Supplementary information for: Inferring social structure and its drivers from refuge use in the desert tortoise, a relatively solitary species

In Behavioral Ecology and Sociobiology

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Table S1: Location, surveyed years, total tortoises tracked and average observations at the study sites

Site	Site abbr	County, State	Survey years	Total tortoises tracked	Average observations (± standard deviation) per month per tortoise
Bird Spring Valley	BSV	Clark, NV	1996-99	237	Active: 3.94 ± 1.72 Inactive: 1.82 ± 1.05
Coyote Springs	CS	Clark, NV	2006-14	71	Active:3.92 ± 3.54 Inactive: 1.51 ± 0.71
Fort Irwin	FI	Barstow, CA	2005-14	2138	Active: 3.43 ± 3.03 Inactive: 1.66 ± 1.27
Halfway	HW	Lincoln, NV	2008-12	49	Active: 2.87 ± 3.30 Inactive: 1.43 ± 0.59
Lake Meade	LM	Clark, NV	1999-00	53	Active: 3.11 ± 1.27 Inactive: 1.52 ± 0.46
McCullough Pass	MC	Clark, NV	2012-13	27	Active: 3.89 ± 1.21 Inactive: 1.29 ± 0.48
Piute Valley	PV	Clark,NV	2001-13	92	Active: 3.99 ± 2.37 Inactive: 1.53 ± 0.82
St. George	SG	Washington, UT	1998-00	62	Active: 4.35 ± 1.87 Inactive: 1.71 ± 1.17
Stateline Pass	SL	Clark, NV	2012-13	15	Active: 3.36 ± 1.02 Inactive: 1.64 ± 0.61

Summary of the nine sites across the desert tortoise habitat used in this study

Table S2: Location of the weather stations used to obtain climatic information for the nine study sites

Site	County, state	Weather Station	Latitude	Longitude
BSV	Clark, NV	Overton, NV	35.551°N	114.458°W
CS	Clark, NV	Overton, NV	35.551°N	114.458°W
FI	Barstow, CA	Barstow Dagget Airport, CA	34.854°N	116.786°W
HW	Lincoln, NV	Pahrangat, NV	37.269°N	115.122°W
LM	Clark, NV	Overton, NV	35.551°N	114.458°W
MC	Clark, NV	Overton, NV	35.551°N	114.458°W
PV	Clark,NV	Overton, NV	35.551°N	114.458°W
SG	Washington, UT	St George, UT	37.107°N	113.561°W
SL	Clark, NV	Overton, NV	35.551°N	114.458°W

Table S3: Network density, degree homophily, clustering coefficient, modularity and degree centralization of tortoise social networks at five study sites with control animals. Tortoise social network is constructed as the single mode projections of bipartite network of burrow use for active (Mar - Oct) and inactive (Nov-Feb) season of each surveyed year. For consistent comparison, networks with less than fives edges were excluded from the analysis

Site	Season	Total networks	Network density	Degree homophily	Clustering coefficient	Modularity	Degree centralization
CS	Active	8	0.151 (8, 0.05)	0.376 (3, 0.05)	0.382 (7, 0.12)	0.573 (7, 0.13)	0.169 (8, 0.05)
	Inactive	2	0.172 (2, 0.01)	1.0 (2, 0.00)	0.467 (2, 0.19)	0.677 (2, 0.02)	0.072 (2, 0.03)
HW	Active	3	0.193 (3, 0.05)	0.588 (1, -)	0.230 (3, 0.21)	0.642 (1, -)	0.149 (3, 0.06)
	Inactive	0	-	-	-	-	-
MC	Active	2	0.266 (2, 0.01)	0.243 (2, 0.49)	0.592 (2, 0.25)	0.338 (1, -)	0.264 (1, -)
	Inactive	0	-	-	-	-	-
PV	Active	7	0.184 (8, 0.06)	0.484 (4, 0.36)	0.350 (7, 0.23)	0.601 (4, 0.07)	0.158 (7, 0.06)
	Inactive	0	-	-	-	-	-
SL	Active	2	0.285 (2, 0.10)	0 (1, -)	0.513 (2, 0.17)	0.416 (2, 0.14)	0.250 (2, 0.10)
	Inactive	0	-	-	-	-	-

Values in parentheses are sample size of individual metric and standard deviation. Only statistically significant values with $P < 0.05$ were used to calculate averages and standard deviation.

Table S4: Correlation between geographical distances and edge occurrence in tortoise social networks during active season of each surveyed year. Tortoise social networks with less than five edges were excluded from the analysis

Site	Year	Nodes	Edges	Edge correlation	P value
CS	2006	9	7	-0.439	0.034
CS	2007	21	35	-0.318	0.001
CS	2008	17	35	-0.384	0.005
CS	2009	22	27	-0.350	0.000
CS	2010	24	35	-0.400	0.000
CS	2011	18	14	-0.322	0.000
CS	2012	17	20	-0.330	0.002
CS	2013	18	16	-0.222	0.033
HW	2009	11	9	-0.581	0.000
HW	2011	9	6	-0.658	0.000
HW	2012	8	7	-0.895	0.000
MC	2012	14	25	-0.586	0.000
MC	2013	13	20	-0.490	0.003
PV	2005	10	13	-0.653	0.001
PV	2008	14	11	-0.392	0.010
PV	2009	8	5	-0.513	0.005
PV	2010	12	21	-0.563	0.009
PV	2011	15	12	-0.402	0.000
PV	2012	20	26	-0.469	0.000
PV	2013	16	16	-0.494	0.000
SL	2012	6	5	-0.777	0.007
SL	2013	11	13	-0.484	0.004

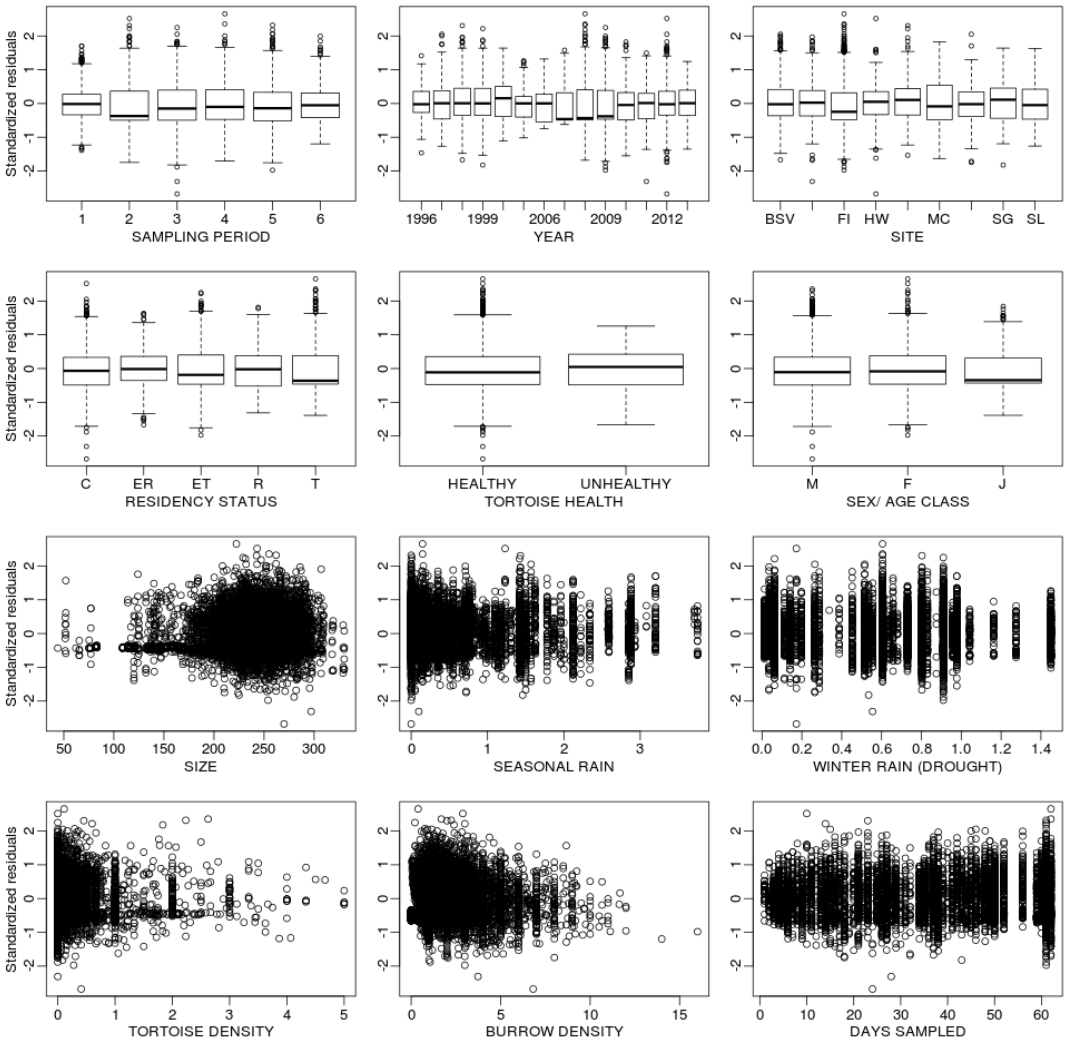

Figure S1: Standardized Pearson residuals of the burrow switching model

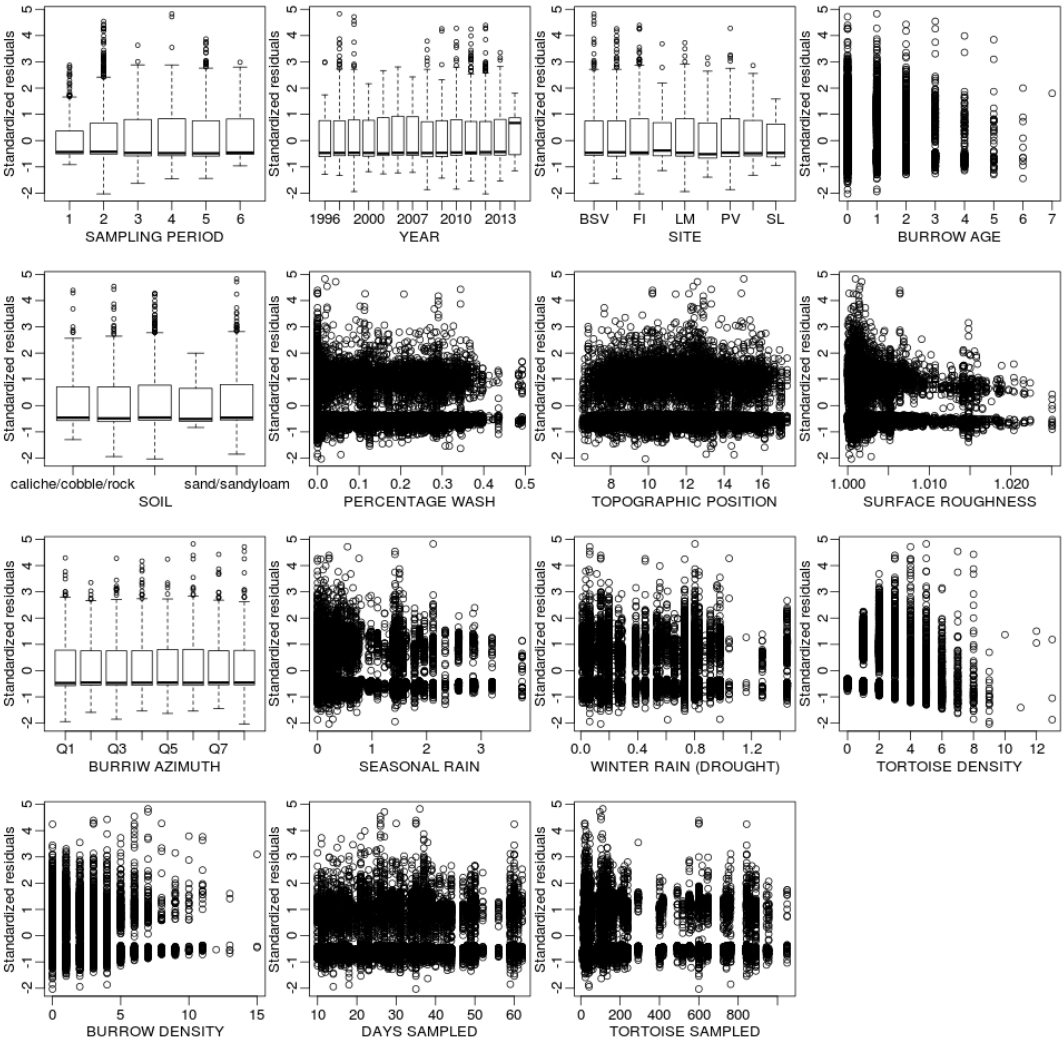

Figure S2: Standardized Pearson residuals of the burrow popularity model

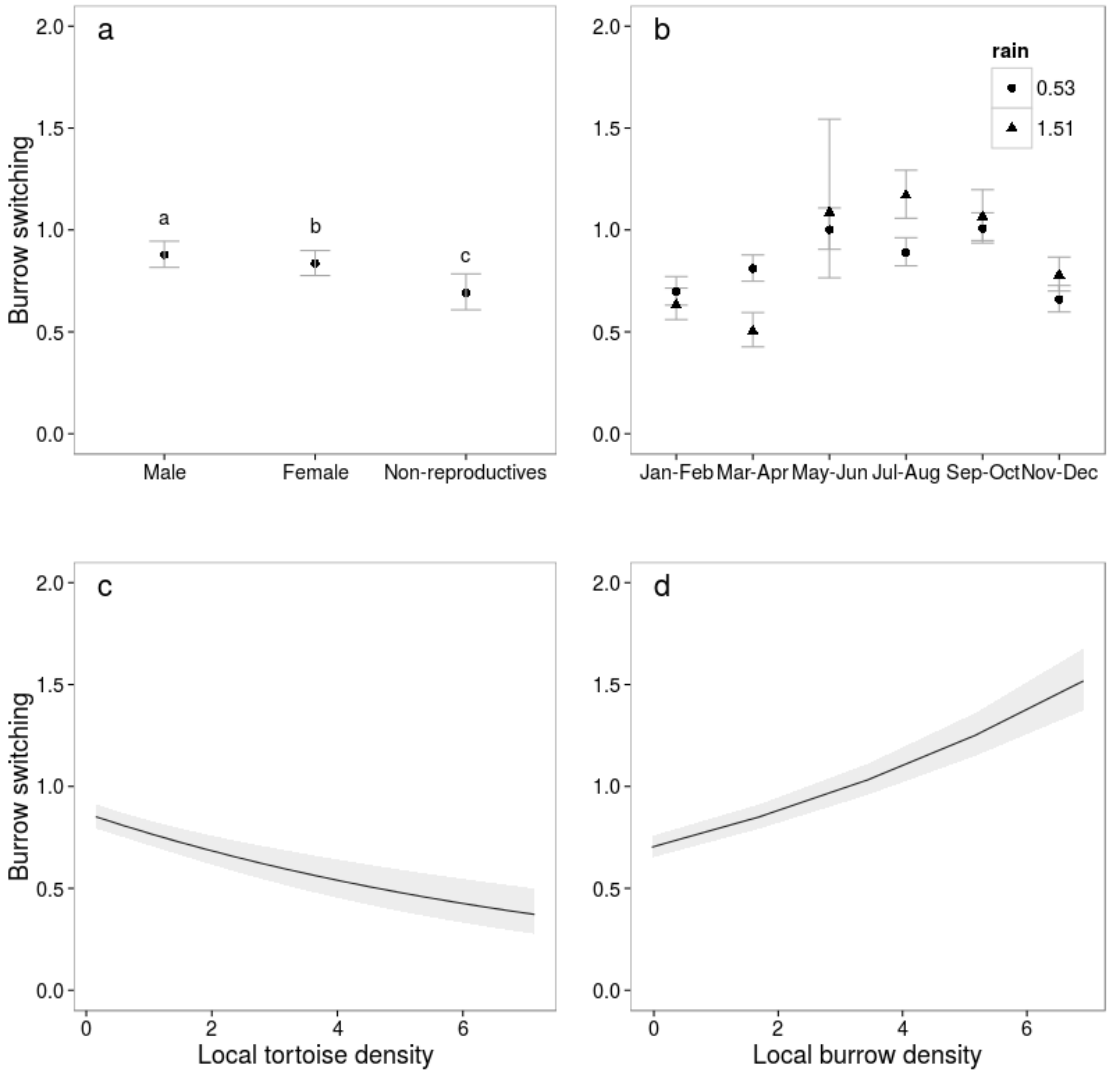

Figure S3: Effect of a) sex/age class, b) sampling period × seasonal rainfall (rain, measured in inches), c) local tortoise density and d) local burrow density on burrow switching levels of desert tortoises. Error bars represent 95% confidence intervals, and different letters above the points denote a significant difference between the means ($P < 0.05$).

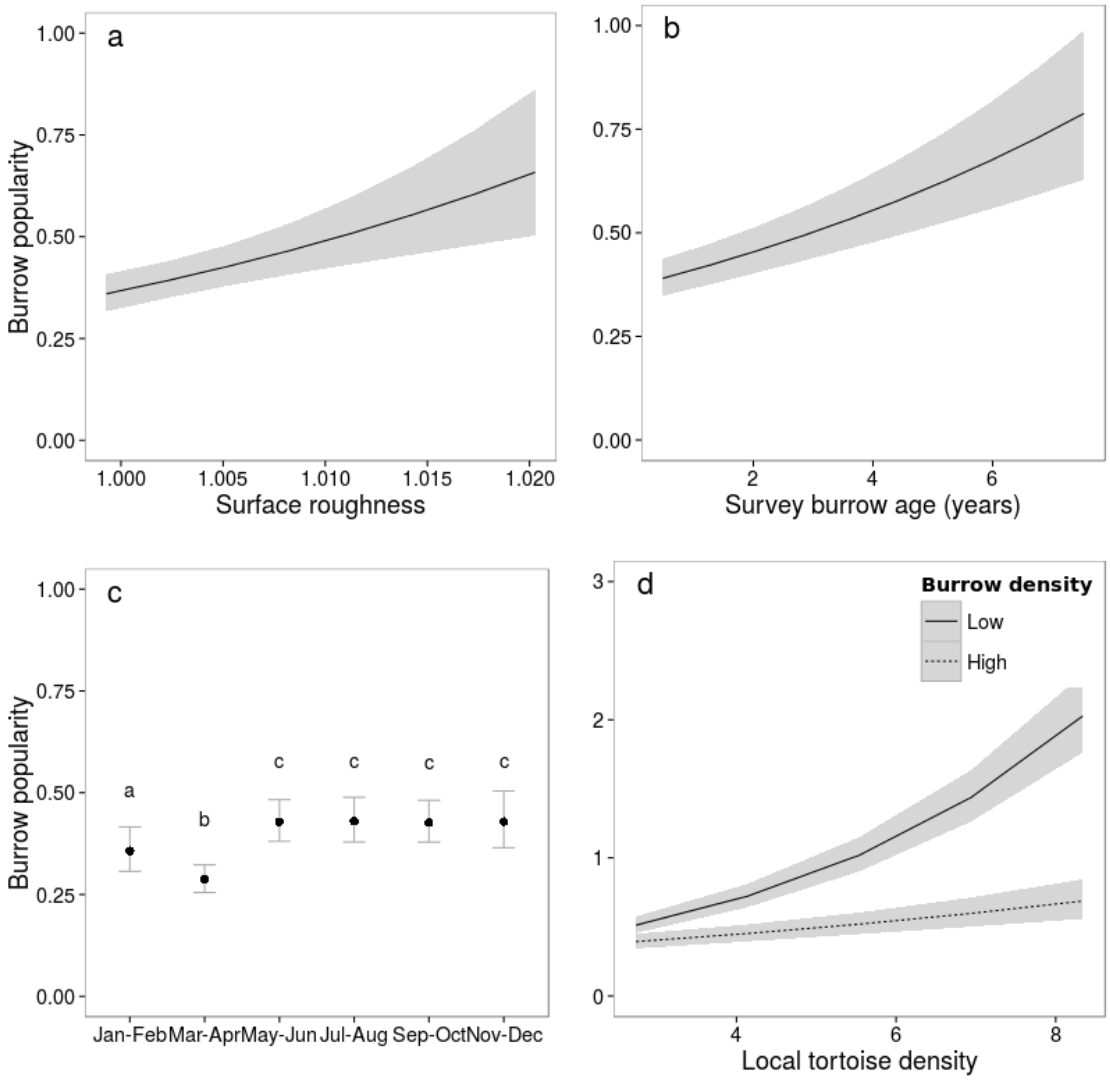

Figure S4: Popularity level of burrows in various a) surface roughness , b) burrow age, c) sampling periods, and d) density conditions. Note that the scale of the y-axis in panel (d) is different. An average of 3 and 6.5 burrows around focal burrows is denoted as low and high burrow density respectively. Error bars represent 95% confidence intervals, and different letters above the points denote a significant difference between the means ($P < 0.05$).

Table S5: Potential interactions considered for the burrow switching and the burrow popularity model

Model	dLogLik	dBIC	df	weight
Burrow switching model				
Fixed effects + sampling period×sex/age class, sampling period× seasonal rainfall, local tortoise density×local burrow density	58.3	76.5	39	<0.001
Fixed effects + sampling period×sex/age class, sampling period× seasonal rainfall	58.2	67.4	38	<0.001
Fixed effects + sampling period×sex/age class, local tortoise density×local burrow density	12.1	122.5	34	<0.001
Fixed effects + sampling period× seasonal rainfall, local tortoise density×local burrow density	45.6	9.1	29	0.011
Fixed effects + sampling period×sex/age class	11.8	113.9	33	<0.001
Fixed effects + sampling period× seasonal rainfall	**45.5**	**0.0**	**28**	**0.989**
Fixed effects + local tortoise density×local burrow density	0.3	53.0	24	<0.001
Fixed effects only	0.0	44.4	23	<0.001
Burrow popularity model				
Fixed effects + sampling period×local tortoise density, sampling period× seasonal rainfall, local tortoise density×local burrow density	186.9	4.8	41	0.082
Fixed effects + sampling period×local tortoise density, sampling period× seasonal rainfall	113.6	141.5	40	<0.001
Fixed effects + sampling period×local tortoise density, local tortoise density×local burrow density	**164.2**	**0.0**	**36**	**0.918**
Fixed effects + sampling period× seasonal rainfall, local tortoise density×local burrow density	102.5	123.4	36	<0.001
Fixed effects + sampling period×local tortoise density	91.4	135.6	35	<0.001
Fixed effects + sampling period× seasonal rainfall	17.3	283.8	35	<0.001
Fixed effects + local tortoise density×local burrow density	83.3	111.6	31	<0.001
Fixed effects only	0.0	268.1	30	<0.001

Fixed effects include all the predictor variables described methods

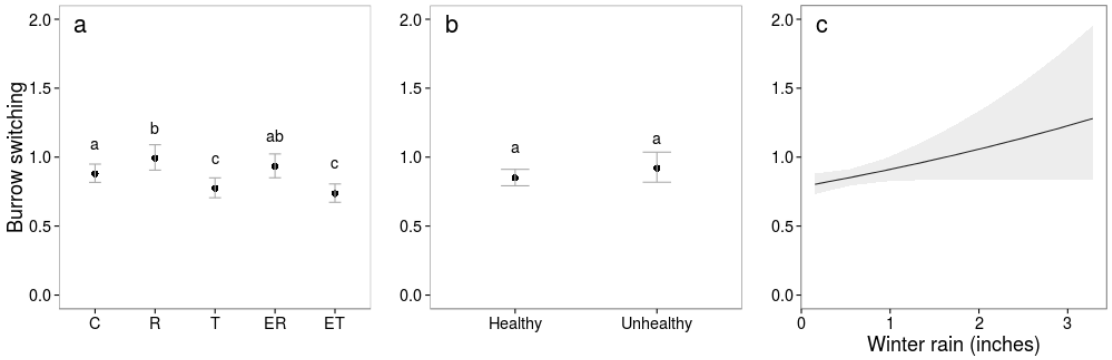

Figure S5: Effect of population stressors of a) translocation, b) URTD, and c) winter rainfall on burrow switching levels of desert tortoises. In panel a), C = Controls, R = Residents, T = Translocated, ER = Ex-Residents and ET= Ex-Translocated. Unhealthy animals in panel b) represents individuals exhibiting clinical signs of the infection and healthy represents uninfected or asymptomatic tortoises. Error bars represent 95% confidence intervals, and different letters above the points denote a significant difference between the means ($P < 0.05$).