Nest relief in cryptically incubating semipalmated sandpiper is quick, but vocal

Martin Bulla bulla.mar@gmail.com, Christina Muck, Daniela Trischer, Bart Kempenaers

Figure S1 | Recording equipment at the nest. The camera is mounted on a little tripod. The battery is hidden at the vegetation. Here, the nest is protected by a cage and radio frequency identification system is visible next to the cage.

Table S1 | Incubating parent's calling rate and fly-off probability before nest relief and during regular incubation.

					95% CI	
Model	Response variable	Effect type	Effect	Estimate	Lower	Upper
a	Calling rate (10min^{-1})	Fixed	Intercept (before exchange)	-0.923	-1.284	-0.557
	(Poisson scale)		Observation (regular incubation)	-0.834	-1.085	-0.58
b	Calling rate (10min^{-1})	Fixed	Intercept (before exchange & ♀)	-0.887	-1.266	-0.506
	(Poisson scale)		Observation (regular incubation)	-0.831	-1.186	-0.454
			Sex (♂)	-0.074	-0.317	0.171
			Day of incubation	-0.041	-0.251	0.17
			Sex × Observation	-0.001	-0.506	0.512
			Day of incubation × Observation	0.02	-0.237	0.28
c	Fly-off (0, 1)	Fixed	Intercept (before exchange)	-1.896	-2.392	-1.387
	(binomial scale)		Length of observation (ln(min))	-0.315	-0.582	-0.044
			Observation (regular incubation)	-0.352	-1.145	0.437
d	Fly-off (0, 1)	Fixed	Intercept (before exchange & ♀)	-2.027	-2.763	-1.331
	(binomial scale)		Length of observation (ln(min))	-0.281	-0.556	0.004
			Observation (regular incubation)	-0.538	-1.781	0.662
			Sex (♂)	0.289	-0.665	1.259
			Day of incubation	0.146	-0.322	0.606
			Sex × Observation	0.29	-1.282	1.894
			Day of incubation × Observation	-0.039	-0.755	0.639

Shown are the posterior estimates (medians) of the effect sizes with the 95% credible intervals (CI) from a posterior distribution of 5,000 simulated values generated by the 'sim' function in R (Gelman and Su 2015). Variance components were estimated by the 'lmer' function in R (Bates *et al.* 2015).

N = 265 observations (148 of before exchange, 117 of regular incubation) from 31 nests. Continuous predictors were z-transformed (mean-centred and divided by SD). All four models contained nest ID as random intercept. Calling was entered as count and offset specified length of observation in minutes (divided by ten minutes and ln-transformed), which not only controlled for the length of observation, but also generated a calling rate 10min^{-1}.

Distribution of fly-offs was bimodal (26 observations with one fly-off, 3 observations with two fly-offs and 3 with four fly-offs, the remaining observation no fly-offs); thus, in the analyses we used fly-off intensity as binary variable (0 = no fly-off, 1 = at least one fly-off).

Table S2 | Incubating parent's timing of calls and fly-offs before the nest relief and during other times of incubation.

Model	Response variable	Effect type	Effect	Estimate	95% CI Lower	95% CI Upper
a	Call time (to observation end)	Fixed	Intercept (before nest relief)	9.59	7.68	11.48
			Type (control)	4.03	1.23	6.84
		Random (variance)	Observation ID within Nest (intercept)	31%		
			Nest (intercept)	10%		
			Residual	59%		
b	Call time (to observation end)	Fixed	Intercept (♀& before nest relief)	9.01	6.64	11.4
			Type (control)	4.4	0.1	8.57
			Sex (♂)	1.2	-1.85	4.22
			Type × Sex	-0.8	-6.54	5.02
		Random (variance)	Observation ID within Nest (intercept)	32%		
			Nest (intercept)	10%		
			Residual	59%		
c	Fly-off time (to observation end)	Fixed	Intercept (before nest relief)	18.22	14.78	21.56
			Type (control)	-5.87	-11.07	-0.45
		Random (variance)	Observation ID within Nest (intercept)	42%		
			Nest (intercept)	0%		
			Residual	58%		
d	Fly-off time (to observation end)	Fixed	Intercept (♀& before nest relief)	21.25	16.11	26.41
			Type (control)	-8.94	-17.11	-0.52
			Sex (♂)	-4.61	-11.35	1.8
			Type × Sex	3.69	-7.39	14.13
		Random (variance)	Observation ID within Nest (intercept)	24%		
			Nest (intercept)	24%		
			Residual	52%		

Shown are the posterior estimates (medians) of the effect sizes with the 95% credible intervals (CI) from a posterior distribution of 5,000 simulated values generated by the 'sim' function in R (Gelman and Su 2015). Variance components were estimated by the 'lmer' function in R (Bates *et al.* 2015).

N_{call} = 261 calling instances from 89 before nest relief observations of 26 nests and 84 calling instances from 36 control observation 18 nests.

$N_{fly\text{-}off}$ =25 fly-offs from 20 before nest relief observations of 14 nests and 19 fly-offs from 12 control observations of 11 nests.

Note that included are only observations (from Table S1) containing at least one call or fly-off

Table S3 | Time components of exchange behaviour in relation to sex and day of incubation.

Model	Response variable	Effect type	Effect	Estimate	95% CI	
					Lower	Upper
a	Presence before nest relief (s)	Fixed	Intercept (♀)	9.74	-9.26	28.03
			Sex of returning parent (♂)	4.77	-18.65	28.32
			Day of incubation	3.79	-26.73	33.21
			Sex × Day of incubation	-6.5	-30.32	17.57
		Random (variance)	Nest ID (intercept)	75%		
			Day of incubation	1%		
			Residual	24%		
b	Nest relief length (log(s))	Fixed	Intercept (♀) & before present)	2.43	2.2	2.66
			Left (while around)	-0.03	-0.37	0.28
			Left (during exchange)	**0.85**	**0.63**	**1.06**
			Sex of returning parent (♂)	0.04	-0.1	0.18
			Day of incubation	**-0.13**	**-0.25**	**-0.01**
			Sex × Day of incubation	0.05	-0.09	0.2
		Random (variance)	Nest ID (intercept)	25%		
			Day of incubation	2%		
			Residual	73%		
c	Exchange gap (log(s))	Fixed	Intercept (♀)	2.59	2.1	3.05
			Sex of returning parent (♂)	0.48	-0.08	1.06
			Day of incubation	-0.01	-0.49	0.47
			Sex × Day of incubation	-0.19	-0.77	0.39
		Random (variance)	Nest ID (intercept)	38%		
			Day of incubation	0%		
			Residual	62%		
d	Nest relief start to incubating leave (s)	Fixed	Intercept (♀ & no 'please leave')	11.98	7.78	16.12
			Sex of returning parent (♂)	-0.56	-5.92	5.07
			'Please leave' (yes)	**13.82**	**2.34**	**25.45**
			Day of incubation	**-4.47**	**-8.97**	**-0.25**
			Sex × 'Please leave'	9.49	-8.93	27.64
			Sex × Day of incubation	1.95	-3.44	7.43
		Random (variance)	Bird ID (intercept)	10%		
			'Please leave' (0,1)	36%		
			Nest ID (intercept)	5%		
			Residual	49%		

Shown are the posterior estimates (medians) of the effect sizes with the 95% credible intervals (CI) from a posterior distribution of 5,000 simulated values generated by the 'sim' function in R (Gelman and Su 2015). Variance components were estimated by the 'lmer' function in R (Bates *et al.* 2015).

N = 163 nest relief observations from 31 nests, except for model 'd' where *N* = 123 exchange observations (from 30 nests) where incubating parent left while or after the returning parent initiated the exchange. Day of incubation was z-transformed (mean-centred and divided by SD), except for random slope in 'Exchange gap' model where non-transformed day of incubation improved model convergence. Note that 'Presence before exchange' is zero inflated (see Results) and hence the model fitted the data poorly, but binomial model with 'Presence before exchange' as binary response variable (0 = not present, 1 = present) generated similar results.

To allow for ln-transformation, we specified instantaneous exchanges (i.e. without any exchange gap) as taking 0.001s.

Table S4 | Calling during exchange in relation to sex, previous calling bouts and day of incubation.

Model	Response variable	Effect type	Effect	Estimate	95% CI Lower	95% CI Upper
a	Calling while initiating (0, 1) (binomial scale)	Fixed	Intercept (♀)	-0.883	-1.471	-0.29
			Sex of returning parent (♂)	-0.283	-1.194	0.606
			Day of incubation	0.009	-0.644	0.677
			Sex × Day of incubation	0.204	-0.671	1.059
		Random (variance)	Bird ID (intercept)	98%		
			Nest ID (intercept)	2%		
b	Reply of incubating parent (0, 1) (binomial scale)	Fixed	Intercept (♀)	-0.583	-1.715	0.542
			Sex of incubating parent (♂)	0.268	-1.194	1.805
			Day of incubation	-0.574	-1.791	0.665
			Sex × Day of incubation	1.15	-0.506	2.865
		Random (variance)	Bird ID (intercept)	100%		
			Nest ID (intercept)	0%		
c	Calling intensity of returning parent (while both parents around)		Intercept (♀)	1.55	1.097	1.978
			Sex of incubating parent (♂)	0.289	-0.314	0.894
			Calling intensity incubating parent	0.594	0.219	0.947
			Day of incubation	0.229	-0.177	0.623
			Sex × Calling incubation parent	-0.649	-1.148	-0.142
			Sex × Day of incubation	-0.031	-0.54	0.503
		Random (variance)	Bird ID (intercept)	33%		
			Calling intensity incubating parent	3%		
			Nest ID (intercept)	3%		
			Residual	60%		
d	Calling intensity during exchange gap		Intercept (♀)	1.641	1.373	1.912
			Sex of returning parent (♂)	-0.407	-0.781	-0.034
			Calling intensity during return	0.491	0.188	0.797
			Day of incubation	0.066	-0.198	0.325
			Sex × Calling during return	0.05	-0.366	0.458
			Sex × Day of incubation	0.199	-0.177	0.574
		Random (variance)	Bird ID (intercept)	5%		
			Calling during return	2%		
			Nest ID (intercept)	0%		
			Residual	93%		
e	Calling intensity after exchange		Intercept (♀)	0.512	0.22	0.819
			Sex of returned parent (♂)	-0.096	-0.517	0.329
			Calling intensity during return	0.139	-0.108	0.386
			Day of incubation	0.08	-0.183	0.344
			Sex × Calling during return	-0.149	-0.494	0.197
			Sex × Day of incubation	0.007	-0.361	0.358
		Random (variance)	Bird ID (intercept)	12%		
			Calling during return	3%		
			Nest ID (intercept)	0%		
			Residual	85%		

Shown are the posterior estimates (medians) of the effect sizes with the 95% credible intervals (CI) from a posterior distribution of 5,000 simulated values generated by the 'sim' function in R (Gelman and Su 2015). Variance components were estimated by the 'lmer' and 'glmer' function in R (Bates *et al.* 2015). Predictors (Day of incubation and Calling intensities) were z-transformed (mean-centred and divided by SD). Note that effects of those continuous predictors that are not specified as random slopes (because of convergence issues) might be inflated. Also, whereas we specified bird and nest as random intercepts in (b), their variance was estimated as zero and hence is not shown.

$N_{\text{Calling while initiating}}$ = 117 nest reliefs (with incubating parent leaving only after partner initiated the nest relief) of 47 parents from 28 nests.

$N_{\text{Reply of incubating parent}}$ = 31 nest reliefs (with returning parent calling while arriving) of 24 parents from 19 nests.

$N_{\text{Calling intensity of returning parent}}$ = 103 nest reliefs of 46 parents from 27 nests.

$N_{\text{Calling intensity during exchange}}$ = 109 nest reliefs of 49 parents from 28 nests.

$N_{\text{Calling intensity after exchange}}$ = 108 nest reliefs of 48 parents from 27 nests.

Table S5 | Calling during exchange in relation to current bout length.

Model	Response variable	Effect type	Effect	Estimate	95% CI Lower	95% CI Upper
a	Calling while initiating (0, 1)	Fixed	Intercept (♀)	-0.753	-1.4	-0.14
	(binomial scale)		Sex of returning parent (♂)	-0.643	-1.594	0.286
			Current bout length	0.169	-0.483	0.86
			Sex × Current bout length	0.555	-0.449	1.566
		Random	Bird ID (intercept)	0%		
			Nest ID (intercept)	100%		
b	Reply of incubating parent (0, 1)	Fixed	Intercept (♀)	-0.1	-1.41	1.219
	(binomial scale)		Sex of incubating parent (♂)	-0.167	-1.82	1.471
			Current bout length	-1.184	-3.149	0.856
			Sex × Current bout length	1.482	-0.817	3.791
c	Calling intensity of returning parent		Intercept (♀)	1.64	1.127	2.15
	(while both parents around)		Sex of incubating parent (♂)	0.315	-0.362	1.002
			Current bout length	-0.115	-0.475	0.236
			Sex × Current bout length	0.449	-0.181	1.058
		Random	Bird ID (intercept)	33%		
		(variance)	Current bout length	3%		
			Nest ID (intercept)	0%		
			Residual	64%		
d	Calling intensity of incubating parent		Intercept (♀)	0.638	0.184	1.087
	(while both parents around)		Sex of incubating parent (♂)	0.146	-0.466	0.782
			Current bout length	-0.265	-0.609	0.084
			Sex × Current bout length	0.433	-0.14	1.003
		Random	Bird ID (intercept)	25%		
		(variance)	Current bout length	1%		
			Nest ID (intercept)	0%		
			Residual	74%		
e	Calling intensity during exchange gap		Intercept (♀)	1.666	1.368	1.977
			Sex of returning parent (♂)	-0.505	-0.976	-0.051
			Current bout length	0.255	-0.132	0.652
			Sex × Current bout length	-0.299	-0.827	0.216
		Random	Bird ID (intercept)	12%		
		(variance)	Current bout length	11%		
			Nest ID (intercept)	0%		
			Residual	77%		
f	Calling intensity after exchange		Intercept (♀)	0.53	0.262	0.799
			Sex or returning parent (♂)	-0.077	-0.468	0.328
			Current bout length	-0.001	-0.24	0.23
			Sex × Current bout length	-0.066	-0.389	0.263
		Random	Bird ID (intercept)	30%		
		(variance)	Current bout length	4%		
			Nest ID (intercept)	0%		
			Residual	66%		

Shown are the posterior estimates (medians) of the effect sizes with the 95% credible intervals (CI) from a posterior distribution of 5,000 simulated values generated by the 'sim' function in R (Gelman and Su 2015). Variance components were estimated by the 'lmer' and 'glmer' function in R (Bates *et al.* 2015). Current and next bout lengths were z-transformed (mean-centred and divided by SD). Note that effects of those continuous predictors that are not specified as random slopes (because of convergence issues) might be inflated. Also, whereas we specified bird and nest as random intercepts in (b), their variance was estimated as zero and hence is not shown.

$N_{\text{Calling while initiating}}$ = 111 nest relief (with incubating parent leaving only after partner initiated the nest relief) of 45 parents from 27 nests.

$N_{\text{Reply of incubating parent}}$ = 30 nest reliefs (with returning parent calling while arriving and scorable reply) of 23 parents from 18 nests.

$N_{\text{Calling intensity of returning parent}}$ = 101 nest reliefs of 46 parents from 26 nests.

$N_{\text{Calling intensity of incubating parent}}$ = 96 nest reliefs of 44 parents from 26 nests.

$N_{\text{Calling intensity during exchange}}$ = 124 nest relief observations of 48 parents from 28 nests.

$N_{\text{Calling intensity after exchange}}$ = 123 nest relief observations of 47 parents from 27 nests.

Table S6 | Next incubation bout in relation to calling during exchange.

Model	Response variable	Effect type	Effect	Estimate	95% CI Lower	95% CI Upper
a	Next bout (min)	Fixed	Intercept (♀ & no arrival call)	688.5	633.4	743.4
			Arrival call (yes)	44.6	-28.5	116.3
			Sex of returning parent (♂)	-26.8	-95.4	39.3
			Sex × Arrival call	-18.7	-116.5	83.9
		Random	Bird ID (intercept)	28%		
			Nest ID (intercept)	10%		
		(variance)	Residual	62%		
b	Next bout (min)	Fixed	Intercept (♀ & no reply call)	596.5	504.3	686.6
			Reply call (yes)	250.1	101	406.2
			Sex of incubating parent (♂)	85	-44	215.9
			Sex × Reply call	-161.4	-369.5	43.6
		Random	Bird ID (intercept)	19%		
			Nest ID (intercept)	4%		
		(variance)	Residual	77%		
c	Next bout (min)		Intercept (♀)	704.2	651.6	756.3
			Sex of returning parent (♂)	-20.2	-78.5	39.5
			Calling intensity returning parent	-12.8	-56.7	29.3
			Calling intensity incubating parent	27.4	-11.4	66.4
			Calling intensity during exchange gap	18.1	-18.7	55.8
			Calling intensity after nest relief	***43.5***	***-9.8***	***97.5***
			Sex × Calling intensity returning parent	-2.5	-61.7	55.5
			Sex × Calling intensity incubating parent	-0.5	-57.1	56.1
			Sex × Calling intensity during exchange gap	33.1	-24.9	88
			Sex × Calling intensity after nest relief	***-78.6***	***-165.3***	***5.2***
		Random	Bird ID (intercept)	1%		
		(variance)	Calling intensity during exchange gap	18%		
			Nest ID (intercept)	31%		
			Residual	50%		

Shown are the posterior estimates (medians) of the effect sizes with the 95% credible intervals (CI) from a posterior distribution of 5,000 simulated values generated by the 'sim' function in R (Gelman and Su 2015). Variance components were estimated by the 'lmer' function in R (Bates *et al.* 2015).

Calling intensities were z-transformed (mean-centred and divided by SD). Note that effects of those continuous predictors that are not specified as random slopes (because of convergence issues) might be inflated, e.g. effect of 'Calling intensity during exchange gap' in (c) disappears when added as random slope. Also note that the estimate of Sex × Calling intensity after nest relief in the (c) is not driven by the other predictors as model containing only this single interaction gives similar results.

N_a= 119 nest reliefs of 47 parents from 27 nests.

N_b= 28 nest reliefs (with returning parent calling while arriving and scorable reply) of 22 parents from 17 nests.

N_c= 92 nest reliefs of 42 parents from 25 nests.

Table S7 | **'Please leave display' in relation to sex, day of incubation and current bout length.**

Model	Response variable	Effect type	Effect	Estimate	95% CI Lower	95% CI Upper
a	'Please leave' (0,1)	Fixed	Intercept (♀)	-3.8	-5.82	-1.77
	(binomial scale)		Sex of incubating parent (♂)	1.31	-1.14	3.78
			Current bout (min)	-1.03	-2.42	0.3
			Sex × Current bout	1.53	-0.3	3.41
		Random	Bird ID (intercept)	99%		
		(variance)	Current bout	1%		
			Nest ID (intercept)	0%		
b	'Please leave' (0,1)	Fixed	Intercept (♀)	-6.2	-10.74	-1.7
	(binomial scale)		Sex of incubating parent (♂)	0.73	-4.84	6.51
			Day of incubation	**1.65**	**0.14**	**3.14**
			Sex × Day of incubation	2.35	-0.77	5.42
		Random	Bird ID (intercept)	93%		
			Day of incubation	7%		

Shown are the posterior estimates (medians) of the effect sizes with the 95% credible intervals (CI) from a posterior distribution of 5,000 simulated values generated by the 'sim' function in R (Gelman and Su 2015). Variance components were estimated by the 'glmer' function in R (Bates *et al.* 2015).

N = 117 nest reliefs of 49 birds from 29 nests. 'Current bout' length and 'Day of incubation' were z-transformed (mean-centred and divided by SD). Note that that models without interactions generated similar results and that in (b) model with nest as random intercept did not converge.

Table S8 | **Probability of calling while leaving the nest.**

Response variable	Effect type	Effect	Estimate	95% CI Lower	95% CI Upper
Called when left (0,1)	Fixed	Intercept (♀)	-2.22	-3.01	-1.42
(binomial scale)		**Sex of incubating parent (♂)**	**1.01**	**0.1**	**1.93**
		Day of incubation (min)	-0.24	-1.02	0.53
		Sex × Day of incubation	0.27	-0.65	1.18
	Random	Bird ID (intercept)	0%		
	(variance)	Nest ID (intercept)	100%		

Shown are the posterior estimates (medians) of the effect sizes with the 95% credible intervals (CI) from a posterior distribution of 5,000 simulated values generated by the 'sim' function in R (Gelman and Su 2015). Variance components were estimated by the 'glmer' function in R (Bates *et al.* 2015).

N = 150 nest reliefs of 55 birds from 30 nests. 'Day of incubation' was z-transformed (mean-centred and divided by SD). Note that model with 'Day of incubation' as random slope did not converge and model without the interaction generated similar results.