95	4-Jun-95	95_3	15-Jun-95	61	24-Jun-95	dead	9-Jul-95	23	85	Predation, unknown, in reserve
re37	H000536	5172	1995	?	17-Apr-95	4-Jun-95	95_3	15-Jun-95	59	18-Jul-95	dead	6-Aug-95	51	111	Predation, unknown, in reserve
re35	H000535	4024	1995	m	15-Apr-95	4-Jun-95	95_3	15-Jun-95	61	17-Jun-95	missing	6-Aug-96	-	-	-
re39	H000542	5515	1995	f	15-Apr-95	10-Jun-95	95_4	20-Jun-95	66	9-Jul-95	alive	25-Mar-98	-	-	-
re34	H000534	4113	1995	?	6-Apr-95	10-Jun-95	95_4	20-Jun-95	75	-	dead	9-Aug-95	50	125	Not predation, hit fence, inside enclosure
re40	H000538	5506	1995	f	12-Apr-95	10-Jun-95	95_4	20-Jun-95	69	5-Jul-95	dead	16-Jan-96	209	279	Predation, unknown, in reserve
re43	H000539	4016	1995	f	13-Apr-95	10-Jun-95	95_4	20-Jun-95	68	30-Sep-95	dead	6-Oct-95	108	176	Predation, unknown, in reserve
re50	H000541	4188	1995	f	18-Apr-95	10-Jun-95	95_4	20-Jun-95	63	1-Jul-95	missing	11-May-96	-	-	-
re48	H000540	4054	1995	f	19-Apr-95	10-Jun-95	95_4	20-Jun-95	62	6-Oct-95	missing	26-Apr-97	-	-	-
re47	H000545	4228	1995	?	18-Apr-95	17-Jun-95	95_5	29-Jun-95	72	6-Sep-95	dead	20-Sep-95	83	155	Predation, unknown, in reserve
re46	H000544	5300	1995	?	19-Apr-95	17-Jun-95	95_5	29-Jun-95	71	5-Jul-95	dead	9-Jul-95	10	81	Predation, unknown, in reserve
re62	H000543	5812	1995	?	21-Apr-95	17-Jun-95	95_5	29-Jun-95	69	6-Aug-95	dead	7-Aug-95	39	108	Predation, unknown, in reserve
re66	H000546	5100	1995	f	23-Apr-95	17-Jun-95	95_5	29-Jun-95	67	7-Aug-95	dead	7-Aug-95	27	106	Predation, unknown, in reserve
re69	H000549	4230	1995	f	17-Apr-95	8-Jul-95	95_6	20-Jul-95	94	6-Sep-95	dead	20-Sep-95	62	156	Predation, unknown, in reserve

NWRC ring	Ring number	Transmitter frequency	Year hatched	Sex	Hatch date	Date moved to reserve	Group number	Release date	Age at release	Date left enclosure	Fate	End date (23 March 1998 if alive)	Days from release until death	Age at death	Cause of death
re60	H000547	5617	1995	f	15-Apr-95	8-Jul-95	95_6	20-Jul-95	96	30-Jul-95	missing	2-May-96	-	-	-
re70	H000548	5717	1995	f	15-Apr-95	8-Jul-95	95_6	20-Jul-95	96	8-Aug-95	missing	21-Mar-96	-	-	-
re99	H000253	4072	1995	m	30-Apr-95	8-Jul-95	95_7	13-Aug-95	105	21-Aug-95	dead	21-Nov-95	6	205	Human, outside reserve
pi02	H000550	4135	1995	m	30-Apr-95	8-Jul-95	95_7	13-Aug-95	105	-	dead	21-Aug-95	8	113	Not predation, inside enclosure
pi01	H000252	5193	1995	m	1-May-95	8-Jul-95	95_7	13-Aug-95	104	29-Aug-95	dead	30-Aug-95	17	121	Predation, fox, in reserve
re100	H000254	5156	1995	f	2-May-95	8-Jul-95	95_7	13-Aug-95	103	-	dead	23-Oct-95	71	174	Not predation, inside enclosure
pi03	H000251	4085	1995	m	1-May-95	8-Jul-95	95_7	13-Aug-95	104	23-Aug-95	missing	13-Jun-96	-	-	-
pi07	H000255	4241	1995	m	10-May-95	7-Aug-95	95_8	18-Aug-95	100	2-Oct-95	dead	5-Nov-95	79	179	Predation, fox, in reserve
pi05	H000256	4263	1995	m	10-May-95	7-Aug-95	95_8	18-Aug-95	100	29-Aug-95	dead	29-Aug-95	11	111	Predation, unknown, in reserve
pi15	H000257	4291	1995	m	18-May-95	7-Aug-95	95_8	18-Aug-95	92	1-Oct-95	dead	8-Oct-95	51	143	Predation, unknown, in reserve
pi10	H000259	4395	1995	f	8-May-95	7-Aug-95	95_9	23-Aug-95	107	2-Oct-95	alive	25-Mar-98	-	-	-
re53	H000258	4414	1995	m	4-May-95	7-Aug-95	95_9	23-Aug-95	111	29-Aug-95	dead	29-Aug-95	6	117	Predation, unknown, in reserve
re95	H000260	4375	1995	f	6-May-95	7-Aug-95	95_9	23-Aug-95	109	29-Aug-95	dead	29-Aug-95	6	115	Predation, unknown, in reserve
re55	H000261	4450	1995	f	2-May-95	7-Aug-95	95_9	23-Aug-95	113	17-Oct-95	missing	30-Dec-95	-	-	-
re58	H000263	5194	1995	m	24-Apr-95	26-Sep-95	95_10	2-Oct-95	161	17-Oct-95	alive	23-Mar-98	-	-	-
re61	H000265	4550	1995	m	18-Apr-95	26-Sep-95	95_10	2-Oct-95	167	8-Oct-95	dead	27-Nov-95	51	223	Predation, unknown, in reserve
re63	H000262	4372	1995	m	21-Apr-95	26-Sep-95	95_10	2-Oct-95	164	16-Dec-95	missing	14-Feb-96	-	-	-
re57	H000264	4518	1995	m	3-May-95	26-Sep-95	95_10	2-Oct-95	152	15-Oct-95	missing	30-Dec-95	-	-	-
g16	H000283	4670	1996	?	24-Mar-96	25-May-96	96_1	2-Jun-96	70	22-Oct-96	alive	25-Mar-98	-	-	-
g28	H000270	4282	1996	m	31-Mar-96	25-May-96	96_1	2-Jun-96	63	24-Sep-96	alive	25-Mar-98	-	-	-
g7	H000284	4714	1996	m	5-Mar-96	25-May-96	96_1	2-Jun-96	89	6-Jun-96	dead	7-Jun-96	5	94	Predation, cat, in reserve
g27	H000267	4780	1996	f	29-Mar-96	25-May-96	96_1	2-Jun-96	65	27-Oct-96	dead	30-Oct-96	145	215	Predation, unknown, in reserve
g38	H000268	4415	1996	m	5-Apr-96	25-May-96	96_1	2-Jun-96	58	12-Jun-96	dead	1-Jul-96	29	87	Predation, unknown, in reserve
g40	H000269	4240	1996	f	6-Apr-96	25-May-96	96_1	2-Jun-96	57	16-Jun-96	dead	16-Jun-96	14	71	Predation, unknown, in reserve
g8	H000282	4739	1996	m	6-Mar-96	25-May-96	96_1	2-Jun-96	88	4-Jun-96	missing	9-Jun-96	-	-	-
g32	H000266	4551	1996	f	3-Apr-96	25-May-96	96_1	2-Jun-96	60	20-Jul-96	missing	5-Nov-96	-	-	-
g46	H000288	4060	1996	m	9-Apr-96	16-Jun-96	96_2	23-Jun-96	75	16-Sep-96	alive	25-Mar-98	-	-	-
g41	H000286	4908	1996	f	6-Apr-96	16-Jun-96	96_2	23-Jun-96	78	-	dead	19-Aug-96	57	135	Not predation, inside enclosure
rose45	H000273	4760	1996	f	12-Apr-96	16-Jun-96	96_2	23-Jun-96	72	25-Jun-96	dead	1-Jul-96	8	80	Predation, unknown, in reserve
g56	H000287	4509	1996	f	14-Apr-96	16-Jun-96	96_2	23-Jun-96	70	23-Oct-96	dead	25-Oct-96	124	194	Predation, unknown, in reserve

NWRC ring	Ring number	Transmitter frequency	Year hatched	Sex	Hatch date	Date moved to reserve	Group number	Release date	Age at release	Date left enclosure	Fate	End date (23 March 1998 if alive)	Days from release until death	Age at death	Cause of death	
	g57	H000289	4136	1996	f	15-Apr-96	16-Jun-96	96_2	23-Jun-96	69	-	dead	12-Jul-96	19	88	Not predation, inside enclosure
	g61	H000272	4224	1996	m	15-Apr-96	16-Jun-96	96_2	23-Jun-96	69	26-Jun-96	dead	26-Jun-96	7	72	Predation, unknown, in reserve
	g64	H000271	4801	1996	f	16-Apr-96	16-Jun-96	96_2	23-Jun-96	68	26-Jun-96	dead	2-Jul-96	10	77	Predation, fox, in reserve
	g65	H000274	5156	1996	f	16-Apr-96	16-Jun-96	96_2	23-Jun-96	68	26-Jun-96	dead	29-Jun-96	6	74	Predation, unknown, in reserve
	g68	H000290	4870	1996	f	19-Apr-96	16-Jun-96	96_2	23-Jun-96	65	26-Jun-96	dead	14-Jul-96	22	86	Predation, unknown, in reserve
	g49	H000285	4262	1996	m	11-Apr-96	16-Jun-96	96_2	23-Jun-96	73	21-Sep-96	missing	28-May-97	-	-	-
	g77	H000279	4337	1996	m	22-Apr-96	2-Jul-96	96_3	8-Aug-96	108	17-Aug-96	alive	25-Mar-98	-	-	-
	g83	H000292	4412	1996	f	24-Apr-96	2-Jul-96	96_3	8-Aug-96	106	15-Aug-96	alive	25-Mar-98	-	-	-
	g90	H000291	5156	1996	m	26-Apr-96	2-Jul-96	96_3	8-Aug-96	104	14-Sep-96	alive	2-Mar-98	-	-	-
	g86	H000280	4630	1996	f	26-Apr-96	2-Jul-96	96_3	8-Aug-96	104	25-Oct-96	alive	25-Mar-98	-	-	-
	g96	H000294	4760	1996	f	1-May-96	2-Jul-96	96_3	8-Aug-96	99	11-Aug-96	alive	27-Jan-98	-	-	-
	g73	H000277	4610	1996	m	20-Apr-96	2-Jul-96	96_3	8-Aug-96	110	10-Aug-96	dead	11-Aug-96	14	113	Predation, fox, in reserve
	g74	H000276	4927	1996	f	20-Apr-96	2-Jul-96	96_3	8-Aug-96	110	21-Oct-96	dead	21-Oct-96	74	184	Predation, unknown, in reserve
	g76	H000278	4224	1996	m	21-Apr-96	2-Jul-96	96_3	8-Aug-96	109	-	dead	21-Aug-96	13	122	Not predation, inside enclosure
	g80	H000275	4840	1996	m	23-Apr-96	2-Jul-96	96_3	8-Aug-96	107	2-Sep-96	dead	2-Sep-96	24	132	Predation, unknown, in reserve
	g93	H000293	4291	1996	m	29-Apr-96	2-Jul-96	96_3	8-Aug-96	101	30-Sep-96	dead	8-Oct-96	9	162	Predation, unknown, in reserve
	pu3	H000298	5569	1996	m	4-May-96	8-Aug-96	96_4	12-Aug-96	100	15-Aug-96	dead	17-Aug-96	4	105	Predation, unknown, in reserve
	pu5	H000297	4241	1996	f	7-May-96	8-Aug-96	96_4	12-Aug-96	97	-	dead	26-Oct-96	75	172	Not predation, inside enclosure
	pu1	H000295	4872	1996	m	8-May-96	8-Aug-96	96_4	12-Aug-96	96	16-Aug-96	dead	20-Aug-96	7	104	Predation, fox, in reserve
NWRC	H000300	4800	1996	m	10-May-96	8-Aug-96	96_4	12-Aug-96	94	16-Oct-96	dead	3-Nov-96	71	177	Predation, fox, in reserve	
	pu21	H000551	4712	1996	f	10-May-96	8-Aug-96	96_4	12-Aug-96	94	18-Sep-96	dead	30-Sep-96	48	143	Predation, unknown, in reserve
	pu18	H000552	4251	1996	f	13-May-96	8-Aug-96	96_4	12-Aug-96	91	15-Aug-96	dead	16-Aug-96	4	95	Predation, unknown, in reserve
	pu19	H000299	4822	1996	m	13-May-96	8-Aug-96	96_4	12-Aug-96	91	8-Oct-96	dead	13-Nov-96	92	184	Predation, unknown, in reserve
	pu20	H000553	4132	1996	m	13-May-96	8-Aug-96	96_4	12-Aug-96	91	16-Aug-96	missing	16-Aug-96	-	-	-
	pu11	H000557	5124	1996	m	17-May-96	10-Aug-96	96_5	14-Aug-96	89	15-Sep-96	alive	25-Mar-98	-	-	-
	pu10	H000560	5812	1996	m	16-May-96	10-Aug-96	96_5	14-Aug-96	90	-	dead	9-Nov-96	71	177	Predation, aerial, inside enclosure
	pu30	H000555	4971	1996	f	21-May-96	10-Aug-96	96_5	14-Aug-96	85	22-Aug-96	dead	22-Aug-96	7	93	Predation, fox, in reserve
	pu32	H000554	4720	1996	?	23-May-96	10-Aug-96	96_5	14-Aug-96	83	-	dead	13-Oct-96	81	143	Not predation, inside enclosure
	pu12	H000559	5172	1996	f	17-May-96	10-Aug-96	96_5	14-Aug-96	89	13-Oct-96	missing	22-Mar-97	-	-	-
	dgn14	H000561	4224	1996	f	8-Jul-96	1-Oct-96	96_6	11-Oct-96	95	-	dead	12-Nov-96	32	127	Not predation, inside enclosure

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g1	H000566	4320	1997	f	26-Jan-97	20-May-97	97_1	11-Jun-97	136	11-Jun-97	dead	24-Jun-97	13	149	Predation, aerial, in reserve
g3	H000569	4555	1997	m	9-Feb-97	20-May-97	97_1	11-Jun-97	122	11-Jun-97	dead	25-Jun-97	14	136	Predation, unknown, in reserve
g5	H000572	4540	1997	m	20-Feb-97	20-May-97	97_1	11-Jun-97	111	11-Jun-97	dead	22-Jun-97	11	122	Not predation, in reserve
g6	H000571	4160	1997	m	24-Feb-97	20-May-97	97_1	11-Jun-97	107	11-Jun-97	dead	20-Jun-97	9	116	Predation, aerial, in reserve
g7	H000565	4310	1997	m	24-Feb-97	20-May-97	97_1	11-Jun-97	107	11-Jun-97	dead	22-Jun-97	11	118	Predation, unknown, in reserve
g8	H000570	4108	1997	f	24-Feb-97	20-May-97	97_1	11-Jun-97	107	11-Jun-97	dead	30-Aug-97	80	187	Predation, unknown, in reserve
g16	H000568	4300	1997	f	8-Mar-97	20-May-97	97_1	11-Jun-97	95	11-Jun-97	dead	23-Jun-97	12	107	Predation, fox, in reserve
g18	H000567	4150	1997	f	11-Mar-97	20-May-97	97_1	11-Jun-97	92	11-Jun-97	dead	20-Jun-97	9	101	Predation, unknown, in reserve
g40	H000580	5958	1997	m	25-Mar-97	14-Jun-97	97_2	22-Jun-97	89	22-Jun-97	dead	14-Sep-97	84	173	Predation, fox, in reserve
g42	H000576	5988	1997	m	25-Mar-97	14-Jun-97	97_2	22-Jun-97	89	22-Jun-97	dead	2-Jul-97	10	99	Predation, unknown, in reserve
g39	H000579	5938	1997	f	25-Mar-97	14-Jun-97	97_2	22-Jun-97	89	22-Jun-97	dead	5-Feb-98	228	317	Predation, unknown, in reserve
g51	H000573	5980	1997	m	28-Mar-97	14-Jun-97	97_2	22-Jun-97	86	22-Jun-97	dead	26-Jun-97	4	90	Predation, fox, in reserve
g68	H000578	5918	1997	f	1-Apr-97	14-Jun-97	97_2	22-Jun-97	82	22-Jun-97	dead	18-Aug-97	57	139	Predation, fox, in reserve
g67	H000577	5900	1997	f	1-Apr-97	14-Jun-97	97_2	22-Jun-97	82	22-Jun-97	dead	30-Jun-97	8	90	Predation, unknown, in reserve
g77	H000574	5930	1997	m	3-Apr-97	14-Jun-97	97_2	22-Jun-97	80	22-Jun-97	dead	30-Jun-97	8	88	Predation, fox, in reserve
g87	H000652	5910	1997	f	6-Apr-97	14-Jun-97	97_2	22-Jun-97	77	22-Jun-97	dead	25-Jun-97	3	80	Predation, unknown, in reserve
g95	H000653	5798	1997	f	7-Apr-97	21-Jun-97	97_3	29-Jun-97	83	29-Jun-97	dead	7-Jul-97	8	91	Not predation, starvation, in reserve
g89	H000655	5816	1997	m	7-Apr-97	21-Jun-97	97_3	29-Jun-97	83	29-Jun-97	dead	1-Jul-97	2	85	Predation, cat, in reserve
g91	H000656	5828	1997	m	7-Apr-97	21-Jun-97	97_3	29-Jun-97	83	29-Jun-97	dead	5-Jul-97	6	89	Predation, fox, in reserve
g99	H000659	5858	1997	m	8-Apr-97	21-Jun-97	97_3	29-Jun-97	82	29-Jun-97	dead	5-Jul-97	6	88	Predation, fox, in reserve
g97	H000658	5847	1997	?	8-Apr-97	21-Jun-97	97_3	29-Jun-97	82	29-Jun-97	dead	6-Jul-97	7	89	Predation, fox, in reserve
p63	H000657	5837	1997	m	13-Apr-97	21-Jun-97	97_3	29-Jun-97	77	29-Jun-97	dead	3-Jul-97	4	81	Predation, fox, in reserve
p62	H000654	5807	1997	f	13-Apr-97	21-Jun-97	97_3	29-Jun-97	77	29-Jun-97	dead	5-Jul-97	6	83	Predation, fox, in reserve
p75	H000662	5888	1997	m	16-Apr-97	21-Jun-97	97_3	29-Jun-97	74	29-Jun-97	dead	3-Jul-97	4	78	Predation, fox, in reserve
p73	H000661	5878	1997	f	16-Apr-97	21-Jun-97	97_3	29-Jun-97	74	29-Jun-97	dead	6-Jul-97	7	81	Predation, fox, in reserve
p74	H000660	5869	1997	f	16-Apr-97	21-Jun-97	97_3	29-Jun-97	74	29-Jun-97	dead	6-Jul-97	7	81	Predation, unknown, in reserve
p64	H000671	5757	1997	m	13-Apr-97	8-Jul-97	97_4	18-Jul-97	96	18-Jul-97	alive	25-Mar-98	-	-	-
p83	H000672	5678	1997	m	20-Apr-97	8-Jul-97	97_4	18-Jul-97	89	18-Jul-97	alive	25-Mar-98	-	-	-
p99	H000664	5742	1997	m	26-Apr-97	8-Jul-97	97_4	18-Jul-97	83	18-Jul-97	alive	25-Mar-98	-	-	-
p98	H000667	5722	1997	f	26-Apr-97	8-Jul-97	97_4	18-Jul-97	83	18-Jul-97	alive	25-Mar-98	-	-	-

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p92	H000668	5768	1997	m	27-Apr-97	8-Jul-97	97_4	18-Jul-97	82	18-Jul-97	alive	25-Mar-98	-	-	-
p86	H000670	5733	1997	m	19-Apr-97	8-Jul-97	97_4	18-Jul-97	90	-	dead	3-Aug-97	16	106	Not predation, starvation, in enclosure
p44	H000665	5688	1997	m	19-Apr-97	8-Jul-97	97_4	18-Jul-97	90	18-Jul-97	dead	23-Aug-97	10	126	Predation, fox, in reserve
p100	H000663	5788	1997	f	26-Apr-97	8-Jul-97	97_4	18-Jul-97	83	18-Jul-97	dead	21-Jan-98	187	270	Predation, unknown, in reserve
y78	H000666	5621	1997	f	2-May-97	8-Jul-97	97_4	18-Jul-97	77	18-Jul-97	dead	24-Nov-97	129	206	Predation, unknown, in reserve
y83	H000683	5642	1997	f	30-Apr-97	15-Jul-97	97_5	22-Jul-97	83	22-Jul-97	alive	25-Mar-98	-	-	-
y84	H000681	5659	1997	m	1-May-97	15-Jul-97	97_5	22-Jul-97	82	22-Jul-97	alive	25-Mar-98	-	-	-
y80	H000676	4598	1997	m	2-May-97	15-Jul-97	97_5	22-Jul-97	81	22-Jul-97	alive	25-Mar-98	-	-	-
p93	H000679	5668	1997	m	27-Apr-97	15-Jul-97	97_5	22-Jul-97	86	5-Aug-97	dead	11-Feb-98	204	290	Not predation, inside enclosure
p95	H000678	4563	1997	f	27-Apr-97	15-Jul-97	97_5	22-Jul-97	86	22-Jul-97	dead	3-Aug-97	12	98	Predation, unknown, in reserve
p97	H000684	4098	1997	f	28-Apr-97	15-Jul-97	97_5	22-Jul-97	85	22-Jul-97	dead	27-Jul-97	9	90	Predation, unknown, in reserve
y85	H000682	5778	1997	f	1-May-97	15-Jul-97	97_5	22-Jul-97	82	-	dead	28-Jul-97	6	88	Not predation, starvation, in enclosure
y79	H000675	4573	1997	f	2-May-97	15-Jul-97	97_5	22-Jul-97	81	-	dead	30-Jul-97	8	89	Not predation, starvation, in enclosure
y82	H000674	4588	1997	f	2-May-97	15-Jul-97	97_5	22-Jul-97	81	-	dead	3-Aug-97	12	93	Not predation, starvation, in enclosure
y81	H000673	4520	1997	f	2-May-97	15-Jul-97	97_5	22-Jul-97	81	22-Jul-97	dead	28-Jul-97	8	87	Predation, fox, in reserve
y86	H000680	5609	1997	f	4-May-97	15-Jul-97	97_5	22-Jul-97	79	-	dead	30-Jul-97	8	87	Not predation, inside enclosure
y88	H000677	4610	1997	f	5-May-97	15-Jul-97	97_5	22-Jul-97	78	-	dead	10-Dec-97	141	219	Not predation, inside enclosure
g21	H000685	4933	1997	m	15-Mar-97	21-Oct-97	97_6	1-Nov-97	231	13-Nov-97	alive	23-Mar-98	-	-	-
y90	H000691	5385	1997	m	10-May-97	21-Oct-97	97_6	1-Nov-97	175	13-Nov-97	alive	23-Mar-98	-	-	-
y89	H000701	4422	1997	m	10-May-97	21-Oct-97	97_6	1-Nov-97	175	26-Nov-97	alive	25-Mar-98	-	-	-
y75	H000693	4854	1997	m	11-May-97	21-Oct-97	97_6	1-Nov-97	174	17-Feb-98	alive	25-Mar-98	-	-	-
y97	H000690	5489	1997	m	14-May-97	21-Oct-97	97_6	1-Nov-97	171	17-Nov-97	alive	25-Mar-98	-	-	-
r74	H000686	4845	1997	m	16-May-97	21-Oct-97	97_6	1-Nov-97	169	13-Nov-97	alive	25-Mar-98	-	-	-
y95	H000692	4151	1997	f	26-May-97	21-Oct-97	97_6	1-Nov-97	159	13-Nov-97	alive	25-Mar-98	-	-	-
y96	H000696	4965	1997	m	27-May-97	21-Oct-97	97_6	1-Nov-97	158	20-Nov-97	alive	25-Mar-98	-	-	-
p78	H000698	4608	1997	m	1-Jun-97	21-Oct-97	97_6	1-Nov-97	153	13-Nov-97	alive	23-Mar-98	-	-	-
g29	H000699	4685	1997	m	20-Mar-97	21-Oct-97	97_6	1-Nov-97	226	13-Nov-97	dead	13-Nov-97	12	238	Predation, unknown, in reserve
p57	H000689	5600	1997	m	13-Apr-97	21-Oct-97	97_6	1-Nov-97	202	13-Nov-97	dead	14-Nov-97	13	215	Predation, unknown, in reserve
g22	H000697	4925	1997	m	15-Apr-97	21-Oct-97	97_6	1-Nov-97	200	-	dead	26-Nov-97	25	225	Predation, aerial, inside enclosure
r88	H000694	4205	1997	m	25-Apr-97	21-Oct-97	97_6	1-Nov-97	190	-	dead	10-Dec-97	39	229	Not predation, inside enclosure



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y62	H000703	4943	1997	f	5-May-97	21-Oct-97	97_6	1-Nov-97	180	17-Nov-97	dead	17-Nov-97	37	196	Predation, unknown, in reserve
y87	H000687	4252	1997	m	5-May-97	21-Oct-97	97_6	1-Nov-97	180	26-Nov-97	dead	26-Nov-97	25	205	Predation, unknown, in reserve
y98	H000695	4961	1997	m	14-May-97	21-Oct-97	97_6	1-Nov-97	171	-	dead	26-Nov-97	25	196	Not predation, inside enclosure
y99	H000702	4915	1997	f	14-May-97	21-Oct-97	97_6	1-Nov-97	171	13-Nov-97	dead	8-Dec-97	37	208	Predation, unknown, in reserve
r72	H000700	4930	1997	m	16-May-97	21-Oct-97	97_6	1-Nov-97	169	13-Nov-97	dead	13-Nov-97	12	181	Predation, unknown, in reserve
r71	H000688	4471	1997	m	6-May-97	21-Oct-97	97_6	1-Nov-97	179	13-Nov-97	missing	6-Jan-98	-	-	-

## (B)

NWRC ring	Ring number	Transmitter frequency	Year hatched	Sex	Hatch date	Date moved to reserve	Release date	Age at release (days)	Fate	End date (23 March 1998 if alive)	Days from release until death	Age at death	Cause of death
nd	H000170	5026	1993	f	01-Mar-93	08-May-93	19-May-93	79	alive	23-Mar-98	-	-	-
nd	H000234	5113	1994	f	25-May-94	11-Sep-94	03-Oct-94	131	alive	23-Mar-98	-	-	-
nd	H000153	5131	1993	f	17-Feb-93	13-Apr-93	02-May-93	74	missing	08-Mar-97	-	-	-
nd	H000523	5210	1994	f	06-Mar-94	16-May-94	11-Jun-94	97	alive	23-Mar-98	-	-	-
nd	H000186	5240	1993	f	22-Apr-93	08-May-93	26-Jun-93	65	alive	23-Mar-98	-	-	-
nd	H000171	5268	1992	f	23-Apr-92	02-Mar-93	09-Mar-93	320	dead	15-Apr-97	1498	1818	Predation, unknown, in reserve
nd	H000240	5358	1994	f	13-Jun-94	17-Sep-94	03-Oct-94	112	alive	23-Mar-98	-	-	-
nd	H000182	5419	1993	f	10-Apr-93	08-May-93	13-Aug-93	125	alive	23-Mar-98	-	-	-
nd	H000191	5441	1993	f	15-Apr-93	12-Jun-93	11-Jul-93	87	alive	23-Mar-98	-	-	-
nd	H000237	5496	1994	f	16-Jun-94	17-Sep-94	03-Oct-94	109	alive	23-Mar-98	-	-	-
nd	H000524	5598	1994	f	08-Mar-94	16-May-94	11-Jun-94	95	alive	23-Mar-98	-	-	-
nd	H000155	4033	1993	m	18-Feb-93	13-Apr-93	02-May-93	73	alive	05-Jul-97	-	-	-
nd	H000228	5123	1994	m	08-May-94	03-Jul-94	12-Sep-94	127	dead	24-Jan-96	499	626	Human - outside reserve
nd	H000224	5177	1994	m	26-Apr-94	26-Jun-94	17-Jul-94	82	alive	23-Mar-98	-	-	-
nd	H000238	5282	1994	m	17-May-94	17-Sep-94	03-Oct-94	139	alive	23-Mar-98	-	-	-
nd	H000160	5411	1993	m	21-Apr-93	18-May-93	01-Jun-93	41	alive	16-Jul-97	-	-	-
nd	H000161	5540	1993	m	01-Apr-93	18-Apr-93	25-May-93	54	alive	23-Mar-98	-	-	-
nd	H000211	5547	1994	m	08-Apr-94	29-May-94	26-Jun-94	79	alive	23-Mar-98	-	-	-
nd	H000214	5653	1994	m	08-Apr-94	29-May-94	26-Jun-94	79	alive	23-Mar-98	-	-	-
nd	H000239	5674	1994	m	15-May-94	17-Sep-94	03-Oct-94	141	alive	21-Apr-97	-	-	-
nd	H000233	5707	1994	m	27-May-94	11-Sep-94	03-Oct-94	129	alive	23-Mar-98	-	-	-

**Appendix 6:** Identity of houbara that were located in a site more than 100 km east of Mahazat as-Sayd Reserve, the timing of their departure and their return. Adult houbara, txs: 5547 and 5026, were excluded from home range analyses in spring 1996.

Tx code	Last in reserve prior to departure	First recorded in eastern site	Last recorded in eastern site	Return to reserve or fate	Maximum days in eastern site
4054	25 Feb 96	10 Mar 96	24 Apr 96	2 May 96	67
4670	27 Jan 98	25 Feb 98	2 Mar 98	Missing	34+
5156	6 Feb 98	25 Feb 98	2 Mar 98	Missing	24+
5617	27 Feb 96	17 Mar 96	18 Mar 96	30 Mar 96	32
5617*	3 Apr 96	24 Apr 96	2 May 96	Missing	29+
5547	14 Jan 96	10 Mar 96	18 Mar 96	21 Mar 96	67
5026	29 Jan 96	10 Mar 96	18 Mar 96	24 Mar 96	55
4085	28 May 96	13 Jun 96	13 Jun 96	Missing	16+

\* this bird returned to the reserve for four days before returning to the eastern site

**Appendix 7:** Parameters used to calculate population simulations using Vortex 5.1 (Lacy 1993), for houbara released into Mahazat as-Sayd reserve. Breeding data based on 1998 values.

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Parameters

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- 1 population(s) simulated for 100 years, 100 iterations
  - No inbreeding depression assumed
  - First age of reproduction for females: 2 for males: 2
  - Age of senescence (death): 15 years (assumed)
  - Sex ratio at birth (proportion males): 0.50000
  - Polygynous mating; but 100 % of adult males assumed to be in the breeding pool because unknown what proportion of males are breeders
  - Reproduction is assumed to be density independent.
    - 52.00 (EV = 5.00 SD) percent of adult females produce litters of size 0
    - 4.00 percent of adult females produce litters of size 1
    - 28.00 percent of adult females produce litters of size 2
    - 12.00 percent of adult females produce litters of size 3
    - 4.00 percent of adult females produce litters of size 4
    - 65.00 (EV = 0.00 SD) percent mortality of females between ages 0 and 1
    - 5.30 (EV = 0.00 SD) percent mortality of females between ages 1 and 2
    - 5.30 (EV = 0.00 SD) percent annual mortality of adult females ( $2 \leq \text{age} \leq 15$ )
    - 65.00 (EV = 0.00 SD) percent mortality of males between ages 0 and 1
    - 5.30 (EV = 0.00 SD) percent mortality of males between ages 1 and 2
    - 5.30 (EV = 0.00 SD) percent annual mortality of adult males ( $2 \leq \text{age} \leq 15$ )
  - EV in reproduction and mortality will be correlated.
  - Initial size of Population 1, based on 1998 values:
  - | Age | 1  | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Total      |
|-----|----|---|---|---|---|---|---|---|---|----|----|----|----|----|----|------------|
|     | 14 | 3 | 3 | 7 | 1 | 0 | 0 | 0 | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 28 Males   |
|     | 14 | 7 | 2 | 5 | 4 | 0 | 0 | 0 | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 32 Females |
  - Carrying capacity = estimated 500 (EV = 0.00 SD)
  - Deterministic population growth rate (based on females, with assumptions of no limitation of mates, no density dependence, and no inbreeding depression):
-